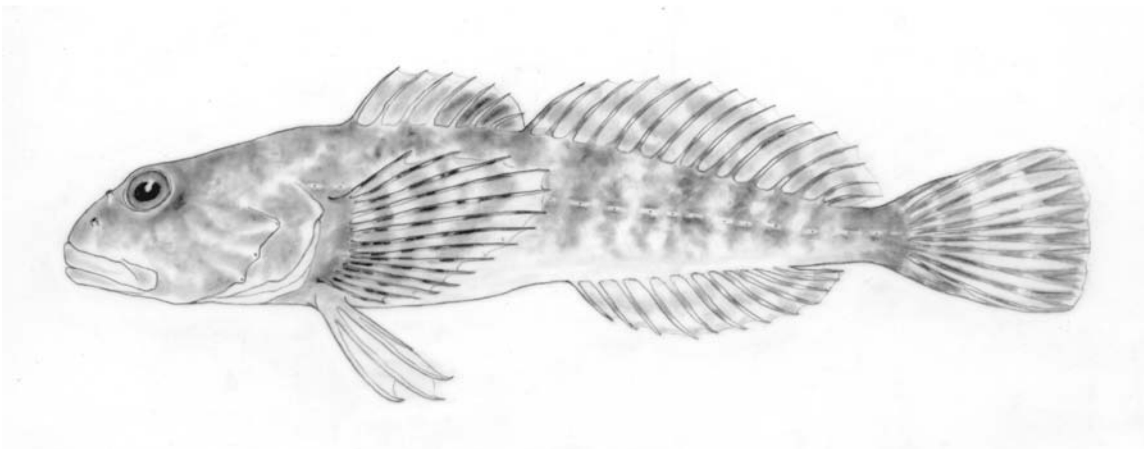
COSEWIC
Assessment and Status Report

on the

Columbia Sculpin
Cottus hubbsi

in Canada



SPECIAL CONCERN
2010

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
Assessment Summary

Assessment Summary – November 2010

Common name
Columbia Sculpin

Scientific name
Cottus hubbsi

Status
Special Concern

Reason for designation
In Canada, this small freshwater fish is endemic to the Columbia River basin where it has a small geographic distribution. It is a bottom-dwelling and sedentary fish as an adult, making it particularly susceptible to declines in habitat area and quality from drought and changes in water flow. It is close to meeting Threatened status owing to its small geographic range, relatively few locations and ongoing declines in habitat quality.

Occurrence
British Columbia

Status history
Designated Special Concern in May 2000. Status re-examined and confirmed in November 2010.

COSEWIC
Executive Summary

Columbia Sculpin
Cottus hubbsi

Wildlife species information

The Columbia Sculpin is a small, bottom-dwelling fish with a body shape that tapers from a relatively large head and pectoral fins to a narrow caudal (tail) fin area. The Columbia Sculpin reaches a maximum total length of about 110 mm. The Columbia Sculpin is distinguished from other co-occurring sculpins by a relatively long head, a complete lateral line, and striking broad, dark bars on the caudal fin, and oblique dark bars on the anal fin. There is no evidence of multiple designatable units with the Columbia Sculpin.

Distribution

In Canada, the Columbia Sculpin is restricted to portions of the Columbia River drainage in south-central British Columbia (BC). In BC, the Columbia River distribution extends from the Keenleyside Dam near Castlegar, BC, downstream to the US border. The species' distribution also includes major and minor Columbia tributaries, including 5 km of the Kettle River below Cascade Falls, and the Similkameen River system and its tributaries from the US border upstream to Similkameen Falls and Tulameen River drainages. The index of total area of occupancy in Canada is 972 km^2.

In the US this species occurs in the Columbia River and its tributaries in Washington, Oregon, and Idaho. Here, its range includes about 1,600 linear km of the Columbia and Snake rivers from below Shoshone Falls downstream to the confluence of the Umatilla and Columbia rivers. Below this point the species' distribution is highly fragmented.

Habitat

During the day, this species shelters in riffles and runs with moderate to fast surface velocities and large rock and boulder substrates. It is active at night. Although this species typically is associated with large rivers and their major tributaries, in places it also occurs in small streams.

Biology

This species usually lives less than five years: females reach sexual maturity in two to three years and males mature in two years. They spawn in the spring and early summer. The eggs are large and take about three to four weeks to hatch. The species is sedentary and adults rarely move more than 50 m.

Population sizes and trends

There are no quantitative data on numbers in the Columbia River population, but most populations in large rivers tributary to the Columbia appear to be stable. This species occurs in a 5 km reach of the Kettle River below Cascade Falls. In the Similkameen system, the distribution in some small streams appears to have shrunk since the 1950s.

Threats and limiting factors

In Canada, natural barriers appear to control the geographic limits of this species: there are no known populations of this species above waterfalls or in large lakes. The major threats to BC populations are drought, urbanization, industrial development, and mining activities. A proposed dam on the Similkameen River at Shanker's Bend, Washington, could flood up to 40 km of the Similkameen Valley in Canada. A proposed "super" open pit mine on Copper Mountain near Princeton could pose a threat to the river. How an approved power project at Cascade Falls on the Kettle River may affect the 5 km of river below the falls is unknown. Similarly, the effects of a proposed private power project on Koch Creek are unknown.

Special significance

Unresolved taxonomic problems and the coexistence of up to five sculpin species in small streams are of scientific interest. The species' limited distribution makes it a unique part of Canada's faunal heritage.

Existing protection, status, and ranks

The *Fisheries Act* provides Fisheries and Oceans Canada with powers to conserve and protect fish and fish habitat. The BC Conservation Data Centre lists the Columbia Sculpin as a species of concern. A previous COSEWIC assessment (May 2000) ranked the Columbia Sculpin a species of Special Concern and it is listed as such on Schedule 1 of the *Species at Risk Act*. The status was re-examined by COSEWIC and confirmed as Special Concern in November 2010. Globally, its NatureServe rank (2010) describes the Columbia Sculpin as globally apparently secure and with uncertain taxonomy (G4T4Q).

TECHNICAL SUMMARY

Genus species: *Cottus hubbsi*

Columbia Sculpin   Chabot du Columbia

Range of occurrence in Canada (restricted to southcentral BC): The Canadian range of the Columbia Sculpin encompasses 41 km of the mainstem Columbia River between Keenleyside Dam and the US border, and about 45 km of the Kootenay River from its confluence with the Columbia River upstream to lower Bonnington Dam, plus the Slocan River from its confluence with the Kootenay River upstream to Slocan Lake (about 45 km) and approximately 10 km of the Little Slocan River and its tributary, Koch Creek. This species also occurs in the 5 km of the Kettle River between Cascade Falls and the US border, and in about 155 km of the Similkameen River between the US border and Similkameen Falls, plus about 20 km of the Tulameen River from Princeton upstream to Lawless Creek, 28 km of Otter Creek, plus about 10 km of Allison Creek, 14 km of Summers Creek, 10 km of Hayes Creek, 2 km of Keremeos Creek, and about 2 km of the Ashnola River.

Demographic Information

Generation time (average age of parents in the population)	3 yrs
Is there an inferred continuing decline in number of mature individuals?	Decline in some small streams in the Similkameen system, appears stable elsewhere.
Estimated percent of continuing decline in total number of mature individuals within 5 years	< 1% of total inferred from potential habitat loss (but about 5% in Otter, Summers, Allison, Hayes, and Keremeos creeks; rest of Canadian populations apparently stable)
Observed percent reduction in total number of mature individuals over the last 10 years.	About 2.5% total (but about 42% in Otter Creek inferred from the loss of about 42% of the habitat there)
Projected percent reduction in total number of mature individuals over the next 10 years.	Unknown
Inferred percent reduction in total number of mature individuals over any 10 year period, over a time period including both the past and the future.	About 5% total (but in the Similkameen system about 10% reduction in the last 10 years and a 10% reduction in the next 10 years inferred from habitat loss trends).
Are the causes of the decline clearly reversible and understood and ceased?	Declines in the small streams in the Similkameen system appear to be due to habitat loss from declining water flows that are inferred to continue from climate change projections (warmer temperature, lower snowpack)
Are there extreme fluctuations in number of mature individuals?	Probably not, but quantitative population size and trend data are lacking.

Extent and Occupancy Information

Estimated extent of occurrence EO Columbia Population EO Kootenay/Slocan Population EO Bonnington Population EO Kettle Population EO Similkameen Population **Total Canadian EO**	 327 km² 613 km² 4 km² 24 km² 3,229 km² **17,593 km²**
Index of area of occupancy (IAO) IAO Columbia Population IAO Kootenay/Slocan Population IAO Bonnington Population IAO Kettle Population IAO Similkameen Population **Total Canadian IAO**	 2X2=160 km² 1X1= 93 km² 2X2= 220 km² 1X1= 125 km² 2X2= 4 km² 1X1= 2 km² 2X2= 24 km² 1X1= 10 km² 2X2= 564 km² 1X1= 317 km² **2X2= 972 km²** 1X1= 546 km²
Is the total population severely fragmented (*sensu* IUCN)?	No, but dams and natural barriers have isolated many populations
Number of locations (total) Columbia Population	**21 locations in Canada** One in the Columbia River, and five in tributaries: Norns, Beaver, Blueberry, and Champion creeks, and Kootenay River below Brilliant Dam. Columbia sculpins only occur near the mouths of the five tributary creeks.
Kootenay/Slocan Population	Five locations in the Slocan River (three in the main river and one in each of the Little Slocan R. and Koch Ck.)
Bonnington Population	One between South Slocan and lower Bonnington dams
Kettle Population	One in the Kettle River
Similkameen Population	Eight in the Similkameen system (one each in the Similkameen, Tulameen, and Ashnola rivers, plus one location in creeks where there is evidence of a population upstream of their confluences with one of the rivers)

Is there an inferred continuing decline in extent of occurrence?	No
Is there an inferred continuing decline in index of area of occupancy?	Yes (Otter Ck.)
Is there an observed continuing decline in number of populations?	No
Is there an observed continuing decline in number of locations?	No
Is there an observed continuing decline in extent and/or quality of habitat?	Yes (Otter Ck. and the Kettle River).
Are there extreme fluctuations in number of populations?	No, stable
Are there extreme fluctuations in number of locations∗?	No, stable
Are there extreme fluctuations in extent of occurrence?	No, stable
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each population)

Population	N Mature Individuals
Columbia population Kootenay/Slocan population Bonnington population Kettle population Similkameen population	unknown
Total	unknown

Quantitative Analysis

Probability of extinction in the wild is at least 20% within 20 years or 5 generations, or 10% within 100 years.	No quantitative analysis

Threats (actual or imminent, to populations or habitats)

Columbia Population: both the pulp mill at Castlegar and the smelter at Trail have discharged effluent into the Columbia mainstem for decades. It is not known if pollution or the operation of Keenleyside Dam has adverse effects on Columbia Sculpins. Continuing flow regulation on the Columbia River causes fluctuations in availability and quality of habitat.

Kootenay/Slocan Population: the proposed hydro project on Koch Ck. may pose a threat to that location. Continuing flow regulation on the Kootenay River causes changes in availability and quality of habitat.

Bonnington Population: appears to be secure, although a change in dam operating procedures might adversely affect the one known site. Continuing flow regulation on the Kootenay River causes changes in availability and quality of habitat.

Kettle Population: fish kills linked to low flows and high water temperatures; the effects of the hydro project on the Kettle River at Cascade Falls are unknown

Similkameen Population: renewed mining activity may reduce water quality in the main river and the proposed Shanker's Bend Dam is a potential major threat. Seasonal drying of tributary streams (e.g., Otter Ck.) and fish kills linked to high temperatures and low flows are a concern.

Rescue Effect (immigration from outside Canada)

Status of outside population(s) Columbia Population: Unknown for the Columbia River; however, the distribution map in Wydoski and Whitney (2003) indicates that *C. hubbsi* is present in the Columbia mainstem between the US border and Roosevelt Reservoir, and there are no barriers between this region and the BC Columbia populations. Kootenay/Slocan Population: In the event of a catastrophe on the Slocan River, immigrants from Koch Creek and the Little Slocan River would probably recolonize the Slocan River; however, Brilliant Dam precludes recolonization of the Kootenay and Slocan system from outside sources. Bonnington Population: there is no outside source for recolonization for this population. Kettle Population: A catastrophe in the Kettle River above Cascade Falls probably would wipe out the Kettle population in Canada; however, over time, downstream populations in the US might recolonize the Canadian Kettle River population. Similkameen Population: In the event of a catastrophe on the Similkameen River, immigrants from the Tulameen River or one of the tributary streams would probably recolonize the Similkameen River. It is also possible that immigrants from the US would move upstream from the short stretch of river between the original site of Squanti Falls and the border; however, if the Shanker's Bend Dam is built this outside source will be lost.	
Is immigration known or possible?	Possible for the Columbia, Kettle, and Similkameen populations but not possible for the Kootenay/Slocan and Bonnington populations.
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	No, if the BC populations remain stable or if the BC populations decline owing to habitat loss or degradation.
Is rescue from outside populations likely?	Probable for Columbia and Kettle populations but not for isolated (by dams) Kootenay/Slocan and Bonnington populations.

Current Status

COSEWIC: re-assessed in 2010 as a Species of Special Concern. SARA: Special Concern (Schedule 1), 2003

Additional Sources of Information:

Status and Reasons for Designation

Status: Special Concern	**Alpha-numeric code:** NA
Reason for Designation: In Canada, this small freshwater fish is endemic to the Columbia River basin where it has a small geographic distribution. It is a bottom-dwelling and sedentary fish as an adult, making it particularly susceptible to declines in habitat area and quality from drought and changes in water flow. It is close to meeting Threatened status owing to its small geographic range, relatively few locations and ongoing declines in habitat quality.	

Applicability of Criteria

Criterion A: Does not meet any criteria (quantitative decline data do not exist)**.**
Criterion B: Meets Threatened for B1b+2b as EO < 20,000 km² and IAO < 2,000 km² and some evidence of past and inferred continued habitat loss, but not sub-criterion (a) [total population is not severely fragmented and there are > 10 (~21) locations] nor (c).
Criterion C: Does not meet criteria. Estimated population size is probably < 10,000 (but is highly uncertain), but no evidence of meeting C1 or C2 criteria.
Criterion D: Does not meet criteria (21 locations and IAO is 972 km²).
Criterion E: Not applicable (necessary data do not exist).

PREFACE

The Columbia Sculpin (*Cottus hubbsi*) is a small, freshwater sculpin (Cottidae). In Canada, it only occurs in the Columbia River and its tributaries in southcentral British Columbia. The species was last reviewed in 2000 and is included in the S*ARA* Schedule 1 list as a species of Special Concern. The following report is the second assessment under the revised criteria required for all species assessed by COSEWIC before 1999. Since the 2000 assessment, the relationship between the Columbia Sculpin and the Mottled Sculpin (*Cottus bairdii*) has been clarified (they are different species), but the Columbia Sculpin still is considered a member of the *Cottus bairdii* clade (a group of related species that share a common ancestor). Nonetheless, there are unresolved taxonomic issues with the Columbia Sculpin and its relationship to the Malheur (*Cottus bendirei*) and the Bonneville (*Cottus semiscaber*) sculpins. Ultimately, the resolution of these taxonomic problems might affect the scientific and common names used for this sculpin, but should not affect our understanding of its geographic distribution in Canada.

Since the last status assessment, this species' Canadian distribution is unchanged. There is evidence of a decline in numbers at some of the known Canadian sites; however, existing data on abundance are scarce and mostly anecdotal. There is some new information on the species' reproductive biology and a few new site-specific estimates of abundance. In terms of threats, there has been an increase in the frequency of drought conditions in the Similkameen and Kettle drainage basins. There are proposals for run-of-the-river hydroelectric projects in the Kettle and Slocan rivers; however, the downstream effects of such projects are unknown. The Kettle River is of specific concern. This river is subject to low water and high temperatures during the irrigation season (summer), and fish kills (Rainbow Trout, *Oncorhynchus mykiss*, and Mountain Whitefish, *Prosopium williamsoni*) have occurred at least six times in the last 20 years (Tara White, pers. comm. 2010). If warming trends in this region continue, the Kettle River population may be in danger of extirpation. The Similkameen River and its tributaries also suffer from frequent low water episodes, and this drainage system contains a number of proposed or active mines that include a water diversion and potentially significant sulfate pollution. Also, there is a proposed dam at Shanker's Bend just south of the border. If this dam is constructed it could flood up to 40 km of the river in Canada. The Columbia Sculpin Recovery Team was established after the species was listed as Special Concern under Schedule 1 of *SARA* in 2000 and a management plan has been completed, but its recommendations have not been implemented (Columbia Sculpin Recovery Team 2009).

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
(2010)

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

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

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

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

Environment Canada / Environnement Canada
Canadian Wildlife Service / Service canadien de la faune
Canada

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

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WILDLIFE SPECIES INFORMATION

Name and classification

Kingdom:	Animalia
Phylum:	Chordata
Class:	Actinopterygii
Order:	Scorpaeniformes
Family:	Cottidae
Scientific name:	*Cottus hubbsi*
Common name:	
English:	Columbia Sculpin
French:	Chabot du Columbia

Taxonomic history

Common name

The original description of *Cottus hubbsi* did not include a common name (Bailey and Dimick 1949), and the first published use of the common name, Columbia Sculpin, appears in McAllister and Lindsey (1961). Later, Bailey and Bond (1963) synonymized *C. hubbsi* with the eastern North American Mottled Sculpin, *Cottus bairdii*. More recently, however, Markle and Hill (2000) and Neely (2002) argue that *C. hubbsi* is a valid species. For *C. hubbsi*, Markle and Hill used the common name Columbia Mottled Sculpin, while Neely (2002) used Columbia Sculpin as the common name. The sixth (2004) edition of the "Common and Scientific Names of Fishes from the United States, Canada, and Mexico" (Nelson *et al*., 2004) uses Columbia Sculpin. Consequently, the official common name for *C. hubbsi* is now the Columbia Sculpin (see further discussion in McPhail 2007).

Scientific name

The Columbia Sculpin (Figure 1) is a western North American member of the Uranidea sculpin clade and, although it has been called *Cottus bairdii* (Cannings and Ptolemy 1998; Wydoski and Whitney 2003), it is not *Cottus bairdii* (see Table 1). *Cottus bairdii*, the Mottled Sculpin, is an eastern North American species. Nelson *et al.* (2004) use the scientific name, *Cottus hubbsi*, for the Columbia Sculpin and this is the scientific name used in this report. There are, however, nomenclatorial problems surrounding the use of this scientific name in British Columbia, and the scientific name may change when these problems are resolved. Unfortunately, understanding these problems requires delving into the minutiae of sculpin taxonomy. Still, even though there are doubts about the appropriate scientific name, south-central BC is the only place in Canada where this fish occurs. Thus, regardless of what scientific name is used when the taxonomy is resolved, this fish is a unique component of the Canadian fauna.

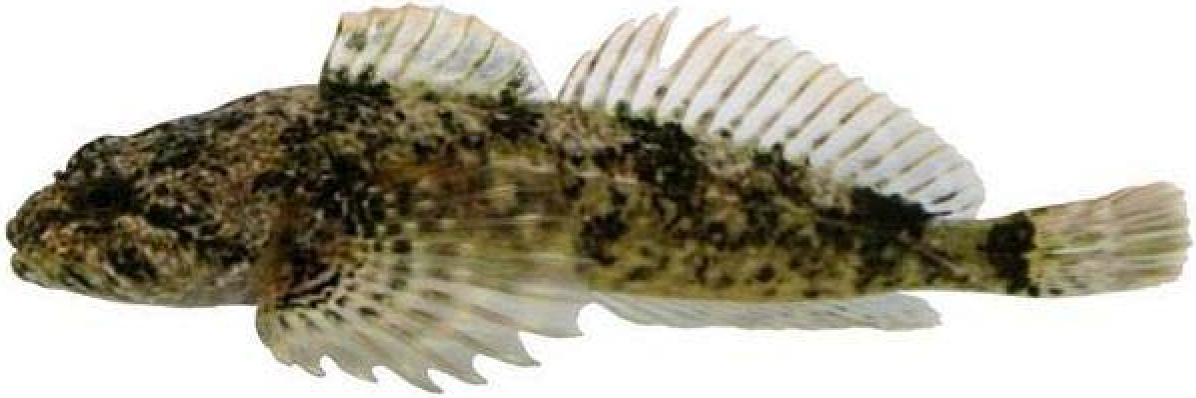

Figure 1. A Columbia Sculpin (*Cottus hubbsi*), about 55 mm total length, collected from the Similkameen River in 2006 (used with permission of the photographer, Gavin Hanke, Victoria, BC).

Table 1. Genetic distances (uncorrected, McPhail unpublished data) among *Cottus bendirei* and putative *C. bendirei* and *C. hubbsi* in the Harney Basin and Similkameen River system. Eastern North American *C. bairdii* (bold face) is added for comparison. A "K" at the end of a code indicates a sequence from GenBank submitted by Kinziger and Wood (2003). The codes are listed below.

BK	HK	BSim1	HSim2	HSLo	CBR	
BK	-------					
HK	0.002	-------				
BSim1	0.011	0.009	-------			
HSim2	0.012	0.010	0.001	-------		
HSLo	0.010	0.008	0.001	0.002	-------	
CBR	**0.043**	**0.044**	**0.042**	**0.043**	**0.041**	**-------**

Codes: BK= *C. bendirei*; HK= *C. hubbsi*; BSim1= putative *C. bendirei* from Otter Creek BC; HSim2= putative *C. hubbsi* from the Similkameen River BC; HSLo= putative *C. hubbsi* from Little Slocan River, BC, and **CBR**= *C. bairdi*i from the Saugeen River, Ontario. BK and HK were collected from Silver Creek, Harney Co., Oregon, and the Silvies River, Harney Co. Oregon, respectively (D. Neeley, pers. comm. 2010).

Markle and Hill (2000) published a paper on the sculpins in the Harney Basin, Oregon. They tentatively concluded that there were two sculpin species: one with reduced prickling and another with dense prickling. Only the sculpin with reduced prickling occurred on the south side of the basin, but both forms occurred on the north side of the basin. Here, the species with reduced prickling was found in headwater streams and was connected by a narrow hybrid zone to the heavily prickled species found in larger rivers. They used the scientific name *Cottus bendirei* for the species with reduced prickling and *Cottus hubbsi* for the heavily prickled species.

Markle and Hill (2000) not only resurrected the scientific name *Cottus bendirei* for the sculpin with a reduced prickling, but also argued that this species was not confined to the Harney Basin but also occurred in lower Snake River tributaries and elsewhere in the Columbia system (perhaps including British Columbia). The latter suggestion was based on the observation in Peden *et al.* (1989) that headwater streams in the Tulameen River system (a major Similkameen tributary) contain sculpins with a reduced number of prickles. If these Tulameen sculpins are actually *C. bendirei* it means that there are two *bairdii*-like sculpins in BC: the heavily prickled *C. hubbsi* and the lightly prickled *C. bendirei*.

The rest of this discussion focuses on the situation in the Similkameen drainage system. Three lines of evidence are examined to address the question of whether the form with reduced prickles is *C. bendirei*: morphology, allozyme data, and mitochondrial sequences. The assumption is that if both *C. bendirei* and *C. hubbsi* occur in the Similkameen system the allozyme and mitochondrial data should be congruent with the morphological data.

<u>Morphological evidence</u>

In the Harney Basin, the major morphological differences between *C. bendirei* and *C. hubbsi* are the extent of prickling and the length of the lateral line (Markle and Hill 2000). *Cottus hubbsi* is absent from the southern portion of the Harney Basin, and here *C. bendirei* has relatively few body prickles (0-30) and the lateral line usually is incomplete. In the northern portion of the basin, *C. bendirei* is restricted to headwater streams and *C. hubbsi* occurs in the larger rivers. Here the counts of body prickles show three distinct groups: *C. bendirei* with a low number of prickles (0-19), *C. hubbsi* with 99 or more prickles, and nominal hybrids with 33-70 prickles.

In the Similkameen system in BC, prickle counts (left side below lateral line) in adults and juveniles (over 45 mm standard length) range from 0 to >100. This spans the entire range of prickle counts from the Harney Basin. Nonetheless, when the BC portion of the river system is divided into lower, middle, and upper sections there is a clear tendency for sculpins in the upper headwaters to have low (*bendirei*-like) prickle counts and for sculpins in the lower river to have high (*hubbsi*-like) prickle counts (Figure 2). There is, however, a major exception to this trend. Several headwater lakes that are high in total dissolved solids (Missezula, Allison, Borgeson, Dry, and Laird lakes) contained densely prickled *hubbsi*-like sculpins. Most (87%, N=53) of the *hubbsi*-like sculpins in the Similkameen system have complete lateral lines (a characteristic of *hubbsi*) but 13% have incomplete lateral lines (a characteristic of *bendirei*). Also, the pattern in pectoral ray counts demonstrated by Peden *et al.* (1989) still holds: in the lower river about 90% of the specimens have 15 or 16 pectoral rays, while in the headwaters about 60% of the specimens have 14 pectoral rays.

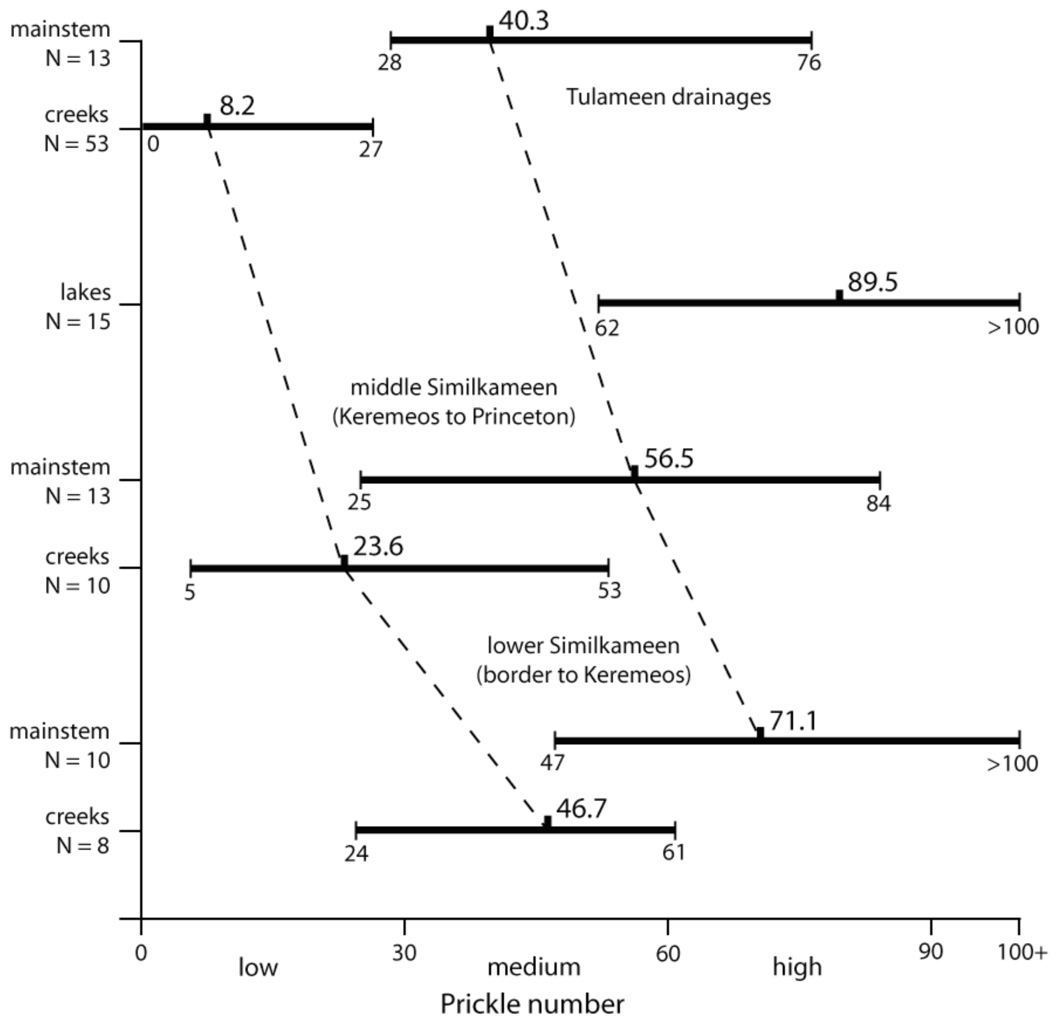

Figure 2. Ranges and means of prickle counts for Columbia Sculpin (*Cottus hubbsi*) in creeks (includes the lakes in the Allison Creek drainage) and the mainstems in the lower and middle Similkameen River and Tulameen River. Dashed lines connect the means.

In summary, with the exception of the lakes mentioned above, the Similkameen morphological data are similar to that described in the Harney Basin — a heavily prickled *hubbsi*-like sculpin in the lower river, and a low prickled *bendirei*-like sculpin in the headwaters. In this case, however, a smooth cline of intermediate prickle morphology connects the two morphological forms (Figure 2).

Allozyme evidence

A set of allozyme data that includes *C. hubbsi* (as *C. b. hubbsi*) is presented in COSEWIC (2000). The data are from an unpublished manuscript attributed to Ruth Withler (DFO) and Alex Peden (RBCM) as summarized in COSEWIC (2000). Nei's genetic distances are given for specimens from the Similkameen system (including Otter Creek), the Kettle River, and the Slocan River. The genetic distances among the lower Similkameen, Otter Creek, and Kettle River samples range from 0.01 to 0.02. The genetic distance between these samples and the sample from the Slocan River is estimated (from Figure 4 in COSEWIC 2000) as 0.03 to 0.04. These genetic distances are well within the range of Nei's genetic distances expected among populations within a relatively small geographic region (Avise 1994).

Mitochondrial DNA evidence

GenBank lists partial (1073 bp) cytochrome *b* sequences for both *Cottus hubbsi* and *Cottus bendirei* (Kinziger *et al.* 2005). Both of these sequences were from fish collected from areas of parapatry in the Harney Basin in Oregon (D. Neeley, pers. comm., 2010). These sequences were compared with sequences for *C. bairdii*, a *C. bendirei*-like sculpin from an upper Similkameen site (Otter Creek), a *C. hubbsi*-like sculpin from a lower Similkameen site (Kobau Park near Keremeos, BC), and a specimen from the Little Slocan River, Kootenay drainage system (McPhail, unpublished data).

With the exception of eastern North American *C. bairdii*, the genetic distances between the two putative species are smaller than expected: they range from 0.001 to 0.002 (0.1% to 0.2%, Table 1). Usually, genetic distances (based on cytochrome *b* sequences) among *Cottus* species, or major groups within species, range from about 2.5 to 5.0% (Yokoyama *et al.* 2008). In particular, note that the genetic distance between the sequences for *C. bendirei* and *C. hubbsi* obtained from GenBank is only 0.002 (0.2%), whereas the genetic distances between Similkameen sculpins and the sequences obtained from GenBank range from 0.009 to 0.012 (0.9 to 1.2%, Table 1). Although the genetic distance between *C. bendirei* and *C. hubbsi* in Table 1 is typical of interpopulation divergences rather than interspecific divergences, this does not necessarily mean that they are the same species. It does, however, argue that there should be compelling reasons for treating them as separate species. Such reasons would be evidence for reproductive isolation in sympatric populations or, in allopatry, consistent morphological differences between the putative species. None of these requirements are met in either the Harney Basin or the Similkameen drainage system.

Fourteen individual sequences were obtained from sculpins from the Similkameen system. Seven individuals were from a headwater stream (Otter Creek) and seven were from the Similkameen River below Keremeos, BC. There were two haplotypes present in the Similkameen system (Table 1): 12 individuals displayed one haplotype and two individuals (one from Otter Creek and one from downstream) had the other haplotype. The genetic distance between the two haplotypes was 0.001 (0.1%). Five of the seven Otter Creek fish had reduced prickles (0-27) and two had incomplete lateral lines. Six of the seven fish from the Similkameen River downstream of Keremeos had intermediate prickle numbers (34-67) and one fish had >100 prickles. Most of the sculpins from the lower river had a complete lateral line but one individual had an incomplete lateral line. The morphologically unusual fish, however, all shared the common mtDNA haplotype. In summary, although the sample size is small, the molecular data argue that within the Harney Basin, and in the Similkameen system, there is no compelling evidence of molecular divergence between individuals with a *C. bendirei*-like morphology (reduced prickles) and those with a *C. hubbsi*-like morphology (high prickle numbers). In addition, it is unusual for recognized species of fishes to demonstrate such low levels of mtDNA divergence (e.g., Johns and Avise 1999; Hebert *et al.* 2004).

Summary of morphological and genetic evidence

In the Harney Basin, Markle and Hill (2000) dismissed the possibility that the high and low prickle-count sculpins were ecotypes of the same species; however, in the Similkameen system the case for two ecotypes is strong. First, the trend towards a reduction in prickle numbers is a relatively smooth cline (Figure 2) from the US border to the headwaters of the Tulameen River (a river distance of about 100 km). Second, the mitochondrial DNA sequences remain identical over this distance while the prickle pattern shifts from heavily prickled (the *C. hubbsi* condition) to reduced prickles (the *C. bendirei* condition). Third, the sculpins that once lived in headwater lakes in this system — the lakes were poisoned in the 1950s — were all heavily prickled. This argues that the degree of prickling in these sculpins is a response to local conditions (i.e., prickle number is a local adaptation). A similar pattern is found in BC in the Torrent Sculpin, *Cottus rhotheus* and in a *C. hubbsi*-like sculpin found in the upper Palouse River, Idaho (McPhail 2007).

No molecular data are available for *C. hubbsi* in the Kettle River below Cascade Falls and the mainstem Columbia River. Morphologically, however, most of these sculpins resemble lower Similkameen *C. hubbsi* in that they have from 40 to >100 prickles. A single sequence is available from Koch Creek (a tributary of the Little Slocan River). This specimen had a low prickle number (17), and its cytochrome *b* sequence (HSlo in Table 1) is similar (0.01 to 0.02%) to the sequences in the Similkameen River system. Thus, although the data are sparse, the pattern of morphological variation and the molecular data in other BC sites are basically similar to the Similkameen sites (i.e., no evidence of a sequence divergence between low and high prickle count *C. hubbsi*-like sculpins).

Thus, within the Similkameen drainage system, there is no compelling evidence for two species of *C. hubbsi*-like sculpins. Instead, the data strongly support the hypothesis of a single species that differs morphologically in different habitats: heavy prickling in mainstem rivers and lakes, and reduced prickles in small headwater streams. The question of whether this species should be called *Cottus bendirei* or *Cottus hubbsi* cannot be answered in Canada. The answer lies in the Harney Basin in Oregon and the Enitat River in Washington; however, if there is a single species in the Harney Basin (as appears possible from the available molecular data), the name *Cottus bendirei* has precedence over *Cottus hubbsi*. Pending further data, therefore, there could be a scientific name change for the Columbia Sculpin in Canada. Regardless of the taxonomic questions that remain, in Canada the Columbia Sculpin is only found in the Columbia River basin.

Morphological description

Diagnosis

Four sculpin species co-occur with the Columbia Sculpin in BC: the Prickly Sculpin, *Cottus asper*; the Torrent Sculpin, *Cottus rhotheus*, and the Shorthead Sculpin, *Cottus confusus*, while the fourth species, the Slimy Sculpin, *Cottus cognatus,* occurs above waterfalls in the Kootenay, Little Slocan, and Kettle rivers and may occasionally be swept downstream into Columbia Sculpin habitat. The Columbia Sculpin (Figure 1) has well developed palatine teeth; 11-14 anal rays; and a moderately deep caudal peduncle (4.4-5.7 into head length). Columbia and Torrent sculpins are difficult to separate; however, their prickle and colour patterns are different — typically there are less than 30 prickles above the lateral line in the Columbia Sculpin, whereas the flanks above the lateral line in Torrent Sculpins usually are densely covered in prickles.

Description

The following description of the Columbia Sculpin is based on specimens from four of the five discrete Canadian populations: the Columbia, Kootenay/Slocan, Kettle, and Similkameen populations. In general body shape, the Columbia Sculpin resembles most other sculpins in the genus *Cottus* (see cover illustration). Head length (HL) goes 2.8-3.3 times into standard length (SL), mouth width goes 4.2-6.0 times into SL, and the caudal peduncle depth goes 13.5-15.7 times into SL. There are two median chin pores and usually a double postmaxillary pore. The first and second dorsal fins are either slightly conjoined or separate, with 7-9 spines in the first dorsal fin and 15-18 rays in the second dorsal fin. There are 11-14 (usually 12 or 13) anal rays and 13-16 (usually 14 or 15) pectoral rays. Pelvic fins have 1 spine and 4 rays. The lateral line can be either complete or incomplete and has 27-34 pores. The number of prickles in, and behind, the pectoral axial but below the lateral line is variable and ranges from 0 to >100. Palatine teeth are present and well developed, and at some sites the occipital region is covered with small, fleshy papillae (nubbles).

Colouration is variable but the back is usually light brown with three or four indistinct dark saddles under the soft dorsal fin. The lower flanks usually are pale. The pectoral fins and the soft dorsal, anal, and caudal fins are often boldly marked with alternating light and dark stripes. In breeding males the first dorsal fin is black with a yellow or orange edge. In non-breeding adults the first dorsal fin has a dark posterior spot.

Designatable units

The Columbia Sculpin does not meet any of the COSEWIC criteria for multiple designatable units. For instance, there are no known molecular/biochemical differences or natural range disjunctions that suggest the species comprises discrete major population groups in Canada. There are, however, at least five populations that are probably demographically discrete owing to natural or human-imposed (e.g., dams) migration barriers: the Columbia population, the Kootenay/Slocan population, the Bonnington population, the Kettle population, and the Similkameen population. These populations are separated by barriers that either prevent, or restrict, gene exchange among the populations. Man-made barriers (i.e., dams and reservoirs) separate the Columbia and Kootenay/Slocan populations; the Bonnington population is sandwiched between the South Slocan Dam and lower Bonnington Dam (COSEWIC 2000); the Kettle population is separated from the other populations by Roosevelt Reservoir and in the past by Kettle Falls, and the Similkameen population is separated from the other populations by Grand Coulee Dam and a natural barrier (Squanti Falls).

In recent times, the downstream limit of *C. hubbsi* in the mainstem Columbia River probably was somewhere near the confluence of the Umatilla River with the Columbia River. The species' presence in northern tributaries of the Columbia River as far downstream as the Yakima River drainage system, however, argues that at sometime in the Holocene the Columbia Sculpin must have had a wider distribution in the Columbia River.

Special significance

The Columbia Sculpin is endemic to the Columbia drainage system in western North America. Within this system (Figure 3), it has a limited and fragmented distribution. Consequently, it has a relatively small global distribution and, in Canada, it only occurs in south-central British Columbia. There are still unresolved taxonomic problems with this species (e.g., its relationship to *Cottus bendirei* and *Cottus semiscaber*) and also problems of interest to evolutionary ecologists (e.g., the apparently independent loss of calcified prickles in scattered populations). From a strictly Canadian perspective, this species is a unique part of our national biological heritage.

Also, in their own right, sculpins are of scientific interest. The Columbia drainage system is a "hotspot" of *Cottus* evolution. This one river system contains half (14) of the 28 *Cottus* species described from North America, and in BC some small rivers (e.g., the Slocan River) contain up to five species of sculpins. For ecologists and evolutionary biologists, how these morphologically and behaviourally similar species partition resources and remain reproductively isolated is an important question.

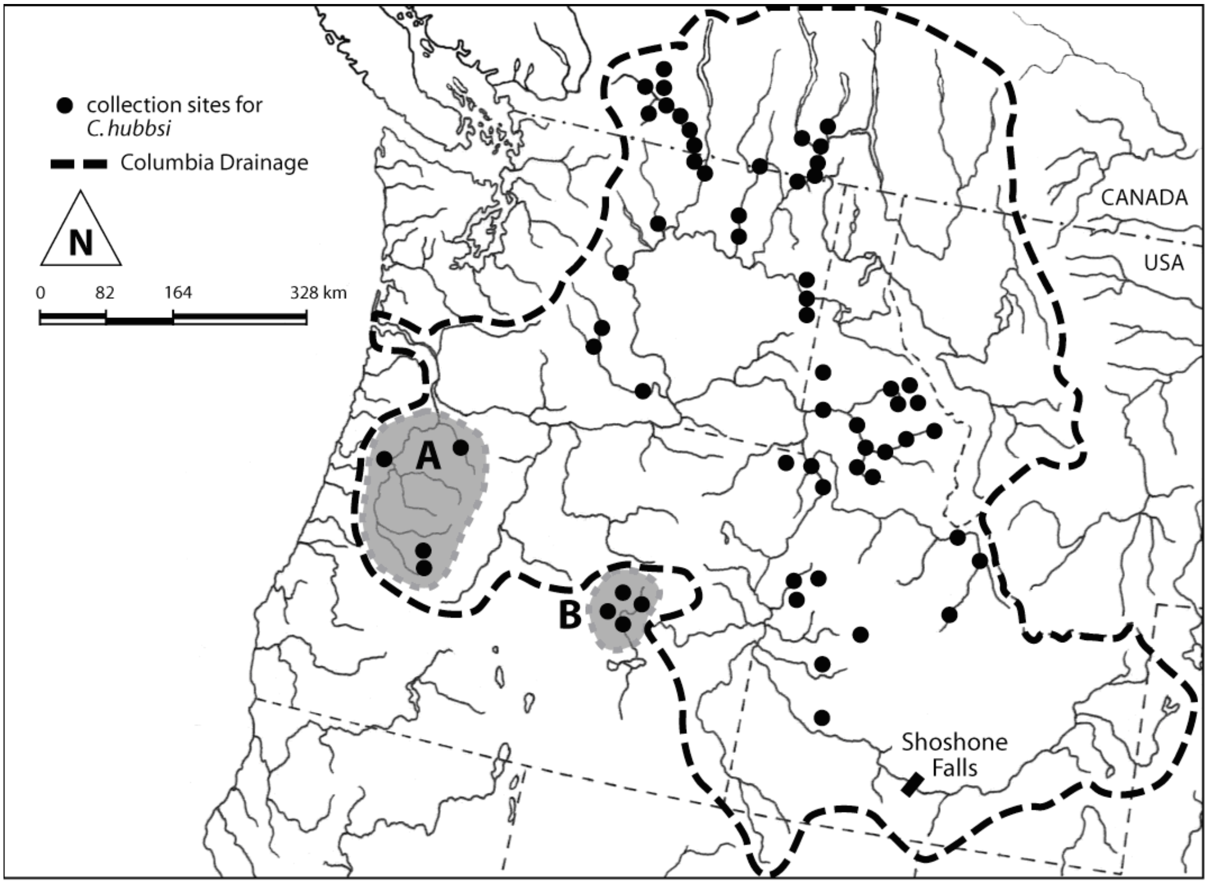

Figure 3. Global distribution of the Columbia Sculpin, *Cotttus hubbsi*. Note isolated populations in A (Willamette River tributaries) and B ((Harney Basin). Data from Bond (1963), Simpson and Wallace (1978), Wydowski and Whitney (2003), COSEWIC 2000, and McPhail (2007).

DISTRIBUTION

Global range

The Columbia Sculpin is endemic to northwestern North America and is restricted to the Columbia River drainage system in BC, Washington, Oregon, and Idaho (below Shoshone Falls on the Snake River). Within this geographic range, the Columbia Sculpin's distribution is highly fragmented (Figure 3). Many of these isolated fragments appear to be natural, but dams now exacerbate this fragmentation.

Canadian range

The Canadian EO (extent of occurrence) of the Columbia Sculpin, as estimated by the polygon method, is 17,593 km^2; however, this range is divisible into the five population groups listed above and includes areas of the Similkameen, Okanagan, and Shuswap First Nations. The Columbia population consists of the 41 km of the mainstem Columbia River between Keenleyside Dam and the US border, plus it occurs sporadically in the lower reaches of Blueberry and Beaver creeks, and 2.8 km of the Kootenay River between Brilliant Dam and the river's confluence with the Columbia River (Figure 4). The Kootenay/Slocan population extends from the Brilliant Dam upstream to the South Slocan Dam (a distance of about 38.5 km), plus the Slocan River from its confluence with the Kootenay River upstream to Slocan Lake (about 45 km) and approximately 10 km of the Little Slocan River and its tributary, Koch Creek (Figure 5). The Bonnington population occupies the 2.5 km of the Kootenay River between the South Slocan and lower Bonnington dams (Figure 6). The Kettle population is restricted to the 5 km stretch of the Kettle River between Cascade Falls and the US border (Figure 7). The Similkameen population occupies about 155 km of the Similkameen River between the US border and Similkameen Falls, plus about 20 km of the Tulameen River from Princeton upstream to Lawless Creek, and 28 km of Otter Creek. This species also occurs in about 14 km of Summers Creek, 10 km of Hayes Creek, and in Allison Creek upstream to the Ministry of Environment's coarse fish barrier (Figure 8). Farther downstream, it is present in 2 km of Keremeos Creek and about 2 km of the lower Ashnola River. A single specimen was also reported in Wolfe Creek approximately 500 m upstream of the creek's confluence with the Similkameen River (Royal BC Museum collections, Gavin Hanke, pers. comm. via Sue Pollard, 2010). The IAO (indices of area of occupancy) for the five population groups based on a 2x2 km grid overlay is 972 km^2. There are an estimated 21 locations for the Columbia Sculpin. Locations were defined on the basis of the principal threats to the species being localized habitat loss or degradation from droughts, flow regulation and water extraction, and other point source effects on habitat (see **Threats and Limiting Factors** section) given the apparently limited dispersal ability of the species (Peden 2000; see also **Dispersal and Migration** section).

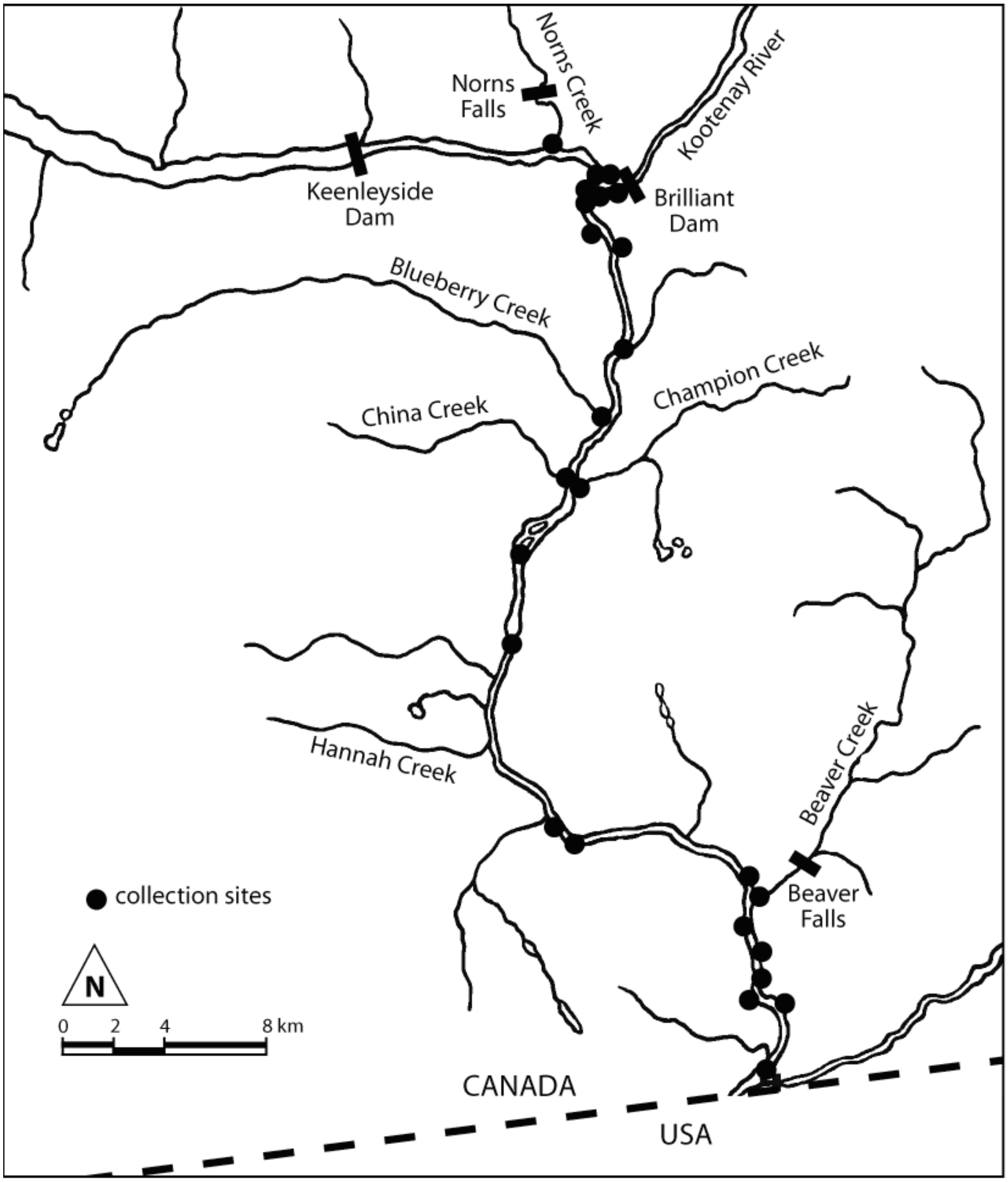

Figure 4. *Cottus hubbsi* collection sites in the Columbia population. Source: University of British Columbia Fish Collection records and McPhail, unpublished.

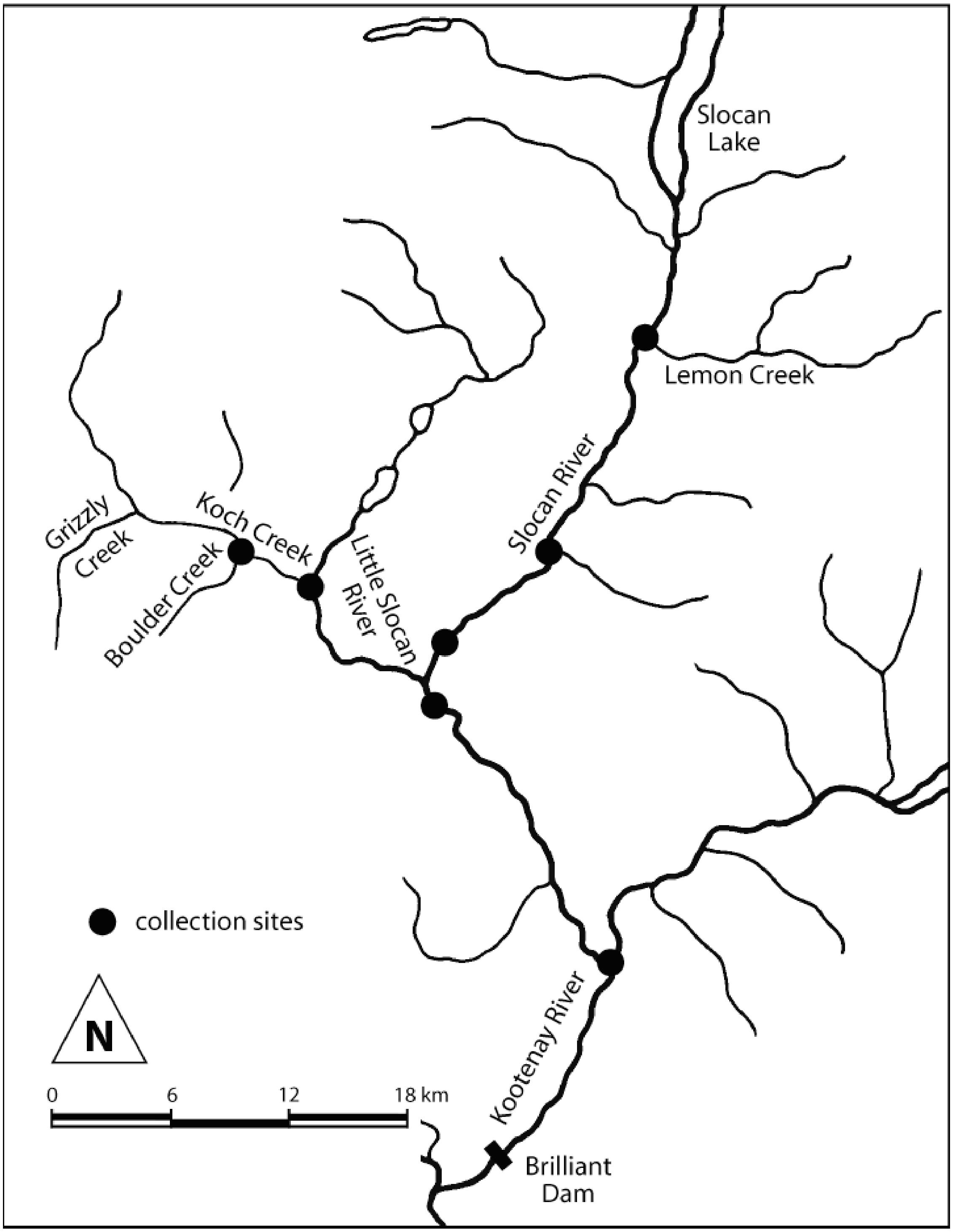

Figure 5. *Cottus hubbsi* sites in the Kootenay/Slocan population. Source: Royal BC Museum Collection records.

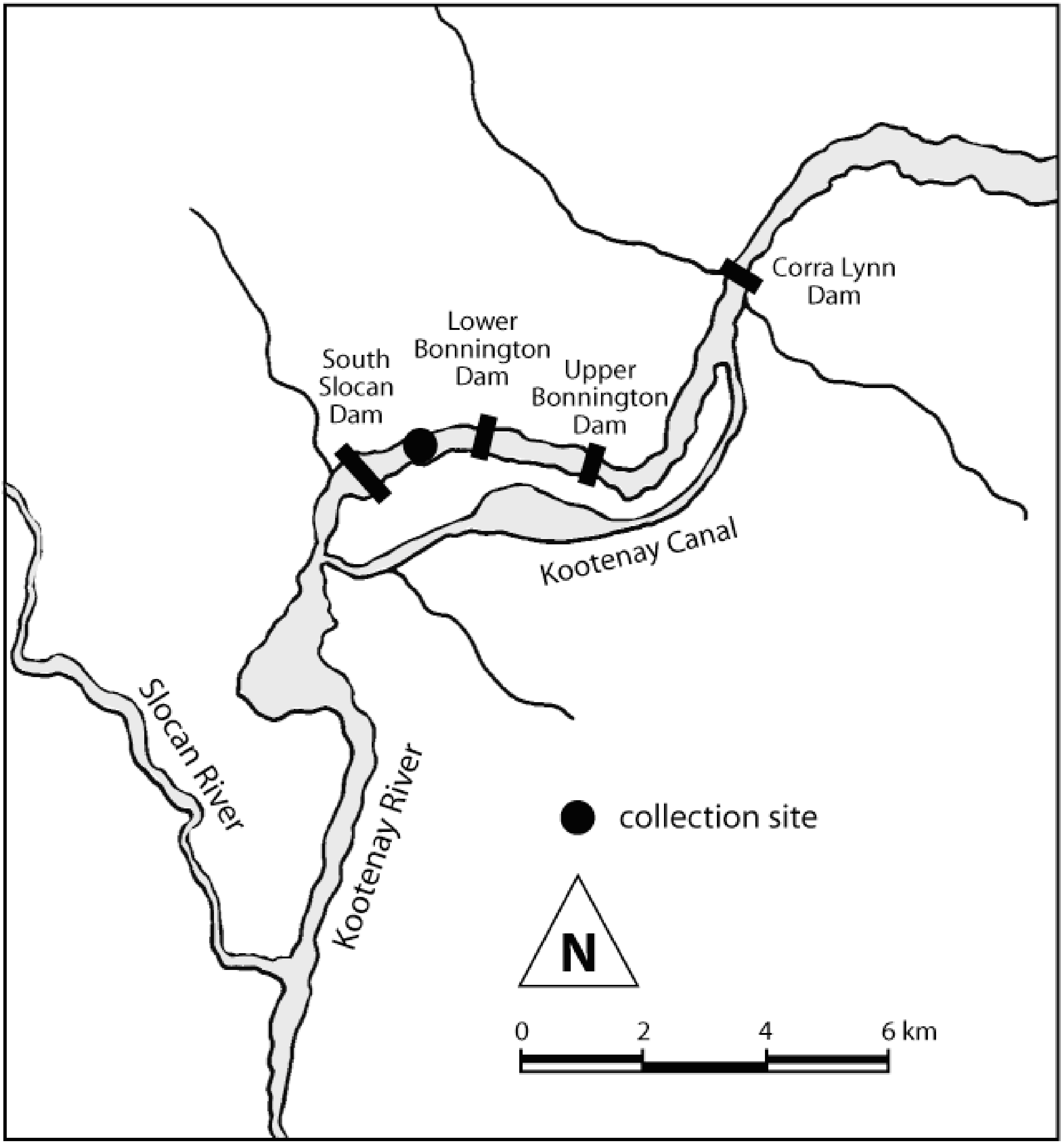

Figure 6. *Cottus hubbsi* collection sites in the Bonnington population. Source: University of British Columbia and Royal BC Museum Collection records.

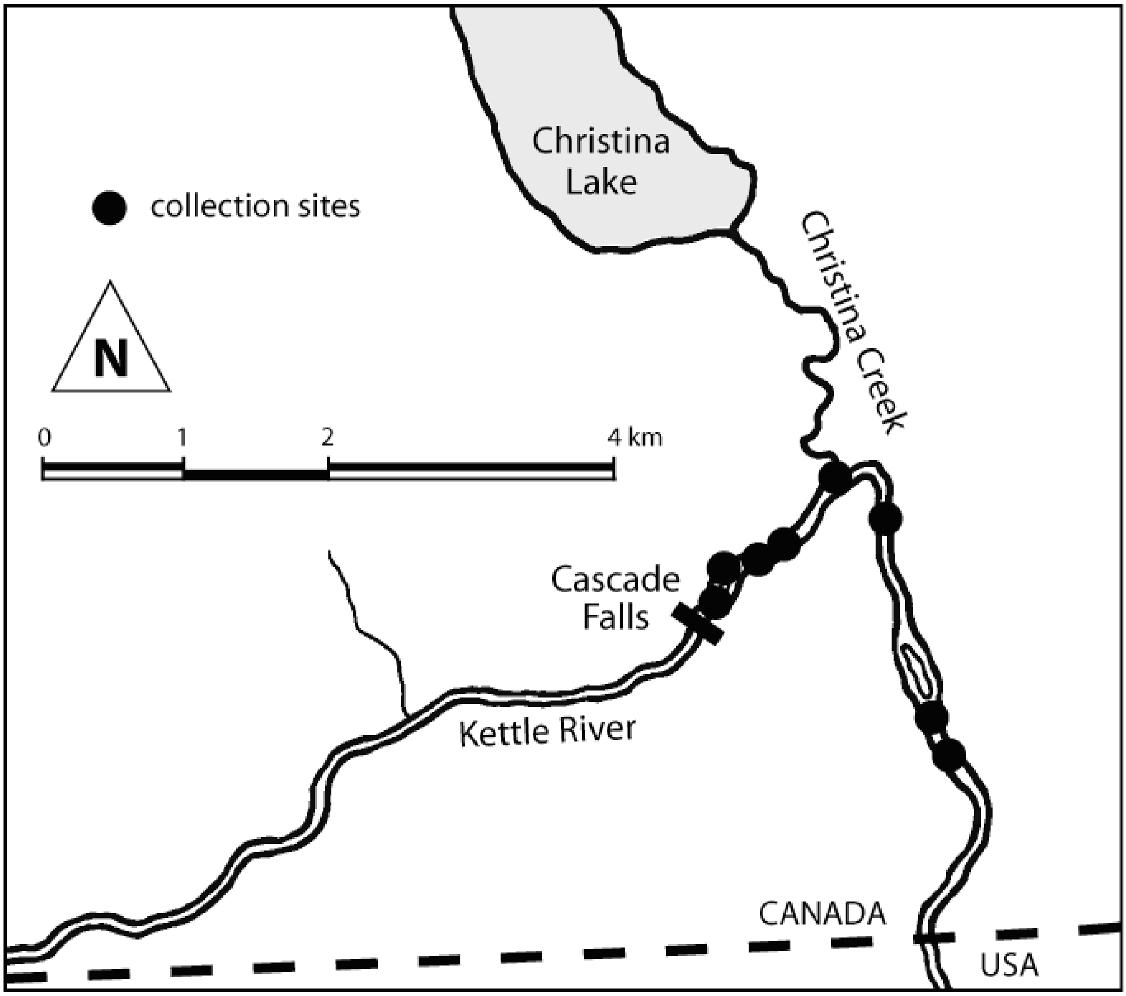

Figure 7. *Cottus hubbsi* collection sites in the Kettle population. Source; University of British Columbia collection records.

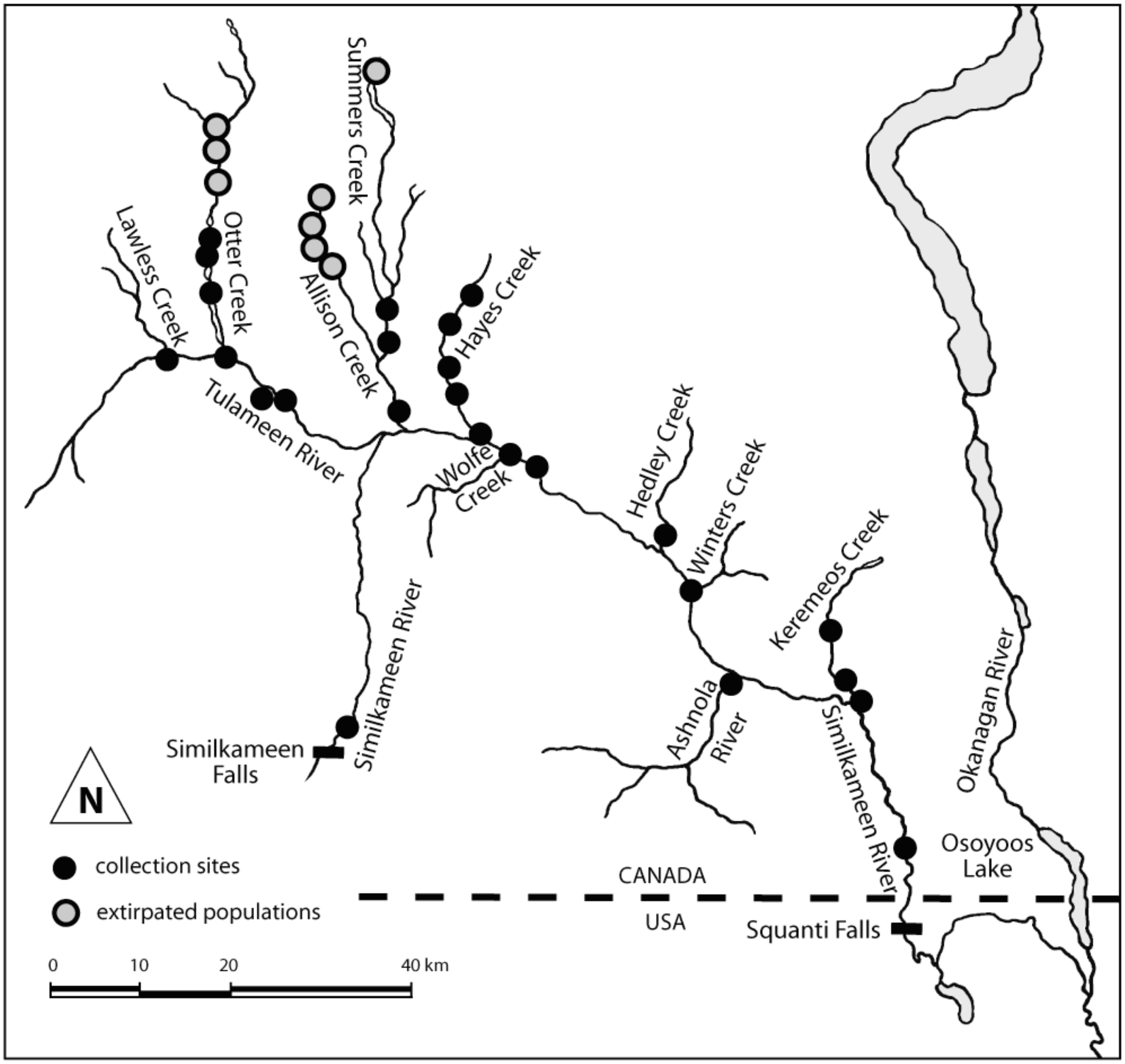

Figure 8. *Cottus hubbsi* collection sites in the Similkameen population.Source: University of BC Collection records.

HABITAT

Habitat requirements

Descriptions of the habitats used by Columbia Sculpins throughout the species' geographic range suggest that they are associated with larger and warmer rivers. Thus, most descriptions of the habitat requirements of Columbia Sculpins are based on information obtained in large rivers; however, in the Similkameen River system, Columbia Sculpins are found in small creeks as well as in the main river. The small creeks that contain Columbia Sculpins in the Similkameen system tend to be lake-fed, low gradient streams draining semi-arid valleys (e.g., Otter, Allison, and Hayes creeks). They are relatively warm in the summer, and Columbia Sculpins occur several kilometres upstream of the confluences of these creeks with the Tulameen or Similkameen rivers. In contrast, within the same river system, similar-sized streams that rise in the mountains (e.g., Granite and Lawless creeks) have high gradients and are cooler in the summer. Columbia Sculpins occur in the lowest reaches of these streams but only within 100-200 m of their confluences with the Tulameen or Similkameen rivers. This pattern suggests that for Columbia Sculpins, gradient and temperature may be important habitat parameters in small streams. In addition, Shorthead Sculpins do not occur in the Similkameen system. In Columbia tributaries these species are often parapatric and, perhaps, the absence of Shorthead Sculpins in the Similkameen system allows Columbia Sculpins access to small streams that elsewhere are occupied by Shorthead Sculpins.

In the past, BC Hydro has commissioned sculpin studies in the Columbia River (e.g., R.L.&L 1995; AMEC 2003). The AMEC study was conducted in February 2003 and included day and night snorkelling, "rock flips" (flipping rocks and capturing fishes so disturbed using nets or electroshocking), and electroshocking surveys on cobble bars, embayments, and fast runs in the Columbia River. Although this survey obtained information on sculpin winter habitat use, fish were not captured and identified to species.

The R.L.&L. study operated from 1993 to 1994, and in 1994 involved year-round quantitative sampling of multiple habitats. Data were collected for 959 sculpins over the two years. The Columbia Sculpin was the second most common species taken in the 1994 survey and made up 27% (261) of the sculpin catch. In the mainstem Columbia River, this species was associated with cobble to boulder substrates. No Columbia Sculpins were recorded at sites with sand or gravel bottoms. Usually, this species occurred at sites with a mean water column velocity of 0.3 to 0.5 m/s and their greatest abundance was recorded at mean velocities of 0.40 to 0.44 m/s. Also, there was evidence of three abundance nodes that were associated with different velocities: 0 to 0.1 m/s, 0.30 to 0.34 m/s, and 0.4 to 0.44 m/s. The smallest individuals were associated with the lowest velocities. Water depth did not appear to be important (average depths at sites where this species occurred ranged from 10 to 69 cm) but most fish were recorded at average depths of < 50 cm (R.L.&L. 1995).

In 2008, another BC Hydro-funded study used micro PIT tags to provide previously unobtainable data on diel and seasonal habitat use. The technology was field tested in 2009 (winter and summer) in the Similkameen River system and is continuing in 2010 (Rachel Keeler, pers. comm., 2010).

Habitat trends

There are no survey data on habitat trends for any of the five population groups of Columbia Sculpin; however, none of the streams and rivers inhabited by these populations are pristine — the region occupied by the Columbia population contains dams, urban centres, heavy industry (a smelter and a pulp mill), and human-altered, eutrophic tributary streams. The Kootenay/Slocan population probably occupies the least altered habitat of the five systems but, in the past, this region was subject to major mining and logging activity within the watershed. As well, the Grand Coulee Dam eliminated the Chinook Salmon (*Oncorhynchus tshawytscha*) run that annually carried a large quantity of nutrients into the Slocan River. This run was estimated to consist of 9,000-18,000 Chinook Salmon. These salmon transported nutrients into the system, estimated at 4.1-8.2 kg/km of phosphorus and 37.8-75.6 kg/km of nitrogen (G. Oliver, pers. comm., 2009). The loss of these nutrients after the completion of Grand Coulee Dam in 1942 probably caused a significant reduction in the nutrient dynamics of the whole river (reviewed by Gresh *et al*. 2000). The Bonnington population is an artifact of the South Slocan Dam and most of the entire 2.5 km of this reservoir is modified habitat. The Kettle River also lost its Chinook Salmon populations to the Grand Coulee Dam, and there was an early (1897) hydroelectric project associated with Cascade Falls. Apparently, the Similkameen River area never had runs of anadromous salmonids — Squanti Falls near the junction of the Similkameen and Okanagan rivers had about a 10 m drop that prevented the upstream migration of Chinook Salmon. The now defunct Enloe Dam on the Similkameen River in Washington State was built in 1920 and decommissioned in 1959; however, there is a proposal to build a new dam at this site that may include fish passage facilities. There is also a proposal to build a dam upstream of this site at a location known as Shanker's Bend; all options could have impacts to varying degrees on the Canadian population of Columbia Sculpin in the Similkameen River mainstem. In BC, in the Princeton area, the Similkameen River has received silt from major mining activity on Copper Mountain since 1923. Over the years, a succession of companies operated mines at, or adjacent to, this site and there is an active proposal for a new "super" open pit operation at the site on Wolfe Creek, a tributary of the Similkameen River. In addition, upstream of Lawless Creek, there are several active mines adjacent to the Tulameen River.

Given the proposals for hydroelectric and mining projects in three of the populations (Kootenay/Slocan, Kettle, and Similkameen) there may be some future degradation of Columbia Sculpin habitat if these projects are undertaken without appropriate conservation and mitigation measures. The degradation of available habitat for the Columbia and Bonnington populations, which occupy regulated rivers, will probably be ongoing. In addition, the Similkameen River and its tributaries occur in the Northern Cascade Ranges Ecoregion (COSEWIC 2009), a region characterized by some of the warmest, driest summers in BC and of low, spring run-off. The problem of summer low flows has become accentuated by increasing draws on water for urban, agricultural and industrial needs in the watershed. Climate warming has the potential to further exacerbate this condition and contribute to loss of aquatic habitat (see **Threats and Limiting Factors** section).

Habitat protection/ownership

The federal *Fisheries Act* provides Fisheries and Oceans Canada with powers to protect and conserve fish and fish habitat. Thus, the *Fisheries Act* can provide some general protection for aquatic habitats used by all the five populations of the Columbia Sculpin. Also, as a transboundary river, the Columbia River is subject to environmental obligations imposed by the International Joint Commission (IJC) and the Columbia River Treaty. So far, in western North America, these international treaties have focused on water storage, flood control, and power generation issues. Recently, however, the Canadian Inter-tribal Fisheries Commission has raised fish and fisheries issues with the IJC.

Although the Columbia, Kootenay, Slocan, Kettle, and Similkameen rivers are public waters, most of the land adjacent to these rivers is private, and there are numerous licences for agricultural and industrial water extraction from these rivers. There is, however, an 81 ha provincial park (Beaver Creek Provincial Park) at the mouth of Beaver Creek, and an 85 ha Community Park on Norns Creek. These parks provide some protection for the small numbers of Columbia Sculpins in the lowest reaches of these streams. In addition, Cathedral Provincial Park (33,272 ha) provides protection for the upper Ashnola River, and there are Columbia Sculpins in the lower reaches of this river. The proposed South Okanagan-Similkameen National Park would protect about 100,000 ha of the lower Similkameen River watershed but not the river. There is no direct protection of the Kettle River below Cascade Falls; however, Gladstone Provincial Park provides some protection for the Christina Lake watershed and Christina Creek flows directly into the Kettle River. The streams in Gladstone Provincial Park have never been sampled and it is possible that the lower reaches of Sander and Troy creeks might contain Columbia Sculpins. Valhalla Provincial Park (49,893 ha) provides some protection for the Slocan and Little Slocan watersheds. Both these rivers contain Columbia Sculpins. The Columbia Sculpin is listed under SARA as a Schedule 1 species of Special Concern and a management plan was completed in 2009 (Columbia Sculpin Recovery Team 2009). The management plan indicates that there are no species-specific habitat protection provisions and lists several activities to define important habitats for this species, information that is generally lacking, especially for juveniles and during winter conditions. In addition, there is no legal requirement to implement any of the recommended management actions for the protection of the Columbia Sculpin.

BIOLOGY

Most regional works on the freshwater fishes of Washington, Oregon, and Idaho treat the Columbia Sculpin either as conspecific with *C. bairdii* or as a subspecies of *C. bairdii*. Consequently, information on the biology of the Columbia Sculpin is often a mix of local data and information derived from eastern North American Mottled Sculpins. This leads to difficulty in sorting out the information that pertains to *C. hubbsi* as opposed to *C. bairdii*. Thus, information from localities within the known range of the Columbia Sculpin has been included. Accordingly, the major sources for information on the biology of *C. hubbsi* are R.L.&L. (1994, 1995), COSEWIC (2000), and McPhail (2007).

Life cycle and reproduction

Spawning period

The Columbia Sculpin spawns in the spring. In BC, the exact time of spawning is unknown; however, in Otter Creek (Similkameen population) rocks with eggs glued to their undersides were found from late-May (water temperature 7ºC) to mid-June (12ºC). Recently (June 8-12, 2009), a survey of Otter Creek, Allison Creek, and the Tulameen River by AMEC (sponsored by BC Hydro) found Columbia Sculpin nests in all three streams (Rachel Keeler, pers. comm. 2009).

Spawning sites

Spawning sites in Otter Creek were similar to the descriptions of spawning sites for other related sculpins (e.g., *C. cognatus*, *C. rhotheus*). Eggs were discovered under large (40 to 60 cm), angular rocks in swift riffles. Presumably, males excavated or enlarged cavities under the rocks. The surface velocities over nests varied from 0.3 to 0.7 m/s. The water depths over the nests usually were < 40 cm.

Spawning behaviour

The spawning behaviour of the Columbia Sculpin has not been studied but, presumably, it is similar to other related species. In these sculpins, males typically excavate a nest cavity and court females. The courtship is complex and usually involves rapid changes in male colour, as well as acoustical and visual signals (Savage 1963; Whang and Jannsen 1994). Often, males are polygynous and spawn with several females. In Otter Creek, most nests contained multiple egg clutches; however, some nests with eyed eggs had a single clutch of eggs.

Fecundity

In sculpins, fecundity varies with female size, and in the Yakima River (Washington State), Patten (1971) found egg number in this species varied from 46 eggs in a 46 mm (total length) female to 275 eggs in a female 91 mm long. The eggs are large, and in Otter Creek they averaged 2.8 mm in diameter.

Incubation period

In most fishes, development rate is temperature-dependent, and this probably is also true of Columbia Sculpin eggs. In the section on spawning period (see above), the nests found in Otter and Allison creeks contained eyed eggs, whereas eggs in a nest found in the colder (10ºC) Tulameen River were at a much earlier stage of development (Rachel Keeler, pers. comm. 2009). In an earlier study, eggs from Otter Creek were transported to Vancouver and hatched in about two weeks at a constant temperature of 12ºC (McPhail 2007). The newly hatched larvae were unpigmented and ranged in total length from 7.5 to 8.2 mm. The larvae remained buried in the substrate for two weeks and then emerged as pigmented, miniature (9.5-10.5 mm in total length) copies of the adults.

Maturity and lifespan

By September, young-of-the-year ranged from 25 to 35 mm in total length and males began maturing late in their second summer. Females began maturing a year later. All males were mature by their third summer (2^+) and all females by their fourth summer (3^+). The oldest Columbia Sculpin recorded from British Columbia was in its sixth summer (5^+) and was 106 mm in total length (McPhail 2007).

Prey and predators

Columbia Sculpins are carnivorous. Their diet consists primarily of the nymphs and larvae of aquatic insects. In the Columbia River population, aquatic insects (caddisflies, stoneflies, mayflies, midges, and blackflies) constituted from 93 to 100% of the contents of 34 stomachs examined (R.L.&L. 1995). There are few data on the predators of Columbia Sculpins; however, in the Columbia River they coexist with native Rainbow Trout (*Oncorhynchus mykiss*) and introduced Walleye (*Sander vitreus*). Given the opportunity, both of these species probably eat sculpins. In all five of the Canadian populations, Columbia Sculpins coexist with the Torrent Sculpin. The Torrent Sculpin becomes piscivorous at about 70-90 mm in length and is known to prey on juvenile sculpins (R.L.&L. 1995).

Physiology

The physiology of the Columbia Sculpin has not been studied; however, the species' distribution pattern suggests that it is more tolerant of warm water than the Shorthead Sculpin.

Dispersal/migration

There are no data on movements or migrations of Columbia Sculpins, but the adults of this species probably are sedentary. Indeed, the only documented migration of adult *Cottus* in western North America is a spawning migration of Torrent Sculpins in the lower Columbia River (Thomas 1973). After the fry of the Columbia Sculpin emerge from the gravel, they move into shallow water along stream edges. At this time, there may be some downstream dispersal. Like other western *Cottus* species (McCleave 1964), once settled, the young probably do not move far from their relatively small home areas; however, as they grow they move laterally into deeper and faster water.

Interspecific interactions

Hybridization

Although hybridization between sympatric *Cottus* species is known (e.g., Zimmerman and Wooten 1981; Strauss 1986), no confirmed hybridizations involving Columbia Sculpins are known from BC. Nonetheless, one possible hybrid between *C. hubbsi* and *C. confusus* was identified biochemically in the Slocan River (COSEWIC 2001). In addition, the morphology of a few individuals collected at the mouths of Norns and Beaver creeks suggest the possibility of rare hybridization between the same two species (McPhail 2007). Markle and Hill (2000) also reported hybrids between *C. hubbsi* and *C. bendirei* in the Harney Basin, Oregon.

Competitive interactions

The documented (R.L.&L. 1994) parapatric distribution pattern of Shorthead and Columbia sculpins in Norns and Beaver creeks suggests some interaction between the species. As well the presence of the Columbia Sculpin in small streams (usually Shorthead Sculpin habitat) in the Similkameen region hints at a competitive interaction between these species.

Adaptability

No experimental data are available concerning the short-term adaptation limits (thermal, chemical, and velocity) beyond which Columbia Sculpins are unable to cope. Again, however, their presence in small streams in the Slocan and Similkameen drainage systems suggest that, given the opportunity, they are capable of adapting to a variety of habitats.

POPULATION SIZES AND TRENDS

Sampling effort

Most of the early sampling for Columbia Sculpins was directed at taxonomic problems (e.g., McAllister and Lindsey 1961; Peden *et al.* 1989). Consequently, quantitative information on sampling effort is not available for most collections made in Canada. An exception is the R.L.&L. (1995) study in the Columbia River. In 1994, this electrofishing survey spanned the winter (3 days), spring (3 days), summer (3 days) and fall (4 days) of 1994 and collected 69 Columbia Sculpins.

Abundance

A previous report (COSEWIC 2000) gives the following estimates of the abundance of adult Columbia sculpins in the Canadian populations — Columbia population >1,000; Kootenay/Slocan population about 100; Bonnington population 200 to 1,000; Kettle population 1,500 to > 2,000, and Similkameen population 3,000 to 5,000. These values were not obtained quantitatively and are best treated as informed estimates. The R.L.&L. (1995) electroshocker survey found that their abundance in the Columbia River varied among sites but ranged from 0.2 to 12.5 per m^2. More recent information suggests that the Columbia Sculpin is modestly abundant in portions of Otter Creek just upstream of the lake with densities of about 0.5 – 1 fish/m^2 (Rachel Keeler, personal communication to Sue Pollard, BC Ministry of the Environment, 2010).

Fluctuations and trends

Without a time-series of population estimates or, at a minimum, a comparable set of collections, population fluctuations and trends cannot be quantified. Nonetheless, this species appears to be declining in small streams where it was previously recorded: Otter, Hayes, and Allison creeks in the Similkameen system. For instance, much of the upper 12 km of Otter Creek that once supported fishes has gone dry over many recent years, at least during summer months. Such habitat loss may be related to the general decline in snowpack over the last 50 years and high frequencies of low water years in the Similkameen River basin (Rae 2005; Rodenhuis 2007). Also, the lacustrine populations of Columbia Sculpins that once inhabited the lakes in the Allison Creek watershed were poisoned in the 1950s and a barrier was constructed to prevent recolonization. In the Columbia population they are now found only at the lower reaches and mouths of Blueberry, Champion, Norns, and Beaver creeks, whereas they were previously reported slightly farther upstream (R.L.& L. 1994; McPhail, pers. obs., 2007).

Rescue effect

The delineation of the five population groups is based on barriers (natural and human-made) to movements among the populations. Still, there are no barriers between the Columbia population and the Columbia River in Washington. Thus, recolonization of this population from downstream is possible. In contrast, the

Kootenay/Slocan and Bonnington populations are isolated from the Columbia population by Brilliant and South Slocan dams, respectively. There are downstream populations of Columbia Sculpins in the US portion of the Kettle River. With time, these US populations could recolonize the Canadian Kettle population. For the Similkameen populations, there are no barriers above Squanti Falls in Washington State and the Canadian portion of the Similkameen River. Thus, recolonization of the lower Similkameen River is possible by fish downstream; however, if Shanker's Bend Dam is constructed (see **Threats and Limiting Factors**) this potential recolonization source may be lost.

THREATS AND LIMITING FACTORS

Threats

Generic threats to all of the Columbia Sculpin populations are climate change, urbanization, and industrial development. The BC distribution of *C. hubbsi* encompasses the warmest (at least in summer) and most arid portions of the province. Except for the mainstem Columbia River, water is in short supply in the summer in tributary streams. For example, in the last decade the linear stream length of this sculpin's distribution in Otter Creek has shrunk by 42% (from 28 km to 16 km above Otter Lake). The upper 12 km of the creek now is dry in the summer. This drought is exacerbated by agricultural water use. Towns like Princeton, Keremeos, Grand Forks, and Trail are growing and their water use (domestic and agricultural) is increasing. In 2009 the Similkameen and Tulameen rivers almost reached record low flows during critical summer months (Tara White, pers. comm., 2010). These stresses on water availability will probably increase as projections of climate change indicate increasing temperatures in southern BC over the next few decades (e.g., Wang *et al*. 2006). Historically, mining and smelting have been major industries in the region, and there are still active mines in the Similkameen and Tulameen valleys. Several concerns potentially threatening to sculpins are associated with a proposal to re-open Copper Mountain Mine on Wolfe Creek. These include: (1) flow reductions especially during summer low-flow months and associated loss of habitat and increase in temperatures; (2) ongoing concerns with declines in water quality associated with waste rock which already exceed aquatic life standards here (e.g., sulfates); and (3) loss of habitat associated with stream infill and diversion of the lower creek (Tara White, pers. comm., 2010). The Kettle River has a history of low summer flows and high temperatures ranging in the sub-lethal to lethal limits for many fishes (i.e., 19-26^{0}C) with record low flows reported in September 2009, and fish kills associated with these low flows have been reported six times in the past two decades (Tara White, pers. comm., 2010); Rainbow Trout and Mountain Whitefish were the species recorded in these kills (they will initially float — unlike sculpins which lack a swim bladder — and thus these salmonids are more easily detected). These trends will likely continue given the large number of water licences on the system and increasing water demands in an area undergoing substantial human population growth (StatsBC 2010). It is not possible to determine if such water temperature increases have the same direct effect on Columbia

Sculpin, which is generally classified as a warm-water species (McPhail 2007), as the necessary tolerance tests have not been conducted as in salmonid fishes. The proposed Shanker's Bend Dam on the Similkameen River in Washington State poses a potential threat to the Similkameen population. At the highest proposed level the dam would flood about 40 km of the river in Canada. This would not only remove about 30% of *C. hubbsi* habitat from the system but also prevent recolonization of Columbia sculpins from downstream populations in Washington State.

It is not clear whether operating procedures at Keenleyside Dam pose a threat to the Columbia population of *C. hubbsi*. In the past, BC Hydro has commissioned studies on fish stranding and, so far, there is no evidence of adverse effects of rapid water level changes on sculpins. Nonetheless, it is possible that sudden changes in water levels at critical stages in the fish's life history might affect spawning success and fry survival. The pulp mill at Castlegar and the smelter at Trail still discharge effluent into the Columbia River (albeit not as much as in the past). Heavy metal contamination is an ongoing problem in the Columbia River and in some Slocan River tributaries. In the Slocan Valley, there are concerns about the potential power project on Koch Creek. Although the site of the project is upstream of the known distribution of the Columbia Sculpin in Koch Creek, there may be downstream effects that have an impact on the small population of *C. hubbsi* that now exists in the creek. The Bonnington population of Columbia Sculpins has been reported to be secure: the dam became operational in 1925 but the population (estimated to be between 200 and 1,000 adults and juveniles) has persisted for at least 75 years (COSEWIC 2000).

A potential threat to the Kettle River below Cascade Falls is the Cascade Heritage Power Project. This project was approved in 2006 but the present economic downturn has delayed construction. The major concern in the Kettle River is a potential increase in maximum summer water temperatures (COSEWIC 2001). This is less of a concern for the population of Columbia Sculpins (a warm-water species) in this area than it is for the sympatric Shorthead Sculpin.

Limiting factors

There are no data on the factors that limit the numbers and distribution of Columbia Sculpins. The Columbia Sculpin's global distribution (Figure 3) suggests that it is a species adapted for life in the large rivers (e.g., the Columbia and Snake rivers) and their major tributaries (e.g., the Similkameen, Yakima, and Clearwater rivers) in the arid, or semi-arid regions, of the middle and upper Columbia drainage system. They do, however, occur in small streams in areas where Shorthead Sculpins are absent. In addition, in large tributary rivers where both species occur (e.g., the Yakima and Clearwater rivers) the distributions of these species usually are parapatric: Shorthead Sculpins in the headwaters and Columbia Sculpins downstream. Thus, their distribution suggests that the presence of Shorthead (and perhaps other sculpins) may limit the distribution of the Columbia Sculpin.

EXISTING PROTECTION OR OTHER STATUS DESIGNATIONS

Existing protection

The habitat protection provisions of the *Fisheries Act* provide protection for fishes in the Canadian portion of the Columbia River system. In addition, after a previous assessment of the Columbia Sculpin (under the name *Cottus bairdii hubbsi* COSEWIC 2000), the species was listed as a species of Special Concern under the *Species at Risk Act* (*SARA*) in May 2001. The status was re-examined by COSEWIC and confirmed Special Concern in November 2010. Consequently, a management plan, including measures for better understanding and protecting the Columbia Sculpin, is required under *SARA* (Schedule 1) and was completed in 2009 (Columbia Sculpin Recovery Team 2009). The various proposed activities within the management plan have not been initiated or completed and there is no legal requirement to act on its recommendations.

Non-legal status and ranks

The BC Conservation Data Centre ranks the Columbia Sculpin as S3 (rare or uncommon). In BC the species is blue listed as a species of special concern. Globally, its NatureServe (as of 2001) rank is G4T4Q — globally secure but of local concern and of questionable taxonomy (NatureServe 2010). The species is not ranked in Washington State, but is ranked as S4 in Oregon (NatureServe 2010). The NatureServe ranks are, however, based on the assumption that the Columbia Sculpin and the Mottled Sculpin (*C. bairdii*) are conspecific and, consequently, that *C. hubbsi* enjoys a wider distribution that it actually has. These two species are quite distinct from one another and, presumably, these rankings will be reassessed now that *C. hubbsi* is recognized as a valid species with a more geographically restricted distribution than once thought.

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Oliver, G. Consultant. Cranbrook, BC, provided excerpts from his M.Sc. thesis on aquatic productivity in the Slocan River.

Pollard, Sue, BC Ministry of Environment.

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J.D. McPhail received a BA (English and Biology) from the University of British Columbia in 1957, an M.Sc. (Zoology) from UBC in 1959, and a PhD (Zoology) from McGill University in 1963. He started his career as a University Professor at the University of Washington in 1963 and moved to UBC in 1966. His early research interest was in Arctic freshwater fishes, and in 1970 he coauthored (with Dr. C.C. Lindsey) a book on the "Freshwater Fishes of northwestern Canada and Alaska." Throughout his career his major research interest has been the ecology, evolution, and biogeography of freshwater fishes, especially sticklebacks, but also other fishes of the inland waters of northwestern North America. He has published over 100 papers and reports on fishes, and acted as an advisor to the BC provincial government on the native fishes of BC and to BC Hydro on species at risk. In 2007 he published a book on BC Fresh Water Fishes.

COLLECTIONS EXAMINED

The specimens examined for this report are housed in the Fish Museum at the University of British Columbia in Vancouver (http://www.zoology.ubc.ca/~etaylor/nfrg/fishmuseum.html) and the Fish Collection of the Royal BC Museum in Victoria (http://www.royalbcmuseum.bc.ca/Collect_Research/default.aspx)