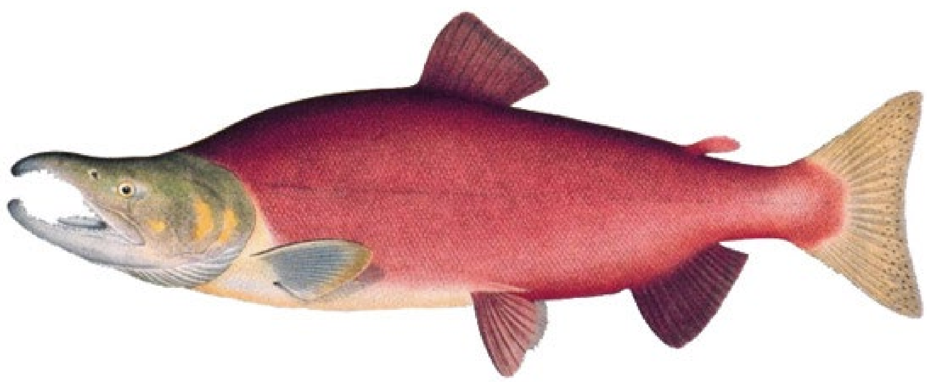
COSEWIC
Assessment and Status Report

on the

Sockeye Salmon
Oncorhynchus nerka

in the Fraser River Drainage Basin, Canada

Alouette-ES population (original)
Coquitlam-ES population (original)
Adams-ES population (original)
Momich-ES population (original)
Fraser-ES population (original)
North Barriere-ES population (original)
Seton-S population (original)



Alouette-ES population (original) - SPECIAL CONCERN
Coquitlam-ES population (original) - SPECIAL CONCERN
Adams-ES population (original) - EXTINCT
Momich-ES population (original) - ENDANGERED
Fraser-ES population (original) - ENDANGERED
North Barriere-ES population (original) - EXTINCT
Seton-S population (original) - EXTINCT
2021

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. 2021. COSEWIC assessment and status report on the Sockeye Salmon *Oncorhynchus nerka*, Alouette-ES population (original), Coquitlam-ES population (original), Adams-ES population (original), Momich-ES population (original), Fraser-ES population (original), North Barriere-ES population (original) and Seton-S population (original) in the Fraser River Drainage Basin, Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xxxiv + 49 pp. (https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry.html).

Previous report(s):

COSEWIC. 2017. COSEWIC assessment and status report on the Sockeye Salmon *Oncorhynchus nerka,* 24 Designatable Units in the Fraser River Drainage Basin, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xli + 179 pp. (https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry.html).

COSEWIC. 2016. COSEWIC assessment and status report on the Sockeye Salmon *Oncorhynchus nerka*, Sakinaw population, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. ix + 39 pp. (https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry.html).

COSEWIC. 2003. COSEWIC assessment and status report on the Sockeye Salmon *Oncorhynchus nerka* Sakinaw population in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. ix + 35 pp.

COSEWIC 2003. COSEWIC assessment and status report on the sockeye salmon *Oncorhynchus nerka* (Cultus population) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. ix + 57 pp.

Production note:
COSEWIC would like to acknowledge Alan Sinclair for writing the status report on Sockeye Salmon, *Oncorhynchus nerka*, original populations Alouette-ES, Coquitlam-ES, Adams-ES, Momich-ES, Fraser-ES, North Barriere-ES and Seton-S. It was prepared under contract with Environment and Climate Change Canada. This report was overseen and edited by Ross Claytor, Co-chair of the COSEWIC Marine Fishes Specialist Subcommittee.

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Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur le Saumon rouge (*Oncorhynchus nerka*), population Alouette-DE (originale), population Coquitlam-DE (originale), population Adams-DE (originale), population Momich-DE (originale), population Fraser-DE (originale), population North Barriere-DE (originale) et population Seton-E (originale) dans le bassin du fleuve Fraser au Canada.

Cover illustration/photo:
Sockeye Salmon freshwater phase adult male (public domain; originally appearing in United States government publication, The Fishes of Alaska, 1907).

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COSEWIC
Assessment Summary

Assessment Summary – November 2021

Common name
Sockeye Salmon - Alouette-ES population (original)

Scientific name
Oncorhynchus nerka

Status
Special Concern

Reason for designation
Sockeye are a key component of the Alouette ecosystem and are culturally significant to Indigenous communities. Historically fully anadromous, this population's ability to migrate to the ocean and return to spawning areas was cut-off by the construction of the hydroelectric dam in 1926 that created the Alouette Reservoir. Since dam construction, the population (currently 20,000 - 33,000 mature individuals) has retained its anadromous capability and has lived entirely in the reservoir. An ecosystem restoration and water management program allowing fish passage to the ocean started in 2005 and returns started 2 years later. Since 2007, zero to 103 mature anadromous individuals have annually returned. The ocean migrants face a number of threats common to sockeye, including declining habitat quality and incidental mortality from Pacific Salmon fisheries. The ecosystem restoration and water management program that enables ocean migration is required to allow expression of the anadromous life history and the loss of this expression will increase the extinction risk of this anadromous population.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Special Concern in November 2021.

Assessment Summary – November 2021

Common name
Sockeye Salmon - Coquitlam-ES (original) population

Scientific name
Oncorhynchus nerka

Status
Special Concern

Reason for designation
Sockeye are a key component of the Coquitlam ecosystem and are culturally significant to Indigenous communities. Historically fully anadromous, this population's ability to migrate to the ocean and return to spawning areas was cut-off by the construction of a dam in 1914 that created the Coquitlam Reservoir. Since dam construction, the population (approximately 14,000 mature individuals) has retained its anadromous capability and has lived entirely in the reservoir. An ecosystem restoration and water management program allowing fish passage to the ocean started in 2005 and anadromous returns started 2 years later. Since 2007, zero to 9 mature anadromous individuals have annually returned. The ocean migrants face a number of threats common to sockeye, including declining habitat quality and incidental mortality from Pacific Salmon fisheries. The ecosystem restoration and water management program that enables ocean migration is required to allow expression of the anadromous life history and the loss of this expression will increase the extinction risk of this anadromous population.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Special Concern in November 2021.

Assessment Summary – November 2021

Common name
Sockeye Salmon - Adams-ES (original) population

Scientific name
Oncorhynchus nerka

Status
Extinct

Reason for designation
This population spawned in the upper Adams River, upstream from the 1913 Hell's Gate landslide. It was considered eliminated by a splash dam at the outlet of Adams Lake that operated between 1908 to 1921 and lacked a fish passage mechanism for upriver migration. Subsequent transplantation programs from other populations would have eliminated remnant surviving fish via genetic replacement. Fish currently returning to the Upper Adams River have not been evaluated to determine whether they are a new population or part of another nearby population.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Extinct in November 2021.

Assessment Summary – November 2021

Common name
Sockeye Salmon - Momich-ES population (original)

Scientific name
Oncorhynchus nerka

Status
Endangered

Reason for designation
This population spawns upstream from the 1913 Hell's Gate landslide and a splash dam that was operational from 1908 to 1921. It is culturally significant to Indigenous communities and a key ecosystem component. Mature fish in this population return to spawn in the Momich River / Cayenne Creek and juveniles rear in the Momich Lake watershed of British Columbia. This small population faces a number of threats, including declining habitat quality both in marine and freshwater environments, and incidental mortality from Pacific Salmon fisheries. The population has been declining since 2000 and is now at its lowest level since 1985.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Endangered in November 2021.

Assessment Summary – November 2021

Common name
Sockeye Salmon - Fraser-ES population (original)

Scientific name
Oncorhynchus nerka

Status
Endangered

Reason for designation
Mature fish in this population returned to spawn in Endako River and Ormonde Creek that flow into the Fraser Lake, British Columbia. This population is upstream from the 1913 Hell's Gate landslide and the 2018 Big Bar landslide. Sockeye have not been seen in Ormonde Creek since 1976, nor in Endako River since 1991, despite two surveys in 1992 and 2000, and Chinook Salmon surveys in late summer from 2001 to the present. Sockeye returning during these surveys would likely have been seen if they were present. Although likely extinct, fewer than 50 years have passed since the last credible record, and so the wildlife species is still considered Endangered.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Endangered in November 2021.

Assessment Summary – November 2021

Common name
Sockeye Salmon - North Barriere-ES population (original)

Scientific name
Oncorhynchus nerka

Status
Extinct

Reason for designation
This population spawned and reared upstream from the 1913 Hell's Gate landslide and was considered eliminated by a dam in the North Barriere watershed that was constructed in 1914 and removed in 1952. More than 50 years have passed since the last credible record of the wildlife species.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Extinct in November 2021.

Assessment Summary – November 2021

Common name
Sockeye Salmon - Seton-S population (original)

Scientific name
Oncorhynchus nerka

Status
Extinct

Reason for designation
This population spawned and reared upstream from the 1913 Hell's Gate landslide. Several factors led to its demise in the early 1900s including poor hatchery techniques, the Hell's Gate rockslide, and water diversion in 1934 from the Bridge River to Seton Lake that reduced primary productivity in the lake and its capacity to rear this species. More than 50 years have passed since the last credible record of the wildlife species.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Extinct in November 2021.

COSEWIC
Executive Summary

Sockeye Salmon
Oncorhynchus nerka

Alouette-ES population (original)
Coquitlam-ES population (original)
Adams-ES population (original)
Momich-ES population (original)
Fraser-ES population (original)
North Barriere-ES population (original)
Seton-S population (original)

Wildlife Species Description and Significance

Sockeye Salmon is one of seven species of the genus *Oncorhynchus* native to North America. Sockeye Salmon exist as isolated populations in fresh water and they evolve local adaptations to the freshwater environments in which they are hatched, juveniles rear, and adults spawn. This report assesses seven designatable units (DU) of Sockeye in the Fraser River that were thought to have been eliminated from their native spawning grounds several decades ago. An additional 24 extant DUs were assessed in 2017.

Distribution

As a species, Sockeye Salmon are distributed through the North Pacific Ocean and its tributary systems in both Asia and North America; however, they are particularly abundant in Alaska and British Columbia (BC). The Fraser River watershed is the largest Sockeye Salmon complex in BC.

Habitat

The Fraser River Sockeye Salmon examined in this report are in the lake-type Sockeye Salmon ecotype. This ecotype spawns in lake tributaries or outflows, or along lake foreshores. Juveniles grow in a rearing lake before migrating downstream in the Fraser River and the majority migrate northward through the Strait of Georgia in late June and July to enter the open ocean via Johnstone Strait to the north. A minority migrate westward through the Strait of Juan de Fuca. They then migrate northwest along the coasts of British Columbia and central Alaska where they grow and reach sexual maturity.

Biology

Adult Fraser River Sockeye Salmon can range in age from three to six years, spending their first one to three winters in freshwater and their last one to three winters in the marine environment. Most Fraser River Sockeye Salmon (~80% total age composition) return to spawn as four-year-olds after spending two winters in the freshwater followed by two winters in the marine environment. Spawning is typically in August and September. Like those of other Sockeye Salmon DUs, their eggs are incubated in the gravel through the winter before emerging as alevins in the spring.

Population Sizes and Trends

These seven DUs were not previously assessed by COSEWIC. Information about abundance of these Sockeye Salmon populations, past and present, is presented for each DU separately.

Threats and Limiting Factors

The main past events contributing to population elimination are discussed separately for relevant DUs. These events included the Hell's Gate landslide in 1913, in-river dam construction, hatchery practices, and habitat degradation. Future threats, where relevant, are presented for each extant DU separately.

Protection, Status and Ranks

As these seven DUs were thought to have been eliminated several decades ago, protection for them has not previously been considered.

DU Naming Convention

Letters after each DU name refer to run timing groups in the Fraser: “ES” is Early Summer and “S” is Summer.

TECHNICAL SUMMARY - Alouette-ES Population (original)

Oncorhynchus nerka

Sockeye Salmon, Alouette-ES population (original)

Saumon rouge, Population Alouette-DE (originale)

Range of occurrence in Canada: British Columbia, Pacific Ocean

Designatable Unit 196 (previously numbered 26; see COSEWIC 2017)

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines (2011) is being used)	4 yrs
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Unknown
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations, whichever is longer up to a maximum of 100 years]	Unknown
[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 up to a maximum of 100 years].	Unknown
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations, whichever is longer up to a maximum of 100 years].	Unknown
[Observed, estimated, inferred, 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.	Unknown
Are the causes of the decline a. clearly reversible and b. understood and c. ceased?	N/A
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence (EOO)	>20,000 km²
Index of area of occupancy (IAO) (Always report 2x2 grid value).	Unknown but <150 km²
Is the population "severely fragmented" i.e., is >50% of its total area of occupancy in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a.No b.No

Number of “locations”* (use plausible range to reflect uncertainty if appropriate)	N/A
Is there an [observed, inferred, or projected] decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	No
Is there an [observed, inferred, or projected] decline in number of subpopulations?	N/A
Is there an [observed, inferred, or projected] decline in number of “locations”*?	No
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	No
Are there extreme fluctuations in number of subpopulations?	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 (in each subpopulation)

Subpopulations (give plausible ranges)	**N Mature Individuals**
All in one subpopulation	20,000 – 33,000 (includes mature individuals with anadromous and non-migratory forms) <250 anadromous individuals
Total	

Quantitative Analysis

Is the probability of extinction in the wild at least [20% within 20 years or 5 generations whichever is longer up to a maximum of 100 years, or 10% within 100 years]?	N/A

* See Definitions and Abbreviations on COSEWIC website and IUCN for more information on this term.

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

Was a threats calculator completed for this species? No The ecosystem restoration and water management program that enables ocean migration is required to allow expression of the anadromous life history and the loss of this expression will increase the extinction risk of this anadromous population. Additional threats to all mature individuals will vary according to life-history expressed. Anadromy: Estuary and Coastal areas are subject to possible threats, for example, from pollution, fisheries, and pinniped predation. High Seas area is subject to threats from, for example, competition and changes in ocean productivity. Both anadromy and non-migrant life histories: Exposed to threats within watershed areas, for example, from habitat degradation, dams, and landslides. The impact level of each of these threats were not assessed, The dam, downstream freshwater effects, and marine threats are only affecting a small proportion of the population. They do not qualify as locations in the context of the total population. What additional limiting factors are relevant? None

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	No outside populations are available for rescue.
Is immigration known or possible?	N/A
Would immigrants be adapted to survive in Canada?	N/A
Is there sufficient habitat for immigrants in Canada?	N/A
Are conditions deteriorating in Canada?[+]	N/A
Are conditions for the source (i.e., outside) population deteriorating?[+]	N/A
Is the Canadian population considered to be a sink?[+]	N/A
Is rescue from outside populations likely?	No

Data Sensitive Species

Is this a data sensitive species?	No

Status History

COSEWIC Status History: Designated Special Concern in November 2021.

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

Status and Reasons for Designation:

Status: Special Concern	Alpha-numeric codes: Not applicable
Reasons for designation: Sockeye are a key component of the Alouette ecosystem and are culturally significant to Indigenous communities. Historically fully anadromous, this population's ability to migrate to the ocean and return to spawning areas was cut-off by the construction of the hydroelectric dam in 1926 that created the Alouette Reservoir. Since dam construction, the population (currently 20,000 - 33,000 mature individuals) has retained its anadromous capability and has lived entirely in the reservoir. An ecosystem restoration and water management program allowing fish passage to the ocean started in 2005 and returns started 2 years later. Since 2007, zero to 103 mature anadromous individuals have annually returned. The ocean migrants face a number of threats common to sockeye, including declining habitat quality and incidental mortality from Pacific Salmon fisheries. The ecosystem restoration and water management program that enables ocean migration is required to allow expression of the anadromous life history and the loss of this expression will increase the extinction risk of this anadromous population.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. There is no indication of decline in the population.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. The dam, downstream freshwater effects, and marine threats are only affecting a small proportion of the population. They do not qualify as locations in the context of the total population.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. There are no subpopulations because genetic exchange occurs among non-migratory and migratory forms and the total number of mature individuals exceeds criterion.
Criterion D (Very Small or Restricted Population): Not applicable. The total population is 20,000 to 33,000 mature individuals.
Criterion E (Quantitative Analysis): Not done.

TECHNICAL SUMMARY - Coquitlam-ES (original) Population

Oncorhynchus nerka

Sockeye Salmon, Coquitlam-ES (original) population

Saumon rouge, Population Coquitlam-DE (originale)

Range of occurrence in Canada: British Columbia, Pacific Ocean

Designatable 197 (previously numbered 27; see COSEWIC 2017)

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines(2011) is being used)	4 yrs
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Unknown
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations, whichever is longer up to a maximum of 100 years]	Unknown
[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 up to a maximum of 100 years].	Unknown
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations, whichever is longer up to a maximum of 100 years].	Unknown
[Observed, estimated, inferred, 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.	Unknown
Are the causes of the decline a. clearly reversible and b. understood and c. ceased?	N/A
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence (EOO)	>20,000 km²
Index of area of occupancy (IAO) (Always report 2x2 grid value).	Unknown but <260 km²
Is the population "severely fragmented" i.e., is >50% of its total area of occupancy in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a.No b.No

Number of "locations"* (use plausible range to reflect uncertainty if appropriate)	N/A
Is there an [observed, inferred, or projected] decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	No
Is there an [observed, inferred, or projected] decline in number of subpopulations?	No
Is there an [observed, inferred, or projected] decline in number of "locations"*?	No
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	No
Are there extreme fluctuations in number of subpopulations?	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 (in each subpopulation)

Subpopulations (give plausible ranges)	**N Mature Individuals**
All in one subpopulation	~14,000 (includes mature individuals with anadromous and non-migratory forms) < 250 anadromous individuals
Total	

Quantitative Analysis

Is the probability of extinction in the wild at least [20% within 20 years or 5 generations whichever is longer up to a maximum of 100 years, or 10% within 100 years]?	N/A

* See Definitions and Abbreviations on COSEWIC website and IUCN for more information on this term.

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

Was a threats calculator completed for this species? No The ecosystem restoration and water management program that enables ocean migration is required to allow expression of the anadromous life history and the loss of this expression will increase the extinction risk of this anadromous population. Additional threats to all mature individuals will vary according to life-history expressed. Anadromy: Estuary and Coastal areas are subject to possible threats, for example, from pollution, fisheries, and pinniped predation. “High Seas area is subject to threats from, for example, competition and changes in ocean productivity. Both anadromy and non-migrant life-histories: exposed to threats within watershed areas, for example, from habitat degradation, dams, and landslides. The impact level of each of these threats were not assessed. The dam, downstream freshwater effects, and marine threats are only affecting a small proportion of the population. They do not qualify as locations in the context of the total population. What additional limiting factors are relevant? None

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	No outside populations are available for rescue.
Is immigration known or possible?	N/A
Would immigrants be adapted to survive in Canada?	N/A
Is there sufficient habitat for immigrants in Canada?	N/A
Are conditions deteriorating in Canada?[+]	N/A
Are conditions for the source (i.e., outside) population deteriorating?[+]	N/A
Is the Canadian population considered to be a sink?[+]	N/A
Is rescue from outside populations likely?	No

Data Sensitive Species

Is this a data sensitive species?	No

Status History

COSEWIC Status History: Designated Special Concern in November 2021.

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

Status and Reasons for Designation:

Status: Special Concern	Alpha-numeric codes: Not applicable
Reasons for designation: Sockeye are a key component of the Coquitlam ecosystem and are culturally significant to Indigenous communities. Historically fully anadromous, this population's ability to migrate to the ocean and return to spawning areas was cut-off by the construction of a dam in 1914 that created the Coquitlam Reservoir. Since dam construction, the population (approximately 14,000 mature individuals) has retained its anadromous capability and has lived entirely in the reservoir. An ecosystem restoration and water management program allowing fish passage to the ocean started in 2005 and anadromous returns started 2 years later. Since 2007, zero to 9 mature anadromous individuals have annually returned. The ocean migrants face a number of threats common to sockeye, including declining habitat quality and incidental mortality from Pacific Salmon fisheries. The ecosystem restoration and water management program that enables ocean migration is required to allow expression of the anadromous life history and the loss of this expression will increase the extinction risk of this anadromous population.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. There is no indication of decline in the population
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. The dam, downstream freshwater effects, and marine threats are only affecting a small proportion of the population. They do not qualify as locations in the context of the total population.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. There are no subpopulations because genetic exchange occurs among non-migratory and migratory forms and the total number of mature individuals exceeds criterion.
Criterion D (Very Small or Restricted Population): Not applicable. The total population is about 14,000 mature individuals.
Criterion E (Quantitative Analysis): Not done.

TECHNICAL SUMMARY - Adams-ES (original) Population

Oncorhynchus nerka

Sockeye Salmon, Adams-ES (original) population

Saumon rouge, Population Adams-DE (originale)

Range of occurrence in Canada: British Columbia, Pacific Ocean

Designatable Unit 198 (previously numbered 25; see COSEWIC 2017)

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines(2011) is being used)	4 yrs
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	N/A. The original population was eliminated by a combination of splash dam effects and genetic effects from transplants from other populations.
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]	N/A
[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 up to a maximum of 100 years].	N/A
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations, whichever is longer up to a maximum of 100 years].	N/A
[Observed, estimated, inferred, 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.	N/A

Extent and Occupancy Information

Estimated extent of occurrence (EOO)	N/A
Index of area of occupancy (IAO) (Always report 2x2 grid value).	N/A
Is the population "severely fragmented" i.e., is >50% of its total area of occupancy in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a.No b.No
Number of "locations"* (use plausible range to reflect uncertainty if appropriate)	N/A

* See Definitions and Abbreviations on COSEWIC website and IUCN for more information on this term.

Is there an [observed, inferred, or projected] decline in extent of occurrence?	N/A
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	N/A
Is there an [observed, inferred, or projected] decline in number of subpopulations?	N/A
Is there an [observed, inferred, or projected] decline in number of "locations"*?	N/A
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	N/A
Are there extreme fluctuations in number of subpopulations?	N/A
Are there extreme fluctuations in number of "locations"*?	N/A
Are there extreme fluctuations in extent of occurrence?	N/A
Are there extreme fluctuations in index of area of occupancy?	N/A

Number of Mature Individuals (in each subpopulation)

Subpopulations (give plausible ranges)	**N Mature Individuals**
Total	0?

Quantitative Analysis

Is the probability of extinction in the wild at least [20% within 20 years or 5 generations whichever is longer up to a maximum of 100 years, or 10% within 100 years]?	N/A

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

Was a threats calculator completed for this species? No, the original population is extinct.

What additional limiting factors are relevant?
None were considered as the original population is extinct.

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	No outside populations are available for rescue.
Is immigration known or possible?	N/A
Would immigrants be adapted to survive in Canada?	N/A
Is there sufficient habitat for immigrants in Canada?	N/A
Are conditions deteriorating in Canada?+	N/A

* See Definitions and Abbreviations on COSEWIC website and IUCN for more information on this term.
+ See Table 3 (Guidelines for modifying status assessment based on rescue effect).

Are conditions for the source (i.e., outside) population deteriorating?+	N/A
Is the Canadian population considered to be a sink?+	N/A
Is rescue from outside populations likely?	No

Data Sensitive Species

Is this a data sensitive species?	No

Status History

COSEWIC Status History: Designated Extinct in November 2021.

Status and Reasons for Designation:

Status: Extinct	**Alpha-numeric codes:** Not applicable.
Reasons for designation: This population spawned in the upper Adams River, upstream from the 1913 Hell's Gate landslide. It was considered eliminated by a splash dam at the outlet of Adams Lake that operated between 1908 to 1921 and lacked a fish passage mechanism for upriver migration. Subsequent transplantation programs from other populations would have eliminated remnant surviving fish via genetic replacement. Fish currently returning to the Upper Adams River have not been evaluated to determine whether they are a new population or part of another nearby population.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable.
Criterion D (Very Small or Restricted Population Not applicable.
Criterion E (Quantitative Analysis): Not done.

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

TECHNICAL SUMMARY - Momich-ES Population (original)

Oncorhynchus nerka

Sockeye Salmon, Momich-ES population (original)

Saumon rouge, Population Momich-DE (originale)

Range of occurrence in Canada: British Columbia, Pacific Ocean

Designatable Unit 199 (previously numbered 29; see COSEWIC 2017**)**

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines(2011) is being used)	4 yrs
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Yes
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]	Not estimated
[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 up to a maximum of 100 years].	>70% decline from 2007 to 2019 >20% decline from 1985 to 2019
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations, whichever is longer up to a maximum of 100 years].	Not estimated
[Observed, estimated, inferred, 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.	Not estimated
Are the causes of the decline a. clearly reversible and b. understood and c. ceased?	a. No b. No c. No
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence (EOO)	>20,000 km²
Index of area of occupancy (IAO) (Always report 2x2 grid value).	Unknown but <500 km²
Is the population “severely fragmented” i.e., is >50% of its total area of occupancy in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a.No b.No

Number of "locations"* (use plausible range to reflect uncertainty if appropriate)	<5
Is there an [observed, inferred, or projected] decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	Unknown
Is there an [observed, inferred, or projected] decline in number of subpopulations?	N/A
Is there an [observed, inferred, or projected] decline in number of "locations"*?	No
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Yes
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 (in each subpopulation)

Subpopulations (give plausible ranges)	**N Mature Individuals**
All in one subpopulation	< 250 since 2009
Total	

Quantitative Analysis

Is the probability of extinction in the wild at least [20% within 20 years or 5 generations whichever is longer up to a maximum of 100 years, or 10% within 100 years]?	Not estimated

* See Definitions and Abbreviations on COSEWIC website and IUCN for more information on this term.

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

Was a threats calculator completed for this species? No

Threats vary according to habitat:

Estuary and Coastal areas are subject to possible threats, for example, from pollution, fisheries, and pinniped predation.

High Seas area is subject to threats from, for example, competition and changes in ocean productivity.

Freshwater habitats are exposed to threats within watershed areas, for example, from habitat degradation, dams, and landslides.

This population is expected to have a high impact from coastal and estuary commercial fisheries. In 2021, a large portion of the Momich / Cayenne drainage burned in forest fires. These fires and clearcutting in the watershed have created a situation where high rainfall events are expected to cause erosion depositing debris and fine substrates that will impact future recruitment.

What additional limiting factors are relevant?

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	No outside populations are available for rescue.
Is immigration known or possible?	N/A
Would immigrants be adapted to survive in Canada?	N/A
Is there sufficient habitat for immigrants in Canada?	N/A
Are conditions deteriorating in Canada?[+]	N/A
Are conditions for the source (i.e., outside) population deteriorating?[+]	N/A
Is the Canadian population considered to be a sink?[+]	N/A
Is rescue from outside populations likely?	No

Data Sensitive Species

Is this a data sensitive species?	No

Status History

COSEWIC Status History:
Designated Endangered in November 2021.

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

Status and Reasons for Designation:

Status: Endangered	**Alpha-numeric codes:** A2bcde; B2ab(iii,v); C2a(i,ii); D1
Reason for designation: This population spawns upstream from the 1913 Hell's Gate landslide and a splash dam that was operational from 1908 to 1921. It is culturally significant to Indigenous communities and a key ecosystem component. Mature fish in this population return to spawn in the Momich River / Cayenne Creek and juveniles rear in the Momich Lake watershed of British Columbia. This small population faces a number of threats, including declining habitat quality both in marine and freshwater environments, and incidental mortality from Pacific Salmon fisheries. The population has been declining since 2000 and is now at its lowest level since 1985.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets Endangered, A2bcde. (A2) The number of mature individuals has declined by >70% over the most recent 3 generations. (b) Abundance estimates based on field surveys, (c) decline in quality of marine habitat (ocean productivity) and freshwater decline (erosion from burning and logging practices), (d) exploitation (incidental mortality from Pacific Salmon fisheries) and (e) sedimentation (from high rainfall events) as a form of pollution; causes of reduction have not ceased.
Criterion B (Small Distribution Range and Decline or Fluctuation): Meets Endangered B2ab(iii,v). IAO is <500 km², exists at <5 locations and there is a continuing decline inferred in quality of habitat and number of mature individuals.
Criterion C (Small and Declining Number of Mature Individuals): Meets Endangered, C2a(i,ii).Continuing decline inferred in number of mature individuals, with one subpopulation of <250 containing all mature individuals.
Criterion D (Very Small or Restricted Population): Population has been <250 (running four-year average) since 2009.
Criterion E (Quantitative Analysis): Not done.

TECHNICAL SUMMARY - Fraser-ES Population (original)

Oncorhynchus nerka

Sockeye Salmon, Fraser-ES population (original)

Saumon rouge, Population Fraser-DE (originale)

Range of occurrence in Canada: British Columbia, Pacific Ocean

Designatable Unit 200 (previously numbered 28; see COSEWIC 2017)

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines(2011) is being used)	4 yrs
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Cannot be determined
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
[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 up to a maximum of 100 years].	Unknown
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations, whichever is longer up to a maximum of 100 years].	Unknown
[Observed, estimated, inferred, 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.	Unknown
Are the causes of the decline a. clearly reversible and b. understood and c. ceased?	N/A
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence (EOO)	>20,000 km²
Index of area of occupancy (IAO) (Always report 2x2 grid value).	Unknown but <500 km²
Is the population "severely fragmented" i.e., is >50% of its total area of occupancy in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a.No b.No

Number of "locations"* (use plausible range to reflect uncertainty if appropriate)	N/A
Is there an [observed, inferred, or projected] decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	No
Is there an [observed, inferred, or projected] decline in number of subpopulations?	N/A
Is there an [observed, inferred, or projected] decline in number of "locations"*?	No
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	No
Are there extreme fluctuations in number of subpopulations?	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 (in each subpopulation)

Subpopulations (give plausible ranges)	**N Mature Individuals**
All in one subpopulation	Last Observation 100 mature individuals in 1991. Surveys since 2000 have not encountered any Sockeye Salmon. Current mature numbers of individuals cannot be determined.
Total	unknown

Quantitative Analysis

Is the probability of extinction in the wild at least [20% within 20 years or 5 generations whichever is longer up to a maximum of 100 years, or 10% within 100 years]?	N/A

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

Was a threats calculator completed for this species? No Poor freshwater habitat What additional limiting factors are relevant?

* See Definitions and Abbreviations on COSEWIC website and IUCN for more information on this term.

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	No outside populations are available for rescue.
Is immigration known or possible?	N/A
Would immigrants be adapted to survive in Canada?	N/A
Is there sufficient habitat for immigrants in Canada?	N/A
Are conditions deteriorating in Canada?[+]	N/A
Are conditions for the source (i.e., outside) population deteriorating?[+]	N/A
Is the Canadian population considered to be a sink?[+]	N/A
Is rescue from outside populations likely?	No

Data Sensitive Species

Is this a data sensitive species?	No

Status History

COSEWIC Status History: Designated Endangered in November 2021.

Status and Reasons for Designation:

Status: Endangered	**Alpha-numeric codes:** D1
Reasons for designation: Mature fish in this population returned to spawn in Endako River and Ormonde Creek that flow into the Fraser Lake, British Columbia. This population is upstream from the 1913 Hell's Gate landslide and the 2018 Big Bar landslide. Sockeye have not been seen in Ormonde Creek since 1976, nor in Endako River since 1991, despite two surveys in 1992 and 2000, and Chinook Salmon surveys in late summer from 2001 to the present. Sockeye returning during these surveys would likely have been seen if they were present. Although likely extinct, fewer than 50 years have passed since the last credible record, and so the wildlife species is still considered Endangered	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. No recent observation; unknown.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. A continuing decline cannot be determined because no fish have been observed over the last few decades.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. A continuing decline cannot be determined, and no fish have been observed over the last few decades.
Criterion D (Very Small or Restricted Population): Meets Endangered, D1. Last observation in 1991 was for 100 fish and surveys since 2001 have not encountered any Sockeye Salmon.
Criterion E (Quantitative Analysis): Not done.

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

TECHNICAL SUMMARY - North Barriere-ES Population (original)

Oncorhynchus nerka

Sockeye Salmon, North Barriere-ES population (original)

Saumon rouge, Population North Barriere-DE (originale)

Range of occurrence in Canada: British Columbia, Pacific Ocean

Designatable Unit 201 (previously numbered 30; see COSEWIC 2017)

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines(2011) is being used)	4 yrs
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	N/A
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]	N/A
[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 up to a maximum of 100 years].	N/A
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations, whichever is longer up to a maximum of 100 years].	N/A
[Observed, estimated, inferred, 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.	N/A
Are the causes of the decline a. clearly reversible and b. understood and c. ceased?	N/A
Are there extreme fluctuations in number of mature individuals?	N/A

Extent and Occupancy Information

Estimated extent of occurrence (EOO)	N/A
Index of area of occupancy (IAO) (Always report 2x2 grid value).	N/A

Is the population "severely fragmented" i.e., is >50% of its total area of occupancy in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a.No b.No
Number of "locations"* (use plausible range to reflect uncertainty if appropriate)	N/A
Is there an [observed, inferred, or projected] decline in extent of occurrence?	N/A
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	N/A
Is there an [observed, inferred, or projected] decline in number of subpopulations?	N/A
Is there an [observed, inferred, or projected] decline in number of "locations"*?	N/A
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	N/A
Are there extreme fluctuations in number of subpopulations?	N/A
Are there extreme fluctuations in number of "locations"*?	N/A
Are there extreme fluctuations in extent of occurrence?	N/A
Are there extreme fluctuations in index of area of occupancy?	N/A

Number of Mature Individuals (in each subpopulation)

Subpopulations (give plausible ranges)	**N Mature Individuals**
All in one subpopulation	0
Total	

Quantitative Analysis

Is the probability of extinction in the wild at least [20% within 20 years or 5 generations whichever is longer up to a maximum of 100 years, or 10% within 100 years]?	N/A

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

Was a threats calculator completed for this species? No The main reason for extinction was a dam that constructed below the spawning grounds. What additional limiting factors are relevant?

* See Definitions and Abbreviations on COSEWIC website and IUCN for more information on this term.

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	No outside populations are available for rescue.
Is immigration known or possible?	N/A
Would immigrants be adapted to survive in Canada?	N/A
Is there sufficient habitat for immigrants in Canada?	N/A
Are conditions deteriorating in Canada?[+]	N/A
Are conditions for the source (i.e., outside) population deteriorating?[+]	N/A
Is the Canadian population considered to be a sink?[+]	N/A
Is rescue from outside populations likely?	No

Data Sensitive Species

Is this a data sensitive species?	No

Status History

COSEWIC Status History: Designated Extinct in November 2021.

Status and Reasons for Designation:

Status: Extinct	**Alpha-numeric codes:** Not applicable.
Reasons for designation: This population spawned and reared upstream from the 1913 Hell's Gate landslide and was considered eliminated by a dam in the North Barriere watershed that was constructed in 1914 and removed in 1952. More than 50 years have passed since the last credible record of the wildlife species.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. No credible record of wildlife species in the last 50 years.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. No credible record of wildlife species in the last 50 years.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. No credible record of wildlife species in the last 50 years.
Criterion D (Very Small or Restricted Population Not applicable. No credible record of wildlife species in the last 50 years.
Criterion E (Quantitative Analysis): Not done.

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

TECHNICAL SUMMARY - Seton-S Population (original)

Oncorhynchus nerka

Sockeye Salmon, Seton-S population (original)

Saumon rouge, Population Seton-E (originale)

Range of occurrence in Canada: British Columbia, Pacific Ocean

Designatable Unit 202 (previously numbered 31; see COSEWIC 2017)

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines(2011) is being used)	4 yrs
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	N/A
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]	N/A
[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 up to a maximum of 100 years].	N/A
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations, whichever is longer up to a maximum of 100 years].	N/A
[Observed, estimated, inferred, 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.	N/A
Are the causes of the decline a. clearly reversible and b. understood and c. ceased?	N/A
Are there extreme fluctuations in number of mature individuals?	N/A

Extent and Occupancy Information

Estimated extent of occurrence (EOO)	N/A
Index of area of occupancy (IAO) (Always report 2x2 grid value).	N/A
Is the population “severely fragmented” i.e., is >50% of its total area of occupancy in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a.No b.No

Number of "locations"* (use plausible range to reflect uncertainty if appropriate)	N/A
Is there an [observed, inferred, or projected] decline in extent of occurrence?	N/A
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	N/A
Is there an [observed, inferred, or projected] decline in number of subpopulations?	N/A
Is there an [observed, inferred, or projected] decline in number of "locations"*?	N/A
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	N/A
Are there extreme fluctuations in number of subpopulations?	N/A
Are there extreme fluctuations in number of "locations"*?	N/A
Are there extreme fluctuations in extent of occurrence?	N/A
Are there extreme fluctuations in index of area of occupancy?	N/A

Number of Mature Individuals (in each subpopulation)

Subpopulations (give plausible ranges)	**N Mature Individuals**
All in one subpopulation	0
Total	0

Quantitative Analysis

Is the probability of extinction in the wild at least [20% within 20 years or 5 generations whichever is longer up to a maximum of 100 years, or 10% within 100 years]?	N/A

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

Was a threats calculator completed for this species? No

The main reasons for extinction were poor hatchery procedures in the early 1900s, the Hell's Gate landslide in 1913, and water diversion from the Bridge River to Seton Lake.

What additional limiting factors are relevant?

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	No outside populations are available for rescue.
Is immigration known or possible?	N/A
Would immigrants be adapted to survive in Canada?	N/A

* See Definitions and Abbreviations on COSEWIC website and IUCN for more information on this term.

Is there sufficient habitat for immigrants in Canada?	N/A
Are conditions deteriorating in Canada?+	N/A
Are conditions for the source (i.e., outside) population deteriorating?+	N/A
Is the Canadian population considered to be a sink?+	N/A
Is rescue from outside populations likely?	N/A

Data Sensitive Species

Is this a data sensitive species?	No

Status History

COSEWIC Status History: Designated Extinct in November 2021.

Status and Reasons for Designation:

Status: Extinct	**Alpha-numeric codes:** Not applicable.
Reasons for designation: This population spawned and reared upstream from the 1913 Hell's Gate landslide. Several factors led to its demise in the early 1900s including poor hatchery techniques, the Hell's Gate rockslide, and water diversion in 1934 from the Bridge River to Seton Lake that reduced primary productivity in the lake and its capacity to rear this species. More than 50 years have passed since the last credible record of the wildlife species.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. No credible record of wildlife species in the last 50 years.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. No credible record of wildlife species in the last 50 years.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. No credible record of wildlife species in the last 50 years.
Criterion D (Very Small or Restricted Population Not applicable. No credible record of wildlife species in the last 50 years.
Criterion E (Quantitative Analysis): Not done.

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

PREFACE

In November 2017, 24 extant designatable units (DU) of Sockeye Salmon in the Fraser River drainage basin were assessed by COSEWIC. Seven additional DUs of Fraser River Sockeye Salmon were identified in the November 2017 report. These additional DUs were not assessed because it was hypothesized that each had stopped returning to their original spawning grounds at some point in the past (COSEWIC 2017). These seven DUs were not previously assessed by COSEWIC.

This report reviews the historical and current information relevant to the 7 DUs: Adams-ES , Alouette-ES, Coquitlam-ES, Fraser -ES, Momich-ES, North Barriere-ES, and Seton-S. All seven DUs have “original” added to their name in case DUs with the same name appear in future. Report sections on WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE, DISTRIBUTION, HABITAT, and BIOLOGY are general for all Fraser Sockeye DUs, they remain largely unchanged from the original report (COSEWIC 2017), and only new information is presented here. There was also general information in the original report on POPULATION SIZES AND TRENDS and THREATS AND LIMITING FACTORS. This information is not repeated here because it is available in COSEWIC (2017). The relevant information on the status of the 7 DUs assessed in this report is presented in separate DU-specific sections.

Note that “ES” in the DU name indicates an early summer run timing and “S” indicates summer run timing. The original DU numbering was followed in this report.

A Two-month report was prepared for presentation at the Spring 2020 COSEWIC Assessment meeting. However, the planned Spring 2020 status reports were not presented because of COVID pandemic restrictions. As a result, the assessment was rescheduled for the April 2021 COSEWIC Assessment meeting. In the intervening period recent genetic, historical sampling data, and current sampling data with respect to DU 25 Adams–ES, DU 29 Momich-ES, DU 26 Alouette-ES, DU 27 Coquitlam-ES, and DU 28 Fraser-ES were brought to COSEWIC’s attention. Presentation of the report to COSEWIC was delayed to November 2021 to allow for additional review because the new information had possible implications for status designation.

Extinction of these DUs will be considered with respect to the COSEWIC criteria described below:

COSEWIC considers a wildlife species to be either extinct or extirpated in Canada if:

1. There exists no remaining habitat for the wildlife species and there have been no records of the wildlife species despite recent surveys: or
2. 50 years have passed since the last credible record of the wildlife species, despite surveys in the interim: or
3. There is sufficient information to document that no individuals of the wildlife species remain alive.

Furthermore, a wildlife species (DU under SARA) is considered extirpated if it ceases to exist in the wild in Canada, but it exists elsewhere, either in the wild in another country or in captivity. A wildlife species (DU) is considered extinct if it no longer exists anywhere in the world.

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
(2021)

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

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

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

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

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

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

COSEWIC Status Report

on the

Sockeye Salmon
Oncorhynchus nerka

in the Fraser River Drainage Basin, Canada

Alouette-ES population (original)
Coquitlam-ES population (original)
Adams-ES population (original)
Momich-ES population (original)
Fraser-ES population (original)
North Barriere-ES population (original)
Seton-S population (original)

2021

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE - SEE COSEWIC (2017)

Designatable Units

This report presents assessments of seven DUs described in COSEWIC (2017): DU 25 Adams-ES, DU 26 Alouette-ES, DU 27 Coquitlam-ES, DU 28 Fraser-ES, DU 29 Momich-ES, DU 30 North Barriere-ES, and DU 31 Seton-S. The timing designations refer to the time when 50% of the fish migrated through Hell's Gate. These were by August 6 for Early Summer run (ES) and by August 17 for Summer run (S) (COSEWIC 2017).

For consistency with the COSEWIC (2017) report, the original DU numbers have been retained throughout the report. However, these 7 DUs were not included in the designatable unit report for all Sockeye Salmon in Canada (COSEWIC 2021). Hence, a new DU number is indicated in order for them to fit into the numbering system for all Sockeye Salmon in Canada (COSEWIC 2021) and facilitate tracking in future status reports.

The report first presents the two DUs downstream from the Hell's Gate Landslide (DU 26 Alouette-ES, DU 27 Coquitlam-ES) and then presents DUs upstream of the Hell's Gate Landslide (DU 25 Adams-ES, DU 29 Momich-ES, DU 28 Fraser-ES, DU 30 North Barriere-ES, and DU 31 Seton-S (Figure 1). Within the downstream group Alouette-ES and Coquitlam-ES DUs are discussed together and within the upstream group Adams-ES and Momich-ES DUs are discussed together because of similar ecological and threat histories. The complete list of all DUs in the Fraser River drainage is given in Table 1.

A group of Sockeye Salmon residing in Kawkawa Lake was also considered for inclusion in this report. Sockeye Salmon in this lake were described by Grant *et al.* (2011) as quoted below.

"Kawkawa Lake was dammed in the past (date unknown) and, as a result, has not been accessible to spawning Sockeye since its construction. There may have been anadromous Sockeye in this system prior to damming, although this has not been confirmed. Roos (1991) reported that Sockeye were observed in Kawkawa Lake during the years of the Hell's Gate fishway construction (late 1920's and early 1930's) after the landslide (1913). However, these spawning fish, were reported to be Adams River Sockeye that had dropped out of upstream migration before Hell's Gate. Currently, Kokanee (non-anadromous Sockeye) do occupy the lake. There have been no experiments, similar to the extirpated Alouette-ES and Coquitlam-ES CU, to explore whether the anadromous life-history occurs in the resident Kokanee population. Although this CU has been included in the current CU list and classified as extirpated, there is only limited evidence currently to suggest that this was a persistent lake-type population in the Fraser watershed".

Additionally, it was not clear if this population ever had the characteristics of discreteness and significance to meet COSEWIC criteria for a DU, and it was not included with Fraser River drainage DUs. DFO did not name it a Conservation Unit (CU). Hence, these Sockeye Salmon are not discussed in this report.

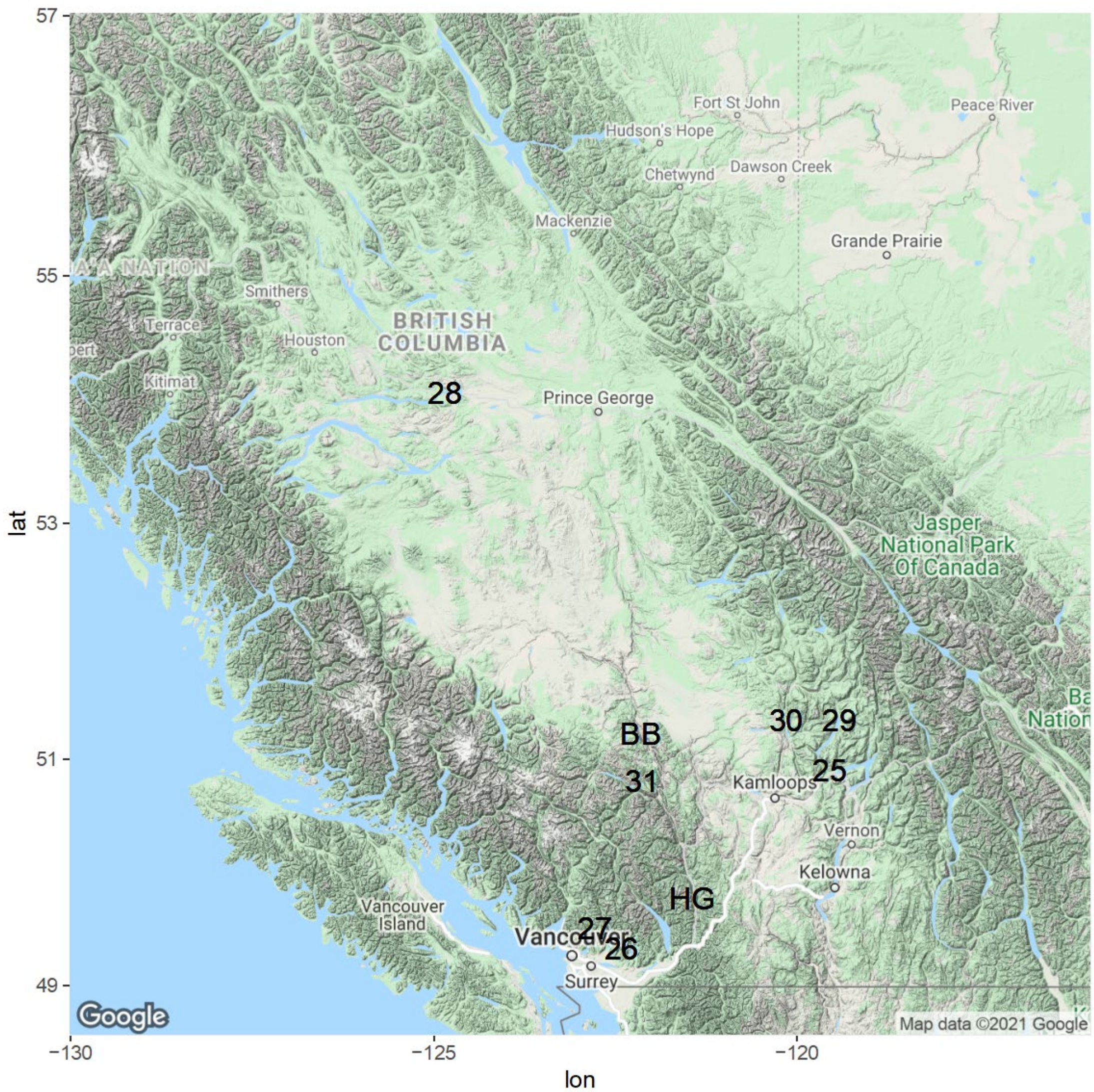


Figure 1. The location of the DUs examined (by original number) with respect to Hell's Gate (HG) and the Big Bar (BB) slide. Big Bar slide is provided for reference because it is a recently occurring slide similar to Hell's Gate. Map method citation: (Kahle and Wickham 2013).

Table 1. DUs for Fraser Sockeye Salmon assessed in COSEWIC (2017) plus the 7 DUs considered in this report. Note that these are identical to the CU names from the Government of Canada's Wild Salmon Policy and those described in Grant *et al.* (2011). Letters after each DU name refer to the four main run timing groups in the Fraser: "EStu" is Early Stuart, "ES" is Early Summer, "S" is Summer, and "L" is Late (COSEWIC 2017, Table 1). The numbers in parentheses are the new numbers to be used in future reports.

Proposed DU Number	Proposed DU Name	Stock name	Rationale
1	Anderson-Seton-ES	Gates	Two nursery lakes in close proximity.
2	Bowron-ES	Bowron	Single nursery lake.
3	Chilko-ES	Chilko	Single nursery lake with DU separated from "Chilko Summer" DU by run timing and location of spawning.
4	Chilko-S	Chilko	Single nursery lake with DU separated from "Chilko Early Summer" DU by run timing and location of spawning.
5	Chilliwack-ES	Miscellaneous early summers	Single nursery lake.
6	Cultus-L	Cultus	Single nursery lake.
7	Francois-Fraser-S	Stellako	Two nursery lakes in close proximity. Francois Lake Sockeye further separated by "Summer" (grouped here) and "Early Summer" (Nadina-Francois-ES) run-timing.
8	Nadina-Francois-ES	Nadina	Two nursery lakes in close proximity (Francois and Nadina). Francois Lake Sockeye further separated by "Summer" (Francois-Fraser-S-S DU) and "Early Summer" (grouped here) run-timing. This DU currently requires validation, as described in Grant *et al.* (2011), to determine if it should be considered two separate CUs.
9	Harrison(D/S)-L	Miscellaneous Lates	Single nursery lake further separated from "Harrison Lake (upstream)" DU by spatial separation of spawners and unique fry migration (downstream to lake).
10	Harrison(U/S)-L	Weaver	Single nursery lake further separated from "Harrison Lake (downstream)" DU by spatial separation of spawners and unique fry migration (upstream from Weaver Creek to lake).
11	Kamloops-ES	Raft and miscellaneous Early Summers	Single nursery lake.
12	Lillooet-Harrison-L	Birkenhead	Two nursery lakes in close proximity.
13	Nahatlatch-ES	Miscellaneous Early Summers	Single nursery lake.
14	North Barriere-ES (de novo)	Upper Barriere and miscellaneous Early Summers	Single nursery lake. Self-sufficient introduced population from hatchery transplants from the Raft River.
15	Pitt-ES	Pitt	Single nursery lake.
16	Quesnel-S	Quesnel	Two nursery lakes (Quesnel and McKinley) in close proximity with vast majority of rearing occurring in Quesnel Lake.
17	Seton-L (de novo)	Portage	Single nursery lake. Self-sufficient introduced population from hatchery transplants from the Lower Adams River.
18	Shuswap Complex-L	Late Shuswap	Multiple closely coupled lakes further separated from the "Shuswap Early Summer" DU by run timing.
19	Shuswap Complex-ES	Scotch, Seymour and miscellaneous Early Summers	Multiple closely coupled lakes further separated from the "Shuswap late" DU by run timing.

Proposed DU Number	Proposed DU Name	Stock name	Rationale
20	Takla-Trembleur-EStu	Early Stuart	Two closely coupled lakes further separated from the “Takla-Trembleur Summer” DU by run timing.
21	Takla-Trembleur-Stuart-S	Late Stuart	Multiple closely coupled lakes further separated from the “Takla-Trembleur Early Stuart” DU by run timing.
22	Taseko-ES	Miscellaneous Early Summers	Single nursery lake.
23	Harrison - River Type	Harrison	Genetically and geographically distinct from other river-type Sockeye.
24	Widgeon - River Type	Miscellaneous Summers	Genetically and geographically distinct from other river-type Sockeye.
25 (198)	Adams-ES (Original)	-	Single nursery lake.
26 (196)	Alouette-ES (Original)	-	Single nursery lake.
27 (197)	Coquitlam-ES (Original)	-	Single nursery lake.
28 (200)	Fraser-ES (Original)	-	Single nursery lake.
29 (199)	Momich-ES (Original)	-	Single nursery lake.
30 (201)	North Barriere-ES (Original)	-	Single nursery lake.
31 (202)	Seton-S (Original)	-	Single nursery lake.

DISTRIBUTION - SEE COSEWIC (2017)

HABITAT - SEE COSEWIC (2017)

BIOLOGY - SEE COSEWIC (2017)

POPULATION SIZES AND TRENDS

Annual abundance and sampling have been presented for these DUs if they are applicable for status designation.

THREATS, LIMITING FACTORS, AND NUMBER OF LOCATIONS (GENERAL)

A Threats Calculator was not done for these DUs because they were all thought to have been eliminated until new information came forward (see **PREFACE**). Nevertheless, four areas where threats occur are similar for all *Oncorhynchus* spp. expressing anadromy. DUs within the same Marine Adaptive Zone, Estuary and Coastal area are subject to possible threats, for example, from pollution, fisheries, and pinniped predation. All DUs are exposed to threats within the High Seas area from, for example, competition and changes in ocean productivity. Finally, DUs within the same Freshwater Adaptive Zone are exposed to threats within watershed areas, for example, from habitat degradation, dams, and landslides. These areas will correspond to COSEWIC defined locations depending on population size, proportion of the population affected, and the level of threat impact. Threats within these areas are identified where relevant in individual DU discussion sections.

DESIGNATABLE UNIT-SPECIFIC CHAPTERS

Designatable Units Below Hell's Gate Landslide

Alouette-ES (DU 26) and Coquitlam-ES (DU 27)

Background

Alouette-ES and Coquitlam-ES are considered together because they are in neigbouring watersheds (Figures 1, 2) and are downstream from the Hell's Gate landslide. Their ecological background is similar because reservoir dams cut off access to the sea for migrating Sockeye Salmon in each lake in the early 1900s. Non-migratory *O. nerka* were present in both lakes after, but not before, dam construction.

The term Kokanee is commonly used to describe non-migratory *O. nerka* and has been used to describe the Sockeye Salmon in Alouette and Coquitlam lakes. However, recent investigations indicate that Sockeye Salmon in these two DUs are more accurately described as residual Sockeye Salmon rather than Kokanee (see **Habitat Trends** and **Biology** sections below).

Designatable units (DU)

The description of the designatable units within Alouette and Coquitlam has been affected by the dam construction and subsequent prevention of anadromy for approximately 80 - 90 years in both reservoirs. Previously the DUs in each lake were described by the anadromous characteristics of Sockeye Salmon but are now best described as DUs of residual Sockeye Salmon in each reservoir. The rationale for this change is explained in the **Habitat Trends** and **Biology** sections below.

Habitat trends: Species composition before and after dam construction

Alouette

Dam construction

The Alouette River drains into the Pitt River and then into the Fraser River. The Alouette-ES DU spawned in the upper Alouette River and reared in Alouette Lake (Figure 2; Grant *et al.* 2011). In 1926, a hydroelectric dam was built at the south end outflow of Alouette Lake creating the Alouette Reservoir. At the north end of Alouette Lake, the dam construction included a 1 km power tunnel, with two discharging outlets, connected to Stave Lake (Figure 2; Hirst 1991; Godbout *et al.* 2011).

The portion of the Alouette Watershed area where salmon are located is 144 km^2 (Sparrow 2019) and Alouette Reservoir surface area is 16.5 km^2 (Hirst 1991).

Species composition

Prior to dam construction, an Early Summer run (April – July migration) spawned in September – November in the mainstem of the Alouette River and reared in Alouette Lake. Other anadromous salmon using the system were Chinook Salmon (*Oncorhynchus tshawytscha*), Coho Salmon (*O. kisutch*), Chum Salmon (*O. keta*), Steelhead Trout (*O. mykiss*), and Cutthroat Trout (*O. clarkii*) (Hirst 1991). Anadromous Sockeye Salmon escapement to this system was considered relatively low in the early 1900s although there are no quantitative estimates (Roos 1991). However, Hirst (1991) reported that large runs of anadromous Sockeye Salmon occurred in Alouette Lake prior to dam construction. There are no historical records indicating that Kokanee were in Alouette Lake prior to dam construction (Godbout *et al.* 2011).

The dam cut off access to the sea and Chinook Salmon were not reported after construction of the Alouette Dam in 1926 and anadromous Sockeye Salmon returns disappeared in 1930. After dam construction the five important sport fish were non-anadromous salmonids: Rainbow trout (*O. mykiss*), cutthroat trout, Lake Trout (*Salvelinus namaycush*), Dolly Varden (*Salvelinus malma*) and (non-migratory *O. nerka* reported as Kokanee) (Hirst 1991).

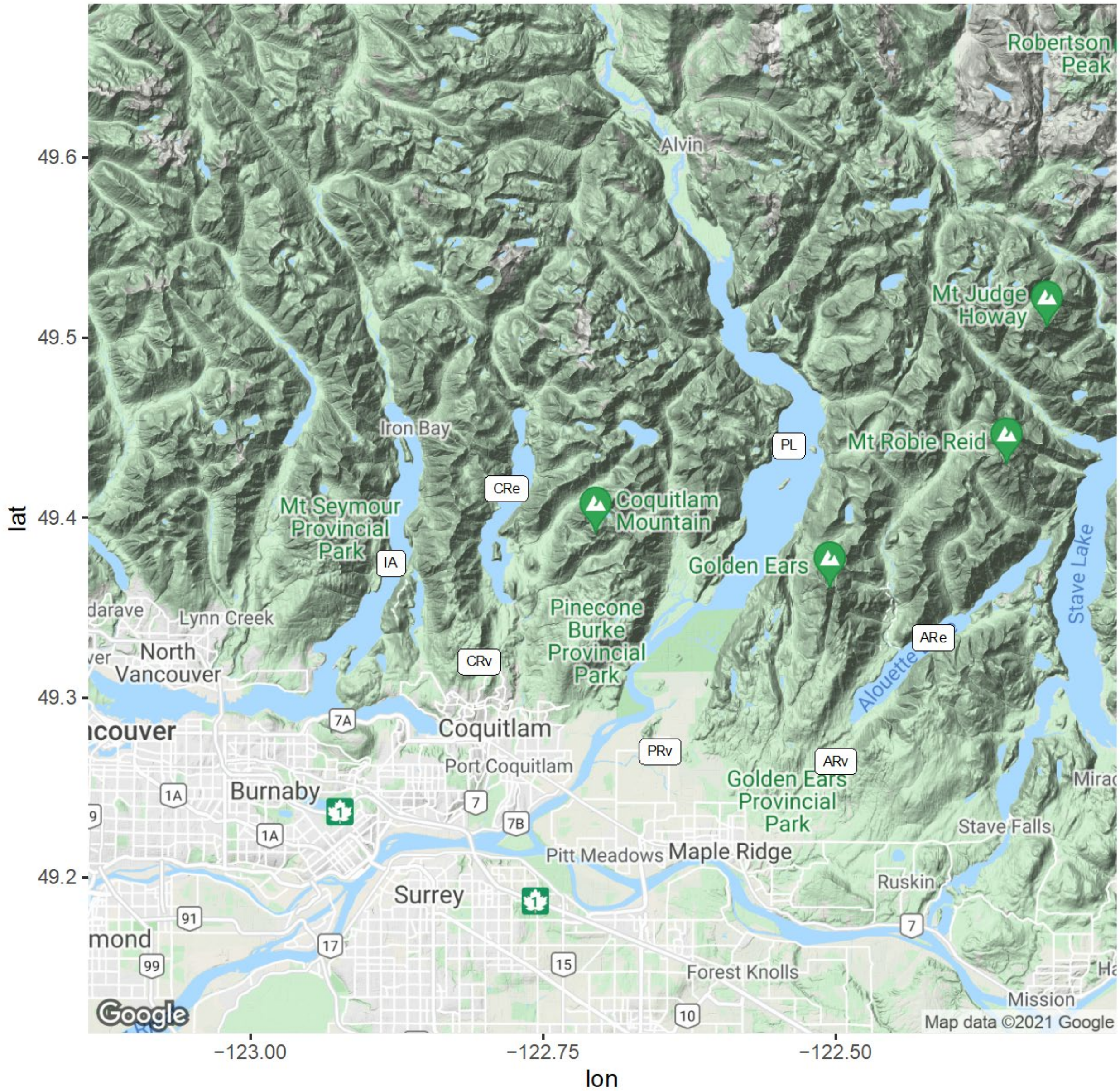


Figure 2. Location of the Alouette and Coquitlam reservoirs. Abbreviations: Alouette Reservoir (ARe), Alouette River (ARv), Coquitlam Reservoir (CRe), Coquitlam River (CRv), Pitt Lake (PL), Pitt River (PRv), Indian Arm (IA). Map method citation: (Kahle and Wickham 2013).

Coquitlam

Dam construction

The Coquitlam River enters directly into the Fraser River at Port Coquitlam and creates supplementary storage for power generation from Buntzen Lake. The Coquitlam-Buntzen facilities present in 1902 were the Coquitlam Dam, the Coquitlam Diversion Tunnel, and Lake Buntzen 1 Powerhouse (BCHydro 2021). The Coquitlam Dam, creating

Coquitlam Reservoir, was completed in 1914 about 16 km above its confluence with the Fraser River (Plate *et al.* 2014). There were no fish passage facilities built into Coquitlam Dam in 1914 (Figure 2; Hirst 1991; Plate *et al.* 2014).

The Coquitlam watershed area is 253 km^2 and the reservoir surface area is 11 km^2 (Plate *et al.* 2014)

Species composition

Prior to dam construction, the Coquitlam-ES DU reared in Coquitlam Lake (Figure 2, Grant *et al*. 2011). The mainstem Coquitlam River was also used by Coho Salmon, Chum Salmon, Pink Salmon (*O. gorbuscha*), and possibly Sockeye Salmon (Hirst 1991). However, escapement to this system was relatively low in the early 1900s although there are no quantitative estimates (Roos 1991). Shortly after dam construction, native anadromous Sockeye Salmon disappeared from Coquitlam Reservoir for 90 years but may have persisted as non-migratory *O. nerka* (reported as Kokanee) (Grant *et al*. 2011). However, there are no historical records indicating Kokanee were in Coquitlam Lake prior to dam construction (Godbout *et al*. 2011).

From 1949 to 1965, channel confinement for flood control led to an increase in gradient, riverbed instability, bankslides, and silting. However, Coho Salmon, Chum Salmon, Steelhead Trout, Cutthroat Trout, and Dolly Varden could still be found in the river (Hirst 1991). Coquitlam Reservoir was closed to public access, but the Coquitlam River continued to be managed for Steelhead Trout and anadromous Cutthroat Trout fisheries (Hirst 1991).

Biology

Kokanee or residual forms

Alouette and Coquitlam

Anadromous Sockeye Salmon disappeared from both the Alouette and Coquitlam lake systems after dam construction but persisted as non-migratory *O. nerka* populations behind these impassable dams. There are no records of the presence of Kokanee in the lake prior to dam construction and no stocking of Kokanee occurred in these systems since 1894 (Godbout *et al.* 2011). Non-migratory *O. nerka* (reported as Kokanee) were first reported in Alouette Reservoir in 1951 and in Buntzen Lake which is immediately downstream from Coquitlam Reservoir in 1955 (Godbout *et al.* 2011).

Residual Sockeye Salmon, first described by Ricker (1938) in Cultus Lake, develop within a cohort and are the “non-migratory progeny of anadromous parents”. In contrast, Kokanee evolved over a long time-period from the anadromous form during recurrent Pleistocene glaciations (Wood *et al.* 2008).

The distinction between Kokanee and residual Sockeye Salmon is important because if non-migratory *O. nerka* remaining in Alouette and / or Coquitlam Reservoirs are residual Sockeye Salmon then they would be considered part of the original DU. However, if they are Kokanee, then the original DU would be considered extinct.

Anadromous Sockeye Salmon, Kokanee, and residual Sockeye Salmon have been found to live sympatrically. Two sympatric examples are described for Cultus Lake (Ricker 1938) and Takla Lake, British Columbia (Wood and Foote 1996). In each case these groups exhibited different morphologies, spawning times, and other life-history characteristics (Ricker 1938; Wood and Foote 1996). For example, Ricker (1938) found mainly males in the residual population, females in the anadromous, and a 50:50 female ratio in Kokanee. Wood and Foote (1986) found differences in morphology, gill raker number, allozyme allele frequencies, and reproductive traits between anadromous and Kokanee forms and concluded that divergence had occurred in sympatry.

Anadromous salmonids can become residualized for several reasons. For example, juvenile Steelhead Trout can become residualized if freshwater habitat does not support growth to the size needed for smoltification (Hausch and Melnychuk 2012). In the case of *O. nerka* in Alouette and Coquitlam reservoirs, residualization could occur because the dams prevented migration to sea.

While Kokanee and residual Sockeye Salmon are both predominately non-migrating, they have both been found to be capable of migrating to sea and returning to spawn (Rounsefell 1958). However, recently specific genes have been associated with migratory behaviour. Christensen *et al.* (2020) found regions of the *O. nerka* genome that differentiate between Sockeye Salmon and Kokanee. These regions are related to smolting ability and are associated with vision cues for smolting. They note that carrying these genes is likely energetically costly for landlocked Kokanee to maintain. Thus, migratory behaviour in Kokanee is expected to be much less than in residual Sockeye Salmon.

Recent genetic analyses of anadromous Sockeye Salmon and Kokanee in the Fraser River and Columbia River drainages indicate that non-migratory *O. nerka* in Alouette and Coquitlam Reservoirs cluster more closely with the anadromous lake-type Sockeye Salmon ecotype than with Kokanee ecotypes (Fig. 1 in Beacham and Withler 2017). Similarly, analyses focusing on Coquitlam and Alouette reservoirs support an anadromous origin for these landlocked populations (Samarasin *et al.* 2017).

Samarasin *et al.* (2017) genetically examined the Coquitlam and Alouette populations with nine other *O. nerka* populations in the Lower Fraser River region. Smolts migrating downstream in the Alouette River because of a reanadromization project (described below) were sampled in a Rotary Screw Trap and genetically compared to residual salmon sampled in the reservoir. There were no morphological differences between the downstream migrating juveniles and the non-migratory juveniles that remained in the reservoir. Analysis of F_{ST} values, using 14 previously characterized microsatellite alleles, showed no significant differences between these two Alouette Reservoir forms. F_{ST}, sometimes called the fixation index, varies between, 0 and 1. At 0 all subpopulations have equal allele frequencies and at 1 all subpopulations are fixed for different alleles (Allendorf *et al.* 2013). In addition, a comparison of F_{ST} values at 14 microsatellite (neutral) loci between out-migrating and resident forms within the Alouette reservoir did not indicate significant genetic differentiation, suggesting likely common origin (from anadromous type) (Samarasin *et al.* 2017). The genetic effective population estimates (numbers) for Alouette sea-run Sockeye Salmon were 98.4 (+-2.5) and 103.8 (+-4.4) for the Alouette residents (Samarasin *et al.* 2017). A significant reduction in effective population numbers was also identified using a bottleneck analysis (Samarasin *et al.* 2017), indicating much smaller effective population numbers currently, than in the past. Note that genetic effective population numbers tend to be orders of magnitude lower than census population numbers (Palstra and Fraser 2012).

The F_{ST} values were similar (0.001) between resident and anadromous forms within Coquitlam Reservoir. However, a discriminant analysis incorporating Principal Component Analysis distinguished between the residual and anadromous forms within Coquitlam Reservoir. It was concluded that there was a "weak genetic differentiation" within Coquitlam Reservoir, contrary to the one population identified within Alouette Reservoir. This separation was estimated to be very recent between the two Coquitlam Reservoir forms (2.7 generations; 5% CI 0.4 – 6.8 generations) (Samarasin *et al.* 2017). The genetic effective population number for Coquitlam sea-runs was 119 (+-2.9) and 98.6 (+-3.6) for the Coquitlam residents. A significant reduction in effective population numbers was also identified using a bottleneck analysis (Samarasin *et al.* 2017).

The genetic analysis of Coquitlam Reservoir *O. nerka* supports a very recent split between the landlocked and anadromous forms (Samarasin *et al.* 2017). Low anadromous returns from the Coquitlam restoration project add to the uncertainty regarding the re-establishment of anadromy in this population. While Samarasin *et al.* (2017) identify some cases where anadromy has been restored in some salmonids, it is uncertain if both anadromous and resident forms can co-exist in sympatry for a long time after an event such as the Alouette and Coquitlam dams' construction. However, without timely assistance to facilitate outmigration and return migration, anadromous adaptations will likely be lost from Alouette and Coquitlam reservoirs.

These genetic results, combined with the lack of Kokanee in the historical record, indicate that residual salmon better describes the origin and current designatable unit characteristics of the *O. nerka* in Alouette and Coquitlam Reservoirs than Kokanee. Relatively small genetic effective population size estimates in both reservoirs also suggests both populations are vulnerable to extinction risk through negative genetic effects such as inbreeding depression and limited adaptive potential (Lynch and Lande 1998; Frankham 2005).

Abundance

Reanadromization programs: Population abundance

Alouette

The Alouette River Sockeye Reanadromization Program (ARSRP) is a joint initiative among the Katzie First Nation, the Alouette River Management Society (ARMS), BC Hydro, BC Ministry of Environment and Climate Change (MOE), DFO, and local stakeholders that seeks to promote the re-establishment of anadromous Alouette Sockeye and investigate the feasibility of fish passage at the Alouette Dam (Borick-Cunningham 2020). Beginning in 2005 the flow regime at the dam was modified to allow juvenile anadromous Sockeye Salmon to migrate downstream in spring (Borick-Cunningham and Driedger 2015). Mature anadromous Sockeye Salmon began to return in 2007. Genetic and otolith analyses demonstrated that the returning fish originated from Alouette Reservoir (Godbout *et al.* 2011). From 2007 to 2020, 446 anadromous Sockeye Salmon returned to the fish fence and 383 of those were transported by truck from the fence and released live into the reservoir (Table 2) (Borick-Cunningham 2020, DFO unpubl. data). The run timing has corresponded with that of the original population (July to early September), although approximately 10 returned in October for the first time in 2019 (Borick-Cunningham 2020).

Table 2. Anadromous Sockeye Salmon returns and live releases into Alouette Reservoir 2007-2020. (Source: Smith 2018 Table 5-1; Borick-Cunningham pers. comm. 2021.)

Year	Returns	Live Release
2007	38	5
2008	54	53
2009	45	43
2010	115	103
2011	11	8
2012	45	43
2013	10	7
2014	0	0
2015	4	0
2016	6	6
2017	3	1
2018	15	15
2019	15	14
2020	85	83

The number of out-smolts migrating has averaged 15,216 individuals per year from 2005 to 2018 with a range of 0 to 31,643 (Borick-Cunnigham 2020) during spring water release. Hydroacoustic studies estimated 12,000 adult non-migratory *O. nerka* in 1998. Since then, hydroacoustic estimates have averaged about 83,000 (2014 – 2016 fall surveys), and about 122,000 (2014-2018 summer surveys). Adult fish in these surveys are defined as those >= 1+, while mature ages are 3 and 4 years old. Based on proportion of the population available to the surveys and proportion of mature fish in other sampling, the number of mature Sockeye Salmon in Alouette Reservoir would be between 20,000 and 33,000 individuals (Vainionpaa *et al.* 2020).

The re-establishment of anadromy requires returning Alouette Sockeye Salmon to successfully breed and produce Sockeye smolts. Godbout *et al.* (2014) tested this aspect of re-establishing anadromy in Alouette Sockeye Salmon. Otolith microchemistry identified whether the female parent inhabited a marine or freshwater environment. Microchemistry at the core of the otolith is determined by the environment inhabited by the female when the egg yolk is formed (Veinott *et al.* 2014). Genetic parentage assignment was used to match DNA sequences between parents and progeny. None of the juveniles sampled were perfectly matched to any pair of returning anadromous Sockeye. While there were several partial matches, these were attributed to false positives caused by low genetic diversity in the resident population. They concluded it was unlikely that returning anadromous adults were spawning successfully together (Veinott *et al.* 2014). However, power to detect an anadromous parent is low because of the sample size and low numbers of residual Sockeye Salmon returning to Alouette Reservoir in relevant brood years.

The initial results from the ARSRP are encouraging in that juvenile anadromous Sockeye Salmon that have been released from the reservoir have gone to sea and returned with a similar sea age and in a similar season to the run that existed before the dam was built.

Coquitlam

Numerous interested parties including government agencies, the Kwikwetlem First Nation, stewardship groups, environmental Non-Government Organizations (NGOs), and concerned citizens have an interest in restoring anadromous salmon runs in the Coquitlam watershed while maintaining Coquitlam Reservoir's important role as a major source of high-quality drinking water for the Greater Vancouver Regional District. Beginning in 2005 the flow regime through a low-level outlet in the dam was modified to allow juvenile anadromous Sockeye Salmon to migrate downstream in the spring (Robichaud and Plate 2018). Mature anadromous Sockeye Salmon began to return in 2008 indicating that reanadromization of landlocked *O. nerka* in this system was possible. Genetic and otolith analysis demonstrated that the returning *O. nerka* originated from Coquitlam Reservoir residual Sockeye Salmon (Godbout *et al.* 2011). From 2007 to 2020, 28 mature anadromous Sockeye Salmon, all female, have returned and been released live into the reservoir (Table 3; Robichaud and Plate 2018; Cone pers. comm. 2021).

Table 3. Returns of individual Sockeye Salmon to the Coquitlam River and the escapement (numbers released live) into Coquitlam Reservoir, 2007-2020 (Source: Figure 1 in Robichaud and Plate 2018, for 2007 to 2015). Data in parentheses are for 2010 – 2020 from BC Hydro through DFO. From 2010 to 2020 all escapements were female.

Year	Total returns	Dead	Live not transferred	Escapement (Live and transferred)
2007	2	2	0	0
2008	10	0	0	9 (9)
2009	1	0	0	1 (1)
2010	6	3	0	3 (2)
2011	6	3	0	3 (5)
2012	3	2	0	2 (1)
2013	2	1	0	1 (2)
2014	2	0	1	1 (2)
2015	0	0	0	0
2016				(1)
2017				(1)
2018				(1)
2019				(0)
2020				(3)

Hydroacoustic surveys in Coquitlam Reservoir estimate there are ~14,000 mature Sockeye Salmon individuals in the resident population for Coquitlam (Plate and Degan 2014).

Maintaining Alouette-ES and Coquitlam DUs requires the water release regime and transport of adults into the reservoir outlined in the reanadromization projects. Current dam infrastructure does not allow natural smolt outmigration or anadromous adult returns to the reservoir without human intervention. Therefore, reduction or cessation of current water management approach will increase the extinction risk for anadromous Sockeye Salmon.

Threats and number of locations

The dam, downstream freshwater effects, and marine threats are only affecting a small proportion of the population. They do not qualify as locations in the context of the total population.

Designatable Units Above Hell's Gate Landslide

DU 25 Adams-ES; DU 28 Fraser-ES; DU 29 Momich-ES; DU 30 North Barriere-ES; DU 31 Seton-S

Railroad construction from 1911 to 1914 in the Fraser Canyon at Hell's Gate (Figure 1) created a landslide in 1913. After this landslide, the International Pacific Salmon Fisheries Commission (IPSFC) reported that Sockeye Salmon returns dropped to 1/3 their pre-Hell's Gate landslide levels (IPSFC 1985). While the landslide did not stop salmon migration, it increased the risk of extinction to those areas also impacted by dams and habitat degradation before and after the landslide occurrence. Early returning salmon were more affected than later returning salmon (IPSFC 1937-1985). This report section considers those DUs above the Hell's Gate landslide (Figure 1).

DU 25 Adams-ES and DU 29 Momich-ES

Background

Adams-ES (DU 25) and Momich-ES (DU 29) are considered together because they are both part of the South Thompson Watershed. They are also both Early Summer DUs which migrated through Hell's Gate by August 6 and spawned between August 27 and September 15 (Williams 1987). They are both upstream of a splash dam that was operational from 1908 to 1921 (Figure 3). Splash dams were built to raise water to heights to facilitate logs moving downstream. This splash dam was 4.5 m in height (Cal-Eco Consultants and Mariposa Trails 2008).

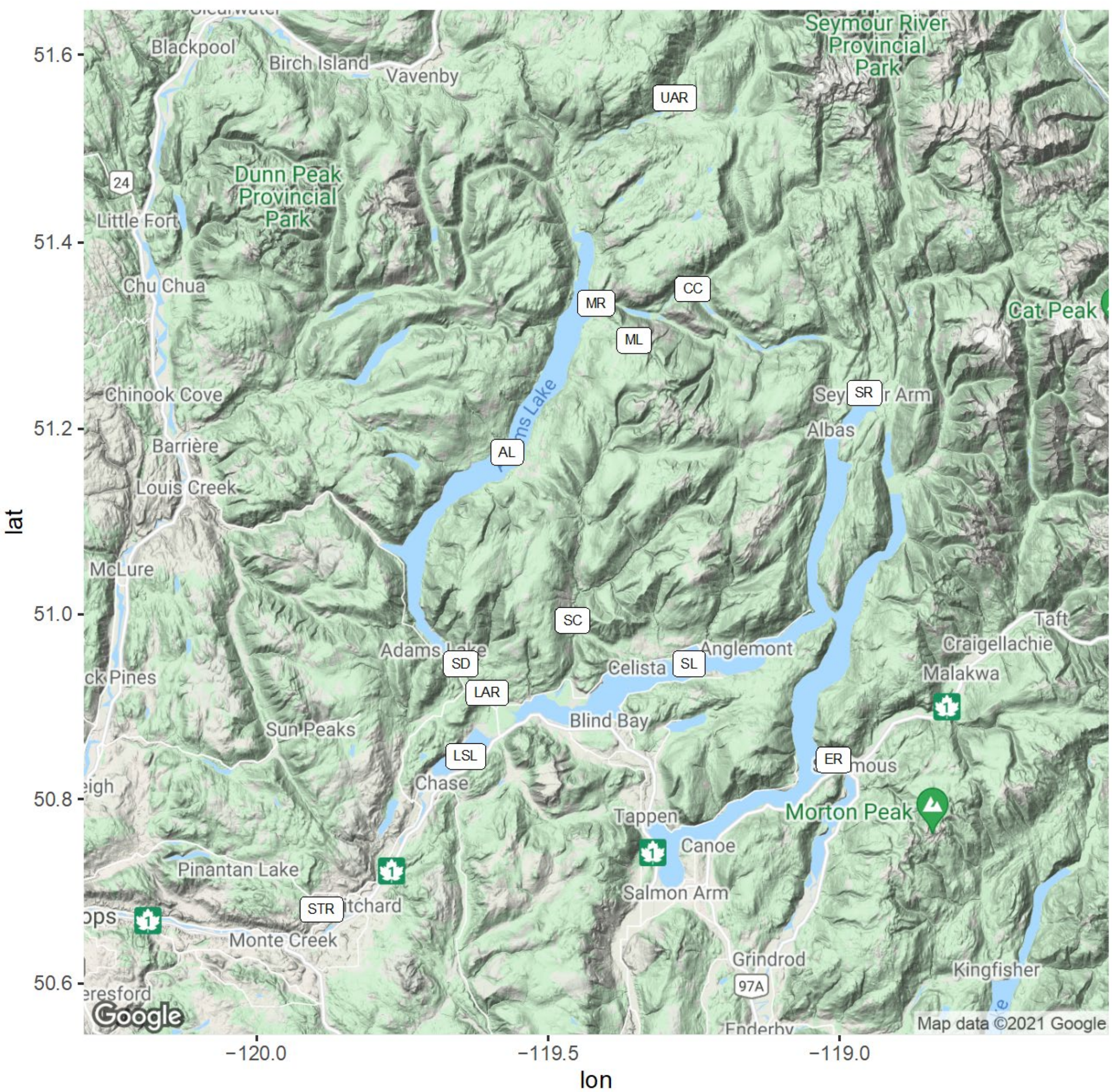


Figure 3. Locations of Adams Lake, the Upper and Lower Adams River, Momich River, Cayenne Creek, and the Seymour River, and other key areas of the South Thompson watershed mentioned in the text. The splash dam was on the Lower Adams River, downstream from Adams Lake. Abbreviations: Upper Adams River (UAR), Momich River (MR), Momich Lake (ML), Cayenne Creek (CC), Adams Lake (AL), Lower Adams River (LAR), Little Shuswap Lake (LSL), Scotch Creek (SC), Shuswap Lake (SL), Seymour River (SR), Eagle River (ER), South Thompson River (STR), Splash Dam (SD). Map method citation: (Kahle and Wickham 2013).

The Adams-ES DU spawned in the Upper Adams River and juveniles reared in Adams Lake (Figure 3, Grant *et al.* 2011). Escapement to this system in the early 1900s was considered relatively large although there are no quantitative estimates available (Williams 1987).

The spawning area in the Upper Adams River has been estimated at 1.25 km^2, the basin size 2,860 km^2, and the river length as 94 km (Hume *et al.* 2003).

The Momich-ES DU spawned in Momich River and Cayenne Creek and likely reared in Momich Lake (Figure 3; Grant *et al.* 2011). There are no estimates of Momich-ES population abundance prior to the splash dam construction.

The spawning area in the Momich River / Cayenne Creek watershed is contained in 0.5 km of the Momich River and 300 m in the Cayenne Creek. Momich Lake, where fry rear, has a surface area of 2.03 km^2 (Hume *et al.* 2003).

The Upper Adams and Momich rivers also contain late runs which spawn between October 11 and November 15 (Williams 1987) and are part of DU-18: Shuswap Complex-L (Grant *et al.* 2011; COSEWIC 2017).

Fish from the Upper Adams Enhancement projects have been hypothesized to be an important source of Sockeye Salmon observed in the Momich DU after the dam was removed (Williams *et al.* 1987). An alternative hypothesis is that remnant populations persisted in the Upper Adams River and the Momich River / Cayenne Creek areas. Sampling effort by the IPSFC, genetic work from the late 1990s and early 2000s, and new genetic work and growth analysis completed in 2018 were examined with respect to these hypotheses and their implication for original and new DU designations.

Habitat trends

The splash dam was operational from 1908 to 1921. It fell into disrepair after 1921 but was not removed until 1945. While there was a fishway in the dam it had questionable effectiveness in allowing passage of spawning fish to the lake and their spawning grounds in the Upper Adams River (DU 25) and in the Momich Lake tributaries (Momich River and Cayenne Creek) (DU 29) (Roos 1991) (Figure 3).

Sampling effort

Small numbers of early-run spawners to the headwaters of Adams Lake were reported in 1913 and 1917 (Thompson 1945 cited in Roos 1991) but were not reported for several decades after that time and no other information during the splash dam operation was available. It was concluded that the original Adams-ES and Momich-ES populations had disappeared (Williams 1987; Roos 1991; Grant *et al.* 2011).

The IPSFC reports from 1937 to 1985 (IPSFC 1937-1985) were examined to determine the sampling effort that took place relevant to considering if Sockeye Salmon in these DUs had been eliminated or remnant Sockeye Salmon persisted (Williams 1987; Roos 1991). Narratives prior to the beginning of enhancement activities in 1960 (Appendix 1) reported surveys as occurring in Adams Lake and Tributaries, for the late run (i.e., not including early run Upper Adams River or Momich). It was not clear if these surveys included Upper Adams River and Cayenne Creek / Momich River early run. However, spawning escapement table entries between 1958 and 1960 indicated that surveys initially described as Adams Lake and tributaries did not include the Upper Adams River and Cayenne / Momich. The reports for 1957 to 1960 separate Upper Adams River from other survey areas back to 1942. Prior to 1957 Momich surveys were only reported in 1945 when 1500 late run returns were observed (Table 4, also see section below DU 29 Momich-ES).

As a result, only those entries that were specifically labeled Upper Adams River or Momich River / Cayenne Creek were used to identify the occurrence of surveys for Sockeye Salmon in these areas.

Table 4. Escapement (mature spawners) and peak spawning times for Upper Adams River and Momich Rivers. Data sources are IPSFC reports (1937-1985) and DFO data files 1986 – present. 1945 is the year the splash dam was removed. Stocking of the Upper Adams River started in 1949 and continued to 2002 (see Abundance in DU 25 Adams-ES and Influence of Transplantation efforts; next section). From 1937 to 1941 there were no surveys specific to Upper Adams River or Momich River / Cayenne Creek. N/A indicates that peak spawning time was not available although fish numbers were recorded. Blank indicates that no surveys occurred and 0 indicates there was a survey, but no fish were observed. See text for explanation of 1960 numbers. Seymour spawning ranged from Aug. 20 to Sep. 13 from 1954 to 1985.

Year	Upper Adams River Numbers	Momich River / Cayenne Creek Numbers	Upper Adams River Peak Spawning	Momich River / Cayenne Creek Peak Spawning Dates
1937 - 1941				
1942	0			
1943-1944				
1945		1500		Oct-Nov
1946	0			
1947	0			
1948	0			
1949				
1950	0			
1951	0			
1952	0			
1953				
1954	205		Sep 3 - 8	
1955	0			
1956	0			
1957				
1958	Present		Sep 9 12	
1959	0		N/A	
1960	Present	1,000	N/A	N/A
1961				
1962	85		Sep 15-20	
1963	6		N/A	
1964	162	823	Sep 3 - 5	Aug 31-Sep 2
1965				
1966	63		Sep 12-15	

Year	Upper Adams River Numbers	Momich River / Cayenne Creek Numbers	Upper Adams River Peak Spawning	Momich River / Cayenne Creek Peak Spawning Dates
1967				
1968		617		Aug 25-28
1969				
1970	4		Sep 7 - 9	
1971	0			
1972	31	1003	Sep 4 -8	Aug 22-25
1973				
1974	13		Sep 5-10	
1975	23		Aug 28-Sep1	
1976	40	1998	Sep 3 – 5	Sep 2-5
1977				
1978	0			
1979	0			
1980	560	3345	Aug 27 - 30	Aug 26-29
1981				
1982	124		Sep 12-15	
1983				
1984	3502	5854	Aug 29 – Sep 2	Aug 22-25
1985	83	56	Sep/ 5 - 9	Aug 30-Sep 1
1986	567	56	Sep 9 - 12	Sep 3-7
1987	2	25	Sep 9 - 12	Sep 3-7
1988	7169	5912	Aug 30 – Sep 4	Aug 24-29
1989	11	99	Sep 2-8	Sep 2-8
1990	625	58	Sep 3-8	Sep 3-8
1991	67	4	Mid Sep	Mid Sep
1992	2990	2486	Aug 30 – Sep 4	Aug 27-Sep 2
1993	47	533	Early Sep	Sep 2-9
1994	581	92	Sep 2-6	Early Sep
1995	90	47	Sep 2-7	Aug 28-Sep 7
1996	24948	9353		Aug 24-31
1997	90	286		Sep 2-10
1998	344	162	Sep 2-7	Sep 2-7
1999	2	67		Aug 30-Sep 4
2000	71322	8334	Aug 26-Sep 1	Aug 26-Sep 3
2001	605	358	Sep 3 – 10	Aug 28-Sep 1
2002	1067	112	Aug 31-Sep 13	N/A
2003	337	149	Sep 4 - 9	Sep 2-9
2004	419	671	Sep 1-8	Sep 1-10
2005	274	135	Sep 1-22	Sep 2-7
2006	292	78	Aug. 28-Sep. 4	Sep 3-9
2007	83	149	Sep. 04-09	Aug 31-Sep 4
2008	805	452	Aug. 30-Sep.7	Aug. 25-Sep. 3
2009	36	232		Sep 2-7
2010	2822	279	Aug. 28-Sep. 2	Sep 3-10
2011	538	14	Sep 1-8	Aug 30
2012	126	130	Aug. 30-Sep. 6	Aug 30-Sep 6
2013	43	511	Sep. 7-13	Sep 1-7
2014	5506	304	Sep. 3-7	Sep 7-12
2015	137	110	Sep. 9-15, F	Sep 3-15
2016	36	6	Aug. 31-Sep. 7	N/A

Year	Upper Adams River Numbers	Momich River / Cayenne Creek Numbers	Upper Adams River Peak Spawning	Momich River / Cayenne Creek Peak Spawning Dates
2017	4	43	N/A	N/A
2018	13318	729	Sep. 3-10	Sep 3-10
2019	2	16	N/A	N/A

Abundance in DU 25 Adams-ES and influence of transplantation efforts

Eggs transplanted from the Seymour River (DU 19 Shuswap-ES) were the main transplant source from 1949 to 1975 and consisted of ~3.5 million from 1954 to 1959 and another ~3.5 million 1974 to 1975. There were also ~2 million eggs (1958 to 1960) from Taseko Lake (DU 22 Taseko-ES) (Table 5; Hume *et al.* 2003). Mature spawners returning to the Upper Adams River from 1954 to 1979 ranged from 0 to 205 and were below the returns expected from the number of transplanted eggs (Table 4, Williams 1987). However, the peak spawning time of Sockeye Salmon in the Upper Adams River corresponded to those expected from early runs (Table 4).

Eggs from the Upper Adams River and Cayenne Creek were used for enhancement from 1980 to 1996 (Hume *et al.* 2000). Plantings to the Upper Adams River were done every four years from 1980 to 1996 (Table 5). Escapement of these cohorts increased from 1984 to 2000 when over 70,000 spawners returned to the Upper Adams River (Table 4). Hume *et al.* (2003) attributed the success of the 2000 Upper Adams run to the use of eggs from the Upper Adams and Momich Rivers, the culture of the fry until release, nutrient enrichment of Adams Lake, and low commercial exploitation rates.

Enhancement of the Upper Adams River ceased in 2002 (Sandher pers. comm. 2018). Escapement has ranged from 2 to 13,315, depending on run cycle since 2002 (Table 4).

Table 5. River of origin, life history phase, and number released to improve Upper Adams River returns from 1949 to 1996 (Hume *et al.* 2003).

Year	Source	Life phase	Number released
1949-1950	Seymour	eggs	825,000
	Seymour	fry	84,000
1952	Seymour	fry	187,000
1954-1959	Seymour	eggs	3,431,000
1958-1960	Taseko	eggs	2,152000
1974-1975	Seymour	eggs	3,514,000
1980	Adams / Cayenne Creek	fry	772,000
	Upper Adams	eggs	1,152000
1984	Cayenne females / Upper Adams males hybrid	eggs	400,000

Year	Source	Life phase	Number released
	Upper Adams	eggs	48,000
	Cayenne females / Upper Adams males hybrid	fry	393,000
1988	Upper Adams, Momich, Cayenne	fry	1,500,000
1992	Upper Adams and Momich Rivers	eggs	316,000
1996	Upper Adams and Momich Rivers	fry	1,302,000

Population returns in DU 29 Momich-ES up to 1960

Prior to 1960, no surveys were conducted specific to Momich River / Cayenne Creek. Momich returns were only reported in 1945 when 1500 late run returns, inferred from a peak spawning time of October to November, coincided with the splash dam removal (Table 4). In 1943 stream quality habitat was mentioned, when it received the following notations that the area contained: Productive Sockeye Streams, Non-productive Sockeye Streams, Unexplored Streams, and Points of Difficult Passage (IFPSC 1943).

The dates of the 1960 returns are not indicated but the text implies they were early run. For example, “No early run of sockeye had ever been observed in the Momich River by the Commission staff in earlier years nor had any been reported by local transients. The fish in 1960 were observed by a Provincial game warden but unfortunately the report of his observation reached the Commission too late for a fruitful investigation. However, the fish in the Momich River spawned at the same time as the few fish returning to Upper Adams River from a transfer of eyed eggs from Seymour River and at the same time as the native run to Seymour River.” (IPSFC 1960).

This reappearance was considered to have originated as strays from plantings in the Upper Adams River using fish primarily originating in the Seymour River (Williams 1987; Roos 1991). The transplant straying origin for the Momich Sockeye Salmon was considered in an IPSFC (1960) report, but a conclusion was not considered possible. The report concludes: “Whether the sockeye observed spawning in the North Thompson and Momich Rivers were the result of straying of transplanted stocks to the Barriere and Upper Adams River respectively or the end result in each case of a few previously unobserved spawners will be difficult if not impossible to determine.” (IPSFC 1960, p.16).

Population returns Upper Adams River and Momich River / Cayenne Creek after 1960

Survey results for Sockeye Salmon began to be reported in the Momich River in 1964 (Table 4). Momich returns were 6 to 50 times higher than the Upper Adams River between 1964 to 1980 (Table 4). During this time Momich returns increased on the 1960 cycle year from 823 in 1964 to 3,345 in 1980. These increases have been attributed to the transplant program directed to the Upper Adams River (Williams 1987). In 1984, the first returns from fry stocking in 1980 returned to the Upper Adams River. Upper Adams River returns in 1984 were nearly 7X those in 1980 and were similar to returns to the Momich. In 1988, 1960 cycle Upper Adams River returns surpassed the Momich. Momich returns peaked in 1996 at 9,353 and in 2000 Momich returns were similar at 8,334. Upper Adams River returns in 1996 were 24,948 and peaked in 2000 at 71,322. Since 2000, the maximum Momich escapement has been 729 in 2018. The Momich returns since 2013 have been non-cyclic and the dominant cycle for the Upper Adams River changed in 2010 (Table 4).

Designatable Unit Structure

Criteria and original DU structure

Sockeye Salmon in Upper Adams River and Momich River / Cayenne Creek correspond to the Lake ecotype where salmon typically spawn in tributaries to lakes or along the lakeshore, and the juveniles rear in these nursery lakes for at least one year before migrating to the ocean (COSEWIC 2021).

The default Sockeye Salmon DU assignment is that individual nursery lakes comprise separate DUs with a few exceptions, where multiple life-histories are found in a single lake. This assumption is supported by genetic studies that have examined Sockeye Salmon (Wood *et al.* 1994; Wood 1995; Gustafson and Winans 1999; Withler *et al.* 2000; Nelson *et al.* 2003; Beacham *et al.* 2005, 2006).

This rationale was the lake-type default DU assignment followed in COSEWIC (2021). In these instances, DFO conservation units (CU) and COSEWIC designatable units are equivalent.

In a few instances, when the lakes are small (<100 ha), close together and ecologically similar (hydrologically coupled) they are combined into one CU or DU unless there is evidence to suggest populations are genetically or ecologically distinct (Grant *et al.* 2011).

For example, the Shuswap Complex-ES DU was established using the hydrologically coupled rationale and is composed of Sockeye that spawn in 23 sites Shuswap – ES DU 19 which consists of: Adams Channel, Adams River, Anstey River, Burton Creek, Bush Creek, Celista Creek, Craigellachie Creek, Crazy Creek, Eagle River, Hiuhill (Bear) Creek, Hunakwa Creek, Loftus Creek, McNomee Creek, Middle Shuswap River, Nikwikwaia (Gold) Creek, Onyx Creek, Pass Creek, Perry River, Ross Creek, Salmon River, Scotch Creek, Seymour River, and Yard Creek (Grant *et al.* 2011).

Holtby and Ciruna (2007) originally assigned Upper Adams River and Momich River / Cayenne Creek to the Shuswap Lake-ES CU because of the interpretation that they were established by transplants with the Shuswap Lake-ES (Seymour River) as the source population. However, Grant *et al.* (2011) moved the Upper Adams River and Momich River / Cayenne Creek to separate CUs (Adams-ES) and (Momich-ES) because Adams Lake, Momich Lake, and Shuswap Lake were more correctly defined as hydrologically uncoupled. This decision was consistent with the rationale used to assign Lake DUs in COSEWIC (2021).

Ecological variability (hydrological coupling) among lakes

Growth differences among sites based on scale analysis of Sockeye Salmon sampled from lake rearing environments can be very different during the first summer. These environmental differences produce different growth patterns on Sockeye Salmon scales and can be used to distinguish lake origin (Gable and Cox-Rogers 1993). The degree of these growth differences can be used to evaluate the hydrological coupling among lakes. The greater the growth differences the more likely the lakes are not hydrologically coupled.

A simple measurement that describes these growth differences is the distance between the centre of the focus and the freshwater annulus of individual fish scales. In 2018, scales were collected from carcasses of spawned sockeye in Cayenne Creek (tributary to Momich Lake), upper Adams River (tributary to Adams Lake), and lower Adams River, Seymour River, and Scotch Creek (tributaries to Shuswap Lake) (Figure 3). Momich Lake Sockeye Salmon had the greatest growth, Shuswap Lake Sockeye the least, and Adams Lake Sockeye were intermediate in growth (Figure 4; Latham pers. com. 2021).

These results indicate different growing environments for fish that returned to these sites and are consistent with the conclusion that Shuswap, Adams. and Momich Lakes are hydrologically uncoupled. However, the relative importance of heritable versus environmental influences in producing these growth pattern differences are not known and they cannot be used to evaluate evolutionary significance.

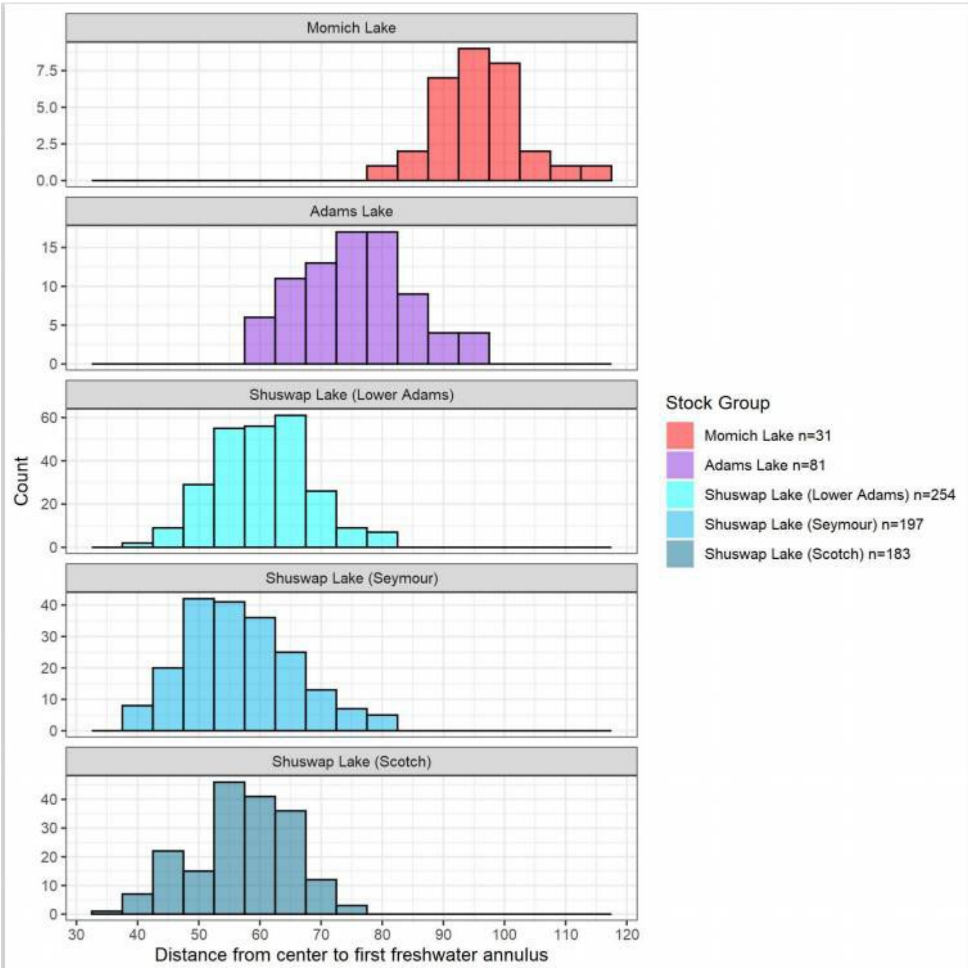


Figure 4. Frequency histograms of the digitized freshwater scale zone radius (distance between the centre of the focus and the freshwater annulus) in fish that putatively reared in Momich Lake, Adams Lake, and Shuswap Lake. Only fish returning at age 4 in 2018 were included (Latham pers. com. 2021).

Baseline genetic analysis

A broad scale microsatellite analysis (Withler *et al.* 2000) investigated bottleneck effects from the Hell's Gate Landslide and transplantation success and indicated that fish from the Upper Adams were distinct but closely related to fish from the Seymour River and were distant from the other donor populations. Thus, it was concluded that plantings from the Seymour River were the origin of this new Upper Adams River run (Withler *et al.* 2000). However, Momich River / Cayenne Creek were not examined.

The relationship among 47 Fraser River Sockeye Salmon populations using 14 microsatellite loci was described in Beacham *et al.* (2004). Samples came from 1994 to 2000 but not all sites were sampled each year.

The Upper Adams and Cayenne River sites shared a common dendrogram node with each other and were part of a major dendrogram node with Shuswap Complex-ES sites (Seymour, Scotch, and Eagle Rivers). Bootstrap simulations tested the replication of dendrogram trees in this analysis. The percentages at each node indicate how many times the branches were supported across the replicated trees out of 500 simulations. The branches in the node including the Shuswap Complex-ES sites were supported 93% of the time and the Upper Adams and Cayenne branches were supported 100% of the time (Figure 2 in Beacham *et al.* 2004).

Beacham and Withler (2017) combined samples across years to investigate population structure among river, lake, and Kokanee eco-types and found more similarity between Upper Adams and Cayenne than between other Shuswap-ES sites. The Shuswap Complex-Es sites node was replicated 92% of the time in a bootstrap analysis similar to Beacham *et al.* (2004), while the Upper Adams and Cayenne node was not examined for bootstrap replication. (Figure 1 in Beacham and Withler 2017).

In 2018, genetic samples collected from adult fish were obtained from Bridge, Momich, Quesnel, and Upper Adams rivers. These were compared to a baseline composed of all the Beacham *et al.* (2004) adult samples including Upper Adams River, Cayenne Creek, and Seymour River which were collected between 1986 and 2000. Some additional Fraser populations (e.g., Taseko) and non-Fraser Sockeye populations were also included in the 2018 analysis. The 2018 genetic analysis used 14 microsatellites and five Single Nucleotide Polymorphisms (SNPs) from the Beacham *et al.* (2004) samples and the newly collected 2018 samples. Only those samples relevant to the Momich – Upper Adams samples and origin are shown in Table 6 (Latham pers. comm. 2021).

Table 6. The number of 2018 samples genetically identified as belonging to the baseline samples (Latham pers. comm. 2021).

	2018 sample sites		
Stock origin baseline – Beacham 2004	**Momich River**	**Upper Adams River**	**Total**
Cayenne Creek	30	1	31
Seymour River	0	31	31
Upper Adams River	7	20	27
Total	37	52	89

These genetic comparisons indicate that Sockeye Salmon sampled from the Upper Adams River in 2018 were identified as Seymour River origin 60% of the time. In contrast, Sockeye Salmon sampled from the Momich River were identified as Upper Adams River origin about 20% of the time and were never identified as originating from the Seymour River (Table 6; Steve Latham pers. comm. 2021).

DU – Conclusions: Upper Adams River and Momich River / Cayenne

Withler *et al.* (2000) found little evidence to support depleted levels of genetic variation due to bottlenecks during and after the 1913-1914 rockslides at Hell's Gate in the upper Fraser River. However, they concluded that for early-migrating upper Fraser Sockeye Salmon it was not clear whether the lack of bottlenecks was because the population numbers remaining after the landslides were bigger than estimated, straying increased at low densities, or because rapid expansion of population numbers in conjunction with recovery prevented a loss of genetic diversity. These conclusions are consistent with the uncertainty proposed in the IPSFC reports described above and indicate that the remnant population hypothesis cannot be excluded. Nevertheless, low population numbers would have increased the extinction risk of Adams-ES and Momich-ES populations. As a result, there is some uncertainty regarding the conclusion of Grant *et al.* (2001) that these DUs were extirpated by the Hell's Gate landslide and splash dam effects.

Adams-ES

The original DU designation for Adams-ES was based on the hydrological distinction among Adams, Momich, and Shuswap Lakes, consistent with the nursery lake rationale for designating CUs (Grant *et al.* 2011) and described in COSEWIC (2021). Sockeye Salmon in the Upper Adams River have been subjected to several transplantation experiments using Sockeye Salmon mainly from the Seymour River and Cayenne Creek. The identification of 60% of Sockeye Salmon in the Upper Adams River as Seymour-origin in 2018 is consistent with the presence of heritable information from outside the original Adams-ES DU. This conclusion applies whether the original Adams-ES was eliminated by the splash dam, or a small remnant population of Sockeye persisted in the Upper Adams River. Nevertheless, the genetic signal of Upper Adams River Sockeye Salmon has been consistently distinct from Seymour River Sockeye (Withler *et al.* 2000; Beacham *et al.* 2004; and Beacham and Wither 2017). On balance, the weight of evidence supports the decision that the original Adams-ES DU is extinct, possibly by the population being reduced to zero, but also because of altered genetic composition.

Sockeye Salmon currently present in the Upper Adams River are increasing (Table 4). However, they have not been evaluated to determine if they are a new DU or part of another nearby DU. It is suggested that this evaluation be done prior to the expected reassessment of Fraser River Sockeye in 2027.

Momich-ES

The Momich River / Cayenne Creek Sockeye have not been the recipients of direct transplants or enhancement activities. There is no evidence that any of the Seymour Sockeye transplanted to the Upper Adams River have contributed heritable information to the Momich-ES. The lack of surveys prior to 1960 in the Momich and the presence of Sockeye Salmon, in greater numbers than in the Upper Adams River, once surveys began are consistent with a remnant population in Momich-ES. Population numbers in the Momich system varied from 600 to 2000 between 1960 and 1976, while they were always less than 200 in the Upper Adams (Table 4).

It has been proposed that strays from the 1949 to 1975 transplants are responsible for the occurrence in Momich River / Cayenne Creek Sockeye Salmon (Grant *et al.* 2011). Sockeye Salmon demonstrate the highest degree of fidelity to their natal spawning grounds of all salmonids with a mean straying rate of 2.4% or less (Quinn *et al.* 1999; Keefer and Caudill 2014; Pess *et al.* 2014). However, there is a tendency for transplanted Pacific salmons in general to stray more than salmon reared and released on-site (Quinn 1993).

Direct transplants from the Seymour River (1949-1975) and Cayenne River (1980 - 1996) have occurred to Upper Adams River Sockeye Salmon. Genetic analyses of Upper Adams River consist of those collected in 1996, 2000, and 2010 and Cayenne Creek Sockeye Salmon consist of samples collected in 2000 (Beacham and Withler 2017).

The identification of Sockeye of Upper Adams origin (20%) in the 2018 Momich samples is higher than would be expected based on stray rates. This rate indicates that some heritable information from outside the DU could be present in the Momich-ES. However, it is not as likely as it is for Seymour origin sockeye in the Upper Adams River. In addition, because the Upper Adams genetic composition could consist of a mixture of original Upper Adams River, Seymour River, and Cayenne Creek genetic characteristics there is uncertainty interpreting the identification of Upper Adams River origin on Momich-ES DU structure. Lastly, Momich-ES and Adams-ES DU sites are consistently associated with separate dendrogram branches in genetic analyses (Beacham *et al.* 2004; Beacham and Withler 2017).

With these uncertainties acknowledged, the weight of evidence supports describing the Momich-ES DU as extant.

Adams and Momich Lakes are not hydrologically coupled and the designation of the Momich-ES as a separate DU is consistent with the designation method described in COSEWIC (2021).

Population Sizes and Trends: Momich DU

Method

Trends as measured by the percent change in number of mature individuals over time were estimated using Maximum Likelihood and Bayesian estimation methods. The software used for the estimation methods is the MetricsCOSEWIC package and can be located at https://github.com/SOLV-Code/MetricsCOSEWIC (Pestal and Holt 2021).

The input data, for Momich DU consisted of the values obtained from a 4-year running average (corresponding to the 4-year generation time) where the annual data point consists of the geometric mean of one year before the data point year and two years after (t-1, t, t+1, t+2; where t is the annual data point) as described in Grant *et al.* (2011) and used in COSEWIC (2017).

Upper Adams River stocking ceased in 2002. Hence, 2006 was the last year for stocking to have had any possible influence on the most recent 3 generation analysis. Hence, the short-term time series begins with 2007 as the first smoothed data point.

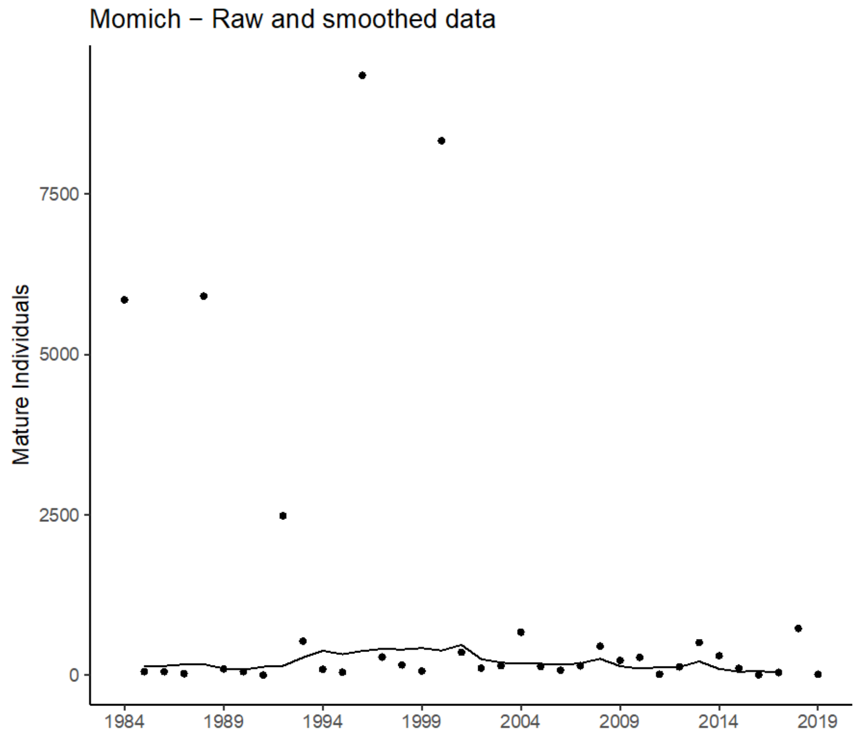
The year 1984 was defined as the starting point for the long-term data. Regular surveys started in this year and the complete data points through to 2017 precluded the need to estimate missing data points (Table 4). Hence the long-term time series starts in 1985 as the first smoothed data point. Any potential influence from the 1949-1975 Upper Adams stocking would have ceased by 1980 but if there was stocking influence on the Momich River between 1980 and 2002, it would affect the long-term trend estimate.

Population abundance and trends

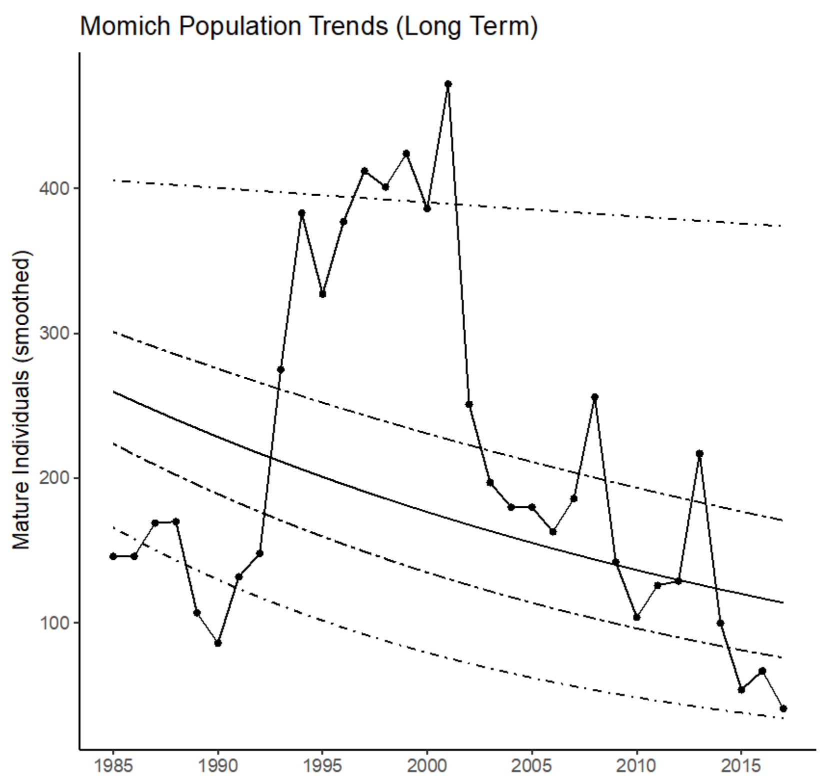
The Cayenne Creek / Momich River running 4-year average indicates a fluctuating but decreasing trend in the number of mature individuals using all estimation methods (Figure 5, Table 7). The decline estimates using only the most recent three generation trend exceeded 70% using each estimation method (Table 7). There was a 75% probability that the observed decline exceeded 67% using the Bayesian (JAGS) estimate. There was a 95% probability that the decline ranged from 42% to 89% (Figure 5, Table 7).

For the long-term analysis, each estimation method indicated a population decline of around 50% for the entire time series (Figure 5; Table 7). The most recent three generation mature individual declines using the long-term estimates indicate the population decline slightly exceeds 20% (Table 7). There was a 25% probability that the expected percent change exceeded 29% (Table 7). There was a 50% probability that the decline was between 16% and 29% (Figure 5; Table 7).

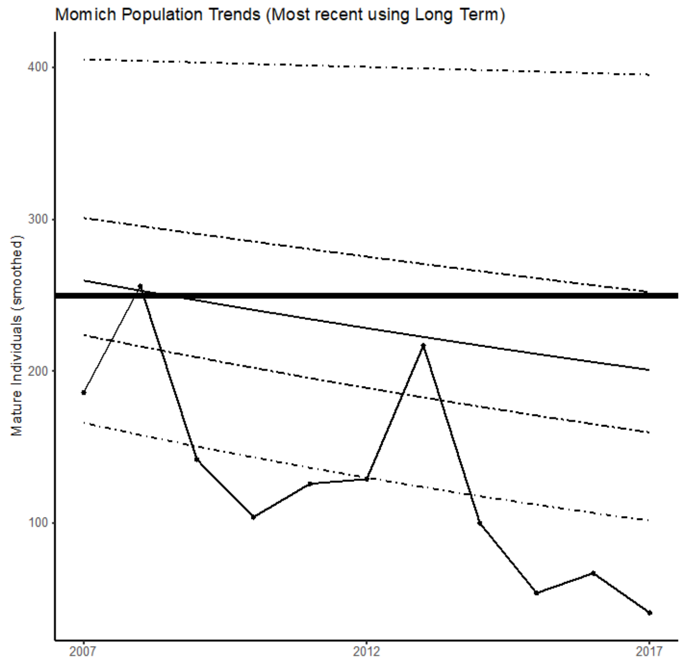
(A)


Momich − Raw and smoothed data
Mature Individuals
7500
5000
2500
0
1984
1989
1994
1999
2004
2009
2014
2019

(B)


Momich Population Trends (Long Term)
Mature Individuals (smoothed)
400
300
200
100
1985
1990
1995
2000
2005
2010
2015

(c)



(D)

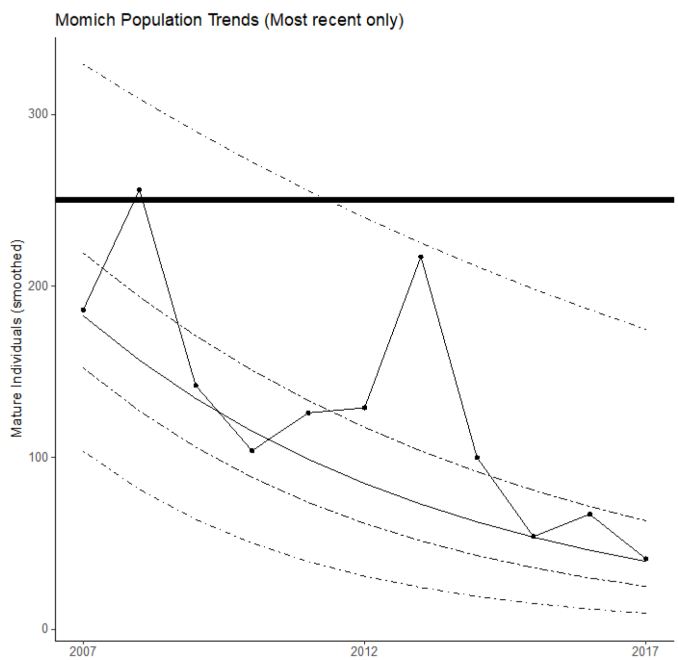


Figure 5. Momich River; (A) smoothed moving 4-year average beginning in 1985. (B) Decline trend using long-term data from 1985 to 2017. (C) Long term data used to estimate declines in most recent 3 generations. (D) Decline trend for most recent 3 generations using only most recent data. Thick solid horizontal line is 250 mature individuals. Numbers of mature individuals trend (JAGS) analysis showing (B, C, D) median trend estimate (solid line), 25% to 75% credible intervals for estimated decline (mid two-dashed line), 2.5% to 97.5% credible intervals for estimated decline (upper and lower dashed line). The smoothed data points are represented by the solid lines connecting the dots in each figure. Percent change associated with each trend line is in Table 7.

Table 7. Parameter estimates from the number of mature individuals trend analysis for Momich River beginning in 1985 and 2007 using maximum likelihood estimation (MLE), and Bayesian estimation methods JAGS software. Jags Med are the most likely estimates using the Bayesian model. The numbers after Jags represent the probabilities associated with the percent change in numbers of mature individuals. Rhat close to 1.0 is a model diagnostic supporting convergence of parameter estimates.

	2007 - 2017			1985-2017			Using 1985-2017
Variable	**Percent change in population**	**Slope**	**Intercept**	**Percent change in population**	**Slope**	**Intercept**	**most recent 3 gen: percent change in population**
MLE	-75	-0.1527	5.3605	-56	-0.0265	5.5967	-24
Jags_Med	-75	-0.1537	5.3608	-55	-0.0257	5.5853	-23
Jags_p2.5	-89	-0.2446	4.8403	-78	-0.0490	5.1611	-39
Jags_p25	-80	-0.1812	5.2131	-65	-0.0337	5.4444	-29
Jags_p75	-68	-0.1258	5.5191	-42	-0.0177	5.7246	-16
Jags_p97.5	-42	-0.0612	5.8524	-8	-0.0025	6.0075	-2
Jags_Rhat		1.0006	1.0005		1.0007	1.0007	

These results indicate that the decline has persisted longer than 3 generations and that the recent number of mature individuals is at the minimum since 1984. The number of mature individuals has been <250 since 2009 (Figure 5).

Threats, limiting factors, and number of locations

The number of locations is expected to be less than 5. This population is expected to have a high impact from coastal and estuary commercial fisheries similar to Thompson Steelhead (COSEWIC 2020). In 2021, a large portion of the Momich / Cayenne drainage burned in forest fires. These fires and clearcutting in the watershed have created a situation where high rainfall events are expected to cause erosion depositing debris and fine substrates that will impact future recruitment.

Other Sites Above the Hell's Gate Landslide

Designatable Unit 28: Fraser-ES

This DU includes sites on the Endako River and Ormonde Creek. Ormonde Creek flows into Fraser Lake, BC. The Endako River drains into a wetland habitat associated with the Stellako River. This DU is the most northern of the remaining three DUs considered in this report (Figure 1; Figure 6). The following is taken from Grant *et al.* 2011: "This CU includes two sites: Endako River and Ormonde Creek. These populations are likely extirpated and were never large since the substrate is of poor quality for salmon and there is much better gravel for Sockeye spawning in other locations. Sockeye are no longer present in the Endako River (since the early 1980s) and the early summer timed component of Ormonde Creek has not been observed since the 1970's. Note there is a later timed (Summer Run timing) component of Sockeye that also spawns in Ormonde Creek that is part of the preceding Francois-Fraser-S section."

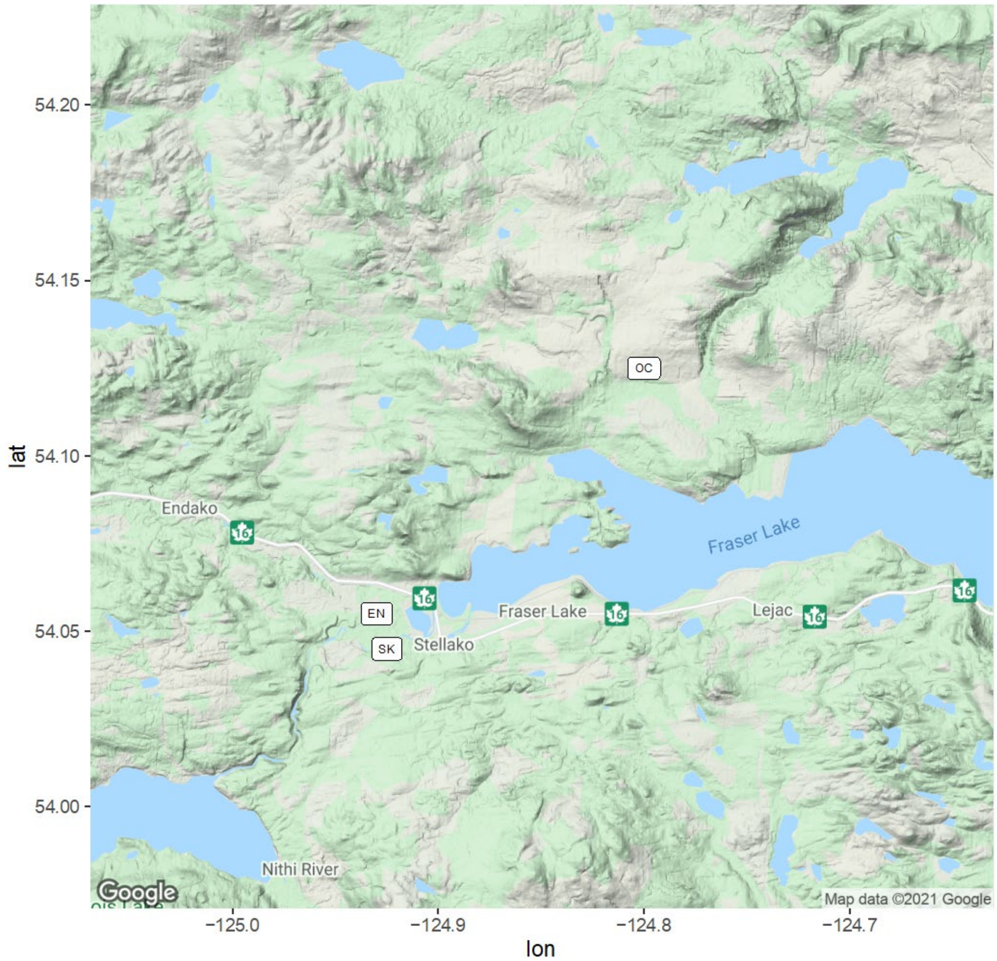


Figure 6. Locations of Ormonde Creek (OC), Endako River (EN), and Stellako River (SK) in Fraser-ES DU.

The spawning area for this DU is unknown but is likely less than 500 km^2 based on description in Toth (2004).

Some Fishery Officer counts or observations on the Endako River were made in 1987 and 1991. Estimates were that there were about 100 Sockeye in 1991 and about 1,000 in 1987. These are consistent with the dominant cycle since at least 1959. There were no surveys between 1991 and 2000, except for 1992 and 2000 neither of which fell on the 1991 dominant line (Table 8). Since 2000, there are no records of Sockeye Salmon during First Nation Chinook Salmon monitoring in late August and early September. Coverage has not been systematic, but Sockeye would likely have been seen if they were present (Decker pers. comm. 2021).

There has not been an enhancement program to re-introduce Sockeye to this area.

Table 8. Returns to Ormonde Creek and Endako River from IFPSC reports (1937-1985), Toth (2004), and DFO data from 1986 to 2019. A zero indicates a survey was done but no Sockeye Salmon were observed; a blank indicates no survey occurred.

Year	Ormonde	Endako
1938	8	65
1939		
1940	36	8
1941	90	45
1942	54	309
1943		46
1944	15	1
1945	400	80
1946	193	368
1947	40	450
1948	150	0
1949	2500	1100
1950	732	900
1951	120	742
1952	996	146
1953	956	605
1954	538	Present
1955	27	594
1956	331	18
1957	1,186	110
1958	210	522
1959	74	1,463
1960	158	0
1961	0	0
1962	47	236
1963	41	2,540
1964	180	7
1965	0	2
1966	5	5
1967	0	949
1968	81	18
1969	0	0
1970	0	0
1971	0	284
1972	54	27
1973	0	0
1974		34
1975	0	192
1976	30	40
1977		
1978		
1979		1294
1980		25
1981		
1982		
1983		583
1984		
1985		0
1986		0

Year	Ormonde	Endako
1987		1000
1988		0
1989		0
1990		0
1991		100
1992		0
1993-1999		
2000		0
2001-2019		

Designatable Unit 30: North Barriere-ES (Original)

This DU is slightly north of the DUs 25 and 29 and south of DU 28 (Figure 1). The original North Barriere-ES population spawned in Harper Creek, Fennell Creek, and the Upper Barriere River, and juveniles reared in North Barriere Lake (Figure 7; Grant *et al.* 2011). The population was eliminated when a dam that prevented upriver migration was constructed below the spawning grounds in 1914 (Grant *et al.* 2011; North Thompson Star/Journal 2021) but surveys of fish presence/absence were not documented. The dam was removed in 1952 and the possibility for upriver migration was restored. As a result of the potential for upriver migration, a new Sockeye Salmon population was established using transplants from the Raft River (DU 11 Kamloops-ES) (Roos 1991). This new DU is different from the original DU. The new Fennell Creek Sockeye Salmon cluster most closely with Sockeye Salmon from the Raft River donor population. There were, however, significant differences at 5 of 6 loci (Withler *et al.* 2000) between these populations.

The term “Original” was added to the name of the DU in this report to avoid confusion with the new North Barriere-ES DU. The new DU was assessed as Threatened by COSEWIC in November 2017 (COSEWIC 2017).

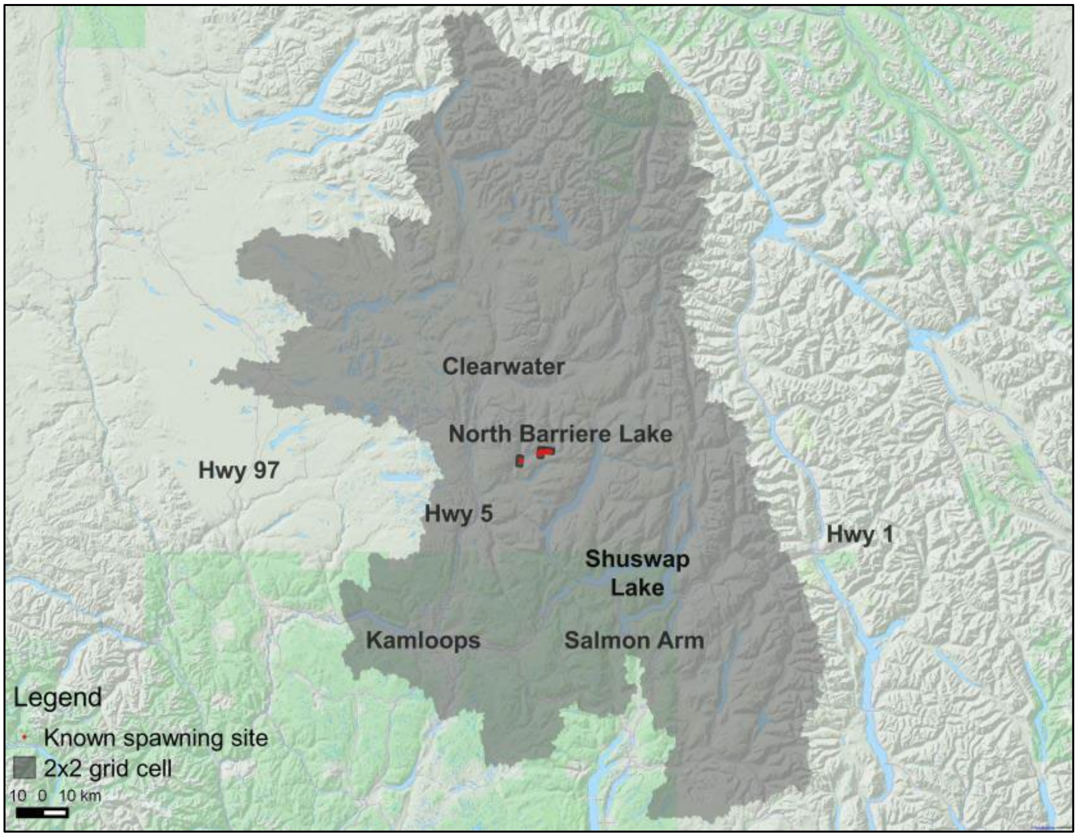


Figure 7. Map showing location of North Barriere Lake. Source: Figure 33 in COSEWIC (2017).

Designatable Unit 31: Seton-S

This DU is the most southerly of the DUs that are above the Hell's Gate Landslide considered in this report (Figure 1). The Seton-S population was a summer run of Sockeye Salmon that spawned in Portage Creek and reared in Seton Lake (Figure 8, Grant *et al.* 2011). Several factors led to the demise of this population in the early 1900s. The first hatchery in BC began operation on Portage Creek in 1903. However, poor techniques in this hatchery were implicated in the early decline of this population (Geen and Andrew 1961). Migrating salmon were diverted to holding pools at the hatchery and prevented from spawning in their native areas. Water temperatures in the holding pools became too high resulting in heavy mortality. The Hell's Gate landslide in 1913 further reduced the population. Water diversion in 1934 from the Bridge River to Seton Lake reduced primary productivity in the Lake and its capacity to rear Sockeye Salmon (Roos 1991). As a result of these effects, the original summer run was considered to have been "extirpated" (Grant *et al.* 2011) but surveys of fish presence/absence were not documented.

A new late run of Sockeye Salmon in this area was established by transplants from other areas in the 1960s including Birkenhead and the Lower Adams River (Grant *et al.* 2011). Allelic frequencies differed significantly at 2 of the 6 loci examined in Withler *et al.* (2000). Given this relatively high degree of genetic similarity between the donor and

Portage Creek, it is likely that fish from the Lower Adams River (DU 18 Shuswap Complex-L) were the most successful in this regard (Withler *et al.* 2000). However, the Portage Creek Sockeye Salmon was less genetically variable, as measured by lower levels of heterozygosity, allelic diversity, and fewer rare alleles, than the Lower Adams River donors (Withler *et al.* 2000). This new Late run DU is different from the original Summer DU. The new Late DU was assessed as Endangered by COSEWIC in November 2017 (COSEWIC 2017).

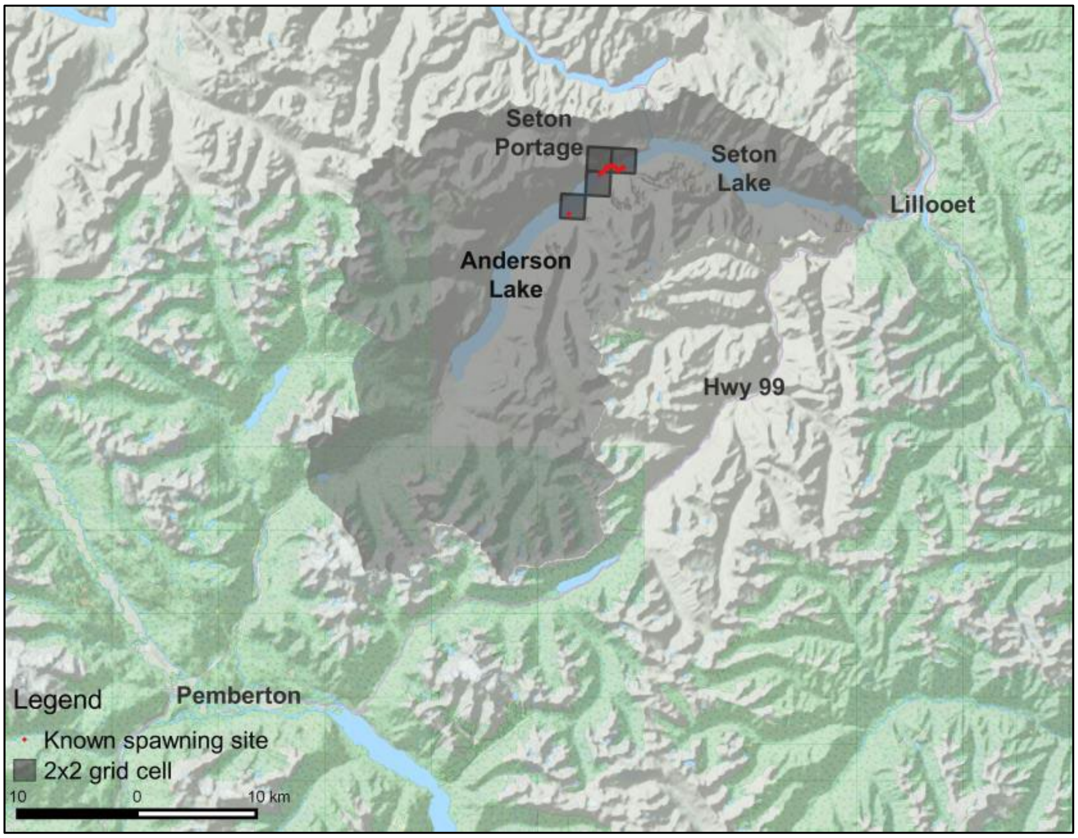


Figure 8. Map of Seton Lake and Portage Creek, former rearing and spawning range of the Seton-S DU. Source: Figure 40 in COSEWIC (2017).

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Appendix 1. Narrative summaries of sampling relevant to Upper Adams and Momich DUs in IFPSC reports 1937- 1960 (International Pacific Salmon Fisheries Commission 1937 – 1985).

Review of IFPSC reports 1937-1960

Available at: Annual Reports of the IPSFC | Pacific Salmon Commission (psc.org)

1937/8

No table summarizing escapements, and no mention of Adams Lake or its tributaries.

1939

No table summarizing escapements, and no mention of Adams Lake.

1940

Table of summary of escapements includes only Shuswap (not Adams).

1941

"A survey of the spawning grounds was made by the observers in a manner similar to that of the past three seasons. All known sockeye streams were visited at least once during· the season, and those containing sockeye were patrolled more frequently." However, this includes all stocks above Hell's Gate (text mentions Chilko and Stuart Lake), so it's not clear they surveyed Momich, or even Adams Lake and Upper Adams River.

Table of summary of escapements includes only Adams River. There was a severe blockage at Hell's Gate in 1941 that resulted in significant mortalities.

1942

Table summarizing escapements includes Adams lake and tributaries. So could have included Momich. The records were "Minimum = 181,021. Maximum = 225,344 Probable = 200,000".

1943

In "Summary of Facts Shown on Fraser River Sockeye Spawning Ground": Momich River contained, "productive sockeye streams", "non-productive sockeye streams", "unexplored streams", and "points of difficult passage".

Table of summary of escapements includes only Adams River.

1944

Table of summary of escapements includes only Adams River.

1945

Table of summary of escapement includes Momich.

Momich River dates of run: Arrival = Oct. End = Nov. Estimated number of sockeye present 1,500 Standard Error = 375.

1946

Table of summary of escapement includes Adams Lake and Tributaries. Dates of run: Arrival= Sept. 25 End= Nov. 25. Estimated number of Sockeye present = 6000.

1947

Table of summary of escapement includes Adams Lake and Tributaries. Estimated number of Sockeye present = nil.

1948

Table of summary of escapement includes Adams Lake and Tributaries. Estimated number of Sockeye present = nil.

1949

Table of summary of escapement includes Adams Lake and Tributaries. Estimated number of Sockeye present = nil.

1950

Table of summary of escapement includes Adams Lake and Tributaries. Dates of peak spawning Oct 16-20. Estimated number of Sockeye present = 2000.

1951

"The once important Adams Lake area, where the sockeye runs were entirely destroyed by a combination of the splash dam at the outlet of Adams Lake and the adverse conditions at · Hell's Gate, has been selected for extensive restocking from Seymour River, tributary to Shuswap Lake." (p.7)

Table of summary of escapement includes Adams Lake and Tributaries. Estimated number of Sockeye present = nil.

1952

Table of summary of escapements includes only Lower Adams River.

1953

Table of summary of escapements includes only Lower Adams River. However, text states, “No sockeye, either marked or unmarked, returned to the tributaries of Adams Lake, and no marked sockeye were found in the tributaries of Shuswap Lake.” (p.28).

1954

Table of summary of escapements includes only Lower Adams River.

“Records of the size of the population produced by Upper Adams River and the related Adams Lake rearing area before 1913 are too obscure to enable the actual size of the original population to be assessed but it is believed that adequate spawning and rearing grounds are available to produce several million sockeye a year for one cycle out of the four.” (p. 11).

1955

Table of summary of escapements includes only Lower Adams River.

1956

Table of summary of escapements includes only Lower Adams River.

1957

Table of summary of escapements includes only Lower Adams River (however, outlook for next year includes Upper Adams River based on returns in 1954).

1958

Table of summary of escapements includes only Lower Adams River and Upper Adams River.

1959

Table of summary of escapements includes only Lower Adams River and Upper Adams River.

1960

"An additional phenomenon was the occurrence of several hundred fish, possibly as many as a thousand in the Momich River, tributary of Adams Lake and having its confluence about six miles downlake from the confluence of Upper Adams River." (p.15)

"No early run of sockeye had ever been observed in the Momich River by the Commission staff in earlier years nor had any been reported by local transients. The fish in 1960 were observed by a Provincial game warden but unfortunately the report of his observation reached the Commission too late for a fruitful investigation. However the fish in the Momich River spawned at the same time as the few fish returning to Upper Adams River from a transfer of eyed eggs from Seymour River and also at the same time as the native run to Seymour River. Whether the sockeye observed spawning in the North Thompson and Momich Rivers were the result of straying of transplanted stocks to the Barriere and Upper Adams River respectively or the end result in each case of a few previously unobserved spawners will be difficult if not impossible to determine." (p.16)

Table of summary of escapement includes Momich (no run timing information) Estimated number of sockeye = 1000, which they suggested was a "newly established run".