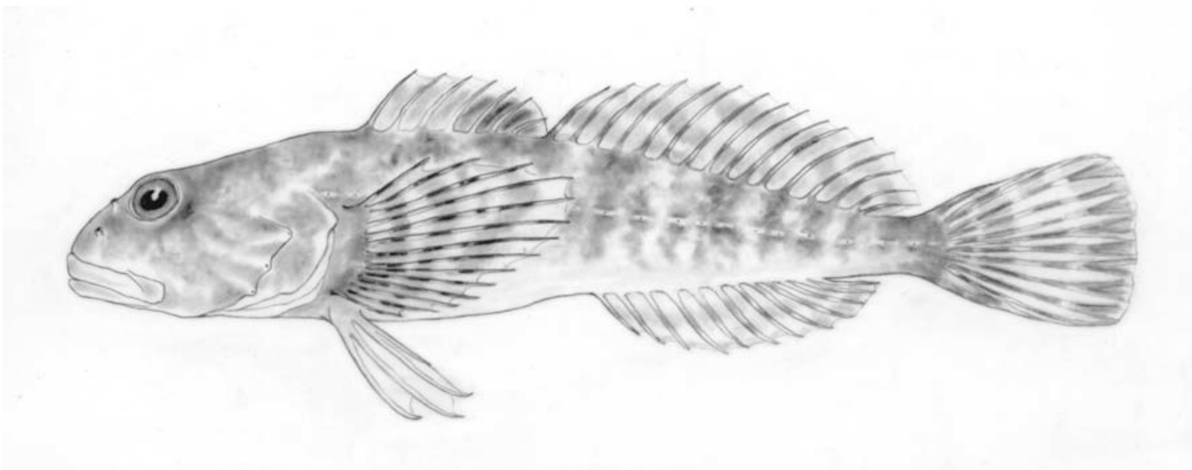
COSEWIC
Assessment and Status Report

on the

Columbia Sculpin
Cottus hubbsi

in Canada



SPECIAL CONCERN
2019

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

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

COSEWIC. 2019. COSEWIC assessment and status report on the Columbia Sculpin *Cottus hubbsi* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xii + 43 pp. (https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry.html).

Previous report(s):

COSEWIC. 2010. COSEWIC assessment and status report on the Columbia Sculpin *Cottus hubbsi* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xii + 32 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

COSEWIC 2000. COSEWIC assessment and status report on the Columbia mottled sculpin *Cottus bairdi hubbsi* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xiv + 57 pp

Peden, A.E. 2000. COSEWIC status report on the Columbia mottled sculpin *Cottus bairdi hubbsi* in Canada, *in* COSEWIC assessment and status report on the Columbia mottled sculpin *Cottus bairdi hubbsi* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 1-57 pp.

Production note:
COSEWIC would like to acknowledge Jake Schweigert for writing the status report on the Columbia Sculpin, *Cottus hubbsi*, in Canada, prepared under contract with Environment and Climate Change Canada. This report was overseen and edited by John Post, Co-chair of the COSEWIC Freshwater Fishes Specialist Subcommittee.

For additional copies contact:

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

Tel.: 819-938-4125
Fax: 819-938-3984
E-mail: ec.cosepac-cosewic.ec@canada.ca
www.cosewic.ca

Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur le Chabot du Columbia (*Cottus hubbsi*) au Canada.

Cover illustration/photo:
Columbia Sculpin — Illustration: Diana McPhail.

Catalogue No. CW69-14/268-2020E-PDF
ISBN 978-0-660-35293-0

COSEWIC Assessment Summary

Assessment Summary – November 2019

Common name
Columbia Sculpin

Scientific name
Cottus hubbsi

Status
Special Concern

Reason for designation
This small freshwater fish is endemic to the Columbia River watershed in southern British Columbia where it has a small geographic distribution. It is a bottom-dwelling and sedentary fish as an adult, affected by multiple past impacts and ongoing threats. It is particularly susceptible to declines in habitat area and quality from drought and changes in water flow resulting from water management and climate change, in addition to pollution and invasive species. It may become Threatened if factors suspected of negatively influencing the persistence of this fish are neither reversed or managed with effectiveness.

Occurrence
British Columbia

Status history
Designated Special Concern in May 2000. Status re-examined and confirmed in November 2010 and November 2019.

COSEWIC
Executive Summary

Columbia Sculpin
Cottus hubbsi

Wildlife Species Description and Significance

Columbia Sculpin is a small, bottom-dwelling fish with a body that tapers from a relatively large head and pectoral fins to a narrow caudal peduncle. Columbia Sculpin reaches a maximum total length of about 110 mm. It 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 supporting multiple designatable units for Columbia Sculpin.

The coexistence of up to five sculpin species in small streams within the Columbia watershed and unresolved taxonomic problems provide ongoing scientific interest in Columbia Sculpin. The species' limited distribution makes it a unique part of Canada's faunal heritage.

Distribution

In Canada, Columbia Sculpin is restricted to portions of the Columbia River drainage in south-central British Columbia. In British Columbia, the Columbia River distribution extends from the Keenleyside Dam near Castlegar, downstream to the United States border. The species' distribution also includes major and minor Columbia River 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.

In the United States, Columbia Sculpin 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. Further downstream the species' distribution is highly fragmented.

Habitat

During the day, Columbia Sculpin shelter in riffles and runs with moderate to fast surface velocities and large rock and boulder substrates. It is active at night, leaving shelter to feed. Although this species typically is associated with large rivers and their major tributaries, it is also known to occur in small streams.

Biology

Columbia Sculpin usually lives less than five years and females reach sexual maturity in two to three years while males mature in two years. Spawning occurs in the spring and early summer. The eggs are large and take about three to four weeks to hatch. Columbia Sculpins, like most sculpins, are sedentary and adults rarely move more than 50 m.

Population Sizes and Trends

There are no quantitative data on Columbia Sculpin numbers in the Columbia River subpopulation, but most subpopulation s in large tributary rivers to the Columbia appear to be stable or have declined slightly inferred from a historical contraction in distribution. In the Similkameen system, the distribution in some small streams also appears to have contracted since the 1950s.

Threats and Limiting Factors

In Canada, natural barriers appear to control the geographic limits of Columbia Sculpin. There are no known subpopulations of this species above waterfalls or in large lakes. The major threats to BC subpopulations are water availability and water quality, which are being affected by drought, urbanization, industrial development, and mining activities. Construction of a hydroelectric facility at the abandoned site at Cascade Falls on the Kettle River may impact the 5 km of river below the falls with unknown effects. The introduction of invasive species is also a potential ongoing threat to the long-term survival of Columbia Sculpin.

Protection, Status and Ranks

The BC Conservation Data Centre ranked Columbia Sculpin as S3 (special concern and vulnerable to extirpation) in 2010. A previous COSEWIC assessment (May 2000) also assessed Columbia Sculpin a species of Special Concern and it was listed as such in 2003 on Schedule 1 of the *Species at Risk Act*. The status was re-examined by COSEWIC and confirmed as Special Concern in November 2010 and November 2019. A management plan was completed in 2012 and progress on implementation between 2012 and 2016 was reviewed and reported in 2017. In the United States it is ranked S4 (Species of Concern) in the Special Status Wildlife Species List in Oregon. Globally, NatureServe ranks Columbia Sculpin as apparently secure (G4Q) while IUCN Red List Category ranked it as least concern in 2011.

TECHNICAL SUMMARY

Cottus hubbsi

Columbia Sculpin

Chabot du Columbia

Range of occurrence in Canada: British Columbia

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)	3 years
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Yes, decline in some small streams in the Similkameen system is inferred from changes in distribution, minor declines elsewhere.
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. No b. Partly c. No
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence	19 735 km²
Index of area of occupancy (IAO)	1 100 km²
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”[*]	>10 locations – we identified the following 10 locations based on broad scale application of threats, but the threats likely occur at finer scales, so we conclude that there are >10 locations. Columbia Subpopulation- One in the Columbia River mainstem, and including tributaries: Norns, Beaver, Blueberry, and Champion Creeks, and Kootenay River below Brilliant Dam. Kootenay/Slocan Subpopulation- Two locations, one in the Slocan and Little Slocan River and another in the Kootenay River mainstem between Brilliant and Bonnington Falls dams. Bonnington Subpopulation- One between South Slocan and lower Bonnington dams . Kettle Subpopulation- One in the Kettle River. Similkameen Subpopulation- Five in the Similkameen system (one in the mainstem plus minor tributaries (Allison, Keremeos, Lower Ashnola, Wolfe), another in each of the major tributaries (Tulameen, Otter, Hayes, Summers)).
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?	Yes, observed decline in Otter Creek
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?	Yes, observed decline in Otter Creek
Are there extreme fluctuations in number of subpopulations?	No
Are there extreme fluctuations in number of “locations”?	No.
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

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

Number of Mature Individuals (in each subpopulation)

Subpopulations (give plausible ranges)	N Mature Individuals
Columbia Kootenay/Slocan Bonnington Kettle Similkameen	Unknown, but likely more than 10,000 adults
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 (direct, from highest impact to least, as per IUCN Threats Calculator)

Was a threats calculator completed for this species? Yes

i. Natural system modification (Medium)
   a. Dams and water management
   b. Other ecosystem modifications

ii. Invasive species (Medium-Low)

iii. Pollution (Medium-Low)
   a. Household/urban
   b. Industrial
   c. Agriculture

iv. Climate change and severe weather (Medium-Low)
   a. Droughts
   b. Temperature extremes

What additional limiting factors are relevant?

Rescue Effect

Status of outside population(s) most likely to provide immigrants to Canada.	Columbia subpopulation: 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 subpopulations. Kootenay/Slocan subpopulation: there is no outside source for re-colonization for this subpopulation. Brilliant Dam precludes re-colonization of the Kootenay and Slocan system from outside sources. Bonnington subpopulation: there is no outside source for re-colonization for this subpopulation. Kettle subpopulation : A catastrophe in the Kettle River above Cascade Falls probably would eradicate the Kettle subpopulation in Canada; however, over time, downstream populations in the US might re-colonize the Canadian Kettle River subpopulation . Similkameen subpopulation : In the event of a catastrophe on the Similkameen River, it is 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.
Is immigration known or possible?	Possible for the Columbia, Kettle, and Similkameen subpopulation s but not possible for the Kootenay/Slocan and Bonnington subpopulation s.
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	No, if the BC subpopulation s remain stable or if the BC subpopulation s decline owing to habitat loss or degradation.
Are conditions deteriorating in Canada?+	Yes, water availability in many systems has become an issue in summer. Climate change is expected to exacerbate the situation particularly with effects of increased fire frequency.
Are conditions for the source population deteriorating?	Unknown
Is the Canadian population considered to be a sink?	No
Is rescue from outside populations likely?	Possible for Columbia, Similkameen, and Kettle subpopulation s but not for Kootenay/Slocan and Bonnington subpopulation s isolated by dams.

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

Data Sensitive Species

Is this a data sensitive species? No

Status History

Designated Special Concern in May 2000. Status re-examined and confirmed in November 2010 and November 2019.

Status and Reasons for Designation:

Status: Special Concern	**Alpha-numeric codes:** Not applicable
Reasons for designation: This small freshwater fish is endemic to the Columbia River watershed in southern British Columbia where it has a small geographic distribution. It is a bottom-dwelling and sedentary fish as an adult, affected by multiple past impacts and ongoing threats. It is particularly susceptible to declines in habitat area and quality from drought and changes in water flow resulting from water management and climate change, in addition to pollution and invasive species. It may become Threatened if factors suspected of negatively influencing the persistence of this fish are neither reversed or managed with effectiveness.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. No information is available on the number of mature individuals.
Criterion B (Small Distribution Range and Decline or Fluctuation): Comes close to meeting Threatened with small EOO (19,735 km²) and IAO (1,100 km²), greater than 10 locations, and declines in habitat quality and range (IAO).
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. No information is available on the number of mature individuals.
Criterion D (Very Small or Restricted Population): Not applicable. No information is available on the number of mature individuals.
Criterion E (Quantitative Analysis): Not applicable. Quantitative analyses have not been done.

PREFACE

Columbia Sculpin (*Cottus hubbsi*) is a small, freshwater sculpin (Cottidae). In Canada, it only occurs in the Columbia River and its tributaries in south-central British Columbia. The species was first reviewed by COSEWIC in 2000 and was included in the *Species at Risk Act* (SARA) *Schedule 1* list as a species of Special Concern in 2003. Status was re-confirmed by COSEWIC in 2010. Since the 2000 assessment, the relationship between Columbia Sculpin and the Mottled Sculpin (*Cottus bairdii*) has been clarified (they are different species), but 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 Columbia Sculpin and its relationship to the Malheur Sculpin (*Cottus bendirei*) and the Bonneville Sculpin (*Cottus semiscaber*). 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.

Columbia Sculpin's Canadian distribution is largely unchanged since the last status assessment. There is evidence of a decline in numbers at some of the known Canadian sites although existing data on abundance are scarce and mostly anecdotal. It should be noted that observations of Columbia Sculpin for most tributaries of the Columbia and Similkameen Rivers are prior to 2000. 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 River drainage basins. As of 2015, at least eight drought-related fish kills (Rainbow Trout, *Oncorhynchus mykiss*, and Mountain Whitefish, *Prosopium williamsoni*) have occurred in the last two decades (S. Pollard, pers. comm. 2019). If warming trends in this region continue, the Kettle River subpopulation 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 active mines that include water diversion and potentially significant sulfate pollution. The Columbia Sculpin Recovery Team was established shortly after the species was listed as Special Concern under SARA in 2003 and a management plan has been completed (Fisheries and Oceans Canada 2012). The Recovery Team has since disbanded, and progress on management plan implementation has recently been reviewed (Fisheries and Oceans Canada 2017).

Recognition of Columbia and Mottled Sculpin as separate species with the latter restricted largely to eastern Canada implies that previous records of Mottled Sculpin in British Columbia likely represent observations of Columbia Sculpin. Consequently, the distribution of Columbia Sculpin was updated using records of both Columbia and Mottled Sculpin from the Royal British Columbia Museum, the Beatty Biodiversity Museum at the University of British Columbia and verified records in the British Columbia Ministry of Environment Fish Inventory Summary System.

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
(2019)

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

on the

Columbia Sculpin
Cottus hubbsi

in Canada

2019

TABLE OF CONTENTS

WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE 5
Name and Classification 5
Morphological Description 7
Population Spatial Structure and Variability 8
Summary of Morphological and Genetic Evidence 10
Designatable Units 11
Special Significance 12
DISTRIBUTION 13
Global Range 13
Canadian Range 13
Extent of Occurrence and Area of Occupancy 18
Search Effort 19
HABITAT 19
Habitat Requirements 19
Habitat Trends 20
BIOLOGY 21
Life Cycle and Reproduction 21
Physiology and Adaptability 23
Dispersal and Migration 23
Interspecific Interactions 24
Hybridization 24
Competitive interactions 24
POPULATION SIZES AND TRENDS 24
Sampling Effort and Methods 24
Abundance 25
Fluctuations and Trends 25
Rescue Effect 26
THREATS AND LIMITING FACTORS 26
Threat 7. Natural System Modifications (medium risk) 26
Threat 8. Invasive & Other Problematic Species & Genes (medium-low impact threat) 27
Threat 9. Pollution (medium-low impact threat) 28
Threat 11. Climate Change and Severe Weather (medium-low impact threat) 29
Limiting Factors 30
Number of Locations 31
PROTECTION, STATUS AND RANKS 32

Legal Protection and Status 32
Non-Legal Status and Ranks 32
Habitat Protection and Ownership 32
ACKNOWLEDGEMENTS AND AUTHORITIES CONTACTED 33
INFORMATION SOURCES 34
BIOGRAPHICAL SUMMARY OF REPORT WRITER(S) 38
COLLECTIONS EXAMINED 39

List of Figures

Figure 1. A Columbia Sculpin (*Cottus hubbsi*), about 55 mm total length, collected from the Similkameen River in 2006 (Photo courtesy of Gavin Hanke, Victoria, BC). 5

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. 9

Figure 3. Global distribution of Columbia Sculpin, *Cottus 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). 12

Figure 4. IAO and EOO for Columbia Sculpin (*Cottus hubbsi*) in Canada. Source: Royal British Columbia Museum, University of British Columbia Beatty Biodiversity Museum, British Columbia Ministry of Environment Fish Inventory Summary System, and J.D. McPhail, unpublished. 14

Figure 5. IAO for *Cottus hubbsi* for collection sites in the Columbia subpopulation . Source: Royal British Columbia Museum, University of British Columbia Beatty Biodiversity Museum, British Columbia Ministry of Environment Fish Inventory Summary System, and J.D. McPhail, unpublished 15

Figure 6. IAO for *Cottus hubbsi* for collection sites in the Kootenay/Slocan and Bonnington subpopulation s. Source: Royal British Columbia Museum, University of British Columbia Beatty Biodiversity Museum, British Columbia Ministry of Environment Fish Inventory Summary System, and J.D. McPhail, unpublished. 16

Figure 7. IAO for *Cottus hubbsi* for collection sites in the Kettle subpopulation . Source: Royal British Columbia Museum, University of British Columbia Beatty Biodiversity Museum, British Columbia Ministry of Environment Fish Inventory Summary System, and J.D. McPhail, unpublished 17

Figure 8. IAO for *Cottus hubbsi* collection sites in the Similkameen subpopulation . Source: Royal British Columbia Museum, University of British Columbia Beatty Biodiversity Museum, British Columbia Ministry of Environment Fish Inventory Summary System, and J.D. McPhail, unpublished 18

List of Tables

Table 1. Genetic distances (uncorrected) among *Cottus bendirei* and putative *C. bendirei* and *C. hubbsi* in the Harney Basin and Similkameen River system (McPhail, unpublished data). 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). Codes are listed below. 6

List of Appendices

Appendix 1. Threat Calculator results for Columbia Sculpin 40

WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Order: Scorpaeniformes

Family: Cottidae

Scientific name: *Cottus hubbsi*

English Common name: Columbia Sculpin

French Common name: Chabot du Columbia

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

Columbia Sculpin (Figure 1) is a western North American member of the Uranidea sculpin clade (Kinzinger *et al.* 2005) and has been referred to as *Cottus bairdii* (Cannings and Ptolemy 1998; Wydoski and Whitney 2003, also see Table 1). The Mottled Sculpin, *Cottus bairdii*, is an eastern North American species. Nelson *et al.* (2004) use the scientific name, *Cottus hubbsi*, for Columbia Sculpin and it is used in this report. However, there are nomenclatorial problems surrounding the use of this scientific name in British Columbia, and it may change when these are resolved. Nevertheless, although debate exists about the appropriate scientific name, south-central BC is the only place in Canada where this sculpin occurs and regardless of the scientific name adopted once taxonomy is resolved, it is a unique component of the Canadian fauna (COSEWIC 2010).

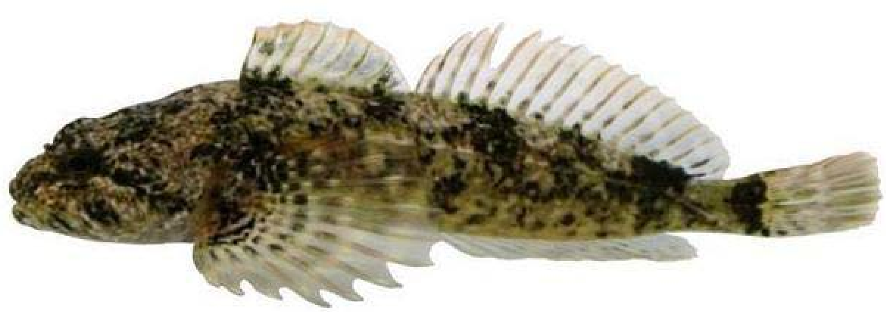


Figure 1. A Columbia Sculpin (*Cottus hubbsi*), about 55 mm total length, collected from the Similkameen River in 2006 (Photo courtesy of Gavin Hanke, Victoria, BC).

Markle and Hill (2000) studied sculpins in the Harney Basin, Oregon. They tentatively concluded that there were two sculpin species present: 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. 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. They also noted that head length and completeness of the lateral line were useful for separating *Cottus hubbsi* from *Cottus bendirei.* Markle and Hill (2000) 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*.

Table 1. Genetic distances (uncorrected) among *Cottus bendirei* and putative *C. bendirei* and *C. hubbsi* in the Harney Basin and Similkameen River system (McPhail, unpublished data). 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). Codes are listed below.

	BK	HK	BSim1	BSim2	HSLo	CBR
BK	-					
HK	0.002	-				
HSim1	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. bairdii* from the Saugeen River, Ontario. BK and HK were collected from Silver Creek, Harney Co., Oregon, and the Silvies River, Harney Co. Oregon, respectively (Neeley, pers. comm. to D. McPhail 2010).

Further discussion below focuses on taxonomy in the Similkameen drainage system. Three lines of evidence 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 (COSEWIC 2010).

Morphological Description

Four sculpin species co-occur with 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 (COSEWIC 2010). Columbia Sculpin (Figure 1) has well developed palatine teeth; 11-14 anal rays; and a moderately deep caudal peduncle. Columbia and Torrent sculpins are difficult to distinguish from one another but exhibit different prickle and colour patterns. Typically, there are less than 30 prickles above the lateral line in Columbia Sculpin, whereas the flanks above the lateral line in Torrent Sculpins usually are densely covered in prickles (COSEWIC 2010).

Columbia Sculpin occurs in five geographically separate subpopulation s in Canada: Columbia, Kootenay/Slocan, Kettle, Similkameen, and Bonnington. The following description of Columbia Sculpin is based on specimens from four of the five areas: the Columbia, Kootenay/Slocan, Kettle, and Similkameen subpopulation s. In general body shape, Columbia Sculpin resembles most other sculpins in the genus *Cottus* (see cover illustration). Standard length (SL) divided by head length ranges between 2.8-3.3, SL divided by mouth width ranges between 4.2-6.0, and SL divided by the caudal peduncle depth ranges between 13.5-15.7 (COSEWIC 2010). There are two median chin pores and usually a double post-maxillary 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 one spine and four 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) (COSEWIC 2010).

Colouration is variable but the dorsal surface 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 (COSEWIC 2010).

Population Spatial Structure and Variability

In the Harney Basin, Oregon, 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 (COSEWIC 2010).

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 (COSEWIC 2010).

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

Allozyme data that includes *C. hubbsi* (as *C. b. hubbsi*) are presented in COSEWIC (2010). 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 2010) as 0.03 to 0.04. These genetic distances are well within the range of Nei's genetic distances expected among subpopulation s within a relatively small geographic region (Avise 1994).

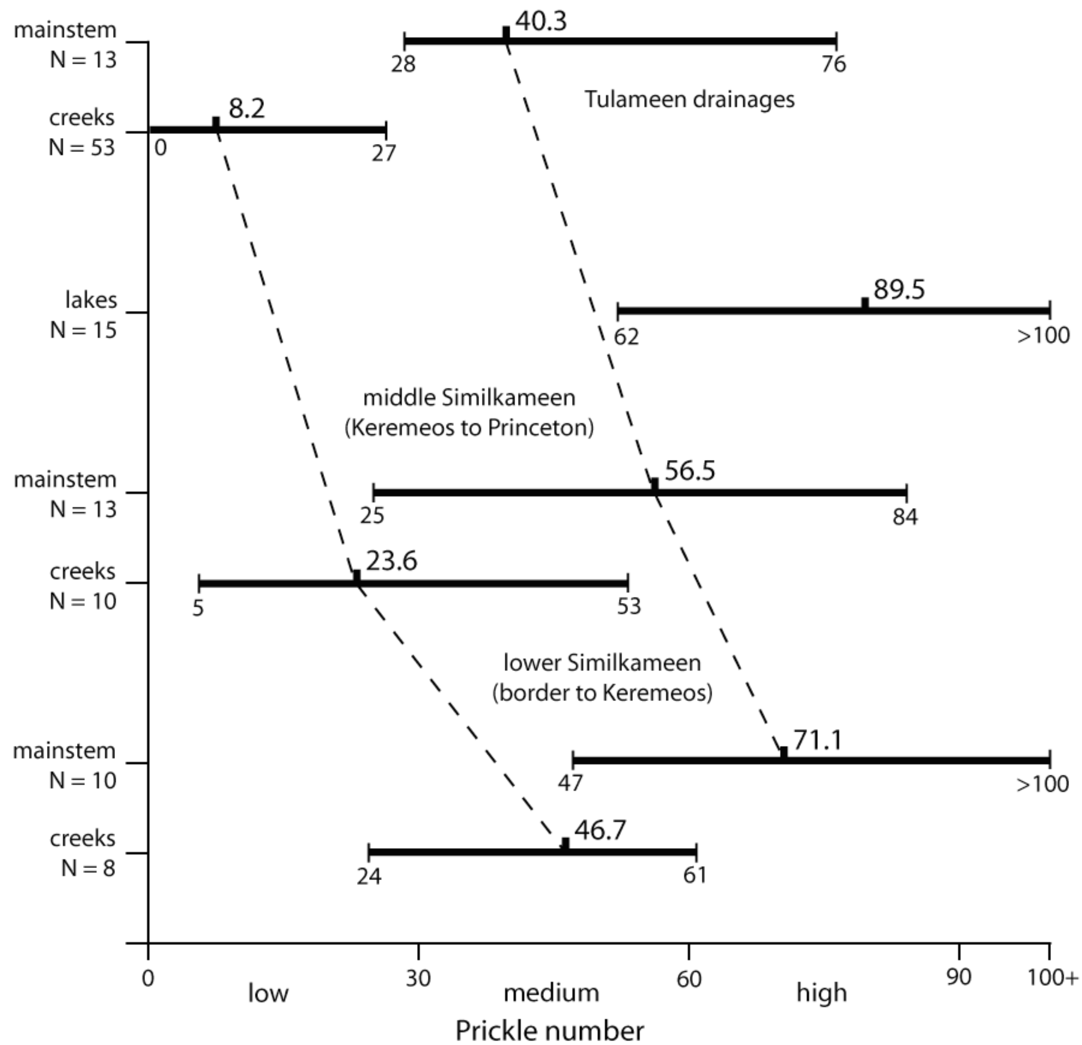


Figure 2. Ranges and means of prickle counts for Columbia Sculpin (*Cottus hubbsi*) in creeks (includes the lakes in the Allison Creek drainage) and the mainstems in the lower and middle Similkameen River and Tulameen River. Dashed lines connect the means.

Mitochondrial DNA has also been examined to describe putative sculpin species. 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 (Neeley, pers. comm. to D. McPhail, 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) (COSEWIC 2010).

Although the genetic distance between *C. bendirei* and *C. hubbsi* in Table 1 is typical of inter-population 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), of which twelve 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 (COSEWIC 2010).

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 but data from the Similkameen system support the existence of two ecotypes. 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 (about 100 km of river length). 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 (they were eradicated for fisheries enhancement in the 1950s) were all heavily prickled. It appears 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. However, morphologically 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. While 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) (COSEWIC 2010).

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 with 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. Recent evidence suggests *C. bendirei* from the Harney Basin are reciprocally monophyletic with respect to *C. hubbsi*, which argues for *C. bendirei* recognition as a distinct species. Although the molecular differences are minor based on new data, there is both mitochondrial and nuclear evidence supporting the *C. bendirei*-*C. hubbsi* split, but only in the Harney Basin (S. Pollard from M. Young, pers. comm. 2018). Regardless of the taxonomic questions that remain, in Canada Columbia Sculpin is only found in the Columbia River basin.

Designatable Units

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

The downstream limit of *C. hubbsi* in the mainstem Columbia River was somewhere near the confluence of the Umatilla River with the Columbia River in the past century. The species' presence in northern tributaries of the Columbia River as far downstream as the Yakima River drainage system suggests that at some time in the Holocene Columbia Sculpin must have had a wider distribution in the Columbia River (COSEWIC 2010).

Special Significance

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 questions 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. Sculpins as a group are also 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.

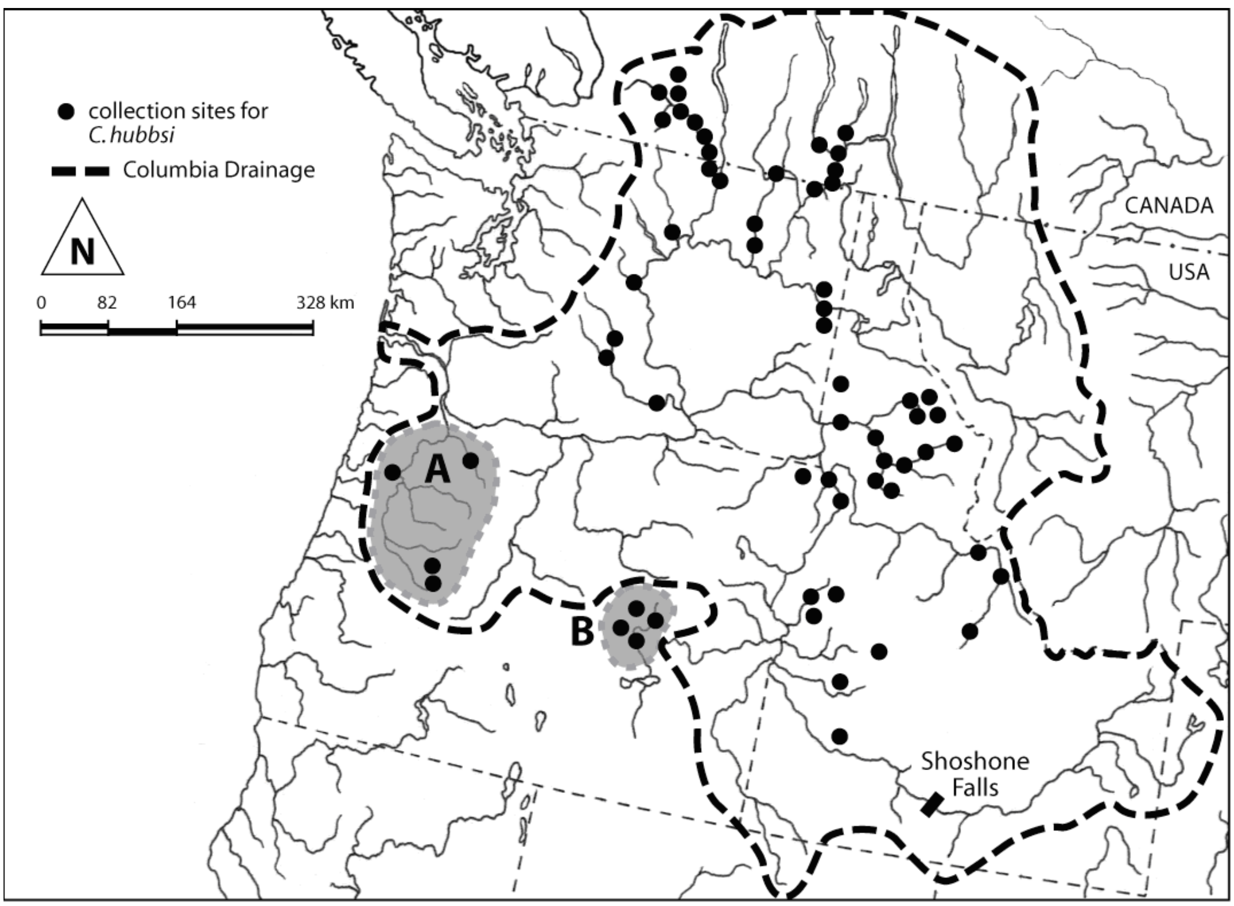


Figure 3. Global distribution of Columbia Sculpin, *Cottus hubbsi*. Note isolated populations in A (Willamette River tributaries) and B (Harney Basin). Data from Bond (1963), Simpson and Wallace (1978), Wydowski and Whitney (2003), COSEWIC (2000), and McPhail (2007).

DISTRIBUTION

Global Range

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, Columbia Sculpin's distribution is fragmented (Figure 3). Many of these isolated fragments appear to be natural, but dams now exacerbate this fragmentation.

Canadian Range

The Canadian range is divisible into five subpopulation s (Figure 4): 1) the Columbia subpopulation 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 5); 2) the Kootenay/Slocan subpopulation extends from the Brilliant Dam upstream to the South Slocan Dam (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 6); 3) the Bonnington subpopulation occupies the 2.5 km of the Kootenay River between the South Slocan and lower Bonnington dams (Figure 6); 4) the Kettle population is restricted to the 5 km stretch of the Kettle River between Cascade Falls and the US border (Figure 7); and 5) 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 (Figure 8). It 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. 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 (Pollard from Hanke pers. comm. 2010).

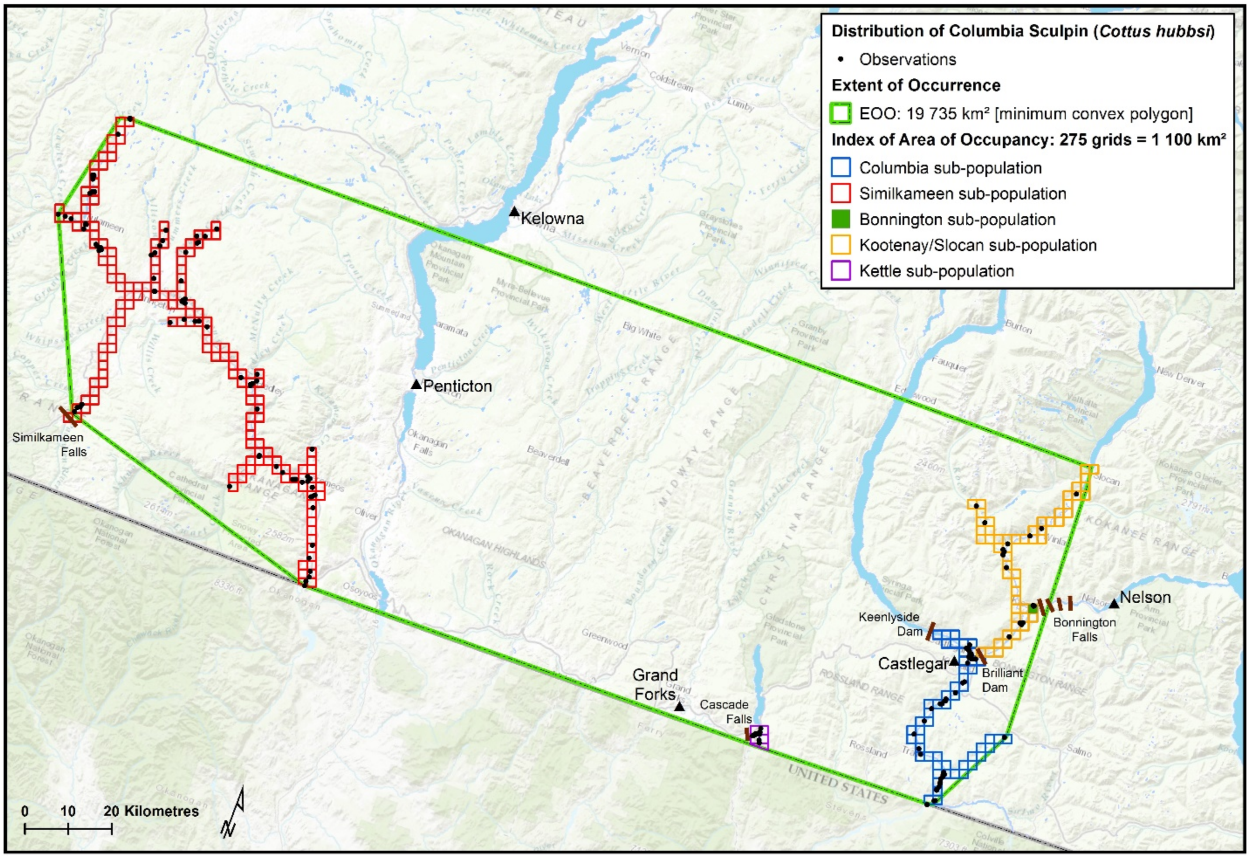


Figure 4. IAO and EOO for Columbia Sculpin (*Cottus hubbsi*) in Canada. Source: Royal British Columbia Museum, University of British Columbia Beatty Biodiversity Museum, British Columbia Ministry of Environment Fish Inventory Summary System, and J.D. McPhail, unpublished.

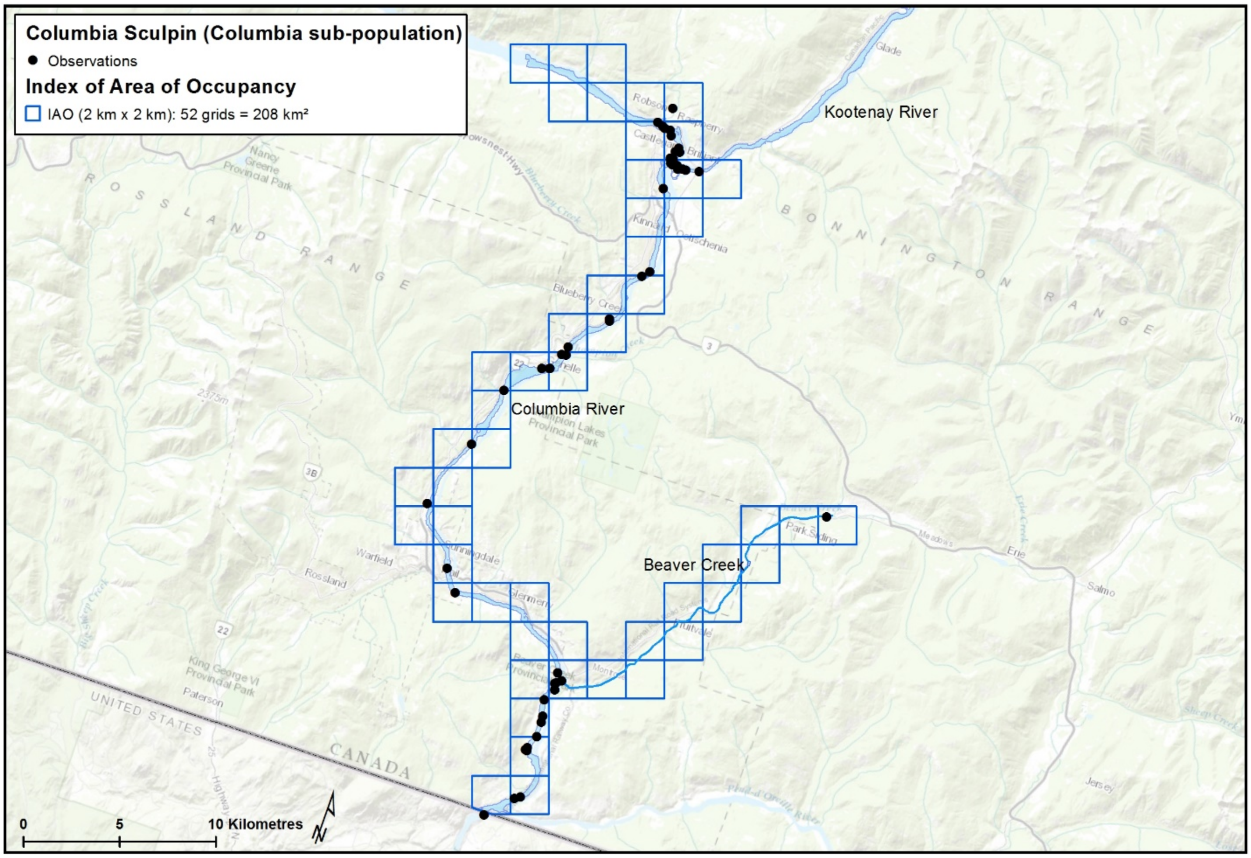


Figure 5. IAO for *Cottus hubbsi* for collection sites in the Columbia subpopulation . Source: Royal British Columbia Museum, University of British Columbia Beatty Biodiversity Museum, British Columbia Ministry of Environment Fish Inventory Summary System, and J.D. McPhail, unpublished.

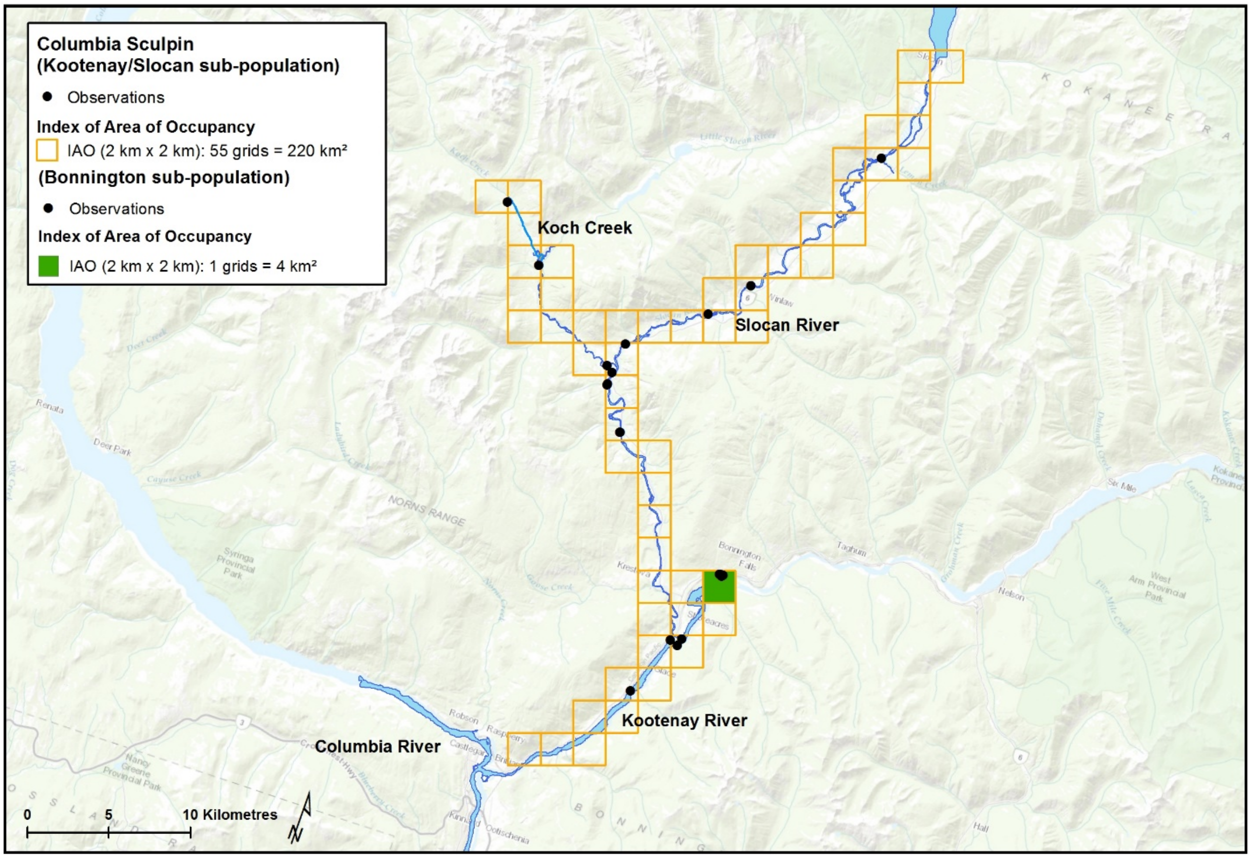


Figure 6. IAO for *Cottus hubbsi* for collection sites in the Kootenay/Slocan and Bonnington subpopulation s. Source: Royal British Columbia Museum, University of British Columbia Beatty Biodiversity Museum, British Columbia Ministry of Environment Fish Inventory Summary System, and J.D. McPhail, unpublished.

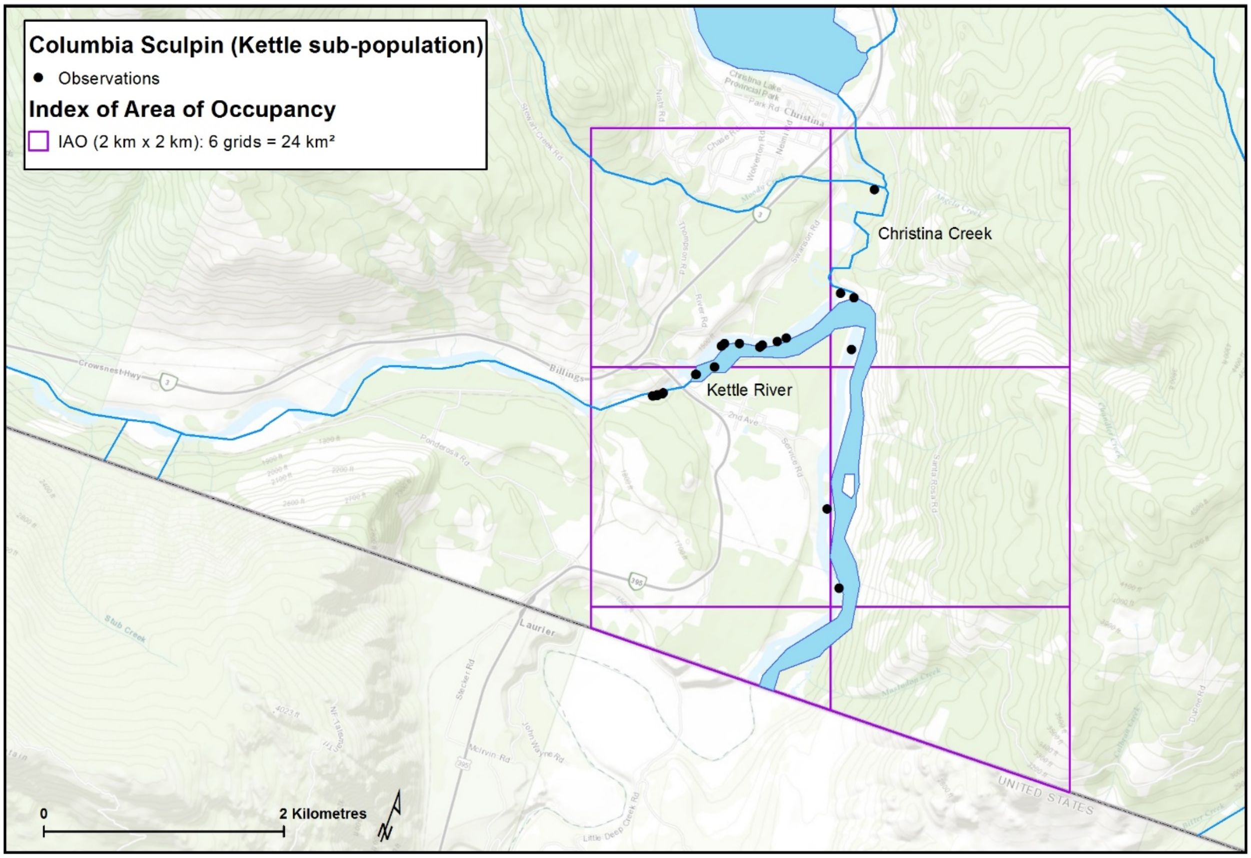


Figure 7. IAO for *Cottus hubbsi* for collection sites in the Kettle subpopulation . Source: Royal British Columbia Museum, University of British Columbia Beatty Biodiversity Museum, British Columbia Ministry of Environment Fish Inventory Summary System, and J.D. McPhail, unpublished.

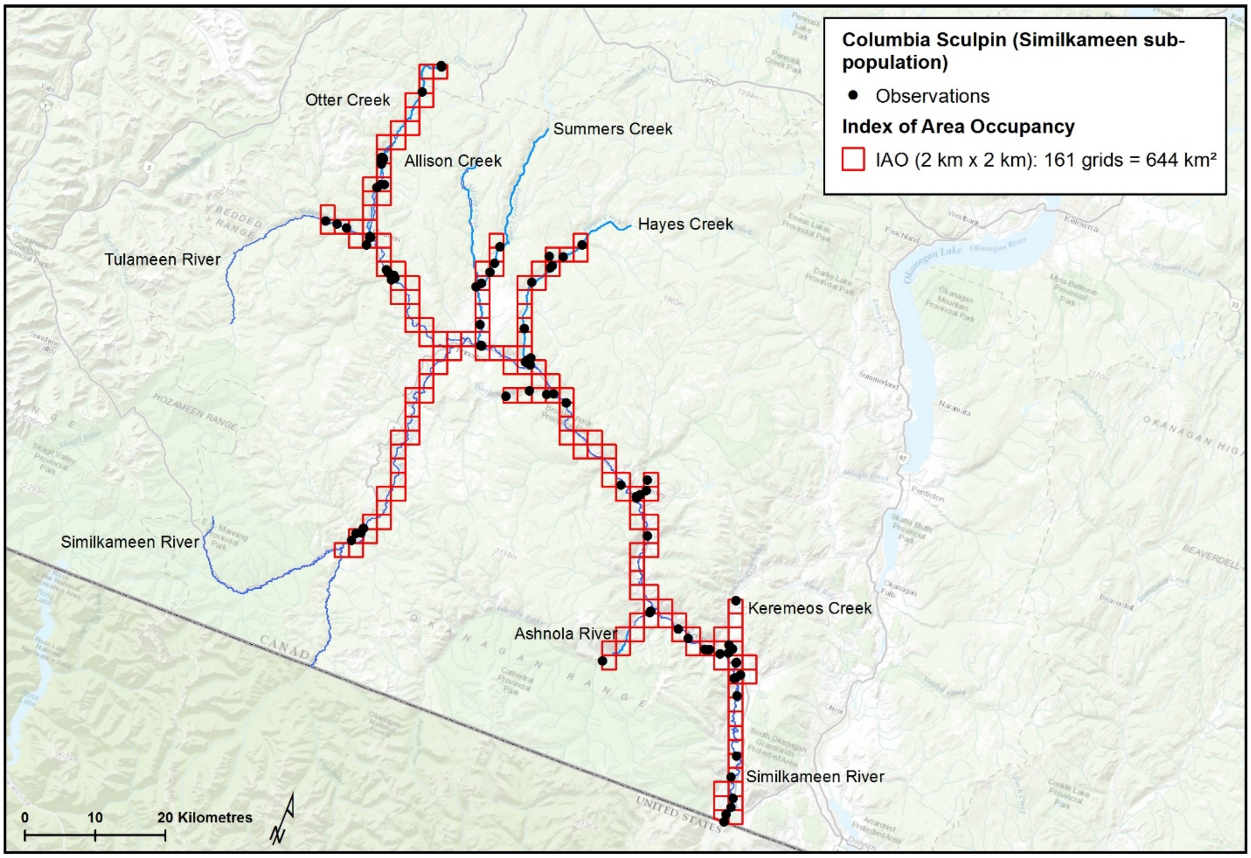


Figure 8. IAO for *Cottus hubbsi* collection sites in the Similkameen subpopulation . Source: Royal British Columbia Museum, University of British Columbia Beatty Biodiversity Museum, British Columbia Ministry of Environment Fish Inventory Summary System, and J.D. McPhail, unpublished.

Extent of Occurrence and Area of Occupancy

The extent of occurrence (EOO) and index of area of occupancy (IAO) for Columbia Sculpin in Canada are 19 735 km^2 and 1 100 km^2, respectively (Figure 4). In determining the overall distribution, a small number of observations of Mottled Sculpin (*C. bairdii*) collected prior to 2000 and not included in previous COSEWIC assessments of Columbia Sculpin have been included here, as it is now evident that the Mottled Sculpin is primarily an eastern species and these specimens were almost certainly what is now known as Columbia Sculpin.

The EOO and IAO of the five subpopulation s are: for the Columbia 517 km^2 and 208 km^2, for the Kootenay/Slocan 613 km^2 and 220 km^2, for the Bonnington 4 km^2 (0.5 km^2 minimum convex polygon) and 4 km^2, for the Kettle 24 km^2 (3.4 km^2 minimum convex polygon) and 24 km^2, and for the Similkameen 3 518 km^2 and 644 km^2, respectively.

Search Effort

Data collection on sculpins in general has been intermittent, primarily from directed studies and surveys by university researchers and museum collections. More recently BC Hydro and various consultants have conducted studies directed at the effects of water drawdowns at dams on distribution and movement of sculpins and other at-risk species (e.g., AMEC 2010, 2014).

HABITAT

Habitat Requirements

Columbia Sculpin appear to have broad habitat requirements occurring in rocky, riffle habitats in streams less than 5 m wide up to rivers the size of the Columbia River (Peden 2000; McPhail 2007; Fisheries and Oceans Canada 2012). They are found primarily in streams, although they occurred in lakes in the Similkameen system before being eradicated for fisheries enhancement programs in the 1950s (Peden 2000; McPhail 2007). They co-occur with Prickly, Torrent and Shorthead sculpins, and there is some evidence of microhabitat partitioning among species and life stages (McPhail 2007). Rearing habitats are riffle areas of clear, cool streams, with cobble substrates. Adults are associated with moderate currents (0.3 to 0.6 m/sec) and depths of 40 to 100 cm (McPhail 2007). In the lower Columbia, peak habitat use occurred at depths of 30 cm and velocities of 0.2 m/sec with almost exclusive use of cobble substrate (AMEC 2014). Juveniles typically occur in shallower, slower water than adults. In July and August young-of-the-year occur in quiet, shallow water with boulders and cobble along stream margins (less than 0.2 m/sec and less than 50 cm deep), sometimes in association with submerged vegetation (McPhail 2007; AMEC 2014). Typically, young-of-the-year occur up to 4 m from shore in pool habitats <1 m deep with cobble and boulders and little flow (AMEC 2014). Columbia Sculpin are most active at night and can be difficult to observe in the day (McPhail 2007). Columbia Sculpin in the lower Columbia and Similkameen rivers were found to show very little seasonal movement and PIT tagging demonstrated little or no migratory movement (AMEC 2014).

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. They also occur in the mainstem of the Kettle River which is low-gradient. In contrast, within the same river system, similar-sized streams that arise 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.

Habitat Trends

Data on habitat trends do not exist for any of the five subpopulation groups of Columbia Sculpin. However, none of the streams and rivers inhabited by these populations are pristine. The region occupied by Columbia Sculpin subpopulation s contains dams, urban centres, heavy industry (mines, smelter, and a pulp mill), and human-altered, eutrophic tributary streams. The Kootenay/Slocan subpopulation probably occupies the least altered habitat of the five systems but this region was subject to major mining and logging activity within the watershed in the past. Additionally, the Grand Coulee Dam eliminated the Chinook Salmon (*Oncorhynchus tshawytscha*) run that annually carried a large quantity of nutrients (eggs and carcasses) into the Slocan River. The loss of these nutrients following completion of Grand Coulee Dam in 1942 probably significantly reduced the nutrient dynamics of the entire river (Gresh *et al*. 2000). The Bonnington subpopulation 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 1897 hydroelectric project associated with Cascade Falls. The Similkameen River area never supported anadromous salmonid populations as Squanti Falls near the junction of the Similkameen and Okanagan rivers had 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. Fragmentation of habitat has occurred due to the presence of dams in the Columbia/Kootenay watershed, including the South Slocan and Brilliant Dams. The dams here have also altered the habitat significantly in terms of the annual hydrograph, likely reducing quality of habitat, particularly associated with stranding resulting from ramping of dams in summer months. Water quantity and quality (temperature and oxygen levels) are also being impacted by increasingly early, prolonged and severe drought conditions especially in the Similkameen and its tributaries, and in the Kettle River. 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. In addition, upstream of Lawless Creek, there are several active mines adjacent to the Tulameen River.

Three new mines have been opened in the Similkameen River drainage since the 2010 COSEWIC report with future development at one site that may cause degradation of Columbia Sculpin habitat without appropriate conservation and mitigation measures. The degradation of available habitat for the Columbia and Bonnington subpopulation s, 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 runoff. The problem of summer low flows has become accentuated by increasing draws on water for urban, agricultural and industrial needs in the watershed (reviewed by Ptolemy 2009). Climate warming has the potential to further exacerbate this condition and contribute to loss of aquatic habitat (see http://plan2adapt.ca/tools/planners).

BIOLOGY

Most regional works on the freshwater fishes of Washington, Oregon, and Idaho treat Columbia Sculpin either as conspecific with *C. bairdii* or as a subspecies of *C. bairdii*. Consequently, information on the biology of Columbia Sculpin is often a mix of local data and information derived from eastern North American Mottled Sculpins. As a result, sorting out information that pertains to *C. hubbsi* as opposed to *C. bairdii* is difficult. In this report information from localities within the known range of Columbia Sculpin has been included whenever possible. Accordingly, the major sources for information on the biology of *C. hubbsi* are R.L.&L. Environmental Services Ltd. (1994, 1995), COSEWIC (2000, 2010), McPhail (2007), and AMEC (2010, 2014).

Life Cycle and Reproduction

<u>Spawning period</u>

Columbia Sculpin reproduce in the spring from February to June, depending on site, when water temperatures are between 4 and 11ºC, and possibly as high as 15ºC (Wydoski and Whitney 2003). In the Similkameen River spawning was observed along the declining limb of the hydrograph when water temperatures were approximately 8°C and despite differing flow regimes at index sites spawning seemed to be triggered by water temperature (AMEX 2010). In Otter Creek (Similkameen subpopulation) rocks with eggs glued to their undersides were found from late-May (water temperature 7ºC) to mid-June (12ºC). AMEC (2014) reported Columbia Sculpin egg laying occurred in the lower Columbia River from late May through mid-July at water temperatures ranging from 9.5 to 15ºC. In the Tulameen River spawning occurred from mid-June to early July at water temperatures ranging from 8 to 15ºC. Spawning was also observed at Otter Creek from mid-May to mid-June between 8 and 15ºC (AMEC 2014).

<u>Spawning sites</u>

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. AMEC (2010) reported that Columbia Sculpin males appeared to select the largest most unembedded substrate available for their nests based on a study in the Similkameen watershed. The surface velocities over nests varied from 0.3 to 0.7 m/s. The water depths over the nests usually were < 40 cm. AMEC (2014) report nests found in the lower Columbia and Similkameen were in areas with cobbles (5 to 10% embedded) in water less than 50 cm deep and current velocity less than 0.2 m/sec. Nests were between 0.5 and 3 m from the shoreline in run and pool habitats.

Spawning behaviour

Columbia Sculpin males typically excavate a nest cavity and court females. Breeding males' entire bodies are black except for a band of orange along the upper tip of the first dorsal fin (McPhail 2007). Breeding females do not develop this obvious spawning colouration although they have noticeable swollen abdomens (McPhail 2007). 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). Male sculpins are territorial and guard nests under rocks (McPhail 2007), and breeding colouration was observed in adult male Columbia Sculpins that were guarding nests (AMEC 2014). Female sculpins deposit their adhesive eggs in a clump on the underside of the nest rock and the male fertilizes them and guards the nest until they hatch (McPhail 2007). Columbia Sculpins are polygynous and most of the nests observed in the lower Columbia and Similkameen systems had more than one clump of eggs indicating that more than one female deposited its eggs at the nest rock (AMEC 2014). In Otter Creek, most nests contained multiple egg clutches but some nests with eyed eggs had a single clutch of eggs. In addition, mature Columbia Sculpin males were observed to move very little at index sites on the Similkameen system during the spawning period as they were likely guarding their nests (AMEC 2014).

AMEC (2014) also reported that in 2010 in the lower Columbia, 11 spawning sculpins were observed guarding their nests even though most eggs were dead and/or showed evidence of fungal growth. The low embryo survival at these nests suggests that males were not able to adequately perform typical nest guarding behaviours even though they remained with the nest. Males will guard nests by attacking potential intruders that approach the nest. They will also fan the eggs with their pectoral fins and clean the surface of the eggs with their anal fin by undulating their body laterally while upside down under the nest rock.

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 long 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 (AMEC 2014).

Incubation period

Length of incubation depends on temperature, but ranges from 20 to 30 days at 10ºC to 15.5ºC (Wydoski and Whitney 2003; McPhail 2007). As noted 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 (Keeler, pers. comm. to D. McPhail, 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 until the egg sac was absorbed and then emerged as pigmented, miniature (9.5-10.5 mm in total length) versions of the adults to begin exogenous feeding. Hatching rate is quite variable but typically high, often exceeding 90 percent (AMEC 2014).

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 BC was in its sixth summer (5+) and was 106 mm in total length (McPhail 2007). Generation time was estimated to be 3 years.

Physiology and Adaptability

The physiology of Columbia Sculpin has not been studied. However, the species' distribution pattern suggests that it is more tolerant of warm water than the Shorthead Sculpin. Their presence in small streams in the Slocan and Similkameen drainage systems suggests that, given the opportunity, they are capable of adapting to a variety of habitats.

Dispersal and Migration

Individuals do not undertake large migrations or movements, and home ranges appear to be very small, based on recent tagging studies in the Similkameen watershed (AMEC 2010). Although the duration between detections was large (up to 3 months) the distances observed were generally very local with maximum displacement between sites not exceeding 138 m and mean displacement varying between 28-68 m depending on season. Similarly, Brown and Downhower (1982) found summer movements by adult Mottled Sculpin in Montana within a two-week period between successive recaptures averaged 1.2 m, with a maximum of 14.3 m. A mark-recapture study of adult Mottled Sculpin in North Carolina measured average movement distances of 12.9 m over a period of 128 days (average period between captures; Hill and Grossman 1987).

AMEC (2014) report that Columbia Sculpins were generally sedentary, moving only in response to reductions in water level associated with dam drawdowns. In this case, the movement is lateral away from shore into deeper water to avoid stranding. The only documented migration of adult *Cottus* in western North America is an upstream spawning migration of Torrent Sculpins in the lower Columbia River following by post-spawning downstream movement (Thomas 1973). After the fry of 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, once settled, the young probably do not move far from their relatively small home areas (McCleave 1964). However, as they grow and mature, they move laterally into deeper and faster water. Dispersal patterns of juveniles are not known.

Interspecific Interactions

Columbia Sculpins are carnivorous, feeding primarily on benthic invertebrates. Their diet consists primarily of the nymphs and larvae of aquatic insects. In the Columbia River subpopulation , aquatic insects (Caddisflies, Stoneflies, Mayflies, Midges, and Blackflies) constituted 93 to 100% of the contents of 34 stomachs examined (R.L.&L. Environmental Services Ltd. 1995). Gammarids, snails, and fish eggs including those of nesting sculpins are also consumed (Wydoski and Whitney 2003). 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*). In the Similkameen River they co-exist with Northern Pikeminnow (*Ptychocheilus oregonensis*), native Rainbow Trout and introduced Cutthroat Trout (*Oncorhynchus clarkii*) and Brook Trout (*Salvelinus fontinalis*) (G. Wilson, pers. comm. 2019). Given the opportunity, all of these species probably eat sculpins. In all five of the Canadian subpopulation s, 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. Environmental Services Ltd. 1995).

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 suggests the possibility of rare hybridization between these 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 parapatric distribution pattern of Shorthead and Columbia Sculpins in Norns and Beaver creeks (R.L.&L. Environmental Services Ltd. 1994) suggests some interaction between the two species. As well, the presence of Columbia Sculpin in small streams (usually Shorthead Sculpin habitat) in the Similkameen region suggests the likelihood of a competitive interaction between these species. AMEC (2014) also report finding both Shorthead and Columbia Sculpins at a number of sampling sites in the lower Columbia and Slocan Rivers that could result in competitive interaction.

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Most of the early sampling for Columbia Sculpins was directed at taxonomic questions (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. Environmental Services Ltd. (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. In 2011, Columbia Sculpin were sampled in September in the Columbia (Beaver and Blueberry Creeks) and Similkameen (Otter and Summers Creeks) river drainages and mark-recapture surveys were conducted (E. Taylor, pers. comm. 2018). More recently, BC Hydro has funded five years of surveys of the lower Columbia River to assess impacts of dewatering on populations of Umatilla Dace (*Rhinichthys umatilla*) and Columbia and Shorthead Sculpins (AMEC 2014). A significant amount of new information on these species has been collected but no estimates of abundance are provided.

Abundance

Estimates of adult Columbia Sculpin abundance in the five Canadian subpopulation s were provided in a previous report: Columbia >1,000; Kootenay/Slocan about 100; Bonnington 200 to 1,000; Kettle 1,500 to > 2,000, and Similkameen 3,000 to 5,000 (COSEWIC 2010). These estimates were not obtained quantitatively, and they should be used with caution. R.L.&L. Environmental Services Ltd. (1995) conducted an electro-shocker survey and found that their abundance estimates in the Columbia River varied among sites but ranged from 0.2 to 12.5/m^2. More recent information suggests that Columbia Sculpin is modestly abundant in portions of Otter Creek just upstream of the lake with densities of about 0.5 to 1 fish/m^2 (Keeler, pers. comm. to S. Pollard, 2010). Mark-recapture surveys conducted in 2011 in the Columbia and Similkameen drainages found slightly higher densities ranging between 1.2 and 5.7 fish/m^2 (Taylor, pers. comm. 2018). These densities suggest that abundances reported in COSEWIC (2010) likely underestimated population size and it is likely >10,000 adults.

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, Columbia Sculpin have declined or disappeared in some 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 Sculpin that once inhabited the lakes in the Allison Creek watershed were eradicated in the 1950s to support enhancement programs and a barrier was constructed to prevent re-colonization. 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 subpopulation groups is based on barriers (natural and human-made) to movements among sites. However, there are no barriers between the Columbia subpopulation and the Columbia River in Washington State. Thus, re-colonization of this subpopulation from downstream is possible. In contrast, the Kootenay/Slocan and Bonnington subpopulation s are isolated from the Columbia subpopulation by Brilliant and South Slocan dams, respectively. There are downstream subpopulation s of Columbia Sculpin in the US portion of the Kettle River. With time, these US subpopulation s could re-colonize the Canadian Kettle River subpopulation . For the Similkameen River subpopulation , there are no barriers above Squanti Falls in Washington State and the Canadian portion of the Similkameen River. Thus, re-colonization of the lower Similkameen River is possible by fish downstream. However, the tendency for Columbia and other sculpins to remain sedentary throughout most of their lives makes re-colonization from other systems unlikely.

THREATS AND LIMITING FACTORS

The identification and assessment of threats to Columbia Sculpin was determined through completion of the IUCN Threats Calculator (based on Salafsky *et al.* 2008) during a conference call with the report writer, identified external experts, and members of the COSEWIC Freshwater Fishes Subcommittee on December 18, 2018. Threats are also discussed in detail in the management plan and some of this material has been incorporated in this section (Fisheries and Oceans Canada 2012). The assigned overall threat impact was assessed as Medium.

Threat 7. Natural System Modifications (medium impact)

These threats refer to physical alterations to the habitat or environment of Columbia Sculpin that would impact its survival within Canada.

<u>7.2 Dams and water management/use (medium impact threat)</u>

The Columbia River valley has been dramatically altered by river impoundment and regulation for the purpose of flood control and hydropower. The most serious issue for sculpins relates to 'stranding' when the water level is quickly reduced at or below a dam with the result that individuals are unable to relocate and become stranded with mortality resulting in most instances (AMEC 2014). Rapid water drawdown at dams occurs regularly on the Columbia River. Numerous dams on the Columbia, Kootenay and Pend d'Oreille rivers have inundated riverine, lake and foreshore habitats and altered flow regimes. It is unclear whether this historic habitat change has had a significant influence on Columbia Sculpin abundance, but the habitat in these rivers has clearly been considerably altered. Much of the current subpopulation is found in the Columbia River mainstem rather than in tributaries (Fisheries and Oceans Canada 2012). The Kootenay River has also been profoundly altered by river impoundment and regulation, and no unaffected habitat exists for Columbia Sculpin on this river below Bonnington Falls (Peden 2000). A few individuals were captured here though, indicating that a small subpopulation continues to persist. The Slocan River remains the only unregulated tributary within the Canadian Columbia Sculpin distribution.

It is unclear whether operating procedures at Keenleyside Dam pose a threat to the Columbia subpopulation of *C. hubbsi*. BC Hydro has commissioned studies on fish stranding and, to date, there is no evidence of adverse effects of rapid water level changes on either Columbia or Shorthead Sculpins (AMEC 2014). 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 Bonnington subpopulation of Columbia Sculpins has co-existed with the dam since 1925 (COSEWIC 2000).

Except for the mainstem Columbia River, water is in short supply in the summer in tributary streams. Between 2001 and 2010, the linear stream length of Columbia Sculpin distribution in Otter Creek shrank by 42% (from 28 to 16 km above Otter Lake). The upper 12 km of the creek now is dry in the summer and the drought is exacerbated by agricultural water use. Princeton, Keremeos, Grand Forks, and Trail continue to grow in population 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 (White, pers. comm. to D. McPhail, 2010; also, Brown *et al*. 2012). Stress on water availability will likely increase as climate projections indicate increasing temperatures in southern BC over the next few decades (e.g., Wang *et al*. 2006).

<u>7.3 Other ecosystem modifications (medium-low impact threat)</u>

The threat refers to the impact to Columbia Sculpin habitat from destruction due to increasing frequency of forest fires. Infestation of much of interior British Columbia by the Mountain Pine Beetle (*Dendroctonus ponderosae*) has rendered large tracks of forest dead or dying with the result that it is more vulnerable to forest fire damage (Mountain Pine Beetle Action Plan 2006-2011 Progress Report 2008). The bulk of the damage is north of Columbia Sculpin habitat but some increase in forest fire risk due to this effect is anticipated. The threat would also include increased sedimentation resulting from loss of vegetation following fires. The threat of other ecosystem modifications was assessed as a medium to low impact.

Threat 8. Invasive & Other Problematic Species & Genes (medium-low impact threat)

The threat refers to the impact on Columbia Sculpin from the introduction of invasive non-native species, problematic native species, or the introduction of genetic material into the population.

8.1 Invasive non-native species (medium-low impact threat)

Sala *et al.* (2000) suggest that non-native species are the leading driver of biotic change in freshwater systems. The Columbia drainage in BC contains 43 species of fish of which 16 species are introduced (McPhail and Carveth 1992), and Northern Pike (*Esox lucius*) is a recent addition (Fisheries and Oceans Canada 2012). Although not all of these introductions co-occur with Columbia Sculpin, and not all would be threats, the high proportion of introduced species (37%) highlights the potential risk (Fisheries and Oceans Canada 2012). Walleye (*Sander vitreus*) are now common in the Columbia River as far north as Castlegar and are a possible threat to sculpins and other fish species. Other non-native predatory fish such as bass may rely heavily on sculpins in their diets (Pflug and Pauley 1984; Summers and Daily 2001; Bonar *et al.* 2005). Largemouth Bass (*Micropterus salmoides*) and Smallmouth Bass (*Micropterus dolomieu*) are present in Christina Lake and the Kettle River downstream of Cascade Falls, at least since 2010, and Northern Pike were confirmed in the Kettle River on the US side of the border in 2015 and would be a significant sculpin predator (Pollard, pers. comm. 2019). Threats from other ecologically similar benthic fishes also exist. The Round Goby (*Neogobius melanostomus*) was introduced to the St. Clair and Detroit rivers, in the Great Lakes region, and appears to have caused the severe decline of the Mottled Sculpin (Jude *et al.* 1992; MacInnis and Corkum 2000; Lauer *et al.* 2004).

Threat 9. Pollution (medium-low impact threat)

The threat refers to the risk to Columbia Sculpin from various human pollutants and effluents that may be introduced into the freshwater habitat of the species. The threat was assessed as medium to low impact.

9.1 Household sewage & urban wastewater (medium-low impact threat)

Various pollution sources have the capacity to affect water quality and to degrade aquatic habitat. Defective septic systems, inputs from agriculture and domestic fertilizers, sedimentation from land-based activities, and poor groundwater quality are factors that may degrade water quality to some degree (Fisheries and Oceans Canada 2012). Nitrite toxicity was reviewed by Lewis and Morris (1986), who found that the related Mottled Sculpin was among the least sensitive. It is unclear the degree to which this type of pollution negatively affects Columbia Sculpin within British Columbia.

9.2 Industrial & military effluents (medium-low impact threat)

Several species of sculpin have been identified as particularly sensitive to changes in water quality (Maret and MacCoy 2002; Mebane *et al.* 2003). For example, Maret and MacCoy (2002) noted that Shorthead Sculpin and other Cottids were absent from sites downstream of hard-rock mining areas in the Coeur d'Alene basin, Idaho, and likely sensitive to elevated metals concentrations. Peden and Hughes (1984) believed sculpin populations were threatened by development of coal mining within the Flathead River basin. Tests for acute and chronic toxicity to zinc found *Cottus bairdii* to be among the most sensitive species examined (Woodling *et al.* 2002). Columbia Sculpin subpopulations in the mainstem Columbia River may have been affected by historic slag dumping. The pulp mill at Castlegar and the smelter at Trail still discharge effluent into the Columbia River and heavy metal contamination is an ongoing problem in the Columbia and in some Slocan River tributaries.

Historically, mining and smelting have been major industries in the region. Two active mines currently exist in the Similkameen and Tulameen valleys. The open pit Copper Mountain Mine is located approximately 800 m east of the Similkameen mainstem 20 km south and upstream of Princeton while the Coalmount Energy Corporation is located on the Tulameen River. In addition, an open pit gold mine located in Hedley approximately 3 km northeast of the Similkameen River was abandoned in 1996 (Nickel Plate Mine). Copper Mountain Mine on Wolfe Creek reopened in 2009, and current fisheries concerns include a proposal to realign and infill Wolfe Creek and channelize Verde Creek, as well as onsite operational issues which have resulted in 8 slides/spills and unauthorized discharges into the Similkameen since 2007 (White, pers. comm. to S. Pollard, 2018). For example, the Coalmount mine had a spill of 65,000 litres of coal slurry on August 24, 2013 into the river at Collin's Gulch when a tailings pond flooded over into the Tulameen River. The mines potentially impact fish habitat by causing: 1) reduced flows especially during summer low-flow months, with associated loss of habitat and increase in temperatures; 2) ongoing declines in water quality associated with waste rock (e.g., sulfates) which already exceed aquatic life standards in the Similkameen; and 3) habitat loss associated with stream infill and diversion (COSEWIC 2010).

Threat 11. Climate Change and Severe Weather (medium-low impact threat)

The threat from climate change and severe weather conditions was assessed as medium to low impact for Columbia Sculpin at the present time. It includes the effects of: changes and alteration to the habitat; droughts; temperature extremes; and storms and flooding.

11.2 Droughts (medium-low impact threat)

Indications are that climate is changing and animal and plant distributions are responding in various ways (Parmesan and Yohe 2003). Because climate affects precipitation, water flow and temperature in a variety of ways, it will likely affect Columbia Sculpin abundance and distribution (Fisheries and Oceans Canada 2012). It was noted earlier that 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. Columbia Sculpin require cool temperatures throughout the year, which are supplied by snowmelt and cool groundwater sources, and these will likely be altered under most projected climate change scenarios (Leith and Whitfield 1998; Morrison*;* 2002; Summit Environmental Consultants Inc. 2012). The limited dispersal ability of this species (Peden 2000) accentuates the threat.

To the end of 2015, at least eight drought-related fish kills have been reported on the Kettle River in the past two decades, two of which were on July 3, 2015 (large-scale fish kills related to high water temperature >24ºC occurred in 2003, 2006, 2009, and 2015). One of these occurred near the international border crossing near Carson when water temperatures were at or exceeded 25ºC. Stream flows in the Kettle River approached or dropped below the rearing threshold and dropped below the spawning and migration thresholds for Mountain Whitefish (*Prosopium williamsoni*) and Speckled Dace (*Rhinichthys osculus*) based on Water Survey information for 2015. Streamflows in the lower Kettle mainstem were at or below recorded minimum flows in late July and August (Pollard, pers. comm. 2019). Low flows impact water quality, habitat capacity and productivity.

11.3 Temperature extremes (medium-low impact threat)

More dramatic temperature fluctuations in both water and air are anticipated as a result of climate change. Within watersheds the temperature extremes are interconnected with reductions in waterflow or drought conditions. In the Columbia River drainage, Otter Creek is outstanding in the region for high temperatures exceeding 22ºC in 2018 (Whitehouse pers. comm. to Pollard, 2018). Within the last 50 years, exceptionally low flow years include 1970, 2001, 2003, and 2006 in the Similkameen River and fish kills were observed in 2009 and 2015 due to elevated temperatures (White, pers. comm. to S. Pollard, 2019). During the 2015 fish kill, temperatures ranged from 22-25ºC. Temperature thresholds for a related sculpin species (*C. bairdii*) indicates that this temperature is approaching the upper lethal level (Hasnain *et al.* 2010). Given the sedentary life history of sculpins where home range appears to be very small, this presents an elevated concern with regards to being able to seek thermal refuges.

Limiting Factors

The limited understanding of Columbia Sculpin biology makes assessment of limiting factors more difficult. Factors that may be important when assessing limiting factors are the low dispersal rate of Columbia Sculpin, habitat preferences, and low fecundity. Other factors are natural and anthropogenic dispersal barriers, such as falls and dams that exist within the range of Columbia Sculpin (Fisheries and Oceans Canada 2012). The relatively short dispersal range of this species makes it difficult to colonize new areas or recolonize depopulated areas (Peden 2000). The Canadian range of the species is at its northern limit, and the factors currently limiting the geographic distribution are unknown. The species prefers riffle habitats in cool, clear streams that may be somewhat scarce or vulnerable to disturbance (Peden 2000). Fecundity of Columbia Sculpin varies with female body size, but clutches have relatively few eggs (50 – 100) and are likely produced only once per year (Wydoski and Whitney 2003; McPhail 2007).

Columbia Sculpin's global distribution (Figure 3) suggests that it is a species adapted for life in 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. However, they do 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 with Shorthead Sculpins in the headwaters and Columbia Sculpins downstream. Thus, their distribution suggests that the presence of Shorthead Sculpin (and perhaps other sculpins) may limit the distribution of Columbia Sculpin.

Number of Locations

A location refers to a geographically or ecologically distinct area in which a single threatening event can rapidly affect all individuals of the taxon present. The size of the location depends on the area covered by the threatening event and may include part of one or many subpopulation s. If more than one threatening event is possible location should be defined based on the most serious plausible threat. If the most serious plausible threat does not affect the entire distribution, other threats can define locations in otherwise unaffected areas. The most serious plausible threat for Columbia Sculpin is dams and water use and its management particularly given the increasing frequency of droughts. While pervasive, different subpopulation s are affected by different types of water-related issues. The Similkameen and Kettle subpopulation s are affected only by water withdrawals. Therefore, the Kettle subpopulation represents one location. The Similkameen mainstem plus minor tributaries (Allison, Keremeos, Lower Ashnola, Wolfe) should be considered as another location. Drought is likely to place some pressure on all of these minor tributaries for irrigation and domestic needs. It is possible that the major tributaries may be influenced differently (i.e., Tulameen, Otter, Hayes, Summers) and these could each be considered as locations. The Columbia and Bonnington subpopulation s are affected by hydroelectric dam operations. In the Columbia, the lower 2.4 km of the Kootenay River is probably as much influenced by Keenleyside Dam as the Brilliant Dam. The upstream distribution of sculpins into Blueberry and Beaver Creeks is unknown and could be as heavily influenced by the dams as the Columbia mainstem, rendering the entire subpopulation as another location. The Bonnington subpopulation experiences dam-related threats associated with the Bonnington Falls dam and represents another location. Slocan/Kootenay subpopulation is composed of two major components affected by two different key threats. The Slocan and Little Slocan Rivers are dominated by fire-related threats and represent one location, whereas the Kootenay River mainstem between Brilliant and Bonnington Falls dams is threatened by water management issues and represents a second location. Based on these broad-scale threats, it is estimated that there are 10 locations. But it is likely that many of these threats, except for climate change, occur at finer scales, leading to an increase in the estimated number of locations. The climate change threat, which would lead to many fewer locations, is likely to be realized over longer time periods than three generations due to the thermally heterogeneous habitats for Columbia Sculpin in these Columbia river tributaries. Invasive species and hybridization are additional threats to the viability of the subpopulation s in these locations but their impact relative to the main threats could not be assessed. We therefore estimate that there are more than 10 locations.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

A previous COSEWIC assessment of Columbia Sculpin (under the name *Cottus bairdii hubbsi* COSEWIC 2000) resulted in a listing as Special Concern under the *Species at Risk Act* in 2003. The status was re-examined by COSEWIC and confirmed Special Concern in November 2010 and November 2019. A Management Plan is required under SARA and was completed in 2012 (Fisheries and Oceans Canada 2012). The management plan lists several activities to define important habitats for this species, information that is generally lacking, especially for juveniles and during winter conditions. Recommendations on conservation measures were made in the plan, some of which are DFO commitments. Additionally, there is a legal requirement to report every 5 years on the status of Management Plan implementation via a Progress Report. A report on the progress of the Management Plan implementation was recently completed (Fisheries and Oceans Canada 2017). The progress report captures activities completed to date toward achieving the objectives set out in the plan.

Non-Legal Status and Ranks

The BC Conservation Data Centre ranks Columbia Sculpin as S3 or vulnerable to extirpation (http://a100.gov.bc.ca/pub/eswp/, accessed March 2019). In BC the species is blue-listed as a species of special concern. Globally, its NatureServe (as of 2001) rank is G4Q indicating globally secure but of questionable taxonomy (NatureServe 2018). The species is not ranked in Washington State, but is ranked as S4 or apparently secure in Oregon (NatureServe 2018). However, the NatureServe ranks are based on the assumption that Columbia Sculpin and the Mottled Sculpin (*C. bairdii*) are conspecific and, consequently, that *C. hubbsi* has a wider distribution than it does. 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 previously assumed (Nelson *et al.* 2004).

Habitat Protection and Ownership

There are no habitat protection provisions specifically for Columbia Sculpin. The *BC Forest and Range Practices Act* has provisions to protect fish habitat from forestry and range activities. Also, as a trans-boundary 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 Sculpin 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 Sculpin 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 western shore of Slocan Lake but does not protect the Slocan and Little Slocan rivers, which both contain Columbia Sculpin.

ACKNOWLEDGEMENTS AND AUTHORITIES CONTACTED

The previous COSEWIC status report on Columbia Sculpin was prepared by Dr. Don McPhail and forms the basis of the present document. Diana McPhail provided the drawing of Columbia Sculpin on the front cover and is gratefully acknowledged. Dr. Rick Taylor at University of British Columbia provided access to unpublished results of Columbia Sculpin distribution and abundance estimates. Jenny Wu and Sydney Allen of the COSEWIC Secretariat prepared the maps of distribution and calculated the extent of occurrence and index of area of occupancy. Greg Wilson and particularly Sue Pollard were very helpful in compiling the updated distribution data.

Dr. Rhonda L. Millikin, Canadian Wildlife Service.

Dr. Robert Anderson, Canadian Museum of Nature.

Dr. Simon Nadeau, Fisheries and Oceans Canada.

Dr. Pippa Sheppard, Parks Canada.

Rachel McDonald, National Defence.

Gregory A. Wilson, British Columbia Ministry of Environment.

Katrina Stipec, British Columbia Conservation Data Centre.

Dr. Danna J. Leaman.

Dr. Arne Mooers, Simon Fraser University.

Dr. John Reynolds, Simon Fraser University.

Kathryn Davis, Canadian Wildlife Service.

Sonia Schnobb, Canadian Wildlife Service.

Sue Pollard, Freshwater Fisheries Society of British Columbia.

Dr. Eric Taylor, University of British Columbia.

INFORMATION SOURCES

AMEC 2010. Lower Columbia River Sculpin and Dace Life History Assessment (CLBMON-43) Year 1 Report (2009). Report prepared for: BC Hydro, Burnaby, British Columbia Prepared by: AMEC Environment & Infrastructure Ltd. 115 pp.

AMEC. 2014. Lower Columbia River Sculpin and Dace Life History Assessment (CLBMON-43). Year 5 Technical Report. Report Prepared for: BC Hydro, Burnaby, British Columbia. Prepared by: AMEC Environment & Infrastructure Ltd. 117 pp + 8 Appendices.

Avise, J.C. 1994. Molecular markers, Natural History and Evolution. Chapman Hall, New York.

Bailey, R.M., and M.F. Dimick. 1949. *Cottus hubbsi*, a new cottid fish from the Columbia River system in Washington and Idaho. Occasional Papers Museum of Zoology, University of Michigan 513:1-19.

Bailey, R.M., and C.E. Bond. 1963. Four new species of freshwater sculpins, Genus *Cottus*, from western North America. Occasional Papers Museum of Zoology, University of Michigan 634:1-27.

Bonar, S.A., B.D. Bolding, M. Divens, and W. Meyer. 2005. Effects of introduced fishes on wild juvenile coho salmon in three shallow Pacific Northwest lakes. Transactions of the American Fisheries Society 134:641–652.

Bond, C.E. 1963. Distribution and ecology of freshwater sculpins, genus *Cottus*, in Oregon. Ph.D. dissertation, University of Michigan, Ann Arbor.

British Columbia Ministry of Environment. 2006. Indicators of climate change for British Columbia 2002. Website http://www.eng.gov.bc.ca/air/climate.

Brown, L. and J.F. Downhower. 1982. Summer Movements of Mottled Sculpins, *Cottus bairdi* (Pisces: Cottidae). Copeia 1982:450-453.

Brown, T., B. Harvey, and M.J. Bradford. 2012. Information in support of the identification of critical habitat for Speckled Dace (*Rhinichthys osculus*). DFO Canadian Science Advisory Secretariat Research Document 2012/065, iv + 29 pp.

Cannings, S.G., and J. Ptolemy. 1998. Rare Freshwater Fishes of British Columbia. Conservation Data Centre, British Columbia Ministry of Environment, Victoria.

COSEWIC, 2000. Assessment and update status report on Columbia Sculpin, *Cottus bairdii hubbsi*, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xiv + 57 pp.

COSEWIC, 2001. Assessment and update status report on the shorthead sculpin, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 64 pp.

COSEWIC, 2019. Operations and procedures manual. Ottawa.

Fisheries and Oceans Canada. 2017. Report on the Progress of Management Plan Implementation for Columbia Sculpin (*Cottus hubbsi*) in Canada for the Period 2012 – 2016 *Species at Risk Act* Management Plan Report Series. Fisheries and Oceans Canada, Ottawa. iii + 10 pp.

Fisheries and Oceans Canada. 2012. Management plan for Columbia Sculpin (*Cottus hubbsi*) in Canada [Final]. Species at Risk Act Management Plan Series. Fisheries and Oceans Canada, Ottawa. 18 + iv. pp.

Gresh, T., J. Lichatowich, and P. Schoonmaker. 2000**.** An estimation of historic and current levels of salmon production in the northeast Pacific ecosystem: Evidence of a nutrient deficit in the Freshwater systems of the Pacific Northwest. Fisheries 25:15-21.

Haas, G.R. 1998. Indigenous fish species potentially at risk in BC, with recommendations and prioritizations for conservation, forestry/resource use, inventory and research. Fisheries Management Report 105. British Columbia Ministry of Fisheries, Victoria, British Columbia.

Hasnain, S.S., C.K. Minns, and B.J. Shuter. 2010. Key ecological temperature metrics for Canadian freshwater fishes. Ontario Forest Research Institute, Ontario, Canada.

Hebert, P.D.N., M.Y. Stoeckle, T.S. Zemlak, and C.M. Francis. 2004. Identification of birds through DNA barcodes. PLoS Biology 2:1657-1663.

Johns, G.C. and J.C. Avise. 1998. A comparative summary of genetic distances in the vertebrates from the mitochondrial cytochrome *b* gene. Molecular Biology and Evolution 15:1481-1490.

Jude, D.J., R.H. Reider, and G.R. Smith. 1992. Establishment of Gobiidae in the Great Lakes basin. Canadian Journal of Fisheries and Aquatic Science 49:416-421.

Kinziger, A.P., and R.M. Wood. 2003. Molecular systematics of the polytypic species *Cottus hypselurus* (Teleostei: Cottidae). Copeia 2003:624-627.

Kinziger, A.P., R.M. Wood, and D.A. Neely. 2005. Molecular systematics of the genus *Cottus* (Scorpaeniformes: Cottidae). Copeia 2005:303-311.

Lauer, T.E., P.J. Allen, and T.S. McComish. 2004. Changes in mottled sculpin and johnny darter trawl catches after the appearance of round gobies in the Indiana waters of Lake Michigan. Transactions of the American Fisheries Society 133:185-189.

Leith, R. and P. Whitfield. 1998. Evidence of climate change effects on the hydrology of streams in south-central BC. Canadian Water Resources Journal 23:219-230.

MacInnis, A.J. and L.D. Corkum. 2000. Fecundity and reproductive season of the round goby *Neogobius melanostomus* in the upper Detroit River. Transactions of the American Fisheries Society 129:136–144.

Maret, T.R. and D.E. MacCoy. 2002. Fish assemblages and environmental variables associated with hard-rock mining in the Coeur d'Alene river basin, Idaho. Transactions of the American Fisheries Society 131:865-884.

Markle, D.F., and D.L. Hill. 2000. Taxonomy and distribution of the Malheur mottled sculpin, *Cottus bendirei*. Northwest Science 74:202-211.

McAllister, D.E., and C.C. Lindsey. 1961. Systematics of freshwater sculpins (*Cottus*) of British Columbia. Bulletin of the National Museum of Canada Contributions in Zoology (1959) No. 172:66-89.

McCleave, J.D. 1964. Movement and population of the mottled sculpin (*Cottus bairdi* Girard) in a small Montana stream. Copeia 1964:506-513.

McPhail. J.D. 2007. The Freshwater Fishes of British Columbia. University of Alberta Press, Edmonton, Alberta.

McPhail, J.D. and R. Carveth. 1992. A foundation for conservation: the nature and origin of the freshwater fish fauna of British Columbia. Report for BC Ministry of Environment, Victoria, BC.

Mebane, C.A., T.R. Maret, and R.M. Hughes. 2003. An index of biological integrity (IBI) for Pacific Northwest rivers. Transactions of the American Fisheries Society 132:239-261.

Morrison, J., M.C. Quick, and M.G.G. Foreman. 2002. Climate change in the Fraser River watershed: flow and temperature projections. Journal of Hydrology 263:230-244.

Mountain Pine Beetle Action Plan 2006-2011 Progress Report. 2008. https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/forest-health/mountain-pine-beetle/mountain_pine_beetle_action_plan_progressreport_2008.pdf

NatureServe. 2018. NatureServe Explorer. http://www.natureserve.org/explorer/

Neely, D.A. 2002. A systematic and taxonomic reassessment of the mottled sculpin species complex, *Cottus bairdii* Girard (Teleostei: Cottidae). Ph.D. dissertation, Department of Biology, University of Alabama, Tuscaloosa.

Nelson, J.S., E.J. Crossman, H. Espinosa-Pérez, L.T. Findley, C.R. Gilbert, R.N. Lea, and J.D. Williams. 2004. Common and Scientific Names of Fishes from the United States, Canada, and Mexico. Sixth Edition. American Fisheries Society Special Publication 29.

Parmesan, C. and G. Yohe. 2003. A globally coherent fingerprint of climate change impacts across natural systems. Nature 421:37-42.

Patten, B.G. 1971. Spawning and fecundity of seven species of northwestern American species of *Cottus*. American Midland Naturalist 85:491-506.

Peden, A.E. and G.W. Hughes. 1984. Status of shorthead sculpin, *Cottus confusus*, in the Flathead River, British Columbia. Canadian Field-Naturalist 98:127-133.

Peden, A.E., G.H. Hughes, and W.E. Roberts. 1989. Morphologically distinct populations of the shorthead sculpin, *Cottus confusus*, and the mottled sculpin, *Cottus bairdi* (Pisces, Cottidae) near the western border of Canada and the United States. Canadian Journal of Zoology 67:2711-2720.

Peden, A.E. 2000. COSEWIC status report on the Columbia Mottled Sculpin *Cottus bairdi hubbsi*. Available at www.sararegistry.gc.ca

Pflug, D.E., and G.B. Pauley. 1984. Biology of smallmouth bass (*Micropterus dolomieui*) in Lake Sammamish, Washington. Northwest Science 58:118-130.

Ptolemy, R.A. 2009. Hydro-ecological characterization of key watersheds in the Similkameen-Boundary Region for the purposes of describing landscape units containing flow-sensitive streams. Unpublished manuscript, BC Ministry of the Environment, 17p.

Rae, R. 2005. The state of fish and fish habitat in the Okanagan and Similkameen Basins. Prepared for the Canadian Okanagan Basin Technical Working Group, Westbank, British Columbia.

R.L. & L. Environmental Services Ltd. 1994. Lower Columbia tributary fisheries assessment. Report prepared for Columbia Basin Fish and Wildlife Compensation Program, Fisheries Technical committee. RL&L Report No. 430F: 85 p + 5 app.

R.L.&L. Environmental Services Ltd. 1995. Shallow-water habitat use by dace spp. and sculpin spp. In the lower Columbia River Basin Development Area. Report prepared for BC Hydro, Environmental Resources Division, Vancouver, British Columbia.

Rodenhuis, D.R., K.E. Bennett, A.T. Werner, T.Q. Murdock, and D. Bronaugh. 2007. Hydro-climatology and future climate impacts in British Columbia. Pacific Climate Consortium, University of Victoria, 132 pp.

Sala, O. E., F.S. Chapin III, J.J. Armesto, E. Berlow, J. Bloomfield, R. Dirzo, E. Huber-Sanwald, L.F. Huenneke, R.B. Jackson, A. Kinzig, R. Leemans, D.M. Lodge, H.A. Mooney, M. Oesterheld, N.L. Poff, M.T. Sykes, B.H. Walker, M. Walker, and D.H. Wall. 2000. Global biodiversity scenarios for the year 2100. Science 287:1770-1774.

Salafsky, N.D., A.J. Salzer, C. Stattersfield, R. Hilton-Taylor, S.H.M. Neugarten, E. Butchart, N. Collen, L.L. Cox, S. Master, D. O'Connor, and D. Wilkie. 2008. A standard lexicon for biodiversity conservation: Unified classifications of threats and actions. Conservation biology 22:897-911.

Savage, T. 1963. Reproductive behavior of the mottled sculpin, *Cottus bairdi* Girard. Copeia 1963:317-325.

Simpson, J.C., and R.L. Wallace, 1978. Fishes of Idaho. Univ. of Idaho Press, Moscow, Idaho.

Strauss, R.E. 1986. Natural hybrids of the freshwater sculpins *Cottus bairdi* and *Cottus cognatus* (Pisces: Cottidae): electrophoretic and morphometric Evidence. American Midland Naturalist. 115(1):87-105.

Summers, J. and K. Daily. 2001. Willamette river bass diet study-spring 2000. Information report number 2001-04, Oregon Department of Fish and Wildlife, Portland, Oregon.

Summit Environmental Consultants Inc. 2012. Kettle River watershed management plan: phase 1 technical assessment. 206 pp.

Thomas, A. 1973. Spawning migration and intergravel movement of the torrent sculpin, *Cottus rhotheus*. Transactions of the American Fisheries Society 102:620-622.

Wang, T., A. Hamann, D. Spittlehouse, and S.N. Aitken. 2006. Development of scale-free climate data for western Canada for use in resource management. International Journal of Climatology, 26(3):383-397.

Whang, A., and J. Jannsen. 1994. Sound production through the substrate during reproduction in the mottled sculpin, *Cottus bairdii* (Cottidae). Environmental Biology of Fishes 40:141-148.

Woodling, J., S. Brinkman, and S. Albeke. 2002. Acute and chronic toxicity of zinc to the Mottled Sculpin *Cottus bairdii*. Environmental Toxicology and Chemistry 21:1922–1926.

Wydoski, R.S., and R.R. Whitney. 2003. Inland Fishes of Washington. American Fisheries Society, Bethesda, Maryland, and University of Washington Press, Seattle, Washington.

Yokoyama, R., V.G. Sideleva, S.V. Shedko, and A. Goto. 2008. Broad-scale phylgeography of the Palearctic freshwater fish *Cottus poecileopus* complex (Pisces: Cottidae). Molecular Phylogenetics and Evolution 48:1244-1251.

Zimmerman, E.G., and M.C. Wooten. 1981. Allozymic variation and natural hybridization in sculpins, *Cottus confusus* and *Cottus cognatus*. Bioch. Systematic Ecology 9:341-346.

BIOGRAPHICAL SUMMARY OF REPORT WRITER(S)

Jacob (Jake) Schweigert received his B.Sc. (Honours) from the University of Toronto in 1974 and his M.Sc. (Zoology) from the University of Manitoba in 1976. Jake is Scientist Emeritus with Fisheries and Oceans Canada at the Pacific Biological Station (PBS), Nanaimo, British Columbia. Prior to his retirement, Mr. Schweigert was employed as a scientist with DFO since 1981, most recently as Section Head for Conservation Biology at PBS. Jake spent most of his career conducting research and stock assessment of Pacific herring and other forage species. He has authored or co-authored more than 40 publications in peer-reviewed scientific journals and over 70 other publications including the COSEWIC status reports for Pacific Sardine, Interior Fraser River Coho Salmon, Sakinaw Lake Sockeye Salmon, and Westslope Cutthroat Trout.

COLLECTIONS EXAMINED

The specimens examined for this report are housed in the Beatty BiodiversityMuseum at the University of British Columbia in Vancouver (http://beatymuseum.ubc.ca/research-2/collections/fish-collection/) and the Fish Collection of the Royal BC Museum in Victoria (http://search-collections.royalbcmuseum.bc.ca/) and the British Columbia Ministry of Environment Fish Inventory Summary System (http://www.env.gov.bc.ca/fish/survey_data/index.html).

Appendix 1. Threat Calculator results for Columbia Sculpin.

Species or Ecosystem Scientific Name	*Cottus hubbsi* Columbia Sculpin		
	18/12/2018		
Assessor(s):	Dwayne Lepitzki (Facilitator), John Post (Co-chair), Jake Schweigert (Status report writer), Sue Pollard (SSC member), Doug Watkinson (SSC member), Eric Taylor (External expert), Greg Wilson (BC), Lea Gelling (External expert), Jenny Wu (Secretariat)		
References:			
Overall Threat Impact Calculation Help:		**Level 1 Threat Impact Counts**	
	Threat Impact	**high range**	**low range**
	A Very High	0	0
	B High	0	0
	C Medium	4	1
	D Low	0	3
	Calculated Overall Threat Impact:	High	High
Assigned Overall Threat Impact:	**C = Medium**		
Impact Adjustment Reasons:	The committee assessed the overall impact as Medium rather than High because the majority of the Level 1 Threats overlap spatially and all are assessed individually as either Medium-Low or Medium. A Medium Overall Threat Impact implies a projected 3-30% population decline over the next 10 years, which was assessed as most plausible.		
Overall Threat Comments	Generation time = 3 years therefore timeframe for severity and timing also is 10 years. Found in Columbia R downstream to US border from near Castlegar; Slocan and Kootenay rivers before flowing into Columbia; Kettle River below Cascade Falls; and Similkameen River (Figures 4&5). No subpopulation estimates (rough estimates in previous COSEWIC report provided but not re-used) to help score scope but do have lengths of rivers/streams as well as IAO calculations that might help. Columbia mainstem 11-16%; Kootenay/Slocan 22-26% (of which ~2.6% in Koch Creek); Bonnington <1%; Kettle 1-2%; Similkameen 60-62% (of which Tulameen 5%). Subpopulation in Columbia River and its tributaries in Canada appears stable but is not being monitored; distribution in tributaries of the Similkameen River declined since 1950s		

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1	Residential & commercial development						
1.1	Housing & urban areas						
1.2	Commercial & industrial areas						
1.3	Tourism & recreation areas						
2	Agriculture & aquaculture		Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)	
2.1	Annual & perennial non-timber crops						
2.2	Wood & pulp plantations						
2.3	Livestock farming & ranching		Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)	Some livestock farming in the Similkameen but scope of the threat expected to be at the lower end of the range

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
2.4	Marine & freshwater aquaculture						
3	Energy production & mining						
3.1	Oil & gas drilling						
3.2	Mining & quarrying						Siltation and pollution from mining is reported under 9.2; gravel extraction or other physical impacts from re-opening or expanding existing mines would be reported here as would the planned diversion of Wolfe Creek.
3.3	Renewable energy						
4	Transportation & service corridors						
4.1	Roads & railroads						
4.2	Utility & service lines						
4.3	Shipping lanes						
4.4	Flight paths						
5	Biological resource use		Negligible	Large (31-70%)	Negligible (<1%)	High (Continuing)	
5.1	Hunting & collecting terrestrial animals						
5.2	Gathering terrestrial plants						
5.3	Logging & wood harvesting						
5.4	Fishing & harvesting aquatic resources		Negligible	Large (31-70%)	Negligible (<1%)	High (Continuing)	Some scientific collections by BC Hydro and other consulting firms supporting monitoring under the management plan
6	Human intrusions & disturbance						
6.1	Recreational activities						
6.2	War, civil unrest & military exercises						
6.3	Work & other activities						Any non-lethal research sampling would be reported here
7	Natural system modifications	C	Medium	Pervasive (71-100%)	Moderate (11-30%)	High (Continuing)	
7.1	Fire & fire suppression		Negligible	Large (31-70%)	Negligible (<1%)	High - Moderate	Refers to water pumped into holding tanks for helicopter access for fire suppression

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
7.2	Dams & water management/use	C	Medium	Pervasive (71-100%)	Moderate (11-30%)	High (Continuing)	Considerable uncertainty around effects of dams and water withdrawal on sculpins. Need for documented impacts. Considerable discussion on whether the severity should be moderate or range from moderate to slight
7.3	Other ecosystem modifications	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High - Moderate	Refers to the effects of fire on habitat including removal of riparian vegetation and resultant siltation. It was noted that rip-rapping is being conducted in some areas but this was not scored
8	Invasive & other problematic species & genes	CD	Medium - Low	Restricted (11-30%)	Moderate - Slight (1-30%)	High (Continuing)	
8.1	Invasive non-native/alien species	CD	Medium - Low	Restricted (11-30%)	Moderate - Slight (1-30%)	High (Continuing)	Northern Pike and Walleye are established in the Castlegar area and some suppression of Pike is being conducted. Clearer confirmation of the species and extent and impact of the invasions is required
8.2	Problematic native species						Didymo invasion may be an issue but the extent and location of occurrence are unknown
8.3	Introduced genetic material						
9	Pollution	CD	Medium - Low	Large (31-70%)	Moderate - Slight (1-30%)	High (Continuing)	
9.1	Household sewage & urban waste water	CD	Medium - Low	Large (31-70%)	Moderate - Slight (1-30%)	High (Continuing)	Sewage treatment, salts, chemicals, siltation from roads. Effects are uncertain, follow-up with local staff required
9.2	Industrial & military effluents	CD	Medium - Low	Large (31-70%)	Moderate - Slight (1-30%)	High (Continuing)	Refers to smelter & pulp mill effluents, chemical spills from pipes, railroads, trucking. Effects are uncertain, follow-up with local staff required
9.3	Agricultural & forestry effluents	CD	Medium - Low	Large (31-70%)	Moderate - Slight (1-30%)	High (Continuing)	Refers to siltation, nutrients, manure runoff associated with farming practices.
9.4	Garbage & solid waste						
9.5	Air-borne pollutants						
9.6	Excess energy						
10	Geological events						
10.1	Volcanoes						
10.2	Earthquakes/tsunamis						
10.3	Avalanches/landslides						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
11	Climate change & severe weather	CD	Medium - Low	Large (31-70%)	Moderate - Slight (1-30%)	High (Continuing)	
11.1	Habitat shifting & alteration						
11.2	Droughts	CD	Medium - Low	Large (31-70%)	Moderate - Slight (1-30%)	High (Continuing)	Warming climate expected to exacerbate water shortages and impact bulk of the population but severity of the impact is uncertain
11.3	Temperature extremes	CD	Medium - Low	Large (31-70%)	Moderate - Slight (1-30%)	High (Continuing)	Recent temperature extremes in some systems expected to continue affecting most populations, severity of the impact on each population is uncertain
11.4	Storms & flooding						
Classification of Threats adopted from IUCN-CMP, Salafsky *et al.* (2008).							