COSEWIC
Assessment and Status Report

on the

Salish Sucker
Catostomus sp. cf. *catostomus*

in Canada

ENDANGERED
2024

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. 2024. COSEWIC assessment and status report on the Salish Sucker *Catostomus* sp. cf. *Catostomus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xv + 84 pp. (https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry.html).

Previous report(s):

COSEWIC. 2012. COSEWIC assessment and status report on the Salish Sucker *Catostomus* sp. cf. *catostomus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xi + 36 pp. (https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry.html).

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. 28 pp.

Production note:
COSEWIC would like to acknowledge Mike Pearson for writing the status report on the Salish Sucker (*Catostomus* sp. cf. *catostomus*) in Canada, prepared under contract with Environment and Climate Change Canada. This report was overseen by Dr. Margaret Docker, 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

E-mail: cosewic-cosepac@ec.gc.ca
www.cosewic.ca

Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur le Meunier de Salish (*Catostomus* sp. cf. *catostomus*) au Canada.

Cover illustration/photo:
Salish Sucker from (Pepin Creek, 1999); photo by Mike Pearson.

Catalogue No. CW69-14/198-2024E-PDF
ISBN 978-0-660-73027-1

COSEWIC
Assessment Summary

Assessment Summary –May 2024

Common name
Salish Sucker

Scientific name
Catostomus sp. cf. *catostomus*

Status
Endangered

Reason for designation
This small fish has a restricted range in southwestern British Columbia. It is susceptible to continuing decline in amount and quality of habitat due to reduced stream flow, pollution, and decreasing oxygen content of the water as a result of increased stream temperature and high nutrient loading. These threats are expected to worsen due to climate change-induced extreme heat and drought events. Moreover, invasive species that prey upon this fish or modify its habitat are also contributing to population declines. Ongoing declines in several streams, in spite of habitat restoration efforts, and projected future declines resulted in the change in status. If these threats cannot be mitigated, they could lead to the extirpation of this species.

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. Status re-examined and designated Endangered in May 2024.

COSEWIC
Executive Summary

Salish Sucker
Catostomus sp. cf. *catostomus*

Wildlife Species Description and Significance

Salish Sucker is a genetically distinct dwarf form of Longnose Sucker (*Catostomus catostomus*). It is a member of a unique fish community that survived continental glaciation in an ice-free refuge in Washington State and is of scientific interest in the study of evolution and glacial history.

Aboriginal (Indigenous) Traditional Knowledge

All species are significant and are interconnected and interrelated. There is no species-specific Aboriginal Traditional Knowledge (ATK) in the report other than the Halq'emeylem name for Salish Sucker, Skwímeth, which translates as “many red markings.”

Distribution

Salish Sucker are documented from the Fraser, Nooksack, and Little Campbell drainages in the Lower Fraser River Valley of British Columbia and from an additional 6 watersheds in western Washington State. Within Canada, 15 subpopulations in 13 watersheds are documented.

Habitat

In British Columbia, Salish Sucker are found in small lowland streams and sloughs, especially headwater marshes and beaver ponds. Adults and yearlings prefer large pools or ponds (> 50 m length) deeper than 70 cm with abundant logs/stumps or aquatic vegetation for cover. They typically spawn in flowing shallow water (up to 50 cm/s) over gravel or cobble bottoms. First-summer juveniles prefer shallower pools and ponds with abundant cover. In winter, Salish Sucker seek quiet water with deep cover and may move more than 1.7 km off the main channel into tributaries and ditches that are dry in summer.

Biology

Salish Sucker live for up to 5 years and mature at 2 years, with generation time estimated at 3 years. The species spawns between April and early July, and the small, adhesive eggs are broadcast over gravel or cobble and fertilized in the water. No nest is constructed. An average female contains about 3,000 eggs and may spawn twice per year, maturing one ovary at a time.

They are most active around dawn and dusk. Summer home range averages approximately 175 m of channel, but fish may undertake longer migrations of more than 1 km to access spawning sites. During the day, they typically retreat to resting sites, often in thick vegetation off the main channel. They tend to return to the same resting site on successive days. Salish Sucker eat a variety of aquatic invertebrates. Salish Sucker are active at temperatures as low as 7°C but are most active between 12°C and 20°C. They are rarely found in water warmer than 20°C. They are captured less frequently where water contains less than 4 mg/L dissolved oxygen, and growth is reduced at levels lower than 3 mg/L.

The combination of small body size, rapid maturation, and high number of eggs relative to body size facilitates rapid population growth, quick positive response to habitat enhancement, and rapid recovery from occasional population losses.

Population Sizes and Trends

Individual subpopulations range in size from well below 100 adults to the low thousands. Most subpopulations have been estimated once or twice using mark-recapture methods, but for several subpopulations, too few fish have been caught to allow a quantitative estimate. The total Canadian population is currently estimated to be between 4,200 and 11,600 adults, but it is unlikely to exceed 6,700.

Salish Sucker abundance in Canada has declined by an estimated 34%–46% over the past decade. One subpopulation, Agassiz Slough, has likely been extirpated, and several more (Sqemélwelh Creek, Mountain Slough, Hope Slough) are believed to be very close to extirpation. Several other subpopulations, in Bertrand Creek, Salmon River, and Pepin Creek, have undergone extreme declines (> 75%) over the same period. Historical (20th century) declines associated with the draining of Sumas Lake, construction of dikes, channelizing of streams, and draining of wetlands were likely much larger even than these recent declines in terms of number of individuals.

Threats

The overall threat level to Salish Sucker is considered Very High. The most pressing threats are pollution, primarily from agricultural nutrients, and habitat drying during drought exacerbated by climate change. Toxic substances in stormwater impact habitats in urban areas and in areas adjacent to major roads. Annual dredging for flood control on agricultural lands affects a large portion of occupied habitat, reducing habitat complexity and sometimes spawning riffles. Additional authorized and illegal modifications to habitat occur annually. Gravel mining occurs in three watersheds, elevating the risk of large-scale sediment releases into habitat, as has occurred several times historically. The hundreds of road and rail crossings on occupied habitat present an ongoing threat of spills. Invasive aquatic and riparian plants degrade key habitats, while several introduced fish and amphibian species may elevate predation risk.

Protection, Status, and Recovery Activities

Salish Sucker is listed as Threatened under Schedule 1 of the federal *Species at Risk Act* (SARA), which protects individuals and critical habitat identified in the SARA recovery strategy. Approximately 42.1 of 196.5 km of habitat identified as critical under SARA flows through protected areas held by the federal, provincial, or municipal governments. The remainder is on private lands. Salish Sucker is Red-listed in British Columbia. The species was assigned a global conservation status of Critically Imperilled (G1) by NatureServe, along with a national status of Imperilled (N2) in both the U.S. and Canada. It is ranked as ranked as Critically Imperilled (S1) in both British Columbia and Washington State. The American Fisheries Society lists Salish Sucker as Endangered. The International Union for the Conservation of Nature (IUCN) Red List does not currently include Salish Sucker. It was listed as Endangered in 1990 and 1994, but not subsequently. Recovery activities include ongoing population monitoring, surveys for undocumented subpopulations, habitat mapping, research on hypoxia impacts, and development and monitoring of numerous habitat enhancement projects.

TECHNICAL SUMMARY

Catostomus sp. cf. *catostomus*

Salish Sucker

Meunier de Salish

Skwímeth (Halq'emeylem)

Range of occurrence in Canada: British Columbia

Demographic Information:

Generation time (usually average age of parents in the population)	Approximately 3 years	Based on IUCN method
Is there an [observed, estimated, inferred, or projected] continuing decline in number of mature individuals?	Yes	Estimated based on catch per unit effort (CPUE) and mark-recapture data.
[Observed, estimated, or projected] percent of continuing decline in total number of mature individuals within 3 years [or 1 generation; whichever is longer up to a maximum of 100 years]	Unknown	Significant decline in some subpopulations, but data not available over this time frame.
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations, whichever is longer up to a maximum of 100 years]	Unknown	Significant decline in some subpopulations, but data not available over this time frame.
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last 10 years [or 3 generations; whichever is longer]	34%–46% reduction over last 10 years	Estimated from changes in mark-recapture abundance estimates and catch per unit effort available from 9 of 15 subpopulations using an abundance-weighted change method (45.8%) and IUCN method (34.3%) that standardized declines to a 10-year period (see Table 6).
[Projected, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations, up to a maximum of 100 years]	>50% reduction over next 10 years	Inferred based on worsening primary threats, although with high uncertainty due to non-linearity of main threat impacts.
[Observed, estimated, inferred, projected, or suspected] percent [reduction or increase] in total number of mature individuals over any period [10 years, or 3 generations; whichever is longer, up to a maximum of 100 years], including both the past and the future.	>50% reduction over a 10 year-period including past and future	Estimated. Rate of decline has increased rapidly over time (non-linear) in response to hypoxia and temperature tolerance limits being exceeded.

Are the causes of the decline clearly reversible?	Perhaps	The primary threat is agricultural nutrient loading, which may be mitigated by changes in legislation/policy. The main watershed in which this species is located (Fraser) is surrounded by significant urban and agricultural development, making such reversals challenging. Climate change impacts could be mitigated by habitat restoration (primarily riparian) and maintenance of minimum in-stream flows.
Are the causes of the decline clearly understood?	Yes	Severe hypoxia driven by agricultural nutrient loading and habitat dewatering in severe drought are dominant causes.
Are the causes of the decline clearly ceased?	No	Current policy allows for continued increases to nutrient loading. Climate change driven drought and heat are expected to worsen.
Are there extreme fluctuations in number of mature individuals	No	Extreme declines have occurred in multiple watersheds, but these are due to anthropogenic impacts. High recruitment years have also (rarely) been observed following habitat restoration, but in general, recovery of numbers following a crash has not occurred.

Extent and Occupancy Information:

Estimated extent of occurrence (EOO)	1,401 km^2	Calculated based on minimum convex polygon around known occurrences in extant subpopulations.
Index of area of occupancy (IAO), reported as 2x2-km grid value	252 km^2	Reduced from 260 km^2 in 2012 status report due to apparent extirpation from Agassiz Slough and parts of Bertrand and Salmon River. Calculated using 2 x 2 km grid but, given that this includes large areas with no evidence of Salish Sucker and stream habitats are typically only a few metres wide, actual area of occupancy is highly unlikely to exceed 1 km^2.

Is the population “severely fragmented”, i.e., is >50% of individuals or >50% of the total area “occupied” (as a proxy for number of individuals) in habitat patches that are both (a) smaller than required to support a viable subpopulation, 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” One per occupied watershed (13 – Agassiz)	12	Main threats are nutrient pollution/hypoxia, habitat dewatering, and heat acting at the watershed level. Although climate change-induced events could potentially act simultaneously on multiple watersheds, even neighbouring watersheds often differ in ways that affect their vulnerability to threats.
Is there an [observed, inferred, or projected] continuing decline in extent of occurrence?	No	Extent of occurrence unaffected by suspected extirpation.
Is there an [observed, inferred, or projected] continuing decline in index of area of occupancy?	Yes	Inferred extirpation in Agassiz Slough and portions of Bertrand Creek and Salmon River.
Is there an [observed, inferred, or projected] continuing decline in number of subpopulations?	Yes	Inferred extirpation from Agassiz Slough.
Is there an [observed, inferred, or projected] continuing decline in number of “locations”?	Yes	Inferred extirpation from Agassiz Slough.
Is there an [observed, inferred, or projected] continuing decline in [area, extent and/or quality] of habitat?	Yes	Yes, worsening water quality across range (Rosenfeld *et al.* 2021)
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	

Number of Mature Individuals (by subpopulation):

1. Agassiz Slough	0	Believed extirpated after multiple surveys over 2 years; > 80% habitat dewatered in 2022
2. Bertrand Creek (Cave)	260–400	95% CI; 2019 mark-recapture

3. Bertrand Creek (Mainstem/Howes)	35–67	Extirpation from headwater reaches and approx. 95% decline in CPUE from 2013 mark-recapture estimate in remaining habitat (700–1,353)
4. Bertrand Creek (Perry Homestead)	341–1,082	95% CI; 2017 mark-recapture
5. Sqemélwelh Creek	5–25	47–93 95% CI in 2019 mark-recapture, prior to > 95% habitat dewatering in 2022 and 2023
6a. Chilliwack Delta (Atchelitz)	490–796	95% CI 2022 mark-recapture
6b. Chilliwack Delta (Little Chilliwack)	103–1,023	95% CI 2022 mark-recapture
6c. Chilliwack Delta (Interception Ditch)	15–100	15 caught in 84 traps 2023
6d. Chilliwack Delta (Luckakuck)	797–1,640	95% CI 2023 mark-recapture
6e. Chilliwack Delta (Semmihault)	327–1,029	95% CI 2015 mark-recapture
7. Fishtrap Creek	5–50	5 caught in 111 traps 2019
8. Hope Slough	0–100	Not caught since 2008, but large habitat area, although not all of it is accessible for sampling
9. Hopedale Slough	346–712	95% CI 2012 mark-recapture; CPUE comparable in 2021
10a. Little Campbell (LaBounty)	116–366	95% CI 2019 mark-recapture
10b. Little Campbell (Campbell Heights)	43–300	95% CI 2020 mark-recapture
11. Miami Creek	166–325	95% CI 2023 mark-recapture
12. Mountain Slough	0–100	2016: 85% decline in CPUE from 2014 mark-recapture estimate (24–200)
13a. Pepin Creek (mainstem)	192–380	2022: 85% decline in CPUE from 2002 mark-recap estimate (1,247–2,461)
13b. Pepin Creek (Salish Creek)	524–1,680	95% CI 2021–22 mark-recap
13c. Gordon’s Brook	7–100	7 captured in 26 traps 2020
14a. Salmon River (mainstem)	91–128	2021: 86% decline in CPUE from 2013 mark-recapture estimate (649–915)
14b. Salmon River (Tyre Creek)	245–900	95% CI 2022 mark-recapture
15. Salwein Creek	108–342	95% CI 2020 mark-recapture
Total	4,216–11,620	CIs for mark-recapture calculated using asymmetric binomial distribution (Krebs 1989). Estimate is always closer to lower confidence interval. Some estimates are very dated and, given pattern of decline across range, likely too high.

Quantitative Analysis:

Is the probability of extinction in the wild at least 20% within 20 years [or 5 generations], or 10% within 100 years]	Unknown	Analysis not conducted

Threats:

Was a threats calculator completed for this species?	Yes (Appendix 3)	Overall assigned threat impact: Very High (2023)
Key threats were identified as: i. Pollution (IUCN 9) – high impact ii. Climate Change and Severe Weather (IUCN 11) – high impact iii. Natural System Modifications (IUCN 7) – high impact iv. Invasive and Other Problematic Species and Genes (IUCN 8) – high impact v. Energy Production and Mining (IUCN 3) – low impact vi. Transportation and Service Corridors (IUCN 4) – low impact		
What limiting factors are relevant? • None. Salish Sucker has a naturally high intrinsic rate of population growth and is well adapted to recover from severe episodic declines in abundance if habitat conditions improve. Ongoing declines are a function of increasing threat severity, not intrinsic limiting factors.		

Rescue Effect (from outside Canada):

Status of outside population(s) most likely to provide immigrants to Canada.	Unknown	Only subpopulations in Pepin, Fishtrap, and Bertrand creeks are connected to waterways outside Canada. Their status in Washington is unknown.
Is immigration known or possible?	Yes	Salish Sucker occurs at the USA border regularly in Pepin Creek, and occasionally in Fishtrap Creek and Cave Creek.
Would immigrants be adapted to survive in Canada?	Yes	Same subpopulations
Is there sufficient habitat for immigrants in Canada?	No	Habitat degradation is driving declines in Canada.
Are conditions deteriorating in Canada?	Yes	Worsening landscape-scale hypoxia is occurring in these watersheds (Rosenfeld *et al*. 2021).
Are conditions for the source (i.e., outside) population deteriorating?	Yes	Washington portion of the population are downstream of Canadian ones and subject to the same threats. Cross-border nutrient pollution in these streams has been a political issue for several decades.
Is the Canadian population considered to be a sink?	No	No evidence of higher abundance in USA or significant immigration into Canada.

Is rescue from outside Canada likely, such that it could lead to a change in status?	No	No evidence of higher abundance in USA or significant immigration into Canada.

Wildlife Species with Sensitive Occurrence Data (general caution for consideration):

Could release of certain occurrence data result in increased harm to the Wildlife Species or its habitat?	No	
COSEWIC Status History	Designated Endangered in April 1986. Status re-examined and confirmed in November 2002. Status re-examined and designated Threatened in November 2012. Status re-examined and designated Endangered in May 2024.	

Status and Reasons for Designation:

Status	Endangered
Alpha-numeric codes	A3bce+4bce
Reason for change in status	I.i; I.ii; II.ix; II.xi; IV.iii; IV.vii
Reasons for designation	This small fish has a restricted range in southwestern British Columbia. It is susceptible to continuing decline in amount and quality of habitat due to reduced stream flow, pollution, and decreasing oxygen content of the water as a result of increased stream temperature and high nutrient loading. These threats are expected to worsen due to climate change-induced extreme heat and drought events. Moreover, invasive species that prey upon this fish or modify its habitat are also contributing to population declines. Ongoing declines in several streams, in spite of habitat restoration efforts, and projected future declines resulted in the change in status. If these threats cannot be mitigated, they could lead to the extirpation of this species.

Applicability of Criteria:

A: Decline in Total number of Mature Individuals:	
Meets Endangered, A3bce+4bce	Future decline is inferred at > 50% (A3bce), based on worsening primary threats, and decline spanning past and future is estimated at > 50% (A4bce). Meets Threatened, A2bce. Decline in number of mature individuals over the past three generations (10 years) estimated conservatively at 34%, based on declines in mark-recapture abundance estimates and catch per unit effort, decline in quality of habitat, and effects of introduced taxa and pollutants (A2bce).
B: Small Range and Decline or Fluctuation	
Not applicable	The EOO (1,401 km^2) and IAO (252 km^2) are below thresholds for Endangered, and the population is experiencing an observed and projected decline in IAO, extent and quality of habitat, number of locations, and number of mature individuals. However, the number of locations (12) exceeds the threshold for Threatened, and it is neither severely fragmented nor subject to extreme fluctuations.

C: Small and Declining Number of Mature Individuals	
Not applicable	Estimated number of mature individuals (4,216–11,620) exceeds the threshold for Endangered, but comes close to meeting the threshold for Threatened (10,000).
D: Very Small or Restricted Population	
Not applicable	Estimate of 4,216–11,620 mature individuals is above thresholds for D1, and IAO (252 km^2) does not meet the threshold for Threatened, D2. Although actual area of occupancy is likely < 1 km^2, the number of locations is 12, and the species is likely not prone to a substantial decline from effects of human activities or stochastic events within 1–2 generations.
E: Quantitative Analysis	
Not applicable	Analysis not conducted.

PREFACE

Since the last status report on Salish Sucker was published (COSEWIC 2012), one previously unknown subpopulation has been discovered, in Sqemélwelh Creek on Chawathil First Nation Reserve Land. Mark-recapture abundance estimates have been attempted for all subpopulations, and estimates from one or more years since 2012 have been completed for 12 of 15 subpopulations (Pearson unpubl. data). Catastrophic declines in abundance have been documented in several subpopulations due to reach-scale dewatering and/or extreme hypoxia events (Bertrand Creek mainstem, Salmon River, Sqemélwelh Creek), and one subpopulation is believed extirpated (Agassiz Slough).

Research has been published on the extent, severity, and impacts of hypoxia on Salish Sucker (Rosenfeld *et al.* 2021; Zinn *et al.* 2021; Ramirez 2022). These studies show that over 40% of identified critical habitat is hypoxic (dissolved oxygen < 4 mg/L) by late summer. Hypoxia is driven by elevated stream temperatures, reduced stream flow, and high nutrient pollution (eutrophication), but it is significantly reduced by shade from riparian forest. A high-level assessment of cumulative impacts on habitat has been published (Boyd *et al.* 2022). An assay for Salish Sucker environmental DNA (eDNA) was developed at the University of Victoria in 2021, but it has yet to be field tested (Helbing pers. comm. 2023).

A number of recovery documents have also been published, including the Recovery Potential Assessment for the Salish Sucker in Canada (Fisheries and Oceans Canada 2015; Pearson 2015a). Critical habitat has been protected by a ministerial Order in Council (2019). The recovery strategy was amended based on new information, which included reducing abundance targets and adding areas of critical habitat to Little Campbell River, Chilliwack Delta, Salmon River, and Bertrand Creek watersheds (Fisheries and Oceans Canada 2020). The action plan for the Nooksack Dace and the Salish Sucker was published (Fisheries and Oceans Canada 2017) and amended (Fisheries and Oceans Canada 2020b), and a report on the progress of recovery strategy and action plan implementation was published (Fisheries and Oceans Canada 2022). Guidelines for the capture, handling, scientific study, and salvage of Salish Sucker were updated (Pearson 2015b).

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
(2024)

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 is 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

Salish Sucker

Catostomus sp. cf. *catostomus*

in Canada

2024

TABLE OF CONTENTS

List of Figures

List of Tables

List of Appendices

WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Current classification:

Class: Actinopterygii
Order: Cypriniformes
Family: Catostomidae
Genus: *Catostomus*
Species: *Catostomus* sp. cf. *catostomus*

Common names:
English: Salish Sucker (Schultz 1947)
French: Meunier de Salish (McPhail 2007)
Indigenous (Halq'emeylem): Skwímeth (Victor pers. comm. 2019)

Synonyms and notes:

The Halq'emeylem name, Skwímeth, translates as “many red markings” (Victor pers. comm. 2019). Salish Sucker was first described for western science by Schultz (1947) from a Lake Cushman, Washington, specimen. Uncertainty remains around its taxonomic status. Although it is clearly a form of Longnose Sucker (*C. catostomus*) that is both genetically and morphologically distinguishable from other “western” and “eastern” Longnose Suckers found in Canada (McPhail and Taylor 1999), the geographic ranges of other forms of “western” Longnose Sucker and Salish Sucker do not overlap.

Description of Wildlife Species

Adult Salish Suckers are dark green, mottled with black on the back, and dirty white on the belly, and they develop a broad, red lateral stripe during the spawning season (Figure 1). The stripe is particularly vivid in males, which also develop callus-like tubercles on the anal fin during the spawning season. Scales are small, as is the mouth, which is located on the underside of the head (McPhail 2007). 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% of females exceed 200 mm (Pearson and Healey 2003). Body size is widely variable among *C. catostomus* populations, and dwarfism is relatively common (Scott and Crossman 1973; McPhail 2007; Lepage 2014). Salish Sucker body size is among the smallest reported for *C. catostomus* forms (Pearson and Healey 2003; LePage 2014). The sexes may be separated by the shape of the anal fin (Figure 2). Juveniles are more silvery and uniform in colouration, with first-year fish having a more pronounced terminal mouth (Pearson pers. obs.).

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

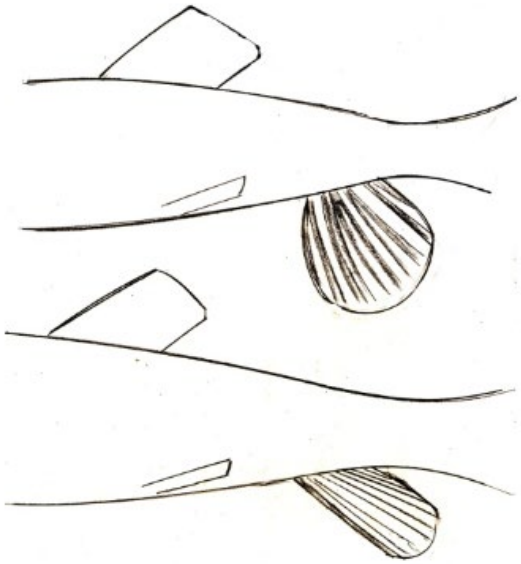

Figure 2. Male Salish Sucker (top) have a larger, fan-shaped anal fin which develops abundant tubercles during the spawning season. Females (below) have distinctly thickened anterior rays and a more rectilinear shape.

Salish Sucker are readily distinguished from Largescale Sucker (*C. macrocheilus*), with which they sometimes occur, by their smaller body size, more numerous scales, and fewer dorsal fin rays (Table 1; McPhail and Taylor 1999).

Table 1. Morphological differences between Salish Sucker, Western Longnose Sucker, and Largescale Sucker (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 (useful for young-of-the-year fish)	Length less than double the depth of caudal peduncle	Length less than double the depth of caudal peduncle	Length more than double the length of caudal peduncle
Lateral line scales	Usually 85–100	Usually > 100	62–83
Mouth length	Equal to eye diameter	Greater than eye diameter	Greater than eye diameter

Designatable Units

Salish Sucker is recognized as an evolutionarily significant unit (McPhail and Taylor 1999) and warrants recognition as a Designatable Unit (DU) within *C. catostomus*, in accordance with the COSEWIC guidelines for recognizing DUs (COSEWIC 2020). Within British Columbia, it occupies three independent drainages: the lower Fraser River, the Nooksack River, and the Little Campbell River. Dispersal between the Fraser and Nooksack drainages is possible via occasional highwater 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 justify treating them as separate DUs within Salish Sucker, in accordance with the COSEWIC guidelines (COSEWIC 2020).

Evidence for Discreteness

Salish Sucker differs, and is diagnosable from other western *C*. sp. cf. *catostomus* populations (McPhail 1987), by adult body size (Pearson and Healey 2003), morphology, and molecular genetic characteristics. 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 Sucker across eight localities in British Columbia and western Washington, and from 94 Longnose Sucker representing 24 localities from western Alaska to Quebec. They showed that Salish Sucker is distinguished from other Longnose Sucker by a single unique haplotype at the cytochrome *b* gene and by two unique haplotypes at the ND2 gene. Thus, it satisfies *criterion D1* in terms of discreteness (i.e., with evidence of heritable traits and markers that clearly distinguish it from other western *C*. sp. cf. *catostomus* populations).

Evidence for Evolutionary Significance

Available evidence suggests that before the Illinoian glaciation (200,000 years ago), *C. catostomus* was distributed across North America and into Siberia, as it is today. The range was subsequently fragmented by glaciation, re-formed at least partly during the Sangamon interglacial period, then re-fragmented during the most recent (Wisconsinan) glaciation (McPhail and Taylor 1999). The present distribution indicates that the populations survived in four ice-free refugia during the Wisconsinan glaciation: the Bering, the Great Plains (Mississippi-Missouri system), the Pacific Ocean, and the Chehalis (in western Washington State), from which Salish Sucker emerged (McPhail 2007). This complex history of fragmentation and isolation produced geographically structured evolutionary divergences among populations. *Catostomus* sp. cf. *catostomus* is quite 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 distinct Salish Sucker. As a distinct lineage originating in a separate Pleistocene glacial refugium, it satisfies *criterion S1* for significance.

As a result of the discovery of the Sqemélwelh Creek subpopulation at Chawathil, Salish Sucker are separated from the most downstream vouchered record of the Columbia form of *C. catostomus* (Fraser River 1.9 km west of Hope,1959, Beaty Biodiversity Museum) by less than 10 km of Fraser River channel. However, the two forms clearly differ with respect to life history and habitat associations. The Columbia form matures at 5–7 years and can survive up to 19 years, while Salish Sucker matures at 2 years and lives a maximum of 5–6 years (McPhail 2007). The Columbia form is primarily associated with cold-water rivers and lakes, while Salish Sucker in British Columbia are predominantly found in slow-moving headwater streams, wetlands, and beaver ponds (McPhail 2007). Salish Sucker is considered a unique element in the evolutionary history of the Longnose Sucker, satisfying *criterion S2* in terms of significance. The selective regime of Salish Sucker has given rise to local adaptations that could not be practically reconstituted if lost.

Special Significance

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 2007). It is of considerable scientific interest in the study of zoogeography and evolution (McPhail and Carveth 1993; McPhail 2007; Lepage 2014). 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).

ABORIGINAL (INDIGENOUS) KNOWLEDGE

Aboriginal Traditional Knowledge (ATK) is relationship-based. It involves information on ecological relationships between humans and their environment, including characteristics of species, habitats, and locations. Laws and protocols for human relationships with the environment are passed on through teachings and stories, and Indigenous languages, and they can be based on long-term observations. Place names provide information about harvesting areas, ecological processes, spiritual significance, or the products of harvest. ATK can identify life history characteristics of a species or distinct differences between similar species.

Cultural Significance to Indigenous Peoples

There is no species-specific ATK in the report other than the Halq'emeylem name. However, Skwímeth (Salish Sucker) is important to Indigenous Peoples who recognize the interrelationships of all species within the ecosystem.

DISTRIBUTION

Global Range

Longnose Sucker is one of the most widely distributed 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). Salish Sucker occupy the lower Fraser River Valley in British Columbia and seven drainages in northwestern Washington State (Figure 3). Additional undocumented subpopulations may occur in both Canada and the United States.

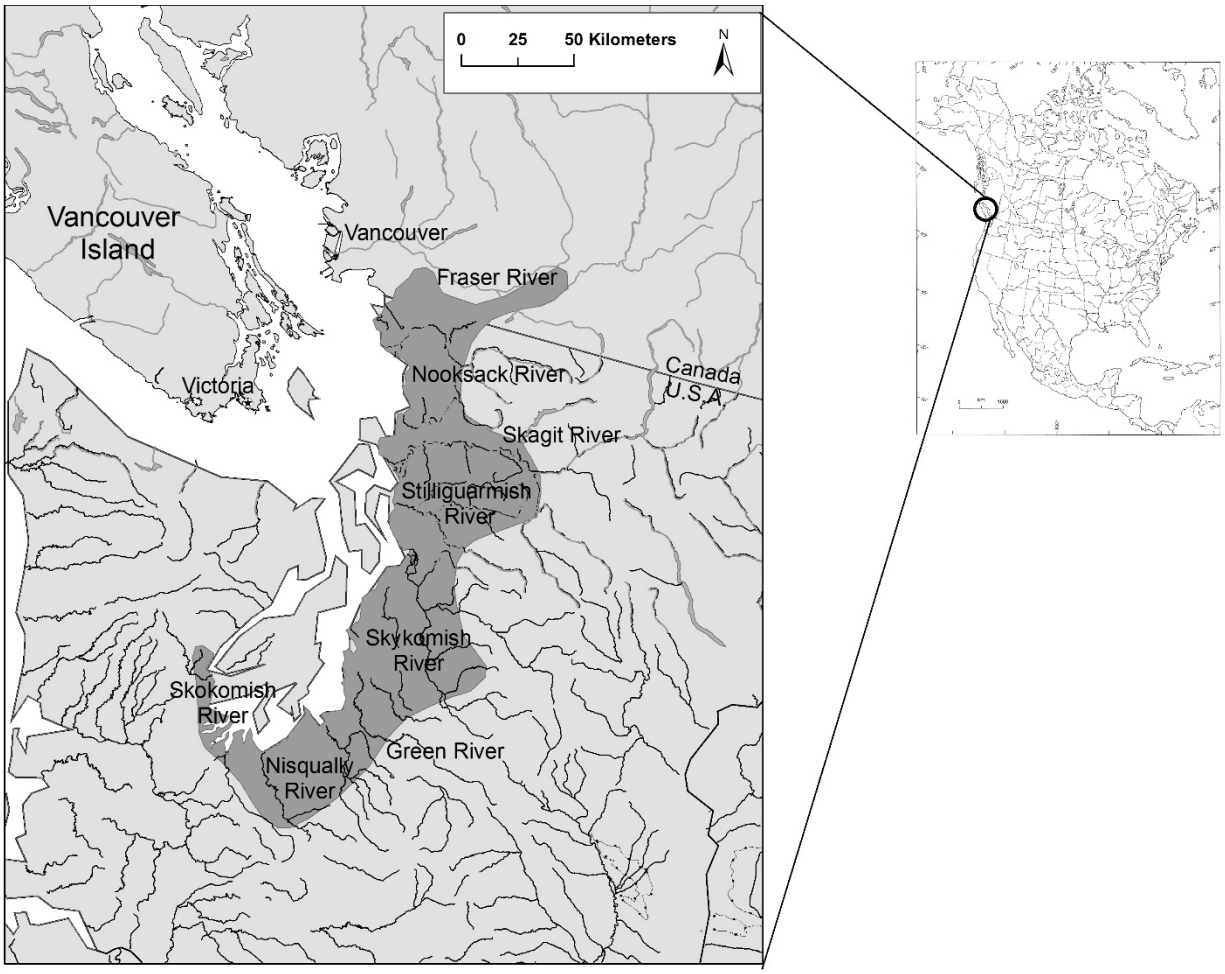

Figure 3. The global range of Salish Sucker is restricted to northern Washington State and the lower Fraser River Valley in southwestern British Columbia (adapted from McPhail 1987; McPhail and Taylor 1999; Molly Hallock, Washington Dept. Fish and Game, unpubl. data; COSEWIC 2012).

Canadian Range

The current Canadian range of Salish Sucker comprises about 5.9% (1,401 km^2) of the 23,912 km^2 global extent of occurrence. It is known from 13 watersheds in Canada, all in the lower Fraser River Valley of British Columbia (Table 2; Figures 4, 5, 6, 7, and 8). The entire range is within the Coastal Western Hemlock Biogeoclimatic Zone in streams flowing primarily through private lands.

Historical changes in the Canadian range are poorly documented, but significant reductions have certainly occurred over the past 150 years. The presence of Salish Sucker in Salwein Creek and Hopedale Slough suggests that it occupied Sumas Lake (Figure 6), into which these waterways flowed prior to drainage of the lake in the 1920s (Woods 2001). The lake's mix of marsh and shallow open water and its small, gravel-bottomed tributary streams would have provided excellent habitat. Anecdotal evidence also suggests the historical presence of Salish Sucker in a headwater wetland of Cave Creek (Bertrand Creek

tributary) prior to its drainage in the 1960s (Pearson 1998). Drainage of headwater wetlands was common, and agricultural and urban development transformed the Fraser Valley landscape. Longnose Sucker was recorded, but not retained, from Davis Lake (Table 3; Figure 4) when it was poisoned with rotenone in 1963 (FIDQ 2022). The subpopulation in the Little Campbell River was believed extirpated (Pearson 2004; McPhail 2007), as were subpopulations in Salwein Creek, Howe's Creek (Bertrand Tributary), and the lower Salmon River (Inglis *et al.* 1992), but the species' presence has since been reconfirmed in these areas (Pearson 2004). The Agassiz Slough subpopulation appears to have been recently extirpated. No Salish Sucker were captured in extensive sampling there in 2021, 2022, and 2023. Approximately 80% of the slough's length was dewatered during the extreme droughts of 2022 and 2023 (Pearson unpubl. data).

Table 2. Known subpopulations and locations (occupied watersheds) of Salish Sucker in Canada. Geographic locations of subpopulations are shown on Figures 5, 6, 7, and 8.

Watershed/ Location Number	Watershed/Location	Subpopulation	Subpopulation Number
1	Agassiz Slough	Agassiz Slough	1
2	Bertrand Creek	Cave Creek	2
2	Bertrand Creek	Mainstem/ Howes Creek	3
2	Bertrand Creek	Perry Homestead Creek	4
3	Sqemélwelh Creek	Chawathil	5
4	Chilliwack Delta	Chilliwack Delta	6
5	Fishtrap Creek	Fishtrap Creek	7
6	Hope Slough/Elk Creek	Hope Slough/Elk Creek	8
7	Little Campbell River	Little Campbell River	9
8	Miami Creek	Miami Creek	10
9	Mountain Slough	Mountain Slough	11
10	Pepin Creek	Pepin Creek	12
11	Salmon River	Salmon River	13
12	Hopedale Slough	Hopedale Slough	14
13	Salwein Creek	Salwein Creek	15

Table 3. Records of western Longnose Sucker, *Catostomus catostomus*, specimens from the lower Fraser River Valley from the Beaty Biodiversity Museum (BBM), and the Fisheries Information Summary System, FISS (Fisheries Inventory Data Queries, FIDQ 2022). Site numbers correspond to those shown on Figure 4. Beaty Museum records have voucher specimens and are known to not be Salish Sucker. FISS records have no voucher specimens and may have been Salish Sucker.

Site	Locality	Year	Source	Reference Number
1	Pothole in Fraser River floodplain 1.6 km west of Hope	1959	BBM	UBC60-0197
1	Fraser River 1.9 km west of Hope	1959	BBM	UBC60-0189
2	Kawkawa Lake, near Hope, of Wright's wharf	1951	BBM	UBC54-0271
3	Hope Coquihalla River near Fraser River	1956	BBM	UBC59-0023
4	Alouette Lake	1979	FIDQ	CLKS-1155, 03-AUG-1979
5	Alouette River	1988	FIDQ	HQ2030, 01-FEB-1998
6	Chilliwack Lake	1995	FIDQ	2FBSRY, 01-JAN-1995
7	Davis Lake	1963	FIDQ	BCLKS-1226, 01-JAN-1963
8	Pitt Lake	1991	FIDQ	HQ0435, 01-JUN-1991
9	Lower Pitt River	1994	FIDQ	EW070, 01-JAN-1994

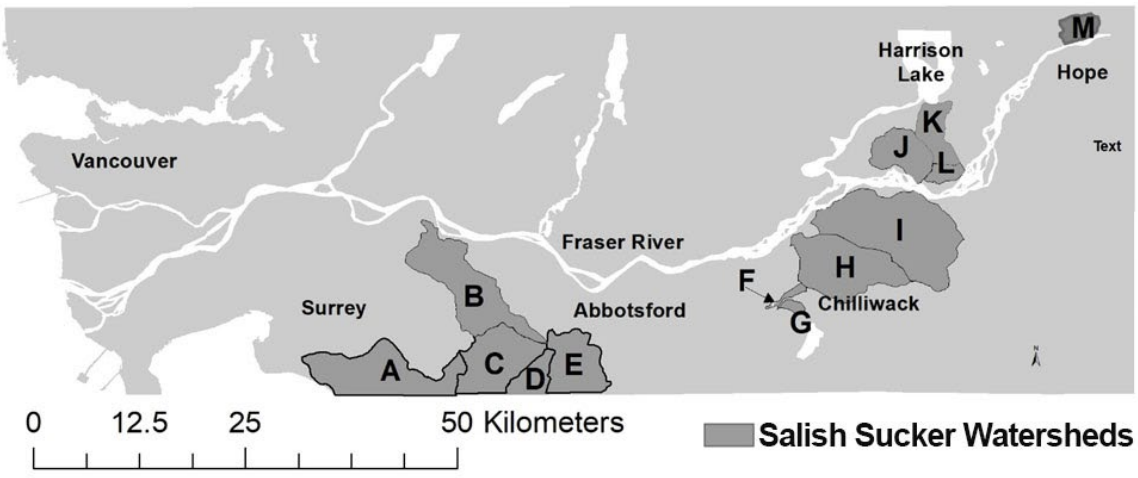

Figure 4. Fifteen subpopulations of Salish Sucker have been documented in Canada: the Little Campbell River (A, 2020), the Salmon River (B, 2022), Bertrand Creek (contains 3 subpopulations; C, 2021), Pepin Creek (D, 2022), Fishtrap Creek (E, 2019), Salwein Creek (F, 2023), Hopedale Slough (G, 2022), Chilliwack Delta (H, 2023), Hope Slough/Elk Creek (I, 2018), Mountain Slough (J, 2016), Miami Creek (K, 2023), Agassiz Slough (L, 2014), and Sqemélwelh Creek (M, 2023) (COSEWIC 2012).

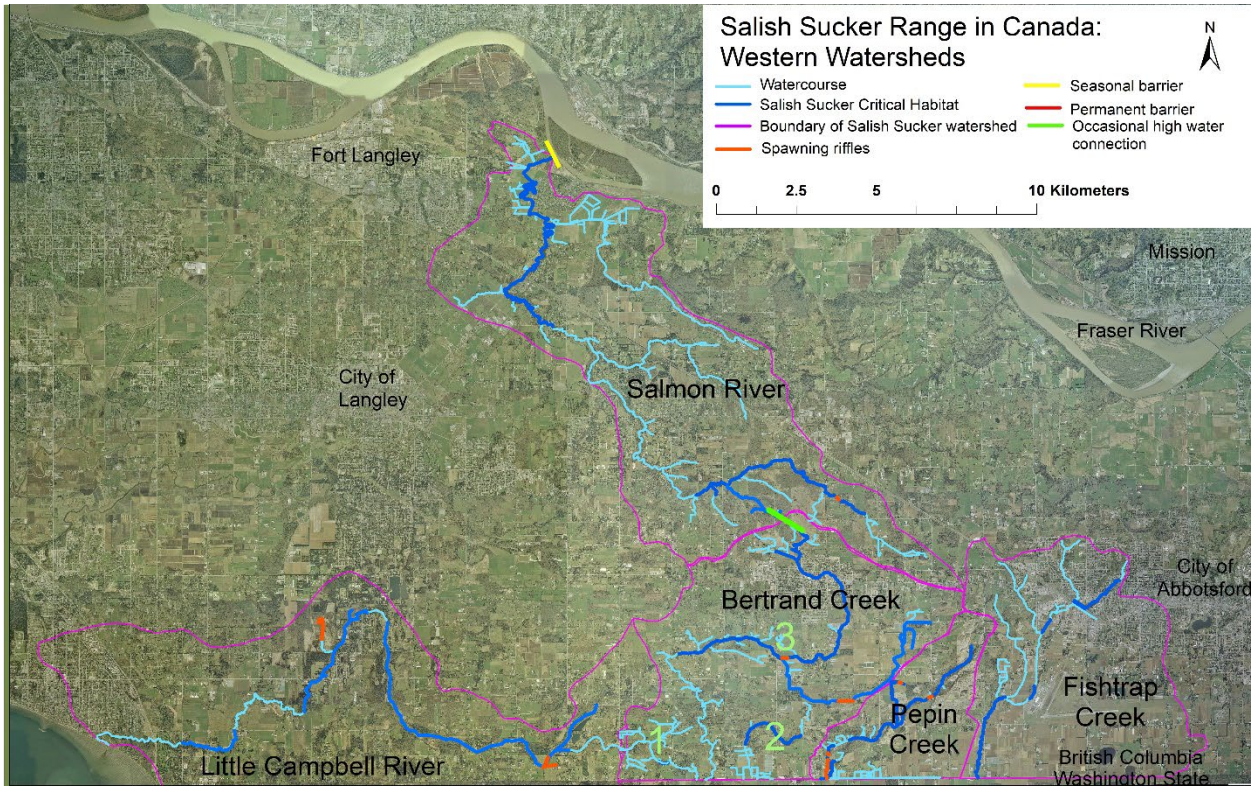

Figure 5. Western watersheds of the Salish Sucker range in Canada showing identified critical habitat (Fisheries and Oceans Canada 2020), known spawning riffles, barriers, and linkages between watersheds. The three Bertrand Watershed subpopulations are numbered: 1) Cave Creek; 2) Perry Homestead Creek; and 3) Howe's Creek/Bertrand mainstems.

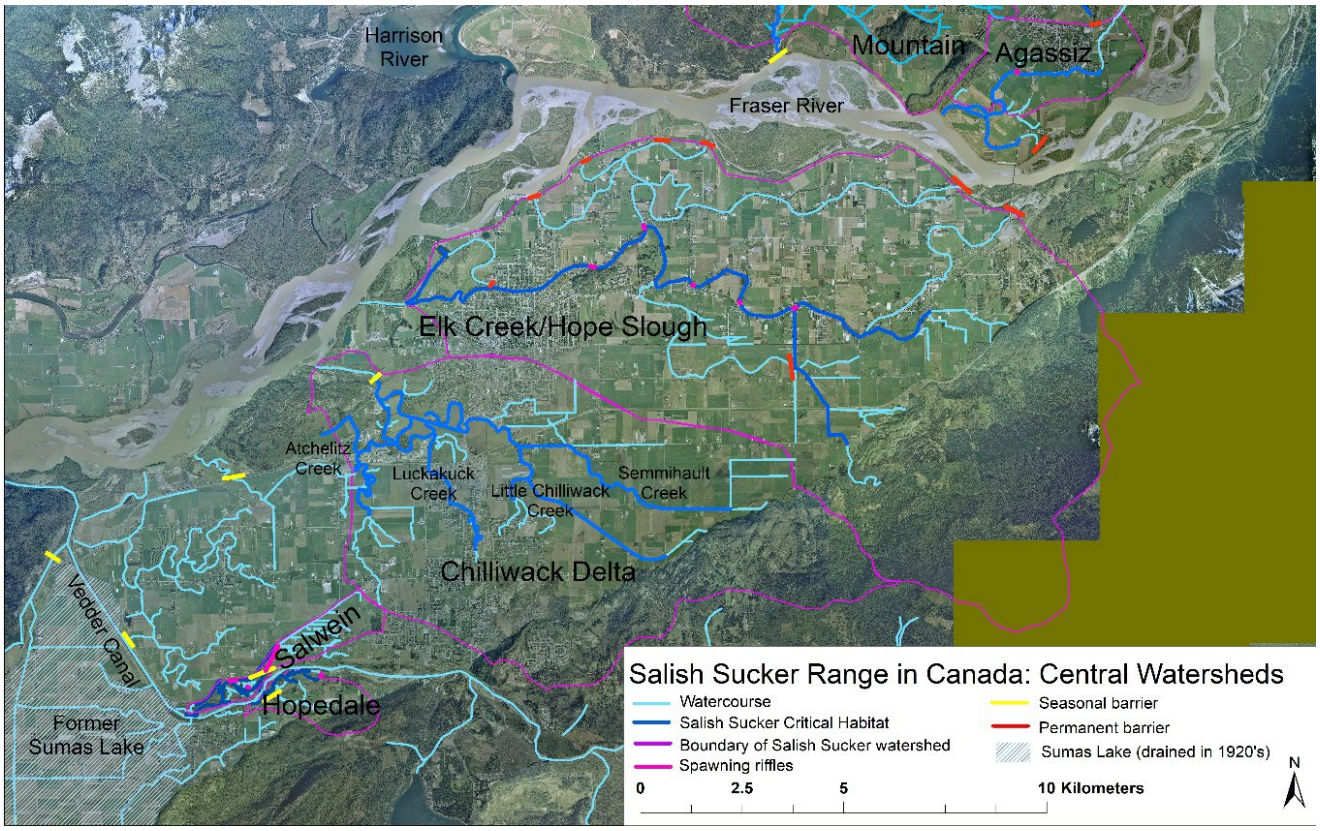

Figure 6. Central watersheds of the Salish Sucker range in Canada showing identified critical habitat (Fisheries and Oceans 2020), spawning riffles, barriers, and linkages between watersheds.

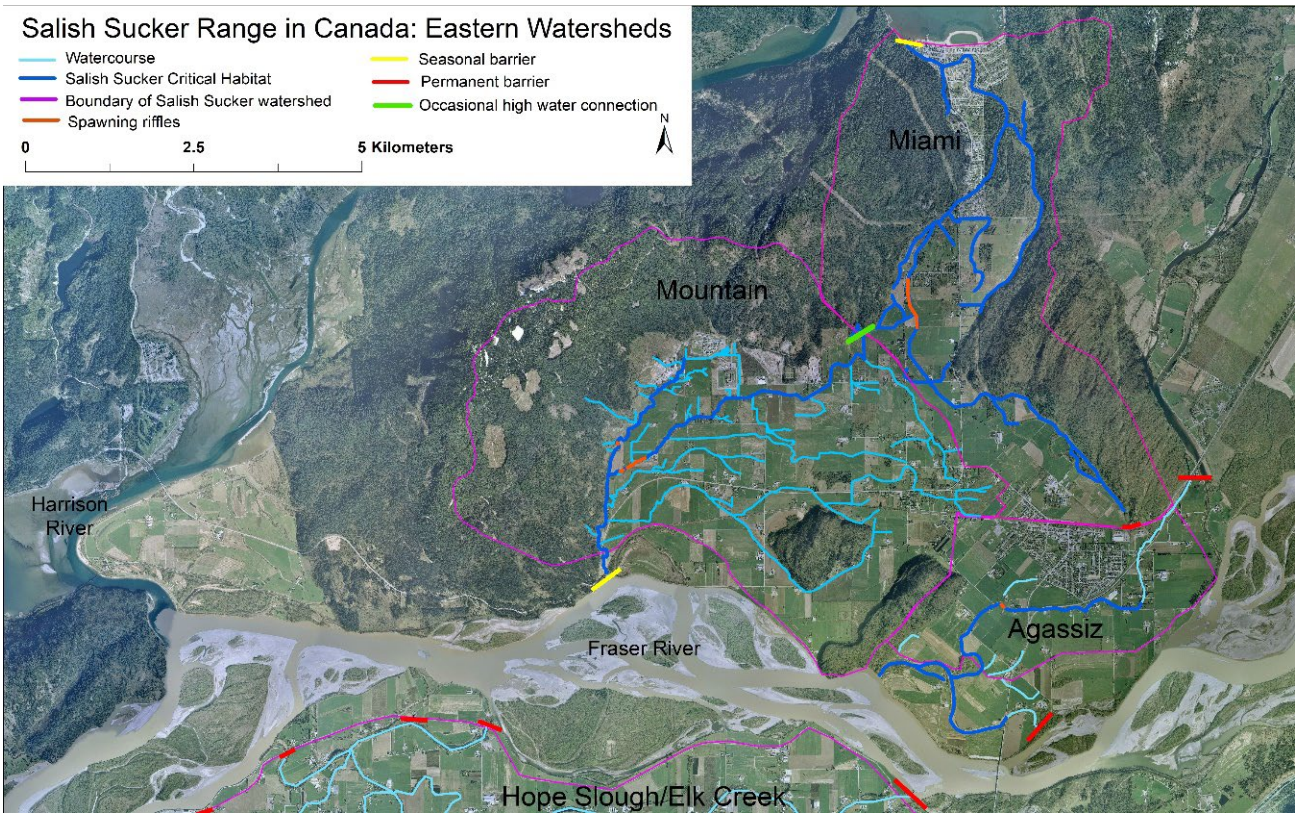

Figure 7. Eastern watersheds of the Salish Sucker range in Canada showing identified critical habitat (Fisheries and Oceans 2020), spawning riffles, barriers, and linkages between watersheds.

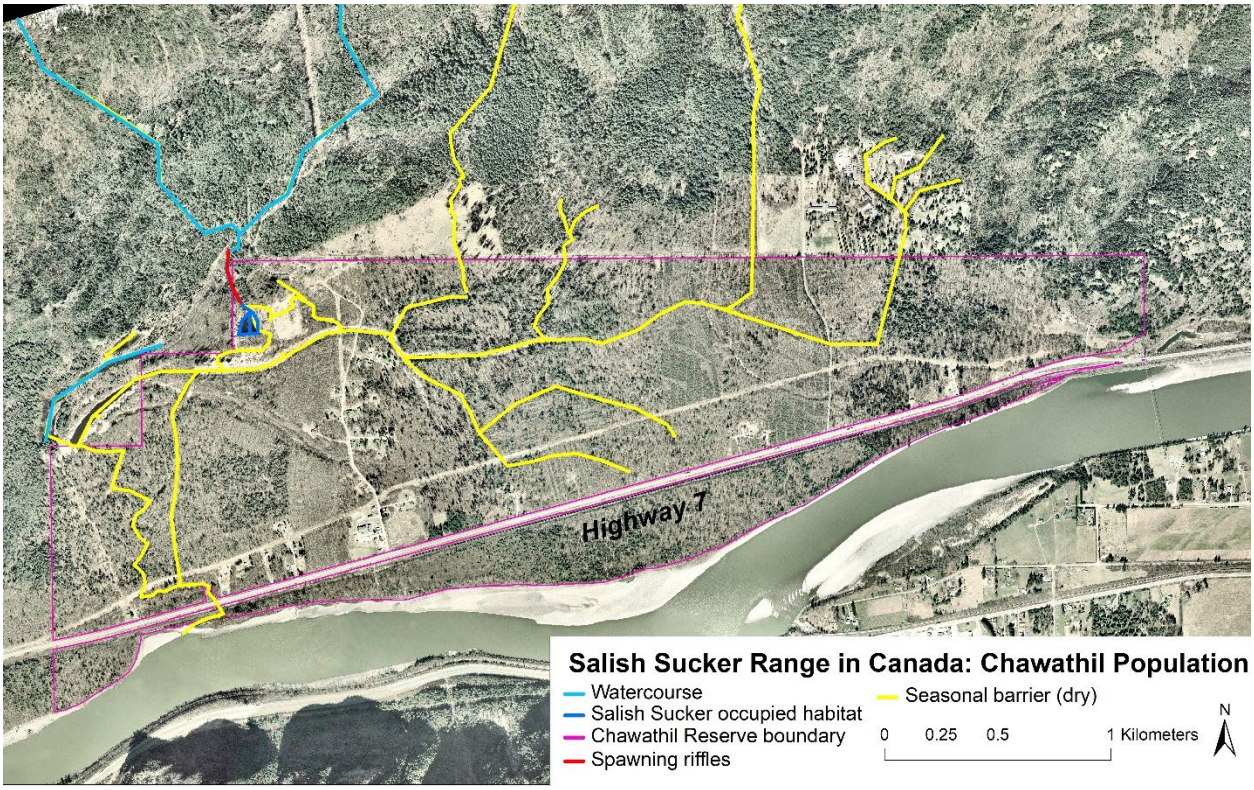

Figure 8. Sqemélwelh Creek at Chawathil Reserve 4, the most eastern watershed known to contain Salish Sucker in Canada, showing occupied habitat, spawning riffles, and barriers.

Table 4. Summary of essential functions, habitat, and detail of habitat for Salish Sucker in Canada by life stage.

Life stage[a]	Habitat function[b]	Habitat[c]	Detail of habitat[d]
Adult and 1+ juvenile	Rearing, feeding, overwintering, refuge	Deep pool habitat	Pools of > 50 m length and > 70 cm depth, adequate cover (macrophytes, wood), adequate quantity and quality of food (terrestrial and aquatic invertebrates), dissolved oxygen > 4 mg/L water temperature > 6 and < 20°C few or no anthropogenic nutrients or other harmful substances
Egg, adult	Incubation, spawning	Riffle habitat	Cobble or gravel substrate little or no additional sediment sufficient water velocity (> 25 cm/s) and flow to maintain riffles sufficient intragravel flow to maintain eggs dissolved oxygen >6.5 mg/L (eggs) dissolved oxygen > 4 mg/L (adults) water temperature > 6 and <20°C few or no anthropogenic nutrients or other harmful substances

Life stage[a]	Habitat function[b]	Habitat[c]	Detail of habitat[d]
Young of year	Rearing, feeding	Shallow pool and glide habitats	adequate cover (macrophytes, wood) water depth < 40 cm current velocity < 15 cm/s adequate quantity and quality of food (terrestrial and aquatic zooplankton and invertebrates) dissolved oxygen >4 mg/L water temperature > 6 and < 20°C few or no anthropogenic nutrients or other harmful substances
All	Spawning, incubation, rearing, feeding	Riparian habitat	Continuous riparian vegetation bordering entire length of aquatic habitat and extending laterally (inland) 5 to 30 m depending on stream characteristics in order to ensure the following functions: protect integrity of aquatic features such as riffle and pool habitats, provide large and small woody debris, provide bank stability, provide shade to buffer water temperatures, provide terrestrial insect input, limit entry of anthropogenic nutrients and other harmful substances, maintain natural channel morphology

[a] Life stage: stage of the life cycle of the species (e.g., seed; egg, seedling, juvenile, larva, pupa, adult).

[b] Habitat function: How a habitat supports a life-cycle process of the species (e.g., habitat that supports spawning, breeding, denning, nursery, rearing, feeding/foraging, migration, flowering, fruiting, seed dispersing, germinating, seedling development).

[c] Habitat: The structural or biological features of the area or type of site needed for a species to carry out its life processes.

[d] Detail of habitat: detailed information such as measurable properties or characteristics of the habitat.

*Adapted from original in recovery strategy (Fisheries and Oceans Canada 2020).

Salish Sucker has been known to western science in Canada since the 1950s. Most early work (1960s to 1980s) was conducted by McPhail (1987). He documented subpopulations in the Little Campbell River, the Nooksack River tributaries (Bertrand, Pepin, and Fishtrap creeks), and Salwein Creek. Considerable effort has been expended to locate additional subpopulations since then (Appendix 1). In 1992, 117 sites in 34 watersheds were sampled using minnow traps and electrofishing, but no additional subpopulations were found (Inglis *et al.* 1992). Pearson (2004) sampled 429 sites in 45 watersheds in 2000 using large funnel traps (Feddes traps). He found previously unknown subpopulations in Miami Creek, Agassiz Slough, and Hopedale Slough. Further sampling between 2001 and 2006 concentrating on adjacent watersheds documented subpopulations in Mountain Slough, Hope Slough/Elk Creek, and the former Chilliwack River Delta. Historical records of purported “Longnose Sucker” (without supporting physical evidence) are concentrated in the Pitt River watershed downstream of Pitt Lake (Table 3,

Figure 4). The Lower Pitt and Alouette rivers, along with Davis Lake, Chilliwack Lake, Hatzic Lake tributaries, Stave Lake tributaries, and Nicomen Slough and tributaries were surveyed in 2016 and 2017, but no additional subpopulations were found. In 2018, Pearson (unpubl. data) identified a subpopulation while conducting sampling for salmonids in Sqemélwelh Creek at Chawathil First Nation near Hope. Additional surveys in the few other potentially suitable water bodies in the Hope area were completed in 2023, but they found no Salish Sucker. A habitat enhancement project carried out by Fisheries and Oceans Canada (DFO) and a local stewardship group in 2019 connected Salwein Creek to Peach Creek, a small stream with wetlands confined between the Vedder River and a set-back dike. Two Salish Sucker were captured on the Peach Creek side in 2020 (Pearson unpubl. data).

Most potentially occupied water bodies in the Fraser Valley have now been sampled at least once for Salish Sucker using appropriate targeted methods (Appendix 1). However, additional undocumented subpopulations may exist, because Salish Sucker have proven difficult to detect when at very low densities and have been mistakenly thought extirpated from watersheds in the past (McPhail 1987; Pearson 2004).

Population Structure and Variability

Twelve of the 15 Salish Sucker subpopulations occur within separate tributaries of a major river (Fraser or Nooksack) or in a small river that enters the ocean independently (Little Campbell). The Bertrand Creek watershed contains three subpopulations each occupying a separate tributary or the upper mainstem and separated by more than 5 km of unsuitable habitat with no occurrence records. Salwein Creek and Hopedale Slough are tributaries on opposite banks of the Vedder River, which is shallow, rocky, and swift. The Vedder River is more than 120 m wide, and Salwein Creek enters it approximately 750 m downstream of Hopedale Slough. As Salish Sucker are unlikely to move between these habitats regularly, they are considered distinct subpopulations.

ND2 haplotypes separate Salish Sucker from other forms of western Longnose Sucker. One of these haplotypes is unique to Pepin Creek (Nooksack drainage), while the other was found in the two Fraser River subpopulations and four Washington State subpopulations examined (McPhail and Taylor 1999).

Extent of Occurrence and Area of Occupancy

Current EOO:

Extent of occurrence (EOO) within Canada is 1,401 km^2, calculated using a minimum convex polygon that encompasses known records in all occupied watersheds (Figure 9) and excluding Washington occurrences. The decrease from the EOO of 1,709 km^2 calculated in the previous status report (COSEWIC 2012) is due to previous mapping errors whereby aquatic habitat in an occupied watershed outside the polygon formed by occurrence records was included. The reduction was partially offset by a range extension resulting from the discovery of the Sqemélwelh Creek subpopulation in 2018. All localities have been confirmed as extant since 2014 except Hope Slough, and its exclusion did not affect the calculation of the EOO. Salish Sucker is believed to have been extirpated from Agassiz Slough sometime after 2013, but this did not affect the EOO either.

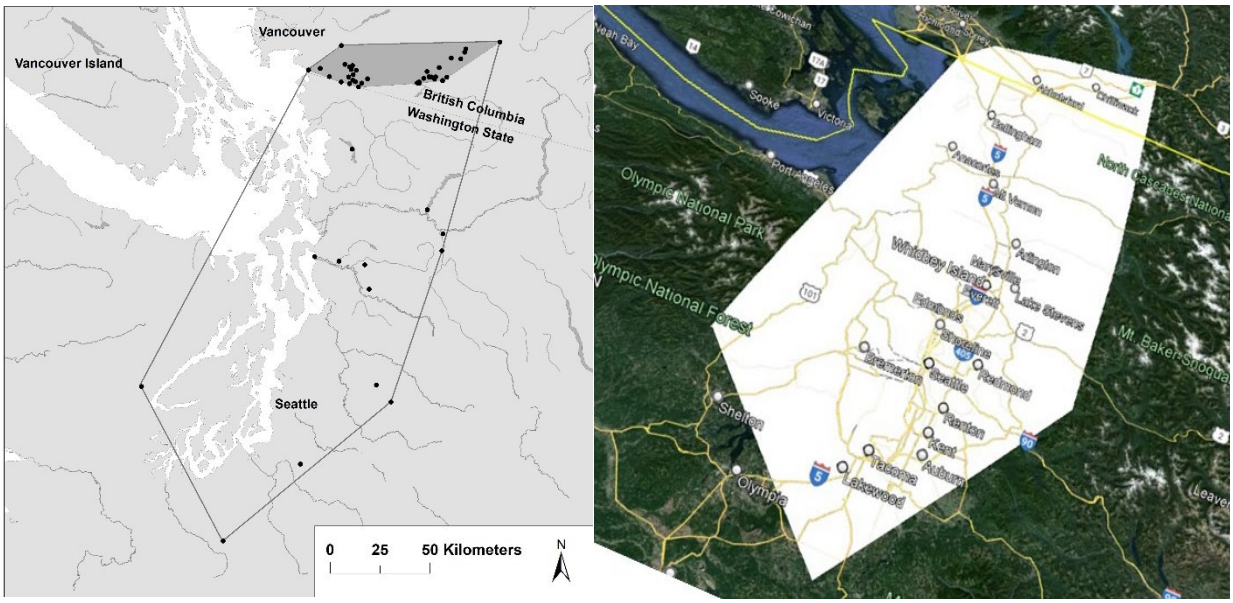

Figure 9. The global extent of occurrence of Salish Sucker based on a minimum convex polygon drawn around confirmed locations encompasses 23,912 km^2, of which 1,401 km^2 (5.9%) is in Canada.

Current IAO:

The index of area of occupancy (IAO) within Canada is 252 km^2, calculated using a 2 x 2 km grid drawn over known records based on continuous stretches of river between the observation records (Continuous IAO). For Salish Sucker, however, the IAO provides a very poor estimate of actual area of occupancy and of threats to persistence, as the stream habitats the fish occupy are typically only a few metres wide. The total area of deep pool habitat (> 70 cm depth) in critical habitat was estimated at 0.48 km^2 by Pearson (2007); however, this number included large areas in which there is no evidence of Salish Sucker occupation. Since then, the Little Campbell River subpopulation was rediscovered, and the Sqemélwelh Creek subpopulation was discovered, both of which are very small and restricted to a small fraction of their watersheds. However, Salish Sucker is now believed to be extirpated from Agassiz Slough, a headwater wetland in Bertrand Creek, and from most of the area they previously occupied in the Salmon River mainstem. Salish Sucker do use additional habitat types—shallower pool habitats as young-of-the-year and riffles for spawning—but the actual area of occupancy is highly unlikely to exceed 1 km^2 of aquatic habitat in Canada.

Fluctuations and Trends in Distribution

Estimates of EOO and IAO have generally increased over time as additional subpopulations have been discovered. However, temporary reductions in estimates also occurred as subpopulations in the Little Campbell River and Chilliwack Delta (Atchelitz Creek) were falsely considered extirpated for several decades (see **Canadian Range** for full discussion). IAO has declined recently due to the suspected extirpation of Salish Sucker from Agassiz Slough and portions of Bertrand Creek and Salmon River.

BIOLOGY AND HABITAT USE

Life Cycle and Reproduction

Salish Sucker is a small-bodied, short-lived (to 5 years), and early-maturing (2 years) fish relative to most other Longnose Sucker populations (McPhail 1987; Pearson and Healey 2003). Generation time is estimated to be 3 years. In more typical, large-bodied populations, lifespan may be 30 years, with maturation occurring at 5–7 years (McPhail 2007). 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 substrate surface are usually consumed, but many are swept under the gravel and cobble where they are more protected (McPhail pers. comm. 1998). Time required for egg hatching and fry emergence 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°C to 7 days at 16°C, and fry remain in the gravel for an additional 1–2 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; LePage 2014). Adults are believed to spawn in multiple years (McPhail 1987). Pearson and Healey (2003) speculated that females may sometimes spawn twice in a season, with eggs maturing early in one ovary and later in the other. This strategy, which increases fecundity in small-bodied fishes (Burt *et al.* 1988), would explain the protracted (3.5-month) spawning period observed in Salish Sucker.

Habitat Requirements

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

Pearson (2004) studied habitat use at the watershed, reach, and channel unit scales in 10 of the 13 watersheds where Salish Sucker occur in Canada. Among the 6 watersheds in which he was able to estimate abundance, mean density was highest (> 450 fish/km) in Pepin Creek, which also had the highest percentage of deep pool habitat, the lowest proportion of shallow pool habitat, and highest proportion of forest cover within 200 m of the channel. Watersheds with high densities (> 100 fish/km) contained less shallow pool habitat and seasonally dry channel.

Salish Sucker is found in reaches with 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. The proportion of deep pool habitat in a reach was a strong predictor of presence and often associated with beaver dams. Salish Sucker presence was also positively associated with the occurrence of riffle habitat in a reach, but these fish were not found in reaches with high proportions of riffle habitat (Pearson 2004).

Spawning occurs in gravel riffles at water velocities of 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. Large (yearling) juveniles occupy similar habitats to adults (Pearson 2004a). Riffle locations and area are very limited in the very low-gradient streams supporting many of the subpopulations (Pearson 2004). Although riffles are required for spawning and egg incubation, a relatively small amount of riffle habitat is needed to support large areas of juvenile and adult habitat. It is also likely that groundwater upwelling areas can be used for spawning because no riffle habitat is available to the Agassiz Slough subpopulation.

In winter, fish seek low velocity habitats with abundant cover. Beaver ponds and marshes are most commonly used, but agricultural or roadside ditches (often < 2 m wide) that are completely dry for months during summer may be occupied in winter (Pearson unpubl. data).

Movements, Migration, and Dispersal

Within watersheds, Salish Sucker subpopulations 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 2004). Hotspots may appear, disappear, or move through the watershed in response to habitat changes due to disturbance and succession. The pattern is consistent with a metapopulation structure (see Brown *et al.* 1995), in which groups of local subpopulations are loosely linked by occasional migrants (Pearson and Healey 2003). Whether these aggregations function as metapopulations depends on the frequency of migration between them. Migration rates are dependent on the spatial arrangement of hotspots and the difficulty in traversing the habitat between them due to physical obstructions or unsuitable habitat (e.g., large open channels, poor water quality).

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** and Pearson 2004). Pearson and Healey (2003) radio-tagged 18 adults in a Pepin Creek beaver pond and followed them for up to 153 days, locating fish a total of 730 times. Fish crossed the beaver dam on only three occasions, although all used the pond, and many ventured hundreds of metres upstream of it. This is consistent with findings of other studies on impacts of beaver 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 Sucker marked in the beaver pond in October 1999 and 2 of 103 marked in March 2000 were captured in a fish fence 1,020 m downstream in a newly constructed tributary in spring 2000. Most were in reproductive condition when recaptured. Seven were subsequently recaptured within the tributary one or more times, always in the largest deepest available pool, a further 600 m upstream (Patton 2003).

Salish Sucker may also move off the main channel to overwinter and have been found up to 1.7 km from the mainstem in habitats that are dry in summer (Pearson unpubl. data).

Radio-tracked adults (Pepin Creek, n = 18) occupied summer home ranges (95% of locations) varying from 42 to 307 linear metres of stream (mean = 177; standard error of the mean, SEM = 24) and from 212 to 1,736 m^2 in 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. Movements were greatest around dawn and dusk, although activity continues throughout the night (Pearson and Healey 2003).

Salish Sucker often occurs, and presumably moves, in aggregations. Typically, the great majority of individuals captured at a site are found in a small proportion of traps, sometimes a single trap, even if multiple traps are set in similar habitats (Pearson 2004). At a very few sites (one known at present), individual overnight trap sets may reliably capture more than 100 adults from spring through fall. Sex ratios within large catches are often heavily skewed towards either males or females (Pearson pers. obs.).

Adult Salish Sucker readily colonize newly available suitable habitats (Patton 2003), but details of juvenile dispersal remain unknown. Many historical dispersal routes potentially linking subpopulations have been blocked by flood control infrastructure (see **Threats**). Currently, occasional dispersal between Canadian subpopulations may occur in three areas, although none are likely to be used regularly. A headwater marsh of Bertrand Creek that supports a high density of Salish Sucker may connect to the upper Salmon River (Figure 5), which also contains another subpopulation, under extreme high-water conditions. Salwein Creek and Hopedale Slough outlets are on opposite banks of the fast-flowing Vedder River just a few hundred metres apart. A headwater pond near the town of Agassiz has permanent connections to both Mountain Slough and Miami Creek that are accessible to fish at least seasonally (Figure 7; Pearson pers. obs.). Dispersal is also possible between Fishtrap Creek and its tributary Pepin Creek via Washington State, just as dispersal is possible from Fishtrap Creek to its neighbouring tributary to the Nooksack River, Bertrand Creek. In these cases, though, the Canadian subpopulations are separated by long stretches of unsuitable habitat in Washington, reducing the likelihood of migration (McPhail 1987; Wydoski and Whitney 2003; Pearson 2004).

Interspecific Interactions

Diet:

Adults feed on benthic insects, particularly chironomid larvae (McPhail 1987), although they likely eat a broad range of invertebrate taxa as do other *C. catostomus* populations (McPhail 2007; Furey *et al.* 2020). Detritus often forms a high proportion or majority of stomach contents in other *C. catostomus* populations (LePage 2014; Furey 2020). The diet of young-of-the-year Salish Sucker is undocumented but presumably consists of zooplankton, which is similar to the diet of other juvenile catostomids (McPhail 2007).

Predators and competitors:

Predation risk for adult Salish Sucker is probably quite low. Most avian predators would have little success in the deep, heavily vegetated habitats they favour, although piscivorous waterfowl may take some of these fish (see Beckman *et al*. 2006). No coexisting predatory fishes are large enough to consume them. Mink (*Mustela vison*) and River Otters (*Lontra canadensis*) are known to prey on Salish Sucker (Pearson pers. obs.). Young-of-the-year Salish Sucker are probably eaten by a variety of native fishes, including Coastal Cutthroat Trout (*Oncorhynchus clarkii*), Rainbow Trout (*Oncorhynchus mykiss*), and Northern Pikeminnow (*Ptychocheilus oregonensis*), and by the introduced Brown Bullhead (*Ameiurus nebulosus*). Great Blue Heron (*Ardea herodias*) and Belted Kingfisher (*Megaceryle alcyon*) likely consume some. Introduced Largemouth Bass (*Micropterus salmoides*) could take larger juveniles and adults. Juvenile Largescale Suckers are potential competitors. They are caught occasionally with Salish Sucker, generally in low numbers, and they seem unlikely to impact Salish Sucker subpopulations.

Host/parasite/disease interactions:

Salish Sucker are commonly infected by a trematode, *Uvulifer* sp. (“blackspot”; Pearson pers. obs.). Low level infections occur across the range, but occasionally individuals show intense, potentially debilitating infections in warmer, sun-exposed reaches of Upper Salmon River and Bertrand Creek mainstem, which contain abundant aquatic snails (Pearson pers. obs.), an intermediate host (Hoffman 1967).

Other interactions:

Salish Sucker have a complex relationship with North American Beaver (*Castor canadensis*). Local abundances are highest in reaches with beaver ponds, 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 some occupied reaches (Pearson 2004). Beaver ponds, however, also tend to be chronically hypoxic (Schlosser 1998; Snodgrass and Meffe 1998), especially in areas subject to nutrient loading and eutrophication from agricultural sources (Rosenfeld *et al.* 2021). The combination of a physical barrier and critically low oxygen produces occasional catastrophic mortality events (Pearson 2004; Rosenfeld *et al.* 2021).

Salish Sucker has been found with 16 species of fishes and amphibians. Of the 12 species caught frequently enough to permit statistical analysis, only Coho Salmon (*Oncorhynchus kisutch*) occurred with Salish Sucker more frequently than would be expected by chance (Pearson 2004), likely due to similar habitat preferences.

Although there is no evidence of hybridization in Salish Sucker*, C. catostomus* in some populations naturally hybridize with other catostomid species (McPhail 2007; Mandeville *et al.* 2017). Hybridization with *C. macrocheilus*, the only other catostomid found in Salish Sucker habitat, has not been documented (McPhail 2007).

Physiological, Behavioural, and Other Adaptations

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 high fecundity relative to body size facilitate rapid population growth and recovery from short-term, limited-area disturbances (Winemiller and Rose 1992). These characteristics should allow subpopulations to recover quickly in response to habitat creation/enhancement efforts (Pearson and Healey 2003).

Salish Sucker are active at temperatures as low as 7°C (Pearson and Healey 2003). Rosenfeld and coworkers (2021) looked at water temperature and dissolved oxygen (DO) in relation to 8,583 Salish Sucker captures in 7,473 trap sets across the Canadian range. Catch per unit effort (CPUE, average number per trap) was highest between 12°C and 20°C, dropping sharply outside this range, at higher temperatures in particular. Salish Sucker were most likely to be caught in reaches where temperature was between 12 and 16°C (Figure 10).

Salish Sucker are tolerant of mild (3.5–5 mg/L) or moderate (2.5–3.5 mg/L) hypoxia. Adults are regularly captured alive in waters containing less than 3 mg/L DO (Pearson 2004; Rosenfeld *et al.* 2021). Although the presence of Salish Sucker was significantly more likely in traps in water with 4–8 mg/L DO, fish were also commonly found in areas of severe hypoxia (< 2.5 mg/L; Figure 10). This is likely due to lack of options, with fish unable to escape areas of hypoxia which are large and widespread in summer across most of their range (Pearson 2015a; Rosenfeld *et al.* 2021). They have been found dead in traps set in water containing < 1 mg/L dissolved oxygen, which suggests that they venture into these environments temporarily to forage (Pearson 2004). Sublethal impacts occur at moderate hypoxia levels. Growth was reduced by 23% in Salish Sucker at 3.1 mg/L DO relative to 9.1 mg/L, although lower temperature at the lower dissolved oxygen level confounded results (Zinn *et al.* 2021). Salish Sucker use of an oxygenated refuge also increased under hypoxic conditions (Zinn *et al.* 2021). Evolution of small-bodied forms of otherwise larger freshwater fish species has been linked to selective pressure for hypoxia tolerance to allow exploitation of otherwise productive habitats (Landry *et al.* 2007). This has been reported for another *Catostomus* sp. cf. *catostomus* population (Lepage 2014).

The United States Environmental Protection Agency categorized *C*. *catostomus* as having “intermediate” pollution tolerance (COSEWIC 2012), although these data no longer appear to be publicly available. Tolerance to specific pollutants remains largely unknown. Pearson (2004) found that Salish Sucker was 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 stormwater outfalls.

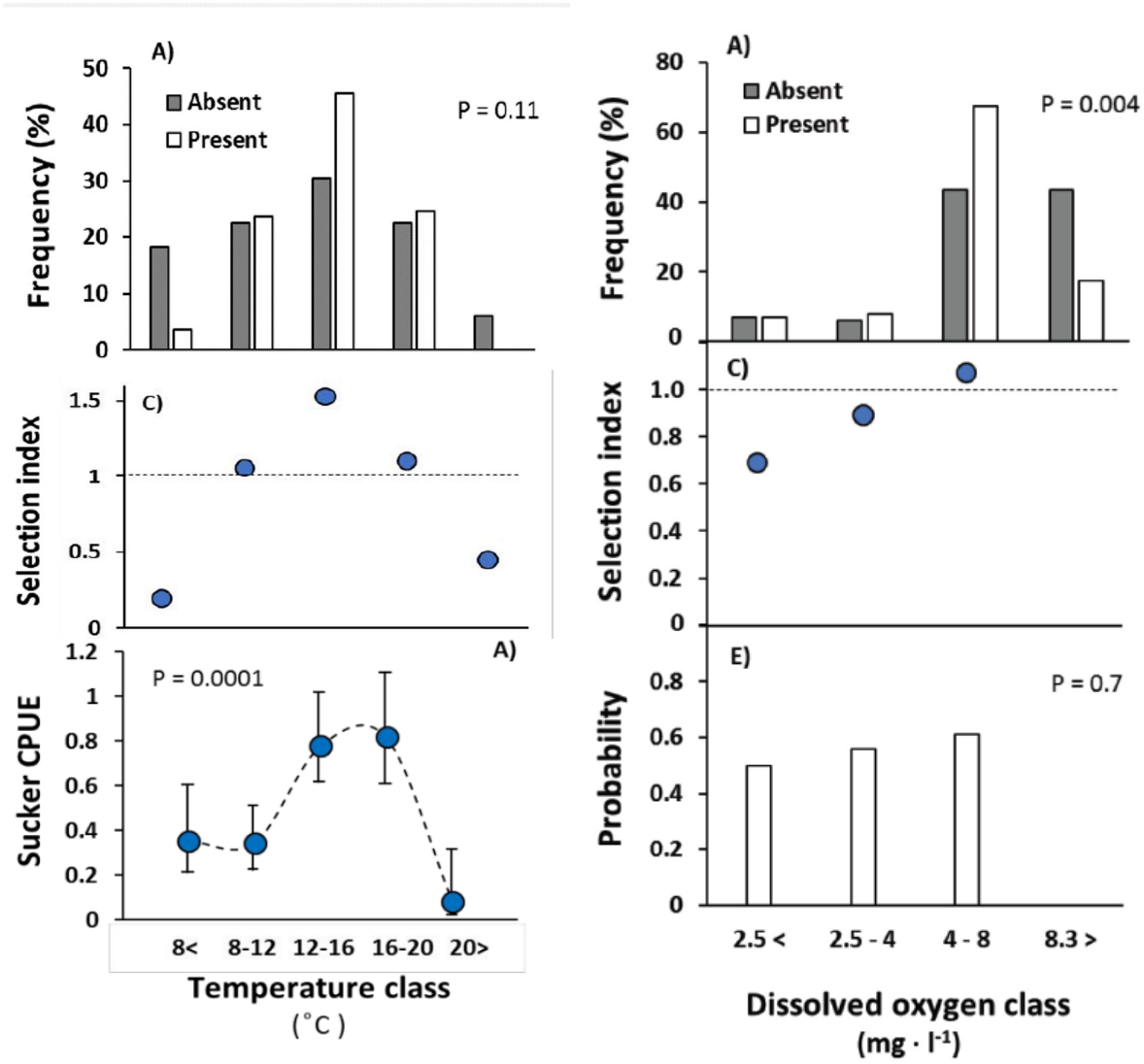

Figure 10. Salish Sucker catches from 7,473 trap sets, across 226 stream reaches, over 16 years (2003–2018) in relation to water temperature (left) and dissolved oxygen (right). Top panels show frequency of presence in reaches set in different temperature ranges. Middle panels show evidence of selection (> 1) and avoidance (< 1) of these ranges. The lower graph left shows catch per unit effort (CPUE, mean number of fish/trap) in relation to temperature. The lower right graph shows that probability of capture does not differ significantly across dissolved oxygen classes. Adapted from Rosenfeld *et al.* (2021).

Limiting Factors

Limiting factors are generally not human-induced and include intrinsic characteristics that make the species less likely to respond to conservation efforts. Limiting factors may become threats if they result in population decline.

Apart from an extremely limited post-glacial distribution which may represent a natural limiting factor, there do not appear to be any intrinsic factors that make Salish Sucker less likely to respond to conservation efforts. In fact, Salish Sucker are relatively tolerant of hypoxia, the main threat they face, and they have a high intrinsic rate of population growth (Pearson and Healey 2003), enabling subpopulations to recover quickly from short-term disturbances of limited spatial scale when habitat conditions improve. The decline of Salish Sucker is occurring because of worsening, large-scale, unmitigated threats, not intrinsic limiting factors.

POPULATION SIZES AND TRENDS

Data Sources, Methodologies, and Uncertainties

Between 2000 and 2008, most subpopulation estimates were made using an equation relating CPUE to population density estimated from mark-recapture studies at four sites in three streams (see **Appendix 2** for detailed methodology). An additional five mark-recapture studies were completed in 2012 to refine the method. Linear regression of log-transformed density and CPUE showed that only 40% of the variation in density was explainable by variation in CPUE, which severely limits the precision of watershed-scale abundance estimates. All subsequent estimates have been made using watershed-scale mark-recapture data (Table 2). Mark-recapture methods are also detailed in **Appendix 2**.

Abundance

Available subpopulation estimates for Salish Sucker range from well under 100 adults to the low thousands (Table 5). There are no “snapshot” estimates of the total Canadian Salish Sucker population from a single year. Mark-recapture-based estimates are time consuming (> 75 field days for Chilliwack Delta alone), so only a few watersheds are completed in any one year, and up to a decade elapsed between estimates for some subpopulations. Abundance has never been estimated in some subpopulations (Hope Slough, Fishtrap Creek) due to extremely low catch rates.

Table 5. Estimates of Salish Sucker abundances unlikely to be exceeded, by watershed. Estimates are based on data and reasoning presented in the Fluctuations and Trends section.

Watershed	Estimation of Likely Maximum Abundance	Relative Uncertainty
Agassiz Slough	0	low to moderate
Bertrand Creek	900	moderate
Chilliwack Delta	2,500	moderate
Fishtrap Creek	50	low
Hope Slough/Elk Creek	100	moderate
Hopedale Slough	500	moderate
Little Campbell River	300	low to moderate
Miami Creek	325	low
Mountain Slough	100	moderate
Pepin Creek	1,100	moderate
Salmon River	500	moderate
Salwein Creek	300	moderate
Sqemélwelh Creek	25	low
Total	**6,750**	**moderate**

The most recent abundance estimates and CPUE data suggest that drastic declines have occurred in multiple subpopulations over the past decade. Available information is summarized for each subpopulation/location in the **Fluctuations and Trends** section. An estimate of the abundance that each subpopulation is unlikely to exceed appears in bold type at the end of each watershed summary. These upper estimates total 6,700 adults across the range (Table 5), with over 75% of the total estimate coming from just four watersheds.

Fluctuations and Trends

Continuing decline[1] in number of mature individuals:

The number of mature Salish Sucker individuals has undergone, and continues to undergo, a clear decline across most of its range. One subpopulation (Agassiz Slough) is believed extirpated, and steep declines in abundance have been observed over the past decade in six other subpopulations/locations. The overall trend is clearly a decline and, given expected trends in threats, particularly climate change, the trend is likely to continue.

[1] A recent, current, or projected future decline (which may be smooth, irregular or sporadic), which is liable to continue unless remedial measures are taken. Fluctuations will not normally count as continuing declines.

Evidence for decline over the past 10 years:

There is evidence of extreme declines in abundance in six subpopulations/locations: Agassiz Slough (100%), Bertrand Creek Mainstem/Howe's Creek (approx. 95%), Mountain Slough (85%), Pepin Creek mainstem (85%), Salmon River mainstem (86%), and Sqemélwelh Creek (95%) over time periods ranging from 2014–2016 (Mountain Slough) to 2002–2022 (Pepin Creek mainstem) (Table 6), although a few subpopulations appear to have been fairly stable over the past decade. Details are provided for each later in this section.

Total overall decline in number of Salish Sucker adults within Canada over the past 10 years was estimated using data from 18 sites from 9 subpopulations for which abundance was estimated at two time points. Because survey intervals varied among sites (averaging 9 years but ranging from 2 to 20 years), two methods were used to standardize percentage change for each subpopulation to a 10-year period (Table 6). The first method calculated the annual change in subpopulation abundance between the two time periods, used it to project the subpopulation abundance forward 10 years, and then calculated the 10-year percentage change weighted by the abundance of each subpopulation. Using this method, the 10-year decline was estimated to be 45.8%. The second method used the IUCN (2024) Criterion A Workbook to back-calculate the abundance of each subpopulation to 2014, project subpopulation abundance to 2024, and sum projected abundances for each subpopulation. Using data from all sites for which abundance was available at the two time points, the 10-year change was -74.2% (Table 6). However, because the IUCN method is biased by very high rates of decline, Sqemélwelh Creek (which showed a 95% decline between 2019 and 2022 due to almost complete dewatering of the habitat in 2022) was removed as an outlier. Without Sqemélwelh Creek, the 10-year decline calculated with the IUCN method was 34.3%. Given the exclusion of Sqemélwelh Creek—as well as several sites where abundance at one or both time periods was unknown but where there are concerns for the species (e.g., Cave Creek, Perry Homestead Creek, Semmihault Creek; see below)—34.3% appears to be a conservative estimate of decline.

Evidence for projected or suspected future decline (next 3 generations or 10 years, whichever is longer, up to a maximum of 100 years):

Declines are clearly being driven by landscape-scale hypoxia (Rosenfeld *et al.* 2021) and extreme weather (drought and potentially temperature). These threats are episodic in nature and non-linear in impact, making specific projections very difficult. Nutrient loading will continue to increase with livestock density in the Fraser Valley. The rate of increase in nutrient loading is determined largely by supply management of dairy and poultry linked to human population growth. When human population increases, demand for these products increases, marketing boards increase production quotas, and farmers increase herd/flock size (Heminthavong 2018). However, they continue to use the same area of land for manure disposal. The frequency and severity of severe heat waves and drought are increasing (see **Threats**). With the overall threat impact to Salish Sucker considered Very High, overall declines of 50%–100% seem likely under these conditions.

Table 6. Summary of estimated changes in Salish Sucker abundance in all occupied watersheds using two methods to account for changes in abundance recorded over various time periods in different subpopulations. The "#1 Abundance weighted change" method calculated the annual subpopulation growth rate ("Annual Instantaneous GR (r)") between Year A and Year B, used it to project the subpopulation abundance forward 10 years ("N Pop 10 years"), and calculated the % change over 10 years ("%Pop Change 10 years") as the difference between "Abundance A" and "N Pop 10 years," using "abundance weighting" to correct each % change for the abundance of the population. The "#2 Pop Estimate" method used the IUCN method (https://www.iucnredlist.org/resources/criterion-a) to back-calculate the abundance of each subpopulation to 2014 and project subpopulation abundance to 2024; the projected abundances for each subpopulation were then summed, and the difference in % change was calculated. The 10-year % change including all subpopulations was -74.2%. However, because the IUCN method is biased by very high rates of decline, Sqemélwelh Creek was removed as an outlier. If abundance estimates were not available for Year B, abundance for Year A is included in the table *(in parentheses)* but excluded from the calculations. Details and data sources are provided, by watershed, in the Fluctuations and Trends section. Note that not all subpopulations have trend data available so numbers here may differ from those in Table 5.

Watershed	Location/Area	Year A	Abundance A	Abundance weighting	Year B	Abundance B	Annual Instantaneous Growth Rate (r)	Annual Multiplicative GR (lambda)	N Pop 10 years	% Pop Change 10 years	#1 Abundance weighted change	Year Diff First Survey to 2014	Year Diff First Survey to 2024	#2 Pop Estimate Pred 2014	#2 Pop Estimate Pred 2024	Comment
Agassiz	Agassiz Slough	2012	807	0.087	2021	0	-1.51	0.22	0.00	-100.00	-8.71	2.00	12.00	39.29	0.00	CPUE
Bertrand	Mainstem	2013	703	0.076	2021	7	-0.58	0.56	2.21	-99.69	-7.56	1.00	11.00	395.11	1.24	CPUE
	Howe's Cr	2013	329	0.036	2020	31	-0.34	0.71	11.26	-96.58	-3.43	1.00	11.00	234.77	8.04	CPUE
	Cave Cr	2019	*(315)*		2022	Unknown										
	Perry Homestead Cr	2017	*(570)*		2022	Unknown										
Chilliwack	Atchelitz	2015	239	0.026	2022	579	0.13	1.13	846.00	253.97	6.55	-1.00	9.00	210.62	745.54	MR
	Little Chilliwack	2015	351	0.038	2022	209	-0.07	0.93	167.36	-52.32	-1.98	-1.00	9.00	377.98	180.22	MR
	Interception Ditch	2015	739	0.080	2023	42	-0.36	0.70	20.51	-97.23	-7.75	-1.00	9.00	1057.59	29.35	CPUE
	Luckakuck	2014	378	0.041	2023	1103	0.12	1.13	1,242.37	228.67	9.33	0.00	10.00	378.00	1242.37	MR
	Semmihault	2015	*(547)*		2022	Unknown										
Fishtrap	Fishtrap Cr	2013	Unknown		2015	Unknown										CPUE
Hope	Hope Slough/Elk Cr	2015	Unknown		2018	Unknown										CPUE

Watershed	Location/Area	Year A	Abundance A	Abundance weighting	Year B	Abundance B	Annual Instantaneous Growth Rate (r)	Annual Multiplicative GR (lambda)	N Pop 10 years	% Pop Change 10 years	#1 Abundance weighted change	Year Diff First Survey to 2014	Year Diff First Survey to 2024	#2 Pop Estimate Pred 2014	#2 Pop Estimate Pred 2024	Comment
Hopedale	Hopedale Slough	2012	*(469)*		2022	Unknown										CPUE
L Campbell	224th Street–232nd St	2017	231	0.025	2020	128	-0.20	0.82	32.28	-86.03	-2.14	-3.00	7.00	416.88	58.26	MR*
Miami	Miami Cr	2012	102	0.011	2023	*204*	0.06	1.07	191.54	87.79	0.97	2.00	12.00	115.70	217.27	MR*
Mountain	Mountain Slough	2014	68	0.007	2016	10	-0.96	0.38	0.00	-99.99	-0.73	0.00	10.00	68.00	0.00	CPUE
Pepin	Pepin Marsh	2002	1711	0.185	2022	264	-0.09	0.91	672.09	-60.72	-11.21	12.00	22.00	557.52	219.00	CPUE
	Lower Salish Cr	2003	62	0.007	2022	341	0.09	1.09	152.07	145.28	0.97	11.00	21.00	166.35	408.03	CPUE
	Upper Salish Cr	2012	1754	0.189	2021	474	-0.15	0.86	409.86	-76.63	-14.51	2.00	12.00	1,311.45	306.45	CPUE
	Gordon's Brook	2010	Unknown		2020	Unknown										CPUE
Salmon	Upper mainstem	2013	751	0.081	2021	105	-0.25	0.78	64.21	-91.45	-7.41	1.00	11.00	587.26	50.21	CPUE
	Tyre Cr	2013	510	0.055	2022	383	-0.03	0.97	371.00	-27.25	-1.50	1.00	11.00	494.03	359.39	MR*
	Tyre Cr	2016	178	0.019	2022	383	0.13	1.14	638.34	258.62	4.97	-2.00	8.00	137.88	494.45	MR
Salwein	Salwein Cr	2012	288	0.031	2020	188	-0.05	0.95	168.99	-41.32	-1.28	2.00	12.00	258.87	151.89	MR*
Sqemélwelh	Sqemélwelh Cr	2019	64	0.007	2022	3	-1.02	0.36	0.00	-100.00	-0.69	-5.00	5.00	*(10,502.14)*	*(0.39)*	> 95% habitat dewatered in 2022
All	**All**		**9,265** ***(11,360)***			**6,355**								**17,309.46**	**4,472.10**	
% 10-year Pop Change*											**-45.77**				**-34.31**	

* confidence intervals overlapped between Year A and Year B estimates

Long-term trends:

No abundance data extending more than 20 years into the past, and little data extending more than 10 years into the past, are available, but large-scale destruction of suitable habitat is well documented and is discussed in the **Historical, Long-term, and Continuing Habitat Trends** section below.

The following paragraphs summarize available information on abundance and trends in each occupied watershed. For each watershed, a table is provided summarizing available CPUE data and (if available) abundance estimates from mark-recapture studies (Tables 7–19). Bracketed numbers indicate the lower and upper 95% confidence limits of abundance estimates. Specific stream reaches are identified by codes (e.g., PEP9). Detailed maps showing locations of reaches are available in the recovery strategy (Fisheries and Oceans Canada 2020).

Table 7. Summary of catch per unit effort (CPUE) from Feddes traps (see Pearson 2015b) and mark-recapture abundance estimates of Salish Sucker in Agassiz Slough, 2000–2022. Unless otherwise indicated, all data are from Pearson (2004).

Year	Traps	# Salish Sucker Caught	CPUE (Mean #/Trap)	Abundance Estimate
2000	6	1	0.16	
2001	24	0	0	
2003	10	0	0	
2004	55	3	0.05	
2005*	20	3	0.15	
2011**	186	485	2.61	807 (700–977)
2012*	125	197	1.58	253 (203–354)
2014	37	8	0.22	
2021	123	0	0	
2022	44	0	0	
2023	77	0	0	

*Pearson (unpubl. data)
**Miners and Pearson (unpubl. data)

Table 8. Summary of catch per unit effort (CPUE) and mark-recapture abundance estimates of Salish Sucker in Bertrand Creek, 1999–2021. Unless otherwise indicated, all data are from Pearson (unpubl.). G = minnow (Gee) trap, F = Feddes trap.

Location	Area	Year	Method	Effort (# Traps)	Salish Sucker	CPUE	Abundance Estimate
a	Mainstem (excluding NRS Aldergrove)	1999	G/F	368	40	**0.11**	
	BTD10, BTD20	2009*	F	61	287	**4.70**	
a		2011	F	55	321	**5.84**	
a		2013	F	212	276	**1.30**	459 (371–642)
a		2020	F	141	3	**0.02**	
a	NRS Aldergrove only	2008	F	18	52	**2.88**	

Location	Area	Year	Method	Effort (# Traps)	Salish Sucker	CPUE	Abundance Estimate
a		2013	F	37	283	**7.64**	244 (210–310)
		2017	F	172	49	**0.28**	42 (25–110)
a		2021	F	57	0	**0**	0
	Howe's Creek	2009	F	8	265	**8.13**	
		2010	F	74	232	**3.14**	
		2011	F	93	333	**3.58**	
		2012**	F	203	391	**1.92**	
a		2013**	F	167	142	**0.85**	329 (206–711)
		2020	F	95	8	**0.08**	
b	Perry Homestead Creek	2001*	F	11	11	**1.0**	
		2004	F	6	85	**14.1**	
		2017	F	217	207	**0.95**	570 (341–1,082)
c	Cave Creek	1999	G/F	147	4	**0.03**	
		2019	F	61	313	**5.13**	315 (260–400)

*Pearson (2004)

**Miners and Pearson (unpubl. data)

Table 9. Summary of catch per unit effort (CPUE) and mark-recapture abundance estimates of Salish Sucker in the Chilliwack Delta, 1999–2021. All data are from Pearson (unpubl.), unless otherwise indicated.

Location	Year	Method	Effort (# Traps)	Salish Sucker	CPUE	Abundance Estimate
All	2012	F	612	176	**0.29**	1,980 (870–4357)
	2014–2015		1271	1,883	**1.48**	2,254 (1480–3015)
Large channels downstream of occupied tribs. (Reaches ATZ2-ATZ5)	2012	F	194	9	**0.05**	
	2015	F	87	0	**0**	
Atchelitz Creek	2000*–2007	G/F	128	31	**0.24**	
	2012	F	37	37	**1.00**	
	2015	F	441	382	**0.87**	239 (212–280)
	2022	F	268	519	**1.94**	579 (490–796)
Luckakuck Creek	2000*	F	8	9	**1.13**	
(no ponds)	2004	F	18	0	**0**	
(Manuel Pond)	2013	F	2	44	**22.00**	
Manuel Park and Creek	2014	F	40	401	**10.03**	378 (345–416)
Manuel Pond	2015	F	2	131	**65.50**	
Manuel Pond/Wells Sanctuary Ponds and Creek	2023	F	123	800	**6.50**	1,103 (797–1640)
Little Chilliwack Creek	2004	G/F	62	91	**1.47**	
	2012	F	48	46	**0.96**	
	2015	F	386	255	**0.66**	351 (280–496)
	2022	F	243	73	**0.30**	209 (103–1,023)
Interception Ditch	2004	F	6	16	**2.67**	
	2012	F	30	24	**0.80**	
	2015	F	262	1,082	**4.04**	739 (315–794)

Location	Year	Method	Effort (# Traps)	Salish Sucker	CPUE	Abundance Estimate
	2023	F	84	15	**0.18**	
Semmihault Creek	1999	G/F	33	3	**0.09**	
	2004	G/F	26	9	**0.35**	
	2009**	G/F/E	5	104	**20.80**	
	2012	F	31	22	**0.71**	
	2015	F	181	188	**1.04**	547 (27–1,029)

*Pearson (2004)

**City of Chilliwack fish salvage in pond at base of mountain. Not sampled in other surveys because access refused.

Table 10. Summary of catch per unit effort (CPUE) of Salish Sucker in Fishtrap Creek, 1999–2019.

Year	Method	Effort (# Traps)	Salish Sucker	CPUE
1999–2000*	G/F	289	7	**0.02**
2013**	F	203	11	**0.05**
2019**	F	111	5	**0.05**

*Pearson (2004)

** Pearson (unpubl. data)

Table 11. Summary of catch per unit effort (CPUE) of Salish Sucker in Hope Slough, 2000–2018. All data from Pearson (unpubl.).

Year	Method	Effort (# Traps)	Salish Sucker	CPUE
2000	G/F	68	0	**0**
2006	F	31	1	**0.03**
2008	F	68	2	**0.03**
2009	F	13	0	**0**
2015	73	0	0	**0**
2017	F	49	0	**0**
2018	F	129	0	**0**

Table 12. Summary of catch per unit effort (CPUE) and mark-recapture abundance estimates of Salish Sucker in Hopedale Slough, 2004–2021. All data from Pearson (unpubl.).

Tributary	Year	Method	Effort (# Traps)	Salish Sucker	CPUE	Abundance Estimate
Browne Road Ponds (HDL5)	2004	F	7	32	**4.57**	
	2012	F	115	228	**1.98**	469 (346–712)
	2015	F	36	3	**0.08**	
	2016	F	4	22	**5.5**	
	2019	F	94	15	**0.16**	
	2021	F	22	73	**3.32**	
All other reaches	2016	F	71	0	**0**	
	2019	F	104	0	**0**	

Table 13. Summary of catch per unit effort (CPUE) and mark-recapture abundance estimates of Salish Sucker in Little Campbell River, 1999–2020.

Tributary	Year	Method	Effort (# Traps)	Salish Sucker	CPUE	Abundance Estimate
Mainstem	1999-2000*	F	64	0	**0**	
	2012**	F	34	0	**0**	
	2013**	F	215	16	**0.07**	
	2014**	F	134	4	**0.03**	
224-232 St	2017**	F	67	81	**1.20**	78 (55–131)^^
	2018***	F	132	320	**2.42**	178 (148–237)^^
	2019***	F	89	198	**2.22**	175 (116–366)^^
	2020***	F	58	72	**1.24**	128 (59–1,600)^^
192 St Trib.	2018^	F	28	28	**1.00**	
	2019**	F	26	1	**0.04**	
	2020***	F	58	72	**1.24**	70 (43–300)^^
Campbell Valley Regional Park	2017***	F	88	9	**0.10**	42 (12–155)

* Pearson (2004)

** Pearson and A Rocha Canada (unpubl. data)

*** A Rocha Canada (Fisheries and Oceans 2022)

^Enkon Consultants

^^Confidence intervals corrected using binomial distribution (Krebs 1989). They are far too narrow when calculated using normal distribution as reported in Fisheries and Oceans Canada (2022)

Table 14. Summary of catch per unit effort (CPUE) and mark-recapture abundance estimates of Salish Sucker in Miami Creek, 2000–2023.

Year	Method	Effort (# Traps)	Salish Sucker	CPUE	Abundance Estimate
2000*	G/F	12	25	**2.08**	
2002*	G/F	86	44	**0.51**	
2011**	F	189	209	**1.11**	
2012**	F	200	137	**0.69**	102 (67–193)
2023**	F	395	198	**0.50**	204 (166–325)

*Pearson (2004)

**Pearson (unpubl. data)

***Miners and Pearson (unpubl. data)

Table 15. Summary of catch per unit effort (CPUE) and mark-recapture abundance estimates of Salish Sucker in Mountain Slough, 2004–2016. All data from Pearson (unpubl.).

Tributary	Year	Method	Effort (# Traps)	Salish Sucker	CPUE	Abundance Estimate
Mainstem	2004	G/F	52	16	**0.31**	
	2005	F	11	0	**0**	

Tributary	Year	Method	Effort (# Traps)	Salish Sucker	CPUE	Abundance Estimate
	2007	F	43	26	**0.60**	
	2008	F	18	42	**2.33**	
	2010	F	30	19	**0.63**	
	2011	F	185	71	**0.38**	
	2014	F	16	3	**0.19**	
	2016	F	376	19	**0.05**	
McCallum Slough	2007	F	30	7	**0.23**	
	2008	F	38	50	**1.31**	
	2009	F	37	24	**0.64**	
	2011	F	64	16	**0.25**	
	2014	F	24	18	**0.75**	
	2016	F	63	16	**0.25**	
Mainstem + McCallum	2011	F	249	87	**0.35**	83 (48–270)
	2014	F	40	21	**0.53**	68 (24–200)
	2016	F	439	35	**0.08**	

Table 16. Summary of catch per unit effort (CPUE) and mark-recapture abundance estimates of Salish Sucker in Pepin Creek, 1999–2022. All data from Pearson (unpubl.) unless otherwise indicated.

Tributary	Year	Method	Effort (# Traps)	Salish Sucker	CPUE	Abundance Estimate
All Critical Habitat	2012	F	267	958	**3.58**	1,754 (1,318–2,900)
All Mainstem	1999*	G/F	797	4,216	**5.29**	
	2011	F	60	12	**0.20**	
	2012	F	135	163	**1.21**	
Pepin Marsh (PEP9)	1999-2002*	G/F	521	4,080	**7.83**	1,711 (1,247–2,461)
	2003	F	13	1	**0.08**	
	2004	F	25	9	**0.36**	
	2005	F	14	0	**0**	
	2011	F	18	0	**0**	
	2012	F	14	0	**0**	
	2021	F	16	1	**0.06**	
	2022	F	48	58	**1.21**	
Lower Salish Creek	2000**	Fish fences				120
	2003	F	14	43	**3.07**	62 (27–386)
	2004	G/F	53	197	**3.71**	
	2011	F	14	43	**30.7**	
	2012	F	32	328	**10.25**	
	2018	F	39	107	**2.74**	
	2020	F	29	139	**4.79**	
	2022	F	61	682	**11.1**	341 (250–480)
Upper Salish Creek (ponds)	1999*	F	4	169	**42.25**	
	2001*	G/F	117	36	**0.31**	
	2004	G/F	20	83	**4.15**	
	2011	F	11	149	**13.54**	
	2012	F	36	359	**9.97**	

Tributary	Year	Method	Effort (# Traps)	Salish Sucker	CPUE	Abundance Estimate
	2018	F	18	468	**26.0**	
	2020	F	24	143	**5.95**	
	2021	F	74	173	**2.34**	474 (274–1,200)
Gordon's Brook	1999*	G/F	16	2	**0.13**	
	2004	G/F	52	274	**3.65**	
	2005	F	13	75	**5.77**	
	2007	F	41	21	**0.51**	
	2008	F	14	2	**0.14**	
	2009	F	58	34	**0.58**	
	2010	F	76	174	**2.89**	
	2011	F	156	181	**1.16**	
	2012	F	64	108	**1.69**	
	2016	F	12	1	**0.08**	
	2017	F	18	3	**0.16**	
	2019	F	38	5	**0.13**	
	2020	F	26	7	**0.27**	
King Rd Restoration (PEP11)	2008	F	4	16	**4.0**	
	2010	F	2	64	**32.0**	
	2022	F	4	31	**7.75**	

*Pearson (2004)

**Patton (2003)

Table 17. Summary of catch per unit effort (CPUE) and mark-recapture abundance estimates of Salish Sucker in Salmon River, 1999–2022. All data from Pearson (unpubl.) unless otherwise indicated.

Location	Area	Year	Method	Effort (# Traps)	Salish Sucker	CPUE	Abundance Estimate
	Lower Salmon River	2000*	G/F	82	**2**	**0.02**	
		2005	F	76	1	**0.01**	
	Upper Salmon River Mainstem	2000*	G/F	273	474	**1.73**	
		2007	F	31	3	**0.09**	
		2008	F	28	7	**0.25**	
		2009	F	37	25	**0.67**	
		2013	F	134	144	**1.07**	751 (649–915)
	Reach SLN15 only	2016	F	49	7	**0.14**	
		2019	F	315	61	**0.19**	
		2021	F	20	3	**0.15**	
	Tyre Creek	2005	F	16	0	**0**	
		2013	F	69	356	**5.20**	510 (420–648)
		2016	F	140	226	**1.61**	178 (160–214)
		2019	F	8	3	**0.38**	
		2022	F	170	139	**0.82**	383 (245–900)

*Pearson (2004)

Table 18. Summary of catch per unit effort (CPUE) and mark-recapture abundance estimates of Salish Sucker in Salwein Creek, 2001–2020. All data from Pearson (unpubl.) unless otherwise indicated.

Year	Method	Effort (# Traps)	Salish Sucker	CPUE	Abundance Estimate
2001	G/F	437	16	**0.04**	
2002	G/F	488	1	**0.002**	
2004	G/F	90	10	**0.11**	
2012*	F	109	77	**0.71**	288 (191–642)
Apr 2020	F	128	25	**0.19**	
Oct 2020	F	108	85	**0.78**	188 (108–342)

*Miners (unpubl. data)

Table 19. Summary of catch per unit effort (CPUE) and mark-recapture abundance estimates of Salish Sucker in Sqemélwelh Creek, 2018–2020. All data from Pearson (unpubl.).

Tributary	Year	Method	Effort (# Traps)	Salish Sucker	CPUE	Abundance Estimate
Beaver Pond	2019	F	31	32	**1.03**	64 (47–93)
	2020		16	5	**0.10**	
Rest of Slough	2019	F	64	1	**0.01**	
			20	0	**0**	

Agassiz Slough:

Salish Sucker was first found here in 2000. Early surveys (2000–2005) produced very few fish (Table 7). In 2011, the catch rate soared and abundance was estimated at over 800 adults (Miners unpubl. data). The following year, the estimate fell significantly to 253 (95% CI = 203–254). In 2014, Salish Sucker was still present, but only eight were captured. Extensive sampling in 2021 (four sessions March to November), 2022 (April), and 2023 (April, July, October) failed to yield a single Salish Sucker. All of the habitat suffers from severe hypoxia in summer, and most of the habitat dewatered completely during the droughts of 2022 and 2023. Total effort consisted of 469 trap sets. The subpopulation is **likely extirpated**.

Bertrand Creek:

The Bertrand watershed consists of three subpopulations: a) Mainstem + Howe's Creek; b) Perry Homestead Creek; and c) Cave Creek. Comparable CPUE data span the period 1999 to 2021 with one to two estimates of abundance for each subpopulation.

Upper mainstem + Howe's Creek Subpopulation:

The longest time series of data is from a large wetland complex at Naval Radio Station (NRS) Aldergrove which is confined by beaver dams (Table 8). Catch per unit effort was relatively high in 2008 and peaked in 2011, when abundance was estimated at 244 adults. CPUE declined 25-fold in the 2017 sampling, when abundance was estimated at 42 adults. In the 2021 sampling, no Salish Sucker were found. CPUE in the mainstem subpopulation (excluding NRS Aldergrove) declined more than 30-fold between 2013 and 2020, while in Howe's Creek, it declined 24-fold. All habitat occupied by this subpopulation is subject to severe hypoxia (Rosenfeld *et al.* 2021). There have been a series of severe droughts in the intervening years that have dewatered most of Howe's Creek for months each summer. Large-scale fish kills are, unfortunately, the most likely explanation for the declines. The declines in CPUE coupled with the pre-crash subpopulation estimates suggest that fewer than 50 adults remain.

Perry Homestead Creek Subpopulation:

Salish Sucker were abundant in a pond on the east side of Highway 13 in 2001 and 2004. By 2017, this pond had become largely infilled with Reed Canary Grass (*Phalaris arundinacea*). An estimated 570 adults occupied the location when it was last surveyed in 2017 (Table 8). Severe hypoxia impacts this population (Rosenfeld *et al.* 2021), raising the risk of a fish kill.

Cave Creek Subpopulation:

Prior to being drained in the 1960s, a large wetland in the headwaters of Cave Creek supported an abundant subpopulation of Salish Sucker. By the late 1990s, they had been extirpated, likely due to poor water quality and dewatering of most of the habitat in summer. The fish were unable to recolonize the site due to an impassable agricultural dam, although they were found in low densities downstream of the dam (Pearson 1998). A local stewardship group installed a fishway in 1999; it was functional for several years before being blocked by beavers. In 2019, sampling upstream of the dam showed that a subpopulation (estimate 315 adults) was now established in a series of beaver ponds (Table 8). Dissolved oxygen levels were dangerously low (< 2.5 mg/L in most ponds), flow had ceased (as it does every summer in Cave Creek), and water levels were below the dam crests, isolating fish in the ponds. Cave Creek has not been surveyed since then but given the severity of drought and heat in the intervening summers, there are concerns about this subpopulation.

Assuming that no declines occurred since the last surveys in Cave Creek (2019) and Perry Homestead Creek (2017), the total current abundance in all of Bertrand Creek is estimated at less than **935 adults** (50+570+315)**, an estimated 41% decline since 2013 (3 generations).**

Chilliwack Delta:

Four interconnected creeks (Atchelitz, Luckakuck, Little Chilliwack, and Semmihault) form the Chilliwack Delta subpopulation. Total numbers were estimated at 1,980 adults in 2012 and 2,254 adults in 2015 (Table 9). Very few have ever been found in the larger, downstream slough channels that connect the tributaries. Within Luckakuck Creek, most Salish Sucker inhabit a pond (approx. 2,500 m^2) in a small municipal park (Manuel Park). Two Chilliwack Delta tributaries were resurveyed in 2022. Abundance appears to have increased significantly in Atchelitz Creek, but it had the lowest abundance among the tributaries in previous sampling. Low recapture rates (three fish) in Little Chilliwack resulted in large confidence intervals, perhaps due to poor water quality. Sampling was done in October 2022 under level 5 drought conditions and associated hypoxia. In summer 2023, Interception Ditch, which supported an estimated 739 adults in 2015, was found to be mostly dewatered and severely hypoxic. Only 15 Salish sucker were caught in 84 trap sets. Semmihault Creek was too hypoxic to sample in 2023, so no current estimate is available. However, it seems unlikely that it supported over 500 individuals as it did in 2015. Based on the available evidence, abundance in the Chilliwack Delta is stable or has declined slightly over the past 3 generations. Current abundance is unlikely to exceed **2,500 adults** (Table 6).

Fishtrap Creek:

Salish Sucker have been caught in the same reaches every time Fishtrap Creek has been surveyed (1999, 2000, 2013, 2019), but never in sufficient numbers to allow a subpopulation estimate (Table 10). One reach, adjacent to Abbotsford Airport, is distinguished by being located within the last remaining patch of riparian forest in the lower watershed. The other reach is in East Fishtrap Creek, which was converted to a large stormwater detention pond in 1990. Prior to this, it contained significant numbers of Salish Sucker (Inglis *et al.* 1992). The total number of adults in the watershed currently seems unlikely to exceed **50**.

Hope Slough/Elk Creek:

A Salish Sucker was first found in Hope Slough in 2006. Targeted surveys since then have only yielded two more individuals (Table 11). City of Chilliwack fish salvages (electrofishing) have yielded a few more individuals over the years from Elk Creek (1 to 4 fish per year). Twelve were observed on a riffle during spawning season at the confluence of Elk Creek and Hope Slough in 2007 (Pearson unpubl. data). It seems unlikely that the subpopulation exceeds **100 individuals**.

Hopedale Slough:

In Hopedale Slough, Salish Sucker have only ever been found in two ponds at the end of Browne Road, although other areas of apparently suitable habitat are found in the watershed. Abundance was estimated at 469 (346–712) adults in 2012 using mark-recapture (Table 12). An attempt to update the estimate in August 2019 failed due to a low catch rate (15 in 94 traps). Daytime dissolved oxygen was adequate for Salish Sucker, but water temperature was close to exceeding 20°C. In spring 2021, with optimal water quality conditions, catch rates rebounded to 73 fish in 22 traps. This catch rate exceeded that of 2012 when the abundance estimate was made. Current abundance in Hopedale Slough is unlikely to exceed **500 adults.**

Little Campbell River:

This subpopulation was believed extirpated in the 1970s (McPhail 1987; Pearson 2004) but was rediscovered in 2011 (COSEWIC 2012). Since then, annual sampling by biologists with A Rocha Canada has consistently found Salish Sucker in the reach between 224th Street and 232nd Street. Abundance estimates ranged from 128 to 231 adults between 2017 and 2020 (Table 3), but their 95% confidence limits overlap significantly. A second area with significant numbers was found in a tributary near 192nd Street in 2018, but mark-recapture work in 2020 suggests that it contains fewer than 100 individuals. Total abundance in the watershed is unlikely to exceed **300 adults**.

Miami Creek:

The Miami Creek subpopulation was first found in 2000 (Pearson 2004). Catch rates have been low to moderate in the years sampling has been completed, and abundance was estimated at 102 adults in 2012 (Table 4). In 2023, abundance was estimated at 204 adults, although confidence intervals were broad, overlapping with those from 2012. Current abundance is unlikely to exceed **325 adults**.

Mountain Slough:

The Mountain Slough mainstem suffers from extreme eutrophication. When the subpopulation was first found in 2002, most of the headwater habitat was completely infilled with Reed Canary Grass, which eliminated open water habitat (Pearson unpubl. data). Following completion of a major habitat enhancement project in 2005 (reconstructing 1.8 km of mainstem channel; reaches MTN5 MTN6), catch rates increased; they peaked in 2008 (Table 15) and then returned to very low levels in subsequent years. The largest tributary, McCallum Slough, contains the primary spawning site in the watershed (200 m of pool-riffle habitat). Following habitat enhancement work (Reed Canary Grass removal and large wood complexing) in 2007 from the reach above the spawning area (MTN28), catch rates increased and then declined over the next years. Mark-recapture abundance estimates in 2011 and 2014 gave a total of less than 100 fish. Extensive damage to the spawning and rearing areas of lower McCallum Slough occurred between 2015 and 2018 as a result of poorly executed channel reconstruction for drainage purposes (Pearson

unpubl. data). Water quality in remaining tributaries in the watershed has been too poor to support fish since before 2002. However, the habitat is otherwise suitable and was likely occupied historically, when the area of suitable habitat was more than double the current area. In 2016, an attempt to estimate abundance using mark-recapture failed due to the low number caught (54 fish in 815 trap sets). Current abundance seems unlikely to exceed **100 fish**.

Pepin Creek:

A watershed-scale abundance estimate (1,754 adults) was completed in 2012, and abundance has been monitored repeatedly in several habitat enhancement projects in the watershed, some for over 20 years (Table 16). Between 1999 and 2002, abundance and CPUE was very high in the mainstem, particularly within Pepin Marsh, a complex of beaver ponds extending from Huntington Road (8th Ave) to Bradner Road (288th Street). However, abundance crashed to near-zero by 2003, likely due to extreme hypoxia (Pearson 2004). Periodic monitoring suggested that it remained near zero for close to 20 years. Some recovery was indicated by 2022, but CPUE remains less than one sixth of what it was prior to 2003. Salish Creek and Gordon's Brook are wholly created habitats completed in 1999 (Patton 2003) and 2001–2010, respectively. Salish Creek has consistently supported significant numbers of Salish Sucker, with a current estimate of approximately 800 adults (combined upper and lower sections). In Gordon's Brook, abundance has fluctuated widely in relation to documented changes in water quality (Rosenfeld *et al.* 2021), and it is currently too low to estimate. Total abundance in the Pepin watershed is unlikely to exceed **1,100 adults**.

Salmon River:

The lower and upper sections of Salmon River are divided by a steep reach flowing in a deep ravine. Only a handful of Salish Sucker have ever been caught in the Lower Salmon River, suggesting that these fish may be strays that have descended through the ravine from the reaches upstream (east) of 248th Street. CPUE in the upper mainstem has varied widely across the years (Table 17). In 2013, abundance was estimated at 751. In 2019, despite high effort (315 traps), too few fish were caught to permit an abundance estimate. Additional trapping in 2021 and 2022 at sites where they have been historically abundant again yielded few or none, suggesting that a population crash occurred between 2013 and 2016. In Tyre Creek, a tributary in which Salish Sucker were first documented in 2016, abundance remains relatively high at 383 adults, but severe hypoxia and lack of flow over large beaver dams in late summer is a significant threat. Total current abundance in Salmon River seems unlikely to exceed **500 adults**.

Salwein Creek:

Prior to the drainage of Sumas Lake in 1920, what is now Salwein Creek was part of the extensive wetlands fringing the lake's east side (see Woods 2001). Its current channels are entirely constructed. Although Salish Sucker has been occasionally caught in linear ditches and ponds north of the dike, the majority of the subpopulation inhabits a wetland

complex between the dike and the Vedder River. Hypoxia exacerbated by flow diversion around these habitats was seriously degrading the habitats in the early 2000s, and catch rates were extremely low (Table 18). Habitat creation and enhancement for salmonids in the early 2010s greatly expanded available habitat for Salish Sucker in 2007–2010. Salish Sucker catch rates peaked in 2012, when abundance was estimated at 288 adults. Catch rate and estimated abundance declined in a 2020 survey (Table 18), although the results were not statistically significant. Current abundance seems unlikely to exceed **300 adults**.

Sqemélwelh Creek (Chawathil):

This subpopulation was discovered in 2018, and adult abundance was estimated to be 64 individuals in 2019 (Table 19). In summer 2019 and 2021, the subpopulation was confined to a 1-ha beaver pond and perhaps 150 m of inlet stream, with the remaining watershed dewatered. In 2022, following unprecedented drought in the Fraser Valley, the beaver pond also became dewatered, presumably decimating the subpopulation. At least a few Salish Sucker likely survived in small pools in the inlet stream, because three were caught there in September immediately before the pond became dewatered (Pearson unpubl. data). Total pool area available to Salish Sucker in October 2022 was likely less than 50 m^2 for the entire subpopulation. Although habitat enhancement work to increase habitat area available under drought conditions is planned for 2023, recovery of the subpopulation may not be possible, depending on the numbers and demographics of survivors. Current abundance is unlikely to exceed **25 adults**.

Population fluctuations, including extreme fluctuations:

Headwater habitats are naturally prone to short-term disturbances, such as drought, heat, freezing, hypoxia, and dewatering through diversion, which cause localized catastrophic mortality. The Salish Sucker is a headwater stream specialist with small body size, early maturation, short life span and a protracted spawning period (Pearson and Healey 2003). This suite of traits imparts a high intrinsic rate of population growth, allowing rapid recovery or recolonization following high mortality over small spatial scales (Winemiller and Rose 1992). In recent years, numbers of adults have shown significant fluctuations at habitat restoration sites, particularly at Gordon's Brook in the Pepin watershed. These fluctuations are clearly associated with changes in water quality over time. Recently constructed habitats tend to be less prone to episodes of extreme hypoxia because biochemical oxygen demand (BOD) is low due to a lack of accumulated organic material. As the habitats mature, BOD increases, elevating the risk of hypoxia. At Gordon's Brook, this process was temporarily reset by physical removal of accumulated aquatic vegetation and increasing flow in 2008–2009. A large increase in Salish Sucker CPUE followed, but catch rate quickly declined again in subsequent years.

Severe Fragmentation

A taxon can be considered to be severely fragmented if most (> 50%) individuals or most (> 50%) of the total area occupied (as a proxy for number of individuals) is in habitat patches that are both (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.

Most Salish Sucker subpopulations are separated by unsuitable habitat (e.g., Fraser River mainstem) and/or impassable barriers (e.g., dikes) that the fish are unlikely or unable to cross. In the Nooksack tributaries (Bertrand, Fishtrap and Pepin watersheds), subpopulations are separated by long sections of unsuitable habitat, such as the Nooksack River mainstem and/or long riffle-rich reaches several times longer than maximum documented dispersal distances.

However, although minimum viable population size (MVP) analysis has not been conducted for Salish Sucker, there is no evidence that more than 50% of individuals occur in habitat patches that are smaller than would be required to support a viable population. Meta-analyses across hundreds of vertebrate species suggest that MVPs are typically in the thousands (Reed *et al.* 2003; Traill *et al.* 2007, 2010), but they may be in the hundreds depending on the time scale of interest and species-specific traits (Jamieson and Allendorf 2012; Rosenfeld 2014; Wang *et al.* 2019). Small-bodied, short-lived freshwater fishes can be highly vulnerable to catastrophic events, which increases the MVP (Velez-Espino and Koops 2012). However, Salish Sucker appears to be well adapted to recover from severe episodic declines in abundance if habitat conditions improve, suggesting that the MVP is not particularly low. If the MVP is not lower than 700 individuals, 58% of the individuals are found in two subpopulations (Chilliwack Delta and Pepin Creek, with an estimated 1,732 and 723 adults, respectively), which would be viable.

Rescue Effect

Three of the Canadian subpopulations occur in streams that flow into Washington State's Nooksack River (Bertrand, Fishtrap, and Pepin creeks). Rescue of the Canadian population is unlikely from south of the border, because there is limited suitable habitat in the American portion of these streams (McPhail 1987; Wydoski and Whitney 2003; Pearson 2004). 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 to 2010 yielded only one Salish Sucker (Vadas pers. comm. 2011).

THREATS

Historical, Long-term, and Continuing Habitat Trends

Over the past 150 years, large-scale landscape changes have fragmented habitat across the Canadian range, likely reducing or eliminating migration between Salish Sucker subpopulations. Habitat fragmentation dates to at least 1875 with the diversion of the Chilliwack River through Vedder Creek, which isolated it from the delta channels through which it flowed to the Fraser River (Rafter 2001). 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 (Figure 6). In the early 1800s, old conifer forest (mean age > 400 years) covered an estimated 71% of the Fraser Valley (Boyle *et al.* 1997), including many areas occupied by Salish Sucker. The remaining occupied watersheds are within the Fraser River floodplain, and they would have been forested with flood-tolerant deciduous trees and shrubs or herbaceous vegetation prior to European contact (see Duffield 2001). Land clearing, road building, and settlement began (outside of the Vancouver area) in the 1860s, and these activities accelerated dramatically with the completion of the Canadian Pacific Railway in 1885. By 1918, most valley bottomland had been altered by logging or fire, and by the 1930s, it had become British Columbia's largest clearcut (Duffield 2001). More than 60% of bank length of Salish Sucker critical habitat lacked woody vegetation or was bordered by strips less than 5 m wide in 2004 (Pearson 2008). Additional losses have occurred annually since then (Pearson pers. obs.). Such massive losses of forest cover, particularly in riparian areas, have profoundly affected Salish Sucker habitat. Removal of woody riparian vegetation elevates peak water temperatures in streams (Bowler *et al.* 2012; Ryan *et al.* 2013), which exacerbates eutrophication and hypoxia. It also reduces bank stability, leading to increased erosion and sedimentation, and reduces habitat complexity by decreasing the supply of large woody debris to the channel.

The highest densities of Salish Sucker are found in headwater wetlands, habitats that were frequently drained for agricultural development. More than 77% of the lower Fraser River Valley's pre-settlement wetlands have been drained or infilled (Boyle *et al.* 1997), and 15% of its streams have been eliminated by urban or agricultural development (Fisheries and Oceans Canada 1998). The largest loss of aquatic habitat occurred with the drainage of Sumas Lake in the 1920s (Woods 2001; Watt 2006) and the isolation of sloughs from the Fraser River by dikes. Dike building began in the 1860s and was largely completed in the aftermath of the 1948 Fraser River flood (Boyle *et al.* 1997; Watt 2006).

Several 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 off completely by dike construction (Figure 6). The floodgates and/or pump houses at the outlets of Hope Slough, Mountain Slough, Miami Creek, Chilliwack Creek, and the Salmon River impose seasonal barriers to movement (Figures 5, 6, and 7), primarily in late spring, during the Fraser River freshet. The flood gate on Agassiz Slough (upgraded in late 2021) may have played a role in the presumed extirpation of Salish Sucker there by preventing

them from exiting as habitat inside the dike became severely hypoxic and largely dewatered. 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. The recent installation of a fish-friendly pump at Mountain Slough (2016) has improved access, but a proposed dike and floodgate across lower Hope Slough will decrease it to some extent. Drainage and the infilling of headwater wetlands have eliminated what was likely a historical dispersal route between the Little Campbell River and Bertrand Creek (Pearson 1998).

Gravel mining has affected 25% of the Pepin Creek watershed, causing an estimated 10% loss in water storage capacity, which is implicated as the primary cause of a significant reduction in base flow (1984–2011; Wang *et al.* 2017). At least two large-scale sediment releases from gravel pits and a debris flow caused by a berm failure and the resulting headwater capture of Howe's Creek in 2008 have infilled habitat in Pepin Creek (Pearson 2015a).

In the past 25 years, habitat creation projects have added substantial areas of suitable habitat for Salish Sucker in the Pepin Creek (approx. 10,000 m^2) and Salwein Creek (approx. 5,000 m^2) watersheds. Enhancement projects have occurred in all occupied watersheds and included Reed Canary Grass removal, expanding deep pool area, and increasing cover through the addition of large woody debris. Moderate to high Salish Sucker catch rates (CPUE > 1 fish/trap) have been documented in many of these areas (Pearson unpubl. data), but all are now seasonally degraded by severe hypoxia, primarily due to agricultural nutrient pollution (Rosenfeld *et al.* 2021) and/or dewatering during drought (Pearson unpubl. data). Numerous riparian planting projects have been completed in the past 25 years (Fisheries and Oceans Canada 2022), but ongoing destruction of riparian vegetation elsewhere in the watersheds has likely resulted in net losses.

At present, subpopulations in Canada are limited by poor water quality, drought, and physical habitat degradation. The human population of the Metro Vancouver and Fraser Valley Regional Districts are projected to increase by 32% from 2023 to 2045 (BC Stats 2023). The associated land development and intensification of livestock farming (through supply managed dairy and poultry) will further degrade stream habitats. Climate change is already having major impacts on habitat through drought and temperature extremes. The cumulative impacts are likely to lead to extirpation of multiple subpopulations without watershed-scale habitat restoration (particularly of riparian areas) and major reductions in nutrient loading.

Current and Projected Future Threats

Salish Sucker is vulnerable to the cumulative effects of various threats, especially agricultural nutrient pollution, which drives eutrophication and severe hypoxia (Rosenfeld *et al.* 2021; Boyd *et al.* 2022), and climate-change induced drought and extreme temperatures. The nature, scope, and severity of these threats has been described in Appendix 3, following the IUCN-CMP (International Union for the Conservation of Nature – Conservation Measures Partnership) unified threats classification system (see Salafsky *et al*. 2008 for definitions and Master *et al*. 2012 for guidelines). The threat assessment process consists of assessing impacts for each of 11 main categories of threats and their subcategories, based on the scope (proportion of population exposed to the threat over the next 10-year period), severity (predicted population decline within the scope during the next 10 years or 3 generations, whichever is longer, up to ~100 years), and timing of each threat. The overall threat impact is calculated by taking into account the separate impacts of all threat categories and can be adjusted by the species experts participating in the threats evaluation.

The overall threat impact for Salish Sucker is considered Very High, corresponding to an anticipated further decline of between 50% and 100% over the next 10 years. These values are to be interpreted with caution, as they may be based on subjective information, such as expert opinion, although efforts have been made to corroborate the scores with available studies and quantitative data.

Pollution (IUCN 9; overall threat impact High):

Severe hypoxia is documented in critical habitat of all occupied watersheds except Sqemélwelh Creek at Chawathil (Rosenfeld *et al.* 2021). It may be lethal or cause sublethal impacts on growth, health, and/or reproduction. The root cause of hypoxia in these habitats is eutrophication driven by nutrient pollution. Hypoxia is most severe and extensive in late summer and fall (Figure 11). Supersaturation is relatively common in spring and early summer, indicating that late summer decomposition of algal biomass contributes to the fall peak in hypoxia. The timing of hypoxia coincides with elevated water temperatures and especially with declining stream flow (Figure 11). Although the pattern is similar across years, it is important to note that the data shown are an average of 16 years of sampling. During the unprecedented episodes of severe drought and heat the habitat has experienced in recent years (see **Climate Change**, IUCN 11), hypoxia has been much more extensive and severe than the figure suggests. Shade from riparian forests has been shown to reduce eutrophication and hypoxia in Salish Sucker habitat even when nutrient levels are high (Ramirez 2022), but very little riparian vegetation is present on agricultural lands within these watersheds (Pearson 2007).

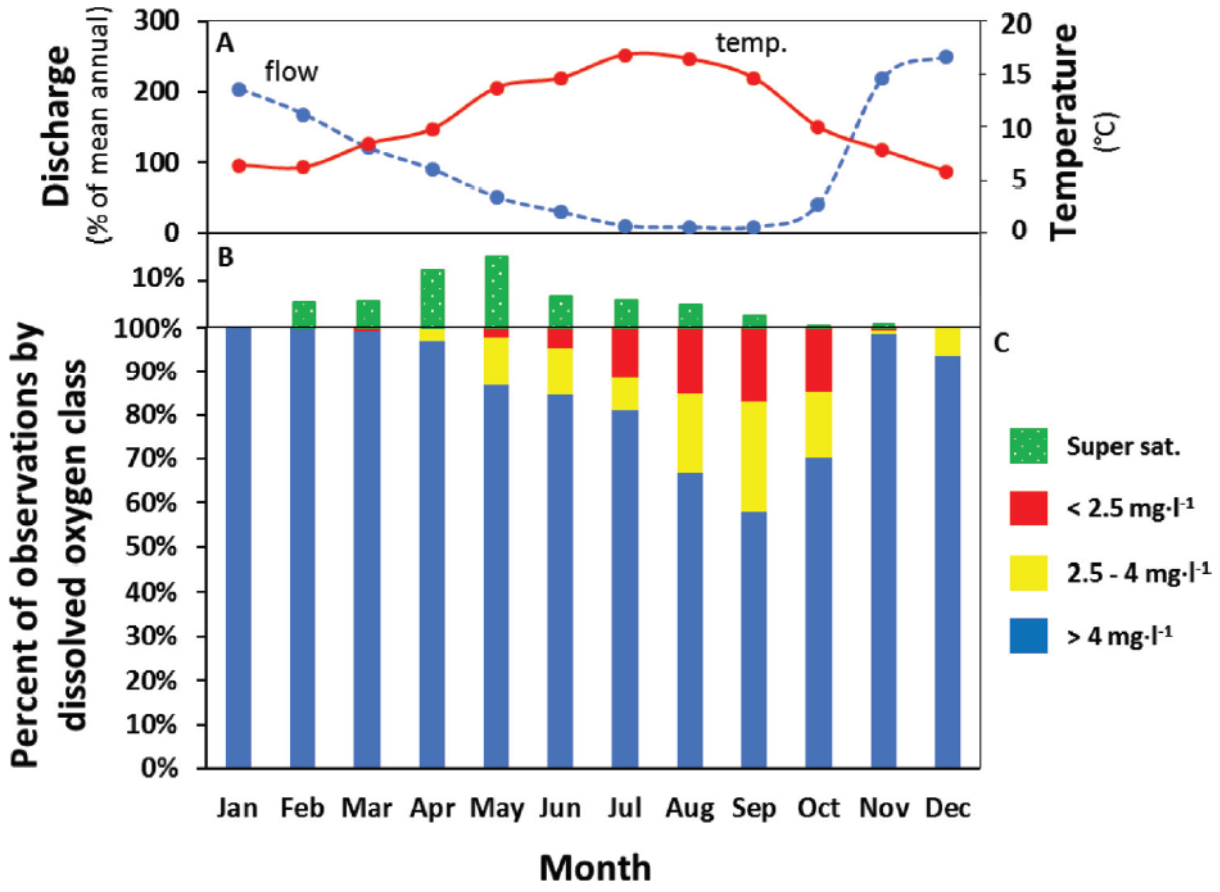

Figure 11. Seasonal changes in dissolved oxygen in 180 km of Salish Sucker critical habitat (Panel C). Daytime dissolved oxygen measurements (n= 7,473, 2003–2018) are binned into severely hypoxic (< 2.5 mg/L, red bars), moderately hypoxic (2.5–4 mg/L, yellow bars) and greater than 4 mg/L (blue bars). Supersaturated measurements indicating algae blooms are included in blue bars to avoid skewing the percentage of hypoxic measurements. Panel A shows a moderate correspondence between the severity of hypoxia and water temperature (red line), but a larger correspondence with average monthly stream flow in the Georgia Depression ecoprovince (blue line). Panel B shows the incidence of supersaturation by month (green bars; from Rosenfeld *et al.* 2021).

Numerous studies have highlighted the predominant role of agricultural sources in nutrient loading to Fraser Valley streams through runoff, groundwater contamination, and aerial deposition. More than 20 years ago, Schreier *et al.* (2003) calculated that on average across the Fraser Valley, nitrogen was being applied at a rate more than 50 kg/ha over the maximum uptake ability of crops. In some watersheds occupied by Salish Sucker, the surplus exceeded 100 kg/ha. Smith (2004) showed positive relationships between animal stocking density and surplus nitrogen applications adjacent to Fraser Valley riparian areas, and she found that the rapid increase in animal density between 1973 and 2003 increased nitrate levels in stream water in winter, when plants were not growing. Leachable nitrogen in fields across the Fraser Valley increased from negative values prior to 1971, to balanced inputs from 1971 to 1976, to a surplus by 1990 (Vizcarra *et al.* 1997). Schindler *et al.* (2006) reviewed the impacts of nitrogen loading on aquatic ecosystems across Canada and concluded that the Fraser River estuary was the most threatened ecosystem in the country due to intensifying Fraser Valley agriculture and expanding human population. Animal density has continued to increase since these studies were completed. More recently, Putt *et al.* (2019) quantified the relative contributions of all sources of nitrogen and phosphorous to Cultus Lake in the Fraser Valley, concluding that agriculture was the largest source of nutrient inputs from both runoff and aerial deposition. The proportion of land devoted to agriculture within Fraser Valley watersheds is significantly and positively correlated with nitrate, nitrite, and orthophosphate levels (Addah 1998; Schupe 2013, 2017) and negatively correlated with dissolved oxygen (Ramirez 2022; Schupe 2013).

Other significant nutrient sources include urban stormwater, leaking septic systems (Lavkulich *et al.* 1999), and aerial deposition from urban sources, particularly nitrous oxide from vehicle exhaust (Putt *et al.* 2019).

Chronic sedimentation originating from urban stormwater systems, agricultural ditches, or upslope logging continues to affect parts of all occupied watersheds. The risk of episodic sediment release from gravel mines and construction sites is ever-present, particularly in association with extreme weather events. Sediment may infill and smother spawning gravels, reducing egg survival or, in extreme cases, infill habitats completely. Localized areas of chronic toxicity are documented within critical habitat in Agassiz Slough (stormwater sediment) and Salwein Creek (polycyclic aromatic hydrocarbons from a 2-km-long creosote retaining wall). The severity of the impact of these pollutants on Salish Sucker is unknown. Toxic spills originating on roads and railways or from pipelines present a constant risk to Salish Sucker habitat.

Climate Change and Severe Weather (IUCN 11; overall threat impact High):

Summer drought severity has exceeded thresholds for impacts to ecosystems in four of the past eight years in the Fraser Valley (Figure 12). Those impacts have been very evident in Salish Sucker habitats. Over 90% of habitat available to the Sqemélwelh Creek subpopulation dewatered completely in September 2022 and August 2023, when drought severity reached an unprecedented Level 5 (Figure 12). Over 50% of critical habitat in Agassiz Slough and large areas in Miami Creek were also dry. The dewatering was likely exacerbated by a change in flow pattern caused by the unprecedented flooding event of

November 2021, which was also linked to climate change (Gillett *et al.* 2022). Air temperatures exceeded 43ºC in the eastern Fraser Valley in the June 2021 "heat dome," a level described as |impossible" prior to the industrial revolution, a 1-in-200-year event under current climate conditions, and a projected 1-in-10-year event should the global average temperature rise by more than 2ºC, which may occur by 2050 (Bartusk *et al.* 2022). Fish kills were widespread in this heat wave and the multiple other heat waves that occurred in 2021 and 2022 during which air temperatures exceeded 35ºC (Pearson pers. obs.). Salish Sucker deaths have not been documented directly, but mortality likely occurred at multiple locations.

Year	Max Drought Level
2022	5
2021	4
2020	1
2019	3
2018	3
2017	4
2016	2
2015	4

Level	Condition	Adverse Impacts
0	Average or wetter	None
1	Starting to become dry	Rare
2	Dry	Unlikely
3	Very dry	Possible
4	Extremely dry	Likely
5	Exceptionally dry	Almost certain

Figure 12. Maximum drought level experienced in the Fraser Valley in the past eight summers (left panel) and the potential for "adverse impacts on ecosystems and socio-economic values" (right panel; adapted from BC Ministry of Forests 2022).

Natural System Modifications (IUCN 7; overall threat impact High):

Other in-stream works (both authorized and illegal) continue to damage habitat across the range. Infilling, bank hardening, and channelization also reduce habitat complexity. Licensed and illegal water withdrawals are commonplace across the range, primarily for agricultural irrigation. There are no data or estimates available on the extent or impacts of agricultural withdrawals. Potential impacts of a proposed municipal well on Little Chilliwack Creek and Luckakuck Creek are currently being studied by the City of Chilliwack (Jefford pers. comm. 2023). Both creeks already partially dewater in drought conditions (Pearson pers. obs.).

Invasive and Other Problematic Species and Genes (IUCN 8; overall threat impact High):

All Salish Sucker subpopulations in Canada have coexisted with invasive predatory fish species for decades. American Bullfrog (*Lithobates catesbeianus*) is present in all occupied watersheds south of the Fraser River, but none to the north (Pearson unpubl. data). The impacts of these predators on Salish Sucker subpopulations remain unknown but may be significant (see **Interspecific Interactions** above for more discussion). Invasive plants also impact aquatic and riparian habitats. Reed Canary Grass infills channels and

may form floating mats over ponds, physically infilling Salish Sucker habitat in waterways. Because the grass leaves are above water, this plant does not contribute oxygen to the water column; however, dead grass accumulates in the water and decomposes, contributing to hypoxia. Himalayan Blackberry (*Rubus armeniacus*) is also widespread. It suppresses the growth of native plant species through competition but does not provide the shade or bank stabilization benefits that larger, deep-rooted woody vegetation does (Murphy 2006). Invasive trees in the walnut family (Juglandaceae) dominate riparian areas in portions of Agassiz Slough and Miami Creek critical habitat (Pearson pers. obs.). They contain juglone, a toxin that leaches into the soil from fallen leaves and eliminates almost all understory plants other than their own progeny (Willis 2000), with likely impacts on soil stability and supply of terrestrial insects to the channel. Himalayan Balsam (*Impatiens glandulifera*) is also widespread and leaches chemicals that have adverse effects on invertebrates and algae (Diller *et al.* 2022). Other invasive plant species that have localized impacts on habitat include Cutleaf Blackberry (*Rubus laciniatus*) and nightshades (*Solanum* spp.). Introductions of new invasive species (animal and plant) can be expected, although the consequences for Salish Sucker cannot be predicted.

Energy Production and Mining (IUCN 3; overall threat impact Low):

Mining activity is continuing in the Pepin Creek watershed and is steadily expanding into the neighbouring Fishtrap Creek watershed. A quarry borders critical habitat in Mountain Slough. Additional impacts on hydrology are likely to occur in these watersheds (see Wang *et al.* 2017).

Transportation and Service Corridors (IUCN 4; overall threat impact Low):

Hundreds of road and farm crossings occur within or upstream of occupied habitats. While the risk of a spill at any one location is low, some significant spills will inevitably impact Salish Sucker habitats over the long term. The nature and severity of the impacts will depend on the substance and volume spilled. The existing Trans Mountain Pipeline and the Trans Mountain Expansion project (mechanical completion is anticipated in the second quarter of 2024) cross through or directly upstream of occupied habitat at 12 sites in 6 watersheds (Trans Mountain 2015).

Cumulative Threats:

The cumulative impact of threats (categorized somewhat differently) on Salish Sucker has been examined by Boyd *et al.* (2022; Figure 13) using a land use, area-based approach. The area of land uses that contribute to various threats upstream of “habitat patches” in all occupied watersheds except Sqemélwelh Creek and Salwein Creek was mapped. “Total contributing area” was used as an index of threat severity. Non-nutrient pollution was identified as the largest threat based on this approach, with nutrient loading and riparian zone disturbance also making large contributions (Figure 13). These results broadly agree with those of the IUCN-CMP method. The lesser emphasis on nutrient pollution is likely an effect of the area-based approach used, which does not consider threat intensity, and of several mapping errors. All threats were treated as equally damaging, with

only the upstream area of contributing land use considered (Boyd *et al.* 2022). Mapping errors in the study consist of the following: inclusion of unsuitable areas (steep, riffle/cascade-dominated reaches in Salmon River and Mountain Slough), areas that are dry most of the year, areas upstream of access barriers, inclusion of a watershed with no confirmed records of occurrence (habitat patch 10), and omission of occupied tributaries (all of Salwein Creek and two Pepin Creek tributaries, Salish Creek and Gordon's Brook).

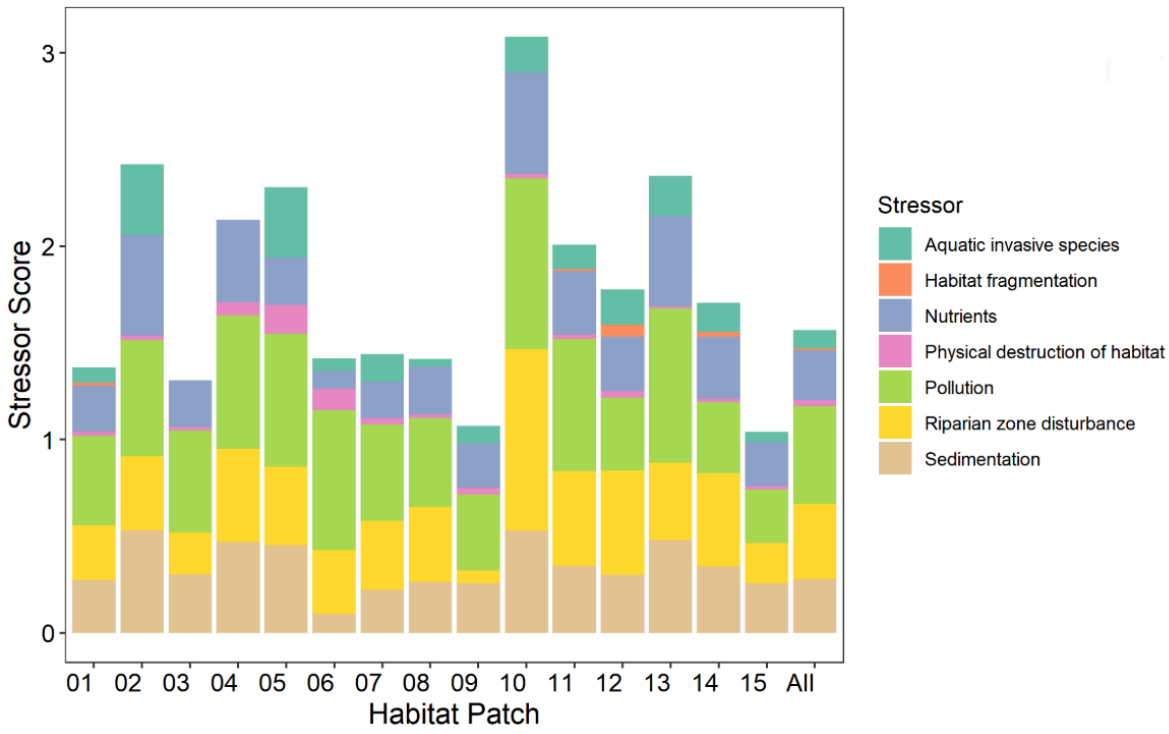

Figure 13. Stacked mean scores of seven threats to Salish Sucker by watershed. Top of the bar represents the mean cumulative effects score. "Habitat patches" examined were Little Campbell River (01), Cave Creek (02), Perry Homestead Creek (03), Unnamed tributary of Bertrand Creek (04), Pepin Creek (05), Fishtrap Creek (06), Bertrand Creek mainstem + Howes Creek (07), Salmon River (08), Hopedale Slough (09), Lewis Slough (not actually occupied;10) Chilliwack Delta (11), Hope Slough/Elk Creek (12), Agassiz Slough (13), Mountain Slough (14), and Miami Creek (15). Significant mapping errors in the study have affected results to an unknown degree (see text). Adapted from Boyd *et al*. (2022).

Number of Threat Locations

Each of the 13 watersheds in the Canadian range is considered a location (Table 2), although with the inferred extirpation of Salish Sucker in Agassiz Slough, 12 locations appear to be extant. With the intensification of drought, heat, and nutrient pollution in recent years, all individuals within a watershed could rapidly be affected by hypoxia and/or heat stress (e.g., in a single threatening event in the summer). Although major climate change-induced events could potentially act simultaneously on multiple neighbouring watersheds—suggesting fewer threat locations—even neighbouring watersheds differ in ways that affect their vulnerability to threats. For example, Pepin Creek drains a glacial moraine and has

large groundwater inputs, while the neighbouring Bertrand Creek watershed has little groundwater inflow. Consequently, Pepin Creek has much higher base flows and cooler maximum temperatures. The Agassiz Slough Salish Sucker subpopulation appears to be extirpated, but the neighbouring Miami subpopulation still seems relatively stable.

PROTECTION, STATUS, AND RECOVERY ACTIVITIES

Legal Protection and Status

Salish Sucker are listed as Threatened 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 habitat in an approved recovery strategy or action plan. Critical habitat was protected by a ministerial Order in Council in July 2019 (SOR/2019-274). Updated maps of critical habitat are provided in the amended recovery strategy (Fisheries and Oceans Canada 2020). Aquatic habitat and some riparian habitat are also protected under the federal *Fisheries Act,* which prohibits harmful alteration, disruption, or destruction of fish habitat. However, meaningful enforcement actions are rare.

The British Columbia *Wildlife Act* prohibits the capture, transport, and possession of wildlife (or their parts) without a licence, and the *Water Sustainability Act* requires authorizations for most works in or around streams that might impact habitat of fish and species at risk. Municipal bylaws protecting streams and/or trees exist in some municipalities, but enforcement is often lacking. Salish Sucker are not listed under the American *Endangered Species Act*.

Non-Legal Status and Ranks

Salish Sucker are considered Critically Imperilled by NatureServe at the global (G1; last reviewed in 2011), national (N2 Canada and N1 United States), and subnational (S1 Washington; S2 British Columbia) levels (NatureServe 2022). The species is on British Columbia's Red List (BC Ministry of Environment 2009), and the American Fisheries Society ranks it as Endangered (Jelks *et al.* 2008). The IUCN Red List does not include Salish Sucker, although it has been listed in the past (COSEWIC 2002).

Land Tenure and Ownership

Approximately 154.4 of the 196.5 km identified as 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 20), with the majority being federal and consisting mostly of First Nations Reserve Land. Notable exceptions include the large habitat areas on NRS Aldergrove (Department of National Defence) and several contiguous parcels (former military lands) on lower Salwein Creek.

Table 20. Length of identified critical habitat for Salish Sucker held by the federal, provincial, or municipal governments. All remaining habitat flows through private lands, although the water and (usually) the stream bed are held by the province. Critical habitat maps are available in the recovery strategy (Fisheries and Oceans Canada 2020).

Watershed	Property	Owner	Habitat length (m)
Bertrand	NRS Aldergrove	GoC[1]	1,500
Bertrand	Vanetta Park	ToL[2]	165
Bertrand	Creekside Park	ToL[2]	195
Chilliwack	Skway IR5	GoC[1]	1,142
Chilliwack	Squiaala IR8	GoC[1]	100
Chilliwack	Squiaala IR7	GoC[1]	5,900
Chilliwack	Aitchelitch IR9	GoC[1]	900
Chilliwack	Skowkale IR10	GoC[1]	550
Chilliwack	Skowkale IR11	GoC[1]	260
Chilliwack	Yakweakwioose IR12	GoC[1]	450
Hope/Elk	Hope River Park	CoC[3]	900
Hope/Elk	Kinsmen Park	CoC[3]	500
Hope/Elk	Skwali IR3	GoC[1]	2,300
Hope/Elk	Skwah IR4	GoC[1]	1,700
Hope/Elk	Skwahla IR2	GoC[1]	560
Fishtrap	Abbotsford Airport	CoA[4]	450
Fishtrap	Field north of 0 Avenue	CoA[4]	500
Fishtrap	East Fishtrap Creek Parks	CoA[4]	1,400
Hopedale	Provincial Crown Land	BC[5]	3,540
Little Campbell	Campbell Valley Regional Park	MVRD[6]	4,500
Little Campbell	Municipal Park	ToL[2]	500
Miami	Spring Park	VHH[7]	180
Miami	East Sector Lands	VHH[7]	3,070
Pepin	Aldergrove Regional Park	MVRD[6]	3,300
Salmon	NRS Aldergrove	GoC[1]	3,280
Salmon	MacMillan Park	ToL[2]	750
Salwein	Great Blue Heron Nature Reserve	CoC[3]	2,200
Salwein	Great Blue Heron Nature Reserve	GoC[1]	1,100
Sqemélwelh	Chawathil IR4	GoC[8]	250

1 Government of Canada
2 Township of Langley
3 City of Chilliwack
4 City of Abbotsford
5 Government of British Columbia
6 Metro Vancouver Regional District
7 Village of Harrison Hotsprings
8 Government of Canada, occupied habitat but not yet identified as critical habitat

Recovery Activities

The majority of the following activities are described in more detail in a recent *Species at Risk Act* report on recovery progress (Fisheries and Oceans Canada 2022).

- Monitoring of subpopulation abundance at all known locations
- Surveying for undocumented subpopulations in suitable habitats (see Appendix 1 for details; one new subpopulation found in Sqemélwelh Creek)
- Mapping of potential winter habitat, known spawning sites, and reach-scale catch per unit effort (2015)
- Graduate research on hypoxia impacts on Salish Sucker growth and behaviour and on relative importance of flow, nutrient load, and water temperature on dissolved oxygen (Zinn *et al.* 2021; Ramirez 2022).
- Analysis of 16 years of field data from all known locations mapping the extent, seasonality, and severity of hypoxia, and linking water quality (dissolved oxygen, water temperature) with Salish Sucker catch rates (Rosenfeld *et al.* 2021)
- Aquatic and/or riparian enhancement projects targeting Salish Sucker were completed at Fishtrap Creek (2018), Chilliwack Delta (2018–2020), Gordon's Brook (Pepin Creek watershed, 2018–2020), Miami River (2018–2019), Little Campbell River (2018–2021), Salmon River (2018), Sqemélwelh Creek (2020), Bertrand Creek 2019–2020), Agassiz Slough (2013, 2017, 2021), Mountain Slough (2017–2021), and Hope Slough (2019, 2022)
- Inventory of habitat completed and potential habitat restoration projects in occupied watersheds (Fisheries and Oceans Canada, unpubl. data 2021)
- Watershed-level, GIS riparian habitat survey of Little Campbell River (2019)
- Monitoring and maintenance at past habitat enhancement projects
- Repair of "fishway" on Cave Creek allowing access around an old agricultural dam on private land (2021)
- Mapping of habitat areas that may dewater seasonally in Bertrand Creek, Little Campbell River, and Sqemélwelh Creek
- Installation of hydrometric stations in Bertrand Creek in 2019 and 2020 (mainstem + Howes Creek)
- Launch of pilot financial incentive program for riparian protection/restoration in Salish Sucker habitat in Mountain Slough (Farmland Advantage 2022)

A review of the report on recovery progress (Fisheries and Oceans 2022) reveals a lack of action to address water quality, the most serious threat impacting Salish Sucker. Nutrient pollution, particularly from agricultural sources, was identified as the primary threat nearly two decades ago (Pearson 2004) and is clearly driving the decline in most subpopulations (Rosenfeld et al. 2021). Recovery efforts have largely focussed on opportunistic habitat creation and restoration projects. Although necessary, these efforts will not result in recovery without simultaneous action to address pervasive water quality issues.

INFORMATION SOURCES

References Cited

Addah, J. 1998. The impact of agricultural land uses on water and sediment quality in the Agassiz/Harrison Hotsprings watershed, BC. MSc thesis, University of British Columbia, Vancouver, British Columbia, Canada.

Bartusk, S., K. Kornhumber, and M. Ting. 2022. 2021 North American heatwave amplified by climate change-driven nonlinear interactions. Nature Climate Change 12:1143-1150. Available from https://www.nature.com/articles/s41558-022-01520-4.

BC Ministry of Environment. 2009. Conservation framework: Conservation priorities for species and ecosystems. Ecosystems Branch, Environmental Stewardship Division, British Columbia Ministry of Environment. Victoria., British Columbia. 14 pp. https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/species-ecosystems-at-risk/species-at-risk-documents/cf_primer.pdf

BC Ministry of Forests. 2022. British Columbia drought information portal. https://governmentofbc.maps.arcgis.com/apps/MapSeries/index.html?appid=838d533d8062411c820eef50b08f7ebc [accessed December, 2022].

BC Stats. 2023. Population estimates and projections for British Columbia. https://bcstats.shinyapps.io/popApp/ [accessed Jan 2, 2023].

Beckman, C., P.A. Biro, and J.R. Post. 2006. Asymetric impact of piscivorous birds on size-structured fish populations. Canadian Journal of Zoology 84: 1584-1593.

Bowler, D.E., R. Orr, D.M. Hannah, and A.S. Pullin. 2012. What are the effects of wooded riparian zones on stream temperature? Environmental Evidence 1:1-9.

Boyd L., P. Grant, J. Lemieux, and J.C. Iacarella. 2022. Cumulative Effects of Threats on At-Risk Species Habitat in the Fraser Valley, British Columbia. Fisheries and Oceans Canada. Canadian Manuscript Report of Fisheries and Aquatic Sciences 3243.

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. 2012. COSEWIC assessment and status report on the Salish Sucker *Catostomus* sp. cf. *catostomus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xi + 36 pp. (https://species-registry.canada.ca/index-en.html#/species/67-50#cosewic_status_reports)

COSEWIC. 2020. COSEWIC guidelines for recognizing designatable units. https://cosewic.ca/index.php/en/reports/preparing-status-reports/guidelines-recognizing-designatable-units.html [accessed December 2022].

Diller, J.G.P., S. Drescher, M. Hofmann, M. Rabus, H. Feldhaar, and C. Laforsch. 2022. The Beauty is a beast: Does leachate from the invasive terrestrial plant *Impatiens glandulifera* affect aquatic food webs? Ecology and Evolution 12:1-12.

Duffield, C. 2001. Constructing a province, clear-cutting a nation. Pages 112-117, *in* K. T. Carlson (ed.). A Stó:lō Coast Salish historical atlas. Douglas and McIntyre and the Stó:lō Nation Trust, Chilliwack, BC.

FIDQ. 2022. British Columbia Fisheries Information Data Queries https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/fish/fish-and-fish-habitat-data-information/search-fish-fish-habitat-data-information/fisheries-inventory-data-queries [accessed December 2022].

Fisheries and Oceans Canada. 1998. Wild, threatened, endangered and lost streams of the lower Fraser Valley. Summary report: 1997. Lower Fraser Valley Stream Review, Vol. 3. Fraser River Action Plan, Habitat and Enhancement Branch, Fisheries and Oceans Canada, Vancouver.

Fisheries and Oceans Canada. 2015. Recovery Potential Assessment for the Salish Sucker in Canada. DFO Canadian Science Advisory Secretariat. Science Advisory Report 2015/038.

Fisheries and Oceans Canada. 2017. Action plan for the Nooksack Dace (*Rhinichthys cataractae*) and Salish Sucker (*Catostomus* sp. cf. *catostomus*) in Canada. Species at Risk Act Action Plan Series. Fisheries and Oceans Canada, Ottawa. v + 22 pp.

Fisheries and Oceans Canada. 2020. Recovery strategy for the Salish Sucker (*Catostomus* sp. cf. *catostomus*) in Canada. 1st amendment. Species at Risk Act Recovery Strategy Series. Fisheries and Oceans Canada, Ottawa. vii + 71 pp.

Fisheries and Oceans Canada. 2020b. Action plan for the Nooksack Dace (*Rhinichthys cataractae*) and the Salish Sucker (*Catostomus* sp. cf. *catostomus*) in Canada. 1st amendment. Species at Risk Act Action Plan Series. Fisheries and Oceans Canada, Ottawa. v + 22 pp.

Fisheries and Oceans Canada. 2022. Report on the progress of recovery strategy and action plan implementation for the Nooksack Dace (*Rhinichthys cataractae* ssp.) and the Salish Sucker (*Catostomus* sp. cf. *catostomus*) in Canada for the period 2016 to 2021. Species at Risk Act Recovery Strategy and Action Plan Report Series. Fisheries and Oceans Canada, Ottawa.

Furey, K.M., H.C. Glassic, C.S. Guy, T.M. Koel, J.L. Arnold, P.D. Doepke, and P.E. Bigelow. 2020. Diets of Longnose Sucker in Yellowstone Lake, Yellowstone National Park, USA. Journal of Freshwater Ecology 35:291-303. Taylor & Francis. Available from https://doi.org/10.1080/02705060.2020.1807421

Gillett, N.P., A. Cannon, E. Malinina, M. Schnorbus, F. Anslow, S. Qiaohong, M. Kirchmeier-Young, F. Zwiers, C. Seller, X. Zhang, G. Flato, H. Wan, G. Li, and A. Castellin. 2022. Human influence on the 2021 British Columbia floods. Weather and Climate Extremes 36:100441.

Helbing, Caren pers. comm. 2023. *Email correspondence to M. Pearson.* August 2023. Professor. Department of Biochemistry and Microbiology, University of Victoria, Victoria, British Columbia.

Heminthavong, K. 2018. Canada's supply management system. Publication No 2018-42-E. Library of Parliament Background Papers. Library of Parliament. Ottawa.

Hoffman, G.L. 1967. Parasites of North American freshwater fishes. 2nd Edition. Cornell University Press.

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

IUCN. 2024. Criterion A tool: population reduction calculator. The IUCN Red List of Threatened Species. Version 2023-1. https://www.iucnredlist.org/resources/criterion-a [accessed May 2024].

Jamieson, I.G., and F.W. Allendorf. 2012. How does the 50/500 rule apply to MVPs? Trends in Ecology and Evolution 27:578-584.

Jefford, K. *Email correspondence to M. Pearson.* January 2023. Director of Engineering. City of Chilliwack. Chilliwack, British Columbia.

Jelks, H.L., S.J. Walsh, S. Contreras-Balderas, J. Lyons, F. McCormick, J.J. Schmitter-Soto, and M.L. Warren. 2008. Conservation status of imperiled North American freshwater and diadromous fishes. Fisheries 33:372-407.

Landry, L., W.F. Vincent, and L. Bernatchez. 2007. Parallel evolution of lake whitefish dwarf ecotypes in association with limnological features of their adaptive landscape. Journal of Evolutionary Biology 20:971-984.

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

Lepage, P. 2014. Life history of dwarf Longnose Sucker (*Catosomus catostomus*) in the Elk River watershed. MSc thesis, University of Waterloo, Waterloo, Ontario.

Mandeville, E.G., T.L. Parchman, K.G. Thompson, R.I. Compton, K.R. Gelwicks, S.J. Song, and C.A. Buerkle. 2017. Inconsistent reproductive isolation revealed by interactions between *Catostomus* fish species. Evolution Letters 1:255-268.

Master, L.L., D. Faber-Langendoen, R. Bittman, G.A. Hammerson, B. Heidel, L. Ramsay, K. Snow, A. Teucher, and A. Tomaino. 2012. NatureServe conservation status assessments: factors for evaluating species and ecosystems risk. NatureServe, Arlington, Virginia.

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. pers. comm. 1998. Notes from interview by M. Pearson. Professor Emeritus. Department of Zoology, University of British Columbia, Vancouver, British Columbia.

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

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, BC.

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.

Murphy M. 2006. Blackberries. Pp xx-xx, *in* P. Boersma, S.H. Reichard, and A.N. Van Buren (eds.). Invasive speices of the Pacific Northwest. University of Washington Press, Seattle, Washington.

NatureServe. 2022. NatureServe Network Biodiversity Location Data accessed through NatureServe Explorer [web application]. NatureServe, Arlington, Virginia. Available https://explorer.natureserve.org/ [accessed: December 30, 2022].

Patton, T.M. 2003. Evaluation of the Salish Creek mitigation project. MSc thesis, Resource Management and Environmental Studies, University of British Columbia, Vancouver, British Columbia.

Pearson, M. 1998. A review of the distribution, status, and biology of the endangered Salish sucker (*Catostomus* sp.) and Nooksack dace (*Rhinichthys* sp.). B.C. Ministry of Fisheries, Vancouver, British Columbia.

Pearson, M. 2004. The ecology, status, and recovery prospects of Nooksack dace (*Rhinichthys cataractae* ssp.) and Salish sucker (*Catostomus* sp.) in Canada. PhD thesis, University of British Columbia, Vancouver, British Columbia.

Pearson, M. 2007. An assessment of potential critical habitat for Nooksack dace (*Rhinichthys cataractae* ssp.) and Salish Sucker (*Catostomus* sp.). DFO Canadian Science Advisory Secretariat Research Document 2007/058.

Pearson, M. 2015a. Recovery potential assessment for the Salish Sucker in Canada. DFO Canadian Science Advisory Secretariat Science Research Document 2015/077.

Pearson, M. 2015b. Guidelines for the capture, handling, scientific study, and salvage of the Salish Sucker (*Catostomus* sp.). Fisheries and Oceans Canada. Vancouver, BritishColumbia.

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

Putt, A.E., E.A. MacIsaa, H.E. Herunter, A.B. Cooper, and D.T. Selbie. 2019. Eutrophication forcings on a peri-urban lake ecosystem: Context for integrated watershed to airshed management. PLoS ONE 14:e0219241.

Rafter, T. 2001. Contested spaces: the Chilliwack River diversion. Pp. 106-107, *in* K.T. Carlson (ed.). A Stó:lo- Coast Salish historical atlas. Douglas and McIntyre and the Sto:lo Nation, Vancouver and Chilliwack, British Columbia.

Ramirez, S.Z. 2022. Modelling the impact of human development and water quality on hypoxia. MSc thesis, Department of Zoology, University of British Columbia, Vancouver, British Columbia.

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

Rosenfeld J.S. 2014. 50/500 or 100/1000? Reconciling short- and long-term recovery targets and MVPs. Biological Conservation 176:287-288.

Rosenfeld, J.S., M. Pearson, J. Miners, and K. Zinn. 2021. Effects of landscape-scale hypoxia on Salish Sucker and salmonid habitat associations: implications for endangered species recovery and management. Canadian Journal of Fisheries and Aquatic Sciences 78:1219-1233.

Ryan, D.K., J.M. Yearsley, and M. Kelly-Quinn. 2013. Quantifying the effect of semi-natural riparian cover on stream temperatures: Implications for salmonid habitat management. Fisheries Management and Ecology 20:494-507.

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

Schaepe, D.M. 2001. The maps of K'hhalserten, c. 1918. Pp. xx-xx, *in* K.T. Carlson (ed.). A Stó:lō-Coast Salish historical atlas. Douglas and McIntyre and the Stó:lō Nation, Vancouver and Chilliwack, British Columbia.

Schindler, D.W., P.J. Dillon, and H. Schreier. 2006. A review of anthropogenic sources of nitrogen and their effects on Canadian aquatic ecosystems. Pp. 25-44, *in* L.A. Martinelli and R.W. Howarth (eds.). 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.

Schreier H., R. Bestbier, and G. Derksen. 2003. Agricultural nutrient management trends in the Lower Fraser Valley, BC (Based on Agricultural Census 1991-2001). (Compact Disc) IRES, University of British Columbia, Vancouver, British Columbia.

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

Schupe, S.M. 2013. Statistical and spatial analysis of land cover impact on selected Metro Vanouver, British Columbia watersheds. Environmental Management. 51:18-31.

Schupe, S.M. 2017. High resolution stream water quality assessment in the Vancouver, British Columbia region: a citizen science study. Science of the Total Environment: 745-759.

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

Smith, I. (2004) Cumulative effects of agricultural intensification on nutrients and trace metal pollution in the Sumas River watershed. MSc thesis, Resources Management and Environmental Studies, University of British Columbia, Vancouver, British Columbia. 275 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.

Traill, L.W., B.W. Brook, R.R. Frankham, and C.J.A. Bradshaw. 2010. Pragmatic population viability targets in a rapidly changing world. Biological Conservation 143:28-34. http://dx.doi.org/10.1016/j.biocon.2009.09.001

TransMountain. 2023. Detailed Route. https://www.transmountain.com/ [accessed January 8, 2023].

Vadas, Robert Jr., pers.comm. 2011. Notes from telephone call from Mike Pearson. Biologist. Washington Department of Fish and Game. Olympia, Washington.

Vélez-Espino, L.A., and M.A. Koops. 2012. Capacity for increase, compensatory reserves, and catastrophes as determinants of minimum viable population in freshwater fishes. Ecological Modelling 247:319-326.

Victor, Carrielynn, pers. comm. 2019. *Email correspondence (Excel spreadsheet) to M. Pearson.* April 2019. Manager. Ayelstexw Consulting, Cheam First Nation, British Columbia.

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.

Wang, T., M. Fujiwara, X. Gao, and H. Liu. 2019. Minimum viable population size and population growth rate of freshwater fishes and their relationships with life history traits. Scientific Reports 9:1-8.

Wang, Y, J.E. Wilson, D. Brayshaw, and L.M. Lavkulich. 2017. Effects of aggregate extraction on water storage in the Pepin Creek watershed, British Columbia, Canada. Natural Resources 8:461-477.

Watt, K.J. 2006. High water: Living with the Fraser floods. Dairy Industry Historical Society of British Columbia. http://www.bcdairyhistory.ca

Willis, R.J. 2000. *Juglans* spp., juglone and allelopathy. Allelopathy Journal 7:1-55.

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. xx-xx, *in* K. T. Carlson (ed.). A Stó:lō-Coast Salish historical atlas. Douglas and McIntyre and the Stó:lō Nation, Vancouver and Chilliwack.

Wydoski, R.S., and R.R. Whitney. 2003. Inland fishes of Washington. 2nd Edition. American Fisheries Society and University of Washington Press, Bethesda, Maine.

Zinn, K.R., J.S. Rosenfeld, and E.B. Taylor. 2021. Effects of experimental flow manipulations on water quality, hypoxia, and growth of threatened salish Sucker (*Catostomus* sp. cf. *catostomus*) and juvenile coho salmon (*Oncorhynchus kisutch*). Canadian Journal of Fisheries and Aquatic Sciences 78:1234-1246.

COLLECTIONS EXAMINED

- Beaty Biodiversity Museum, University of British Columbia, Vancouver, BC http://www.beatymuseum.ubc.ca/collections/fish
- Royal British Columbia Museum, Victoria, BC
- University of Washington/Burke Museum Fish Collection, Seattle, Washington. https://www.burkemuseum.org/collections-and-research/biology/ichthyology

AUTHORITIES CONTACTED

- British Columbia Conservation Data Centre, Ecosystems Branch, BC Ministry of Environment. Victoria, British Columbia.
- COSEWIC Secretariat, Canadian Wildlife Service, Environment and Climate Change Canada. Gatineau, Quebec.
- Ilves, K.L. Research Scientist. Canadian Museum of Nature. Ottawa, Ontario.
- May-McNally, S. Acting Senior Science Advisor. Species at Risk and Atlantic Salmon. Department of Fisheries and Oceans. Ottawa. Ontario.
- McDonald, R. Senior Environmental Advisor. National Defence, Ottawa, Ontario.
- Rosenfeld, J.S.R. Research Scientist. British Columbia Ministry of Environment/ University of British Columbia. Vancouver, British Columbia.
- Species at Risk Group, Fisheries and Oceans Canada. Vancouver, British Columbia.
- Sadler, K. Head. Species at Risk Recovery, Environment and Climate Change Canada, Canadian Wildlife Service Pacific Region. Nanaimo, British Columbia.
- Shepherd, P. Species Conservation and Management Ecosystem Scientist III. Parks Canada. Vancouver, British Columbia.
- Wilson, G.A. Aquatic Species at Risk Specialist. Ecosystem Protection and Sustainability Branch, British Columbia Ministry of the Environment. Victoria, British Columbia.

ACKNOWLEDGEMENTS

Funding for the preparation of this report was provided by Environment and Climate Change Canada. Drafts of the report were prepared for COSEWIC by Dr. Mike Pearson (Pearson Ecological, 2840 Lougheed Highway, Agassiz BC, British Columbia V0M 1A1). COSEWIC is indebted to Dr. J.D. McPhail (Emeritus, UBC), who provided observations, insights, and data on many occasions. Dr. Jordan Rosenfeld (BC Ministry of Environment) has led most of the recent research on the species with the help of UBC graduate students Jill Miners, Kaitlyn Zinn, and Samantha Ramirez. Dr. Eric Taylor (UBC) provided genetic confirmation of Salish Sucker identification at Chawathil. Most of the new information presented in this report was collected in research funded by Fisheries and Oceans Canada under contribution agreements with British Columbia Ministry of Environment. Previous COSEWIC Reports on Salish Sucker were prepared by Dr. Alex Peden (2002) and Dr. Mike Pearson (2012).

BIOGRAPHICAL SUMMARY OF REPORT WRITER

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. cf. *catostomus*) and Nooksack Dace (*Rhinichthys cataractae*). He has led fieldwork on these species annually since 1997 and contributed to several peer-reviewed papers on them. He was a member of the National Recovery Team for Non-Game Freshwater Fishes (BC). He authored the Recovery Potential Assessment for the Salish Sucker in Canada (2015a), the guidelines for the capture, handling, scientific study and salvage (2015b), COSEWIC Assessment and Update Status Reports for Salish Sucker (2012), Nooksack Dace (2007, 2018), and Morrison Creek Lamprey (*Lampetra* sp.; 2010). Since 2001, Dr. Pearson has run Pearson Ecological, a small consulting firm based in Agassiz, BC and specializing in species at risk, and aquatic habitat assessment, enhancement, and monitoring.

Appendix 1. Targeted efforts to locate Salish Sucker populations in lower Fraser River Valley, 1992–2022. Effort refers to number of traps set or sites electrofished. Method codes: G = minnow (Gee) trap, F = Feddes trap (Pearson 2015); EF = electrofishing. Only the first documented occurrence is shown for known populations. Details of effort in occupied watersheds are provided in the Fluctuations and Trends section.

Drainage	Watershed	Watershed Code	Year	Effort	Salish Sucker	Method	Reference
Fraser	Addington Point	100-026700-09000	2021	88	N	F	Pearson unpubl. data
Fraser	Agassiz Slough	100-086400-45800	2000	12	Y	G/F	Pearson 2004
Fraser	Alouette River	100-026700-06000	2000	24	N	G/F	Pearson 2004
Fraser	Alouette River	100-026700-06000	2000	17	N	F	Pearson unpubl. data
Fraser	Alouette River	100-026700-06000	2017	102	N	F	Pearson unpubl. data
Fraser	Alouette River	100-026700-06000	2019	52	N	F	Pearson unpubl. data
Fraser	Alouette River	100-026700-06000	2020	102	N	F	Pearson unpubl. data
Fraser	Alouette River	100-026700-06000	2021	60	N	F	Pearson unpubl. data
Fraser	Bridal Creek/Cheam Lake	100-089400-07100	2010	30	N	F	Pearson unpubl. data
Fraser	Brunette River	100-020100	2012	28	N	F	Pearson unpubl. data
Fraser	Brunette River	100-020100	2013	108	N	F	Pearson unpubl. data
Fraser	Brunette River	100-020100	2014	296	N	F	Pearson unpubl. data
Fraser	Brunette River	100-020100	2015	160	N	F	Pearson unpubl. data
Fraser	Brunette River	100-020100	2016	166	N	F	Pearson unpubl. data
Fraser	Brunette River	100-020100	2017	120	N	F	Pearson unpubl. data
Fraser	Burnaby Lake	100-020100	2010	10	N	G/F	Pearson unpubl. data
Fraser	Camp Slough	100-074100-28700-50400	2000	11	N	G/F	Pearson 2004
Fraser	Camp Slough	100-074100-28700-50400	2006	10	N	G/F	Pearson unpubl. data
Fraser	Camp Slough	100-074100-28700-50400	2009	73	N	G/F	Pearson unpubl. data
Fraser	Cardinalis Creek	100-047100-21600	2017	30	N	F	Pearson unpubl. data
Fraser	Centre Creek	100-029000	2014	30	N	F	Pearson unpubl. data
Fraser	Centre Creek	100-029000	2015	28	N	F	Pearson unpubl. data
Fraser	Centre Creek	100-029000	2016	28	N	F	Pearson unpubl. data
Fraser	Centre Creek	100-029000	2017	28	N	F	Pearson unpubl. data
Fraser	Centre Creek	100-029000	2018	28	N	F	Pearson unpubl. data
Fraser	Chester Creek	100-049300	2000	6	N	G/F	Pearson 2004
Fraser	Chester Creek	100-049300	2017	13	N	F	Pearson unpubl. data
Fraser	Chester Creek	100-049300	2018	18	N	F	Pearson unpubl. data

Drainage	Watershed	Watershed Code	Year	Effort	Salish Sucker	Method	Reference
Fraser	Chester Creek	100-049300	2019	9	N	F	Pearson unpubl. data
Fraser	Chilliwack Delta (Atchelitz Creek)	100-071800-16300	2000	2	Y	G/F	Pearson 2004
Fraser	Chilliwack Delta (Atchelitz Creek)	100-071800-16300-72624	2007	29	Y	G	Taylor pers. comm.
Fraser	Chilliwack Delta (Little Chilliwack River)	100-071800	2004	62	Y	G/F	Pearson unpubl. data
Fraser	Chilliwack Delta (Luckakuck Creek)	100-071800-42400	2000	8	Y	G/F	Pearson 2004
Fraser	Chilliwack Lake	100-065700-09700	2019	27	N	F	Pearson unpubl. data
Fraser	Chilliwack Delta	100-071800	1992	5	N	EF/G	Inglis *et al.* 1992
Fraser	Chilqua Creek	100-058500-46900	2010	17	N	G/F	Miners and Pearson unpubl. data
Fraser	Clifford Slough/Downes Cr./McLennan Cr.	100-053600	2000	21	N	G/F	Pearson 2004
Fraser	Coquitlam Oxbow Side Channel	100-024500	2018	19	N	F	Pearson unpubl. data
Fraser	Coquitlam Oxbow Side Channel	100-024500	2019	18	N	F	Pearson unpubl. data
Fraser	Coquitlam River	100-024500	2000	10	N	G/F	Pearson 2004
Fraser	Coquitlam River (Colony Farm)	100-024500	2012	36	N	F	Pearson unpubl. data
Fraser	Coquitlam River (Colony Farm)	100-024500	2013	72	N	F	Pearson unpubl. data
Fraser	Coquitlam River (Colony Farm)	100-024500	2014	72	N	F	Pearson unpubl. data
Fraser	Coquitlam River (Colony Farm)	100-024500	2015	72	N	F	Pearson unpubl. data
Fraser	Coquitlam River (Colony Farm)	100-024500	2016	72	N	F	Pearson unpubl. data
Fraser	Coquitlam River (Colony Farm)	100-024500	2010–2011	232	N	G/F	Pearson unpubl. data
Fraser	Davis Lake	100-047100-22800	2017	18	N	F	Pearson unpubl. data
Fraser	DeBoville Slough	100-026700-06100	2000	15	N	G/F	Pearson 2004
Fraser	DeBoville Slough	100-026700-06100	2021	33	N	F	Pearson unpubl. data
Fraser	Devil Lake	100-111800	2023	20	N	G/F	Pearson unpubl.data
Fraser	Devil's Lake	100-047100-13400	2017	36	N	F	Pearson unpubl. data
Fraser	Duncan Slough	110-071000	2000	3	N	G/F	Pearson 2004
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/F	Pearson 2004
Fraser	Elk Creek/Hope Slough	100-074100	2000	53	N	G/F	Pearson 2004
Fraser	Elk Creek/Hope Slough	100-074100	2006	46	Y	G/F	Pearson unpubl. data
Fraser	Frank Dan Slough (Sts'ailes)	110	2017	10	N	F	Pearson unpubl. data
Fraser	Frank Dan Slough (Sts'ailes)	110	2018	22	N	F	Pearson unpubl. data
Fraser	Frank Dan Slough (Sts'ailes)	110	2019	12	N	F	Pearson unpubl. data

Drainage	Watershed	Watershed Code	Year	Effort	Salish Sucker	Method	Reference
Fraser	Gifford Slough	100-053600	1992	5	N	EF/G	Inglis *et al*. 1992
Fraser	Harrison River/Lake	110	2000	29	N	G/F	Pearson 2004
Fraser	Hatzic Slough	100-058500	2000	32	N	G/F	Pearson 2004
Fraser	Herrling Island Swamp	100	2017	18	N	F	Pearson unpubl. data
Fraser	Hicks Creek	100-093700	2010	3	N	G/F	Pearson unpubl. data
Fraser	Jimmie Charlie Slough (Sts'ailes)	110	2017	23	N	F	Pearson unpubl. data
Fraser	Jimmie Charlie Slough (Sts'ailes)	110	2018	42	N	F	Pearson unpubl. data
Fraser	Jimmie Charlie Slough (Sts'ailes)	110	2019	18	N	F	Pearson unpubl. data
Fraser	Johnsons Slough	100-101900	2021	10	N	F	Pearson unpubl. data
Fraser	Kanaka Creek	100-037400	2000	15	N	G/F	Pearson 2004
Fraser	Kanaka Creek	100-037400	2009	11	N	G/F	Pearson unpubl. data
Fraser	Katzie Marsh (Pitt Polder)	100-026700-19100	2012	18	N	F	Pearson unpubl. data
Fraser	Katzie Marsh (Pitt Polder)	100-026700-19100	2013	15	N	F	Pearson unpubl. data
Fraser	Katzie Marsh (Pitt Polder)	100-026700-19100	2014	15	N	F	Pearson unpubl. data
Fraser	Katzie Marsh (Pitt Polder)	100-026700-19100	2015	15	N	F	Pearson unpubl. data
Fraser	Katzie Marsh (Pitt Polder)	100-026700-19100	2016	30	N	F	Pearson unpubl. data
Fraser	Katzie Marsh (Pitt Polder)	100-026700-19100	2017	89	N	F	Pearson unpubl. data
Fraser	Katzie Marsh (Pitt Polder)	100-026700-19100	2021	64	N	F	Pearson unpubl. data
Fraser	Katzie Slough	100-026700-02800	2012	15	N	F	Pearson unpubl. data
Fraser	Katzie Slough	100-026700-02800	2013	15	N	F	Pearson unpubl. data
Fraser	Katzie Slough	100-026700-02800	2014	15	N	F	Pearson unpubl. data
Fraser	Katzie Slough	100-026700-02800	2015	15	N	F	Pearson unpubl. data
Fraser	Katzie Slough	100-026700-02800	2016	30	N	F	Pearson unpubl. data
Fraser	Katzie Slough	100-026700-02800	2018	16	N	F	Pearson unpubl. data
Fraser	Katzie Slough/Cranberry Slough	100-026700-02800	2000	50	N	G/F	Pearson 2004
Fraser	Kawkawa Lake/Sucker Creek	100-115400-03100	2023	38	N	G/F	Pearson unpubl. data
Fraser	Lake Errock and outlet stream	110-036900	2008	28	N	G/F	Pearson unpubl. data
Fraser	Lorenzetta Creek	100-102000	1992	1	N	EF/G	Inglis *et al*. 1992
Fraser	Lower Stave River	100-047100	2017	85	N	F	Pearson unpubl. data
Fraser	Maple Creek (Coquitlam River Trib.)	100-024500-11232	2011	12	N	F	Pearson unpubl. data
Fraser	Maple Creek (Coquitlam River Trib.)	100-024500-11232	2013	13	N	F	Pearson unpubl. data

Drainage	Watershed	Watershed Code	Year	Effort	Salish Sucker	Method	Reference
Fraser	Maple Creek (Coquitlam River Trib.)	100-024500-11232	2014	14	N	F	Pearson unpubl. data
Fraser	Maple Creek (Coquitlam River Trib.)	100-024500-11232	2015	15	N	F	Pearson unpubl. data
Fraser	Maple Creek (Coquitlam River Trib.)	100-024500-11232	2016	12	N	F	Pearson unpubl. data
Fraser	Maria Slough	100	2000	10	N	G/F	Pearson 2004
Fraser	Maria Slough	100	2001	4	N	G/F	Pearson 2004
Fraser	Maria Slough	100	2007	66	N	G/F	Pearson unpubl. data
Fraser	Maria Slough	100	2012	16	N	F	Pearson unpubl. data
Fraser	Maria Slough	100	2021	97	N	F	Pearson unpubl. data
Fraser	Maria Slough	100	2022	80	N	F	Pearson unpubl. data
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/F	Pearson 2004
Fraser	Matsqui Slough	100-054300	1992	3	N	EF/G	Inglis *et al*. 1992
Fraser	Matsqui Slough	100-054300	2021	11	N	F	Pearson unpubl. data
Fraser	Matsqui Slough/Willbrand Cr./Stoney Cr.	100-054300	2000	38	N	G/F	Pearson 2004
Fraser	McGillvary Slough/Lewis Slough	100-065700-09300-37400	2000	24	N	G/F	Pearson 2004
Fraser	McLean Creek	100-026700-07600	2021	33	N	F	Pearson unpubl. data
Fraser	McLennan Creek	100-053600	2021	45	N	F	Pearson unpubl. data
Fraser	McLennan Creek	100-053600	2022	63	N	F	Pearson unpubl. data
Fraser	Miami River	110-232100	2000	12	Y	G/F	Pearson 2004
Fraser	Miami River	110-232100	2011	88	Y	L	Miners and Pearson unpubl. data
Fraser	Munday Creek	100-033300-4840	1992	2	N	EF/G	Inglis *et al*. 1992
Fraser	Nancy and William Phillips Sloughs (Sts'ailes)	110	2022	26	N	F	Pearson unpubl. data
Fraser	Nathan Creek	100-043700	1992	7	N	EF/G	Inglis *et al*. 1992
Fraser	Nathan Creek	100-043700	2000	6	N	G/F	Pearson 2004
Fraser	Nathan Creek	100-043700	2001	16	N	G/F	Pearson 2004
Fraser	Nelson Slough	100-078900	2021	69	N	F	Pearson unpubl. data
Fraser	Nicomen Slough	100	2000	6	N	G/F	Pearson 2004
Fraser	Nicomen Slough	100	2012	18	N	F	Pearson unpubl. data
Fraser	Nicomen Slough	100	2016	36	N	F	Pearson unpubl. data
Fraser	Nicomen Slough	100	2021	78	N	F	Pearson unpubl. data
Fraser	Nicomen Slough	100	2015	85	N	F	Pearson unpubl. data

Drainage	Watershed	Watershed Code	Year	Effort	Salish Sucker	Method	Reference
Fraser	Norrish Creek	100-064000	2000	30	N	G/F	Pearson unpubl. data
Fraser	Norrish Creek Delta	100-064000	2017	68	N	F	Pearson unpubl. data
Fraser	Norrish Creek Delta	100-064000	2018	72	N	F	Pearson unpubl. data
Fraser	North Nicomen Slough (Nicomen Slough)	100-066500	2021	95	N	F	Pearson unpubl. data
Fraser	North Nicomen Slough (Nicomen Slough)	100-066500	2022	23	N	F	Pearson unpubl. data
Fraser	Or Creek Side Channel (Coquitlam River Trib)	100-024500-34800	2017	18	N	F	Pearson unpubl. data
Fraser	Or Creek Side Channel (Coquitlam River Trib.)	100-024500-34800	2018	14	N	F	Pearson unpubl. data
Fraser	Or Creek Side Channel (Coquitlam River Trib.)	100-024500-34800	2019	15	N	F	Pearson unpubl. data
Fraser	Palmateer Creek	100-041800	2000	3	N	G/F	Pearson 2004
Fraser	Peach Creek	100-065700-09700	2017	17	N	F	Pearson unpubl. data
Fraser	Peach Creek	100-065700-09700	2018	36	N	F	Pearson unpubl. data
Fraser	Peach Creek	100-065700-09700	2019	18	N	F	Pearson unpubl. data
Fraser	Peach Creek	100-065700-09700	2021	6	Y	F	Pearson unpubl. data
Fraser	Pretty Creek	110-090200-05000	2000	3	N	G/F	Pearson 2004
Fraser	Quaamitch Slough	100-068800	2000	3	N	G/F	Pearson 2004
Fraser	Quaamitch Slough (Nicomen Slough)	100-068800	2015	36	N	F	Pearson unpubl. data
Fraser	Red Slough	100-026700-45500	2020	91	N	F	Pearson unpubl. data
Fraser	Red Slough	100-026700-45500	2021	98	N	F	Pearson unpubl. data
Fraser	Red Slough	100-026700-45500	2022	90	N	F	Pearson unpubl. data
Fraser	Saar Creek/Arnold Slough	100-065700-48300	2000	29	N	G/F	Pearson 2004
Fraser	Salmon River	100-038800	1992	14	Y	EF/G	Inglis *et al*. 1992
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/F	Pearson 2004
Fraser	Schkam Lake	100-115100	2023	36	N	G/F	Pearson unpubl. data
Fraser	Silverdale Wetlands	100-051900-02800	2018	16	N	F	Pearson unpubl. data
Fraser	Silverdale Wetlands	100-051900-02800	2019	13	N	F	Pearson unpubl. data
Fraser	Skumalasph Slough (Nicomen Slough)	100-072600	2015	25	N	F	Pearson unpubl. data
Fraser	Skumalasph Slough (Nicomen Slough)	100-072600	2021	9	N	F	Pearson unpubl. data

Drainage	Watershed	Watershed Code	Year	Effort	Salish Sucker	Method	Reference
Fraser	Sq'ewlets Slough East	100	2020	17	N	F	Pearson unpubl. data
Fraser	Sq'ewlets Slough East	100	2021	17	N	F	Pearson unpubl. data
Fraser	Sq'ewlets Slough West	100	2020	16	N	F	Pearson unpubl. data
Fraser	Sq'ewlets Slough West	100	2021	19	N	F	Pearson unpubl. data
Fraser	Squawkum Creek	110-036900	2020	54	N	F	Pearson unpubl. data
Fraser	Squawkum Creek	110-036900	2021	19	N	F	Pearson unpubl. data
Fraser	Stave River/Silvermere Lake	100-047100	2000	8	N	G/F	Pearson 2004
Fraser	Stewart Creek	100-065700-15100-51500	2000	5	N	G/F	Pearson2004
Fraser	Street Creek/Hopedale Slough	100-065700-09700-07400	1992	1	N	EF/G	Inglis *et al*. 1993
Fraser	Street Creek/Hopedale Slough	100-065700-09700-07400	2000	11	Y	G/F	Pearson 2004
Fraser	Street Creek/Hopedale Slough	100-065700-09700-07400	2004	38	Y	G/F	Pearson unpubl. data
Fraser	Stuart Creek	100-026700-17400	2016	42	N	F	Pearson unpubl. data
Fraser	Sumas River	100-065700	1992	4	N	EF/G	Inglis *et al*. 1992
Fraser	Sumas River	100-065700	2000	35	N	G/F	Pearson unpubl. data
Fraser	Sumas River	100-065700	2012	18	N	F	Pearson unpubl. data
Fraser	Surrey Bend Enhancement Channels	100	2014	34	N	F	Pearson unpubl. data
Fraser	Surrey Bend Enhancement Channels	100	2015	36	N	F	Pearson unpubl. data
Fraser	Surrey Bend Enhancement Channels	100	2016	36	N	F	Pearson unpubl. data
Fraser	Surrey Bend Enhancement Channels	100	2017	77	N	F	Pearson unpubl. data
Fraser	Surrey Bend Enhancement Channels	100	2018	76	N	F	Pearson unpubl. data
Fraser	Sweltzer Creek	100-065700-09700-13300	2000	10	N	G/F	Pearson 2004
Fraser	Sweltzer River	100-065700-09700-13300	1992	2	N	EF/G	Inglis *et al*. 1994
Fraser	Taylor Road Slough	100	2021	32	N	F	Pearson unpubl. data
Fraser	Tilbury Slough	100	2021	88	N	F	Pearson unpubl. data
Fraser	Tilbury Slough	100	2022	54	N	F	Pearson unpubl. data
Fraser	Tommy Alex Slough (Sts'ailes)	110	2017	4	N	F	Pearson unpubl. data

Drainage	Watershed	Watershed Code	Year	Effort	Salish Sucker	Method	Reference
Fraser	Tommy Alex Slough (Sts'ailes)	110	2018	8	N	F	Pearson unpubl. data
Fraser	Tommy Alex Slough (Sts'ailes)	110	2019	4	N	F	Pearson unpubl. data
Fraser	Trestle Channel	100-065700-09700	2017	17	N	F	Pearson unpubl. data
Fraser	Trestle Channel	100-065700-09700	2018	33	N	F	Pearson unpubl. data
Fraser	Trestle Channel	100-065700-09700	2019	18	N	F	Pearson unpubl. data
Fraser	Tributary to Maria Slough	100-093600	2010	34	N	G/F	Pearson unpubl. data
Fraser	Trout Lake	110-259000	2000	3	N	G/F	Pearson 2004
Fraser	UBC Tributary (Maria Slough)	100-093600	2010	15	N	F	Pearson unpubl. data
Fraser	Weaver Creek	110-149200-85400	2000	6	N	G/F	Pearson 2004
Fraser	West Creek	100-041600	1992	3	N	EF/G	Inglis *et al*. 1992
Fraser	West Creek	100-041600	2000	18	N	G/F	Pearson 2004
Fraser	West Creek	100-041600	2021	27	N	F	Pearson unpubl. data
Fraser	Westan Creek	100-072800	2000	4	N	G/F	Pearson 2004
Fraser	Whonnoek Creek	100-045300	2000	4	N	G/F	Pearson 2004
Fraser	Widgeon Slough	100-026700	2017	32	N	F	Pearson unpubl. data
Fraser	Willbrand Creek	100-054300-53400	2009	72	N	G/F	Pearson unpubl. data
Fraser	Willbrand Creek	100-054300-53400	2010	30	N	G/F	Pearson unpubl. data
Fraser	Wilson Slough	100-069200	2000	6	N	G/F	Pearson 2004
Fraser	Wilson Slough	100-069200	2015	18	N	F	Pearson unpubl. data
Fraser	Worth Creek (Norrish Trib.)	100-064000-91100	2010	45	N	G/F	Miners and Pearson unpubl.
Fraser	York Creek/Benson Slough	100-045000	2000	14	N	G/F	Pearson 2004
Fraser	Yorkson Creek	100-033300	2021	58	N	F	Pearson unpubl. data
Fraser	Yorkson Creek	100-033300	2022	37	N	F	Pearson unpubl. data
Fraser	Zaitscullachan Slough (Nicomen Slough)	100-071820	2016	54	N	F	Pearson unpubl. data
Fraser	Zaitscullachan Slough (Nicomen Slough)	100-071820	2021	64	N	F	Pearson unpubl. data
Little Campbell	Little Campbell River	900-000500	1992	11	N	EF/G	Inglis *et al*. 1992
Little Campbell	Little Campbell River	900-000500	1999	48	N	G/F	Pearson 2004

Drainage	Watershed	Watershed Code	Year	Effort	Salish Sucker	Method	Reference
Little Campbell	Little Campbell River	900-000500	2000	15	N	G/F	Pearson 2004
Little Campbell	Little Campbell River	900-000500	2011	18	Y	L	Pearson unpubl. data
Nicomekl	Nicomekl River	900-004300	1992	9	N	EF/G	Inglis *et al*. 1992
Nicomekl	Nicomekl River	900-004300	2000	34	N	G/F	Pearson 2004
Nicomekl	Nicomekl River	900-004300	2000	5	N	G/F	Pearson 2004
Nicomekl	Nicomekl River	900-004300	2001	32	N	G/F	Pearson 2004
Nicomekl	Nicomekl River	900-004300	2006	6	N	G/F	Pearson unpubl. data
Nicomekl	Nicomekl River	900-004300	2007	16	N	G/F	Pearson unpubl. data
Nicomekl	Nicomekl River	900-004300	2008	100	N	G/F	Pearson unpubl. data
Nicomekl	Nicomekl River	900-004300	2009	136	N	G/F	Pearson unpubl. data
Nicomekl	Nicomekl River	900-004300	2010	231	N	G/F	Pearson unpubl. data
Nooksack	Bertrand Creek	970-046800-25200	1992	15	Y	EF/G	Inglis *et al*. 1992
Nooksack	Fishtrap Creek	970-046800-26400	1992	5	Y	EF/G	Inglis *et al*. 1992
Nooksack	Pepin Creek	970-046800-25200-38700	1992	16	Y	EF/G	Inglis *et al*. 1992
Nooksack	Perry Homestead Creek (Bertrand Trib.)	970-046800-25200-38700-2501-1000	2001	17	Y	G/F	Pearson 2004
Serpentine	Serpentine River	900-005500	1992	4	N	EF/G	Inglis *et al*. 1992
Serpentine	Serpentine River	900-005500	2000	39	N	G/F	Pearson 2004

Appendix 2. Details of population estimate methods.

2000–2008

Early population 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. Sites were trapped using Feddes traps baited with dried dog food (Pearson 2015b). They were set for approximately 24 hours over one or more nights. All captured adults (fork length $\geq$ 100 mm) were marked with subcutaneous injections of fluorescent elastomer (Northwest Marine Technologies, Shaw Island, WA). Fish smaller than 100 mm are considered juveniles (Pearson 2004) and were not included, as the number of breeding adults is the population parameter of interest.

Each site was trapped 1–4 times over periods of 5–37 days following initial marking sessions. Mean population sizes with confidence limits were calculated using Schnabel or Petersen methods (Krebs 1989) 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 summer home range size) or at beaver dams, which Salish Sucker rarely cross (Pearson and Healey 2003). CPUE (mean number adults 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 14) and used to estimate densities for each reach of each watershed (see recovery strategy; Fisheries and Oceans Canada 2020 for reach maps and coordinates). Data from another researcher (Patton 2003) fit the equation well. Reach population estimates were obtained by multiplying density estimates by the area of deep pool habitat (> 70 cm depth).

One of the reach estimates from Pearson (2004) had an extraordinarily high population density and CPUE (18.7 fish per trap) that had a large effect on the equations developed from so few points (n=4). An additional five mark-recapture studies were completed in 2011 to refine the method. None had a CPUE above three fish per trap. Linear regression of log-transformed variables showed that only 40% of the variation in density was explainable by variation in CPUE, which severely limits the precision of watershed-scale abundance estimates. The balance of variation may be due to differences among sites, seasonal water quality (e.g., water temperature or oxygen), or perhaps spatial clumping of fish at low densities. The latter possibility is supported by the observation that most Salish Sucker captured at sites are typically found in a small fraction of the traps set (Pearson pers. obs.).

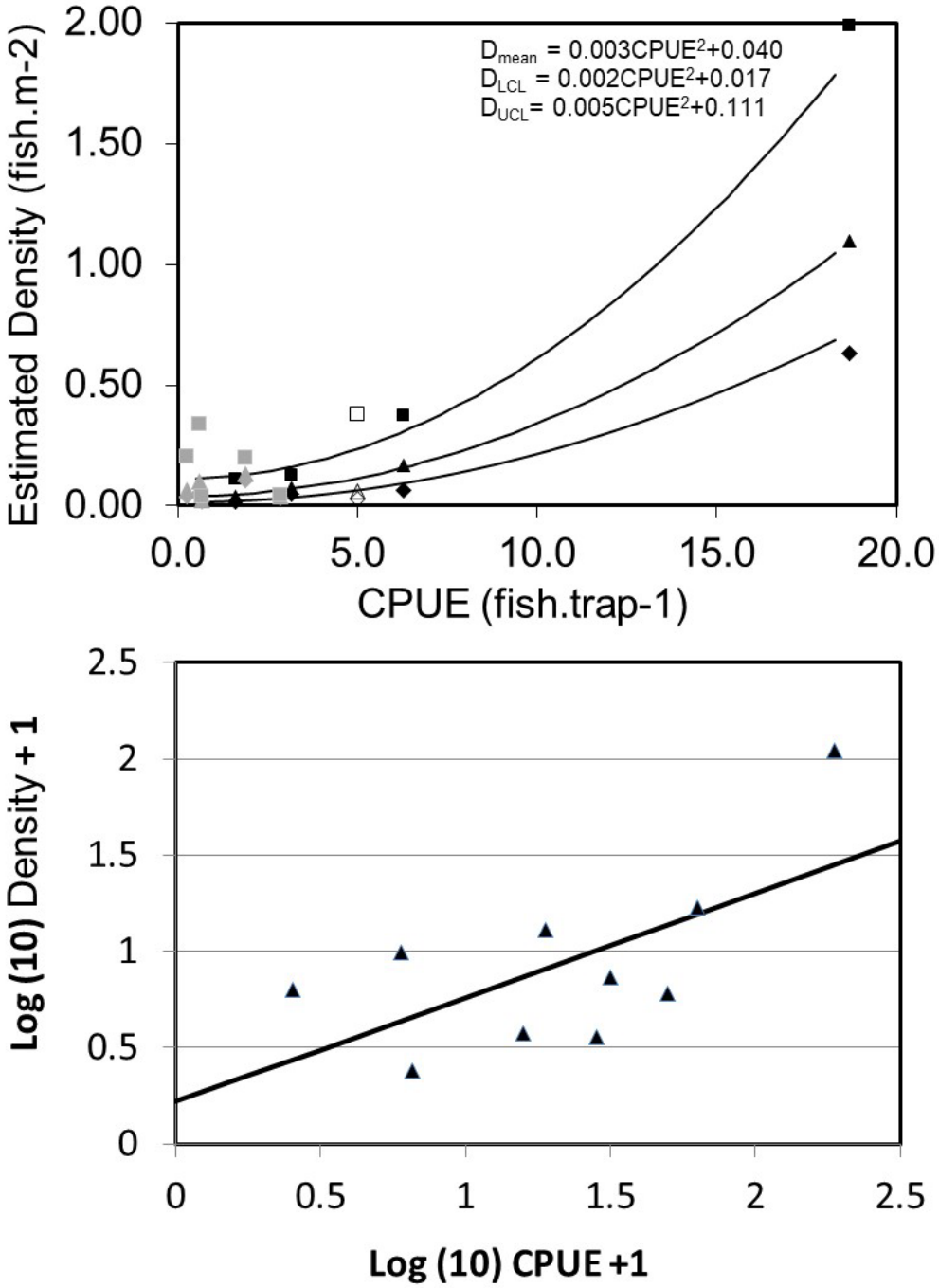

Figure 14. Relationship of Salish Sucker density to catch per unit effort (CPUE) calculated by Pearson (2004; top panel). Equations are based on mean, lower confidence limit and upper confidence limits of four density estimates. The unfilled point is an independent value obtained from a separate reach by another investigator (Patton 2003) using similar methods, and grey points are from additional mark-recapture studies in 2011 (Miners and Pearson unpubl. 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.

After 2008

Beginning in 2012, mark-recapture methods were applied to all critical habitat reaches (Table 2). In 2012, passive integrated transponder (PIT) tags (Biomark, Boise Idaho) injected into the body cavity were used by Jill Miners (University of British Columbia) to estimate abundance in 5 populations (Miners unpubl. data). Unlike elastomer marks, PIT tags allow identification of individuals. Concerns about unacceptably high mortality, however, led to abandonment of this method and a return to the use of subcutaneous elastomer injections from 2013 onward.

For mark-recapture estimates, each critical habitat reach in a watershed was trapped using custom built “Feddes” funnel traps (Pearson 2015b) baited with dried dog food and set overnight. Traps were set in the best available habitat (deep water with abundant cover) at approximately 100-m intervals. If less than 50 fish are captured (almost always the case), traps are reset for up to 3 additional nights. Traps that capture no fish for the first two consecutive nights may be moved to increase density in sections of the reach where catches are higher. A minimum of 10 days after the marking session has ended, the reach is re-trapped using the same method. Fish are inspected for marks using an ultraviolet flashlight to maximize fluorescent elastomer mark detectability. Mean population sizes with confidence limits were calculated using the Petersen method (Krebs 1999). In cases where not enough fish are marked or recaptured to permit estimation, the total number of individuals captured is reported. Detailed reports on each estimate are held by Fisheries and Oceans Canada Species at Risk Group, Vancouver.

Appendix 3. Threats assessment worksheet

Species or Ecosystem Scientific Name	*Catostomus* sp. cf. *catostomus*	**Element ID**		**English Name**	Salish Sucker
Version Date:	June 1, 2023				
Assessor(s):	Mike Pearson (report writer), Margaret Docker (FWF SSC co-chair), Dwayne Lepitzki (facilitator), Jennifer Diment, Eva Enders, Trevor Pitcher (FWF SSC members), Courtney Druce, Oliver Barker, Maggie Boothroyd (DFO), Joanna James, Dean Whitehead (COSEWIC Secretariat)				
References:	Draft calculator (26 Dec 2022) from report writer based on draft COSEWIC report; telecon 1 June 2023; with additional comments from D Lepitzki (prior to call) and M Docker (notes from call) added				
Generation Time:	3 years (therefore, timeframe for severity and timing = 10 years)				

Overall Threat Impact Calculation Help:		**Level 1 Threat Impact Counts**	
Threat Impact		**high range**	**low range**
A	Very High	0	0
B	High	4	4
C	Medium	0	0
D	Low	2	2
Calculated Overall Threat Impact:		**Very High**	**Very High**
Assigned Overall Threat Impact:		**A = Very High**	
Impact Adjustment Reasons:			
Overall Threat Comments		Scope based on estimates of numbers [%] in each watershed (Table 5). L. 69–75: Salish Sucker abundance in Canada declined an estimated 46% over the past decade. One subpopulation, Agassiz Slough, has likely been extirpated, and several more (Sqemélwelh Creek [0.04%], Mountain Slough [1.6%], Hope Slough [1.6%]) are believed to be very close. Abundance of several other locations in Bertrand Creek [14.7%], Salmon River [14.2%] and Pepin Creek [15.7%] have undergone catastrophic declines (75%) over the same time period. Box 26: Only subpopulations in Pepin [15.7%] Fishtrap [1.6%] and Bertrand [14.7%] creeks are connected to waterways outside Canada. Box 31: Cross-border nutrient pollution in these streams has been a political issue for several decades.	

Threat		**Impact (calculated)**		**Scope (next 10 Yrs)**	**Severity (10 Yrs or 3 Gen.)**	**Timing**	**Comments** (Limit of 2,000 characters in each row. Avoid using ampersand '&'.)
1	Residential & Commercial Development		Negligible	Small (1-10%)	Negligible or <1% pop. decline	High (continuing)	New development directly in aquatic habitat, including riparian areas identified as critical habitat, or diversion of water (not extraction); physical footprint only
1.1	Housing & urban areas		Negligible	Small (1-10%)	Negligible or <1% pop. decline	Moderate - low	Most suitable building areas protected from development by Agricultural Land Reserve; some pressure to remove lands adjacent to Agassiz Slough [0%]. Some developments on First Nations Reserves bordering habitat likely in future on Hope Slough [1.6%] and Chawathil [0.04%]. Redevelopment of mall site in downtown Aldergrove may result in improvements to critical habitat in Bertrand Creek [14.7%]. Scope probably at lower end of “small” (closer to 1%). Severity way less than 10%, probably negligible. Timing probably not within the next 10 years. Developers try to get land removed from the Agricultural Land Reserve, but it goes in cycles.
1.2	Commercial & industrial areas		Negligible	Small (1-10%)	Negligible or <1% pop. decline	High (continuing)	Major industrial developments recently approved in headwaters of Fishtrap Creek (Abbotsford) [1.6%] and immediately adjacent to critical habitat (spawning area) in Little Campbell (Surrey) [4.7%]. Additional developments on FN Reserve land in Chilliwack Delta likely. Severity is now negligible but expected to increase if not mitigated.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments (Limit of 2,000 characters in each row. Avoid using ampersand '&'.)
1.3	Tourism & recreation areas						Campbell Valley Park redevelopment includes habitat restoration work in (unoccupied) critical habitat. Tiny creeks, not places where people put boat launches and marinas.
2	Agriculture & Aquaculture		Negligible	Small (1-10%)	Negligible or <1% pop. decline	High (continuing)	
2.1	Annual & perennial non-timber crops		Negligible	Small (1-10%)	Negligible or <1% pop. decline	High (continuing)	Removal of riparian zone for agricultural purposes has mostly already happened, so remaining scope small. Drainage maintenance work in Chilliwack, Agassiz, Abbotsford areas results in excavators dredging many kilometres of critical habitat annually. Dredging for agriculture = threat 7.2 (dredging for shipping = 4.3)
2.2	Wood & pulp plantations						None in range
2.3	Livestock farming & ranching		Negligible	Small (1-10%)	Negligible or <1% pop. decline	High (continuing)	Note that major impacts of livestock farming are described under the Agricultural Pollution category and Annual and Perennial non-timber crops (impacts of producing feed crops). Vast majority of animals are in barns for entire life, so impacts are not direct. Trampling only. Siltation and manure scored under 9.3. This has improved in the past 20 years, with only about 6 farms left in the range of Salish Sucker, mostly in Bertrand (so scope max of 14.7% if all of Bertrand, and not all so < 10%). Trend towards increased fencing and other mitigation makes severity negligible at moment.
2.4	Marine & freshwater aquaculture						None in range
3	Energy Production & Mining	D	Low	Restricted (11-30%)	Slight or 1-10% pop. decline	High (continuing)	
3.1	Oil & gas drilling						None in range
3.2	Mining & quarrying	D	Low	Restricted (11-30%)	Slight or 1-10% pop. decline	High (continuing)	Gravel pits adjacent to Upper Mountain Slough [1.6%] and Fishtrap Creek [1.6%] steadily expanding. Ongoing infilling of existing pits adjacent to Pepin Creek [15.7%]. Upper Mountain Slough under biggest threat due to gravel pits. Most damage has already been done, and remaining habitat is not suitable due to hypoxia and other factors. Pollution/siltation = 9.2.
3.3	Renewable energy						None in range
4	Transportation & Service Corridors	D	Low	Large (31-70%)	Slight or 1-10% pop. decline	High (continuing)	
4.1	Roads & railroads	D	Low	Large (31-70%)	Slight or 1-10% pop. decline	High (continuing)	Road widening, repaving, culvert/bridge upgrades, etc. are ongoing across the range. Rail crossings in riparian areas of Chilliwack Delta [31.4%], Hope Slough [1.6%], Mountain Slough [1.6%], Chawathil [0.04%], Salmon River [14.2%]). Percent of fish exposed will increase in next 10 years, with bridge replacements and paving (given road density). Scope maybe about 50%. Mitigations to public roads would reduce severity (permits needed), although farming roads less regulated. Severity 1%–10% assumes mitigation on public roads.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments (Limit of 2,000 characters in each row. Avoid using ampersand '&'.)
4.2	Utility & service lines		Negligible	Small (1-10%)	Negligible or <1% pop. decline	High (continuing)	TMX crossing of Hopedale Slough (Browne Creek) [1.6%] is underway. The existing Kinder-Morgan Trans Mountain pipeline and the TransMountain Expansion (currently under construction) cross through or directly upstream of occupied habitat at 12 locations in 6 watersheds. Severity reduced due to assumed appropriate mitigations and permitting. Spills = 9.2.
4.3	Shipping lanes						None in range
4.4	Flight paths						
5	Biological Resource Use						
5.1	Hunting & collecting terrestrial animals						Not applicable
5.2	Gathering terrestrial plants						Not applicable
5.3	Logging & wood harvesting						Additional logging upslope of Chawathil [0.04%], Mountain Slough [1.6%] likely in coming years [but not occurring currently], not adjacent to Salish Sucker habitat. All logging occurred a long time ago. SARA restrictions on logging in critical habitat. This category includes only logging debris falling directly into aquatic habitat; siltation = 9.3.
5.4	Fishing & harvesting aquatic resources						Bait and bycatch unlikely. Lethal research on sucker scored here. Maybe about 12 fish lethally sampled in past 20 years (e.g., voucher specimens). Unintentional mortality from non-lethal sampling (e.g., due to hypoxia in traps) = 6.3. Suckers as a group 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. However, available data do not support these perceptions. There might be some persecution where they're caught and thrown up on the bank, but probably not deliberately sought and killed.
6	Human intrusions & disturbance		Negligible	Pervasive (71-100%)	Negligible or <1% pop. decline	High (continuing)	
6.1	Recreational activities		Negligible	Small (1-10%)	Negligible or <1% pop. decline	High (continuing)	Recreational use of Aldergrove Regional Park (adjacent to habitat in Bertrand Cr., Salmon R), Campbell Valley Regional Park, and various municipal parks is passive recreation. Dog access to riffles can be an issue.
6.2	War, civil unrest & military exercises						Naval Radio Station Aldergrove (Bertrand watershed) is the only land adjacent to Salish Sucker habitat; in active military use, but it is a radio listening station, with a large area to keep area close to radio antennae quiet. Limited activity on lands outside, but ongoing beaver/flood control activities [dewatering] have caused past damage and present some future risk. Beaver control could be under 7.2 or 7.3
6.3	Work & other activities		Negligible	Pervasive (71-100%)	Negligible or <1% pop. decline	High (continuing)	Non-lethal research on sucker scored here; other research on other species in habitat also scored here. Risk of mortality in traps because of hypoxia (100% exposed and timing high), but permits are required and protocols to mitigate have been in place since 2015, so severity negligible. And most standard traps unlikely to catch Salish Sucker apart from a few juveniles.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments (Limit of 2,000 characters in each row. Avoid using ampersand '&'.)
7	Natural System Modifications	B	High	Large (31-70%)	Serious or 31-70% pop. decline	High (continuing)	
7.1	Fire & fire suppression	D	Low	Small (1-10%)	Slight or 1-10% pop. decline	Moderate (short-term)	Wildfire risk is increasing in Fraser Valley. Several have occurred in past 5 years close to Salish Sucker subpopulations. Timing moderate because there's a really good chance in next 10 years. One in 2022 was adjacent to a Mountain Slough tributary (not critical habitat, but winter use is documented in area). Severity slight because most riparian habitat already removed. Bucketting to fight fires scored here; modification of catchment basins due to forest fires = 7.3. Flame retardants = 9.3
7.2	Dams & water management/use	B	High	Large (31-70%)	Serious or 31-70% pop. decline	High (continuing)	Extensive water withdrawals for irrigation across most of the range; municipal and private wells are a huge threat to species; dewatering streams could lead to catastrophic subpopulation declines. Dewatering interacts with drought and is likely to increase with climate change. Mitigation likely required in the future to counter dewatering. Illegal agricultural use of water without licences is happening more and more with drought; pumping water from creeks (almost emptying creeks) to save crops. Proposed municipal well development in Chilliwack Delta watershed [31.4%]. Flow decreases greatly increase hypoxia risk in nutrient loaded streams. Dams negligible.
7.3	Other ecosystem modifications	C	Medium	Large (31-70%)	Moderate or 11-30% pop. decline	High (continuing)	Authorized and unauthorized bank hardening/channelization to mitigate erosion is increasing with increasing flood frequency and severity; permanent, no recovery from it; illegal but it happens. Major works currently underway at Chawathil [0.04%]. Riparian clearing, removal of snags on private lands is ongoing and poorly monitored; removal of large woody debris pervasive.
8	Invasive & Other Problematic Species & Genes	B	High	Pervasive (71-100%)	Serious or 31-70% pop. decline	High (continuing)	
8.1	Invasive non-native/alien species	B	High	Pervasive (71-100%)	Serious or 31-70% pop. decline	High (continuing)	Several introduced species that share habitat with Salish Sucker and may predate on young-of-year (Brown Bullhead, Pumpkinseed, Black Crappie, American Bullfrog). Largemouth Bass could take adults. All of these are found across all or most of range and have coexisted with Salish Sucker for decades, but population impacts are unknown. Reed Canary Grass also potential threat. By 2017, this pond [Perry Homestead Creek in Bertrand Creek watershed] was largely infilled with Reed Canary Grass. The Mountain Slough mainstem suffers from extreme eutrophication. Most of the headwater habitat was completely infilled with Reed Canary Grass when the subpopulation was first found in 2002 (subsequent removal of Canary Grass has occurred). Canary Grass contributes to hypoxia (unlike submerged vegetation that adds oxygen to the water); Canary Grass is pervasive, but highly seasonal (July-Sept)
8.2	Problematic native species						
8.3	Introduced genetic material						
8.4	Problematic species/diseases of unknown origin						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments (Limit of 2,000 characters in each row. Avoid using ampersand '&'.)
8.5	Viral/prion-induced diseases						
8.6	Diseases of unknown cause						
9	Pollution	B	High	Pervasive (71-100%)	Serious or 31-70% pop. decline	High (continuing)	Agricultural nutrient pollution drives eutrophication and severe hypoxia
9.1	Household sewage & urban waste water	C	Medium	Pervasive (71-100%)	Moderate or 11-30% pop. decline	High (continuing)	Increased urban stormwater flows from proposed developments (see 1.1), additional (or unmaintained) septic fields in rural areas. Salt, oil, other pollutants from roads; domestic fertilizers, herbicides from lawns, golf courses. Almost no subpopulations NOT exposed when roadways included (e.g., salt), etc., so scope pervasive. Severity: impact of stormwater on macroinvertebrate communities (on which Salish Sucker feed), although more mitigation of urban pollution than agricultural pollution (which is getting worse, with density of farm animals increasing)
9.2	Industrial & military effluents	D	Low	Restricted (11-30%)	Moderate - slight	High (continuing)	Increased stormwater from proposed and future developments (see 1.2). Spills from transportation, pipelines, mining. At least two large-scale sediment releases from gravel pits and a debris flow caused by a berm failure and the resulting headwater capture of Howe's Creek in 2008 have infilled habitat in Pepin Creek (Pearson 2015a) [15.7%]. Severity potentially high (e.g., if oil spill), but it would depend on where the spill is (upstream or downstream of Salish Sucker habitat), so moderate-slight (1%–30%) reflects uncertainty. Timing high because it's already happened, and mines are still active.
9.3	Agricultural & forestry effluents	B	High	Pervasive (71-100%)	Serious or 31-70% pop. decline	High (continuing)	Nutrient loading to lands will continue to increase as livestock density increases. Supply management of dairy and poultry ensures that this will continue. Already considered the most serious threat across the range (Rosenfeld *et al*. 2021).
9.4	Garbage & solid waste						Landfill borders Hope Slough; waste sorting station borders Howe's Creek (Bertrand Watershed) [14.7%] Microplastics are in fish generally, but nobody has looked at them here. Shopping carts pulled out of Bertrand Creek occasionally but probably not a threat.
9.5	Air-borne pollutants	CD	Medium - Low	Pervasive (71-100%)	Moderate - slight	High (continuing)	Worsening nitrogen pollution from agriculture (manure spreading [waterborne = 9.3] and machinery emissions) and urban sources (mainly vehicle exhaust) contribute significantly to nutrient loading/eutrophication. For example, majority of nitrogen and phosphorus inputs to Cultus Lake are aerially delivered, mostly fertilizer aerosol with some from vehicles (Fraser Valley Airshed Workshop)
9.6	Excess energy						Noise and light pollution scored here. Salish Sucker are most active around dawn and dusk, although activity continues through the night. Effect of light pollution studied in one other fish in the Fraser Valley, but not Salish Sucker.
10	Geological Events		Negligible	Small (1-10%)	Negligible or <1% pop. decline	High (continuing)	
10.1	Volcanoes						None in range

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments (Limit of 2,000 characters in each row. Avoid using ampersand '&'.)
10.2	Earthquakes/tsunamis		Unknown	Unknown	Unknown	Unknown	Pollution of water as a result of catastrophe can be significant, as it was in 2021 flooding of Fraser Valley (see RainCoast reports) [under 11.4]. Major earthquake likely to be worse. However, most subpopulations are not near the coast where they'd be inundated, although Little Campbell could be; it empties directly into the ocean rather than the Fraser.
10.3	Avalanches/landslides		Negligible	Small (1-10%)	Negligible or <1% pop. decline	High (continuing)	Risks along Mountain Slough [1.6%] mainstem, Interception Ditch and Elk Creek (Chilliwack Delta and Houpe Slough, respectively) [<1%]. Increased sedimentation caused by increased frequency and magnitude of landslides outside the natural range of variation. Blockage, re-routing of streams. No risk in Chilliwack Delta, only in areas close to mountains and valley edge, like Mountain Slough. Areas subject to landslides are high in watershed, where there would be less effect of a blockage on Salish Sucker, although it's possible that a slug of sediment could come downstream.
11	Climate change & severe weather	B	High	Large (31-70%)	Serious or 31-70% pop. decline	High (continuing)	Climate change induced drought and extreme temperatures
11.1	Habitat shifting & alteration						Habitat alterations aside from those caused by drought, temperature extremes, storms and flooding seem unlikely. Sea level rise and saltwater inundation maybe, but not within 10 years.
11.2	Droughts	B	High	Large (31-70%)	Serious or 31-70% pop. decline	High (continuing)	Four of past eight summer have seen level 4 drought or higher; this is likely to continue/worsen, without recovery in between, so timing high. Almost all fish exposed, although some uncertainty/protection based on local conditions (e.g., ground water at Chilliwack maintains flow even in late summer), so scope and severity about 70%; sublethal impacts at the population scale
11.3	Temperature extremes	B	High	Large (31-70%)	Serious or 31-70% pop. decline	High - moderate	Peak summer temperatures in Fraser Valley have increased dramatically in past decade. Now regularly exceeds 35 C; 42 C in Agassiz in June 2021 (heat dome). The fish are rarely found in water warmer than 20 C. Some protection from groundwater so scope/severity about 70% (as in 11.2)
11.4	Storms & flooding	D	Low	Large (31-70%)	Slight or 1-10% pop. decline	High (continuing)	Scope similar to 11.2, 11.3. Increased rainfall intensity documented, but most habitats are low gradient with low risk of major erosion; spawning occurs outside high-risk season, so egg loss to scour is low and snow melt not an issue in these streams. Negligible severity would be too low.
Classification of Threats adopted from IUCN-CMP, Salafsky *et al*. (2008).							