COSEWIC
Assessment and Status Report

on the

Salish Sucker
Catostomus sp. cf. *catostomus*

in Canada

THREATENED
2012

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

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

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Previous report(s):

COSEWIC. 2002. COSEWIC assessment and update status report on the Salish Sucker *Catostomus* sp in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 27 pp.

McPhail, J.D. 1986. COSEWIC status report on the Salish Sucker *Catostomus* sp. in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 29 pp.

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Salish Sucker — Photo by ©Mike Pearson.

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COSEWIC
Assessment Summary

Assessment Summary – November 2012

Common name
Salish Sucker

Scientific name
Catostomus sp. cf. *catostomus*

Status
Threatened

Reason for designation
This small fish has a restricted and fragmented range in southwestern British Columbia where it is susceptible to a continuing decline in habitat quality. An improvement in status from Endangered stems from a small increase in the number of known locations (from 9 to 14), including one location thought to have been extirpated, and some improvements in quality of habitat in areas subject to restoration.

Occurrence
British Columbia

Status history
Designated Endangered in April 1986. Status re–examined and confirmed in November 2002. Status re–examined and designated Threatened in November 2012.

COSEWIC
Executive Summary

Salish Sucker
Catostomus sp. cf. *catostomus*

Wildlife Species Description and Significance

The Salish Sucker comprises a genetically and morphologically distinct group of populations within the Longnose Sucker (*Catostomus catostomus*) complex. It is small-bodied (to 287 mm in Canada), dark green mottled with black above, and dirty white below. Males display a broad red, lateral stripe during the spawning season. Scales are small, as is the mouth, which is located on the lower surface of the head. The Salish Sucker is a member of the 'Chehalis fauna', a unique fish community that survived continental glaciation in an ice-free refuge in Washington State. It may represent a 'species in the making' and is of considerable scientific interest in the study of evolution and the history and causes of animal distributions.

Distribution

The Longnose Sucker occurs across Canada and the northern United States and even into far eastern Siberia. The Salish Sucker is restricted to southwestern British Columbia (BC) and northwestern Washington State. Within BC, it is known from 11 watersheds, all in the lower Fraser River Valley. Historical changes in the Canadian range are poorly documented, but declines in distribution and abundance over the past century have likely occurred.

Habitat

Salish Suckers are found in a few lakes in Washington State, but all known Canadian populations occupy lowland streams and sloughs. Here, they are most abundant in deep pools within headwater marshes and beaver ponds. Spawning occurs in gravel riffles. Juveniles are usually found in shallower water during their first year. Over the past century, large-scale landscape changes have destroyed and fragmented habitat across the Canadian range. In the past decade, habitat creation and restoration projects have added small areas of habitat to several watersheds, and monitoring has shown that Salish Suckers are using them.

Biology

Salish Suckers are short lived (to 5 years) and typically spawn between early April and early July. They do not construct a nest, but broadcast adhesive eggs which stick to gravel and rocks. They likely spawn in more than one year and females may spawn more than once in a single year. Adults feed on aquatic insects, but the diet of first-year juveniles is unknown. Adults move most around dawn and dusk, but are active all night. During the day they rest in heavy cover, often among thick vegetation adjacent to the open channel. They tend to return to the same resting location on successive days. Salish Suckers are active at temperatures as low as 7^{o}C and are commonly found in water exceeding 20^{o}C. They are relatively tolerant of low dissolved oxygen levels. Within watersheds populations are highly clumped, with a small proportion of habitat supporting the great majority of individuals. Beaver dams, and probably other shallow-water areas, are significant barriers to movement, although fish will cross these areas to access spawning sites. Adults are preyed upon by Mink and River Otters. Juveniles are probably eaten by a variety of fishes and birds.

Population Sizes and Trends

Adult population sizes range from the low hundreds to the low thousands in each of the six watersheds for which estimates are available, but numbers are unknown for other areas. Numbers are believed to be at or below levels required for long-term persistence. There is insufficient information to assess trends or fluctuations for any of the populations, but trend data for a few areas in one creek show large fluctuations that appear to be related to severe changes in dissolved oxygen levels.

Threats and Limiting Factors

Severe Hypoxia (low dissolved oxygen concentration) is considered a major threat to Salish Sucker in most occupied watersheds. Several interacting factors contribute to it, including elevated nutrient levels in ground and surface waters, and lack of shade from riparian vegetation to inhibit in-stream plant growth. Habitats that lack significant water movement in summer due to low flows or ponding are especially vulnerable. Physical destruction of habitat has likely been the most serious threat to Salish Sucker populations historically, and channelization, dredging and infilling of habitat continues to occur regularly. Habitat fragmentation by flood gates, beaver dams, low oxygen and other factors, commonly prevent movement between habitats. Most barriers date from the past 50 to 130 years, and known populations have persisted, although the effects of habitat fragmentation may occur over longer time frames. Toxic compounds enter occupied habitats from urban storm runoff, contaminated groundwater, direct industrial discharges, and accidental spills in some watersheds. Sediment deposition originates from direct discharges, storm drain runoff, gravel mines with inadequate sediment control, and from bank erosion, which is accelerated by lack of riparian vegetation and high peak flows. Introduced predators are found in all watersheds occupied by Salish Sucker.

Protection, Status, and Ranks

The Salish Sucker is listed as Endangered under the federal *Species at Risk Act.* Critical habitat has been included in a proposed Recovery Strategy, which was finalized in June 2012. The British Columbia *Wildlife Act* prohibits the capture, transport and possession of Salish Suckers without a license. The Salish Sucker is considered critically imperiled by NatureServe, is on British Columbia’s Red List and is considered a ‘Highest Priority’ species under the Province’s Conservation Framework. The American Fisheries Society lists it as Endangered. The great majority of Salish Sucker habitat occurs in waterways flowing through private land.

TECHNICAL SUMMARY

Catostomus sp. cf. *catostomus*
Salish Sucker — Meunier de Salish
Range of occurrence in Canada : Southwestern British Columbia

Demographic Information

Generation time	3 yrs
Is there a continuing decline in number of mature individuals?	Unknown
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Unknown
Estimated percent change in total number of mature individuals over the last 3 generations.	Unknown
Estimated percent change in total number of mature individuals over the next [10 years, or 3 generations].	Unknown
Estimated percent reduction in total number of mature individuals over any 3 generations, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible and understood and ceased? They are reversible and understood, but have not ceased.	No
Are there extreme fluctuations in number of mature individuals? Extreme fluctuations at the watershed/subwatershed scale are believed to occur, but not at the scale of the entire Canadian range. Life history analysis suggests high potential for rapid population growth (Pearson and Healey 2003). Availability of adequate oxygen in occupied habitats is known to fluctuate predictably depending on summer flows and temperatures (Pearson 2004a and unpubl data). This combination meets IUCN criteria for extreme fluctuations without direct observation (IUCN Standards and Petitions Subcommittee 2010).	Possibly

Extent and Occupancy Information

Estimated extent of occurrence Calculated from GIS adaptation of maps from McPhail and Taylor (1999) and U.S. location information supplied by Molly Hallock; Marine habitats excluded from area	1,709 km²
Index of area of occupancy (IAO) (2x2 km grid value). AO (area of deep pool habitat within Canada)	260 km² 0.95 km^2
Is the total population severely fragmented? Unable to assess quantitatively with respect to IUCN criteria	Probably not
Number of locations∗ One location per watershed except Bertrand Creek (2) Salmon River (2), and Salwein Creek/Hopedale Slough (2)	14
Is there an inferred continuing decline in extent of occurrence?	No
Is there an inferred continuing decline in index of area of occupancy?	Unknown
Is there an inferred continuing decline in number of populations?	No
Is there an observed continuing decline in number of locations*?	No
Is there an observed continuing decline in area and quality of habitat?	Yes
Are there extreme fluctuations in number of populations?	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 2010 for more information on this term.

Number of Mature Individuals (in each population)

Population (Source)	N Mature Individuals
Salmon River (headwater subpopulation only, Pearson 2004a)	1,390
Bertrand Creek (Pearson 2004a + unpublished data 2008)	2,620
Pepin Creek (Pearson 2004a)	2,860
Fishtrap Creek (Pearson 2004a)	490
Salwein Creek (excluding Hopedale Slough; Pearson 2004a)	1,290
Miami Creek (Pearson 2004a)	850
Chilliwack Delta	Unknown
Mountain Slough	Unknown
Agassiz Slough	Unknown
Elk Creek/Hope Slough	Unknown
Little Campbell River	Unknown
Total	> 9,648

Quantitative Analysis

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

Threats (actual or imminent, to populations or habitats)

Severe hypoxia
Physical destruction of habitat (dredging, channelization, infilling)
Habitat fragmentation
Toxic compounds from urban storm drains, pesticides, creosote preserved structures
Sediment deposition from bank erosion, gravel mining and/or urban and agricultural development.
Introduced predators

Rescue Effect (immigration from outside Canada)

Status of outside population(s)? Very small, but secure (at least in lakes)	
Is immigration known or possible?	Possible in three watersheds
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	No

Status History

COSEWIC: Designated Endangered in April 1986. Status re-examined and confirmed in November 2002. Status re-examined and designated Threatened in November 2012.

Status and Reasons for Designation

Status: Threatened	**Alpha-numeric code:** D2

Reasons for designation:
This small fish has a restricted and fragmented range in southwestern British Columbia where it is susceptible to a continuing decline in habitat quality. An improvement in status from Endangered stems from a small increase in the number of known locations (from 9 to 14), including one location thought to have been extirpated, and some improvements in quality of habitat in areas subject to restoration.

Applicability of Criteria

Criterion A: Not applicable. Unable to assess criteria as decline data unavailable.
Criterion B: Meets Endangered B1 and B2 as EO and IAO are below threshold (1,709 and 260 km^2, respectively). Meets sub-criterion b(iii) as habitat quality continues to decline, but neither a or c as locations are > 10, and total population probably not severely fragmented nor experiences severe fluctuations for any parameter over entire range.
Criterion C: Does not meet criteria as total population likely greater than 10,000.
Criterion D: Meets D2 Threatened as area of critical habitat < 2 km^2.
Criterion E: Not conducted (necessary data unavailable).

PREFACE

Since the last status report on Salish Sucker was published (COSEWIC 2002), four previously unknown populations have been discovered. Two are in the District of Kent (Mountain Slough and Agassiz Slough) and two are in the City of Chilliwack (Elk Creek/Hope Slough and Hopedale Slough). In addition, a population believed extirpated (Little Campbell River) was rediscovered in 2011 (Pearson unpub. data, 2011). New information on abundance, distribution and habitat use at the channel unit, reach and watershed scale has been published (Pearson 2004a,b, 2008) in addition to data on movement, growth, and other life history characteristics (Pearson and Healey, 2003). Threats have been more thoroughly described (Pearson 2004b) and a proposed Recovery Strategy has been completed (Recovery Team for Salish Sucker 2012), with critical habitat proposed for identification under the *Species at Risk Act*.

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
(2012)

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

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

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

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

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

Canada

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

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Phylum:	Chordata
Subphylum:	Vertebrata
Class:	Osteichthys
Order:	Cypriniformes
Family:	Catostomidae
Genus:	*Catostomus*
Species:	*Catostomus* sp. cf. *catostomus*
Common Name:	Salish Sucker, Meunier de Salish

The Salish Sucker was first described from Lake Cushman in Washington State (Schultz 1947), but uncertainty remains around its taxonomic status. It is clearly a form of Longnose Sucker (*C.* sp. cf. *catostomus*) that is distinguishable both genetically and morphologically from other 'western' and 'eastern' Longnose Sucker lineages found in Canada (McPhail and Taylor 1999). The Longnose and Salish Suckers have geographic ranges that do not overlap.

Morphological Description

The Salish Sucker is dark green, mottled with black dorsally, dirty white ventrally, and develops a broad red, lateral stripe during the spawning season (Figure 1). The stripe is particularly vivid in males, which also develop tubercles on the anal fin during the spawning season. Scales are small, as is the mouth which is located on the lower surface of the head (McPhail and Carveth 1994). Males are smaller than females as adults. Very few males exceed 200 mm in length (maximum 206 mm), and they may be sexually mature at slightly less than 100 mm. The largest female captured in Canada was 287 mm, although only 10 percent exceeded 200 mm (Pearson and Healey 2003). Although body size is widely variable among other *C.* sp. cf*. catostomus* sp. cf. *catostomus* populations, and dwarfism is common (Scott and Crossman 1973; McPhail 2007), Salish Sucker body size is smaller than any others reported (Pearson and Healey 2003). The sexes may be separated by the shape of the anal fin (Figure 2).

Figure 1. A male Salish Sucker (142 mm fork length, 37.2 g, May 20, 1999, Pepin Creek, BC, UTM 10U 541247 5430169).

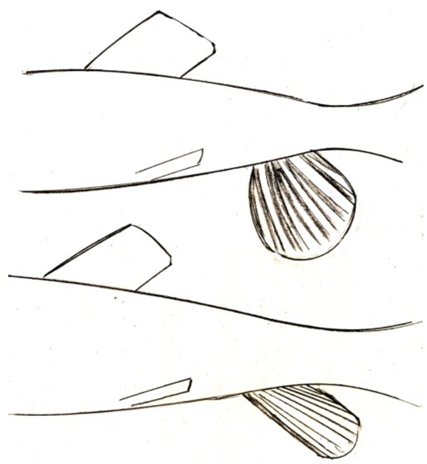


Figure 2. Male Salish Suckers (top) have a larger, fan shaped anal fin upon which abundant tubercles develop during the spawning season. Females (below) have a more rectilinear anal fin with a distinctly thickened anterior ray.

Salish Suckers are readily distinguished from Largescale Suckers (*C. macrocheilus*), with which they sometimes occur, by their smaller body size, more numerous scales and by fewer dorsal fin rays (Table 1). They are separable from other western Longnose Suckers by a shorter, blunter snout, smaller mouth and fewer scales along the lateral line (Table 1; see also McPhail and Taylor 1999).

Table 1. Morphological differences between Salish Sucker, other Western Longnose Suckers and Largescale Suckers (McPhail 1987, 2007; McPhail and Carveth 1994).

Character	Salish Sucker	Western Longnose Sucker	Largescale Sucker
Dorsal fin rays	9-11	9-11	13-16
Dorsal fin insertion (good character for young-of-the-year fish)	Length less than double depth of caudal peduncle	Length less than double depth of caudal peduncle	Length more than double depth of caudal peduncle
Lateral line scales	Usually 85-100	Usually >100	62-83
Mouth position	Snout barely overhangs mouth	Snout clearly overhangs mouth	Snout barely overhangs mouth
Mouth length	Equal to eye diameter	Greater than eye diameter	Greater than eye diameter

Population Spatial Structure and Variability

Available evidence suggests that before the Illinoian glaciation (200,000 years ago), *C.* sp. cf. *catostomus* was distributed across northern North America and into Siberia, as it is today. The range was fragmented by the Illinoian glaciation, at least partly reformed during the Sangamon interglacial period, and then re-fragmented during the most recent (Wisconsinan) glaciation (McPhail and Taylor 1999). The present distribution indicates that populations survived in four refugia during the Wisconsinan glaciation, the Bering, the Great Plains (Mississippi-Missouri system), the Pacific, and the Chehalis, in western Washington State, from which the Salish Sucker emerged (McPhail 2007). This complex history of fragmentation and isolation would be expected to produce geographically structured evolutionary divergences among populations and, indeed, some have been found. *Catostomus* sp. cf. *catostomus* is extremely variable in form and a number of subspecies have been recognized historically (Scott and Crossman 1973). McPhail (2007) reported that three morphological types of Longnose Sucker occur in British Columbia; a typical large-bodied form (sexual maturity at >300 mm), geographically scattered 'dwarf' populations, which may or may not be genetically distinct, and the genetically and morphologically distinctive Salish Sucker.

McPhail and Taylor (1999) sequenced PCR amplified mitochondrial DNA fragments of the cytochrome *b* gene (360 bp) and the NADH subunit 2 (ND2) gene (510 bp) from 45 Salish Suckers across eight localities from British Columbia and western Washington, and from 94 Longnose Suckers representing 24 localities from western Alaska to Québec. They showed that Salish Suckers are distinguished from other Longnose Suckers by a single unique haplotype at the cytochrome b gene, and by two at the ND2 gene. One of the ND2 haplotypes was unique to Pepin Creek (Nooksack system), while the other was found in the two Fraser River populations and four Washington State populations examined.

Salish Sucker populations and all other *C.* sp. cf. *catostomus* populations are apparently allopatric, although their ranges are in close proximity. The Columbia form of Longnose Sucker is found in the Fraser River upstream of Hope, BC, but has not been collected more than 2 km downstream of that town (McPhail and Taylor 1999), while Salish Suckers have not been collected upstream of Agassiz Slough (Pearson 2004a), locations separated by less than 35 km of unobstructed river. The two forms may or may not have been in contact during deglaciation, but there is no evidence of gene flow between Salish and western Longnose Suckers. It is unclear if this is due to physiological or behavioural barriers to reproduction between the groups, or simply to allopatry (McPhail and Taylor 1999).

Designatable Units

The Salish Sucker differs, and is diagnosable, from other western *C.* sp. cf. *catostomus* populations (McPhail 1987; McPhail and Taylor 1999), by adult body size (Pearson and Healey 2003), morphology, and molecular genetic characters (McPhail and Taylor 1999). It also appears to be separated from its nearest *C.* sp. cf. *catostomus* neighbour, the Columbia form, by a 35 km natural range disjunction in the eastern lower Fraser River Valley. Consequently, the Salish Sucker appears to be a unique element in the evolutionary history of the Longnose Sucker, has been recognized as an evolutionarily significant unit (McPhail and Taylor 1999), and warrants recognition as a designatable unit within *C. catostomus*, in accordance with the COSEWIC criteria for recognizing units below the species level (COSEWIC 2009).

Salish Suckers occupy three independent drainages within British Columbia, the lower Fraser River, the Nooksack River system, and the Little Campbell River. Dispersal between the Fraser and Nooksack drainages is possible via occasional high-water connections between headwaters (Pearson 2004a; see **Habitat Trends** below). Although there is some evidence of genetic distinction between these groups (different mtDNA haplotypes at the ND2 gene; McPhail and Taylor 1999), it is not sufficient to support distinguishing them as separate conservation units within Salish Suckers, in accordance with the COSEWIC guidelines for recognizing designatable units (COSEWIC 2009).

Special Significance

The Salish Sucker is a member of the ‘Chehalis fauna’, a unique fish community that survived continental glaciation in an ice-free refuge in Washington State (McPhail 1967). It is of considerable scientific interest in the study of zoogeography and evolution (McPhail and Carveth 1993; McPhail and Taylor 1999). The Suckers (Catostomidae) are a diverse family of fishes (at least 76 species), many of which are at risk. As a group they suffer from the perceptions that they are ‘trash’ fish, tolerant of poor habitat conditions and a predatory threat to eggs and juveniles of economically important species, although available data do not support these perceptions (Cooke *et al*. 2005).

DISTRIBUTION

Global Range

Catostomus catostomus is one of the most widely distributed freshwater fishes in North America, occurring from Labrador south to Maryland, west through Pennsylvania, northern Minnesota, northern Colorado and Washington State, and north to the Arctic Ocean and Alaska. It also occurs in several eastern Siberian drainages (Scott and Crossman 1973; McPhail 2007). The Salish Sucker is known from the lower Fraser River Valley in British Columbia and seven drainages in northwestern Washington State (Figure 3). Additional populations may occur in both countries.

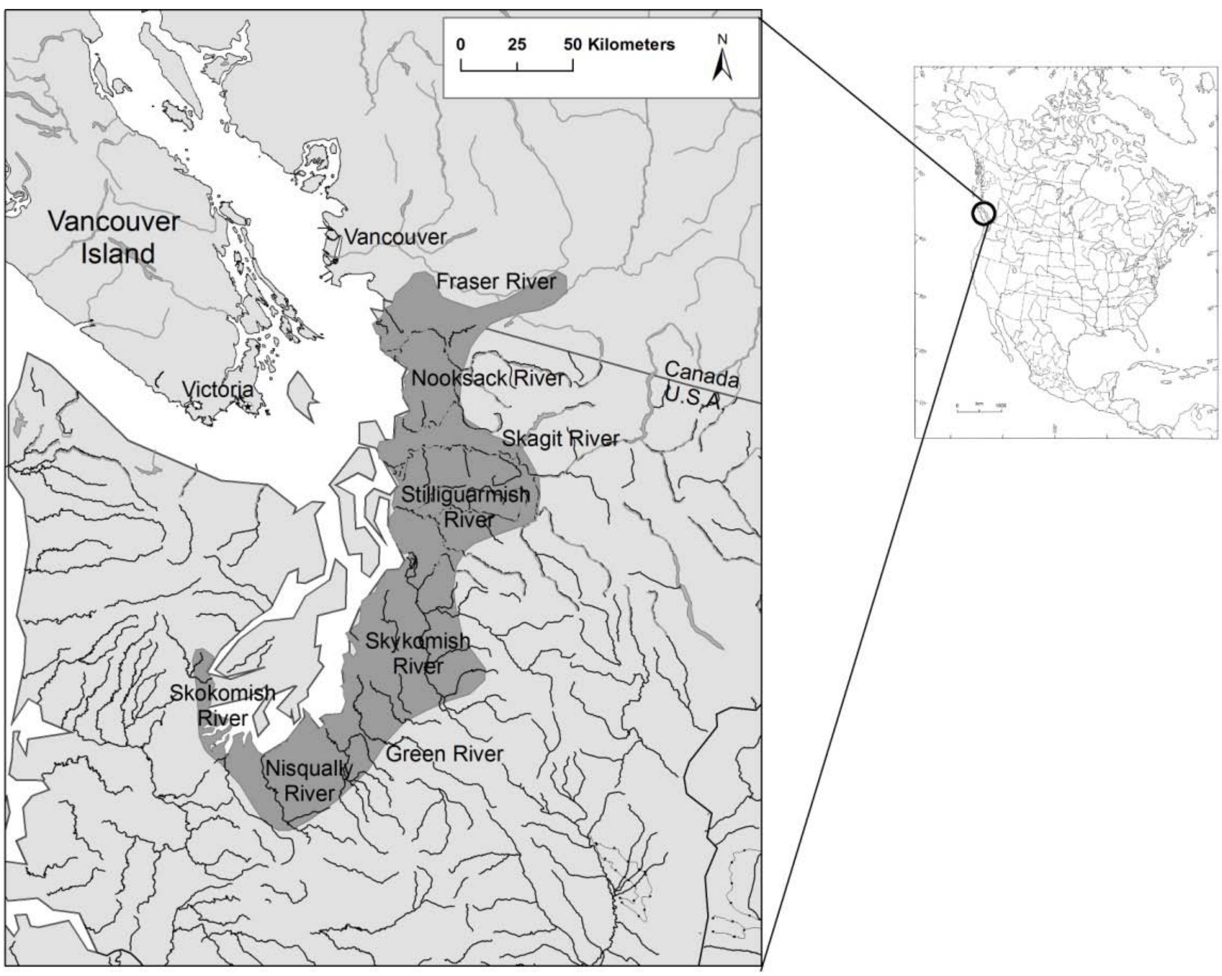


Figure 3. The global range of the Salish Sucker is restricted to northwestern Washington State and the lower Fraser River Valley in southwestern British Columbia (Adapted from McPhail 1987; McPhail and Taylor 1999; and Molly Hallock, Washington Dept. Fish and Game, unpubl. data).

Canadian Range

Within Canada, the Salish Sucker is known from 11 watersheds, all in the lower Fraser River Valley of British Columbia (Figures 4, 5, 6, and 7). The entire range is within the Coastal Western Hemlock Biogeoclimatic Zone. The current Canadian range of the Salish Sucker comprises about 9.3% (1,709 km^2) of the 18,459 km^2 global extent of occurrence. The total area of deep pool habitat (>70 cm depth) in proposed critical habitat (Pearson 2008) reaches within Canada was estimated at 0.95 km^2 across a total length of critical habitat of about 146 km, most of which flows through private land (Recovery Team for Salish Sucker 2012). The actual biological area of occupancy would be somewhat larger than this area of deep pool critical habitat because Salish Suckers use shallow pool habitats (<70 cm depth) as young-of-the-year and riffles for spawning, but it would be unlikely to be more than double (i.e., 1.9 km^2 total). The index of the area of occupancy estimated from an overlaid grid of cell size 2 km x 2 km grid is 260 km^2. For Salish Suckers, however, the use of IAO is considered to be a particularly unrealistic estimate of actual occupancy and threats to persistence given the very narrow (a few metres or less) widths of much of the stream habitats of this species, and given the fact that so much effort has been expended to map the area of critical habitat actually occupied. None of these occupancy values, however, include habitat in the Little Campbell River, where habitat surveys are pending.

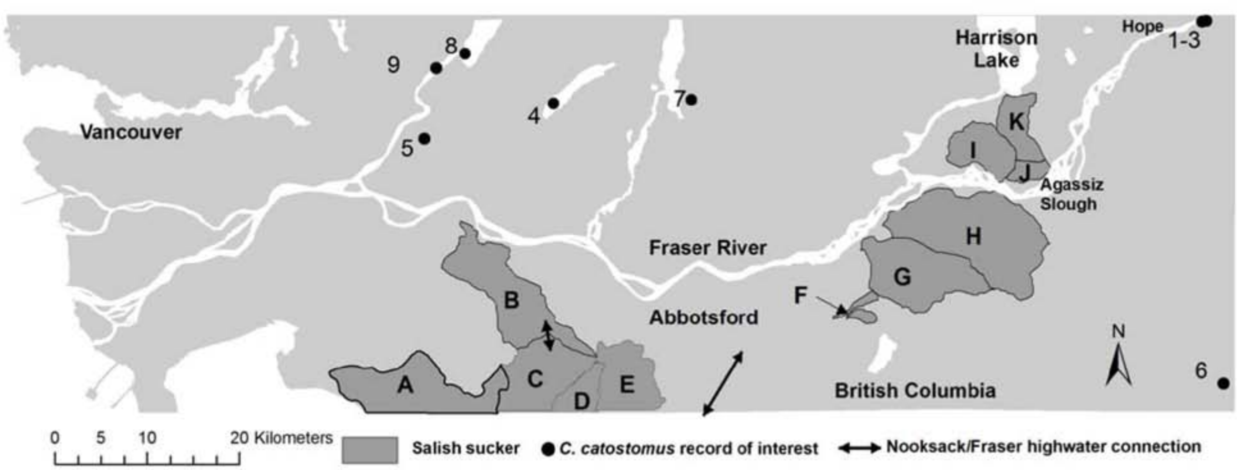


Figure 4. Salish Sucker populations are known from the Little Campbell River (A, believed extirpated), the Salmon River (B, 2009), Bertrand Creek (C, 2010), Pepin Creek (D, 2010), Fishtrap Creek (E, 1999), Salwein Creek and Hopedale Slough (F, 2008), the Chilliwack Delta streams (G, 2007), Elk Creek and Hope Slough (H, 2009), Mountain Slough (I, 2010), Agassiz Slough (J, 2011) and the Miami Creek (K, 2011). Years refer to the date of most recent capture (Appendix 1). Numbers refer to records of *C*. sp. cf. *catostomus* from other watersheds as detailed in Table 3.

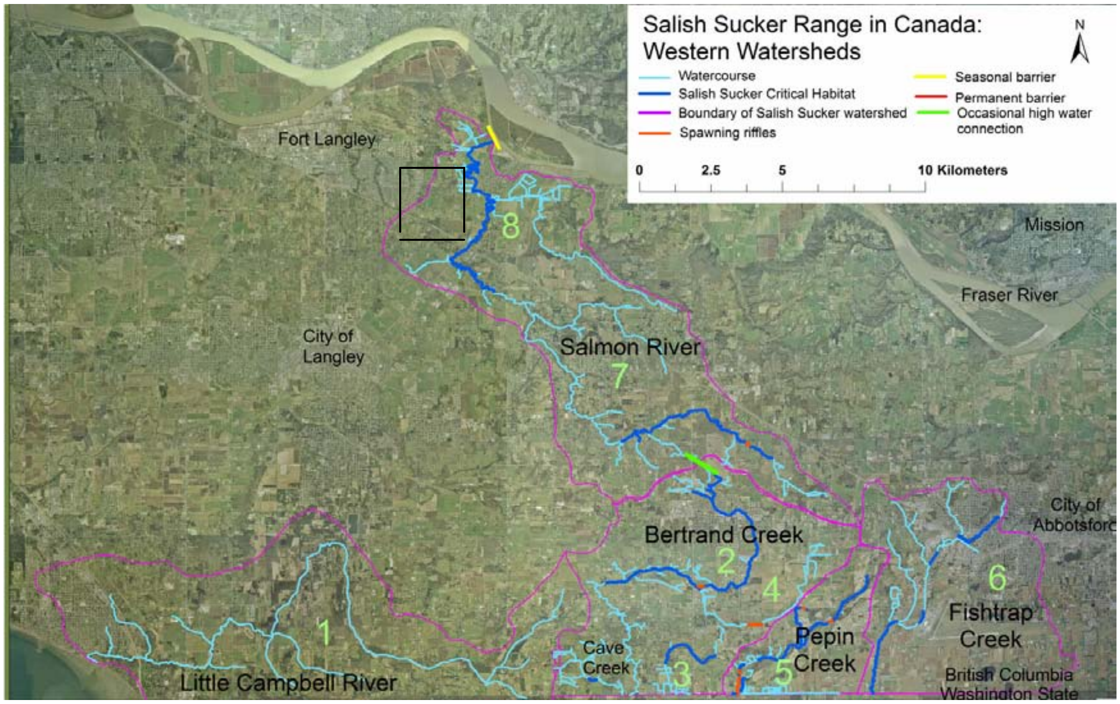


Figure 5. Western watersheds of the Salish Sucker range in Canada showing proposed critical habitat (Recovery Team for Salish Sucker 2012), spawning riffles, barriers and linkages between watersheds. Numbers refer to locations listed in Table 2.

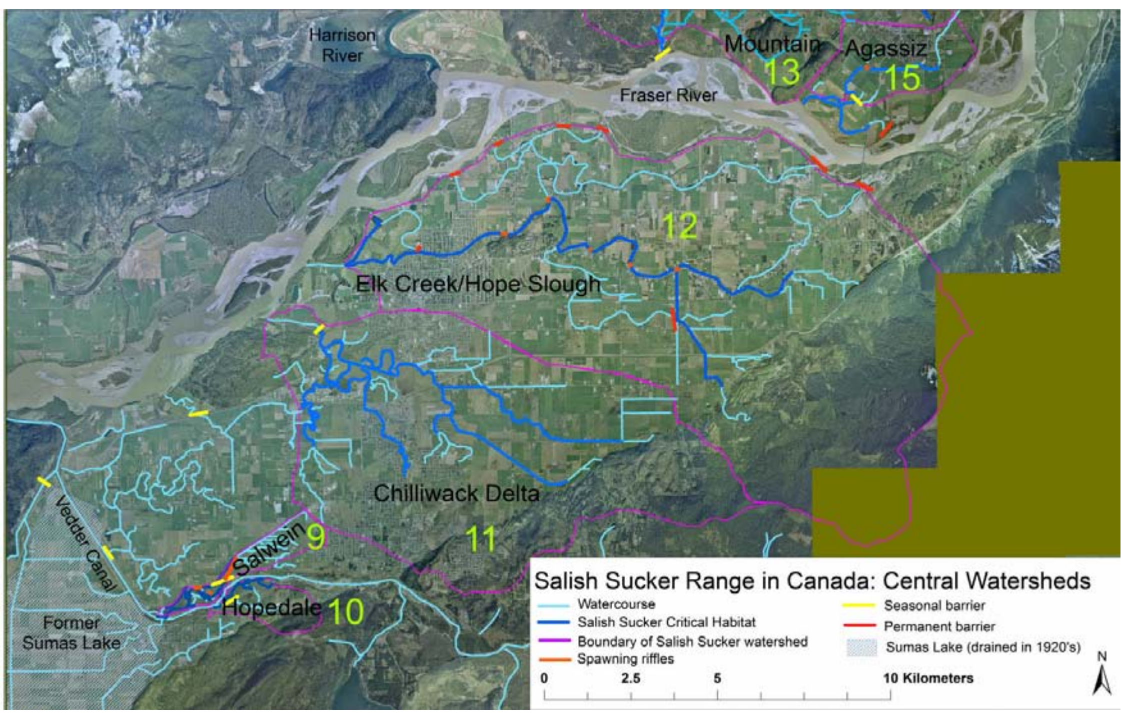


Figure 6. Central watersheds of the Salish Sucker range in Canada showing proposed critical habitat (Recovery Team for Salish Sucker 2012), spawning riffles, barriers and linkages between watersheds. Numbers refer to locations listed in Table 2.

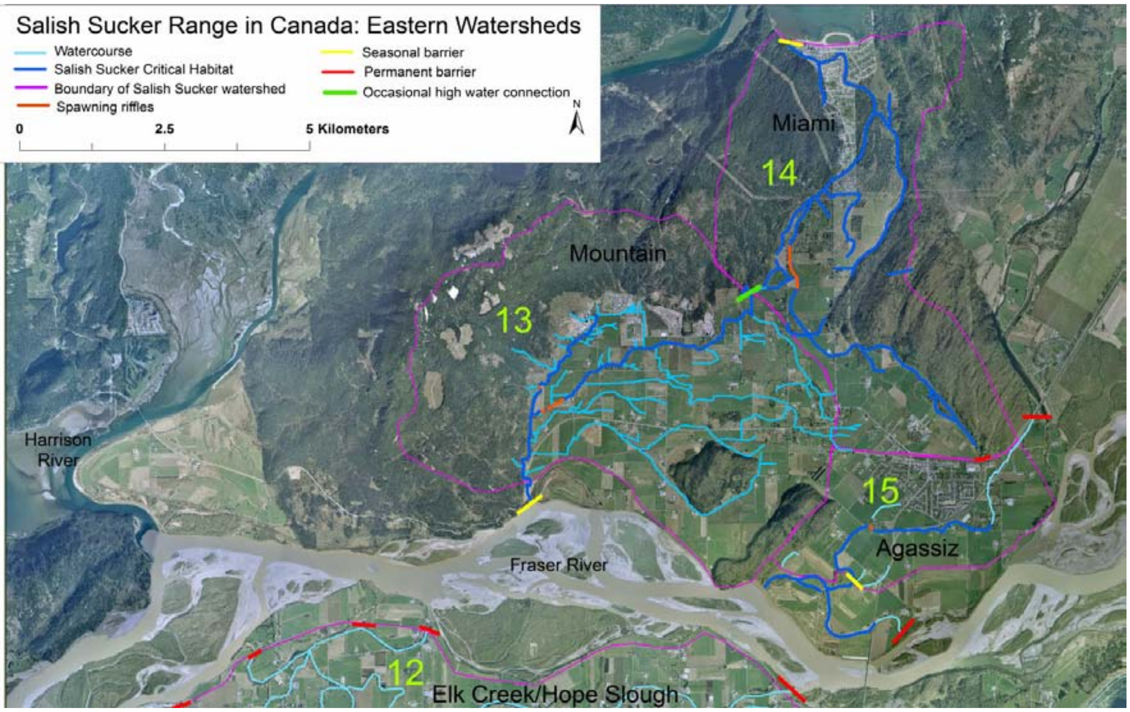


Figure 7. Eastern watersheds of the Salish Sucker range in Canada showing proposed critical habitat (Recovery Team for Salish Sucker 2012), spawning riffles, barriers and linkages between watersheds. Numbers refer to locations listed in Table 2.

Locations for Salish Suckers were defined in terms of the most significant threat to populations being localized hypoxia and related degraded water quality (see **Threats and Limiting Factors** section). The localized nature of these threats and the typically clumped distribution of Salish Suckers and their limited movements (< 1 km – see **Biology** below) suggested that each watershed constituted a single location except for Bertrand Creek (2 locations), Salwein Creek/Hopedale Slough (2), and the Salmon River (2) each of which contain one or more tributaries. The total number of locations was therefore estimated as 14 (Table 2).

Table 2. Population estimates for watersheds containing Salish Sucker in Canada. Estimates are sums of reach scale estimates calculated from catch-per-unit-effort (CPUE) data. CPUE was too low to allow estimation in six watersheds. Bracketed values indicate year of sampling. Some watersheds contain more than one location. Location numbers are shown on Figures 5-7.

Location Number	Population	Location	Population Estimate		
			Mean	**Minimum**	**Maximum**
1	Little Campbell	Little Campbell River	?	?	?
2	Bertrand Creek	Bertrand mainstem (2008)	2,620	1,380	6,050
3		Perry Homestead	?	?	?
4	Pepin Creek	Pepin Creek (2004)	3,008	1,990	9,200
5	Fishtrap Creek	Fishtrap Creek (1999)	490	210	1,370
6	Salmon River	Upper Salmon River (2000)	1,390	650	3,580
7		Lower Salmon River	?	?	?
8	Salwein/Hopedale	Salwein Creek (2002)	1,290	550	3,580
9		Hopedale Slough	?	?	?
10	Chilliwack Delta	Chilliwack Delta	?	?	?
11	Elk/Hope	Elk Creek/Hope Slough	?	?	?
12	Mountain Slough	Mountain Slough	?	?	?
13	Miami Creek	Miami Creek (2002)	850	350	2480
14	Agassiz Slough	Agassiz Slough	?	?	?
	Canada		>9,648	>5,130	>26,260

Historical changes in the Canadian range are poorly documented, but some decline over the past century has likely occurred. The presence of Salish Sucker in Salwein Creek and Hopedale Slough suggests that the species occurred in Sumas Lake (Figure 6), into which they flowed prior to its drainage in the early 1920s (Woods 2001). Its mix of marsh and open water would have provided excellent habitat. Anecdotal information also suggests the historical presence of Salish Suckers in a headwater wetland of Cave Creek (Bertrand Creek tributary) prior to its drainage in the 1960s (Pearson 1998). Drainage of such headwater wetlands was common as agricultural and urban development transformed the landscape. The population in the Little Campbell River was believed extirpated (McPhail 1987; Pearson 2004a), as were populations in Salwein Creek, Howe's Creek (a tributary of Bertrand Creek), and the lower Salmon River (Inglis *et al*. 1992), but their presence has since been reconfirmed in these areas (Pearson 2004a and unpublished data).

Search Effort

The Salish Sucker has been known in Canada since the 1950s. Most early work (to 1980s) was conducted by McPhail (1987). He documented populations in the Little Campbell River, the Nooksack River tributaries (Bertrand, Pepin and Fishtrap creeks), Semmihault Creek, and Salwein Creek (McPhail 1987). Considerable effort has been devoted to locating additional populations since then (Appendix 1). In 1992, 117 sites in 34 watersheds were sampled with minnow traps or electrofished for Salish Sucker, but no additional populations were found and no Salish Suckers were captured in Salwein Creek (Inglis *et al*. 1992).

Pearson sampled 429 sites in 45 watersheds in 2000 using large funnel traps (Pearson 2009). He found previously unknown populations in the Miami Creek, Agassiz Slough and Hopedale Slough, and confirmed the continued presence of Salish Suckers in Salwein Creek. Using this information he conducted intensive searches in watersheds adjacent to the newly discovered populations from 2001 through 2006, finding additional occurrences in Mountain Slough, Hope Slough/Elk Creek and several watercourses connected to Semmihault Creek within the former Chilliwack River delta. Given the frequency of discovery of previously unknown populations in relation to the effort expended since 2000, it seems likely that one or more Canadian populations remains undiscovered. Of particular interest is the Pitt Meadows area, as several independent reports of *C.* sp. cf. *catostomus* have been made in the lower Pitt River and the Alouette Rivers since the late 1970s (Table 3).

Table 3. Records of western Longnose Sucker, *Catostomus catostomus,* specimens from the lower Fraser River Valley from the UBC Fish Museum[1], and the British Columbia Fisheries Information Summary System (FISS)[2]. Site numbers correspond to those shown on Figure 4.

Site	Drainage	Location	Year	Long.	Lat.	Reference
1	Fraser	Fraser River pothole in floodplain 1.6 km west of Hope	1959	-121.45	49.38	UBC60-0197
1	Fraser	Fraser River 1.9 km west of Hope	1959	-121.45	49.38	UBC60-0189
2	Fraser	Kawkawa Lake, near Hope, off Wright's wharf	1951	-121.45	49.38	UBC 54-0271
3	Fraser	Hope Coquihalla River near mouth	1956	-121.45	49.38	UBC-59-0023
4	Fraser	Alouette Lake	1979			CLKS-1155, 03-AUG-1979
5	Fraser	Alouette River	1988			HQ2030, 01-FEB-1998
6	Fraser	Chilliwack Lake	1995			2FBSRY, 01-JAN-1995
7	Fraser	Davis Lake	1963			BCLKS-1226, 01-JAN-1963
8	Fraser	Pitt Lake	1991			HQ0435, 01-JUN-1991
9	Fraser	Lower Pitt River	1994			EW070, 01-JAN-1994

[1] http://www.beatymuseum.ubc.ca/collections/fish
[2] http://a100.gov.bc.ca/pub/fidq/main.do

The Little Campbell River population was believed extirpated for many years. The only known spawning site in the watershed was surveyed repeatedly in the years following the last recorded occurrence of Salish Sucker in 1976, and the watershed was sampled for Salish Suckers in 1983 (minnow traps; McPhail 1987) and in 1999 (larger traps; Pearson 2004a), but none were found. Unconfirmed reports of *C.* sp. cf. *catostomus* were made; however, in 1986 and 2004 (FISS 2011), and in 2011, three suckers were captured at two locations and positively identified as Salish Suckers (M. Pearson and E.B. Taylor, unpublished data).

HABITAT

Habitat Requirements

Although several lacustrine populations occur in Washington State, all known British Columbia populations occupy small lowland streams and sloughs. Within these systems Salish Suckers are most abundant in headwater reaches, particularly marshes and beaver ponds (McPhail 1987; Pearson 2004a).

Pearson (2004a) studied habitat use at the watershed, reach and channel unit scales across the Canadian range. Among the six watersheds in which he was able to estimate population size, mean density was highest (>450/km) in Pepin Creek, which also had the highest percentage of deep pool habitat, the lowest proportion of shallow pool habitat, and the highest proportion of forest cover within 200 m of the channel. Watersheds with high densities (>100 fish/km) contained less shallow pool and seasonally dry channel.

Pearson (2004) studied reach scale distributions in the Pepin, Fishtrap, Bertrand creeks and Salmon River watersheds. Presence and abundance appears to be largely controlled by the quantity of deep pool habitat, which in turn, was heavily influenced by beaver activity. Salish Sucker were found in reaches with wider channels, higher proportions of deep pool habitat, lower proportions of riffle habitat, and more abundant in-stream vegetation than in reaches where they were not captured. Logistic regression analyses showed that the percentage of reach length occupied by deep pool habitat was the most significant predictor of Salish Sucker presence. Presence of Salish Suckers was also positively associated with the occurrence of riffle habitat in a reach, but they were not found in reaches with high proportions of riffle habitat (Pearson 2004), which is consistent with their need for a small amount of riffle for spawning (McPhail 1987).

Radio-tracked adults (Pepin Creek, *n* = 18) occupied summer home ranges (95% of locations) varying from 42-307 linear metres of stream (Mean = 177 SEM = 24) and from 212 to 1,736 m^2 of area (Mean = 1,273 SEM = 107). Daytime resting positions were generally in heavy cover, often among thick emergent vegetation adjacent to the open channel. Fish tended to return to the same resting location on successive days (Pearson and Healey 2003).

Spawning occurs in gravel riffles at water velocities up to 50 cm/s (McPhail 1987). Young-of-the-year fish are usually found in shallow pools or glides (depth<40 cm), although they are occasionally found in deeper habitats, while larger juveniles (>70 mm) occupy similar habitats to adults (Pearson 2004a).

Habitat Trends

Over the past century, large-scale landscape changes have fragmented habitat across the Canadian range, likely reducing or eliminating migration between Salish Sucker populations and subpopulations and increasing the rates of reach or watershed-scale extirpations. Habitat fragmentation dates to at least 1875, with the diversion of the Chilliwack River through Vedder Creek, which isolated it from the delta of branching and reconnecting channels through which it had previously flowed into the Fraser River. This changed the hydrology and reduced connections between the former delta streams – presently Atchelitz, Luckakuck, Little Chilliwack and Semmihault creeks (Schaepe 2001), all of which currently support Salish Sucker populations (Figure 6). Perhaps the largest losses of habitat occurred with the drainage of Sumas Lake in the 1920s and the isolation of sloughs from the Fraser River by dykes. Dyke building began in the 1860s and was largely completed in the aftermath of the 1948 Fraser River flood (Boyle *et al*. 1997; Watt 2006). A number of historical dispersal routes were cut off completely or seasonally by this flood control infrastructure. The Hope Slough system connected to the Fraser River in several places across from the outlets of Agassiz and Mountain Slough. These were closed completely by dyke construction (Figure 6). The floodgates and/or pump houses at the outlets of Hope Slough, Mountain Slough, Agassiz Slough, the Miami Creek, the Chilliwack Delta, and the Salmon River impose seasonal barriers to movement (Figures 5, 6 and 7), primarily in late spring and early summer, during the Fraser River freshet. The swift-flowing, turbid Fraser River also poses a formidable barrier to dispersal between its tributaries, particularly in the upstream direction and especially during the spring and summer when its discharge is highest. Drainage and infilling of headwater wetlands has eliminated a likely historical dispersal route between the Little Campbell River and Bertrand Creek (Pearson 1998).

Dredging of habitat for flood control still occurs regularly within the range (Recovery Team for Salish Sucker 2012). Severe hypoxia limits summer productivity in large areas of physically suitable habitat (Pearson and Healey 2003). This is discussed further in the discussion of threats, below. Mapping of the extent and duration of hypoxia within critical habitat was initiated in 2011, and a University of British Columbia (UBC) graduate thesis on the relationships between hypoxia, Salish Sucker distribution and upstream land use is underway (J. Miners, Dept. of Zoology, University of British Columbia, unpubl. data).

Dispersal between Canadian populations likely occurs in three areas. A headwater marsh of Bertrand Creek that supports a high density of Salish Suckers connects to the upper Salmon River (Figure 5), which also contains a population, via a tributary under high water conditions (Pearson unpubl. data). Salish Suckers inhabit both Salwein Creek and Hopedale Slough, which enter the Vedder River across from one another, and have been considered a single population (Figure 6; Pearson 2004a). A headwater pond near the town of Agassiz has permanent, fish-accessible connections to both Mountain Slough and the Miami Creek (Figure 7; Pearson pers. obs.). Dispersal is also possible between Fishtrap Creek and its tributary, Pepin Creek, via Washington State, as it is from Fishtrap Creek to Bertrand Creek, as both are tributary to Washington's Nooksack River. In these cases, however, the Canadian populations are separated by long stretches of unsuitable habitat in Washington, reducing the likelihood of migration (McPhail 1987; Pearson 2004a)

In the past decade, habitat creation projects have added substantial areas of suitable habitat for Salish Sucker in the Pepin Creek (ca. 10,000 m^2) and Salwein Creek (ca. 5,000 m^2) watersheds. Enhancement projects in Bertrand Creek, Mountain Slough and the Salmon River have improved existing habitat by removing Reed Canary Grass (*Phalaris arundinacea*) overgrowth, expanding deep pool area and increasing habitat complexity through the addition of large woody debris. Moderate to high Salish Sucker densities (CPUE >1 fish/trap) have been documented in most of these areas (Pearson unpubl data.). Riparian plantings associated with these projects and in other areas have restored native trees and shrubs along several km of stream bank in Salish Sucker watersheds, which will likely provide further habitat benefits over the long term.

BIOLOGY

Most of the information in this section is gleaned from McPhail's original status report (1987) and a more recent doctoral thesis (Pearson 2004a), also published, in part, as Pearson and Healey (2003).

Life Cycle and Reproduction

The Salish Sucker is small-bodied, short-lived (to 5 years) and early maturing (2 years) relative to other Longnose Sucker populations (McPhail 1987; Pearson and Healey 2003). Generation time is estimated to be 3 years. Adults typically spawn between early April and early July (Pearson and Healey 2003). Reproduction is oviparous with fertilization occurring in the water. The fish do not construct a nest, but broadcast adhesive eggs which stick to gravel and rocks. Those on the surface are usually consumed, but many are swept under gravel and cobble where they are more protected (McPhail, pers. comm. 1998). Time required for egg hatching and fry emergence from the gravel is unknown and likely varies widely with water temperature given the breadth of the spawning season. Time to hatch in other Longnose Sucker populations varies from 11 days at 10^{o}C to 7 days at 16^{o}C and fry remain in the gravel for an additional one to two weeks (McPhail 2007). Fecundity is unknown, but in other small-bodied *C.* sp. cf. *catostomus* populations, females of 150 mm fork length contain about 3,000 eggs (McPhail 2007). Adults are believed to spawn in more than one year (McPhail 1987) and Pearson and Healey (2003) speculated that females may sometimes spawn more than once in a single year. This strategy, which increases effective fecundity in small-bodied fishes (Burt *et al.* 1988), would explain the very protracted (3.5 month) spawning period observed in Salish Suckers. Other Longnose Sucker populations typically spawn over a 2-3 week period. Known areas of spawning by Salish Suckers are extremely limited and consist of riffle areas (Figures 5-7).

Hybridization involving *C.* sp. cf. *catostomus* is rare, but does occur in British Columbia. It has not been documented with *C. macrocheilus*, the only catostomid that co-occurs with Salish Sucker in Canada (McPhail 2007).

Adults feed on benthic insects, primarily chironomid larvae, but the diet of young-of-the-year fish is unknown (McPhail 1987). Radio-telemetry work (April–September) has revealed adult movement is greatest around dawn and dusk, although activity continues throughout the night (Pearson and Healey 2003).

Physiology and Adaptability

The Salish Sucker possesses a suite of life-history characteristics associated with an ‘opportunistic life history strategy’ (Pearson and Healey 2003; Cooke *et al.* 2005), in which small body size, early maturation, and protracted spawning periods facilitate rapid population growth and recovery from short-term, limited-area disturbances (Winemiller and Rose 1992). These characteristics should allow populations to recover quickly in response to habitat creation/restoration efforts or following re-introductions, assuming that habitat conditions are adequate for all life history stages (Pearson and Healey 2003).

Salish Suckers are active at temperatures as low as 7^{o}C and are commonly found in water exceeding 20^{o}C (Pearson and Healey 2003), a wide range that is similarly documented in other *C. sp. cf. catostomus* populations (Scott and Crossman1973). Adults are regularly captured in waters containing less than 3 mg/l dissolved oxygen (DO) suggesting that they may be somewhat tolerant of mildly hypoxic conditions. By contrast, Salish Suckers are occasionally found dead in traps set in severely hypoxic water (<1 mg/l DO), which suggests that they venture into these environments temporarily to forage or that hypoxic areas are ephemeral/mobile (Pearson 2004a). Tolerance to pollutants remains unknown. Pearson (2004) found that Salish Suckers were less likely to occur in reaches bordered by urban land use, and speculated that this may be due, in part, to toxic materials originating from storm water outfalls.

Dispersal and Migration

Within watersheds, Salish Sucker populations are highly clumped, with a small proportion of stream habitat harbouring the great majority of individuals. The fish occur at much lower densities, or may be absent from reaches around and between these 'hotspots' (Pearson 2004a). The pattern is consistent with a metapopulation structure, in which groups of local sub-populations within a watershed are loosely linked by occasional migrants (Pearson and Healey 2003). 'Hotspots' may appear, disappear, or move through the watershed over time in response to patterns of disturbance and succession (Brown *et al*. 1995).

Beaver dams, and probably other shallow-water areas, are significant barriers to movement in both upstream and downstream directions – and may form sink habitats (see **Interspecific Interactions** section and Pearson 2004a). Pearson and Healey (2003) captured and radio-tagged 18 adults in a beaver pond in Pepin Brook and followed them for 27 to 153 days, locating fish a total of 730 times. Fish were found below the dam on only three occasions, although all used the pond regularly and many ventured hundreds of metres upstream of it. This is consistent with findings elsewhere on the impacts of dams on stream fish dispersal and colonization (Schlosser 1995; Schlosser and Kallemyn 2000). Some fish did cross the dam during the spawning period. Eight of 265 Salish Suckers marked in the beaver pond in October 1999 and two of 103 marked in March 2000 were recaptured in a fish fence on a recently reconstructed tributary 1,020 m downstream in the spring of 2000. Most were in reproductive condition when recaptured. Seven were subsequently recaptured at least once during a study on the tributary during the spring and summer – always in the largest, deepest pool available, a further 450-600 m upstream (Patton 2003). Additional mark-recapture studies are currently underway in five watersheds (Pearson unpubl. data).

Interspecific Interactions

The Salish Sucker's relationship with North American Beaver (*Castor canadensis*) is complex. Local abundances are highest in beaver-ponded reaches, presumably due to the stable presence of deep water and abundant cover. During late summer low-flow periods beaver ponds provide the only wetted habitat available in a number of occupied reaches (Pearson 2004a). Beaver ponds, however, tend to be chronically hypoxic (Snodgrass and Meffe 1998; Schlosser and Kallemyn 2000) and create significant barriers to movement of stream fishes (Schlosser 1998), including the Salish Sucker (Pearson and Healey, 2003). The combination of a physical barrier and critically low oxygen is likely to produce occasional, localized catastrophic mortality, as was observed in a Pepin Brook beaver pond in 2003 (Pearson 2004a).

Predation risk for adult Salish Suckers is probably quite low. Most avian predators would have little success in the deep, heavily vegetated habitats they favour, although piscivorous waterfowl likely take some. No coexisting predatory fish are large enough to consume them. Mink (*Mustela vison*) and River Otters (*Lontra canadensis*), are known to prey on Salish Suckers (Pearson, pers. obs.). Young-of-the-year Salish Suckers are probably taken by a variety of native and introduced fishes, including Coastal Cutthroat Trout (*Oncorhynchus clarkii clarkii*), Rainbow Trout (*Oncorhynchus mykiss*), Northern Pikeminnow (*Ptychocheilus oregonensis*), Largemouth Bass (*Micropterus salmoides*) and Brown Bullhead (*Ameiurus nebulosus*). Great Blue Herons (*Ardea herodias fannini*) and Belted Kingfishers (*Megaceryle alcyon*) likely also take some.

Salish Suckers have been found with 16 other fishes and amphibians (Table 4). Of the 12 species caught frequently enough to permit statistical analysis only Coho Salmon (*Oncorhynchus kisutch*) co-occurred with Salish Suckers more frequently than would be expected by chance. Salish Sucker presence was not negatively correlated with the occurrence of any of the species.

Table 4. Expected and observed frequencies of fish and amphibian species captured in the same reach as Salish Sucker. 'N' indicates that statistical analysis was not possible because not enough individuals were captured (from Pearson 2004a).

Common Name	Species	Obs.	Exp.	*p*
Native Species				
Coho Salmon	Oncorhynchus *kisutch*	42	35.6	0.029*
Coastal Cutthroat Trout	*Oncorhynchus clarkii clarkii*	29	27.9	0.841
Steelhead/Rainbow Trout	*Oncorhynchus mykiss*	12	12.6	0.98
Nooksack Dace	*Rhinichthys cataractae*	9	10	0.788
Northern Pikeminnow	*Ptychocheilus oregonensis*	5	4.5	N
Redside Shiner	*Richardsonius balteatus*	3	1.7	N
Largescale Sucker	*Catostomus macrocheilus*	2	1.7	N
Prickly Sculpin	*Cottus asper*	1	4.5	N
Threespine Stickleback	*Gasterosteus aculeatus*	52	47.1	0.16
Lamprey	*Lampetra* spp.	11	7	0.076

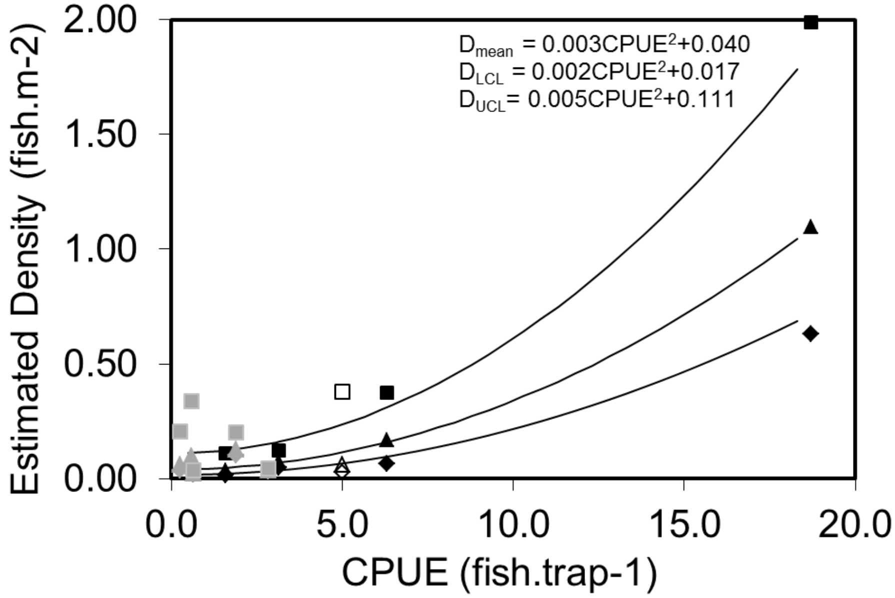
Common Name	Species	Obs.	Exp.	*p*
Northwestern Salamander	*Ambystoma gracile*	8	7	0.793
Introduced Species				
Brown Bullhead	*Ameiurus nebulosus*	3	3.5	N
Pumpkinseed	*Lepomis gibbosus*	2	5.2	0.118
Largemouth Bass	*Micropterus salmoides*	6	3.5	N
Fathead Minnow	*Pimephales promelas*	1	1.7	N
Bullfrog tadpoles	*Rana catesbeiana*	12	10.5	0.659

Salish Suckers from Pepin Creek and the Salmon River are commonly infected by a trematode *Uvulifer* sp. (causes 'blackspot') and *Myxobolus* sp. (Johal 2001). Low level *Uvulife*r infections are common across the range (Pearson, pers. obs.).

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Pearson (2004a) estimated adult population size in six watersheds by summing reach scale population estimates in each watershed (Table 2). Reach estimates were made using an equation relating CPUE (catch per unit effort) to population density estimated from mark-recapture studies at four sites in three streams. Each site was trapped one to four times over periods of five to 37 days following initial marking sessions. Mean population sizes with confidence limits were calculated using Schnabel or Petersen methods (Krebs 1999) and site density was estimated by dividing by the area trapped. Areas for these calculations were bounded at the closer of 85 m from the terminal trap location (50% mean Salish Sucker home range size) or at beaver dams (which Salish Suckers rarely cross; Pearson and Healey 2003). Catch per unit effort (mean number of fish per trap) was calculated for each site and plotted against estimated fish density. Equations relating site density to CPUE were fitted as squared functions by regression (Figure 8) and used to estimate densities for each reach of the watershed. Data from another site collected by another researcher fit the equations well. Reach population estimates were obtained by multiplying density estimates by the area of deep pool habitat (>70 cm depth).



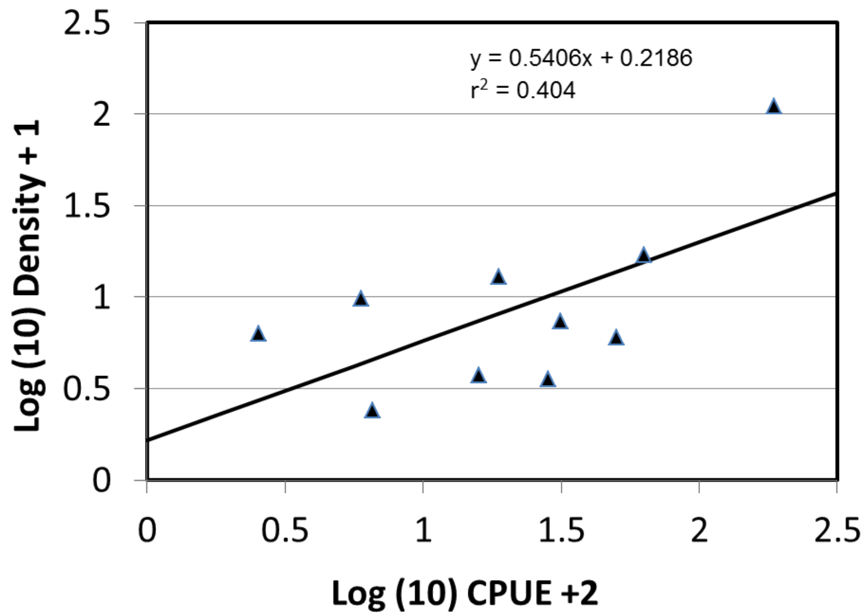


Figure 8. Relationship of Salish Sucker density to catch per unit effort (CPUE) calculated by Pearson (2004a; top panel). Equations are based on mean, lower confidence limit and upper confidence limits of four density estimates. Unfilled points are independent values obtained from a separate reach by another investigator (Patton 2003) using similar methods and grey points are from additional mark-recapture studies in 2011 (Miners and Pearson unpub. data). Triangles indicate the density estimate, diamonds show the lower 95% confidence limit and squares denote the 95% upper confidence limit. Log transformations of both axes (bottom panel) show that only about 40% of variation in density is captured by variation in CPUE.

One of the reach estimates from Pearson (2004a) had an extraordinarily high population density and CPUE (18.7 fish/trap) that had a large effect on the equations developed from so few points (n = 4, Figure 8). An additional five mark-recapture studies were completed in 2011 to refine the method (J. Miners and M. Pearson unpub. data). None had a CPUE above 3 fish per trap. Linear regression of log transformed variables shows that only 40 percent of the variation in density is explainable by variation in CPUE, which severely limits the precision of watershed scale abundance estimates (Figure 8). This may be due to habitat differences among sites or to spatial clumping of fish within sites at lower densities. This is supported by the observation that most of the suckers captured at sites are typically found in a small fraction of the traps set (Pearson pers. obs.). More robust population estimates will require mark-recapture work at the watershed scale. This is underway in five watersheds as part of a graduate thesis project at UBC (J. Miners, Dept. of Zoology, University of British Columbia, unpubl. data).

Abundance

Available population estimates for the Salish Sucker range from the low hundreds to the low thousands in each watershed (Table 2). Extensive literature reviews of hundreds of studies and species indicate that minimum viable population (MVP) size is in the low thousands for the great majority of vertebrates (Reed *et al.* 2003; Traill *et al.* 2007). Salish Sucker populations in all watersheds for which data are available appear to be close to or below this threshold. The applicability of these data to Salish Sucker populations, however, is questionable as the literature reviews included only a few fish species, and these were of marine populations with very large MVPs (median 1.2 million in Traill *et al*. 2007).

Fluctuations and Trends

There is insufficient information to quantify watershed scale trends or fluctuations for any of the Canadian populations. Some trend data are, however, available for Pepin Creek. Between 1999 and 2002 exceptionally high densities of Salish Suckers were found in a main stem beaver pond (over 1,000 in 1,420m^2 estimated by mark-recapture), but in 2003 the habitat was nearly anoxic and apparently devoid of fish during the summer (Pearson 2004b). Sampling in 2004, 2005, and 2011 showed that the reach remains severely hypoxic and supports very few fish.

Catch per unit effort has been monitored in a second reach, the Gordon's Brook restoration site, since 2002 (Figure 9), the year after it was reconstructed (Pearson 2004a). A single baseline point from 1999 was obtained from sampling in the agricultural ditch through which the stream flowed prior to reconstruction. Here CPUE increased rapidly from 2002 to 2004 (as severe hypoxia occurred in much of the main stem), but declined to near zero in 2007. Again this was accompanied by the onset of severe hypoxia (<1mg/l dissolved oxygen at outflow in August 2008; Pearson unpubl. data). Following removal of Reed Canary Grass and the cessation of manure spreading on an adjacent field in 2008, both oxygen and Salish Sucker abundance have shown signs of rebound.

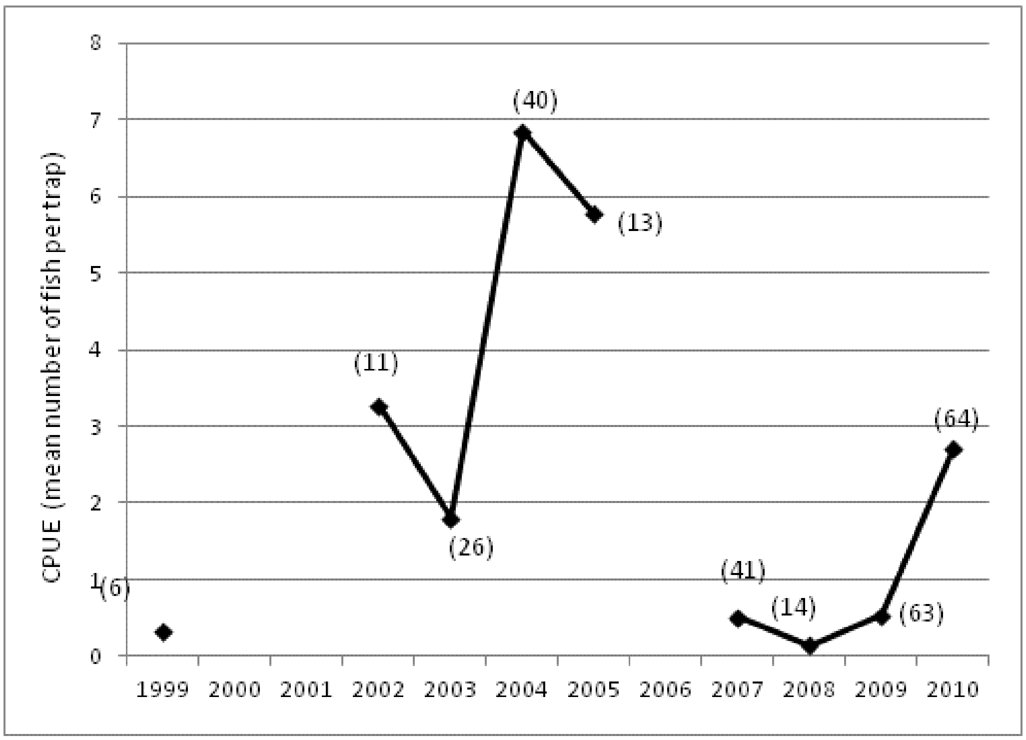


Figure 9. Catch per unit effort (mean number Salish Sucker per trap) in Gordon's Brook 1999-2010. Habitat restoration work began in 2001. Bracketed values indicate the number of traps. Gordon's Brook is a tributary to Pepin Creek.

Rescue Effect

Three of the Canadian populations occur in streams that flow into Washington State's Nooksack River (Bertrand, Fishtrap, and Pepin creeks). Rescue of Canadian populations is unlikely from south of the border, as there is limited suitable habitat in the American portion of these streams (McPhail 1987; Pearson 2004a). Intensive sampling of the entire fish community at six sites in Bertrand Creek and one site in Fishtrap Creek in the U.S. from 2006-2010 yielded only one Salish Sucker (Robert Vadas, Washington Department of Fish and Wildlife, pers. comm., 2011).

THREATS AND LIMITING FACTORS

Populations in Canada are probably limited by poor water quality and physical habitat degradation in most of their native watersheds. The following sections are adapted from a comprehensive threats assessment for Salish Sucker (Pearson 2004a; Recovery Team for Salish Sucker 2012). All threats listed are likely to intensify in the coming years. The human population of the lower Fraser Valley is among the fastest growing in North America averaging 9.2% between 2006 and 2011 and projected to expand by a further 33% by 2032 (BC Stats 2012). The land development associated with this growth can be expected to further degrade stream habitats unless a considerable commitment to management is made.

Imminent Threats Likely to Cause Harm or Population-scale Impacts

Severe hypoxia is documented from occupied or otherwise suitable habitats in portions of all 11 watersheds. It is considered a major threat to Salish Sucker in seven of these (Recovery Team for Salish Sucker 2012). Summer dissolved oxygen concentrations in some areas remain below 1 mg/l for months during hot dry periods of the summer (Pearson unpubl. data). Several interacting factors contribute to the threat. These include elevated nutrient levels in ground and surface waters as a result of over-application of manure and fertilizers to Fraser Valley agricultural lands (Vizcarra *et al*. 1997; Schindler *et al*. 2006), but also from urban storm water runoff and septic systems (Lavkulich *et al*. 1999). The nutrient-rich water produces algal blooms and thick growth of grasses and other vascular plants, many of them invasive species. The plants consume oxygen at night through respiration, depleting levels in the water. Decomposition of the large biomass exacerbates the problem, often depressing oxygen concentration during the day as well. Lack of shade from riparian vegetation contributes to plant growth through photosynthesis and warms water, increasing decomposition rates while increasing oxygen demand in the fish. Approximately 60% of the bank length of proposed critical habitat for Salish Sucker currently lacks woody riparian vegetation or is bordered by strips less than 5 m wide (Pearson 2008). Habitats that lack significant water movement in summer due to low flows or ponding are especially vulnerable (Pearson pers. obs.). The impacts of climate change on the frequency or intensity of hypoxia events are difficult to predict. Mean annual temperature is projected to increase by 1 to 1.5^{o}C in southwestern British Columbia, which is likely to exacerbate problems, but precipitation is also expected to increase which will tend to alleviate them (Gayton 2008).

Physical destruction of habitat has likely been the most serious threat to Salish Sucker populations historically. Channelization, dredging and infilling damage or destroy fish habitat directly. Channelization also reduces habitat area (via channel length) and exacerbates hypoxia by reducing mixing. Dredging removes spawning riffles and reduces habitat complexity. The highest densities of Salish Suckers are found in headwater wetlands, habitats that were frequently drained for agricultural development historically. Approximately 77% of the lower Fraser River Valley's pre-settlement wetlands have been drained or in-filled (Boyle *et al*. 1997) and fifteen percent of its streams have been eliminated by urban or agricultural development (Fisheries and Oceans Canada 1998). Annual watercourse maintenance programs for flood control and other in-stream works (both authorized and illegal) continue to damage habitat across the range (Recovery Team for Salish Sucker 2012).

Imminent Threats of Uncertain Impact

Habitat fragmentation by perched culverts, flood gates, beaver dams, dry sections of channel, hypoxia and agricultural weirs commonly impede or prevent fish movement between habitats for all or part of the year in these streams. Potential impacts include loss of access to spawning habitats, inability to recolonize habitat after a local extirpation, and increased extirpation risk among small isolated subpopulations. Most barriers found in Salish Sucker watersheds originated from 50 to 130 years ago (Pearson 2004a; Table 5), and all known populations have persisted, although the effects of fragmentation may occur over longer time frames.

Table 5. Degree of isolation of Salish Sucker populations within the 11 watersheds known to be occupied.

No.	Population	Isolated?	Explanation
1	Agassiz Slough	Y	Historical headwater connection to Miami Creek cut by Highway 7. Historical connection to Elk-Hope across Fraser severed by dykes. Connection to Fraser seasonally closed by flood gate Connection to Maria Slough (not currently believed occupied) severed by Highway 7.
2	Mountain Slough	N	Headwater connection to Miami Creek.
3	Miami Creek	N	Headwater connection to Mountain Slough.
4	Elk-Hope	Y	Historical connection to Agassiz and Mountain Sloughs across Fraser severed by dykes
5	Chilliwack delta	Y	Historical connection to Elk-Hope and Salwein-Hopedale severed by drainage of Sumas Lake and other drainage and dyking works.
6	Salwein-Hopedale	Y	Dispersal possible across Vedder River between Salwein Creek and Hopedale Slough is possible, but viability of combined populations is uncertain. Isolated from Chilliwack Delta populations by drainage of Sumas Lake.
7	Salmon River	N	High water connection to Bertrand Creek through headwater wetland
8	Bertrand Creek 1	N	High water connection to Salmon R through headwater wetland Dispersal from Bertrand headwater location Perry-Homestead location (tributary) unlikely due to lack of suitable habitat. Part of mainstem population is upstream of a drop culvert. No immigration from downstream is possible, but emigration to downstream areas is.
9	Little Campbell River	Y	Historical dispersal route to Bertrand eliminated by drainage and infilling of headwater wetlands.
10	Fish Trap Creek	Y	Isolated from Pepin and Bertrand populations by poor habitat in Washington State.
11	Pepin Creek	Y	Isolated from Fishtrap and Bertrand Creek by poor habitat in Washington State

Toxic compounds enter lower Fraser River Valley streams and wetlands from urban storm runoff, contaminated groundwater (e.g. pesticides and herbicides), direct industrial discharges, aerial deposition and accidental spills (Lavkulich 1999). Untreated storm water discharges directly into occupied habitat in seven of the ten occupied watersheds. The 1.6 km perimeter of a pond on Salwein Creek is ringed by a submerged creosote-treated retaining wall. Most occupied streams are crossed by major roads and/or rail lines that bring significant long-term spill risks. The vulnerability of Salish Suckers to the individual or combined compounds is unknown. The United States Environmental Protection Agency categorizes *C.* sp. cf. *catostomus* as having ‘intermediate’ pollution tolerance (EPA 2012)

Sediment deposition occurs when the sediment supply to a stream exceeds its ability to mobilize and carry it downstream. Direct discharges, storm drain runoff, and bank erosion, accelerated by lack of riparian vegetation and increased peak flows all contribute to sedimentation (Waters 1995). Massive amounts of deposited sediment severely degraded Pepin Creek following failures of sediment settling ponds in two separate gravel pits in the 1990s (Pearson 2004a). The material is slowly working its way downstream. Salish Sucker are still found in affected areas, but spawning habitat was degraded or lost. Gravel mining is now also underway in the Fishtrap Creek and Mountain Slough watersheds. A berm failure in 2007 released a considerable amount of sediment into Mountain Slough. Although mitigation measures are (and have been) in place at most or all gravel pits, the risk of future sediment releases is likely significant.

Introduced predators including Largemouth Bass (*Micropterus salmoides*), Smallmouth Bass (*Micropterus dolomieu*), Brown Bullhead (*Ameiurus nebulosis*), Pumpkinseed (*Lepomis gibbosus*), and Bullfrog (*Lithobates catesbeianus*) are found in all watersheds occupied by Salish Sucker (Pearson 2004a; Hatfield and Pollard 2009; Runciman and Leaf 2009). While Salish Sucker have coexisted with these species for more than 15 years in most cases, the long-term impacts on abundance are uncertain, as are potential interactions with other threats. For example Brown Bullheads are extremely tolerant of severe hypoxia (Scott and Crossman 1973), and may become a greater threat under these conditions.

PROTECTION, STATUS, AND RANKS

Legal Protection and Status

The Salish Sucker is listed as Endangered under Schedule 1 of the federal *Species at Risk Act (SARA),* which states that “no person shall kill, harm, harass, capture or take …” or “possess, collect, buy sell or trade an individual*”. SARA* also prohibits the destruction of a species residence or habitat identified as critical in an approved recovery strategy or action plan, but the competent minister must make an order before the prohibitions apply. Critical habitat has been mapped for the Salish Sucker in the proposed Recovery Strategy (Recovery Team for Salish Sucker 2012)[1].

[1] Legal deadline for adoption was September 15, 2012.

The British Columbia *Wildlife Act* prohibits the capture, transport and possession of wildlife (or their parts) without a licence. Most habitat could be protected under the federal *Fisheries Act,* but changes to the Act proposed to take effect in 2013 will eliminate protection for fishes like the Salish Sucker because they are not the focus of any fishery although some incidental protection may occur in habitats that they share with protected fishes such as salmon and trout*.* The British Columbia *Land* and *Water Acts,* and/or by municipal bylaws exist but application and enforcement of legislation is often lacking (Pearson 2004b; Gage 2007). The Salish Sucker is not listed under the American *Endangered Species Act*.

Non-Legal Status and Ranks

The Salish Sucker is considered critically imperiled by NatureServe at the global (G1; last reviewed in 2011), National (N1; Canada and United States), and sub-national (S1; Washington and British Columbia) levels (NatureServe 2012). It is on British Columbia's Red List and is considered 'Highest Priority' under the province's conservation framework. The American Fisheries Society lists it as Endangered (Jelks *et al*. 2008). The IUCN Red List does not include the Salish Sucker although it has been listed in the past (COSEWIC 2002).

Habitat Protection and Ownership

Approximately 115 of the 145.7 km of proposed critical habitat for Salish Sucker occurs in waterways flowing through private land. The remainder is on a mix of federal, provincial and municipal lands (Table 6). The majority of this is on federal lands, most of which are First Nations reserves. Notable exceptions are the large habitat areas on NRS Aldergrove (Department of National Defence) and a number of contiguous parcels on lower Salwein Creek.

Table 6. Length of proposed critical habitat for Salish Sucker (from Pearson 2008) owned by federal, provincial or municipal governments. All remaining habitat flows through private lands.

Watershed	Property	Owner	Habitat length (m)
Bertrand	NRS Aldergrove	GoC1	1,500
Bertrand	Vanetta Park	ToL2	165
Bertrand	Creekside Park	ToL[2]	195
Chilliwack	Skway IR 5	GoC[1]	1,142
Chilliwack	Squiaala IR 8	GoC[1]	100
Chilliwack	Squiaala IR 7	GoC[1]	5,900
Chilliwack	Aitchelitch IR 9	GoC[1]	900
Chilliwack	Skowkale IR 10	GoC[1]	550
Chilliwack	Skowkale IR 11	GoC[1]	260
Chilliwack	Yakweakwioose IR 12	GoC[1]	450
Elk/Hope	Hope River Park	CoC3	900
Elk/Hope	Kinsmen Park	CoC[3]	500
Elk/Hope	Skwali IR 3	GoC[1]	2,300

Watershed	Property	Owner	Habitat length (m)
Elk/Hope	Skwah IR 4	GoC[1]	1,700
Elk/Hope	Skwahla IR 2	GoC[1]	560
Fishtrap	East Fishtrap Creek Parks	CoA4	1,400
Fishtrap	Abbotsford Airport	CoA[4]	450
Fishtrap	Field north of 0 Avenue	CoA[4]	500
Hopedale	Provincial Crown Land	BC5	3,540
Miami	Spring Park	VHH6	180
Pepin	Aldergrove Lake Regional Park	MVRD[7]	3,300
Salmon	NRS Aldergrove	GoC[1]	1,550
Salmon	McMillan Park	ToL[2]	750
Salwein	Great Blue Heron Nature Reserve	CoC[3]	2,200
Salwein	Great Blue Heron Nature Reserve	GoC[1]	1,100
Salwein	Crown Land	BC[5]	1,000
Total			33,092

1 Government of Canada
2 Township of Langley
3 City of Chilliwack
4 City of Abbotsford
5 Government of British Columbia
6 Village of Harrison Hotsprings
7 Metro Vancouver Regional District

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INFORMATION SOURCES

BC Stats. 2012. Sub-provincial population projections. BC Stats Web Site: http://www.bcstats.gov.bc.ca/StatisticsBySubject/Demography/PopulationProjections.aspx [Accessed April 26, 2012].

Boyle, C.A., L. Lavkulich, H. Schreier, and E. Kiss. 1997. Changes in land cover and subsequent effects on Lower Fraser Basin ecosystems from 1827 to 1990. Environmental Management 21:185-196.

Brown, J.H., D.W. Mehlman, and G.C. Stevens. 1995. Spatial variation in abundance. Ecology 76:2028-2043.

Burt, A., D. Kramer, K. Nakatsuru, and C. Spry. 1988. The tempo of reproduction in *Hyphessobrycon pulchripinnis* (Characidae) with a discussion on the biology of 'multiple spawning' in fishes. Environmental Biology of Fishes 22:15-27.

Cooke, S.J., C.M. Bunt, S.J. Hamilton, C.A. Jennings, M.P. Pearson, M.S. Cooperman, and D.F. Markle. 2005. Threats, conservation strategies, and prognosis for suckers (Catostomidae) in North America: insights from regional case studies of a diverse family of non-game fishes. Biological Conservation 121:317-331.

COSEWIC. 2002. COSEWIC assessment and update status report on the Salish Sucker, *Catostomus* sp. in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa. vii + 27 pp.

COSEWIC. 2009. Guidelines for recognizing designatable units. COSEWIC Web Site: http://www.cosewic.gc.ca/eng/sct2/sct2_5_e.cfm. [Accessed May 15, 2011].

EPA. 2012. United States Environmental Protection Agency Web Site: http://www.epa.gov/bioiweb1/html/fish_suckers.html [Accessed September 12, 2012]

FISS. 2011. Fisheries Information Summary System. British Columbia Ministry of Environment Web Site:http://a100.gov.bc.ca/pub/fidq/fissSpeciesSelect.do [Accessed April 24, 2012].

Fisheries and Oceans Canada. 1998. Wild, threatened, endangered and lost streams of the lower Fraser Valley Summary Report: Lower Fraser Valley Stream Review Vol. 3. Fraser River Action Plan, Habitat and Enhancement Branch, Fisheries and Oceans Canada, Vancouver, British Columbia. v + 27 pp.

Gage, A. 2007. No response: A survey of environmental law enforcement and compliance in BC. West Coast Environmental Law, Vancouver. 44 pp.

Gayton, D.V. 2008. Impacts of climate change on British Columbia's biodiversity: a literature review. FORREX Forest Research Extension Society, Kamloops, British Columbia, Canada. v + 24 pp.

Hatfield, T. and S. Pollard. 2009. Non-native freshwater fish species in British Columbia: biology, biotic effects and potential management actions. Province of BC, Fisheries Management Report 121. vi + 206 pp.

Inglis, S., A. Lorenz, and M.L. Rosenau. 1992. Distribution and habitat of the endangered Salish Sucker (*Catostomus* sp.). BC Ministry of Environment, Lands and Parks, Surrey. 21 pp.

IUCN Standards and Petitions Subcommittee. 2010. Guidelines for using the IUCN Red List categories and criteria. Version 8.1. Prepared by the Standards and Petitions Subcommittee in March 2010. IUCN Web Site: http://intranet.iucn.org/webfiles/doc/SSC/RedListGuidelines.pdf. [Accessed September 9, 2012].

Jelks, H.L., S.J. Walsh, N.M. Burkhead, S. Contreras-Balderas, E. Diaz-Pardo, D.A. Hedrickson, J. Lyons, N.E. Mandrak, F.McCormick, J.S. Nelson, S.P. Platania, B.A. Porter, C.B. Renaud, J.J. Schmitter-Soto, E.B. Taylor, and M.L. Warren, Jr. 2008. Conservation status of imperiled North American freshwater and diadromous fishes. Fisheries 33: 378-407.

Johal, N. 2001. Examination of Salish Sucker (*Catostomus* sp.) for parasitic infection. Unpublished undergraduate thesis, Zoology Department. University of British Columbia, Vancouver. 20 pp

Krebs, C.J. 1999. Ecological Methodology. 2nd Edition. Adison-Welsey, Menlo Park, California. xii + 631 pp.

Lavkulich, L.M., K.J. Hall, and H. Schreier. 1999. Land and water interactions: Present and future. Pp. 170-201 *in*: Seeking sustainability in the lower Fraser Basin: Issues and choices. M.C. Healey (ed.). Institute for Resources and Environment, Westwater Research, University of British Columbia, Vancouver.

McPhail, J.D. 1967. Distribution of freshwater fishes of western Washington. Northwest Science 41:1-11.

McPhail, J.D. 1987. Status of the Salish Sucker, *Catostomus* sp., in Canada. Canadian Field Naturalist 101:231-236.

McPhail, J.D. 2007. The freshwater fishes of British Columbia. University of Alberta Press, Edmonton. lxxiv + 620 pp.

McPhail, J.D., and R. Carveth. 1993. A foundation for conservation: The nature and origin of the freshwater fish fauna of British Columbia. Fish Museum, Department of Zoology, University of British Columbia, Vancouver. 39 pp.

McPhail, J.D., and R. Carveth 1994. Field key to the freshwater fishes of British Columbia. Superior Repro, Vancouver. ii + 239 pp.

McPhail, J.D., and E.B. Taylor. 1999. Morphological and genetic variation in northwestern Longnose Suckers, *Catostomus catostomus*: the Salish Sucker problem. Copeia 1999:884-893.

NatureServe. 2012. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. http://www.natureserve.org/explorer. [Accessed: April 27, 2012].

Patton, T.M. 2003. Evaluation of the Salish Creek mitigation project. M.Sc. Thesis. Institute for Resources, Environment and Sustainability. University of British Columbia., Vancouver. vii + 89pp

Pearson, M.P. 1998. Habitat inventory and enhancement needs for the endangered Salish Sucker (*Catostomus* sp.) and Nooksack Dace (*Rhinichthys* sp.). British Columbia Ministry of Fisheries, Fisheries Project Report No. 76, Vancouver, BC.

Pearson, M.P. 2004a. The ecology, status, and recovery potential of Nooksack Dace (*Rhinichthys cataractae ssp*.) and Salish Sucker (*Catostomus* sp.) in Canada. Ph.D. thesis, University of British Columbia, Vancouver, Canada. Xv + 239 pp.

Pearson, M.P. 2004b. Using recovery science and recovery action in mutual support: A case study of habitat restoration for the Salish Sucker *in* T. D. Hooper, editor. Proceedings of the Species at Risk 2004 Pathways to Recovery Conference. Species at Risk 2004 Pathways to Recovery Organizing Committee, Victoria, B.C.

Pearson, M.P. 2008. An assessment of potential critical habitat for Nooksack dace (*Rhinichthys cataractae* ssp.) and Salish Sucker (*Catostomus* sp.). Canadian Science Advisory Secretariat Research Document 2007/058., Ottawa. Downloadable from: http://www.dfo-mpo.gc.ca/CSAS. [Accessed April 23, 2011].

Pearson, M.P. 2009. Guidelines for the Collection of Salish Sucker. Recovery Team for Non-game Freshwater Fish Species (BC). Vancouver. University of British Columbia Zoology Department Web Site: http://www.zoology.ubc.ca/~schluter/stickleback/Salish_sucker/Guidelines%20for%20collection%20of%20Salish%20sucker.pdf [Accessed April 23, 2011]

Pearson, M.P., and M.C. Healey. 2003. Life history characteristics of the endangered Salish Sucker (*Catostomus* sp.) and their implications for management. Copeia 2003:759-768.

Recovery Team for Salish Sucker. 2012. Recovery Strategy for Salish Sucker (*Catostomus* sp.) in Canada [Proposed]. Species at Risk Act Recovery Strategy Series. Fisheries and Oceans, Canada. xiii+60 pp.

Reed, D.H., J.J. O'Grady, B.W. Brook, J.D. Ballou, and R. Frankham. 2003. Estimates of minimum viable population sized for vertebrates and factors influencing those estimates. Biological Conservation 113:23-34.

Runciman, J.B., and B.R. Leaf. 2009. A review of yellow perch (*Perca flavescens*) smallmouth bass (*Micropterus dolomieu*), largemouth bass (*Micropterus salmoides*), pumpkinseed (*Lepomis gibbosus*), walleye (*Sander vitreus*) and northern pike (*Esox lucius*) in British Columbia. Canadian Mansuscript Report of Fisheries and Aquatic Sciences 2882: xvi + 123 p.

Schaepe, D.M. 2001. The maps of K'hhalserten, c. 1918. Pp. 126-127. *in* K. T. Carlson, editor. A Sto:lo- Coast Salish historical atlas. Douglas and McIntyre and the Sto:lo Nation, Vancouver and Chilliwack.

Schindler, D.W., P. J. Dillon, and H. Schreier. 2006. A review of anthropogenic sources of nitrogen and their effects on Canadian aquatic ecosystems. P.p. 25-44. *in* L. A. Martinelli, and R. W. Howarth, editors. Nitrogen Cycling in the Americas: Natural and Anthropogenic Influences and Controls. Springer, Netherlands.

Schlosser, I.J. 1995. Dispersal, boundary processes and trophic level interactions in streams adjacent to Beaver ponds. Ecology 76:908-925.

Schlosser, I.J. 1998. Fish recruitment dispersal and trophic interactions in a heterogenous lotic environment. Oecologia 113:260-268.

Schlosser, I.J., and L.W. Kallemyn. 2000. Spatial variation in fish assemblages across a Beaver-influenced successional landscape. Ecology 81:1371-1382.

Schultz, L.P. 1947. A fine-scaled sucker, *Catostomus*, from Lake Cushman, Washington State. Copeia 1947:202.

Scott, W.B., and E.J. Crossman 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada, Fisheries and Oceans Canada, Ottawa. Xviii + 966 pp.

Snodgrass, J.W., and G.K. Meffe. 1998. Influence of Beavers on stream fish assemblages: effects of pond age and watershed position. Ecology 79:928-942.

Traill, L.W., C.J.A. Bradshaw, and B.W. Brook. 2007. Minimum viable population size: a meta-analysis of 30 years of published estimates. Biological Conservation 139:159-166.

Vizcarra, A.T., K.V. Lo, and L. Lavkulich. 1997. Nitrogen balance in the lower Fraser River basin of British Columbia. Environmental Management 21:269-282.

Waters, T.F. 1995. Sediment in streams: sources, biological effects and control. American Fisheries Society Monograph 7, Bethesda, Maryland. Xix + 251 pp.

Watt, K.J. 2006. High water: Living with the Fraser floods. Dairy Industry Historical Society of British Columbia. Xii + 320 pp.

Winemiller, K.O., and K.A. Rose. 1992. Patterns of life-history diversification in North American fishes: Implications for population regulation. Canadian Journal of Fisheries and Aquatic Science 49:21196-22218.

Woods, J.R. 2001. Sumas lake transformations Pp. 104-105. *in* K. T. Carlson, editor. A Sto:lo-Coast Salish historical atlas. Douglas and McIntyre and the Sto:lo Nation, Vancouver and Chilliwack.

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Mike Pearson holds a Ph.D. in Resource Management and Environmental Science from the University of British Columbia (2004). His doctoral research focused on the ecology, status and recovery prospects of the *SARA* listed Salish Sucker (*Catostomus* sp.) and Nooksack Dace (*Rhinichthys cataractae*). He was a member of the National Recovery Team for Non-Game Freshwater Fishes (BC). He is lead author of the draft *SARA* Recovery Strategies for Nooksack dace and Salish Sucker (2008, 2011) and author of COSEWIC Assessment and Update Status Reports for Nooksack Dace (2007) and Morrison Creek Lamprey (2010). He is also lead author of the web site Species at Risk and Local Government: A Primer for British Columbia (www.speciesatrisk.bc.ca). Currently Dr. Pearson runs Pearson Ecological, a Vancouver-based consulting firm specializing in species at risk issues and aquatic habitat restoration.

COLLECTIONS EXAMINED

University of British Columbia Fish Museum, Vancouver, BC
http://www.beatymuseum.ubc.ca/collections/fish

Royal British Columbia Museum, Victoria, BC

University of Washington/Burke Museum Fish Collection, Seattle, WA
http://www.washington.edu/burkemuseum/collections/ichthyology/

Appendix 1. Targeted efforts to locate Salish Sucker populations in the lower Fraser River Valley, 1992-2011. Effort refers to number of traps set or sites electrofished. Method codes: G = Minnow (Gee) trap; L= large funnel trap; EF = electrofishing

Drainage	Watershed	Watershed Code	Year	Effort	Salish Sucker	Method	Reference
Fraser	Agassiz Slough	100-086400-45800	2000	12	Y	G/L	Pearson 2004a
Fraser	Agassiz Slough	100-086400-45801	2011	24	Y	EF	Miners and Pearson unpub.
Fraser	Alouette River	100-026700-06000	2000	21	N	G/L	Pearson 2004a
Fraser	Burnaby Lake	100-020100	2010	10	N	G/L	Pearson unpub
Fraser	Camp Slough	100-074100-28700-50400	2000	11	N	G/L	Pearson 2004a
Fraser	Camp Slough	100-074100-28700-50400	2006	10	N	G/L	Pearson unpub
Fraser	Camp Slough	100-074100-28700-50400	2009	73	N	G/L	Pearson unpub
Fraser	Cheam Lake/Inlet and outlet creeks	100-089400-07100	2010	60	N	G/L	Pearson unpub
Fraser	Chester Creek	100-049300	2000	6	N	G/L	Pearson 2004a
Fraser	Chilliwack Delta (Atchelitz Creek)	100-071800-16300	2000	2	Y	G/L	Pearson 2004a
Fraser	Chilliwack Delta (Atchelitz Creek)	100-071800-16300-72624	2007	29	Y	G	Josh Taylor pers. comm.
Fraser	Chilliwack Delta (Little Chilliwack River)	100-071800	2004	62	Y	G/L	Pearson unpub
Fraser	Chilliwack Delta (LuckakuckCreek)	100-071800-42400	2000	8	Y	G/L	Pearson 2004a
Fraser	Chilliwack Delta (LuckakuckCreek)	100-071800-42400	2004	18	N	G/L	Pearson unpub
Fraser	Chillwack Delta	100-071800	1992	5	N	EF/G	Inglis *et al.* 1992
Fraser	Chilqua Creek	100-058500-46900	2010	17	N	G/L	Miners and Pearson unpub.
Fraser	Clifford Slough/Downes Cr./McLennan Cr.	100-053600	2000	21	N	G/L	Pearson 2004a
Fraser	Coquitlam River	100-024500	2000	10	N	G/L	Pearson 2004a
Fraser	Coquitlam River (Colony Farm)	100-024500	2010-11	232	N	G/L	Pearson unpub
Fraser	DeBoville Slough	100-026700-06100	2000	15	N	G/L	Pearson 2004a
Fraser	Duncan Slough	110-071000	2000	3	N	G/L	Pearson 2004a
Fraser	Elk Creek/Hope Slough	100-074100	1992	2	N	EF/G	Inglis *et al*. 1992
Fraser	Elk Creek/Hope Slough	100-074100	2000	3	N	G/L	Pearson 2004a
Fraser	Elk Creek/Hope Slough	100-074100	2000	53	N	G/L	Pearson 2004a
Fraser	Elk Creek/Hope Slough	100-074100	2006	46	Y	G/L	Pearson unpub
Fraser	Elk Creek/Hope Slough	100-074100	2009	?	Y	EF/L	David Blair, City of Chilliwack
Fraser	Gifford Slough	100-053600	1992	5	N	EF/G	Inglis *et al*. 1992
Fraser	Harrison River/Lake	110	2000	29	N	G/L	Pearson 2004a
Fraser	Hatzic Slough	100-058500	2000	32	N	G/L	Pearson 2004a
Fraser	Hicks Creek	100-093700	2010	3	N	G/L	Pearson unpub
Fraser	Kanaka Creek	100-037400	2000	15	N	G/L	Pearson 2004a
Fraser	Kanaka Creek	100-037400	2009	11	N	G/L	Pearson unpub
Fraser	Katzie Slough/Cranberry Slough	100-026700-02800	2000	50	N	G/L	Pearson 2004a

Drainage	Watershed	Watershed Code	Year	Effort	Salish Sucker	Method	Reference
Fraser	Lake Errock and outlet stream	110-036900	2008	28	N	G/L	Pearson unpub
Fraser	Lorenzetta Creek	100-102000	1992	1	N	EF/G	Inglis *et al*. 1992
Fraser	Maria Slough	100	2000	10	N	G/L	Pearson 2004a
Fraser	Maria Slough	100	2001	4	N	G/L	Pearson 2004a
Fraser	Maria Slough	100	2007	66	N	G/L	Pearson unpub
Fraser	Marshall (Lonzo) Creek	100-065700-43900	1992	6	N	EF/G	Inglis *et al*. 1992
Fraser	Marshall (Lonzo) Creek	100-065700-43900	2000	30	N	G/L	Pearson 2004a
Fraser	Matsqui Slough	100-054300	1992	3	N	EF/G	Inglis *et al*. 1992
Fraser	Matsqui Slough/Willbrand Cr./Stoney Cr.	100-054300	2000	38	N	G/L	Pearson 2004a
Fraser	McGillvary Slough/Lewis Slough	100-065700-09300-37400	2000	24	N	G/L	Pearson 2004a
Fraser	Miami Creek	110-232100	2000	12	Y	G/L	Pearson 2004a
Fraser	Miami Creek	110-232100	2011	88	Y	L	Miners and Pearson unpub.
Fraser	Mountain Slough	100-083600	2000	25	N	G/L	Pearson 2004a
Fraser	Mountain Slough	100-083600	2003	14	Y	G/L	Pearson 2004a
Fraser	Mountain Slough	100-083600	2010	60	Y	G/L	Pearson unpub
Fraser	Munday Creek	100-033300-4840	1992	2	N	EF/G	Inglis *et al*. 1992
Fraser	Nathan Creek	100-043700	1992	7	N	EF/G	Inglis *et al*. 1992
Fraser	Nathan Creek	100-043700	2000	6	N	G/L	Pearson 2004a
Fraser	Nathan Creek	100-043700	2001	16	N	GL	Pearson 2004a
Fraser	Nicomen Slough	100	2000	6	N	G/L	Pearson 2004a
Fraser	Norrish Creek	100-064000	2000	30	N	G/L	Pearson unpub
Fraser	Palmateer Creek	100-041800	2000	3	N	G/L	Pearson 2004a
Fraser	Pretty Creek	110-090200-05000	2000	3	N	G/L	Pearson 2004a
Fraser	Quaamitch Slough	100-068800	2000	3	N	G/L	Pearson 2004a
Fraser	Saar Creek/Arnold Slough	100-065700-48300	2000	29	N	G/L	Pearson 2004a
Fraser	Salmon River	100-038800	1992	14	Y	EF/G	Inglis *et al*. 1992
Fraser	Salmon River	100-038800	2009	60	Y	G/L	Pearson unpub
Fraser	Salwein Creek	100-065700-09700-06600	1992	2	N	EF/G	Inglis *et al*. 1992
Fraser	Salwein Creek	100-065700-09700-06600	2000	20	Y	G/L	Pearson 2004a
Fraser	Salwein Creek	100-065700-09700-06600	2008	49	Y	G/L	Pearson unpub
Fraser	Stave River/Silvermere Lake	100-047100	2000	8	N	G/L	Pearson 2004a
Fraser	Stewart Creek	100-065700-15100-51500	2000	5	N	G/L	Pearson 2004a
Fraser	Hopedale Slough	100-065700-09700-07400	1992	1	N	EF/G	Inglis *et al*. 1993
Fraser	Hopedale Slough	100-065700-09700-07400	2000	11	Y	G/L	Pearson 2004a
Fraser	Hopedale Slough	100-065700-09700-07400	2004	38	Y	G/L	Pearson unpub
Fraser	Sumas River	100-065700	1992	4	N	EF/G	Inglis *et al*. 1992
Fraser	Sumas River	100-065700	2000	35	N	G/L	Pearson unpub
Fraser	Sweltzer Creek	100-065700-09700-13300	2000	10	N	G/L	Pearson 2004a
Fraser	Sweltzer River	100-065700-09700-13300	1992	2	N	EF/G	Inglis *et al*. 1994
Fraser	Tributary to Maria Slough	100-093600	2010	34	N	G/L	Pearson unpub
Fraser	Trout Lake	110-259000	2000	3	N	G/L	Pearson 2004a

Drainage	Watershed	Watershed Code	Year	Effort	Salish Sucker	Method	Reference
Fraser	Weaver Creek	110-149200-85400	2000	6	N	G/L	Pearson 2004a
Fraser	West Creek	100-041600	1992	3	N	EF/G	Inglis *et al*. 1992
Fraser	West Creek	100-041600	2000	18	N	G/L	Pearson 2004a
Fraser	Westan Creek	100-072800	2000	4	N	G/L	Pearson 2004a
Fraser	Whonnoek Creek	100-045300	2000	4	N	G/L	Pearson 2004a
Fraser	Willbrand Creek	100-054300-53400	2009	72	N	G/L	Pearson unpub
Fraser	Willbrand Creek	100-054300-53400	2010	30	N	G/L	Pearson unpub
Fraser	Wilson Slough	100-069200	2000	6	N	G/L	Pearson 2004a
Fraser	Worth Creek (Norrish Trib)	100-064000-91100	2010	45	N	G/L	Miners and Pearson unpub.
Fraser	York Creek/Benson Slough	100-045000	2000	14	N	G/L	Pearson 2004a
Campbell	Little Campbell River	900-000500	1992	11	N	EF/G	Inglis *et al*. 1992
Campbell	Little Campbell River	900-000500	1999	48	N	G/L	Pearson 2004a
Campbell	Little Campbell River	900-000500	2000	15	N	G/L	Pearson 2004a
Campbell	Little Campbell River	900-000500	2011	18	Y	L	Pearson unpub
Nicomekl	Nicomekl River	900-004300	1992	9	N	EF/G	Inglis *et al*. 1992
Nicomekl	Nicomekl River	900-004300	2000	34	N	G/L	Pearson 2004a
Nicomekl	Nicomekl River	900-004300	2001	32	N	G/L	Pearson 2004a
Nicomekl	Nicomekl River	900-004300	2006	6	N	G/L	Pearson unpub
Nicomekl	Nicomekl River	900-004300	2007	16	N	G/L	Pearson unpub
Nicomekl	Nicomekl River	900-004300	2008	100	N	G/L	Pearson unpub
Nicomekl	Nicomekl River	900-004300	2009	136	N	G/L	Pearson unpub
Nicomekl	Nicomekl River	900-004300	2010	231	N	G/L	Pearson unpub
Nooksack	Bertrand Creek	970-046800-25200	1992	15	Y	EF/G	Inglis *et al*. 1992
Nooksack	Bertrand Creek	970-046800-25200	2010	92	Y	G/L	Pearson unpub
Nooksack	Fishtrap Creek	970-046800-26400	1992	5	Y	EF/G	Inglis *et al*. 1992
Nooksack	Fishtrap Creek	970-046800-26400-87800	1999	146	Y	G/L	Pearson 2004a
Nooksack	Pepin Creek	970-046800-25200-38700	1992	16	Y	EF/G	Inglis *et al*. 1992
Nooksack	Pepin Creek	970-046800-25200-38700	2010	152	Y	G/L	Pearson unpub
Nooksack	Perry Homestead Creek (Bertrand Trib.)		2001	17	Y	G/L	Pearson 2004a
Serpentine	Nicomekl River	900-004300	2000	5	N	G/L	Pearson 2004a
Serpentine	Serpentine River	900-005500	1992	4	N	EF/G	Inglis *et al*. 1992
Serpentine	Serpentine River	900-005500	2000	39	N	G/L	Pearson 2004a