COSEWIC
Assessment and Status Report

on the

Chinook Salmon
Oncorhynchus tshawytscha

Designatable Units in Southern British Columbia
(Part One – Designatable Units with No or Low Levels of Artificial Releases in the Last 12 Years)

in Canada

Designatable Unit 2: Lower Fraser, Ocean, Fall population - THREATENED
Designatable Unit 3: Lower Fraser, Stream, Spring population - SPECIAL CONCERN
Designatable Unit 4: Lower Fraser, Stream, Summer (Upper Pitt) population - ENDANGERED
Designatable Unit 5: Lower Fraser, Stream, Summer population - THREATENED
Designatable Unit 7: Middle Fraser, Stream, Spring population - ENDANGERED
Designatable Unit 8: Middle Fraser, Stream, Fall population - ENDANGERED
Designatable Unit 9: Middle Fraser, Stream, Spring (MFR+GStr) population - THREATENED
Designatable Unit 10: Middle Fraser, Stream, Summer population - THREATENED
Designatable Unit 11: Upper Fraser, Stream, Spring population - ENDANGERED
Designatable Unit 12: South Thompson, Ocean, Summer population - NOT AT RISK
Designatable Unit 14: South Thompson, Stream, Summer 1.2 population - ENDANGERED
Designatable Unit 16: North Thompson, Stream, Spring population - ENDANGERED
Designatable Unit 17: North Thompson, Stream, Summer population - ENDANGERED
Designatable Unit 19: East Vancouver Island, Stream, Spring population - ENDANGERED
Designatable Unit 27: Southern Mainland, Ocean, Summer population - DATA DEFICIENT
Designatable Unit 28: Southern Mainland, Stream, Summer population - DATA DEFICIENT
2018

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

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COSEWIC
Assessment Summary

Assessment Summary – November 2018

Common name
Chinook Salmon - Designatable Unit 2: Lower Fraser, Ocean, Fall population

Scientific name
Oncorhynchus tshawytscha

Status
Threatened

Reason for designation
While the calculation of decline rates is complicated by hatchery releases from 1981 to 2004, this fall run of chinook spawning in the lower Fraser River has steadily declined in abundance. The abundance data over all available years was thought to best represent natural spawner abundance. Declines in marine and freshwater habitat quality, harvest and ecosystem modification in the lower Fraser estuary are threats facing this population.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Threatened in November 2018.

Assessment Summary – November 2018

Common name
Chinook Salmon - Designatable Unit 3: Lower Fraser, Stream, Spring population

Scientific name
Oncorhynchus tshawytscha

Status
Special Concern

Reason for designation
This spring run of chinook, which spawns in the lower Fraser River watershed, has declined over the last three generations. Declines in marine and freshwater habitat quality, and harvest, are continuing threats. Should the present low number of mature individuals decline further, this population may become Threatened.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Special Concern in November 2018.

Assessment Summary – November 2018

Common name
Chinook Salmon - Designatable Unit 4: Lower Fraser, Stream, Summer (Upper Pitt) population

Scientific name
Oncorhynchus tshawytscha

Status
Endangered

Reason for designation
This summer run of chinook spawning in the Pitt River in the lower Fraser River watershed has declined, and is now at its lowest recorded abundance. Declines in freshwater and marine habitat quality, and harvest, are continuing threats to this population.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Endangered in November 2018.

Assessment Summary – November 2018

Common name
Chinook Salmon - Designatable Unit 5: , Lower Fraser, Stream, Summer population

Scientific name
Oncorhynchus tshawytscha

Status
Threatened

Reason for designation
This summer run of chinook spawning in the Lillooet and Harrison Rivers in the Lower Fraser watershed has declined to low levels. Declines in freshwater and marine habitat quality, and harvest, are threats facing this population.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Threatened in November 2018.

Assessment Summary – November 2018

Common name
Chinook Salmon - Designatable Unit 7: Middle Fraser, Stream, Spring population

Scientific name
Oncorhynchus tshawytscha

Status
Endangered

Reason for designation
This population of spring run chinook spawning in the Nahatlatch and Anderson watersheds has declined to very low levels. Declines in freshwater and marine habitat quality, and harvest, are threats facing this population.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Endangered in November 2018.

Assessment Summary – November 2018

Common name
Chinook Salmon - Designatable Unit 8: Middle Fraser, Stream, Fall population

Scientific name
Oncorhynchus tshawytscha

Status
Endangered

Reason for designation
This population of fall run chinook spawning in the Seton and Anderson watersheds along the middle Fraser River has declined to very low levels, and decline is anticipated to continue. Declines in freshwater and marine habitat quality, and harvest, are threats facing this population.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Endangered in November 2018.

Assessment Summary – November 2018

Common name
Chinook Salmon - Designatable Unit 9: Middle Fraser, Stream, Spring (MFR+GStr) population

Scientific name
Oncorhynchus tshawytscha

Status
Threatened

Reason for designation
This spring run of chinook spawning in multiple middle Fraser River tributaries has declined in abundance. Declines in marine and freshwater habitat quality, and harvest, and pollution from mining activities are threats to this population.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Threatened in November 2018.

Assessment Summary – November 2018

Common name
Chinook Salmon - Designatable Unit 10: Middle Fraser, Stream, Summer population

Scientific name
Oncorhynchus tshawytscha

Status
Threatened

Reason for designation
This summer run of chinook spawning in multiple middle Fraser River tributaries has declined in abundance. Declines in marine and freshwater habitat quality are threats facing this population.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Threatened in November 2018.

Assessment Summary – November 2018

Common name
Chinook Salmon - Designatable Unit 11:Upper Fraser, Stream, Spring population

Scientific name
Oncorhynchus tshawytscha

Status
Endangered

Reason for designation
This spring run of chinook spawning in the Salmon and Raush Rivers in the upper Fraser watershed has declined in abundance. Declines in marine and freshwater habitat quality, and harvest, are threats facing this population. Anticipated changes to North Pacific weather systems that affect ground water availability, will impact spawning sites and overwinter survival.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Endangered in November 2018.

Assessment Summary – November 2018

Common name
Chinook Salmon - Designatable Unit 12: South Thompson, Ocean, Summer population

Scientific name
Oncorhynchus tshawytscha

Status
Not at risk

Reason for designation
This summer run of chinook to the South Thompson River has been steadily increasing in abundance, and the most recent population index is the second highest on record.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Not at risk in November 2018.

Assessment Summary – November 2018

Common name
Chinook Salmon - Designatable Unit 14: South Thompson, Stream, Summer 1.2 population

Scientific name
Oncorhynchus tshawytscha

Status
Endangered

Reason for designation
This summer run of chinook spawning in the South Thompson River has steeply declined in abundance to a very low level. Declines in marine and freshwater habitat quality, and harvest, are threats facing this population.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Endangered in November 2018.

Assessment Summary – November 2018

Common name
Chinook Salmon - Designatable Unit 16: North Thompson, Stream, Spring population

Scientific name
Oncorhynchus tshawytscha

Status
Endangered

Reason for designation
This spring run of chinook spawning in the North Thompson River has steeply declined in abundance to a low level. Declines in marine and freshwater habitat quality, and harvest, are threats facing this population. Anticipated changes in North Pacific weather systems that affect groundwater availability will impact spawning sites and overwinter survival.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Endangered in November 2018.

Assessment Summary – November 2018

Common name
Chinook Salmon - Designatable Unit 17: North Thompson, Stream, Summer population

Scientific name
Oncorhynchus tshawytscha

Status
Endangered

Reason for designation
This summer run of chinook spawning in the North Thompson River has steeply declined in abundance. Declines in marine and freshwater habitat quality, and harvest, are threats facing this population.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Endangered in November 2018.

Assessment Summary – November 2018

Common name
Chinook Salmon - Designatable Unit 19: East Vancouver Island, Stream, Spring population

Scientific name
Oncorhynchus tshawytscha

Status
Endangered

Reason for designation
This spring run of chinook to the Nanaimo River has been at a very low abundance for a long time. Declines in marine and freshwater habitat quality are threats facing this population.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Endangered in November 2018.

Assessment Summary – November 2018

Common name
Chinook Salmon - Designatable Unit 27: Southern Mainland, Ocean, Summer population

Scientific name
Oncorhynchus tshawytscha

Status
Data Deficient

Reason for designation
This summer run of chinook to spawn in the remote glacial Homathko River watershed in the southern mainland has not been surveyed sufficiently to assess its population status.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Data Deficient in November 2018.

Assessment Summary – November 2018

Common name
Chinook Salmon - Designatable Unit 28: Southern Mainland, Stream, Summer population

Scientific name
Oncorhynchus tshawytscha

Status
Data deficient

Reason for designation
This summer run of chinook to spawn in the remote glacial Klinaklini River watershed in the southern mainland of British Columbia has not been recently surveyed to assess its population status.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Data deficient in November 2018.

INTRODUCTION

COSEWIC assessed the status of 16 of 28 Designatable Units of Southern British Columbia Chinook Salmon in November 2018. Those DUs were considered to have received only relatively small levels of artificial supplementation over the past three generations, or were previously considered by the Department of Fisheries and Oceans Canada to be Data Deficient. The results of the assessment are provided in this report. The list of the assessed Designatable Units is:

DU Number and Name

DU 2: Lower Fraser, Ocean, Fall population

DU 3: Lower Fraser, Stream, Spring population

DU 4: Lower Fraser, Stream, Summer (Upper Pitt) population

DU 5: Lower Fraser, Stream, Summer population

DU 7: Middle Fraser, Stream, Spring population

DU 8: Middle Fraser, Stream, Fall population

DU 9: Middle Fraser, Stream, Spring (MFR+GStr) population

DU 10: Middle Fraser, Stream, Summer population

DU 11: Upper Fraser, Stream, Spring population

DU 12: South Thompson, Ocean, Summer population

DU 14: South Thompson, Stream, Summer 1.2 population

DU 16: North Thompson, Stream, Spring population

DU 17: North Thompson, Stream, Summer population

DU 19: East Vancouver Island, Stream, Spring population

DU 27: Southern Mainland, Ocean, Summer population

DU 28: Southern Mainland, Stream, Summer population

The remainder (12) of the Southern British Columbia Chinook Salmon Designatable Units include those that have received more substantial levels of artificial supplementation over the past three generations. COSEWIC will meet in the near future to determine the status of those DUs. After that meeting, the final version (Part 1 and Part 2) of this report will be prepared.

COSEWIC
Executive Summary

Chinook Salmon
Oncorhynchus tshawytscha

Designatable Units in Southern British Columbia
(Part One – Designatable Units with No or Low Levels of Artificial Releases in the Last 12 Years)

Wildlife Species Description and Significance

Chinook Salmon is the largest-bodied of the Pacific salmon, and can be distinguished by small black spots on the lower lobes of their caudal fin, a pointed lower jaw, and black gums. In Canada, Chinook Salmon are an important food source for other fish and certain marine and terrestrial mammals, as well as a key target species for recreational and commercial fisheries, and highly significant to First Nations and Métis in British Columbia (BC) as a cultural symbol and connection to a way of life for subsistence.

Distribution

In Canada, Chinook Salmon occur in river systems that drain into the Pacific Ocean (incl. the Okanagan River system), the Bering Sea (Yukon River system), and the Arctic Ocean. For this status report, southern BC Chinook Salmon populations are subdivided into 28 Designatable Units (DUs) using methods based on COSEWIC guidelines and work by Fisheries and Oceans Canada to identify Conservation Units under the Wild Salmon Policy. The DUs that are defined and accepted for this assessment represent distinct groups of southern BC Chinook Salmon based on geographic distribution, life-history variation, and genetic data.

Habitat

Chinook Salmon spawning occurs from near tidal influence to 3,000 kilometres upstream near river headwaters. Successful incubation requires stable flows that are adequate to supply enough oxygen, but not so high as to cause gravel movement or streambed scour. Provided that adequate subgravel flow conditions are met, Chinook Salmon will spawn in a broad range of water depths, water velocities, and substrates. The suitable temperature range for egg survival is 0-15°C.

Rearing occurs in freshwater, estuaries, and the ocean. In freshwater, the abundance of juveniles tends to be highest in shallow waters with low velocity and small substrate particle size. Water temperatures of 10-14°C provide suitable rearing conditions. Coastal estuaries offer an environmental transition zone for acclimating to the change from freshwater to saltwater. Shoreline vegetation provides an important refuge from predators as well as a productive environment for insects and plankton, both major dietary components for juvenile Chinook Salmon.

Chinook Salmon have been adversely affected in their freshwater habitat by numerous factors, including water withdrawals, construction of dams (for power generation or water diversion) that limit fish passage or entrain/harm migrating fish, and degradation of habitat through industrial, agricultural and urban usage. Salmon survival is also linked to conditions in the marine environment. Both natural and human-induced impacts on marine ecological processes, including climate change, contribute to changes in ocean conditions that affect Chinook Salmon growth and survival.

Biology

The generalized life history of Pacific salmon involves incubation, hatching, and emergence in freshwater, freshwater rearing, migration to the ocean and subsequent initiation of maturation, and return to freshwater for completion of maturation and spawning. Within this general life-history strategy, Chinook Salmon exhibit marked variation in age at seaward migration; length of freshwater, estuarine, and oceanic residence; ocean distribution and ocean migratory patterns; and age and season of spawning migration.

Two general behavioural and life-history forms of Chinook Salmon are generally assigned or discussed: stream-type and ocean-type. Stream-type Chinook Salmon were understood to spend up to one or more years as fry or parr in freshwater before migrating to sea, perform extensive offshore oceanic migrations, and return to their natal stream in the spring or summer several months prior to spawning. Ocean-type Chinook Salmon were understood to migrate to sea during their first year of life, normally within two to five months after emergence from the spawning gravel, spend most of their ocean life in coastal waters, and return to their natal stream in the fall, a few days or weeks before spawning.

In recent decades, it has become more accepted to consider a continuum of diverse life-history strategies ranging from ocean-type to stream-type. Variations within the ocean-type and stream-type behavioral forms have been identified based on the geographic origins of the fish and the resulting conditions to which they have adapted. Ocean-type Chinook Salmon can rear in freshwater for up to six months post-emergence, while stream-type Chinook Salmon may only remain in freshwater for a few weeks. This “plasticity” is critical for the persistence of Chinook Salmon as it spreads risk across many different strategies in the face of variable climatic conditions.

The duration Chinook Salmon remain at sea before homeward migration for spawning can range from 1 to 6 years, but more commonly ranges from 2 to 4 years. Peak migratory activity occurs in June for northern river systems and can range from April to September further south depending on migration strategy. This migration timing is not always correlated with spawning timing as the latter requires Chinook Salmon to access the spawning grounds, which can in turn depend on freshet timing and suitable stream temperatures.

Chinook Salmon diet varies by life stage. In freshwater, rearing Chinook Salmon feed on crustacea, aquatic insects, aphids, ants, mites, and spiders. In estuaries, food items include chironomid larvae and pupae, and crab larvae, copepods, and other small crustaceans. As smolts grow larger, small fish also become an important component of their diet. In the nearshore environment Chinook Salmon eat mainly forage fish, with invertebrates like pelagic amphipods, squids, shrimp, euphausids, and crab larvae comprising the remainder of their diet. Forage fish dominate the diet of adult Chinook Salmon, especially Herring, Sand Lance, and Northern Anchovy.

As with diet, predation on Chinook Salmon also varies by life stage. Spiny Dogfish, Northern Pikeminnow, Bull Trout, and River Lamprey are predators of juvenile Chinook Salmon during early freshwater and estuarine life stages. Avian predation is also key during these stages (e.g., gulls, merganser). Southern resident killer whales in the lower Strait of Georgia as well as northern resident killer whales have a preference for Chinook Salmon adults (≥2 years at sea). Hake, Mackerel, Sea Lions, Harbour Seals, White-sided Dolphins, and cormorants are also known predators of salmon in the marine environment. River otters, bears, and eagles commonly prey on adult Chinook Salmon when they return to freshwater.

Population Sizes and Trends

Information about population sizes and trends is presented for each DU separately, including extent of occurrence and area of occupancy, habitat trends, sampling effort and methods (for abundance, enhancement, hatchery releases), fluctuations and trends, and threats and limiting factors.

Threats and Limiting Factors

Potential threats to Chinook Salmon include harvest, changes in freshwater and marine habitat, climate change, hatcheries, and pathogens/aquaculture.

Harvest impacts vary according to geographic region, depending on where fisheries intercept adult and rearing immature Chinook Salmon during their marine residence, as well as by fishery type (e.g., troll, net, recreational fisheries). The annual total landed catch of Chinook Salmon in BC has declined considerably since the mid-1970s. Despite reduced harvests, over the past three generations many areas have experienced declines in spawning escapements due to the cumulative effects of harvest and other factors.

Most Chinook Salmon spend the majority of their lifetime in the marine environment where they are exposed to a wide array of limiting factors. A long-term warming trend in ocean temperatures combined with the effects of climatic cycles such as the Pacific

Decadal Oscillation, has negative implications for prey availability. Climatic changes also threaten Chinook Salmon populations in freshwater through rising stream temperatures, as well as reduced glacier size and altered precipitation and snowpack patterns, all of which drive stream flow regimes. Many predator populations have also dramatically increased since the 1970s (esp. pinnipeds). While not as stressed by marine and freshwater pollutants as Chinook Salmon from other regions (e.g., Lake Michigan), industrial discharge, storm water runoff, sewage and agricultural runoff are all critical challenges contributing to the species' status as one of the most toxin laden fishes in BC.

A number of Chinook Salmon populations are supplemented ("enhanced") by hatchery fish, and there is substantial evidence that enhancement may pose risks to natural populations. However, the effects of enhancement vary among DUs and are poorly understood because of data limitations.

Protection, Status and Ranks

Prior to the current assessments, the only Canadian Chinook Salmon that had been evaluated for protection status is Okanagan DU, which was assessed as Endangered by COSEWIC. The Okanagan DU is unique because it is the only Chinook Salmon population in BC that originates in the Columbia River drainage. As such, this DU was evaluated separately and is not included among the 28 DUs reviewed in this report.

TECHNICAL SUMMARIES

Oncorhynchus tshawytscha

Chinook Salmon

Saumon chinook

Range of occurrence in Canada (all DUs in this report): British Columbia, Pacific Ocean

Designatable Unit 2: Lower Fraser, Ocean, Fall population
Population du bas Fraser, type océanique, automne

Demographic Information

Generation Time	3.8 years		
Is there a continuing decline in the number of mature individuals?	Yes		
Change in number of mature individuals based on last 3 generations observations	-57%	p > 30% decline 85%	p > 50% decline 63%
Change in number of mature individuals based on all observations	-17%	p > 30% decline 9%	p > 50% decline 0%
Are there extreme fluctuations in the number of mature individuals?	No		
Index of Area of Occupancy*	175 km^2		
Number of mature individuals	58,621		

Threats

A threats calculator was completed. The main threats were harvest, ecosystem modifications and climate change. The overall threat was High (B). Exploitation rates have been at 20-30% for the last ten years and there is a possibility that this rate is higher than sustainable. Several low productivity years have occurred and it is unclear whether the exploitation rate is low enough to compensate. Ecosystem modifications are also relevant because a large portion of the Lower Fraser River and estuary are significantly altered, leading to a loss of critical tide marsh habitat.

Status and Reasons for Designation:

Status: Threatened	**Alpha-numeric codes:** Meets Endangered, A2acd, but designated Threatened, A2acd, because the longer time series shows lesser decline.

Reasons for Designation:
While the calculation of decline rates is complicated by hatchery releases from 1981 to 2004, this fall run of chinook spawning in the lower Fraser River has steadily declined in abundance. The abundance data over all available years was thought to best represent natural spawner abundance. Declines in marine and freshwater habitat quality, harvest and ecosystem modification in the lower Fraser estuary, are threats facing this population.

Applicability of Criteria

* Following methods used for the COSEWIC Fraser Sockeye Salmon Status Report, the area of occupancy of each DU is calculated as two times the spawning length, and is reported in square kilometres. This method is equivalent to overlaying a 2×2 km^2 grid over the stream, and adding up the total area.

Criterion A (Decline in Total Number of Mature Individuals): Meets Endangered A2acd. While the rate of decline over the last three generations caused by reduction in habitat quality and harvest exceed the threshold for Endangered A2acd, use of the rate of decline of mature individual over the entire time series is warranted because of the potential influence of stock enhancement.
Criterion B (Small Distribution Range and Decline or Fluctuation): Does not meet criterion. IAO meets criterion for Endangered and the quality of the freshwater and marine habitats is declining, but the population is not severely fragmented, “locations” does not apply and there are no extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Criterion not met because the number of mature individuals exceeds the threshold.
Criterion D (Very Small or Restricted Population): Does not meet criterion for D1, as number of mature individuals exceeds the threshold. Threatened D2 does not apply as the number of locations is unknown and the IAO threshold of 20 km^2 is exceeded.
Criterion E (Quantitative Analysis): Not done.

Designatable Unit 3: Lower Fraser, Stream, Spring population
Population du bas Fraser, type fluvial, printemps

Demographic Information

Generation Time	4.5 years		
Is there a continuing decline in the number of mature individuals?	Yes		
Change in number of mature individuals based on last 3 generations observations	-16%	p > 30% decline 38%	p > 50% decline 20%
Change in number of mature individuals based on all observations	21%	p > 30% decline 0%	p > 50% decline 0%
Are there extreme fluctuations in the number of mature individuals?	No		
Index of Area of Occupancy*	105 km2		
Number of mature individuals	526 (index, not count)		

Threats

A threats calculator was not completed. This stock migrates to the north, and most of the harvest occurs off Alaska.

Status and Reasons for Designation:

Status: Special Concern	**Alpha-numeric codes:** Not applicable

Reasons for Designation:
This spring run of chinook, which spawns in the lower Fraser River watershed, has declined over the last three generations. Declines in marine and freshwater habitat quality, and harvest, are continuing threats. Should the present low number of mature individuals decline further, this population may become Threatened.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Criterion not met. While the two estimates of the rates of decline for indices of abundance are divergent, both estimates are below the thresholds.

Criterion B (Small Distribution Range and Decline or Fluctuation): Criterion not met. While IAO meets criterion for Endangered and the quality of the freshwater and marine habitats is declining, the population is not severely fragmented, the number of locations is unknown and there are no extreme fluctuations.

Criterion C (Small and Declining Number of Mature Individuals): Does not meet, as there is no decline that meets thresholds.

Criterion D (Very Small or Restricted Population): Does not apply. Total number of individuals is unknown, but could be close to the threshold for Threatened. Threatened D2 does not apply as the number of locations is unknown and the IAO threshold of 20 km² is exceeded.

Criterion E (Quantitative Analysis): Not done.

* Following methods used for the COSEWIC Fraser Sockeye Salmon Status Report, the area of occupancy of each DU is calculated as two times the spawning length, and is reported in square kilometres. This method is equivalent to overlaying a 2×2 km^2 grid over the stream, and adding up the total area.

Designatable Unit 4: Lower Fraser, Stream, Summer (Upper Pitt) population
Population du bas Fraser, type fluvial, été (haute Pitt)

Demographic Information

Generation Time	4.5 years		
Is there a continuing decline in the number of mature individuals?	Yes.		
Change in number of mature individuals based on last 3 generations observations	-73%	p > 30% decline 98%	p > 50% decline 92%
Change in number of mature individuals based on all observations	-73%	p > 30% decline 98%	p > 50% decline 92%
Are there extreme fluctuations in the number of mature individuals?	No		
Index of Area of Occupancy*	191 km^2		
Number of mature individuals	71 (index, not numbers)		

Threats

A threats calculator was not completed.

Status and Reasons for Designation:

Status: Endangered	**Alpha-numeric codes:** A2bcd
Reasons for Designation: This summer run of chinook spawning in the Pitt River in the lower Fraser River watershed has declined, and is now at its lowest recorded abundance. Declines in freshwater and marine habitat quality, and harvest, are continuing threats to this population.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets Endangered A2bcd because there has been a 73% decline in the index of mature fish in the past three generations as a result of declining habitat quality and harvest.
Criterion B (Small Distribution Range and Decline or Fluctuation): Criterion not met. While IAO meets criterion for Endangered and the quality of the freshwater and marine habitats is declining, the population is not severely fragmented, the number of locations is unknown and there are no extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Criterion not met; subpopulation structure is unknown and there are no extreme fluctuations.
Criterion D (Very Small or Restricted Population): Criterion not met.
Criterion E (Quantitative Analysis): Not done.

* Following methods used for the COSEWIC Fraser Sockeye Salmon Status Report, the area of occupancy of each DU is calculated as two times the spawning length, and is reported in square kilometres. This method is equivalent to overlaying a 2×2 km^2 grid over the stream, and adding up the total area.

Designatable Unit 5: , Lower Fraser, Stream, Summer population
Population du bas Fraser, type fluvial

Demographic Information

Generation Time	4.5 years		
Is there a continuing decline in the number of mature individuals?	Yes		
Change in number of mature individuals based on last 3 generations observations	-36%	p > 30% decline 52%	p > 50% decline 43%
Change in number of mature individuals based on all observations	-36%	p > 30% decline 52%	p > 50% decline 43%
Are there extreme fluctuations in the number of mature individuals?	No		
Index of Area of Occupancy*	645 km^2		
Number of mature individuals	52 (index, not count)		

Threats

A threats calculator was not completed.

Status and Reasons for Designation:

Status: Threatened	**Alpha-numeric codes:** A2bcd
Reasons for Designation: This summer run of chinook spawning in the Lillooet and Harrison Rivers in the Lower Fraser watershed has declined to low levels. Declines in freshwater and marine habitat quality, and harvest, are threats facing this population.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets Threatened A2bcd because there has been a 36% decline in the index of mature fish in the past three generations as a result of declining habitat quality and harvest.
Criterion B (Small Distribution Range and Decline or Fluctuation): Criterion not met. While IAO meets criterion for Endangered and the quality of the freshwater and marine habitats is declining, the population is not severely fragmented, the number of locations is unknown and there are no extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Criterion not met.
Criterion D (Very Small or Restricted Population): Criterion not met.
Criterion E (Quantitative Analysis): Not done.

* Following methods used for the COSEWIC Fraser Sockeye Salmon Status Report, the area of occupancy of each DU is calculated as two times the spawning length, and is reported in square kilometres. This method is equivalent to overlaying a 2×2 km^2 grid over the stream, and adding up the total area.

Designatable Unit 7: Middle Fraser, Stream, Spring population
Population du moyen Fraser, type fluvial, printemps

Demographic Information

Generation Time	4.5 years		
Is there a continuing decline in the number of mature individuals?	n/a		
Change in number of mature individuals based on last 3 generations observations	n/a	n/a	n/a
Change in number of mature individuals based on all observations	n/a	n/a	n/a
Are there extreme fluctuations in the number of mature individuals?	No		
Index of Area of Occupancy*	103 km^2		
Number of mature individuals	65 (index, not count)		

Threats

A threats calculator was not completed.

Status and Reasons for Designation:

Status: Endangered	**Alpha-numeric codes**: D1
Reasons for Designation: This population of spring run chinook spawning in the Nahatlatch and Anderson watersheds has declined to very low levels. Declines in freshwater and marine habitat quality, and harvest, are threats facing this population.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Too few data to apply criterion.
Criterion B (Small Distribution Range and Decline or Fluctuation): Criterion not met. While IAO meets criterion for Endangered and the quality of the freshwater and marine habitats is declining, the population is not severely fragmented, the number of locations is unknown and there are no extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Criterion not met as subpopulation structure is not known and there are no extreme fluctuations.
Criterion D (Very Small or Restricted Population): Meets Endangered D1 as there are fewer than 250 mature individuals.
Criterion E (Quantitative Analysis): Not done.

* Following methods used for the COSEWIC Fraser Sockeye Salmon Status Report, the area of occupancy of each DU is calculated as two times the spawning length, and is reported in square kilometres. This method is equivalent to overlaying a 2×2 km^2 grid over the stream, and adding up the total area.

Designatable Unit 8: Middle Fraser, Stream, Fall population
Population du moyen Fraser, type fluvial, automne

Demographic Information

Generation Time	4.5 years		
Is there a continuing decline in the number of mature individuals?	Yes		
Change in number of mature individuals based on last 3 generations observations	-67%	p > 30% decline 90%	p > 50% decline 77%
Change in number of mature individuals based on all observations	-67%	p > 30% decline 90%	p > 50% decline 77%
Are there extreme fluctuations in the number of mature individuals?	No		
Index of Area of Occupancy*	63 km^2		
Number of mature individuals	59 (index, not count)		

Threats

A threats calculator was not completed.

Status and Reasons for Designation:

Status: Endangered	**Alpha-numeric codes:** A2bcd; C2a(i,ii), D1.
Reasons for Designation: This population of fall run chinook spawning in the Seton and Anderson watersheds along the middle Fraser River has declined to very low levels, and decline is anticipated to continue. Declines in freshwater and marine habitat quality, and harvest, are threats facing this population.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets Endangered A2bcd because there has been a 67% decline in the index of mature individuals over three generations as a result of declining habitat quality and harvest.
Criterion B (Small Distribution Range and Decline or Fluctuation): Criterion not met. While IAO meets criterion for Endangered and the quality of the freshwater and marine habitats is declining, the population is not severely fragmented, the number of locations is unknown and there are no extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Meets Endangered C2a(i,ii) due to the continuing decline of all individuals in one population.
Criterion D (Very Small or Restricted Population): Meets Endangered D1 as there are fewer than 250 mature individuals.
Criterion E (Quantitative Analysis): Not done.

* Following methods used for the COSEWIC Fraser Sockeye Salmon Status Report, the area of occupancy of each DU is calculated as two times the spawning length, and is reported in square kilometres. This method is equivalent to overlaying a 2×2 km^2 grid over the stream, and adding up the total area.

Designatable Unit 9: Middle Fraser, Stream, Spring (MFR+GStr) population
Population du moyen Fraser, type fluvial, printemps (MF+DetG)

Demographic Information:

Generation Time	4.5 years		
Is there a continuing decline in the number of mature individuals?	Yes		
Change in number of mature individuals based on last 3 generations observations	-28%	p > 30% decline 48%	p > 50% decline 22%
Change in number of mature individuals based on all observations	-49%	p > 30% decline 87%	p > 50% decline 47%
Are there extreme fluctuations in the number of mature individuals?	No		
Index of Area of Occupancy*	4490 km^2		
Number of mature individuals	5931 (index, not count)		

Threats

The most important threats specific to this DU are from ecosystem modifications. Irrigation diking and ditching in the Lower Fraser Basin contributes to a loss of backwater and off-channel habitat. These practices are increasingly expanding upstream along the Fraser River (a loss of rearing and overwintering habitat is also occurring due to conversion of agricultural land use to residential/commercial land use). Chinook salmon experts who participated in the IUCN Threats Calculator Workshop in February 2017 concluded that this DU should be assigned a threat impact of High - Medium (B/C). Wildfire activity in 2017 and 2018 have created significant habitat issues within this DU.

Status and Reasons for Designation:

Status: Threatened	**Alpha-numeric codes:** A2bcde
Reasons for Designation: This spring run of chinook spawning in multiple middle Fraser River tributaries has declined in abundance. Declines in marine and freshwater habitat quality, and harvest, and pollution from mining activities are threats to this population.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets Threatened A2bcde because there has been a 49% decline in the index of mature fish in the entire time series as a result of declining habitat quality, harvest, and pollution.
Criterion B (Small Distribution Range and Decline or Fluctuation): Criterion not met..
Criterion C (Small and Declining Number of Mature Individuals): Criterion not met.
Criterion D (Very Small or Restricted Population): Criterion D1 not met because number of mature individuals exceeds thresholds. Threatened D2 does not apply as the number of locations is unknown and the IAO threshold of 20 km^2 is exceeded.
Criterion E (Quantitative Analysis): Not done.

* Following methods used for the COSEWIC Fraser Sockeye Salmon Status Report, the area of occupancy of each DU is calculated as two times the spawning length, and is reported in square kilometres. This method is equivalent to overlaying a 2×2 km^2 grid over the stream, and adding up the total area.

Designatable Unit 10: Middle Fraser, Stream, Summer population
Population du moyen Fraser, type fluvial, été

Demographic Information

Generation Time	4.5 years		
Is there a continuing decline in the number of mature individuals?	Yes		
Change in number of mature individuals based on last 3 generations observations	-38%	p > 30% decline 64%	p > 50% decline 26%
Change in number of mature individuals based on all observations	-29%	p > 30% decline 48%	p > 50% decline 14%
Are there extreme fluctuations in the number of mature individuals?	No		
Index of Area of Occupancy*	2616 km^2		
Number of mature individuals	15598 (index, not count)		

Threats

A threats calculator was not completed. However, expert knowledge indicates placer and hard rock mining, acid mine drainage, and contaminant leaching occurs at several “locations” in the Quesnel River and Cariboo River. Acid mine drainage has potential for long-term devastating impacts to the aquatic community and reduced productive capacity of these rivers. The 2014 Mount Polley mining disaster occurred in this DU and involved a breach of the copper/gold mine’s tailings pond, discharging toxic mud and water into Polley Lake. The Kenney dam, which is outside of the southern edge of the DU, may affect temperature and flow rates in the Nechako River, thereby changing the migration timing of Chinook salmon smolts).

Status and Reasons for Designation:

Status: Threatened	**Alpha-numeric codes:** A2bc
Reasons for Designation: This summer run of chinook spawning in multiple middle Fraser River tributaries has declined in abundance. Declines in marine and freshwater habitat quality are threats facing this population.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets Threatened A2bc because there has been a decline of 38% in the index of mature fish in the past three generations as a result of declining habitat quality.
Criterion B (Small Distribution Range and Decline or Fluctuation): Criterion not met.
Criterion C (Small and Declining Number of Mature Individuals): Criterion not met. The number of mature individuals is well above the threshold for threatened.
Criterion D (Very Small or Restricted Population): Criterion not met because the number of mature individuals exceeds threshold. Threatened does not apply as the number of locations is unknown and the IAO threshold of 20 km² is exceeded.
Criterion E (Quantitative Analysis): Not done.

* Following methods used for the COSEWIC Fraser Sockeye Salmon Status Report, the area of occupancy of each DU is calculated as two times the spawning length, and is reported in square kilometres. This method is equivalent to overlaying a 2×2 km^2 grid over the stream, and adding up the total area.

Designatable Unit 11:Upper Fraser, Stream, Spring population
Population du haut Fraser, type fluvial, printemps

Demographic Information

Generation Time	4.5 years		
Is there a continuing decline in the number of mature individuals?	Yes		
Change in number of mature individuals based on last 3 generations observations	-49%	p > 30% decline 79%	p > 50% decline 48%
Change in number of mature individuals based on all observations	-43%	p > 30% decline 81%	p > 50% decline 28%
Are there extreme fluctuations in the number of mature individuals?	No		
Index of Area of Occupancy*	4065 km^2		
Number of mature individuals	13,786 (index, not count)		

Threats

A threats calculator was completed. Chinook salmon experts who participated in the IUCN Threats Calculator Workshop in February 2017 concluded that this DU should be assigned a threat impact of High - Medium (B/C). There has been limited success at maintaining a harvest target of 30% for this DU, with the most recent brood year at 40%.

Status and Reasons for Designation:

Status: Endangered	**Alpha-numeric codes:** A2bcd+3c+4c
Reasons for Designation: This spring run of chinook spawning in the Salmon and Raush Rivers in the upper Fraser watershed has declined in abundance. Declines in marine and freshwater habitat quality, and harvest, are threats facing this population. Anticipated changes to North Pacific weather systems that affect ground water availability, will impact spawning sites and overwinter survival.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets Threatened A2bcd, as there has been an estimated decline in the index of numbers of mature individuals of more than 30% in the last three generations and over the entire time series. Future decline of >30% is projected.
Criterion B (Small Distribution Range and Decline or Fluctuation): Criterion not met.
Criterion C (Small and Declining Number of Mature Individuals): Criterion not met. The number of mature individuals is well above the threshold
Criterion D (Very Small or Restricted Population): Does not meet criterion. The number of mature individuals is well above the threshold. Threatened D2 does not apply as the number of locations is unknown and the IAO threshold of 20 km^2 is exceeded.
Criterion E (Quantitative Analysis): Not done.

* Following methods used for the COSEWIC Fraser Sockeye Salmon Status Report, the area of occupancy of each DU is calculated as two times the spawning length, and is reported in square kilometres. This method is equivalent to overlaying a 2×2 km^2 grid over the stream, and adding up the total area.

Designatable Unit 12: South Thompson, Ocean, Summer population
Population de la Thompson Sud, type océanique, été

Demographic Information

Generation Time	3.8 years		
Is there a continuing decline in the number of mature individuals?	No		
Change in number of mature individuals based on last 3 generations observations	+26%	p > 30% decline 7%	p > 50% decline 2%
Change in number of mature individuals based on all observations	+64%	p > 30% decline 0%	p > 50% decline 0%
Are there extreme fluctuations in the number of mature individuals?	No		
Index of Area of Occupancy*	1125 km^2		
Number of mature individuals	116,888 (index, not count)		

Threats

A threats calculator was not completed. However, there have been significant habitat alterations within this Designatable Unit, including dredging and removal of spawning gravel (Thompson River).

Status and Reasons for Designation:

Status: Not at risk	**Alpha-numeric codes:** Not applicable.
Reasons for Designation: This summer run of chinook to the South Thompson River has been steadily increasing in abundance, and the most recent population index is the second highest on record.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Criterion not met. The number of mature individuals has increased in the last three generations.

Criterion B (Small Distribution Range and Decline or Fluctuation): Criterion not met. While IAO meets criterion for Endangered and the quality of the freshwater and marine habitats is declining, the population is not severely fragmented, the number of locations is unknown, and there are no extreme fluctuations.

Criterion C (Small and Declining Number of Mature Individuals): Does not meet criterion, number of mature individuals exceeds thresholds.

Criterion D (Very Small or Restricted Population): Does not meet criterion. Criterion not met as the number of mature individuals exceeds thresholds. Threatened D2 does not apply as the number of locations is unknown and the IAO threshold of 20 km^2 is exceeded.

Criterion E (Quantitative Analysis): Not done.

* Following methods used for the COSEWIC Fraser Sockeye Salmon Status Report, the area of occupancy of each DU is calculated as two times the spawning length, and is reported in square kilometres. This method is equivalent to overlaying a 2×2 km^2 grid over the stream, and adding up the total area.

Designatable Unit 14: South Thompson, Stream, Summer 1.2 population
Population de la Thompson Sud, type fluvial, été 1.2

Demographic Information

Generation Time	3 years		
Is there a continuing decline in the number of mature individuals?	Yes		
Change in number of mature individuals based on last 3 generations observations	-47%	p > 30% decline 59%	p > 50% decline 48%
Change in number of mature individuals based on all observations	-76%	p > 30% decline 98%	p > 50% decline 92%
Are there extreme fluctuations in the number of mature individuals?	No		
Index of Area of Occupancy*	70 km^2		
Number of mature individuals	138 (index, not count)		

Threats

Chinook salmon experts who participated in the IUCN Threats Calculator Workshop in February 2017 recommended using the DU15 Threats Calculator as a proxy for this DU with the main difference being that juveniles in DU14 stay in freshwater for one year and utilize smaller rivers. These characteristics make the fish more vulnerable than DU15 Chinook salmon to water management issues and increased development. In the Bessette and Duteau Rivers, for example, Chinook salmon contend with dewatering events, agricultural runoff and rising stream temperatures. Considerable agriculture occurs in the DU with cattle ranching and farming adversely affecting the amount and quality of the riparian habitat. Dams occur in the headwaters of this system, diverting water out of the drainage and affecting mean annual discharge and seasonal low discharge. Based on these points and DU15 results, participants concluded that DU14 should be assigned a threat impact of High-Medium (B/C), implying a population decline rate of up to 70% over three generations.

Status and Reasons for Designation:

Status: Endangered	**Alpha-numeric codes:** A2bcd
Reasons for Designation: This summer run of chinook spawning in the South Thompson River has steeply declined in abundance to a very low level. Declines in marine and freshwater habitat quality, and harvest, are threats facing this population.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets Endangered A2bcd as there has been a 76% decline in the index of number of individuals over the entire time series as a result of decline in habitat quality and harvest. It is appropriate to use the population trend over the entire time series because there has been no artificial enhancement.

* Following methods used for the COSEWIC Fraser Sockeye Salmon Status Report, the area of occupancy of each DU is calculated as two times the spawning length, and is reported in square kilometres. This method is equivalent to overlaying a 2×2 km^2 grid over the stream, and adding up the total area.

Criterion B (Small Distribution Range and Decline or Fluctuation): Criterion not met. While IAO meets criterion for Endangered and the quality of the freshwater and marine habitats is declining, the population is not severely fragmented, the number of locations is unknown, and there are no extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Criterion not met.
Criterion D (Very Small or Restricted Population): Criterion not met.
Criterion E (Quantitative Analysis): Not done.

Designatable Unit 16: North Thompson, Stream, Spring population
Population de la Thompson Nord, type fluvial, printemps

Demographic Information

Generation Time	4.5 years		
Is there a continuing decline in the number of mature individuals?	Yes		
Change in number of mature individuals based on last 3 generations observations	-91%	p > 30% decline 100%	p > 50% decline 100%
Change in number of mature individuals based on all observations	-88%	p > 30% decline 100%	p > 50% decline 100%
Are there extreme fluctuations in the number of mature individuals?	No		
Index of Area of Occupancy*	291 km^2		
Number of mature individuals	181 (index, not count)		

Threats

Chinook salmon experts who participated in the IUCN Threats Calculator Workshop in February 2017 recommended using the DU11 Threats Calculator as a proxy for this DU. Based on DU11 results DU16 should be assigned a threat impact of High - Medium (B/C)..

Status and Reasons for Designation:

Status: Endangered	**Alpha-numeric codes**: A2bcd+3c+4c

Reasons for Designation:
This spring run of chinook spawning in the North Thompson River has steeply declined in abundance to a low level. Declines in marine and freshwater habitat quality, and harvest, are threats facing this population. Anticipated changes in North Pacific weather systems that affect groundwater availability will impact spawning sites and overwinter survival.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets Endangered A2bcd. Decline rates of 91 and 88% were observed for indices of abundance calculated for three generations from 2000 to 2015 and the entire time series, respectively. Future decline of >50% are projected.

Criterion B (Small Distribution Range and Decline or Fluctuation): Criterion not met. While IAO meets criterion for Endangered and the quality of the freshwater and marine habitats is declining, the population is not severely fragmented, the number of locations is unknown, and there are no extreme fluctuations.

Criterion C (Small and Declining Number of Mature Individuals): Criterion not met.

Criterion D (Very Small or Restricted Population): Criterion not met.

Criterion E (Quantitative Analysis): Not done.

* Following methods used for the COSEWIC Fraser Sockeye Salmon Status Report, the area of occupancy of each DU is calculated as two times the spawning length, and is reported in square kilometres. This method is equivalent to overlaying a 2×2 km^2 grid over the stream, and adding up the total area.

Designatable Unit 17: North Thompson, Stream, Summer population
Population de la Thompson Nord, type fluvial, été

Demographic Information

Generation Time	4.5 years		
Is there a continuing decline in the number of mature individuals?	Yes		
Change in number of mature individuals based on last 3 generations observations	-62%	p > 30% decline 93%	p > 50% decline 75%
Change in number of mature individuals based on all observations	-64%	p > 30% decline 98%	p > 50% decline 86%
Are there extreme fluctuations in the number of mature individuals?	No		
Index of Area of Occupancy*	714 km^2		
Number of mature individuals	3027 (index, not count)		

Threats

A threats calculator was not completed.

Status and Reasons for Designation:

Status: Endangered	**Alpha-numeric codes:** A2bcd
Reasons for Designation: This summer run of chinook spawning in the North Thompson River has steeply declined in abundance. Declines in marine and freshwater habitat quality, and harvest, are threats facing this population.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets Endangered A2bcd. Decline rates of 62 and 64% were observed for indices of abundance calculated for three generations using data from 2000 to 2015 and the entire time series, respectively, as a result of decline in habitat quality and harvest.
Criterion B (Small Distribution Range and Decline or Fluctuation Criterion not met. While IAO meets criterion for Endangered and the quality of the freshwater and marine habitats is declining, the population is not severely fragmented, the number of locations is unknown, and there are no extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Criterion not met.
Criterion D (Very Small or Restricted Population): Does not meet criterion. The number of mature individuals is well above the threshold. Threatened D2 does not apply as the number of location is unknown and the IAO threshold of 20 km² is exceeded.
Criterion E (Quantitative Analysis): Not done.

* Following methods used for the COSEWIC Fraser Sockeye Salmon Status Report, the area of occupancy of each DU is calculated as two times the spawning length, and is reported in square kilometres. This method is equivalent to overlaying a 2×2 km^2 grid over the stream, and adding up the total area.

Designatable Unit 19: East Vancouver Island, Stream, Spring population
Population de l'est de l'île de Vancouver, type fluvial, printemps

Demographic Information

Generation Time	3.5 years		
Is there a continuing decline in the number of mature individuals?	Unknown		
Change in number of mature individuals based on last 3 generations observations	Unknown	Unknown	Unknown
Change in number of mature individuals based on all observations	Unknown	Unknown	Unknown
Are there extreme fluctuations in the number of mature individuals?	Unknown		
Index of Area of Occupancy*	41 km^2		
Number of mature individuals	< 250 (index, not count)		

Threats

A threats calculator was not completed. The habitat in this Designatable Unit is more heavily modified than the average across all DUs in this report.

Status and Reasons for Designation:

Status: Endangered	**Alpha-numeric codes:** D1
Reasons for Designation: This spring run of chinook to the Nanaimo River has been at a very low abundance for a long time. Declines in marine and freshwater habitat quality are threats facing this population.	

Applicability of Criteria

riterion A (Decline in Total Number of Mature Individuals): Too few data to apply criterion.
Criterion B (Small Distribution Range and Decline or Fluctuation): Criterion not met. While IAO meets criterion for Endangered and the quality of the freshwater and marine habitats is declining, the population is not severely fragmented, the number of locations is unknown, and there are no extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Unknown.
Criterion D (Very Small or Restricted Population): Meets Endangered D1 as there are fewer than 250 mature individuals.
Criterion E (Quantitative Analysis): Not done.

* Following methods used for the COSEWIC Fraser Sockeye Salmon Status Report, the area of occupancy of each DU is calculated as two times the spawning length, and is reported in square kilometres. This method is equivalent to overlaying a 2×2 km^2 grid over the stream, and adding up the total area.

Designatable Unit 27: Southern Mainland, Ocean, Summer population
Population du sud de la partie continentale (C.-.B.), type océanique, été

Demographic Information

Generation Time	4.5 years		
Is there a continuing decline in the number of mature individuals?	Unknown		
Change in number of mature individuals based on last 3 generations observations	Unknown	Unknown	Unknown
Change in number of mature individuals based on all observations	Unknown	Unknown	Unknown
Are there extreme fluctuations in the number of mature individuals?	Unknown		
Index of Area of Occupancy*	154 km^2		
Number of mature individuals	Unknown		

Threats

Chinook salmon experts who participated in the IUCN Threats Calculator Workshop in February 2017 concluded that this DU should be assigned a threat impact of Low (D). Some risk exists from ecosystem modifications due to independent power producers (minimal) and from avalanches/landslides due to the steep terrain in this system. However, this DU is data limited. Threat Calculator results for this population are based on those from DU28. Many issues need to be further investigated. There are a number of 'Unknown' Threat Calculator scores that, if populated, could change the overall threat rating.

Status and Reasons for Designation:

Status: Data Deficient	**Alpha-numeric codes:** Not applicable
Reasons for Designation: This summer run of chinook to spawn in the remote glacial Homathko River watershed in the southern mainland has not been surveyed sufficiently to assess its population status..	

Applicability of Criteria

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

* Following methods used for the COSEWIC Fraser Sockeye Salmon Status Report, the area of occupancy of each DU is calculated as two times the spawning length, and is reported in square kilometres. This method is equivalent to overlaying a 2×2 km^2 grid over the stream, and adding up the total area.

Designatable Unit 28: Southern Mainland, Stream, Summer population
Population du sud de la partie continentale (C.-.B.), type fluvial, été

Demographic Information

Generation Time	4.5 years		
Is there a continuing decline in the number of mature individuals?	Unknown		
Change in number of mature individuals based on last 3 generations observations	Unknown	Unknown	Unknown
Change in number of mature individuals based on all observations	Unknown	Unknown	Unknown
Are there extreme fluctuations in the number of mature individuals?	Unknown		
Index of Area of Occupancy*	447 km^2		
Number of mature individuals	Unknown		

Threats

A threats calculator was completed. Chinook salmon experts who participated in the IUCN Threats Calculator Workshop in February 2017 concluded that this DU should be assigned a threat impact of Low (D). Some risk exists from ecosystem modifications due to independent power producers (minimal) and from avalanches/landslides due to the steep terrain in this system. However, this DU is data deficient. Many issues need to be further investigated. There are a number of 'Unknown' Threat Calculator scores that, if populated, could change the overall threat rating.

Status and Reasons for Designation:

Status: Data deficient	**Alpha-numeric codes:** Not applicable
Reasons for Designation: This summer run of chinook to spawn in the remote glacial Klinaklini River watershed in the southern mainland of British Columbia has not been recently surveyed to assess its population status.	

Applicability of Criteria

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

* Following methods used for the COSEWIC Fraser Sockeye Salmon Status Report, the area of occupancy of each DU is calculated as two times the spawning length, and is reported in square kilometres. This method is equivalent to overlaying a 2×2 km^2 grid over the stream, and adding up the total area.

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
(2018)

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

Chinook Salmon
Oncorhynchus tshawytscha

Designatable Units in Southern British Columbia
(Part One – Designatable Units with No or Low Levels of Artificial Releases in the Last 12 Years)

in Canada

2018

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Class: Actinopterygii

Order: Salmoniformes

Family: Salmonidae

Latin binomial: *Oncorhynchus tshawytscha* (Walbaum)

Designatable Unit: See DU section

Common species names:

English – Chinook Salmon, Spring Salmon, King Salmon (Scott and Crossman 1973)

French – saumon Chinook

First Nations – tyee, sac'up, k^{w}ex^{w}e, k'utala, keke'su7, po:kw' (Ducommun 2013); ntitiyix, sk'elwis (Vedan 2002), t'kwinnat or quinnat (Scott and Crossman 1973)

Morphological Description

Chinook Salmon are the largest of the Pacific salmon (Netboy 1958), reaching over 55 kg in weight (Bailey pers. comm. 2018). In addition to their distinctive size, Chinook Salmon adults (Figure 1) differ from other *Oncorhynchus* species by: (1) the presence of small black spots on both lobes of the caudal fin (also occurs in Coho Salmon *O. kisutch*); (2) black gums at the base of the teeth in the lower jaw; (3) a pointed lower jaw; (4) a large number of pyloric caeca (>100) (McPhail and Lindsey 1970; McPhail and Carveth 1994; Bailey pers. comm. 2018); and (5) large otoliths. Chinook Salmon also differ from all but Coho Salmon in terms of their variable flesh colour, which ranges from white through different shades of pink, to red (Healey 1991; Lehnert *et al*. 2016).

Figure 1. Chinook Salmon adult, showing distinguishing spots on caudal fin. Image accessed from http://endlessocean.wikia.com/wiki/Chinook Salmon_Salmon. Image uploaded by Mcqueen9000.

Chinook Salmon fry and parr are distinguished by the presence of parr marks extending well below the lateral line, the deepest of which are deeper than the vertical eye diameter (McPhail and Carveth 1994). The adipose fin is normally unpigmented in the centre, but edged with black (Dahlberg and Phinney 1967). The anal fin is usually only slightly falcate, and the leading rays do not reach past the posterior insertion of the fin when folded against the body. The anal fin has a white leading edge, but the adjacent dark line present in Coho Salmon is absent. However, juvenile characteristics are highly variable, so proper identification often requires otolith measurements (M. Trudel, pers. comm.) or meristic and pyloric caeca counts (Healey 1991).

Population Spatial Structure and Variability

Information about population spatial structure and variability is addressed in the following section about Designatable Units.

Designatable Unit Delineation

The Designatable Units (DUs) reviewed in this report have been approved by COSEWIC. Using methods based on both COSEWIC guidelines ("*Appendix F5: Guidelines for Recognizing Designatable Units*") and work by Fisheries and Oceans Canada (DFO) ("*Conservation Units for Pacific Salmon under the Wild Salmon Policy*" (Holtby and Ciruna 2007) and *"Canada's Policy for Conservation of Wild Pacific Salmon"* (DFO 2005a)), the southern British Columbia (BC) populations of Chinook Salmon were subdivided into 28 DUs based on geographic distribution, life-history variation, and genetic data. DU designation is detailed in "*COSEWIC Report on Proposed Designatable Units for Chinook Salmon* Oncorhynchus tshawytcsha *in Southern British Columbia*" (COSEWIC 2015).

Both the Wild Salmon Policy (WSP) Conservation Units (CUs) and COSEWIC DUs share the same fundamental approach: they are both oriented toward maintaining genetic variability at the wildlife species level. Therefore, isolation and distinctiveness of populations are important in both cases. Based on the similarities of underlying rationale and process for developing CUs and DUs, the existing CU definitions are used as a starting point for DUs. The similarities and differences between these delineation types are outlined below.

The goal of the WSP is to preserve the ability of the fish to adapt to local stresses by maintaining genetically diverse spawning (reproducing) populations. Thus, the protection of 'pattern' (groups of populations) as well as 'process' (habitat integrity and connectedness for those populations) is required (Moritz 2002). The definition and documentation of CUs is used for protection of pattern. A Conservation Unit is defined as a group of wild salmon sufficiently isolated from other groups (i.e., *discrete* groups) that, if extirpated (destroyed), is unlikely to recolonize naturally in an acceptable timeframe (Holtby and Ciruna 2007). CUs are defined by studying ecology, life-history, and biochemical genetics to identify evolutionarily significant units (populations that are reproductively isolated and/or exhibit adaptive variation from larger populations). The aim of the CU is to (when possible) maintain genetic diversity by preserving one or more subpopulations within each local population so the population does not become closed. A key difference between CUs and DUs is the inclusion of “wild” in the definition of CUs, as COSEWIC DUs could include enhanced populations provided they have a neutral or positive effect on fitness of the wild populations. It should be noted that there is considerable evidence that hatchery-origin fish have a detrimental effect on the fitness of wild Chinook Salmon populations (DFO 2017, in press).

Designatable Units are defined as “*discrete* and *evolutionarily significant* units of the taxonomic species”, where “significant” means that the unit is important to the evolutionary legacy of the species as a whole and if lost would likely not be replaced through natural dispersion”. This statement aligns with the definition of a CU (a group that is sufficiently isolated from other groups that, if extirpated (destroyed), is very unlikely to recolonize naturally), with the exception that the DU does not dictate a timeframe for recolonization or replacement.

The codes *D*1, *D*2 and *D*3 are used to describe the three criteria for discreteness.

Discreteness may be based on one or more of the following criteria:

1. Genetic distinctiveness including inherited traits (including life history or behaviour) and/or neutral genetic markers (including DNA microsatellites);
2. Natural differences in geographic range (such that local adaptation is likely); and/or
3. Occupation of differing eco-geographic regions that reflect historical or genetic distinction.

The codes *E*1, *E*2, *E*3 and *E*4 are used to describe the four criteria for evolutionary significance.

Evolutionary significance of a discrete population is determined by one or more of the following criteria, each of which can be considered a measure of evolutionary significance:

1. Evidence that the discrete population is markedly genetically different;
2. Persistence of the discrete population in a unique ecological setting that is likely or known to have given rise to local adaptation;
3. Evidence that the discrete population is the only surviving natural occurrence of a species that is only found elsewhere as an introduced species; and/or
4. Evidence that loss of the discrete population would result in an extensive gap in the range of the species in Canada.

In general, the criteria used to define CUs and DUs share enough similarities that it was possible to use the work from Holtby and Ciruna (2007) to define DUs. Discrepancies between CU and DU designation methods mean there is not a direct translation from CU to DU for all cases, and some DUs will contain multiple CUs. Because of these differences, the methods (see below) for defining DUs is slightly different than previously documented for CUs.

Methods

Designatable Unit (DU) designation methods are adapted from Conservation Unit (CU) designation methods (Holtby and Ciruna 2007) and involve separating different populations of Chinook Salmon using a hierarchy of characteristics to determine distinctiveness and evolutionary significance. Specifically, geographic differences are applied to demonstrate distinctiveness while life-history characteristics are applied to demonstrate evolutionary significance.

For comparison, the CU designation methodology is visualized in Figure 2 and the DU methodology is illustrated in Figure 3.

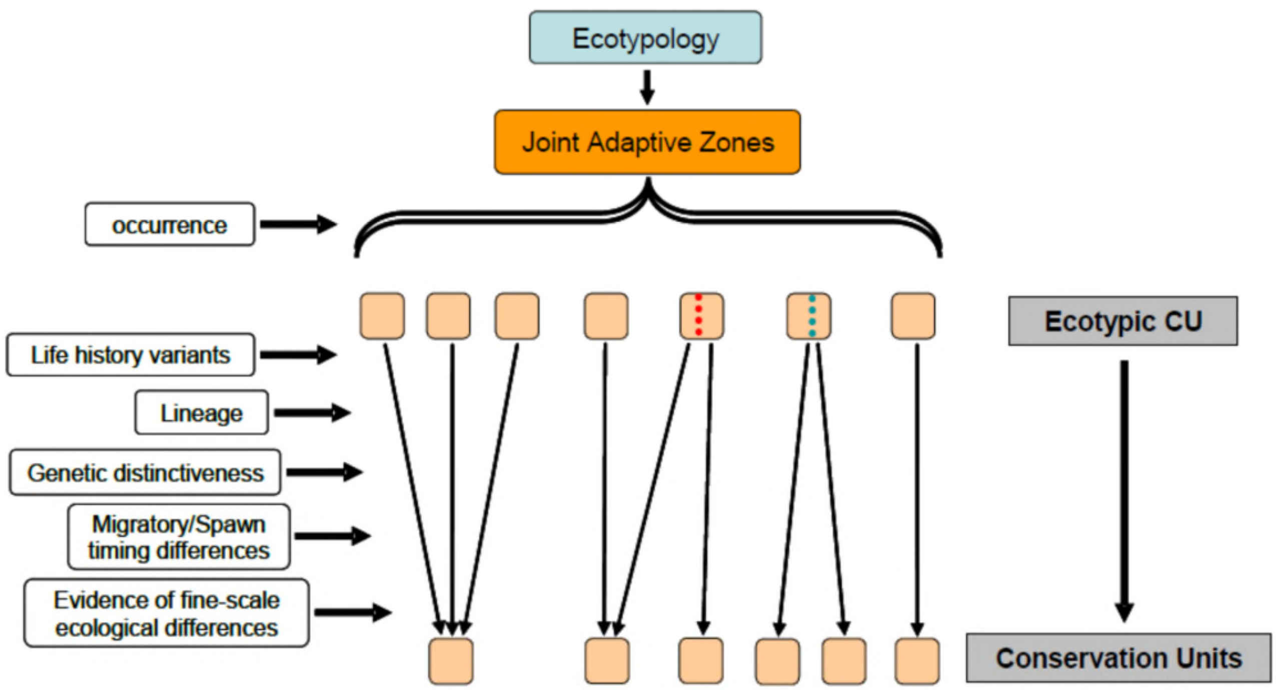


Figure 2. Methods for defining Conservation Units. This figure is a reproduction of Figure 1 in Holtby and Ciruna 2007.

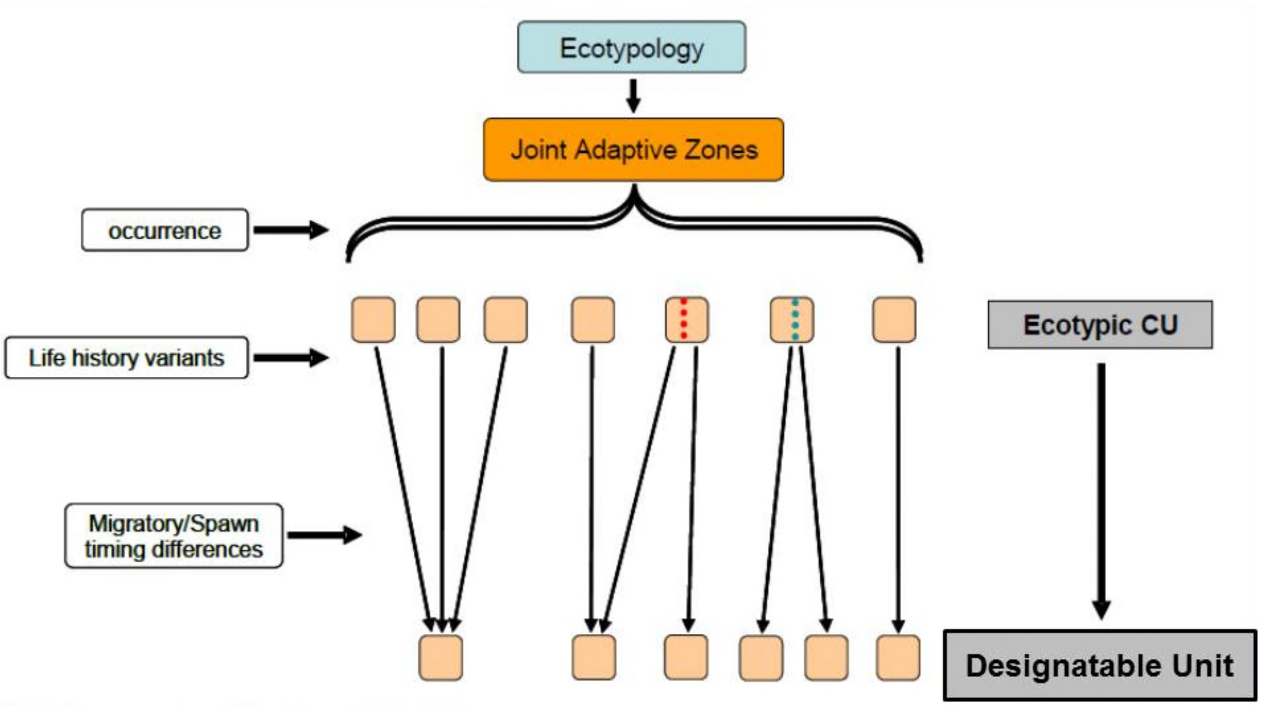


Figure 3. Methods for defining Designatable Units. This figure is adapted from Figure 1 in Holtby and Ciruna 2007.

The step-wise method shown in Figure 3 can be summarized in three steps that distinguish populations by:

- Ecotypology (geographic region supported by genetics data);
- Life history variant; and
- Migratory/spawning timing differences.

Distinctiveness (Ecotype / Joint Adaptive Zones)

The first DU division occurs at the geographic level based on ecotypic regions called Joint Adaptive Zones (JAZ) that meet the criteria for discreteness of populations (*D*2, geographic range) and (*D*3, eco-geographic regions). Joint Adaptive Zones represent distinct geographic ranges that are described by the intersection between a Freshwater Adaptive Zone (FAZ) (Figure 4) and a Marine Adaptive Zone (MAZ) (Figure 5) where local adaptation is likely (Table 1, Figure 6). Short-hand codes used to describe the MAZ and FAZ are shown in Table 2 and Table 3 respectively. There are 39 JAZ defined in BC, and 34 of these contain Chinook Salmon; 19 of the Chinook Salmon-bearing JAZ are in southern BC (DFO 2013a).

Table 1. Description of Joint Adaptive Zones, Freshwater Adaptive Zones, and Marine Adaptive Zones.

<table>
<tr><th colspan="2">Joint Adaptive Zones (JAZ)</th></tr>
<tr><td colspan="2">JAZs occur at the intersection of Freshwater Adaptive Zones (FAZ) and Marine Adaptive Zones (MAZ). They are considered to be locations of recently adaptive populations and therefore each JAZ is considered to contain at least one CU. There are 34 JAZs that contain Chinook Salmon; 19 of these are in southern British Columbia.</td></tr>
<tr><th>Freshwater Adaptive Zones (FAZ)</th><th>Marine Adaptive Zones (MAZ)</th></tr>
<tr><td>Based on ecological classification of freshwater ecosystems under Environmental Assessment (EA) BC (mainly freshwater ecoregions and ecological drainage units (EDUs) within ecoregions).
EDUs are river systems with a common zoogeographic history and therefore likely represent distinct habitats.
Each EDU contains one or more species that align them with the other aquatic ecoregions and at least one species not found in adjacent EDUs; therefore, each EDU where salmon are found should contain at least one CU.
EDUs were further refined based on climate, drainage density, gradient, hydrology and connectivity relevant to salmon populations.
36 EDUs were defined, not all have salmon; therefore, 31 FAZs were defined.</td><td>Previously defined watershed-coastal salmon ecoregions (ecosystems of distinct physical characteristics) were mapped out using GIS:
Level 1 - Arctic Ocean or Pacific Ocean and associated freshwater drainages; Level 2 – Semi-enclosed seas and ocean circulation systems and associated drainages (2 Arctic and 16 Pacific); Level 3 - Finer scale discontinuities within seas (fjords, straits, upwelling/down welling) (3 Arctic and 36 Pacific); Level 4 - Major drainage basin networks (defined as > Kanchalan River) entering each Level 3 (14 Arctic and 52 Pacific).
Level 3 chosen as the level for designating MAZs.
12 previously identified salmon ecoregions in BC.
Adjustments made to the Vancouver Island Coastal Current Ecoregion on the advice of DFO biologists based on survival patterns and run-timing.
A new MAZ created in mainland inlets, including Johnstone and Queen Charlotte Straits and the adjacent portions of Vancouver Island.
Puget Sound – Georgia Basin salmon Ecoregion was cut in half at the boundary of the Johnstone Strait and Georgia Strait to form the Queen Charlotte Strait – Johnstone Strait – Southern Fjords MAZ (on Vancouver Island and the mainland) to the north of the Georgia Strait MAZ.
Result was 13 MAZs, and each MAZ was considered to have at least one DU.</td></tr>
</table>

Table 2. Legend of short-hand codes used for Marine Adaptive Zones (MAZ) (Holtby and Ciruna 2007).

Short name	Long name
GStr	Georgia Strait
ORWA	Oregon-Washington Coastal
WVI	Vancouver Island Coastal Current
SFj	Queen Charlotte Strait-Johnstone Strait-Southern Fjords
HStr	Hecate Strait – Queen Charlotte Sound
WQCI	Outer Graham Island
NQCI	North Graham Island
NSKEst	Nass - Skeena Estuary
TBFj	Transboundary Fjords
AKCst	Alaska Coastal Downwelling
Ber	Bering Sea
AO	Arctic Ocean

Table 3. Legend of short-hand codes used for the Freshwater Adaptive Zones (FAZ) (Holtby and Ciruna 2007).

Short name	Long name
OK	Okanagan
BB	Boundary Bay
LFR	Lower Fraser
LILL	Lillooet
FRCany	Fraser Canyon
MFR	Middle Fraser
UFR	Upper Fraser
LTh	Lower Thompson
STh	South Thompson
NTh	North Thompson
SC	South Coastal Streams
EVI	East Vancouver Island
WVI	West Vancouver Island
HK	Homathko - Klinaklini rivers
RSI	Rivers-Smith Inlets
BCD	Bella Coola - Dean rivers
QCI	Queen Charlottes
NC	North Coastal Streams
HecLow	Hecate Lowlands
LSK	Lower Skeena
MSK	Middle Skeena
USK	Upper Skeena

Short name	Long name
LNR-P	Lower Nass - Portland
UNR	Upper Nass
UNUK	Unuk River
LStk	Lower Stikine
Whtng	Whiting River
Taku	Taku
Lynn	Lynn Canal
Alsek	Alsek
TesHW	Teslin Headwaters
Liard	Lower Liard

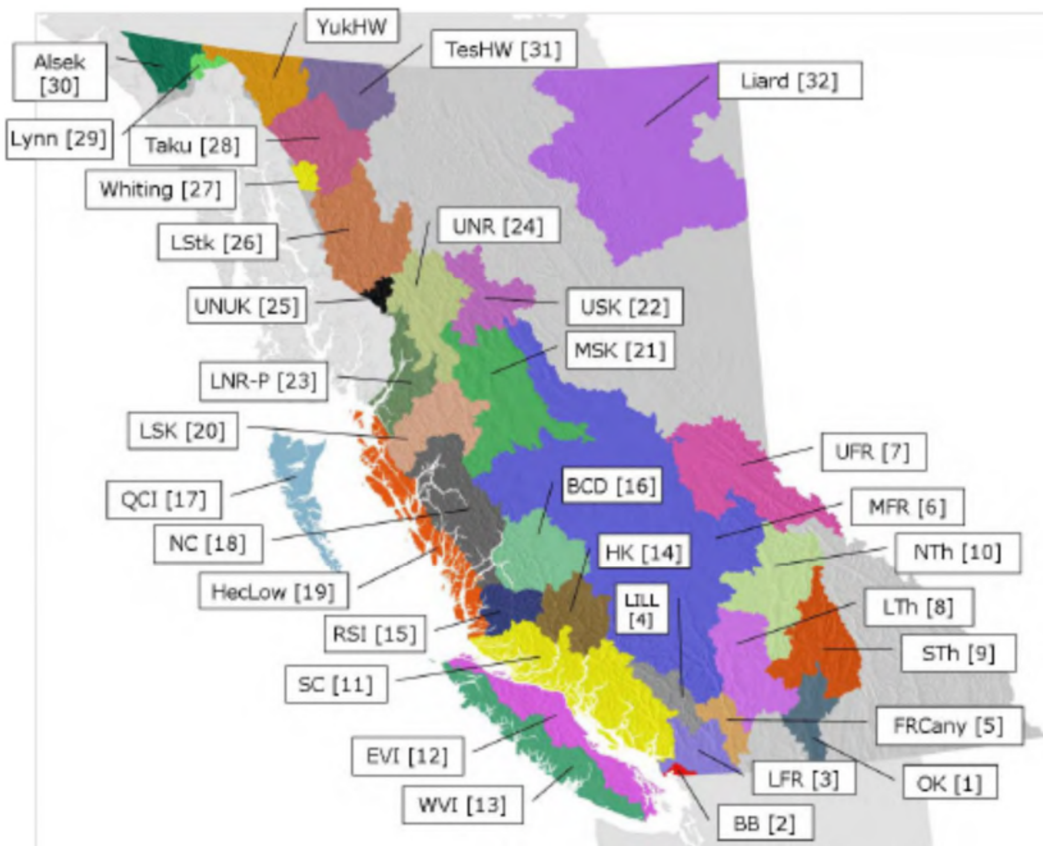


Figure 4. Map of Freshwater Adaptive Zones in British Columbia. This figure is a reproduction of Figure 76 in Holtby and Ciruna (2007).

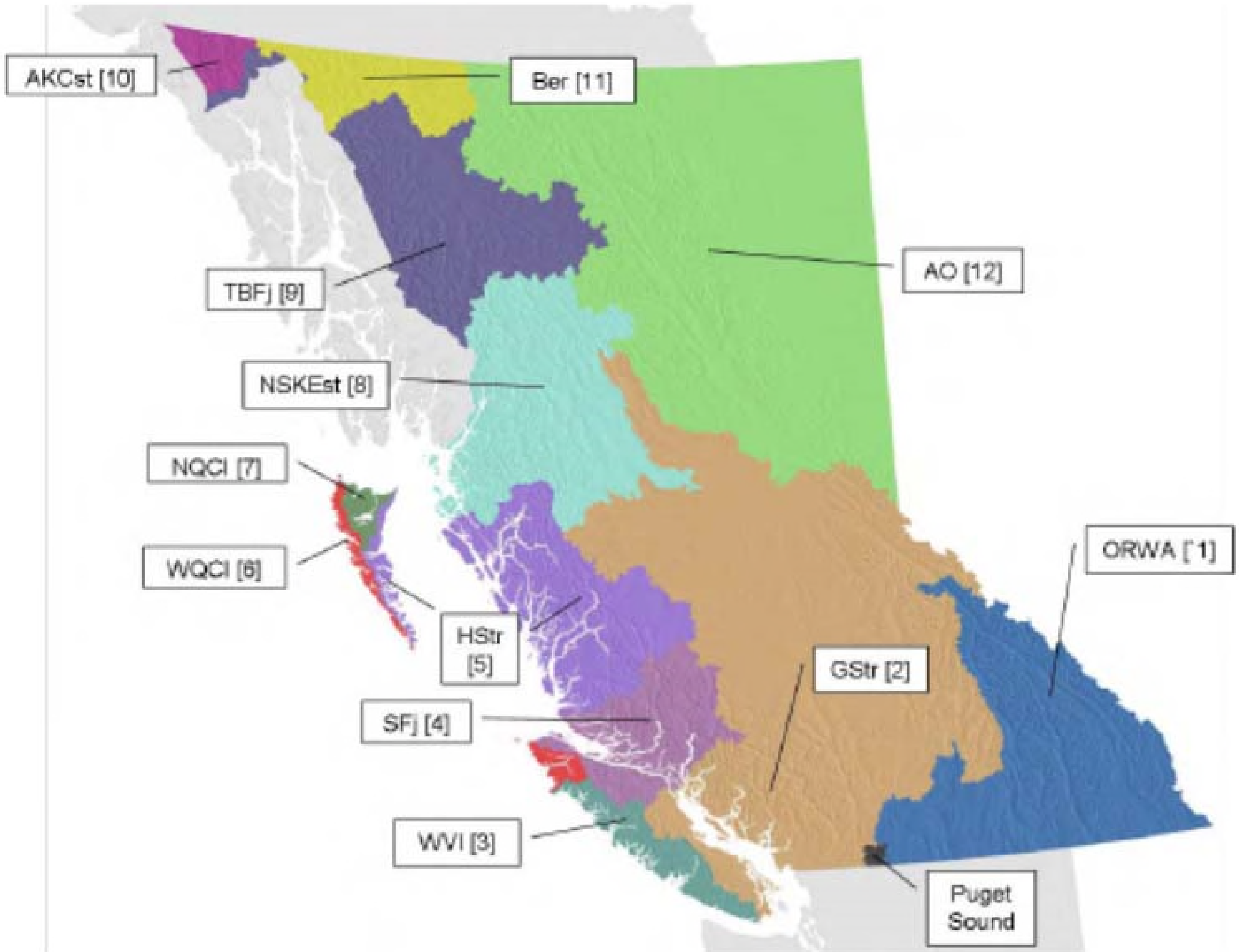


Figure 5. Map of Marine Adaptive Zones in British Columbia. This figure is a reproduction of Figure 77 in Holtby and Ciruna (2007).

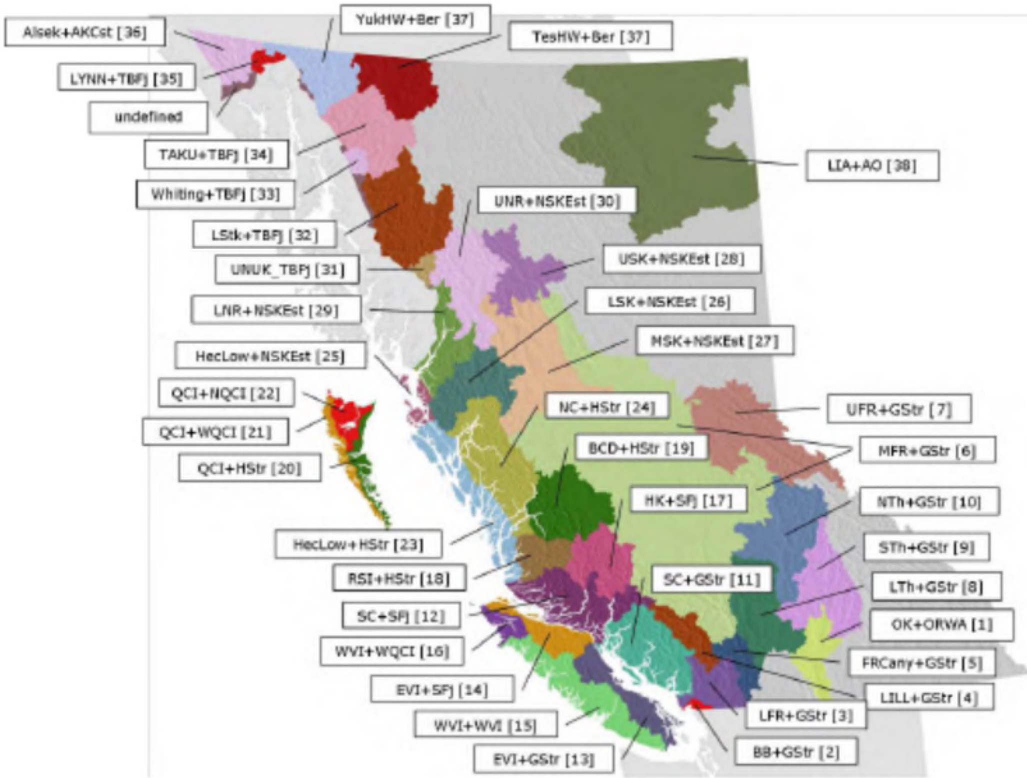


Figure 6. Joint Adaptive Zones in British Columbia. This figure is a reproduction of Figure 78 in Holtby and Ciruna (2007).

Salmon population presence within a JAZ is based on criteria defined in Holtby and Ciruna (2007). To determine which sites in each JAZ are relevant to defining Chinook Salmon DUs, a list of Annual Escapement Water Bodies was created using data from DFO's New Salmon Escapement Database System (NuSEDS). Sites that meet one or more of the following criteria are considered to contain Chinook Salmon:

- The site has five or more entries in NuSEDS from 1950-2006;
- Genetic Chinook Salmon samples have been obtained from the site (Chinook Salmon genetic samples were available for 312 sites);
- Records of spawn timing for Chinook Salmon are available in NuSEDS;
- Local knowledge and/or public consultation in the area confirmed the presence of Chinook Salmon.

The sites in NuSEDS were geo-referenced against the JAZ map. Joint Adaptive Zones that did not appear to include any Chinook Salmon habitat were not considered further in this process, as per Holtby and Ciruna (2007) (Figure 7).

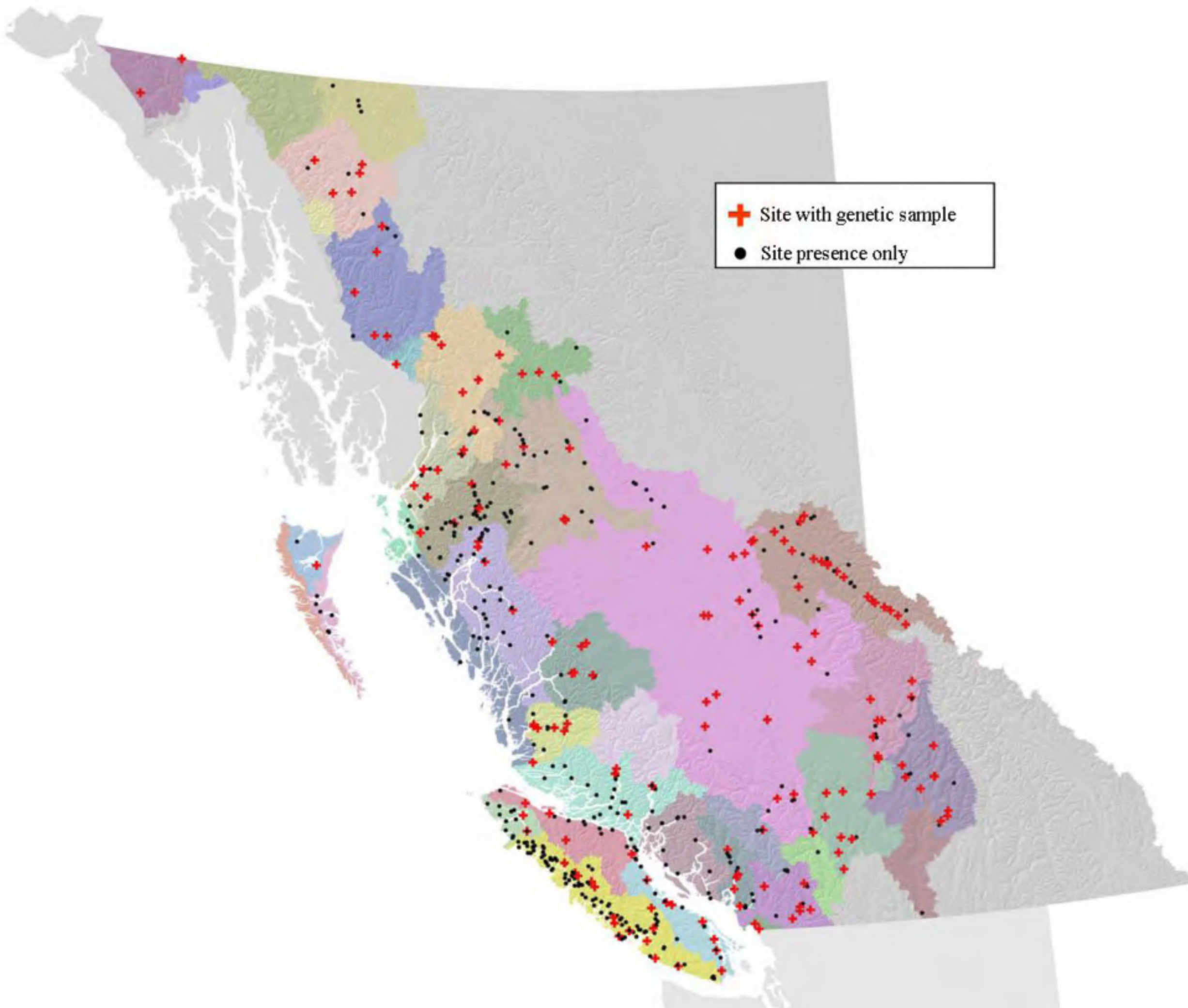


Figure 7. Map of sites in British Columbia with Chinook Salmon. Colored polygons represent JAZs. This figure is a reproduction of Figure 40 in Holtby and Ciruna (2007).

Genetic data support the use of JAZ to characterize southern BC Chinook Salmon DUs. First, Chinook Salmon demonstrate extreme fidelity to natal spawning grounds (Bentzen *et al.* 2001). Second, Chinook Salmon from a given JAZ tend to have a high degree of relatedness and reproductive isolation from other groups.

Spawning ground fidelity is demonstrated through data from redd sampling and a captive rearing program. Chinook Salmon from redds in the same reach of the river were more related to each other than they are to salmon from redds further away in the river, implying within-river substructure and fine-scale homing (Bentzen *et al.* 2001). Because of this extreme fidelity, the geographic range can be divided on a finer scale than would be typical for species that are less philopatric to natal areas than Chinook Salmon (Sockeye Salmon (*O. nerka*) can exhibit similar homing capabilities).

Genetic differences from microsatellite array data support the use of JAZ to classify DUs. Differences in neutral genetic structure for all genetic samples were assessed using Cavalli-Sforza and Edwards (1967) chord distance (CSE) calculated using 10 or more microsatellite loci for Chinook Salmon and fixation index (F_{st}) trees drawn using an unrooted neighbour-joining clustering algorithm. The resulting dendrograms (Figure 8) were compared with the JAZ to determine the likelihood that more than one distinct subpopulation is present.

Genetic samples were available for 312 sites in Canada. In most cases, demonstrated by very high F_{st} values, the streams within a given JAZ grouped together. Based on F_{st} pairwise exact tests of population differentiation (with 8,128 paired comparisons) performed using GENEPOP (Raymond and Rousset 1995), 99.8% of pairwise distances were statistically significant with α=0.05 (note that GENEPOP does not apply a Bonferroni correction (Goudet *et al.* 1996)). This genetic difference is further supported by a bootstrap analysis using the program PHYLIP (Felsenstein 2004) to build consensus trees across loci to assess how reliably a tree topology can be produced from the data at hand (Figure 9). These bootstrapped datasets were analyzed the same way as the single dataset, but data were re-sampled 1,000 times to generate random datasets from the original dataset.

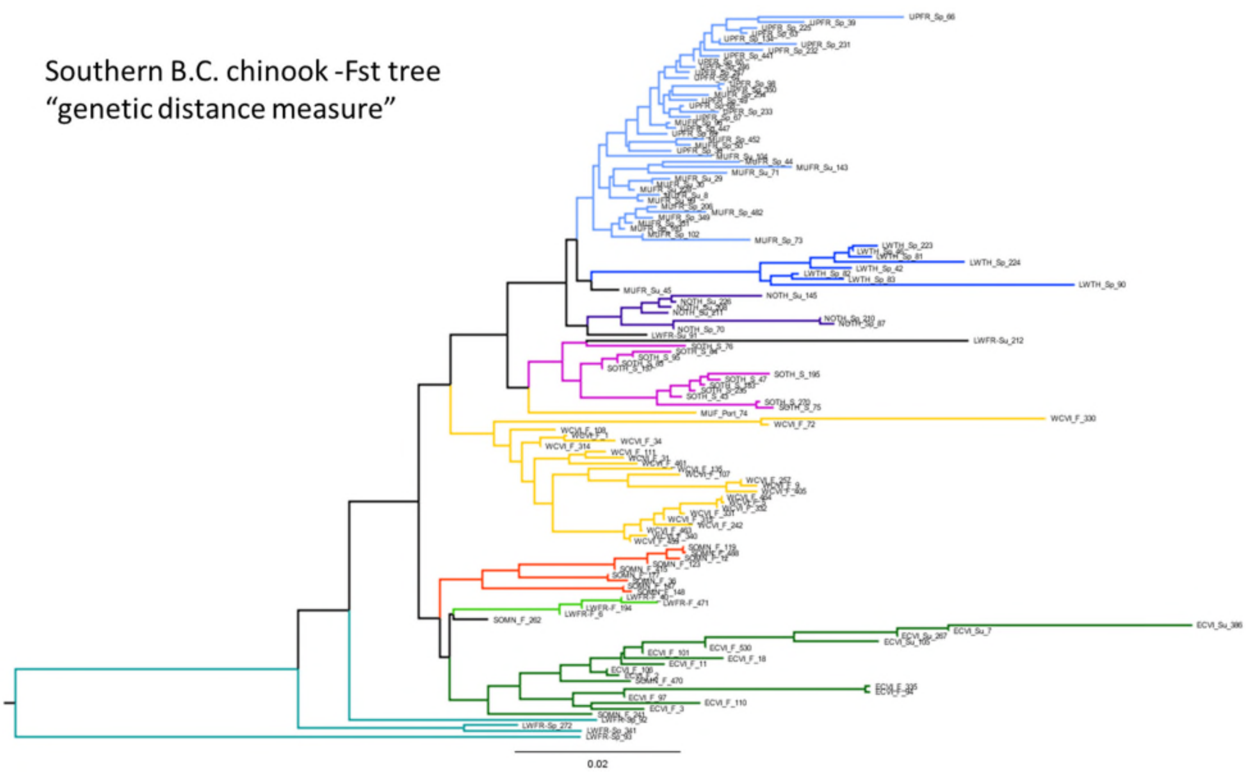


Figure 8. Southern BC Chinook Salmon F_{st} tree – Genetic distance measure (Candy 2013). Figure for illustration purposes only.

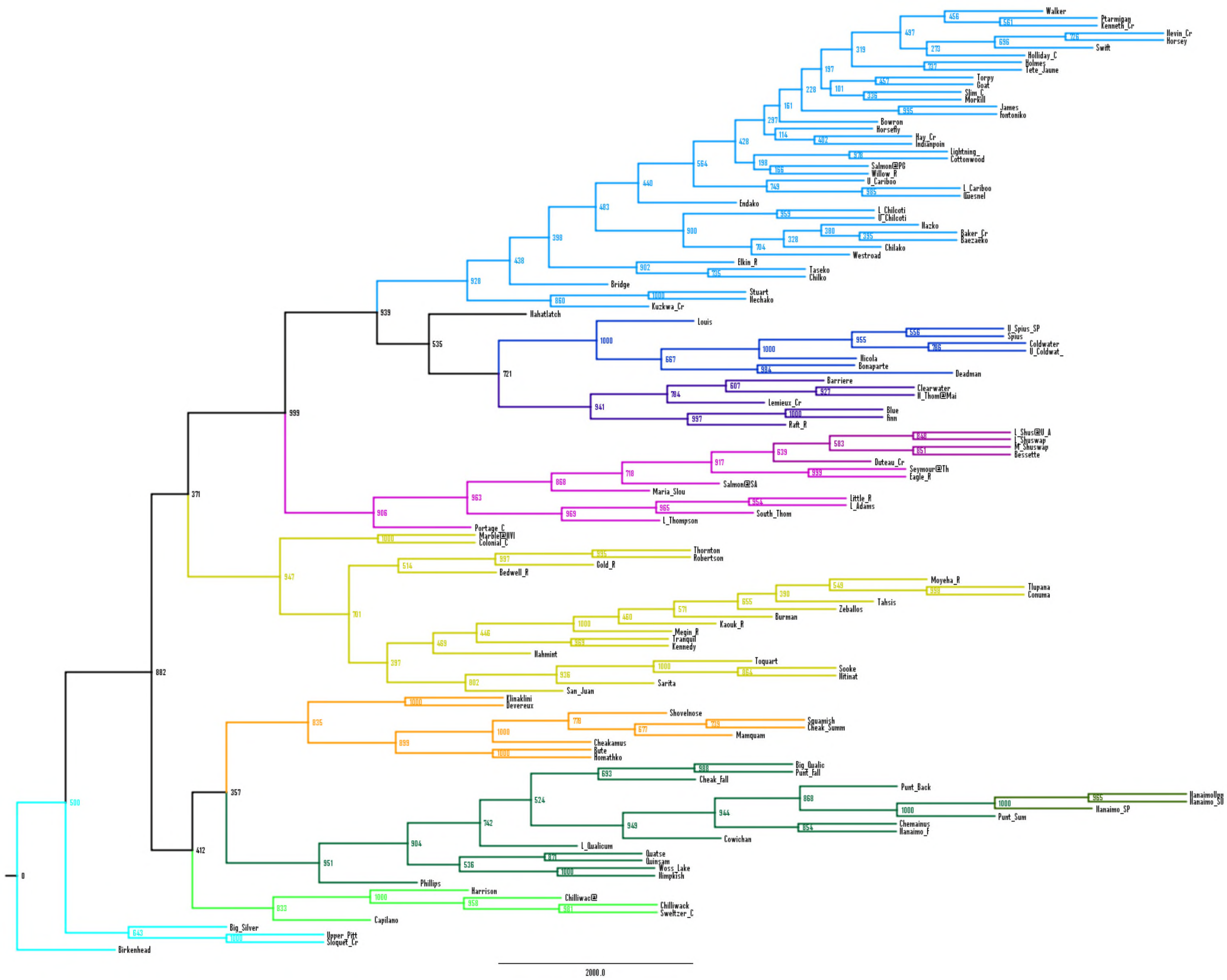


Figure 9. Consensus tree from bootstrap analysis of southern BC Chinook Salmon using the program PHYLIP. Branch lengths are a measure of the consensus of different runs (n=1,000). Figure for illustration purposes only.

Evolutionary Significance (Life History Variants / Spawn/Run Timing)

Evolutionary significance of a population is based on demonstrated local adaptation (*E*2) and on the likelihood that the loss of a population would lead to a gap in the geographic range (*E*4). Two attributes of Chinook Salmon meet these criteria: (1) life-history variants; and (2) spawn/run-timing differences.

Life History Variants

Chinook Salmon are unique among species of Pacific salmon in the wide variety of strategies they exhibit at all life stages, including: variation in the age at which juveniles disperse from their natal streams; length of freshwater, estuarine and ocean residence; ocean distribution; and age/timing of the spawning migration (Brown *et al.* 2013a). Differences in timing of when Chinook Salmon go to open water lead to distinct life-history variants that do not readily interbreed, even though the Chinook Salmon population in a given geographic area is often a mixture of types (Healey 1991, 2001). Originally framed dichotomously as stream and ocean behavioural types, stream-type Chinook Salmon were understood to spend a year in freshwater before migrating to the ocean, and return to freshwater early to spawn farther inland. Ocean-type Chinook Salmon were understood to migrate to the ocean a few weeks to months after emerging from gravel, and return late to spawn a short distance inland.

In recent decades, it is considered more accurate to frame Chinook Salmon life-history strategies along a continuum ranging from ocean-type to stream-type. Variations within the ocean-type and stream-type behavioural forms have been identified based on the geographic origins of the fish and the resulting conditions to which they have adapted (Brannon *et al.* 2004). Many local adaptations have resulted in atypical return timing and freshwater rearing strategies (Healey 1991; Waples *et al.* 2004). Ocean-type Chinook Salmon can rear in freshwater for up to six months post-emergence, while in some systems, stream-type Chinook Salmon may only remain in freshwater for a few weeks. This variation is critical for Chinook Salmon persistence as it spreads risk across many different strategies in the face of variable climatic conditions (Bradford and Taylor 1997).

Spawning Chinook Salmon populations at opposite ends of the strategy continuum are generally geographically separated to a considerable degree (there are exceptions) (Bailey pers. comm. 2018). Ocean-type life-history variants dominate all runs south of the Alaskan border except the Yakoun River on Haida Gwaii (the Queen Charlotte Islands), the Fraser River, and the Columbia River. Stream-type life-history variants make an important contribution to runs south of the BC-Alaska border/Dixon Entrance. Wherever the two ends of the continuum are sympatric, stream-type variants are found more frequently in headwater spawning areas and ocean-type variants occur more frequently in downstream spawning areas (Rich 1925; Hallock *et al.* 1957; Healey and Jordan 1982).

Evidence suggests that ocean-type and stream-type variants have different racial origins (Healey 1991; Waples *et al.* 2004). Waples *et al.* (2004) note that within the Columbia River, the two lineages behave essentially as two different species with little evidence of gene flow, despite co-migrating through large areas of riverine and ocean habitat, and in some cases spawning in adjacent systems (alternative interpretations suggest that ocean-type and stream-type Chinook Salmon south of the Upper Columbia River Basin share the same lineage – see Moran *et al*. 2013). Similar situations also exist within the Thompson basin of the Fraser River (Fraser *et al.* 1982; Candy *et al.* 2002; Bailey unpublished data). Various authors (e.g., McPhail and Lindsey 1986, Healey 1991, and Waples *et al.* 2004) have postulated that the two lineages may have arisen from different glacial refugia (‘Beringia’ in the north and ‘Cascadia-Columbia’ in the south), and then become locally adapted since the last ice age. Within the Fraser River CUs there is much diversity in terms of freshwater rearing, ocean distributions, and return run-timing. Both stream- and ocean-type variants are represented, and many of the interior Fraser CUs are thought to be descended from Beringia-origin stream-type variants. Other populations on the South Coast, excluding some of the Fraser River stock groups, are thought to be of Cascadia-Columbia origin, and appear to be resident in waters over the continental shelf (Brown *et al.* 2013a).

Each JAZ was examined for information regarding the presence of different life-history variants. If both types were present, two separate DUs were defined within that JAZ. Since some genetic ‘straying’ is known to occur (Waples *et al* 2004; Walter *et al* 2009), when genetic information was available, it was used to confirm that the populations in the DUs were not interbreeding.

Spawn/Run Timing

Spawn timing is the time of year when sexually mature individuals complete migration, reach spawning grounds, and reproduce. Chinook Salmon sexual maturation can occur during the first to the seventh year (Bailey pers. comm. 2018). The most common age at maturity varies among populations and females generally have an older average age at maturity than males (Quinn 2005; DFO unpublished data). Spawn timing can precede actual spawning activity by weeks, or even months for some individual spawning populations. Genetics and environmental factors appear to be the primary determinants of these characteristics for individual populations (Quinn 2005).

Beacham and Murray (1990) consider spawn timing for Chinook Salmon and other salmon species to be evidence of local adaptation and timing differences are thought to limit the capacity for interbreeding (Waples *et al.* 2004). Within BC, peak ‘in-migration’ timing for northern Chinook Salmon populations generally occurs from July to September, and for southern populations from April to September (Bailey pers. comm. 2018). Within a given river system, multiple populations may co-exist, each with different spawning times and occupying specific reaches of the river (Parken *et al.* 2008). The diversity of timing strategies demonstrates the specificity of thermal requirements for hatching and emergence of fry, as well as the need to synchronize these requirements with other environmental factors such as food availability and hydraulic conditions.

Typically, spawn timing is expressed as run-timing in the literature. For example, to estimate run-timing from spawn timing, Holtby and Ciruna (2007) use a linear regression model.

mean DOY spawning = 161.4 + 0.482 median DOY migration	$r^2_{adj} = 0.595$ $SE_{est} = 20.75$ $F_{1,49} = 74.4; P < 0.0001$

Run timing is the time at which adult Chinook Salmon begin their return migration to natal streams. Waples *et al.* (2004) provide standardized run-timing definitions (Table 4) that are used to classify southern BC Chinook Salmon populations (Parken *et al.* 2008).

Table 4. Adult return run-timing definitions as outlined by Waples *et al.* (2004). This table is a reproduction of Table 1 in Brown *et al.* 2013a.

Migration Timing (Month)	Timing Name
March – May	Spring
June	Early Summer
July	Mid-Summer
August	Late Summer
September-November	Fall
December-February	Winter

The New Salmon Escapement Database System (NuSEDS) records run-timing as specific dates. These dates are available for multiple sites in some JAZs. If there are sufficient observations for a given population in more than one run-timing categorization, the average Day-of-Year (DOY) of the different spawn timing groups is calculated and compared for statistical significance using an ANOVA. If the difference is found to be statistically significant, the groups are separated into different DUs. DUs that contain only one run-timing group are simply classified according to JAZ name.

Summary of Overall Approach

In this analysis, populations were first distinguished by ecotype (i.e., the JAZ), then if required, they were distinguished by run-timing. For each life-history variant in a given JAZ, available information was reviewed for spawn/run-timing differences. If more than one run-timing group was present for a given life-history type in a given JAZ, each run-timing group was defined as its own DU. When available, genetic data were compared to confirm that the Chinook Salmon from DUs with different run-timing were not interbreeding. While gene flow is not large among Chinook Salmon DUs, it does occur (Waples *et al*. 2004; Walter *et al*. 2009).

Results

The DU designations established using the methods described above are summarized below and in Table 5. Corresponding CU designations are also included in Table 5 to illustrate the key similarities and differences in results using each approach.

Distinctiveness - Geography (Ecotype)

Based on ecotype, of the 19 JAZ identified in southern BC, seven contained a single discernible population (Boundary Bay–Georgia Straight, Fraser Canyon–Georgia Straight, Upper Fraser River, Lower Thompson–Georgia Straight, South Coast–Georgia Straight, South Coast–Southern Fjords, East Vancouver Island–Southern Fjords). The remaining 12 JAZ contained multiple populations based on evolutionary significance characteristics (life-history types, run-timing, and/or spawn timing groups), and required further analysis.

Evolutionary Significance - Life History

Four of the 12 JAZ with multiple population groups contained both ocean and stream life-history variants. Two of these four, South Thompson–Georgia Straight (STh-GStr) and Homathko–Southern Fjords (HK-Sfj), were each found to contain two distinct DUs, one stream-type population and one ocean-type population. The remaining two JAZ required further analysis. In the Lower Fraser River–Georgia Straight (LFR–GStr) JAZ, the populations corresponding to each type of life-history variant were both found to have further divergences. In the East Vancouver Island–Georgia Straight (EVI–GStr) JAZ, the stream-type population was found to be unique, while the ocean-type population had further divergences.

Evolutionary Significance - Spawn/Run Timing

Four of the 12 JAZ with multiple population groups contained multiple run-timing groups. In Lower Fraser River-Georgia Strait (LFR–GStr), ocean-type populations occurred with run-timings in both fall and summer, and stream-type populations occurred with run-timings in both spring and summer. The Middle Fraser River–Georgia Straight (MFR–GStr) JAZ only contained stream-type variants but these had run-timings in the spring, summer, and fall. Similarly, North Thompson River–Georgia Straight (NTh-GStr) contained only stream-type variants, but with separate runs in the spring and summer. EVI–GStr ocean-type variants were observed to have runs in both the summer and the fall.

These populations were separated into different DUs based on run-timing. When available, Day-of-Year (DOY) spawn timing data were also analyzed to determine if the runs required further separation. However, only 12 populations contained more than one spawn timing categorization, and only four had a sufficient number of observations in more than one category (Holtby and Ciruna 2007). Evaluation led to the further division of two groups into five separate DUs: the LFR–GStr stream-type summer run, which was found to have two different spawn timing groups, and the EVI ocean-type fall run, which was found to have three different spawn timing groups.

Comparison to CU designation

Although the WSP CU designations differ from the DU designations defined in this report, they share some similarities. The greater emphasis placed on neutral loci genetic differences by the WSP CU methodology compared to the DU process led to a larger number of CUs (Figure 10).

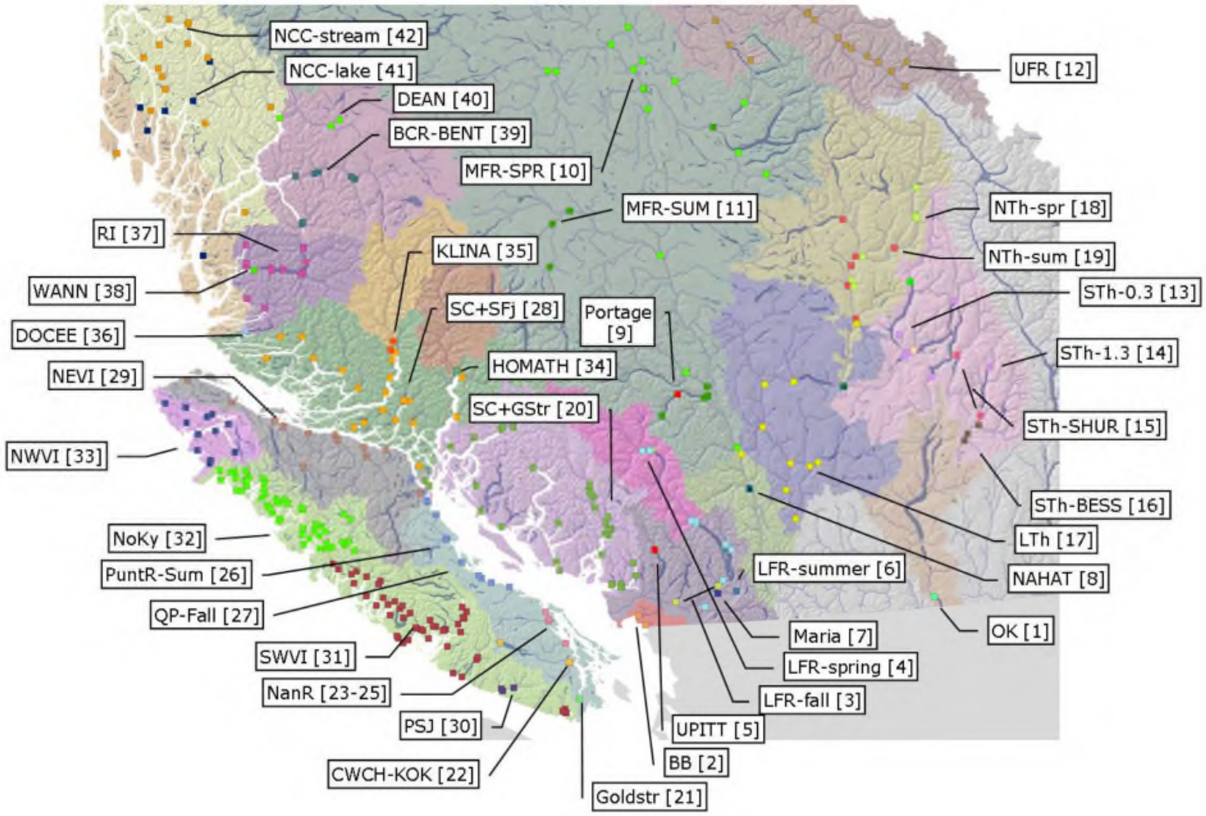


Figure 10. Chinook Salmon CUs in the southern and central British Columbia. This figure is a reproduction of Figure 58 in Holtby and Ciruna (2007).

Table 5. Accepted DU designation for southern BC Chinook Salmon with rationale. Wild Salmon Policy (WSP) Conservation Units (CUs) for Chinook Salmon are also presented for comparison (LHV = life-history variant; RT = run time; DOY = day-of-year).

DU Number	DU Name	DU Short name	JAZ	Life History	Run Timing	CU ID	CU Name	CU Code	Basis for CU Designation	Basis for DU Designation	Rationale
1	Southern Mainland - Boundary Bay, Ocean, Fall population	BB+GStr/Ocean/Fall	BB+GStr	Ocean	Fall	CK-02	CK_Boundary Bay_FA_0.3	BB	Life history, geography	Geography	Only one LHV type and RT within this JAZ
2	Lower Fraser, Ocean, Fall population	LFR+GStr/Ocean/Fall	LFR+GStr	Ocean (Immediate)	Fall	CK-03	CK_Lower Fraser River_FA_0.3	LFR-fall	Life history and run-timing.	Geography, life-history, and run-timing	There are five distinct LHV type/RT combinations in this JAZ. These sites also group together genetically, distinct from other Lower Fraser River sites.
3	Lower Fraser, Stream, Spring population	LFR+GStr/Stream/Spring	LFR+GStr	Stream	Spring	CK-04	CK_Lower Fraser River_SP_1.3	LFR-spring	Life history and run-timing	Geography, life-history, and run-timing	There are five distinct LHV type/RT combinations in this JAZ. These sites also group together genetically, distinct from the other Lower Fraser River sites.

DU Number	DU Name	DU Short name	JAZ	Life History	Run Timing	CU ID	CU Name	CU Code	Basis for CU Designation	Basis for DU Designation	Rationale
4	Lower Fraser, Stream. Summer (Upper Pitt) population	LFR+GStr/Stream/Summer (Upper Pitt)	LFR+GStr	Stream	Summer	CK-05	CK_Lower Fraser River-Upper Pitt_SU_1.3	LFR-UPITT	Spawn and run-timing (DOY analysis)	Geography, life-history, and run-timing	There are five distinct LHV type/RT combinations in this JAZ. Spawn timing difference between DU4 and 5 is sufficient to demonstrate evolutionary significance (DOY analysis).
5	Lower Fraser, Stream, Summer population	LFR+GStr/Stream/Summer	LFR+GStr	Stream	Summer	CK-06	CK_Lower Fraser River_SU_1.3	LFR-summer	Spawn and run-timing (DOY analysis)	Geography, life-history, and run-timing	There are five distinct LHV type/RT combinations in this JAZ. Spawn timing difference between DU4 and 5 sufficient to demonstrate evolutionary significance (DOY analysis).
6	Lower Fraser, Ocean, Summer population	LFR+GStr/Ocean/Summer	LFR+GStr	Ocean	Summer	CK-07	CK_Maria Slough_SU_0.3	Maria	Geography (otherwise similar to CU-13)	Geography, life-history, and run-timing	There are five distinct LHV type/RT combinations in this JAZ. This DU also groups genetically with DU12 rather than other Lower Fraser DUs
7	Middle Fraser, Stream, Spring (FRCany+GStr) population	FRCany+GStr/Stream/Spring	FRCany+GStr	Stream	Spring	CK-08	CK_Middle Fraser-Fraser Canyon_SP_1.3	NAHAT	Genetics	Geography	Only one LHV type and RT within this JAZ
8	Middle Fraser, Stream, Fall population	MFR+GStr/Stream/Fall	MFR+GStr	Stream	Fall	CK-09	CK_Middle Fraser River - Portage_FA_1.3	Portage	run-timing	Geography, life-history, and run-timing	There are four distinct RTs in this JAZ. This site is also genetically distinct from other Mid-Fraser River DUs.
9	Middle Fraser, Stream, Spring (MFR+GStr) population	MFR+GStr/Stream/Spring	MFR+GStr	Stream	Spring	CK-10	CK_Middle Fraser River_SP_1.3	MFR-spring	Run timing	Geography, life-history, and run-timing	There are four distinct RTs in this JAZ.
10	Middle Fraser, Stream, Summer population	MFR+GStr/Stream/Summer	MFR+GStr	Stream	Summer	CK-11	CK_Middle Fraser River-SU_1.3	MFR-summer	Run timing	Geography, life-history, and run-timing	There are four distinct RTs in this JAZ
11	Upper Fraser, Stream, Spring population	UFR/Stream/Spring	UFR	Stream	Spring	CK-12	CK_Upper Fraser River_SP_1.3	UFR-spring	Run timing	Geography, life-history, and run-timing	There are four distinct RTs in this JAZ. The run-timing of the Upper Fraser is different from DU9.
12	South Thompson, Ocean, Summer population	STh+GStr/Ocean/Summer	STh+GStr	Ocean	Summer	CK-13	CK_South Thompson_SU_0.3	STh-0.3	Life history, age and spawning location (genetics similar to CU-07)	Geography and life-history	There are two distinct LHV types within this JAZ. The differences in spawn timing between the different CUs in this DU are not sufficient to demonstrate significance.
						CK-15	CK_Shuswap River_SU_0.3	STh-SHUR	Genetics (otherwise similar to CU-13)		
13	South Thompson, Stream, Summer 1.3 population	STh+GStr/Stream/Summer/1.3	STh+GStr	Stream	Summer	CK-14	CK_South Thompson_SU_1.3	STh-1.3	Life history, age and genetics.	Geography and life-history	There are two distinct LHV types within this JAZ. Like DU14, this DU is stream-type. Unlike DU14, it has a 4-year generation time, typical of Chinook Salmon (nuSEDS avg. generation time is 4.5yrs based on Dome Creek Spring proxy).

DU Number	DU Name	DU Short name	JAZ	Life History	Run Timing	CU ID	CU Name	CU Code	Basis for CU Designation	Basis for DU Designation	Rationale
14	South Thompson, Stream, Summer 1.2 population	STh+GStr/Stream/Summer/1.2	STh+GStr	Stream	Summer	CK-16	CK_South Thompson-Bessette Creek_SU_1.2	STh-BESS	Life history, age and genetics.	Geography and life-history	There are two distinct LHV types within this JAZ. Like DU13, this DU is stream-type. Unlike DU13, it has a 3-year generation time, atypical of Chinook Salmon (nuSEDS avg. generation time is 4.1yrs based on Nicola River Spring proxy)
15	Lower Thompson, Stream, Spring population	LTh+GStr/Stream/Spring	LTh+GStr	Stream	Spring	CK-17	CK_Lower Thompson_SP_1.2	LTh	Genetics, run-timing and age	Geography	Only one LHV type and RT within this JAZ. These sites also group together genetically.
16	North Thompson, Stream, Spring population	NTh+GStr/Stream/Spring	NTh+GStr	Stream	Spring	CK-18	CK_North Thompson_SP_1.3	NTh-spr	Genetics, run-timing and age	Geography, life-history, and run-timing	There are two distinct RTs in this JAZ.
17	North Thompson, Stream, Summer population	NTh+Gstr/Stream/Summer	NTh+GStr	Stream	Summer	CK-19	CK_North Thompson_SU_1.3	NTh-sum	Run timing	Geography, life-history, and run-timing	There are two distinct RTs in this JAZ
18	South Coast - Georgia Strait, Ocean, Fall population	SC+GStr/Ocean/Fall	SC+GStr	Ocean	Fall	CK-20	CK_Southern Mainland-Georgia Strait_FA_0.x	SC-GStr	Geography (modelled after Coho and Chum Salmon CU structure)	Geography	Only one LHV type and RT within this JAZ
19	East Vancouver Island, Stream, Spring population	EVI+GStr/Stream/Spring	EVI+GStr	Stream	Spring	CK-23	CK_East Vancouver Island-Nanaimo_SP_1.x	NanR-spr	Run timing and life-history	Geography, life-history, and run-timing	There are three distinct combinations of LHV type/RT in this JAZ.
20	East Vancouver Island, Ocean Summer, population	EVI+GStr/Ocean/Summer	EVI+GStr	Ocean	Summer	CK-83	Vancouver Island-Georgia Strait_SU_0.3	EVIGStr-sum	Genetics, ecotypology and run-timing	Geography, life-history, and run-timing	There are three distinct combinations of LHV type/RT in this JAZ.
21	East Vancouver Island, Ocean, Fall population	EVI+GStr/Ocean/Fall	EVI+GStr	Ocean	Fall	CK-21	CK_East Vancouver Island-Goldstream_FA_0.x	Goldstr	Genetics	Geography, life-history, and run-timing	There are three distinct combinations of LHV type/RT in this JAZ. The CUs combined in this DU do not have sufficient evidence of differences in spawn timing to demonstrate significance (data are limited).
						CK-22	CK_East Vancouver Island-Cowichan & Koksilah_FA_0.x	CWCH-KOK	Genetics and run-timing		
						CK-25	CK_East Vancouver Island-Nanaimo & Chemainus_FA_0.x	midEVI-fall	Genetics and run-timing		
						CK-27	CK_East Vancouver Island-Qualicum & Puntledge_FA_0.x	EVI+GStr	Genetics and run-timing		
22	South Coast - Southern Fjords, Ocean, Fall population	SC+SFj/Ocean/Fall	SC+SFj	Ocean	Fall	CK-28	CK_Southern Mainland-Southern Fjords_FA_0.x	SC+SFj	Run timing and habitat	Geography	Only one LHV and RT within this JAZ.
23	East Vancouver Island, Ocean, Fall (EVI + SFj) population	EVI+SFj/Ocean/Fall	EVI+SFj	Ocean	Fall	CK-29	CK_East Vancouver Island-North_FA_0.x	NEVI	Run timing and habitat	Geography	Only one LHV and RT within this JAZ.

DU Number	DU Name	DU Short name	JAZ	Life History	Run Timing	CU ID	CU Name	CU Code	Basis for CU Designation	Basis for DU Designation	Rationale
24	West Vancouver Island, Ocean, Fall (South) population	WVI/Ocean/Fall (South)	WVI+WVI	Ocean	Fall	CK-31	CK_West Vancouver Island-South_FA_0.x	SWVI	Run timing (and habitat - based on CU tombstone)	Geography, life-history, and run-timing	There are two distinct RTs in this JAZ. The differences are within the fall RT 'group' but are enough to demonstrate significance.
25	West Vancouver Island, Ocean, Fall (Nootka & Kyuquot) population	WVI/Ocean/Fall (Nootka & Kyuquot)	WVI+WVI	Ocean	Fall	CK-32	CK_West Vancouver Island-Nootka & Kyuquot_FA_0.x	NoKy	Run timing and spawn timing	Geography, life-history, and run-timing	There are two distinct RTs in this JAZ. The differences are within the fall RT 'group' but are enough to demonstrate significance.
26	West Vancouver Island, Ocean, Fall (WVI + WQCI) population	WVI+WQCI/Ocean/Fall	WVI+WQCI	Ocean	Fall	CK-33	CK_West Vancouver Island-North_FA_0.x	NWVI	Ecotype classification	Geography, life-history, and run-timing	Only one LHV type and RT within this JAZ.
27	Southern Mainland, Ocean, Summer population	HK+SFj/Ocean/Summer	HK+SFj	Ocean	Summer	CK-34	CK_Homathko_SU_x.x	HOMATH	Genetics	Geography and life-history	Two distinct LHV types in this JAZ.
28	Southern Mainland, Stream, Summer population	HK+SFj/Stream/Summer	HK+SFj	Stream	Summer	CK-35	CK_Klinaklini_SU_1.3	KLINA	Genetics	Geography and life-history	Two distinct LHV types in this JAZ.

Special Significance

Chinook Salmon are one of five anadromous and semelparous species of Pacific salmon native to North America (Healey 1991). Chinook Salmon constitute a key component of natural ecosystems, being an important food source for other piscivorous fish and for certain marine mammals. For example, the fish is a very important prey species for ‘resident’ fish-eating killer whales (*Orcinus orca*) in southern British Columbia (BC), whose survival has been linked to Chinook Salmon abundance on the west coast (Ford and Olesiuk 2012). In Georgia Strait during summer months, nearly 80% of DNA sequences found in killer whale fecal samples are from Chinook Salmon (Ford *et al.* 2016). The fish species is also highly significant to First Nations and Métis in BC as a cultural symbol and source of food (Brown *et al.* 2013a; COSEWIC 2014), and represent an important target species for recreational and commercial fisheries in BC (Brown *et al.* 2013a).

The distribution of Chinook Salmon on Vancouver Island, Sunshine Coast, and the Fraser River overlaps with the traditional territory and interests of more than 170 different First Nations and Tribal Councils (COSEWIC 2014). Chinook Salmon are a culturally defining species and often the most highly desired fish amongst Nations across the species’ range. Salmon (including Chinook Salmon) form an important foundation of tribal cultures with economic, nutritional, cultural, and spiritual significance. In addition to providing a highly desired food source, Chinook Salmon have been used both historically and currently for sale or trade, various ceremonies, and as the basis of many stories related to First Nation origins (COSEWIC 2014).

Chinook Salmon is also a species of high economic and recreational value along the entire western Pacific coast from California to Alaska as well as elsewhere in the world where this fish occurs naturally, or has been successfully naturalized (Brown *et al.* 2013a).

The history of human interaction with Chinook Salmon is long and extensive in the western Pacific and as a consequence, significant fisheries targeting this species have evolved in all regions. These fisheries occur as regulated commercial and recreational activities in marine inshore and offshore areas, as well as in tidal and non-tidal portions of river systems. Fishing activities involve a variety of gear types with the principal capture methods relying on hook-and-line gear (troll and recreational fisheries) and gill and seine net gear. In marine areas, Chinook Salmon are also caught as by-catch in certain fisheries, e.g., pollock fisheries in the Gulf of Alaska. In certain freshwater systems, traditional capture methods are still employed by First Nations. Fishery participants include many First Nations, licensed commercial fishers who are First Nations and non-First Nations in origin, and members of the general public (citizens of BC and visitors to BC) who fish for recreational enjoyment or as fishing guides for the purpose of earning income (Brown *et al.* 2013a).

DISTRIBUTION

Global Range

Spawning populations of Chinook Salmon are distributed from northern Hokkaido (Japan) to the Anadyr River (Russia) on the Asian coast, and from central California to the MacKenzie River (Northwest Territories, Canada) along the North American coast (McPhail and Lindsey 1970; Major *et al.* 1978; Bailey pers. comm. 2018) (Figure 11). The species may be establishing new populations at higher latitudes (e.g., Arctic regions of Alaska – see Dunmall *et al.* 2013), possibly due to global warming and other climatic changes (Heard *et al.* 2007). Recent evidence for range expansion comes in the form of annual catches of adult Chinook Salmon by subsistence fisheries near Point Barrow, and the collection in 2004 of four adult Chinook Salmon in Ublutuoch River, a tributary stream near the mouth of the Coville River, Alaska (Heard *et al.* 2007). Occasional records exist of Chinook Salmon captures in the Canadian Arctic; however, there are no current records of continuous spawning (McLeod and O'Neill 1983; Stephenson 2006; Irvine *et al*. 2009; Dunmall *et al.* 2013).

Chinook Salmon have also been introduced by humans into areas beyond their natural range. Successful transplants have established spawning populations of Chinook Salmon in New Zealand (McDowall 1994), and in the Great Lakes and tributary streams (e.g., Lake Michigan, Lake Superior, Lake Ontario) (Carl 1982). Chinook Salmon were also transplanted to Chile, and landlocked populations rapidly established in Chilean and Argentinian rivers (Becker *et al.* 2007).

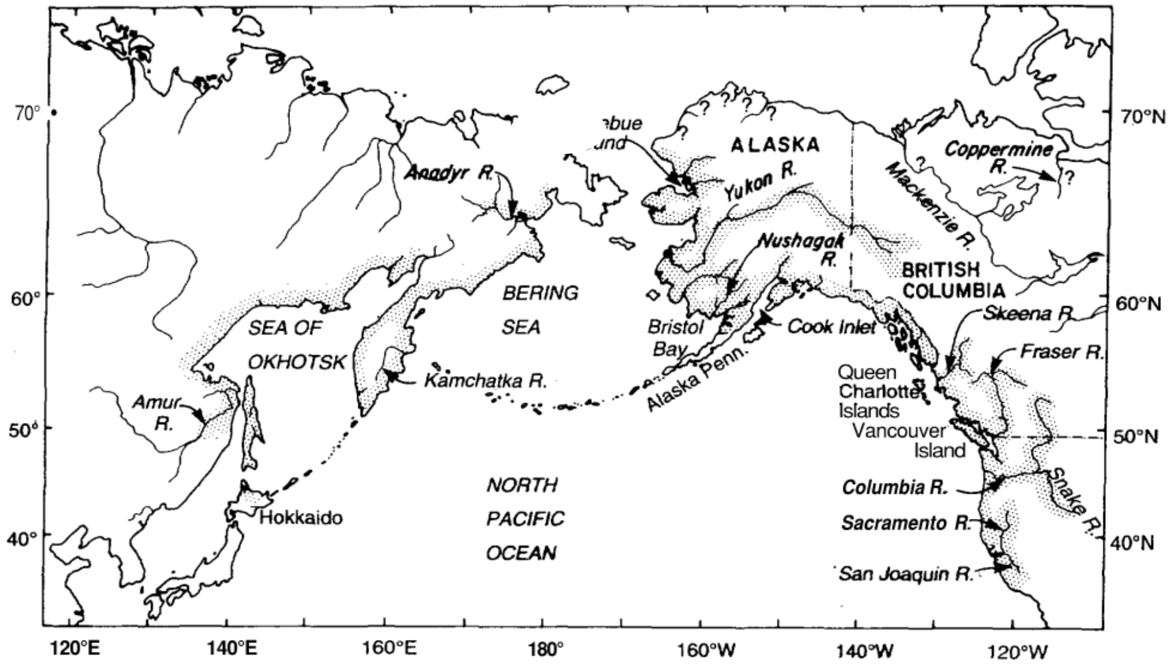


Figure 11. Map of the North Pacific Ocean and Bering Sea, showing the distribution of Chinook Salmon spawning populations (stippled). This figure is a reproduction of Figure 3 in Healey 1991.

Canadian Range

Chinook Salmon are native to rivers along the entire west coast of Canada, and may also be found in rivers on the Canadian Arctic coast (McLeod and O'Neill 1983; Stephenson 2006; Irvine *et al*. 2009; Dunmall *et al.* 2013) (Figure 12, Figure 13). McLeod and O'Neil (1983) reported recovering a single specimen from the Liard River in the upper Mackenzie River drainage, and Hart (1973) cited an unpublished report of 13 specimens from the Coppermine River. Chinook Salmon also occur in the Okanagan River, between McIntyre Dam at the outlet of Vaseux Lake (near Oliver, BC) and the north basin of Osoyoos Lake near the border with Washington State (COSEWIC 2006).

Chinook Salmon are characterized by high plasticity and life-history variability, so it is not surprising that the species may be responding to warming climatic conditions in Arctic environments by expanding its range into new regions, especially into the Beaufort Sea drainages of North America (McLeod and O'Neill 1983; Stephenson 2006; Irvine *et al*. 2009; Dunmall *et al.* 2013).

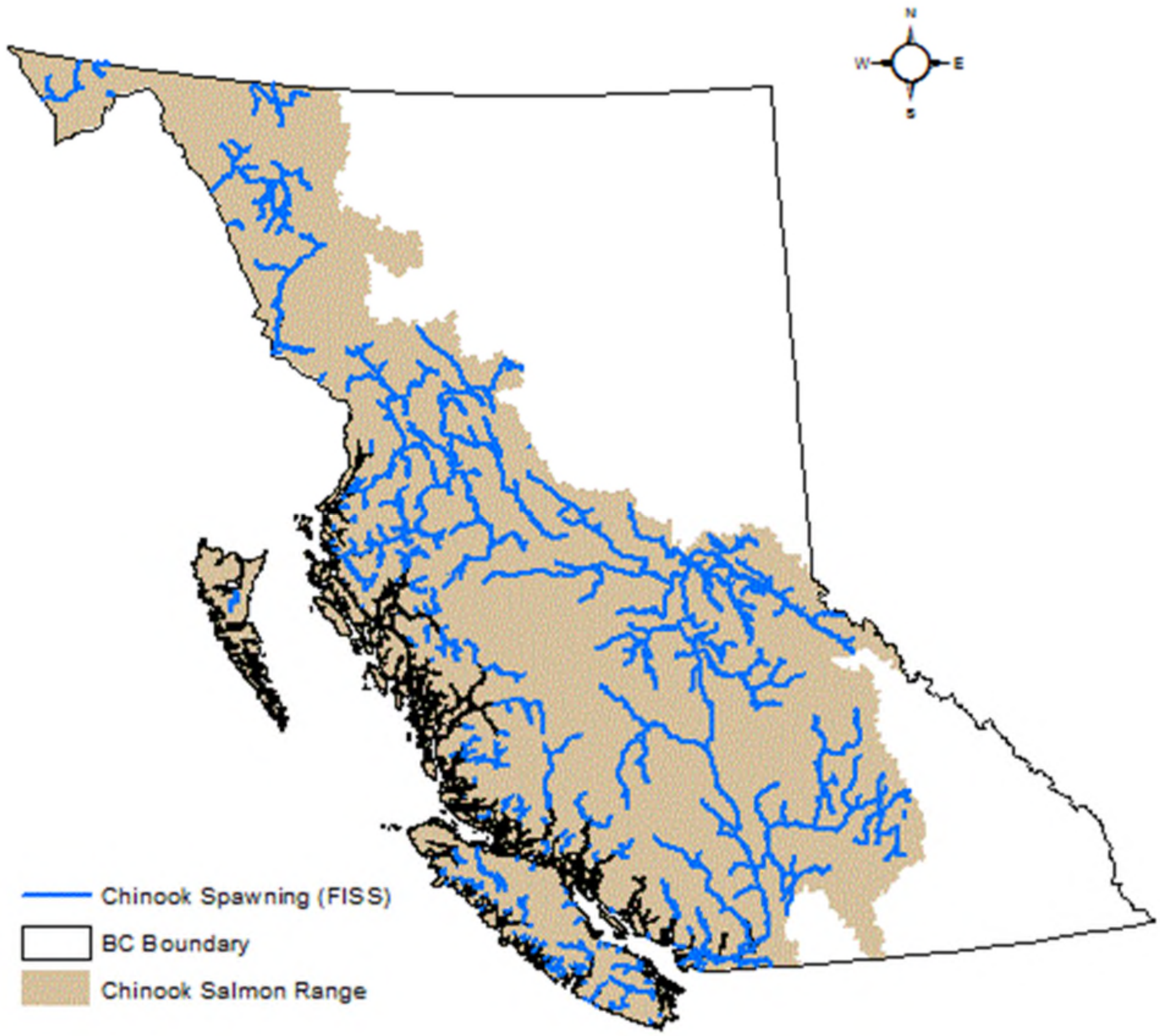


Figure 12. British Columbia range of Chinook Salmon including known Chinook Salmon spawning streams from the Fisheries Information Summary System (FISS).

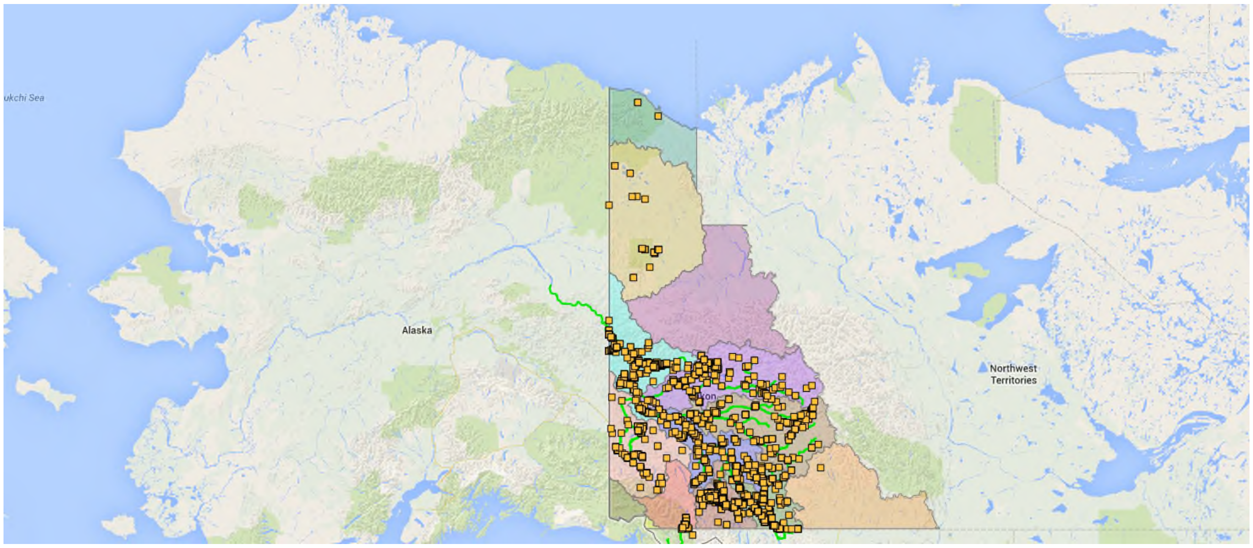


Figure 13. Yukon range of Chinook Salmon based on spawning sightings from Yukon FISS (http://cmnmaps.ca/fiss_yukon/) accessed May 16, 2014.

Extent of Occurrence and Area of Occupancy

Information about extent of occurrence and area of occupancy for southern BC Chinook Salmon is presented for each Designatable Unit (DU).

A comprehensive source of distributional data does not currently exist for southern BC Chinook Salmon populations. Definition and application of quantitatively rigorous measures of population distribution have been covered extensively for Sockeye Salmon populations in the Fraser River (see de Mestral Bezanson *et al.* 2012). Similar methods should in principle be developed and applied to Chinook Salmon where possible. As an interim proxy for distributional metrics for each CU, Brown *et al.* (2013a) provide the number of watersheds, the total watershed area, and the length of known Chinook Salmon spawning habitat. As discussed, CU delineations are defined by life history (i.e., run-timing), genetics and ecotypology and are limited to Canadian freshwater systems (Holtby and Ciruna 2007). Since each DU is based on adapted CU metrics, marine areas are not directly included in DU delineations. However, marine ranges are indirectly considered through the ecotypology component, where each CU is assigned a freshwater adaptive zone and marine adaptive zone which, combined, make up a Joint Adaptive Zone (JAZ=FAZ+MAZ). Direct inclusion of marine areas would result in very large extents of occurrence and areas of occupancy and would preclude comparisons across DUs.

HABITAT

Habitat Requirements

Chinook Salmon spawning occurs from near tidal influence to between 1,000 (ocean-type) and 3,000 (stream-type) kms upstream near river headwaters (Diewart 2007). Chinook Salmon require an average of 16-24 m^2 of gravel per spawning pair (Burner 1951). Successful incubation requires stable flows that are adequate to supply enough oxygen, but not so high as to cause gravel movement or streambed scour. The substrate must be small enough to enable the fish to move it for redd construction, and large enough to allow sufficient through-flow for the incubating eggs and later for the developing alevins. Good subgravel flow is a key factor driving the choice of redd sites by all Chinook Salmon; this is because the relatively large size and small surface-to-volume ratio of Chinook Salmon eggs makes them sensitive to reduced oxygen levels. Provided the conditions of good subgravel flow are met, Chinook Salmon will spawn in a broad range of water depths, water velocities, and substrates (Scott and Crossman 1973; Healey 1991; Diewart 2007). This apparent need for sufficient subgravel flow may mean that suitable Chinook Salmon spawning habitat is more limited in most rivers than superficial observation might suggest (Healey 1991). In terms of thermal conditions, spawning Chinook Salmon require cooler water temperatures than those that can be tolerated during the adult migration. The optimum temperature range for egg and hatchling survival is 5-15°C (Leitritz and Lewis 1976; Van Vleck *et al.* 1988; McCullough 1999; Diewart 2007). If held constant, the upper and lower temperatures for 50% pre-hatch mortality of Chinook Salmon are 16°C and 2.5-3.0°C, respectively (Alderdice and Velsen 1978). The upper lethal temperature for Chinook Salmon fry is 25.1°C (Scott and Crossman 1973), although anecdotal evidence suggests this may be higher since Chinook Salmon fry were observed in 2017 feeding at 25°C in Coldwater River (Bailey pers. comm. 2018). Stock-specific differences in thermal tolerance may also occur (Perry *et al*. 2013; Plumb and Moffitt 2015).

Chinook Salmon rearing occurs in freshwater (streams, lakes), estuaries, and the ocean. In freshwater, juvenile abundance tends to be highest in shallow waters with low velocity and small substrate particle size, although individuals occur over a wide range of substrate types, water depths, and velocities (Chapman and Bjornn 1969; Everest and Chapman 1972). Older, larger fish tend to prefer higher velocity habitats and greater depths. Chinook Salmon rarely occur in still water or where velocity is greater than 30 cm/s (Murphy *et al.* 1989). Water temperatures of 10-14°C provide suitable rearing conditions (Scott and Crossman 1973; Van Vleck *et al.* 1988; McCullough 1999). Temperatures in excess of 18°C will disrupt juvenile migration to the sea (Yates *et al.* 2008).

While in freshwater, juvenile Chinook Salmon feed primarily on invertebrate species, including adult and larval insects. Optimal substrate for maintaining a diverse invertebrate population includes a combination of mud, gravel, and rubble. A pool:riffle ratio of about 1:1 appears to provide an optimal mix of food-producing and rearing habitat for Chinook Salmon in streams. Healthy, natural streamside vegetation is important for maintaining temperatures, controlling erosion and sedimentation, and supplying food items that are an important component of stream-type Chinook Salmon diets. Additionally, freshwater rearing habitat must have water of sufficient quality and quantity (Diewart 2007). Increasing evidence suggests that, in both winter and summer, groundwater and hyporheic water are important moderators of stream temperature and can create thermal refugia for stream-type Chinook Salmon (e.g., protection from anchor ice formation) (Bailey pers. comm. 2018).

Coastal estuaries provide an environmental transition zone, extensive opportunities for feeding and growth, and refuge from predators for rearing Chinook Salmon. As environmental transition zones, brackish estuaries allow juvenile Chinook Salmon an opportunity to acclimate from freshwater to saltwater and between waters of differing temperatures. These habitats provide substantial opportunities for feeding, and typically have higher food productivities than adjacent ocean or freshwater areas. Estuaries may thus offer the opportunity for enhanced growth and therefore, larger size at ocean entry, which may translate to higher marine survival (Quinn 2005). Another role of estuaries is to provide refuge from predators. The higher turbidity often associated with estuarine areas limits the ability of visual predators to key on salmon juveniles. The extensive aquatic vegetation associated with estuaries also provides important structural cover (Diewart 2007). These benefits are likely more important to ocean-type Chinook Salmon, since stream-types are larger when they enter the ocean and do not spend much time in the nearshore environment.

Chinook Salmon are thought to require productive nearshore marine habitats, and survival during the period of early ocean residence may influence total production (Brown *et al.* 2013a). Chinook Salmon generally remain in sheltered, nearshore environments for varying periods depending on factors such as food availability, competition, predation, and environmental conditions. Coastal areas provide a rich habitat with opportunities for feeding and growth. Throughout this period, kelp and other shoreline vegetation provide an important refuge from predators as well as a productive environment for plankton, a major dietary component for juvenile Chinook Salmon (Williams 1989; Healey 1991; Diewart 2007). Therefore, the health of coastal ocean ecosystems plays a key role in the production of Chinook Salmon stocks.

As they grow and mature, Chinook Salmon disperse widely throughout the North Pacific where they eat mainly small fish (primarily Herring and sandlance), with crab larvae, squid and large zooplankton also contributing to their diet. While migration patterns and other aspects of their marine ecology remain poorly understood, ocean residence is recognized as a very important component of the life cycle of all Pacific salmon. During their time at sea, Chinook Salmon migrate varying distances while increasing in size and acquiring the energy reserves required for reproduction. While distribution patterns vary among years and stocks, all stream-type Chinook Salmon utilize coastal and offshore habitats during a period of rapid growth that is critical to reproductive success (Diewart 2007).

Adult Chinook Salmon generally require access to their home spawning grounds to successfully reproduce at a sufficient level of fitness. Strays can reproduce successfully outside their natal streams, but may have lower fitness. Features such as human-made dams, beaver dams, waterfalls, or rock/mud slides that block upstream migration can limit access to spawning areas and impact production (Diewart 2007; Bailey pers. comm. 2018). Suitable adult homeward/upstream migration conditions are limited to areas and seasons where water temperatures are generally lower than 19°C (Yates *et al.* 2008). Adult Chinook Salmon stop migration and seek temperature refuges when water temperatures exceed 22°C (Alexander *et al.* 1998). Adult survival and the viability of unspawned eggs decline at temperatures greater than 16°C and less than 3°C (Van Vleck *et al.* 1988). If conditions such as high water temperature or extreme flows (high or low) are encountered when spawners arrive at their river of origin, fish will hold in the vicinity of the river mouth waiting for conditions to improve. This delay in river entry can adversely affect survival and spawning success as fish may be exposed to predation from marine mammals (Diewart 2007).

Habitat Trends

Habitat trends are discussed in detail within each DU's chapter. This section outlines general factors affecting freshwater and marine habitat.

Freshwater

The status of all Pacific salmon is closely linked to the availability of productive freshwater environments. Human-induced impacts have greatly reduced or eliminated historically accessible habitat and/or resulted in direct mortality of juvenile salmonids. Adverse impacts occur from water withdrawals, construction of dams (for power generation or water diversion) that limit fish passage or entrain/harm migrating fish, and degradation of habitat through industrial, agricultural and urban usage (Raymond 1988; Myers *et al.* 1998). Water quality is negatively affected by aquatic pollution (e.g., agricultural runoff, chemicals from industry), altered movement of sediments from terrestrial to aquatic environments (e.g., via road construction for forestry), and channelization/erosion leading to the loss of deep water refugia (Groot and Margolis 1991; Bailey pers. comm. 2018). Additionally, modification of natural flow regimes has resulted in a range of adverse impacts, including: increased water temperatures; changes in fish community structures; and depleted flows necessary for migration, spawning, rearing, flushing of sediments from spawning gravels, gravel recruitment and transport of large woody debris (NOAA Fisheries 2014a). The physical features of dams such as turbines and sluiceways also increase mortality of both adults and juvenile salmonids. The infrequent attempts in southern BC to mitigate adverse impacts of these structures have to date rarely met with success.

Marine

Scientists have long recognized the ocean's importance to salmon population dynamics (e.g., Pearcy 1992; Beamish 1993 Schindler *et al.* 2013). Chinook Salmon spend most of their life history, and gain more than 95% of their weight, while at sea. Two time periods are believed to be especially important: (1) the spring and summer months immediately after smolt outmigration; and (2) the first winter at sea (Beamish and Mahnken 2001). During winter, Chinook Salmon endure long periods of low forage and must rely on stored energy accumulated during the growing season for survival. As a result, conditions that cause changes in migration timing can lead to matches or mismatches with important prey resources and predators that ultimately translate into varying growth opportunities and differences in survival (e.g., Scheuerell *et al.* 2009; Holsman *et al.* 2012).

Natural and human-induced changes in the physical ocean environment (e.g., temperature/climate change) can affect salmon directly via physiological processes, as well as indirectly through impacts to the surrounding biological environment (e.g., food chain). For example, ocean conditions that benefit spiny dogfish (*Squalus acanthias*) and River Lamprey (*Lampetra ayresii*) in the Strait of Georgia lead to increased predation pressure on young Chinook Salmon (Beamish and Neville 2000). Studies of ocean conditions have focused on a range of temporal and spatial scales from large-scale phenomena and indices like the Pacific Decadal Oscillation (Mantua *et al.* 1997; Hertz *et al.* 2016b), the Arctic Oscillation Index, the North Pacific Index, the North Pacific Gyre Oscillation, and the Bering Sea Pressure Index (Scheuerell 2012; Hertz *et al.* 2016b; Malick *et al.* 2017) to direct measurements of regional physical conditions like sea surface temperature (Mueter *et al.* 2002 for Chum (*Oncorhynchus keta*), Sockeye (*O. nerka*), and Pink Salmon (*O. gorbuscha*)). Scheuerell (2012) found evidence that sea-level pressure and, to a lesser extent, sea temperature may contribute to some of the temporal trends observed in Chinook Salmon recruits-per-spawner among Arctic-Yukon-Kuskokwim Chinook Salmon stocks. Hertz *et al.* (2016b) found that Chinook Salmon smolt survival off the west coast of Vancouver Island can be linked to large-scale climate variability through feeding ecology. While associations between survival and large-scale climate indices do not provide a mechanistic explanation for which specific ocean processes are causing variation in survival, they do suggest that broad-scale changes in the environment are affecting the suitability of ocean conditions encountered by juvenile Chinook Salmon during their early marine life phase (Schindler *et al.* 2013).

Human-induced impacts on marine ecological processes also likely contribute to changes in ocean conditions that affect Chinook Salmon growth and survival. For example, a number of Chinook Salmon populations are supplemented (enhanced) by hatchery fish, and there is evidence that enhancement poses risks to natural populations. However, the effects of enhancement vary from DU to DU, and they are poorly understood because of data limitations. In the Bering Sea, hatchery production and distribution of other salmon species (Pink Salmon, Chum Salmon, Sockeye Salmon) in Chinook Salmon foraging areas may create conditions of increased competition for food (Myers *et al.* 2010; Ruggerone and Irvine 2018). Competition at sea can lead to reduced growth and survival, and potentially to lower reproductive potential among survivors (Ruggerone and Nielson 2009; Ruggerone and Agler 2010; Schindler *et al.* 2013). Industrial-scale marine fisheries can act as both competitor (e.g., reduction of key fish prey densities) and predator (e.g., salmon bycatch), thereby altering the productivity, community structure and dynamics through large removals of target species (Schindler *et al.* 2013). Finally, human-induced climate change is a significant factor affecting marine temperature regimes.

BIOLOGY

The general biology of Chinook Salmon is well documented in North America. The following sections draw heavily from Healey (1991) and Myers *et al.* (1998).

Life Cycle and Reproduction

The generalized life history of Pacific salmon involves incubation, hatching, and emergence in freshwater, freshwater rearing, migration to the ocean and subsequent initiation of maturation, and return to freshwater for completion of maturation and spawning (Myers *et al.* 1998). Juvenile rearing in freshwater can be minimal or extended; some male Chinook Salmon mature in freshwater, thereby forgoing emigration to the ocean (e.g 'jimmies', Bailey pers. comm. 2018; Johnson *et al.* 2012). Maturation occurs between the ages of one and seven, but is typically achieved by about age five (DFO 2008). Like many *Oncorhynchus* species, Chinook Salmon are semelparous (i.e., they die after spawning once) (Healey 1991).

Within this general life-history strategy, a continuum exists between two behavioural forms – ocean-type and stream-type. Life history variants occur along this continuum that express a range of tactics in both freshwater and ocean phases (see **Life History Variants**). Generalized life-history strategies of Chinook Salmon and the range of tactical variation within each behavioural type are illustrated in Figure 14 (from Healey 1991).

It is important to note that for Chinook Salmon that tend toward either end of the behavioural form continuum, competing views exist regarding the distinctiveness of genetic lineages (see Waples *et al.* 2004; Beacham and Withler 2010; Moran *et al*. 2012; Braun *et al.* 2015). The study of maternal lineage through mitochondrial DNA is one potential way to resolve these differences (Bailey pers. comm. 2018).

Generally, stream-type Chinook Salmon spend one or more years as fry or parr in freshwater before migrating to sea, perform extensive offshore oceanic migrations, and return to their natal stream in the spring or summer, several months prior to spawning. Occasionally, males of this form mature 'precociously' without ever going to sea (Johnson *et al.* 2012).

Ocean-type Chinook Salmon migrate to sea during their first year of life, normally within three months after emergence from the spawning gravel, spend most of their ocean life in coastal waters, and return to their natal stream in the fall, a few days or weeks before spawning (Healey 1991). Migration timing is not always correlated with spawning timing as the latter requires Chinook Salmon access to spawning grounds, which can in turn depend on freshet timing and suitable stream temperatures.

These life-history variations are thought to represent adaptation to uncertainties in juvenile survival and productivity within particular freshwater and estuarine nursery habitats. Chinook Salmon appear to have evolved a variety of juvenile and adult behaviour patterns that serve to spread the risk of mortality across years and across habitats (e.g., Stearns

1976; Real 1980). Disastrously high mortality in any particular year or habitat can thus be ameliorated (Healey 1991). Risk is also mitigated by the fact that Chinook Salmon have a variable maturation schedule with spawning occurring between ages 2-5 for ocean-type life-history variants and between 3-7 for stream-type life-history variants (Bailey pers. comm. 2018).

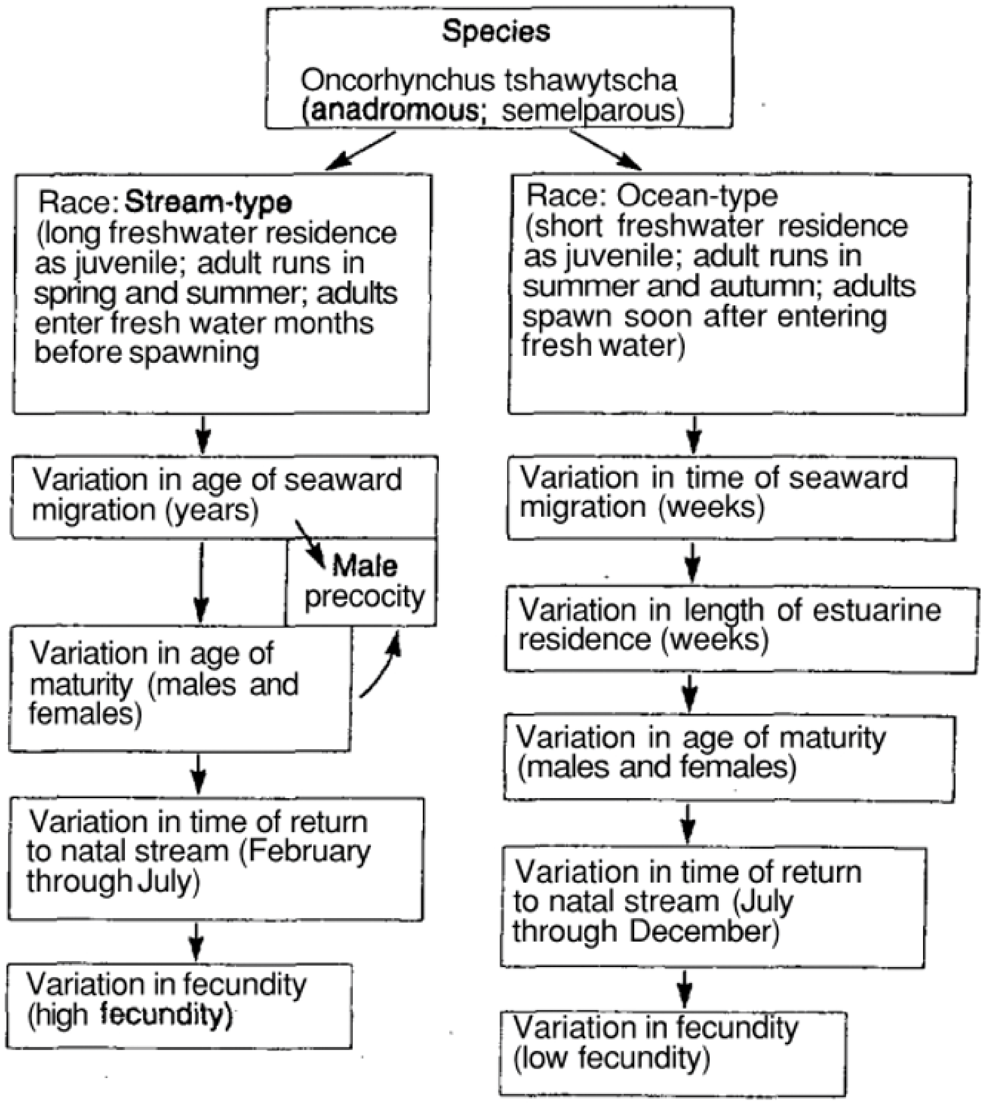


Figure 14. Life history structure of Chinook Salmon showing the division of the species into two types (ocean and stream), and the range of tactical variation within each type, which leads to a continuum between the two rather than a truly discrete dichotomous split. This figure is a reproduction of Figure 1 in Healey 1991.

In preparation for spawning, the female Chinook Salmon digs a depression in the gravel of the stream bottom by performing vigorous swimming movements on her side near the bottom. Gravel and sand thrown out of the depression accumulate in a mound, or tailspill, at the downstream margin of the depression. Once the nest is complete, the female deposits a group or "pocket" of eggs in the depression which are fertilized by one or more males; she then moves to a spot immediately upstream and repeats the process. The material removed by digging in the new site covers the fertilized eggs in the downstream depression, thereby protecting them from predation and from being washed away by the scouring action of the river or stream (Diewart 2007). Over the course of one to several days, the female deposits four or five such egg pockets in a line running upstream, enlarging the spawning excavation in an upstream direction as she does so. The total area of excavation, including the tailspill, is termed a "redd" (Healey 1991). Redds vary in size (area) and depth depending on flow velocity and coarseness of the spawning gravels (Vronskiy 1972; Neilson and Banford 1983; Healey 1991). Stream-type Chinook Salmon typically build smaller redds in coarser gravels than do ocean-type Chinook Salmon (Burner 1951; Diewart 2007).

Females defend their redds for a period of days to weeks, with the average length of residence declining throughout the spawning season (Healey 1991). In the Morice River (upper Skeena drainage), females remained on redds between 4 and 18 days (Neilson and Geen 1981), and in the Nechako River (upper Fraser drainage) they defended redds for 6 to 25 days (Neilson and Banford 1983). Both the Morice River and Nechako River populations are mainly stream-type fish, although the presence of ocean-type Chinook Salmon has been established with scale analysis.

Considerable variation in fecundity exists both within and between different Chinook Salmon populations, and from year to year (McGregor 1922, 1923; Healey and Heard 1984; Myers *et al.* 1998). In a study of 16 different Chinook Salmon populations, female fecundity ranged from fewer than 2,000 eggs to more than 17,000 eggs (Healey and Heard 1984). Fecundity was significantly correlated with female size in all but one of the populations examined, but size explained only 50% or less of the variation between individuals within a population; a great deal of individual variation remained to be explained. Healey and Heard (1984) speculated that this high variation may reflect an uncertain trade-off between egg size and egg number in the overall fitness of Chinook Salmon populations. In a stable population, fecundity is ultimately sufficient to result in an average production of one adult female spawner for each female spawner in the parent generation (Healey 1991).

The survival of eggs in undisturbed natural redds appears to be quite high. Vronskiy (1972) reported survival of 97% to hatching, and Briggs (1953) reported 90% survival to the eyed stage and 82% to hatching. Neither author dealt with losses due to scouring or siltation (Healey 1991). The length of time required for the eggs to incubate is partially dependent on water temperature; in general, the lower the water temperature, the longer the incubation period required. Alderdice and Velsen (1978) identified the time to 50% hatch as about 159 days at 3°C and 32 days at 16°C. Since no natural population incubates to a constant temperature, it is more useful to convert these values to Accumulated Thermal Units (ATUs), thus the ATUs required for 50% hatch range from 477-

512 (159x3 = 477; 32x16 = 512). Upon hatching, the alevins move varying distances within the spaces between the gravel particles depending on gravel size (Diewart 2007). The newly hatched fish have an attached yolk sac that provides nutrition. Towards the end of incubation in the spring, alevins move up through the gravel to emerge as fry. This process occurs at night which helps to minimize predation and generally coincides with the complete absorption of the yolk sac. The survival of Chinook Salmon eggs from spawning to emergence as fry varies widely between systems and years and is influenced by stream flow, water temperature, dissolved oxygen, gravel composition, spawning timing, and spawner density. Studies suggest that survival to emergence averages about 30% (Healey 1991).

Physiology and Adaptability

Seaward migration is regarded as one of the most demanding and physiologically challenging phases of the salmon life history, and represents a complex interplay between physiology and behaviour (Miller *et al.* 2009). After emergence in freshwater, Chinook Salmon fry feed and grow from a few months to two years before migrating to the ocean as smolts. During migration, salmon experience extreme changes in their environment (e.g., salinity, temperature, olfactory cues, flow). Smolts undergo profound physiological changes in their transition from freshwater to salt water. They then spend the next one to seven years growing and maturing at sea (mini-jacks and mature parr are exceptions that do not spend a full year at sea). Mature adults return to their natal streams to complete sexual maturation and spawn (National Wildlife Federation 2002; NOAA Fisheries 2014b). Returning stream-type Chinook Salmon adults must maintain their ion balance, without feeding, in the osmotically rigorous freshwater environment for several months before spawning (Healey 1991).

Prior to their run upriver, Chinook Salmon once again undergo significant physiological changes. Fish swim by contracting longitudinal red muscles and obliquely oriented white muscles. Red muscles are used for sustained activity, such as ocean migrations. White muscles are used for bursts of activity, such as bursts of speed or jumping (Kapoor and Khanna 2004). As they enter the estuary of their natal river Chinook Salmon are faced with two major metabolic challenges: (1) to supply energy suitable for swimming the river rapids; and (2) to support maturation of the sperm and eggs required for the reproductive effort ahead. The water in the estuary receives the freshwater discharge from the natal river. Relative to ocean water, this has a high chemical load from surface runoff. Miller *et al.* (2009) found evidence that as the salmon encounter the resulting drop in salinity and increase in olfactory stimulation, two key metabolic changes are triggered – a switch from using red muscles for swimming to using white muscles, and an increase in the sperm and egg load. Pheromones at the spawning grounds trigger a second shift that further enhances reproductive loading (Miller *et al.* 2009).

Chinook Salmon produce the largest eggs of all Pacific salmon (Diewart 2007). Physiological and ecological factors have been identified that may limit the potential minimum and maximum egg sizes, 0.12 and 0.47 g, respectively (Quinn and Bloomberg 1992). A recent study by Einum *et al.* (2002) suggests salmonid egg oxygen consumption does not increase at a greater rate with increasing egg mass and available egg surface area for oxygen diffusion.

Water percolation through spawning gravels is essential for egg and alevin survival, a requirement that can be severely compromised by siltation of spawning beds (Healey 1991). Shelton (1955) concluded that survival to hatching was greater than 97% at percolation rates of at least 0.03 cm/s, but that emergence was 13% or less from small gravel when percolation rates were less than 0.06 cm/s. Much higher emergence rates (87%) were recorded for Chinook Salmon in large gravel with adequate subgravel flow.

Chinook Salmon exhibit a high degree of life-history variation, as evidenced by variability in the duration of freshwater and saltwater rearing stages, age at maturation, spawning habitat requirements, and rearing habitat requirements. The high degree of life-history variation suggests a high degree of adaptability in the species (Healey 1991). However, there is considerable debate as to what degree this variability is the result of local adaptation or the general plasticity of the salmonid genome (Ricker 1972; Healey 1991; Taylor 1991).

Adaptability is also suggested by the level of success achieved with hatchery transplantation. Chinook Salmon have been produced in hatcheries in North America for more than a century, with hatchery outplants introduced to a wide range of rivers with and without native Chinook Salmon populations (Myers *et al.* 1998). The species has also been successfully introduced into highly novel environments, including the Canadian Great Lakes system and New Zealand rivers. However, there is considerable concern about the apparently low fitness of many hatchery outplants and the impacts this may have on naturally spawning populations (Berejikian and Ford 2003).

Dispersal and Migration

Upon emergence from spawning gravels, Chinook Salmon fry swim and/or are passively displaced downstream by flow (Healey 1991). A large downstream movement immediately after emergence is typical of most populations (e.g., Lister and Walker 1966; Bjornn 1971; Reimers 1971; Healey 1980b; Kjelson *et al.* 1982), and is probably a dispersal mechanism that helps distribute fry among the suitable rearing habitats (Healey 1991; Myers *et al.* 1998). As a result, Chinook Salmon fry often rear in non-natal streams, underscoring the importance of these streams as habitat despite the fact that they are not spawning streams (Scrivener *et al.* 1994). In larger rivers, Chinook Salmon fry migrate more at the river edges than in high velocity waters near the centre of the channel and, when the river is deeper than about 3 m, they prefer the surface (Mains and Smith 1964; Healey and Jordan 1982). These observations provide further support for the idea that downstream movement of fry is not entirely passive displacement controlled by water velocity, but that some active behaviour of the fry helps direct the migration (Healey 1991). Distance of migration to the marine environment, stream stability, stream flow and temperature regimes, stream and estuary productivity, and general weather regimes have also been implicated in the evolution and expression of specific migration timing (Myers *et al.* 1998).

For populations that spawn close to tidewater, downstream dispersal carries fry to estuarine nursery areas; in others, it serves principally to distribute the fry among suitable freshwater nursery areas (Healey 1991). Downstream dispersal occurs mainly at night, generally concentrated around midnight, although small numbers of fry may move during the day (Healey 1991). Fry dispersal is normally most intense between February and May, and occurs earlier in more southern populations. South Thompson Chinook Salmon appear to disperse later in the summer (July-August) (Beamish *et al.* 2010). The timing of the peak can vary substantially from year to year in the same system, and there is also tremendous daily variation in abundance. The causes of annual and daily variation in the downstream dispersal are not well understood (Healey 1991), but may be related to the timing of high discharge events (Mains and Smith 1964; Healey 1980b; Kjelson *et al.* 1981; Irvine 1986).

In addition to discharge, both intra- and interspecific interaction may serve to stimulate the downstream dispersal of young Chinook Salmon. Reimers (1968) observed lateral displays, chasing, fighting, fleeing, and submission behaviours among juvenile fall Chinook Salmon in stream tanks and in natural stream populations, whereby the agonistic behaviour of one or a few dominant fish apparently stimulated the downstream movement of subordinate fish. Taylor (1988) also reported aggressive behaviour among juvenile Chinook Salmon fry, and between Chinook Salmon and Coho Salmon fry; stream-type Chinook Salmon were more aggressive than ocean-type Chinook Salmon. For stream-type Chinook Salmon, dispersal and seaward migration can be related to resource allocation and dispersal to overwintering habitat, but it is part of the natural life history (Myers *et al.* 1998). Patterns vary significantly depending on rearing locations (Bradford and Taylor 1997). If suitable overwintering habitat such as large cobble is not available then the fish will tend to migrate downstream (Bjornn 1971; Hillman *et al.* 1987). Additionally, Stein *et al.* (1972) observed that juvenile Chinook Salmon grew more slowly in the presence of juvenile Coho Salmon than they did on their own, and speculated that interaction with Coho Salmon may influence the downstream movement of Chinook Salmon.

In the southern half of the Chinook Salmon's range, following close on the heels of fry outmigration, many fry migrate seaward as fingerlings between April and June of their first year (Healey 1980b, 1982; Kjelson *et al.* 1981, 1982). For ocean-type variants, this migration may occur any time between immediately post-emergence and ~150 days post-emergence; however, the majority move seaward in 60-90 days (hence the term 'underyearling'). For some stocks, passing through large lakes is required to get to sea (e.g., Mabel, Mara, Shuswap, Little Shuswap, and Kamloops lakes). The fingerlings migrate downstream throughout the day, but most do so at night (Mains and Smith 1964; Lister *et al.* 1971). Ocean-type Chinook Salmon are also known to use lakes during rearing (Brown and Winchell 2004; Roseneau 2014), and make extensive use of estuaries prior to seaward migration.

Stream-type variants typically delay migration until the spring following their emergence (hence the term 'yearling') and sometimes wait for an additional year (Healey 1983). Yearling 'smolts' normally migrate seaward in the early spring (April to July), sometimes preceding and sometimes intermixed with the main migrations of fry and fingerlings (Healey 1991). Yearling migrants appear to be less nocturnal than underyearlings, although on average more smolts move at night (Meehan and Siniff 1962; Major and Mighell 1969).

For all life-history variants, the rate of downstream migration appears to be both time and size dependent. Larger Chinook Salmon travel downstream faster than smaller Chinook Salmon, and the rate of migration increases as the season advances (Healey 1991). Downstream travel rates may also be positively related to river discharge (Bell 1958; Raymond 1968), but there has been no systematic study of the triggers (Healey 1991).

Limited data are available concerning the ocean migration of wild stream-type variants; they apparently move quickly offshore and into the central North Pacific, where they make up a disproportionately high percentage of the commercial catch relative to ocean-type variants (Healey 1983; Myers *et al.* 1987; Trudel *et al.* 2011; Trudel and Hertz 2013). Coded-wire tag returns have shown that Chinook Salmon from British Columbia, Washington, and Oregon migrate as far west as 160°-175°W longitude (Dahlberg 1982; Wertheimer and Dahlberg 1983; Dahlberg and Fowler 1985; Dahlberg *et al.* 1986). Stream-type variants perform extensive offshore oceanic migrations before returning to their natal river in the spring or summer, several months prior to spawning. Ocean-type variants migrate to sea during their first year of life, but spend most of their ocean life in coastal waters before returning to their natal river in the fall (Healey 1991). This migration timing is not always correlated with spawning timing as the latter requires Chinook Salmon access to spawning grounds, which can in turn depend on freshet timing and suitable stream temperatures (Bailey pers. comm. 2018).

Transplantation studies and recoveries of marked hatchery fish from ocean fisheries provide evidence of a genetic basis for ocean distributions. Chinook Salmon stocks follow predictable ocean migration patterns based on “ancestral” feeding routes (Brannon and Setter 1987). The productivity of various ocean regions (e.g., West Vancouver Island) has been correlated with the degree of wind-driven upwelling (Bakun 1973, 1975). Upwelling brings cold, nutrient-rich waters to the surface, resulting in an increase in plankton and ultimately salmon production (Beamish and Bouillon 1993). Ocean migration patterns represent an important form of resource partitioning and are important to the evolutionary success of the species (Myers *et al.* 1998).

The availability of coded-wire tag recoveries in recent years has resulted in more detailed stock-specific information on the marine distribution of Chinook Salmon (Beamish *et al.* 2011a,b; Trudel *et al.* 2009; Tucker *et al.* 2011, 2012; Weitkamp 2010). Juvenile Chinook Salmon are found throughout the Strait of Georgia from the surface to 60 m depth from June through to November. Smolts of the stream-type variants generally enter the ocean the earliest in the year (March-May) (Trudel *et al.* 2007). Ocean-type Chinook Salmon variants from the South Thompson region of the Fraser River enter as late-ocean migrants in July-August (Barraclough and Phillips 1978; Healey 1980a, 1991; Healey and Groot 1987; Beamish *et al.* 2003). Smolts of the stream-type variants enter the ocean in April-May. These smolts do not remain near shore, but move into the deeper areas of the Strait (Healey 1980a, 1991). Beamish *et al.* (2011a) found that a proportion of variants of both ocean-type and stream-type life-history strategies spend approximately 3-5 months in the Strait of Georgia, but not all the fish leave. For example, some ocean-type Chinook Salmon overwinter in the Strait as evidenced by fish in their second year of ocean residence caught in the Strait of Georgia sport fishery (Brown *et al.* 2013a).

Declining abundance of ocean-type and stream-type variants observed in the Strait of Georgia in June/July is likely a result of mortality within the strait combined with migration out of the strait. Chinook Salmon mortality in the Strait of Georgia is thought to be quite high, ranging from 70-92% for wild fish (Beamish *et al.* 2011). There is also evidence that some Strait of Georgia Chinook Salmon stocks may have specific and refined distribution during their early marine period. For example, South Thompson River Chinook Salmon occur on the west coast Vancouver Island in the fall and remain in the region over the winter months (Tucker *et al.* 2011). These fish disperse further north as they get older (Tucker *et al.* 2011; PSC-CTC 2012a). Lower Fraser River ocean-type Chinook Salmon appear to migrate off the west coast of Vancouver Island later than South Thompson River Chinook Salmon, and are rarely found north of Vancouver Island (Tucker *et al.* 2011; PSC-CTC 2012a). In contrast, Cowichan River Chinook Salmon rear primarily in the coastal waters around the southern islands (the “Gulf Islands”) of the Strait of Georgia (also referred to as the “Salish Sea”) (Beamish *et al.* 2011a, 2011b). The catches of this stock remain high in the region from May through to September. This stock is rarely identified (based on DNA analysis) from other areas of the Strait of Georgia (Brown *et al.* 2013a).

On the west coast of Vancouver Island, Chinook Salmon migrate to sea as smolts of ocean-type variants in May-June (Healey 1991) and remain on the west coast of Vancouver Island for nearly a year before migrating north along the continental shelf (Trudel *et al.* 2009; Tucker *et al.* 2011). They are found primarily on the shelf and in inlets within the 200m depth contour. In the fall and winter of their first year at sea, most stocks can be found between their ocean entry point and Quatsino Sound, at the north end of Vancouver Island. For instance, Robertson Creek Chinook Salmon are located from Barkley Sound to Quatsino Sound, whereas Marble River Chinook Salmon are distributed exclusively within Quatsino Sound during their first year at sea (Trudel *et al.* 2012a). Mortality rates have not been quantified for the early marine residence period off the west coast of Vancouver Island, although the overall marine survival of Robertson Creek Chinook Salmon appears to be related to the availability of energy-rich prey (Trudel *et al.* 2012b; Hertz *et al.* 2016a). During winter, mortality rates for Marble River Chinook Salmon range from 60% to 90% depending on the year (Trudel *et al.* 2012a). The factors contributing to this mortality are currently unknown, but do not appear to be related to size, growth, or energy accumulation (Middleton 2011; Trudel *et al.* 2012a).

Coastwide, Chinook Salmon remain at sea from one to six years (more commonly two to four years) (Myers *et al.* 1998). Adult and subadult southern BC Chinook Salmon range as far north as Cook Inlet in Alaska, with the majority of the recoveries in Southeast Alaska and the west coast of Vancouver Island (Weitkamp 2010; PSC-CTC 2012a). Generally, adult Chinook Salmon may make the return migration to their natal river mouth during almost any month of the year (Snyder 1931; Rich 1942; Hallock *et al.* 1957) (southern BC Chinook Salmon are an exception). There are, however, typically one to three peaks of migratory activity, and the timing and number of these peaks varies among river systems. For northern river systems, a single peak of migratory activity during June appears typical, although peaks may occur from April to September (Bailey pers. comm. 2018; Brady 1983; Vronskiy 1972; Yancey and Thorsteinson 1963). Further south, runs can peak anytime between April and September (Bailey pers. comm. 2018). Returning to the "home stream" provides a mechanism for local adaptation and reproductive isolation (Myers *et al.* 1998).

The upstream migration of mature Chinook Salmon occurs mainly during daylight hours, at least for the ocean-type variants (Neave 1943). A few fish do, however, migrate upstream at night (Healey 1991).

Interspecific Interactions

Chinook Salmon rearing in freshwater feed on terrestrial insects, crustacea, chironomids, corixids, caddisflies, mites, spiders, aphids, corethra larvae, and ants (Scott and Crossman 1973; Healey 1991). Insects are predominant during this phase, providing up to 95% of the freshwater diet in all seasons, with adult chironomids comprising 58-63% of the food items taken (Becker 1973). The basic Chinook Salmon diet is similar to that of Coho Salmon (*O. kisutch*), Steelhead Salmon (*O. mykiss*), and other stream-dwelling salmonids (Mundie 1969; Chapman and Bjornn 1969).

The food habits of Chinook Salmon in estuaries vary considerably from estuary to estuary, and from place to place within a given estuary (Healey 1991). Food items include chironomid larvae and pupae, crab larvae, harpacticoid copepods, *Daphnia*, *Eogammarus*, *Corophium*, and *Neomysis* (Dunford 1975; Northcote *et al.* 1979; Levy *et al.* 1979; Levy and Northcote 1981). As Chinook Salmon grow larger, small fish (e.g., juvenile Herring (*Clupea pallasii*), sticklebacks (e.g., *Gasterosteus aculeatus*), Chum Salmon fry (*O. keta*) also become important in the diet (Goodman 1975; Healey 1980b; Levings 1982).

Young Chinook Salmon in the marine environment eat mainly fish (particularly Herring), with invertebrates like pelagic amphipods, squids, shrimp, euphausiids, crab larvae, and insects comprising the remainder of their diet (Scott and Crossman 1973; Healey 1980a; Hertz *et al*. 2016b). Subadult Chinook Salmon (27 to 72 cm in length) in the Qualicum River area of the Strait of Georgia have been reported to feed on Chum Salmon fry, larval and adult Herring, Sand Lance (*Ammodytes hexapterus*), and euphausiids (Robinson *et al.* 1982). Fish dominate the diet of adult Chinook Salmon, especially Herring (Reid 1961; Prakash 1962); other food fish include Sand Lance, pilchards/sardines, and sticklebacks (Pritchard and Tester 1944). Invertebrate taxa form a relatively small component of the ocean adult diet, although there is considerable regional (and seasonal) variation in diet composition (Healey 1991). Coast-wide data suggest that the importance of Herring and Sand Lance in the adult diet increases from south to north, whereas the importance of rockfishes (*Sebastes* sp.) and anchovies (*Engraulis mordax*) decreases (Healey 1991).

Chinook Salmon and Coho Salmon reside sympatrically in many streams and rivers that are tributary to the North Pacific Ocean (Taylor 1991). There is some evidence that agonistic behaviours occur between Chinook Salmon and Coho Salmon fry (Taylor 1988), and that competition for resources between these species may occur (Stein *et al.* 1972). In a controlled setting, Stein *et al.* (1972) observed that juvenile Coho Salmon apparently dominated Chinook Salmon and grew faster in sympatric groupings in stream troughs. When alone in the troughs, however, Chinook Salmon were able to grow as rapidly as Coho Salmon. Also in a controlled setting, Taylor (1991) reported that Coho Salmon behaviourally dominated Chinook Salmon and outnumbered them in upstream channels where food was introduced. However, in natural stream settings where Chinook Salmon and Coho Salmon were sympatric, the two species used different habitats – Coho Salmon preferred slow, deep 'pool' areas whereas Chinook Salmon preferred faster, shallow 'riffle' areas. Chinook Salmon made greater use of pool habitats. While Coho Salmon may socially dominate Chinook Salmon in pool habitats, differences in habitat preference between the species that have developed during sympatric evolution probably minimize the extent to which Coho Salmon influence the duration of freshwater residence by Chinook Salmon (Taylor 1991).

Spiny Dogfish (*Squalus acanthias*) and River Lamprey (*Lampetra ayresii*) have been identified as major predators of juvenile Chinook Salmon in the Strait of Georgia (Beamish and Neville 2000). Southern resident killer whales also have a strong preference for Chinook Salmon throughout much of the year, especially in the lower Georgia Strait (Ford and Ellis 2005). Hake (*Merluccius productus*), Mackerel (*Scomber japanicus*), Sea Lions (*Zalophus californianus*, *Eumetopias jubatus*), Harbour Seals (*Phoca vitulina*), White-sided Dolphins (*Lagenorhynchus obliquidens*), and Humpback Whales (*Megaptera novaeangliae*) are also known predators of salmon in the marine environment (Riddell *et al.* 2013).

POPULATION SIZES AND TRENDS

Information about population sizes and trends is presented for each DU separately in a series of DU-specific chapters, including extent of occurrence and area of occupancy, habitat trends, sampling effort and methods (for abundance, enhancement, hatchery releases), fluctuations and trends, and threats and limiting factors.

An introduction to the DU-specific chapters describes the type of information provided in each chapter, explains how that information is collected and/or calculated, and identifies general findings across all DUs.

Enhancement

In British Columbia (and elsewhere), enhancement programs were developed to support populations of Chinook Salmon (Brown *et al.* 2013a) through hatchery releases (Mackinlay *et al.* 2004). These hatchery releases have been ongoing in BC since 1967, and are largely directed towards increasing or maintaining fishing opportunities (i.e., increasing harvest). Few of the programs have been directed at a purely conservation objective (Figure 15).

DFO's Salmonid Enhancement Program (SEP) is responsible for fish production, habitat restoration and community stewardship activities intended to support Chinook Salmon stocks in southern British Columbia. The program was initiated in 1977 and currently consists of 13 DFO-operated facilities, 11 Community Economic Development Program (CEDP) hatcheries, and 25 volunteer-supported Public Involvement Projects (PIP) (Table 6, Figure 16). Most of these sites occur on Vancouver Island and southern mainland DUs, with the remainder located in the Fraser River drainage. Table 7 summarizes the number of nuSEDS sites by level of enhancement for each Designatable Unit. A 'site' is defined in nuSEDS as a freshwater location where an observation has been made of Chinook Salmon spawners. The database contains a separate record for each site and a single stream may contain multiple sites. For those spawning records with a numerical population estimate, site-level data most often represents the population spawning within a particular river system or tributary of a larger river system.

Table 6. Summary of Salmon Enhancement Program facilities in southern BC. CEDP – Community Economic Development Program; PIP – Public Involvement Project. This table is an adaptation of Table 2 in Brown *et al.* 2013a.

DU Groups	DFO Hatcheries	CEDP Hatcheries	PIP Hatcheries
Boundary Bay (DU1)			L Campbell R Nicomekl R Serpentine R
Lower Fraser (DU2, DU3, DU4, DU5, DU6)	Chehalis R		Alouette R
(Spring/Summer) (DU3, DU4, DU5, DU6)	Chilliwack R Inch Cr		Poco Hatchery
South Thompson Ocean Summer (DU12)	Shuswap R		Kingfisher Cr
Lower Thompson Spring (DU15)	Spius Cr		
South Coast Georgia Strait (DU18)	Capilano R Tenderfoot Cr	Powell R Sechelt Band Seymour R Sliammon R	Chapman Cr Reed Point/Ioco Westridge Term
East Vancouver Island – Goldstream (DU21)			Goldstream R
East Vancouver Island – Cowichan-Koksilah (DU21)		Cowichan R	
East Vancouver Island – Georgia Strait (Summer/Fall) (DU20, DU21)	Puntledge R	Nanaimo R	
East Vancouver Island – Qual/Punt (DU21)	Big Qualicum R L Qualicum R		Englishman Enh Oyster R
Southern Fjords (DU22)			Gillard Pass

DU Groups	DFO Hatcheries	CEDP Hatcheries	PIP Hatcheries
Northeast Vancouver Island (DU23)	Quinsam R	Gwa'ni P Hardy/Quatse	Kokish R Sayward F&G Woss Comm H
Southwest Vancouver Island (DU24)	Nitinat R Robertson Cr	Clayoquot San Juan R Thornton Cr	Esquimalt Harbour Sooke R Tofino
West Vancouver Island Ocean Fall Nootka & Kyuquot (DU25)	Conuma R		Nootka Sd Wtrshd Soc Tahsis R Zeballos R
Northwest Vancouver Island (DU26)			Holberg In P Hardy/Marble

Table 7. Summary of spawning sites and enhancement status for southern BC Chinook Salmon Designatable Units. This table is an adaptation of Table 3 in Brown *et al.* 2013a. A dash indicates there is no evidence of directed enhancement activity for the enhancement category from the Enhancement Planning and Assessment Database (EPAD). Unknown/no Enhancement refers to sites with no release records, brood records or enhanced contribution estimates available during the 2000-2011 period (spanning approximately three generations). Low-Moderate Enhancement refers to sites with these records only prior to 2000 (low), or with ≤25% coverage across 2000-2011 (moderate). High Enhancement refers to sites with >25% coverage across 2000-2011.

DU Number	DU Name	Unknown/No Enhancement	Low-Moderate Enhancement	High Enhancement	Total Enhanced	Total Sites
1	Southern Mainland - Boundary Bay, Ocean, Fall population	2	-	1	1	3
2	Lower Fraser, Ocean, Fall population	-	1	-	1	1
3	Lower Fraser, Stream, Spring population	6	1	-	1	7
4	Lower Fraser, Stream, Summer population	2	-	-	-	2
5	Lower Fraser, Stream, Summer population	6	-	1	1	7
6	Lower Fraser, Ocean, Summer population	6	-	1	1	1

DU Number	DU Name	Unknown/No Enhancement	Low-Moderate Enhancement	High Enhancement	Total Enhanced	Total Sites
7	Middle Fraser, Stream, Spring (FRCany+GStr) population	1	-	-	-	1
8	Middle Fraser, Stream, Fall population	1	-	-	-	1
9	Middle Fraser, Stream, Spring (MFR+GStr) population	21	2	-	2	23
10	Middle Fraser, Stream, Summer population	20	-	1	1	21
11	Upper Fraser, Stream, Spring population	22	2	-	2	24
12	South Thompson, Ocean, Summer population	6	1	1	2	8
13 & 14	BC South Thompson Stream Summer 1.3 & 1.2	7	-	1	1	8
15	Lower Thompson, Stream, Spring population	4	2	2	4	8
16	North Thompson, Stream, Spring population	10	-	-	-	10
17	North Thompson, Stream, Summer population	7	-	-	-	7
18	South Coast - Georgia Strait, Ocean, Fall population	5	2	7	9	14
19	East Vancouver Island, Stream, Spring population	1	-	-	-	1
20	East Vancouver Island, Ocean, Summer population	1	-	2	2	3
21	East Vancouver Island, Ocean, Fall population	2	1	9	10	12

DU Number	DU Name	Unknown/No Enhancement	Low-Moderate Enhancement	High Enhancement	Total Enhanced	Total Sites
22	South Coast - Southern Fjords, Ocean, Fall population	10	1	1	2	12
23	East Vancouver Island, Ocean, Fall (EVI + SFj) population	4	2	4	6	10
24	West Vancouver Island, Ocean, Fall (South) population	16	3	12	15	31
25	West Vancouver Island, Ocean, Fall (Nootka & Kyuquot) population	29	1	8	9	38
26	West Vancouver Island, Ocean, Fall (WVI + WQCI) population	5	-	3	3	8
27	Southern Mainland, Ocean, Summer population	1	-	-	-	1
28	Southern Mainland, Stream, Summer population	1	-	-	-	1

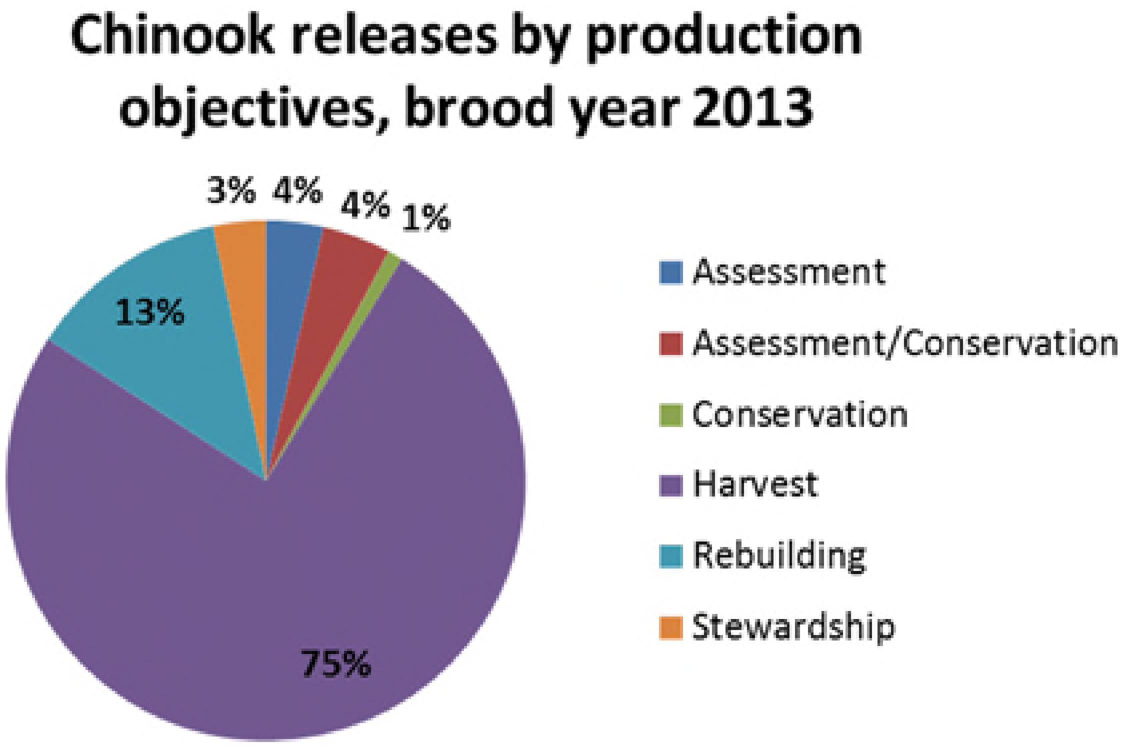


Figure 15. Distribution of southern BC Chinook Salmon hatchery releases by program type (total hatchery production ~40million smolts and fed fry). This figure is a reproduction of Figure Hat-2 in Riddell *et al*. 2013. Hatchery production objectives are described in more detail in the 'Fish Production' section below.

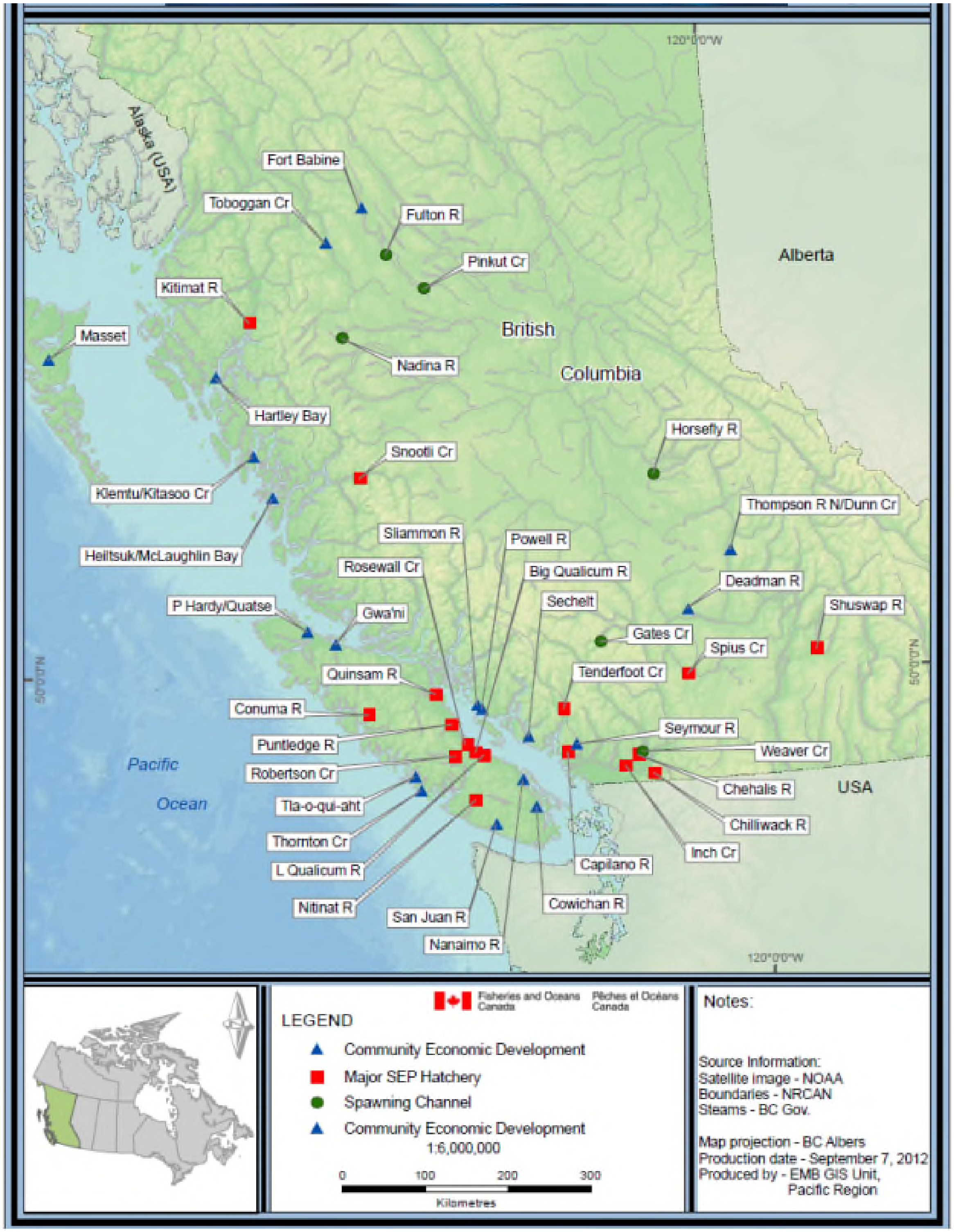


Figure 16. Map of major SEP hatcheries, spawning channels and economic development projects. This figure is a reproduction of Figure 2 in Brown *et al*. 2013a.

Fish Production

Production of Chinook Salmon at SEP facilities directly supports the delivery of several departmental priorities, which include:

- Harvest – enhancement for fisheries that are reliant on enhanced production, and would disappear or become severely constrained in the absence of enhancement. This includes harvest opportunities for First Nations, recreational, and commercial fisheries. When the objective is to provide a targeted-fishery opportunity, production targets may be set to consider both natural spawning and harvest requirements.
- Assessment – fish produced for mark-recapture analysis where stock assessment information contributes to Pacific region assessment priorities, such as the Pacific Salmon Treaty. This information may also contribute to assessment as defined under the regional stock assessment framework, Area stock assessment priorities and regional SEP assessment priorities, i.e., those produced for program performance measurement. Fish produced for assessment generally address other objectives as well but, in a few instances, fish are produced solely for marking for assessment purposes.
- Conservation – enhancement of a stock at high risk of extirpation, or a vulnerable stock that has been identified as a regional priority (e.g., populations which have an approved conservation/recovery strategy). This includes re-establishing locally extinct populations according to transplant guidelines (Fedorenko and Shepherd 1986) and rebuilding populations at high risk of extirpation.
- Rebuilding – enhancement of a stock that is below apparent carrying capacity. This includes rebuilding depleted populations and mitigating for habitat loss.
- Stewardship and Education – small numbers of fish produced to provide a stewardship or educational opportunity. Production for these purposes is assessed based on contribution to stewardship and educational goals and not on production levels or contribution to harvest or escapement.

Production planning occurs annually as part of the Integrated Fisheries Management Planning process. Internal priorities from all DFO sectors, including Fisheries Management, Science Stock Assessment and SEP are brought forward and integrated with partner and stakeholder priorities in the development of a comprehensive production plan. The annual SEP production plan identifies production targets by species, stock, release site, and release strategy in order to meet specific production objectives. Production targets are calculated using current bio-standard survival rates by species and release stage, and are set at a level intended to produce a number of returning adult salmon that will support harvest, conservation or assessment goals.

In 2012, the SEP Production Plan for southern BC Chinook Salmon included a total production target of nearly 40 million Chinook Salmon juveniles. Total Chinook Salmon production in 2011 was approximately 34 million juveniles (Brown *et al.* 2013a).

Since 1995 there has been active enhancement in 19 of the 28 DUs in southern BC, while the remaining eight DUs have had no active enhancement. Over this period, mean annual production has been 49.3 million juvenile Chinook Salmon, although this has decreased during the most recent generation (2007-2011) to 39.7 million per year (Brown *et al*. 2013a). Although direct estimates of enhanced production as a percentage of total DU production cannot be calculated, the relative scale of enhancement by DU over the past three generations is summarized in Table 8.

Table 8. Summary of average annual Chinook Salmon releases by Conservation Unit and Designatable Unit and time period. This table is an adaptation of Table 4 in Brown *et al.* 2013a using updated data from Brown *et al.* (in prep).

Conservation Unit	DU Number	Mean juvenile Chinook Salmon releases, in millions (1995-2015 avg)	Mean juvenile Chinook Salmon releases, in millions (2011-2015 avg)
Boundary Bay	DU1	0.1	0.2
Lower Fraser – fall	DU2	1.2	0.3
Lower Fraser – spring	DU3	0.1	0.0
Lower Fraser – summer	DU5	0.4	0.5
Lower Fraser – Maria Slough	DU6	<0.1	0.0
Middle Fraser – spring – age 1.3	DU9	<0.1	0.0
Middle Fraser River – summer – age 1.3	DU10	0.1	0.0
Upper Fraser River – spring	DU11	0.1	0.0
South Thompson – Shuswap R	DU12	0.9	0.7
South Thompson – summer – age 1.3	DU13	0.1	0.1
Lower Thompson – spring – age 1.2	DU15	0.4	0.3
South Coast-Georgia Strait – fall	DU18	1.0	0.6
East Vancouver Island – Qualicum/Puntledge	DU21	8.4	6.8
Cowichan – Koksilah	DU21	1.6	0.8
East Vancouver Island – Nanaimo – fall	DU21	0.5	0.4
East Vancouver Island – Goldstream	DU21	0.1	0.0
South Coast – Southern Fjords	DU22	0.1	0.2
Northeast Vancouver Island	DU23	3.4	3.3
Southwest Vancouver Island	DU24	13.5	13.0
Nootka – Kyoquot	DU25	3.1	3.4
Northwest Vancouver Island	DU26	0.5	0.6

Release Strategies

Hatchery-released juvenile Chinook Salmon can be unfed fry, fed fry, smolts, or ‘super smolts’. In most cases releases attempt to mimic indicator stock characteristics (e.g., size, timing). However, super smolts are fish for which release is delayed by 2-3 months, which is also likely to alter freshwater life histories, increase straying, and shorten the number of years they spend at sea (Clarke *et al.* 2016; Westley *et al.* 2013). These fish are grown at a fast rate to achieve an unusually large size at release for the actual age. Most releases occur close to when naturally produced juveniles are migrating to the ocean and undergoing the smolting process (not the case for unfed fry or fry). Therefore, release timing is dependent on life-history type and variations therein: juveniles of ocean-type variants are generally released in the spring as 0+ smolts (i.e., underyearlings), while those of stream-type variants are released in the spring as 1+ smolts (i.e., yearlings).

SEP has developed several options for releasing Chinook Salmon progeny from hatcheries into the natural environment. Each strategy has advantages and disadvantages and is selected to best meet the enhancement objective as per the production planning framework. The release strategies are shown in Table 9, in order from the youngest life-history stage to the oldest. The information in this table has been adapted from HSRG (2004) and California HSRG (2012).

Table 9. Hatchery Chinook Salmon release strategies, with advantages and disadvantages. This table is a reproduction of Table 5 in Brown *et al.* 2013a.

Release strategy	Advantages	Disadvantages
Egg plants	• Used when surplus taken if rearing habitat is available • Lower cost	• Lower survival rates than smolt or fed fry • Vulnerable to extreme weather events
Unfed Fry (incubator boxes)	• Slower early growth may produce more natural age class structure • Less domestication • More exposure to competition and predation to allow natural selection • Lower cost	• Lower survival rates than smolt or fed fry • Vulnerable to extreme weather events
Fed Fry	• Slower early growth may produce more natural age class structure • Less domestication • More exposure to competition and predation to allow natural selection • Lower cost • May facilitate homing	• Lower survival rate than smolt • Forced release • May displace or out-compete wild fry • More exposure to competition and predation • Requires available rearing habitat • Should be same size as wild at release
Smolt 0+	• Highest survival rates for production of ocean-type Chinook Salmon • Used for assessment as indicator of wild production (must be over 2g in body weight to tag and mark) • Often a volitional release • Most cost effective strategy • May be accelerated to produce a larger smolt with improved survival rate	• Large size at release may produce higher proportion of jacks

Release strategy	Advantages	Disadvantages
Smolt 1+	• Used for stream-type Chinook Salmon in BCI where this is a natural life history to improve survival rate and reduce impacts on wild • Used for assessment as indicator of wild production of stream-type stocks • Improved survival rate for ocean-type Chinook Salmon if stock status is extremely poor	• Higher cost • Increased risk of un-natural mortality in hatchery • Increased domestication • Increased risk of stress-related disease • Immature returning adults
Seapen	• Minimizes competition with wild smolts in the estuary • Increases acclimation time before release, • Higher survival rate • May contribute more to harvest than river releases • May avoid predators such as birds and marine mammals at release • Offers stewardship opportunities to external partners	• Higher cost • Vaccination required because smolts are reared in seawater and exposed to pathogens such as vibriosis • Infrastructure and resources required to rear at the site • Seapen site influence over homing ability of adults • Forced release • High stray rates often observed
Fall, late or delayed release	• Larger size before release may improve survival rate • Reduced interaction with wild stocks	• Higher cost • Increased risk of un-natural mortality in hatchery • Increased domestication • Increased risk of stress-related disease • Immature returning adults • May residualize • May miss spring marine plankton blooms

Assessment and Monitoring

As part of ongoing program development and monitoring, SEP employs many program- and project-level tools to guide operations and planning. At the program level, several integrated planning tools guide management and decision-making. These include *SEP Production Planning: A Framework* (DFO 2012), the *Biological Risk Management Framework for Enhancing Salmon in the Pacific Region* (DFO 2013b), and an infrastructure strategy. These tools will be integrated into a long-term planning process that will focus on program-level strategic management as well as directing annual program and project planning. This will ensure that enhanced salmon production objectives of the Department and stakeholders are being met.

At the operational level, Fish Health Management Plans (FHMPs) have been implemented at all DFO-operated hatcheries. These plans were summarized by Stephen *et al.* (2011), as part of *Cohen Commission Technical Report 1A*. In addition to the FHMPs, SEP implements *Enhancement Guidelines for Salmon Enhancement Programs* (DFO

2005c), which provide guidance at the operational level to ensure that any genetic, disease and ecological risks of enhancement are managed appropriately. Hatchery operations are evaluated as a component of periodic program review processes, such as the *2004/5 SEP Facility Operations Review (FORT)* (DFO 2005b).

THREATS AND LIMITING FACTORS

Each spawning pair of Chinook Salmon has a reproductive potential of between 2,000 and 17,000 progeny, depending primarily on the size of the female (McPhail 2007). In the case of declining populations, fewer than two of these progeny survive to adulthood. The actual number of offspring that survive to reproduce the next generation is dependent on the threats (direct human-induced interactions) and limiting factors (such as natural fluctuations in the environment) that are encountered at each stage in the Chinook Salmon life history. These threats can be natural such as predation or food restrictions, direct human interaction such as fishing, or habitat pressures exacerbated by human activities such as pollution, forestry or urbanization (Brown *et al.* 2013a).

Primary threats to Chinook Salmon include harvest, changes in freshwater or marine habitat, hatcheries, pathogens/aquaculture, and climate change.

Harvest

The threat that harvest poses to southern BC Chinook Salmon should be considered on a DU by DU basis. Total fishing impacts vary according to geographical regions where fisheries occur and intercept Chinook Salmon during their oceanic migrations. These impacts also vary for each of the southern BC indicators according to fishery type, e.g., troll, net, and recreational fisheries (Brown *et al.* 2013a).

The total landed catch of Chinook Salmon in BC has declined considerably since the mid-1970s (Figure 17). Harvests of Chinook Salmon originating from southern BC streams have declined (Figure 18), with reduced commercial landings accounting for most of this decline (Figure 19). Some of these reductions are at least in part attributable to changes in the marine environment driven by large scale climate oscillations (e.g., NPGO, PDO) (Braun *et al*. 2015; Dorner, 2017).

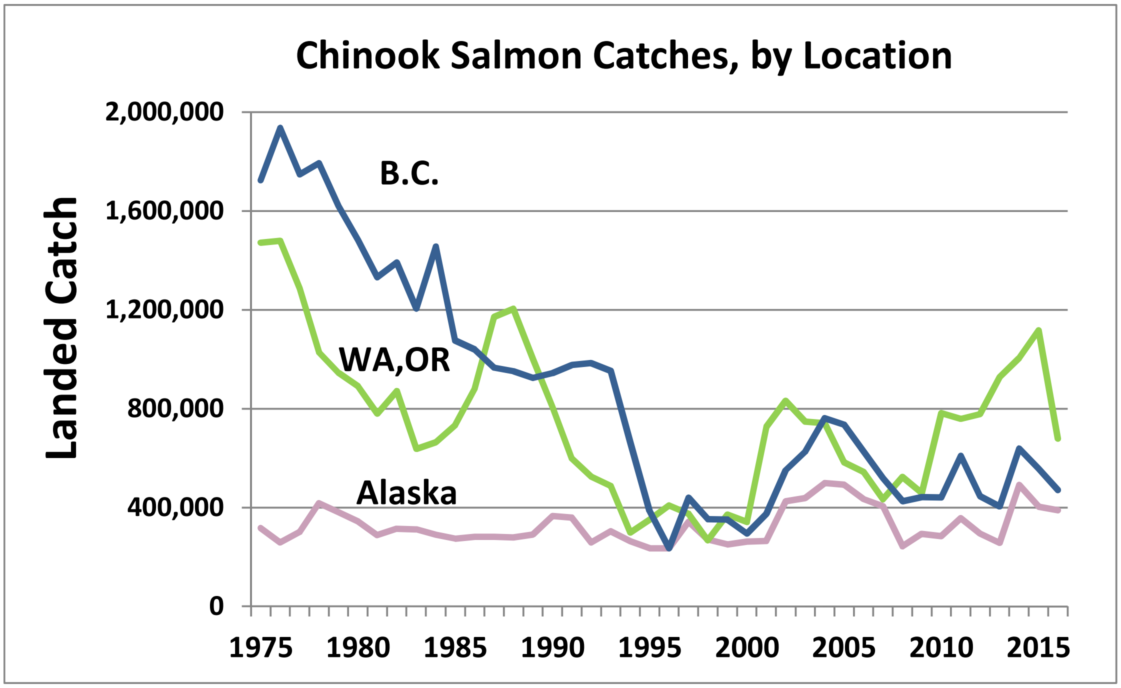


Figure 17. Total landed catch of Chinook Salmon in three regions by catch year, regardless of geographic origin of the fish. These catches include all catches from commercial, sport, and Tribal/First Nations fisheries within marine and freshwater Pacific Salmon Treaty boundaries. Data for this figure are derived from PSC-CTC (2017b).

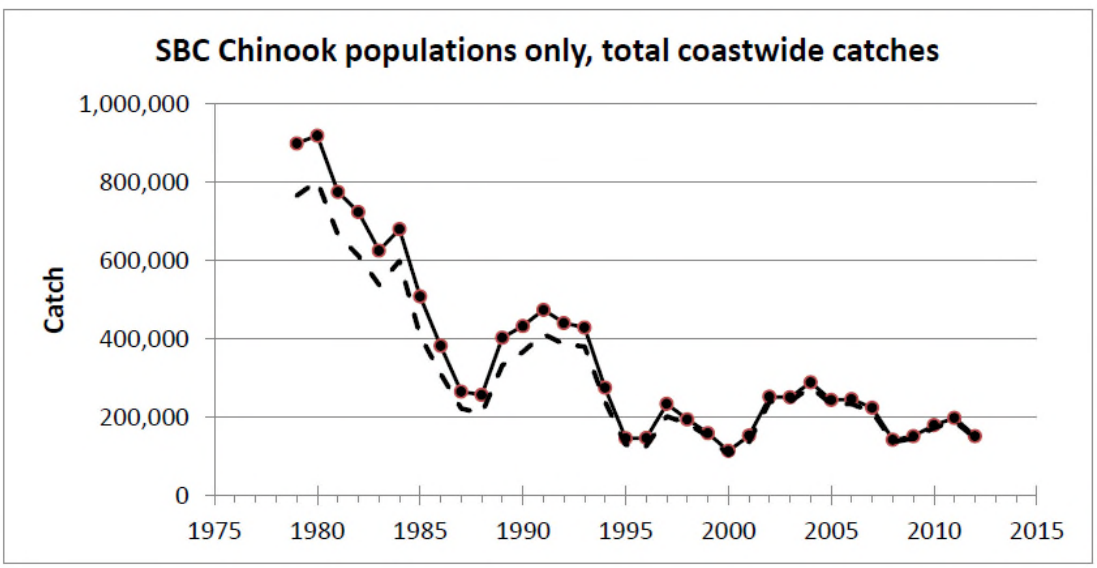


Figure 18. Estimated coast-wide ocean fishery landings of Chinook Salmon (excluding terminal net catches in the Fraser River and along the west coast of Vancouver Island) originating from streams in southern British Columbia only. Solid line includes ocean net (gill nets, purse seine) catches of Chinook Salmon; dashed line excludes ocean net catches. Based on Chinook Salmon Technical Committee modelled stock composition and agency-reported landings (plot created by B Riddell with data provided from CTC catch files). This figure is a reproduction of Figure H-8 in Riddell *et al*. (2013).

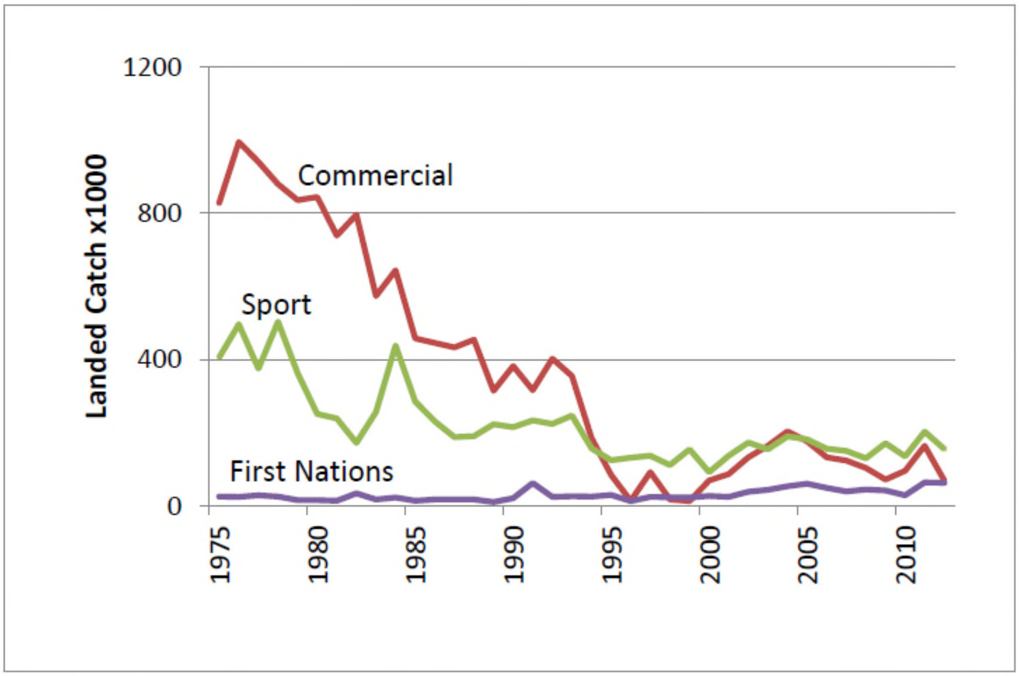


Figure 19. Total landed catch of Chinook Salmon in southern BC ocean fisheries. Based on data summaries available in CTC catch and escapement reports. This figure is a reproduction of Figure H-5 in Riddell *et al*. (2013).

Total exploitation rates, expressed as the proportion of adults harvested in fisheries over a brood year's complete life span, are computed based on coded-wire tag (CWT) recovery data for indicator stocks (Figure 20). Total exploitation rates declined substantially over brood years 1973-1993 for both far-north migrating and locally distributed stock types, from an average of approximately 75% to an average of about 45%. A rate in the range of 70% to 80% is likely well above what is necessary for maximum sustainable yield (MSY) during periods of average productivities (PSC-CTC 2017a). Total exploitation rates for all three ocean distribution types have been similar since about the 1993 brood year and have ranged from about 25% to 50%. Despite these dramatic reductions in total exploitation rates and ocean fishery landings, many stocks have experienced declines in spawning escapements over the past three generations.

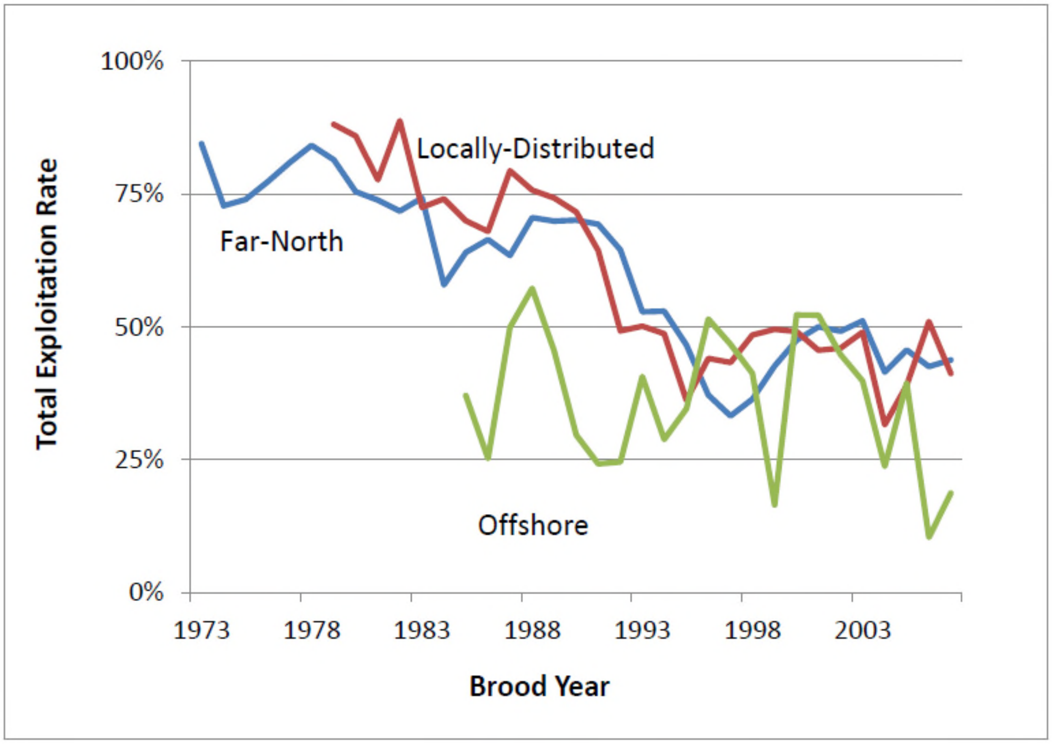


Figure 20. Average estimated total exploitation rates by brood year for adipose fin clipped and coded-wire tag (AD+CWT) indicator stocks exhibiting one of three general ocean distribution patterns: far north-migrating, locally distributed and offshore. This figure is a reproduction of Figure H-13 in Riddell *et al*. (2013).

Under low productivity, harvest is a significant threat for many DUs. Riddell *et al.* (2013) note that although the total exploitation rate has reduced considerably since about the 1993 brood year, a corresponding decline in stock-specific productivities could substantially reduce the MSY. This decreased stock-specific productivity could be due to low marine survival, and suggests that even the lowered exploitation rates could be too high. Realized exploitation rates can be compared to approximate total exploitation rates for MSY (E_{MSY}) to understand whether fishing has been an important stressor on southern BC Chinook Salmon (Table 10). Based on existing estimates of productivity, only Dome Creek (DU11) has exploitation rates that could be regarded as 'stressful'. However, relatively strong evidence from the marine habitat suggests that productivity has decreased coast-wide since the early 1990s (Kilduff *et al*. 2014; Dorner *et al*. 2018), and that estimates of exploitation rates for E_{MSY} are therefore overestimated. Recent evidence suggests changed maturation schedules, decreased size at age, and decreased fecundity at age all contributed to decreased productivity (Bailey pers. comm. 2018). When E_{MSY} was adjusted to account for lower productivity, six of 12 indicator stocks showed total exploitation rates that exceeded E_{MSY} values. It is therefore possible that many stocks are being over-exploited as their productivity falls (Bailey pers. comm. 2018).

Table 10. Mean stock- (CU-) specific brood year total exploitation rate 1995-2008, assumed Ricker 'a' productivity parameter, E_{MSY} (total exploitation rate at MSY), adjusted Ricker 'a' parameters, and adjusted E_{MSY}. Boldface identifies stocks for which 1995-2008 brood year total exploitation rates exceed adjusted E_{MSY} based on a conjecture that current productivities (Ricker 'a' parameter) are half of those that have been assumed to be 'average' in stock assessments. This table is a reproduction of Table H-1 in Riddell *et al.* (2013).

CU	Indicator Stock	Mean 1995-2008 brood exploit. Rate	Assumed Ricker 'a'	E_{MSY}	Adjusted Ricker 'a'	Adjusted E_{MSY}
FAR NORTH MIGRANTS						
SWVI	Robertson	**0.578***	2.03	0.73	1.015	**0.44**
NEVI	Quinsam	0.405	2.03	0.73	1.015	0.44
Qual-Punt Falls	Big Qualicum	0.415	2.03	0.73	1.015	0.44
Mid ECVI Summer	Puntledge	0.302	2.03	0.73	1.015	0.44
Shuswap Summer 0.3	Lower Shuswap	**0.486**	2.07	0.74	1.035	**0.44**
Thompson Summer 0.3	Lower Shuswap	**0.486**	1.59	0.62	0.80	0.35
LOCALLY-DISTRIBUTED						
Nanaimo-Chemainus	Nanaimo	**0.507**	2.34	0.79	1.17	**0.49**
Cowichan	Cowichan	**0.644**	1.87	0.69	0.99	**0.43**
Lower Fraser Fall	Harrison (Chehalis)	0.355	1.67	0.64	1.34	0.54
Lower Fraser Fall	Chilliwack	0.301	1.67	0.64	1.34	0.54
OFFSHORE						
Lower Thompson Spring (1.2)	Nicola	0.238	1.51	0.60	0.75	0.34
Upper Fraser Spring	Dome	**0.698**	1.65	0.63	0.82	**0.36**

*The total exploitation rate for the Robertson Creek stock is probably unusually high due to the intensive terminal fisheries targeting these hatchery-origin fish.

Freshwater Habitat

Habitat modification and degradation can cause a decline in southern BC Chinook Salmon abundance: (1) directly through continuous deterioration of freshwater habitats; and/or (2) indirectly through interactions between human-induced declines in habitat quality and other stressors whereby populations from poorer freshwater habitats are more vulnerable to other stressors (Riddell *et al.* 2013). Evidence suggests that the freshwater life history of Chinook Salmon is plastic, with juveniles undergoing a variety of migration and rearing strategies in their first year (Bradford and Taylor 1997) in response to environmental variation. This diversity in life history reduces the likelihood that a single environmental or biological forcing agent will be able to generate coherent trends in freshwater survival across a broad spatial scale.

Dams can alter flow regimes, impede access to spawning and rearing habitats, affect the quality and quantity of those habitats, and create stress on migrating Chinook Salmon. Identified dams that affect Chinook Salmon include hydroelectric facilities on the Puntledge, Bridge, Seton, Nechako, Middle Shuswap, Alouette, Stave, Cheakamus, Cheekeye, Nanaimo, Quinsam, Campbell, Salmon, Theodosia, Capilano, Seymour, Coquitlam, Cowichan and Big Qualicum rivers.

With the caveat that their study did not consider changes from historical levels (e.g., in the Canadian portion of the Columbia River), Riddell *et al.* (2013) concluded that there were no obvious freshwater environmental drivers that could explain recent trends in southern BC Chinook Salmon spawner abundance. No correlations were found between recent trends in escapement and human-induced changes characterized by a set of pressure indicators (see Stahlberg *et al.* 2009). Human-induced watershed changes that have been considered include urbanization, forestry, Mountain Pine Beetle (*Dendroctonus ponderosae*), changes in land cover, mining development (Kjelson *et al.* 1981, 1982), agricultural/rural development, road development (Bradford and Irvine 2000), stream crossing density, riparian disturbance, permitted waste water discharge, and water allocation (Kjelson *et al.* 1981, 1982). In recent years, climate-related observations for freshwater habitat include warmer river temperatures and earlier freshets (DFO 2017), which can influence upstream migration conditions, temperatures on the spawning grounds, and smolt outmigration conditions.

Despite the findings of Riddell *et al.*, watershed changes were quantified for this report based on available data from Porter *et al.* (2013) and were included in the IUCN threats calculator assessment (see **Format of Designatable Unit-specific Chapters** section below).

Marine Habitat

While migration patterns and other aspects of marine ecology continue to be investigated, ocean residence is recognized as a very important component of the life cycle of all Pacific salmon (Brown *et al.* 2013a). Riddell *et al.* (2013) concluded that marine habitat conditions during the first year of marine residency were very likely a key driver of recent trends in survival and productivity. All DUs share the marine environment, but stocks that start their marine life in the Strait of Georgia, for example, encounter a different marine environment than those that start off the west coast of Vancouver Island. The fish in each DU may also have different marine migration patterns as described in the **Dispersal and Migration** section of this report. Regardless, because of the broader shared environment, large-scale changes are likely to affect all DUs in a coherent way. This is supported by the fact that an overall declining trend is observed across DUs of southern BC Chinook Salmon (Riddell *et al.* 2013).

Chinook Salmon spend much of their lifetime in the marine environment, where they are exposed to a wide array of factors that can affect growth and survival (e.g., Peterman 1987; Beamish and Mahnken 2001; Pearcy and McKinnell 2007; Farley *et al.* 2007). The importance of the early marine period to survival of Pacific salmon is supported by studies of spatial scales of covariation in recruits per spawner and studies that demonstrate greater correlation between coastal ocean conditions during early sea life and marine survival than survival at other life-history stages (Magnusson 2001; Wertheimer *et al.* 2004; Mueter *et al.* 2005; Pyper *et al.* 2005). Local marine conditions (i.e., the marine environment near the point of ocean entry) are also demonstrated to have a high correlation with Chinook Salmon marine survival (Riddell *et al.* 2013). Stocks that enter the ocean near each other have more similar trends in survival than those entering the ocean further apart (Figure 21), although a recent study suggests a more complex story, with Salish Sea stocks exhibiting weaker coherence than those located outside the Salish Sea (Ruff *et al.* 2017).

In both direct and indirect ways, marine water temperature poses a number of challenges to all species of Pacific salmon (Meuter *et al.* 2005; Richter and Kolmes 2005). In 2012, Irvine and Crawford summarized Pacific Ocean oxygen, salinity and temperature conditions to examine their potential food web effects (phytoplankton, zooplankton, invertebrate, piscine, and avian populations). Their data at the time showed that the Northeast (NE) Pacific Ocean was cooler than average, continuing a trend beginning in 2005. More recent data indicate ocean and land temperatures in the NE Pacific and British Columbia/Yukon were above average from 2013 through to 2016 (DFO 2017), in part due to large scale climate anomalies (the 'warm blob' – see Bond *et al*. 2015; Di Lorenzo and Mantua 2016).

Large scale climate anomalies can share patterns with salmon marine survival rates. For example, the North Pacific Gyre Oscillation (NPGO) has exhibited a pattern since 1995 similar to the widely shared trend in marine Chinook Salmon survival (Riddell *et al.* 2013) (Figure 22, Figure 23) (excluding Salish Sea stocks – see Ruff *et al.* 2017). In the latter half of 2013 a warm sea-surface-temperature (SST) anomaly, referred to as the 'warm blob', developed in the NE Pacific, extending to depths of 100m. By 2014 the blob had moved into BC and Yukon coastal waters and, in 2015, combined with the effects of an El Niño event. Together, these events further increased local land and ocean temperatures. In the Northeast Pacific shifts were observed from cool to warm water copepod species (DFO 2016; DFO 2017). Unusual fish species from southern latitudes were also observed, which may have affected predator-prey dynamics within the salmon ecosystem (DFO 2016; DFO 2017). Beginning in late 2016 and through to 2017, the blob and El Niño were no longer present in the NE Pacific. In 2017, adult returns to many southern BC Chinook Salmon DUs (e.g., in the Fraser and West Coast Vancouver Island systems) were extremely poor across most salmon species and populations. More variable responses occurred in the more northern Pacific salmon populations.

With the exception of Fraser River stocks, most southern BC Coded Wire Tag (CWT) indicator stocks are released at or near the ocean, and therefore provide excellent indicators of marine survival conditions from release to ocean age two (Riddell *et al.* 2013). Fraser River CWT stocks are released roughly more than 100km from the ocean, so data from these stocks represent the combined effect of survival after the fish were released until the first age of maturity. Based on CWT data, reduced survival rates have been observed in recent years for most southern BC Chinook Salmon indicator stocks, although some Chinook Salmon DUs did not show a decline (Figure 24, Figure 25). These latter populations entered the Strait of Georgia either early or late, as opposed to the more common May/June timing, suggesting that temporal differences in early marine conditions can have strong effects on early marine survival (Beamish *et al.* 2010).

Of the 31 species of marine mammals that occur in waters off the Pacific coast of Canada, seven are known to prey on salmonids (Brown *et al.* 2013a). Although rates of predation specifically for Chinook Salmon are in many cases unknown, it is generally understood that in some cases marine mammal predation can play a significant role in mortality rates for certain Chinook Salmon stocks.

Simulation modelling indicates that mortality rates of Chinook Salmon from marine mammal predation increased in the 1990s relative to levels during the preceding 30 years (Figure 26). These results may be partially explained because predators were eating a higher proportion of fish due to declining Chinook Salmon populations (Bailey pers. comm. 2018), although other models suggest this interpretation may not be supported by the evidence (Preikshot *et al*. 2013). Nevertheless, populations of Sea Lions, Harbour Seals, White-sided Dolphins, and Humpback Whales dramatically increased since the 1970s and may have led to higher consumption (Riddell *et al.* 2013; Chasco *et al.* 2017). Between 1970 and 2015, for example, the annual biomass of Chinook Salmon consumed by pinnipeds in Puget Sound (Washington State, USA) rose from 68 to 625 tons (Chasco *et al.* 2017).

Northern and southern resident killer whales – which in 2013 totalled approximately 350 animals in BC waters – are considered salmonid specialists (Brown *et al.* 2013a). These whales congregate in groups during summer and fall in specific areas to intercept salmon migrating to natal spawning rivers. Extensive field studies of foraging behaviour indicate that resident killer whales forage selectively for Chinook Salmon and, to a lesser extent, Chum Salmon (Ford and Ellis 2006; Hanson *et al.* 2010). The whales appear to target large fish, with most being four years of age or older. Riddell *et al.* (2013) discuss workshop findings that identified the South Thompson Chinook Salmon population (DU12, DU13 and DU14) as the dominant stock in the diet of southern resident killer whales. Other Fraser River stocks of Chinook Salmon, some of which are declining, also figure prominently in the diet of resident killer whales. While only assessed during a single year and not considered in relation to relative DU abundance for that year, Hanson *et al.* (2010) ranked each DU in terms of inferred importance as follows: Upper Fraser (DU11), Middle Fraser (DU7, DU8, DU9, DU10), South Thompson River (DU12, DU13, DU14), and Lower Fraser stocks (DU2, DU3, DU4, DU5, DU6).

Harbour Seal abundance along the Pacific coast has increased dramatically since harvests ended in the late 1960s (Brown *et al.* 2013a). Consistent with trends south of the border, Harbour Seal abundance increased in the Strait of Georgia at a rate of 11.5% per year after the mid-1970s before stabilizing in the mid-1990s at about 40,000 animals. This trend is typical of the BC coast generally, with current total abundance estimated at 105,000 animals (Olesiuk 2010). Extensive scat collections during the 1980s indicated that Harbour Seals in the Strait of Georgia consumed a wide variety of prey species, but their diet was dominated by Herring and Hake. Overall, salmonids represented only about 4-7% of their diet, with salmonid consumption concentrated on pre-spawning adult salmon in estuaries and rivers (Olesiuk 1993; Thomas *et al.* 2016). Such predation can potentially be a major source of mortality for returning adult Chinook Salmon in cases where run size is small and habitat modification increases vulnerability to predation (e.g., channelization of lower Puntledge River). Juvenile salmon, including Chinook Salmon, are also preyed upon by Harbour Seals (Thomas *et al.* 2016). Predation of juveniles can occur in marine areas as well as in rivers. Predation rates of downstream migrating juveniles can be significant in areas that are artificially illuminated at night such as bridge crossings (e.g., Puntledge River, Olesiuk *et al.* 1996). The constrained morphology of a river can increase vulnerability to highly mobile and agile predators such as seals. The extent of predation on juvenile Chinook Salmon by Harbour Seals in natural settings is currently unknown. Chasco *et al*. (2017) estimate that between 1970 and 2015 the annual biomass of Chinook Salmon consumed by pinnipeds (Harbour Seals [*Phoca vitulina*], California Sea Lions [*Zalophus Californianus*], Steller Sea Lions [*Eumetopias jubatus*]) in Puget Sound increased from 68 to 625 metric tons. By 2015, pinnipeds consumed double that of resident killer whales and six times the combined commercial and recreational catches.

Steller Sea Lion abundance in British Columbia has increased approximately three-fold in BC since harvesting ended in the late 1960s (Brown *et al.* 2013a). Prior to 2013, abundance was increasing at 5% per annum and, based on pup production, current abundance in BC and adjacent waters of Southeast Alaska is approximately 60,000 animals, which is considerably greater than the estimated abundance for the early 1900s. Steller Sea Lions range widely in coastal waters, but during summer the majority congregate at traditional breeding rookeries, the largest of which are found in the Scott Islands, off the north end of Vancouver Island, and at Forrester Island, Alaska just north of the Haida Gwaii (Queen Charlotte Islands). Diet studies using prey remains found in scats collected at these rookeries and other haul-out sites indicate that Steller Sea Lions feed on a variety of fish and cephalopods, and that salmon constitutes a significant portion of their diet particularly in summer and fall. Salmonids have been estimated to represent about 10% of their overall diet (Olesiuk *et al.* 2010). On average, Steller Sea Lions eat about 18 kg of prey per capita per day, which may translate to about 17,200 tonnes per year for the population that uses Canadian waters. Preliminary studies on the salmonid species composition of Steller Sea Lion diets indicates that Chinook Salmon may represent a significant component of salmonids consumed (Olesiuk *et al.* 2010).

Other species of marine mammals in the region that are known to consume salmonids include Dall's porpoise, Pacific White-sided Dolphin, California Sea Lion, and Northern Fur Seal. The extent of predation by these species on different species of salmonids is poorly known (Ford and Olesiuk 2010).

There is no consistent association between harmful algal blooms and Chinook Salmon marine survival (Riddell *et al.* 2013). However, Cowichan River (DU21) and Dome Creek

(DU11) stocks did have lower survival during major bloom years, as shown by a large negative mean survival anomaly compared to a mean survival rate, suggesting that the location of blooms might affect some populations more than others (Figure 27) (Riddell *et al.* 2013).

There is no evidence of a correlation between southern BC Chinook Salmon marine survival and competition with Pink Salmon juveniles, as no consistent patterns were observed in years exhibiting contrasting abundance of juvenile Pink Salmon in the Strait of Georgia (high abundance of juvenile Pink Salmon in even years, and almost absent in odd years) (Riddell *et al.* 2013) (Figure 28).

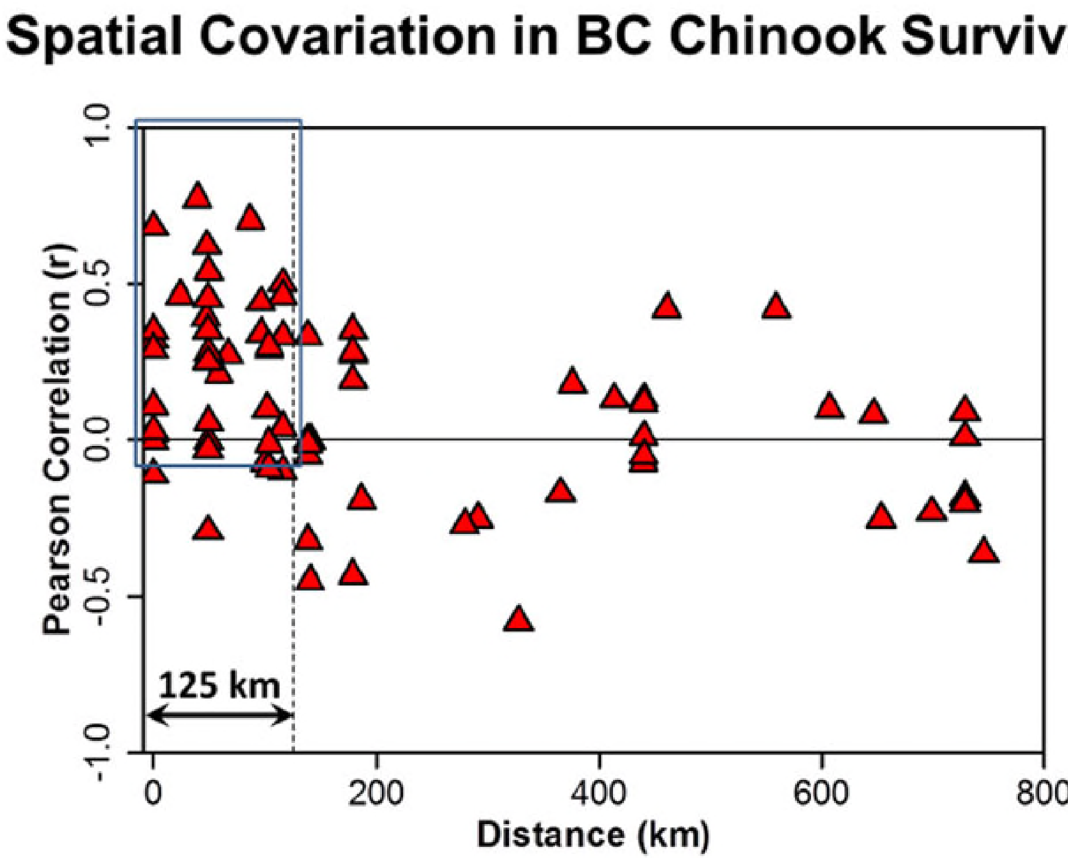


Figure 21. Bivariate Pearson correlation coefficients of marine survival rates and distance between marine entry points for British Columbia Chinook Salmon stocks. From Marc Trudel, DFO. This figure is a reproduction of Figure MH-4 from Riddell *et al*. (2013).

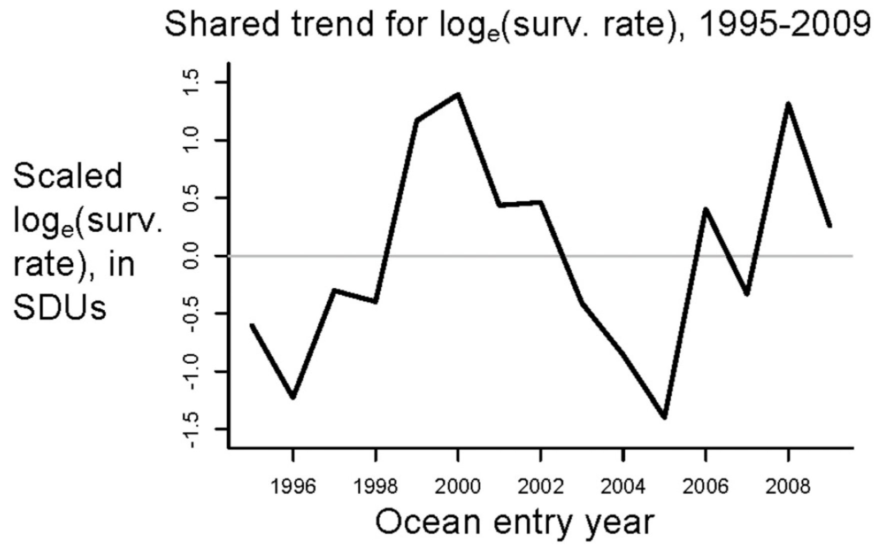


Figure 22. The shared, or common, time trend in the CWT-based age-2 cohort marine survival rate, for ocean-entry years 1995-2009, derived with Dynamic Factor Analysis (DFA), based on data from Oregon, the Columbia River, Washington, British Columbia, and Southeast Alaska. This figure is a reproduction of Figure ST-11 from Riddell *et al*. (2013).

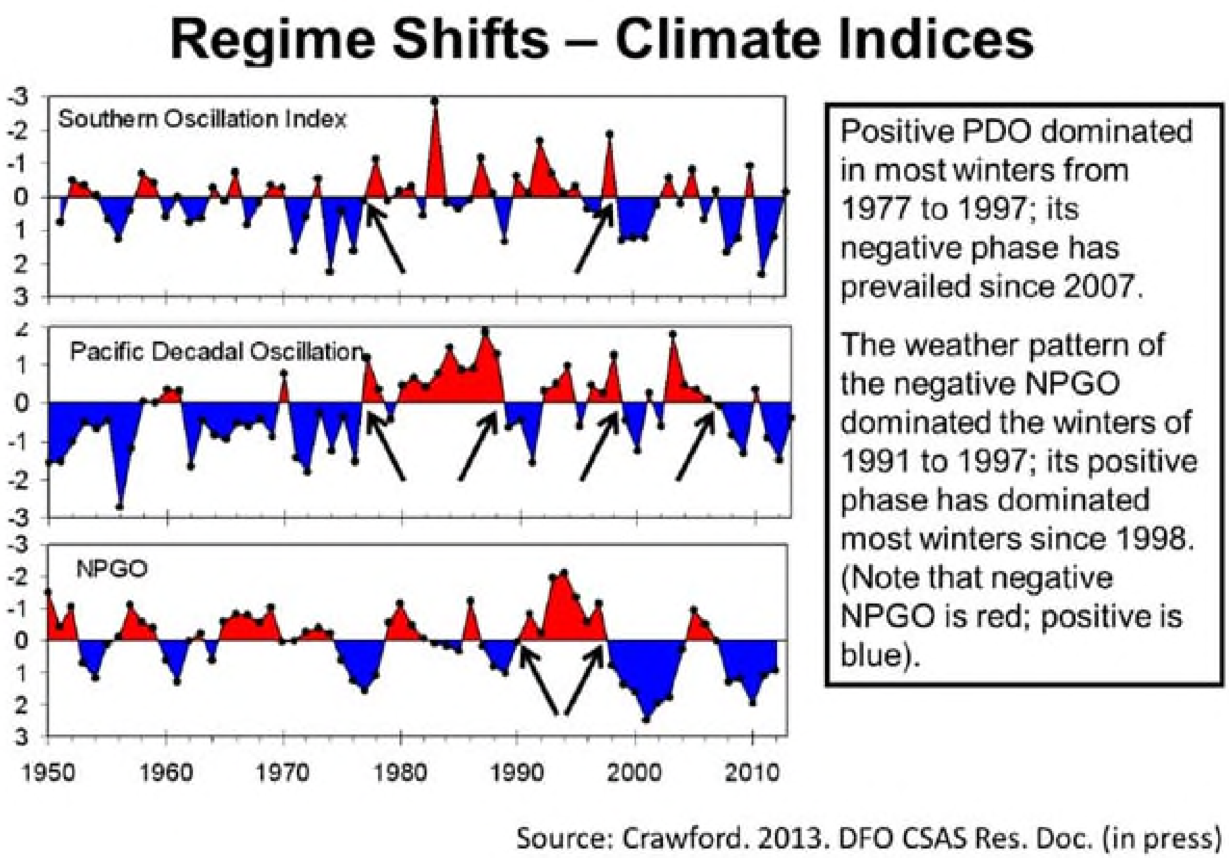


Figure 23. Climate indices reflecting temperature and oceanographic conditions in the North Pacific Ocean. From Marc Trudel, DFO. This figure is a reproduction of Figure MH-5 in Riddell *et al*. (2013). Note that PDO and NPGO are increasingly correlated later in the time series. As of 2018 these climate anomalies are no longer independent and should therefore not be used in the same analysis (P. Westley, pers. comm.)

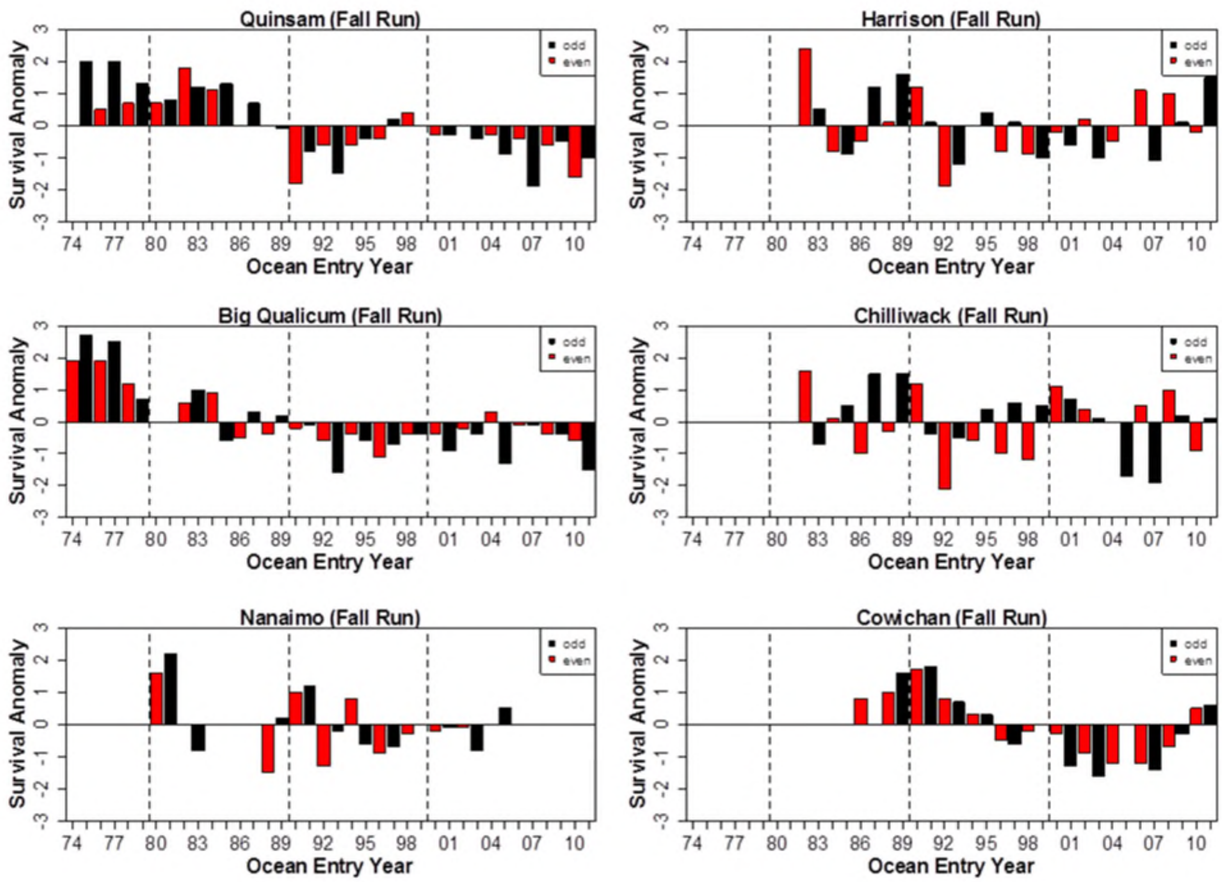


Figure 24. Marine survival anomalies for hatchery indicator stocks for Strait of Georgia fall Chinook Salmon populations. From Marc Trudel, DFO. This figure is a reproduction of Figure MH-1a in Riddell *et al*. (2013).

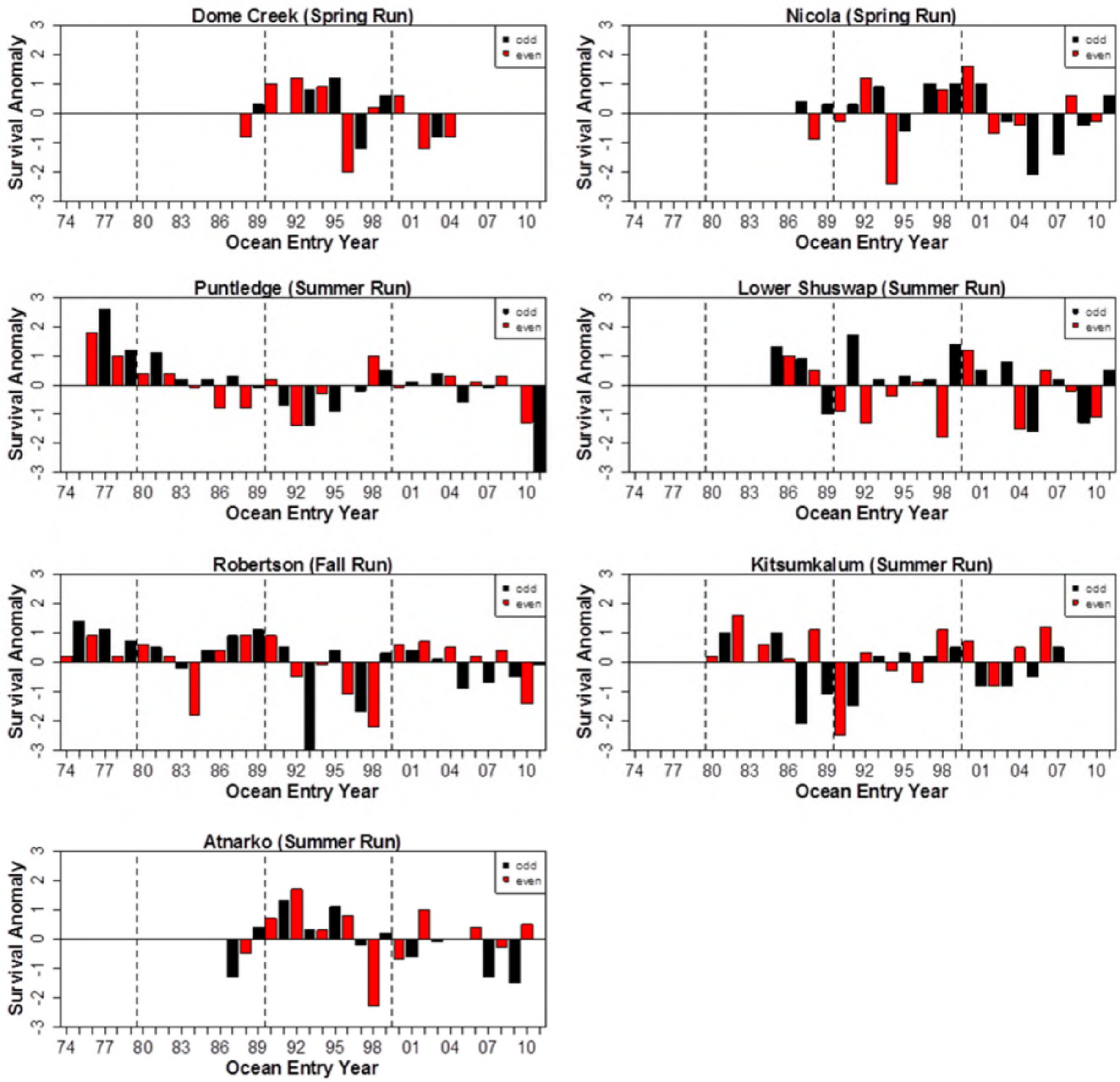


Figure 25. Marine survival anomalies for hatchery indicator stocks for Strait of Georgia spring and summer Chinook Salmon (upper four graphs) and outer coast Vancouver Island fall and summer Chinook Salmon (lower three graphs). From Marc Trudel, DFO. This figure is a reproduction of Figure MH-1b from Riddell *et al*. (2013).

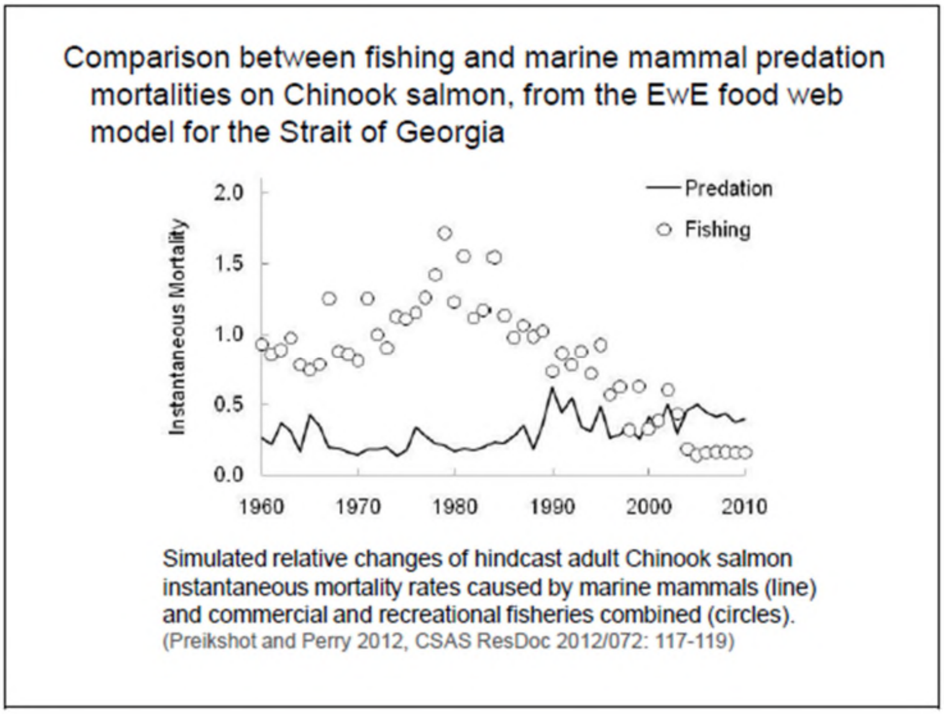


Figure 26. Eco-path model simulation of adult Chinook Salmon mortality due to marine mammal predation and fishing. From Marc Trudel, DFO. This figure is a reproduction of Figure MH-10 from Riddell *et al*. (2013).

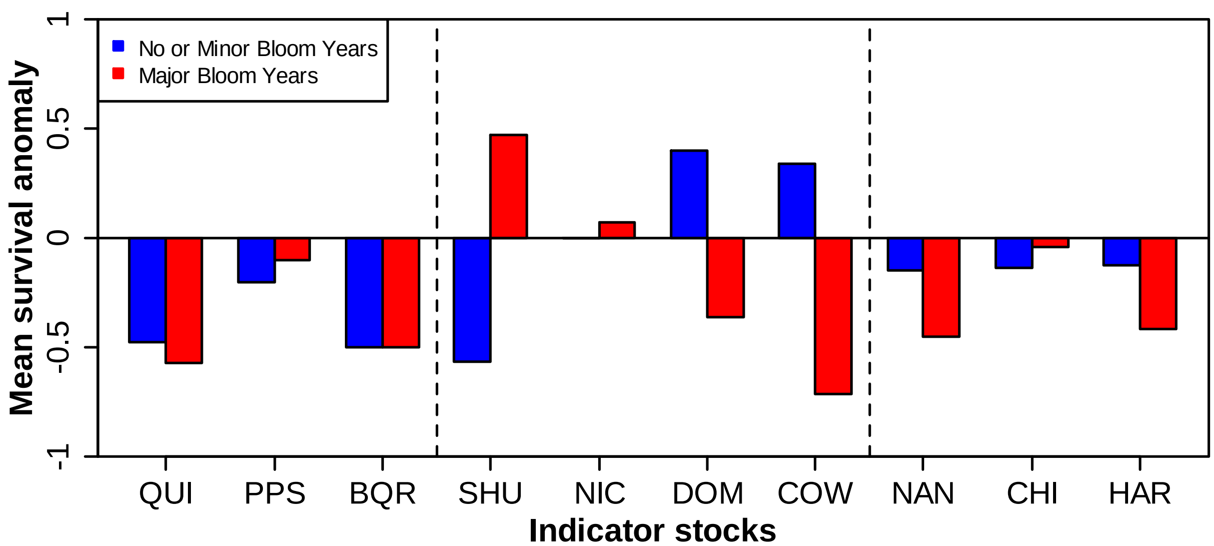


Figure 27. British Columbia Chinook Salmon marine survival in relation to harmful algal blooms. From Marc Trudel, DFO. This figure is a reproduction of Figure MH-11 from Riddell *et al*. (2013).

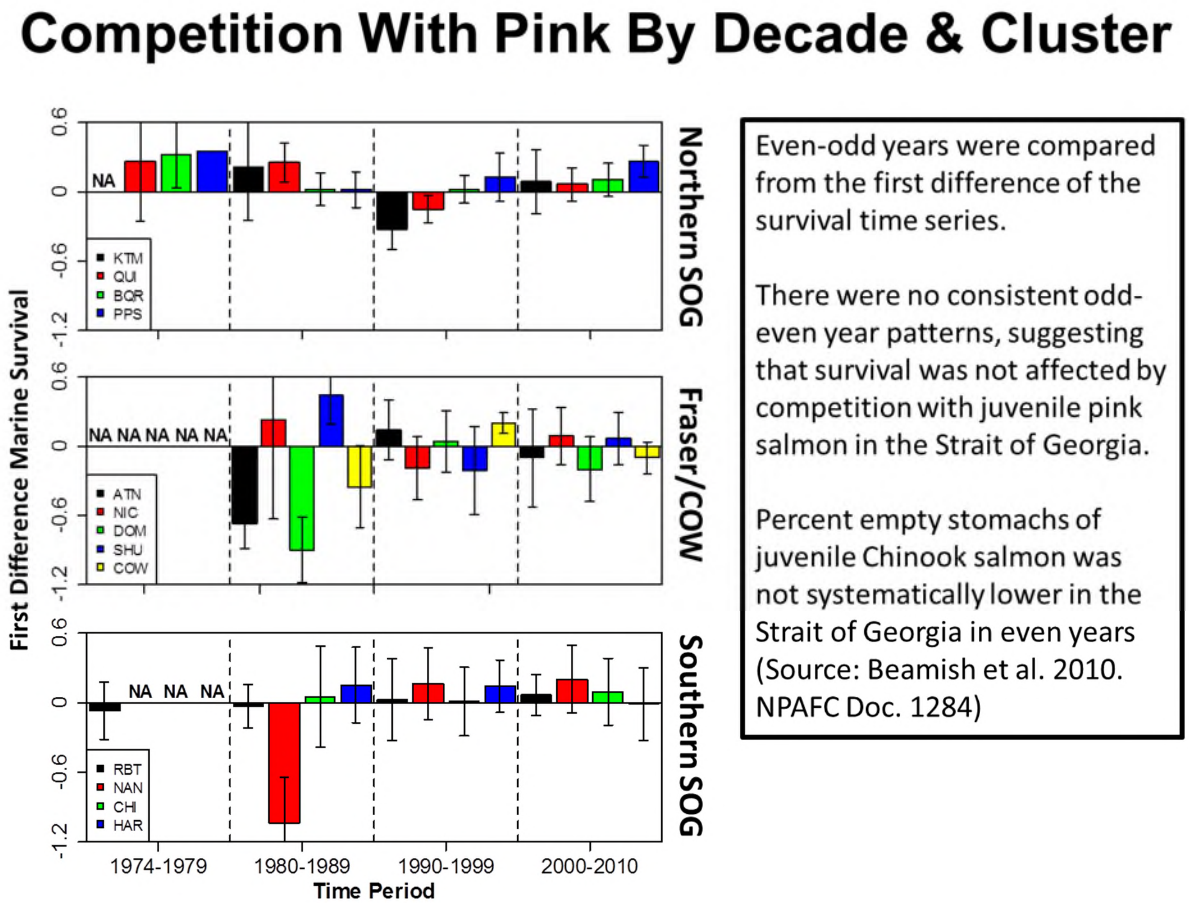


Figure 28. Analysis of effect of Pink Salmon on survival rates of British Columbia Chinook Salmon. From Marc Trudel, DFO. This figure is a reproduction of Figure MH-12 from Riddell *et al*. 2013.

Hatcheries

Since the beginning of the Salmonid Enhancement Program Chinook Salmon populations have been supplemented continuously, particularly those from the coastal areas of Vancouver Island and the Lower Fraser River (MacKinlay et. al. 2004).

COSEWIC considers hatchery fish as part of the population provided they supplement wild populations. The resultant naturally produced offspring are included in the application of quantitative criteria provided these individuals are predicted to provide a net positive impact on the wildlife species assessed and do not decrease the average fitness of individuals in the population (*Guideline #7 in Appendix E7: Guidelines on Manipulated Populations*, COSEWIC 2010).

Withler *et al.* (2018) recently summarized the current knowledge of the impacts of hatchery operations on wild stocks of Chinook Salmon. They conclude that hatcheries represent a risk factor to wild genetic diversity that requires management and mitigation to safeguard Pacific salmon biodiversity in Canada.

Based on data through 2013, the impact of hatcheries varies among DUs. The Middle and Upper Fraser DUs have had a low level of hatchery production over the last three generations, and therefore hatchery programs are unlikely to have influenced population viability or trends in abundance in natural populations in recent years (Riddell *et al.* 2013). Hatchery production was deemed unlikely to have a direct effect on the Thompson River DUs or Lower Fraser DUs. Several lines of evidence indicate that the hatchery program has reduced productivity and caused declines in abundance in Georgia Strait DUs and West Vancouver Island DUs, but data are limited. In these DUs, there are indications of significant genetic change and homogenization (Riddell *et al.* 2013).

It is important to note that widespread efforts to enhance Chinook Salmon populations started in the 1970s and hatcheries were constructed in a number of sites in the Fraser River watershed (Bailey pers. comm. 2018). At that time, the biology of many Fraser River stocks was poorly understood, and many projects attempted to enhance returns by producing age 0+ smolts in stocks that naturally smolted as yearlings. Success was rare, and many projects were discontinued, including hatcheries at Fort St. James, Quesnel River, Eagle River and Clearwater River (Bailey pers. comm. 2018). While these early attempts have been discontinued, it is unknown whether the attempted life-history manipulations resulted in any long-term negative impacts on the stocks. Enhancement continues in some DUs within the Fraser River system, and is strictly regulated and licensed. Most projects now feature native broodstocks, and produce juveniles released at similar timing and sizes to the natural populations. Previously, some intentional extra-DU crosses were carried out, and releases in non-natal DUs still occur. Additionally, some juveniles are released at much larger sizes than naturally produced juveniles which has resulted in greater survivals and altered maturation schedules. The long-term impact of enhancement on Southern BC stocks is not well understood. Overfishing of natural populations may occur in mixed-stock fisheries, but other impacts may be more subtle and difficult to detect. Recent advances in genetic and epi-genetic science suggest that the impact of hatchery enhancement may not be positive, and that inappropriate strategies combined with inter-basin transfers may compound those impacts.

Hatchery production most strongly affects variation in population trends (i.e., annual proportional changes in abundance) (Hoekstra *et al.* 2007). There is evidence that enhancement may pose a risk to natural populations. Myers *et al.* (1998) argue that artificial propagation poses a number of genetic risks for natural salmon and Steelhead Salmon populations in addition to the complications it brings to evaluation of natural replacement rates. Interbreeding of hatchery and natural fish can lead to loss of fitness in local populations, e.g., loss of local adaptations, loss of genetic diversity among populations. There is also some evidence that the survival rate of hatchery fish is lower than wild fish during times of low ocean productivity (Nickelson 1986; Zimmerman *et al*. 2015 – Coho Salmon, Beamish *et al.* 2012 – Chinook Salmon). However, there is little correlation between the scale of hatchery releases and marine survival of hatchery origin fish except for east coast of Vancouver Island stocks (Riddell *et al.* 2013) (Figure 29). Another critical potential effect is reduced reproductive capacity of natural origin fish (see Nickelson 2003; Buhle *et al.* 2009; Chilcote *et al*. 2011; Ford *et al.* 2012).

Gardner *et al.* (2004) prepared a comprehensive review of the information available on interactions between hatchery origin and wild origin salmon for the Pacific Fisheries Resource Conservation Council. The positive and/or negative effect of each interaction type was explained, with examples. In order of risk, Gardner *et al.* (2004) drew the following conclusions:

1. Mixed stock fishing: Research has identified situations where wild salmon have been negatively affected on a large scale, with the worst impacts related to the Georgia Basin[17] hatcheries. Fishery management strategies and fishing techniques are being directed towards lessening mixed stock harvesting of wild salmon.
2. Genetic interactions: Although evidence of actual impacts is scarce, current theory indicates that enhancement could significantly reduce the genetic diversity and fitness of wild salmon. Genetic changes to hatchery fish may well be inevitable; the uncertainty relates to how extensive these changes are and how strongly they affect wild salmon. Hatchery practices implemented in recent years have alleviated some risks of genetic impacts, but the risks are still significant.
3. Competition: Some studies have pointed to negative impacts on wild salmon as enhanced salmon consume food supplies that would otherwise be available to wild salmon. The increasing concerns about limited carrying capacity relate to both freshwater and at-sea habitats.
4. Predation interactions: Shown to have a negative impact on wild salmon in some cases but other studies indicate that the presence of enhanced salmon can have a neutral or even positive effect on predation on wild salmon.
5. No studies illustrating negative fish health interactions between enhanced and wild salmon could be found through this research. Nevertheless, the potential for disease transfer between enhanced and wild fish does exist, because conditions in hatcheries can promote the spread of disease, which in theory can then be transferred to wild fish through water or fish-to-fish.
6. Negative impacts of enhancement facilities on local fish habitat are possible, but research has not identified these as being significant. These facilities are the most localized and the easiest of the potential interactions to mitigate or avoid.

Weber and Fausch (2003) also present information on the negative effects of hatchery production in the presence of wild Chinook Salmon. They found that despite the intent to reduce pressure on wild salmon stocks, the presence of hatchery-origin fish can have a suppressing effect on non-enhanced populations. Among a number of potential effects, artificially increasing the abundance of a few stocks in the presence of wild stocks can allow for higher fishing pressure by recreational and commercial fishing groups because of

[17] The Georgia Basin is an international water body that includes the marine waters of Puget Sound, the Strait of Georgia, and the Strait of Juan de Fuca (Gustafson *et al.* 2000)

the greater overall abundance of fish (unless hatchery fish are marked and selectively retained), and high release mortality of wild unmarked fish. Although the propagation of hatchery-based stocks can continue with lower abundances, wild stocks at similarly low productivity levels are unable to withstand this level of exploitation.

In their pre-release life stage, hatchery-reared Chinook Salmon are not exposed to predators so normal aggressive behaviours result in reward (more food resources) rather than exposure to potential predation. These fish can also show rapid local adaptation to hatchery environments (Christie *et al.* 2012). After release into the natural environment, the generally larger, more aggressive hatchery smolt can out-compete their wild origin counterparts for food resources (Weber and Fausch 2003). This competitive advantage, in the situation of limited food, can be detrimental to wild fish, decreasing their initial survival.

Another application of hatchery practices not considered by Gardner *et al.* (2004) includes the use of seapen releases. This strategy has been used as a technique for increasing recreational fishing opportunities in marine areas, particularly off the West Coast of Vancouver Island (also in Vancouver harbour and Burrard inlet). Some seapen release sites (e.g., Discovery Pass, Maclean Bay, Poett Nook) do not have local Chinook Salmon populations associated with the site. As a result, returning seapen Chinook Salmon have difficulty finding creeks and rivers to spawn in. In the Campbell River area, Quinsam Hatchery Chinook Salmon were released from a seapen site in Discovery Pass, and were subsequently found in small creeks on Quadra Island (Drew, Granite Bay and McKercher) that do not have the right spawning habitat for Chinook Salmon (DFO NuSEDs data). Additionally, returning seapen releases could be straying into rivers and breeding with established Chinook Salmon populations that are distinct from the seapen population, with unknown effects on the genetics of the locally adapted Chinook Salmon population (Brown *et al.* 2013a). CWT marking of seapen releases is infrequent, precluding characterization of movement patterns using existing study designs; however, recent research by DFO suggests higher ‘stray’ rates than previously considered (Bailey pers. comm. 2018).

The hatchery programs in the Middle-Upper Fraser River, Thompson River, and Lower Fraser River DU groups have been reduced to levels where the risk to wild Chinook Salmon is small and additional hatchery monitoring would yield little contribution to understanding hatchery impacts. However, hatchery programs in the Strait of Georgia and the WVI DU groups influence many aspects of Chinook Salmon natural population ecology and dynamics.

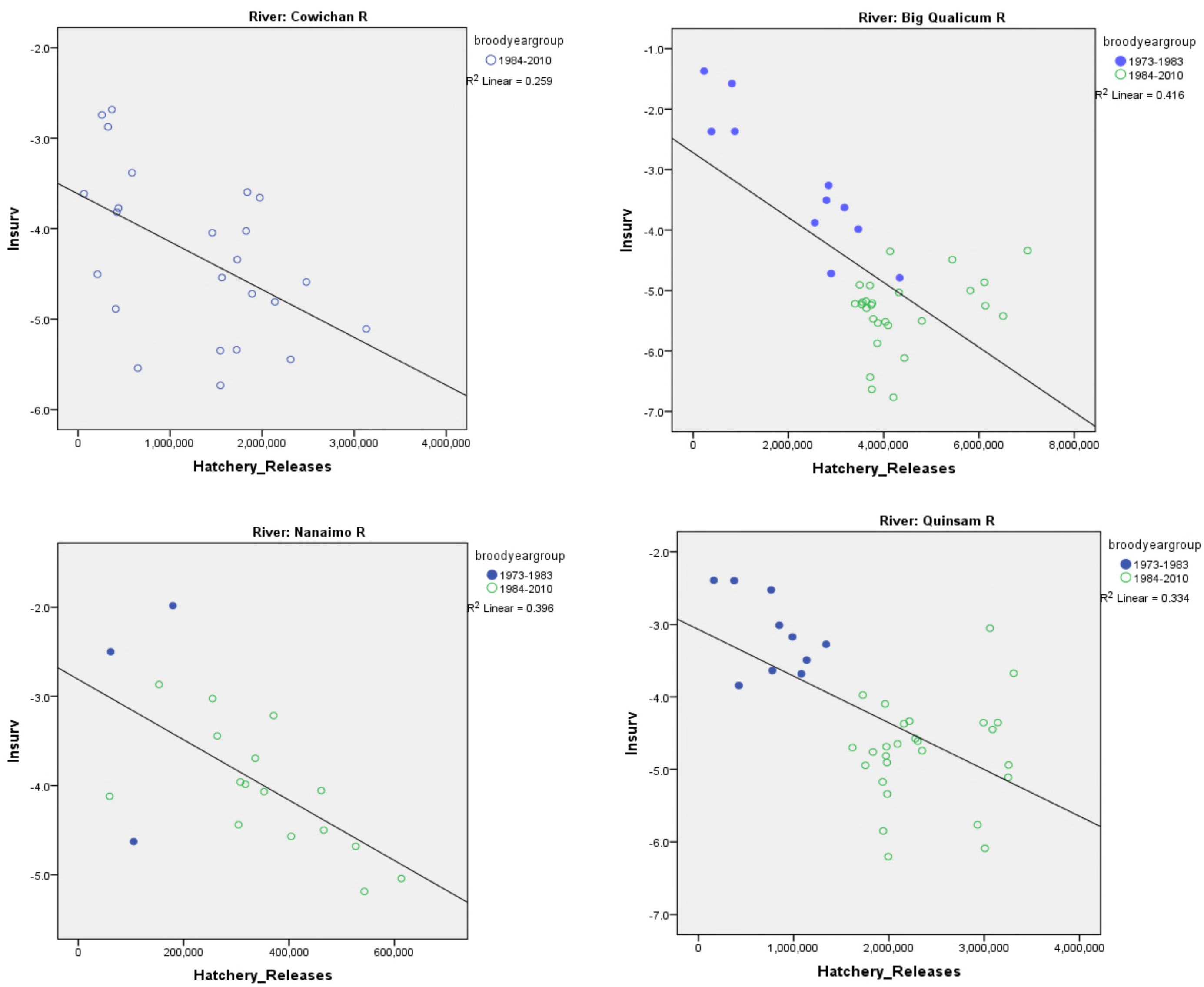


Figure 29. Marine survival of east coast Vancouver Island Chinook Salmon stocks in relation to the number of hatchery fish released. From David Willis, DFO. This figure is a reproduction of Figure MH-13 from Riddell *et al*. (2013).

Pathogens and Aquaculture

The risk of population level impacts of pathogens on southern BC Chinook Salmon is inconclusive because monitoring of wild salmon populations for disease is largely non-existent in BC (Riddell *et al.* 2013). However, laboratory studies and observations from captive (farmed or hatchery) Chinook Salmon have shown that pathogens and disease can cause mortality. Three pathogens were identified as potential risks to Chinook Salmon productivity – *Renbacterium salmoninarum*, *Aeromonas salmonicida*, and *Vibrio anguillarum* (Riddell *et al.* 2013).

The risks of open net-pen salmon aquaculture on wild Chinook Salmon is considered low but data are limited (Riddell *et al.* 2013). The risk of transmission from farmed Atlantic salmon to wild Chinook Salmon is thought to be low because of differences in susceptibility to various diseases.

Global Climate Change

Globally, land and air temperatures have been increasing (NOAA 2017). The effects of climate change could produce coherent trends over a broad spatial scale, including within the freshwater environment. These changes are expected to manifest as increased stream temperatures to critical levels (>18°C) (Morrison *et al.* 2002; Ferrari *et al.* 2007), changes in stream flow rate and seasonality (Dery *et al.* 2012), increased glacier melt (Schiefer *et al.* 2007; Stahl *et al.* 2008), increased contaminants (Harvell *et al.* 2002; Noyes *et al.* 2009, Sanderson *et al.* 2009; Walker and Winton 2010), and changes in the marine environment (Moore *et al.* 2008; Mooney *et al.* 2009; Rensel *et al.* 2010). The possible impacts of such changes for salmon are summarized for different life stages below (Puget Sound Partnership (2017) and IUCN (2009)):

<u>Freshwater eggs, fry and juveniles</u>

Increased winter floods may increase scour of eggs, or increase mortality of rearing juveniles where flood refugia are not available. Rearing juveniles could also be displaced to less desirable habitats. A reduction in summer flow levels will serve to increase water temperatures further and is likely to reduce the overall habitat available to salmon. Increased summer temperature may decrease growth or kill juvenile salmon. Increased winter flows are likely to scour the river beds, disturbing nests and causing physical damage to both salmon eggs and juveniles.

<u>Marine sub-adults and adults</u>

Many of the food webs that include salmon are expected to be disrupted by climate change. For example, the timing of planktonic blooms required by young salmon is governed by climatic factors. Changes in the timing of these blooms could cause a scarcity of food at a critical life stage (IUCN 2009). Also, oceans help absorb increased concentrations of atmospheric carbon dioxide but this has caused a 30% increase in ocean acidity since 1750 (Orr *et al*. 2005). Consequences are expected to impact ocean food webs, including increased predation impacts on salmon (Fabry *et al*. 2008).

Freshwater adults

As freshwater temperatures increase, a number of negative effects on adult salmon may arise. Direct biological impacts on salmon include physiological stress, increased depletion of energy reserves, increased susceptibility and exposure to disease and disruptions to breeding efforts (IUCN 2009). Temperature-related barriers to migration and possible decreased access to or availability of spawning habitat may also occur. However, there is currently no evidence that increased summer temperatures will decrease spawning fecundity for salmon.

For many Chinook Salmon DUs, snow is predicted to be replaced by rain. This shift will lead to a reduction in summer flows for many rivers, coupled with an increase in freshwater inputs during the winter. At a regional scale, an ensemble of 30 projections to 2070 show that projected warming will be greater in the Interior portions of southern BC compared with the coastal region (Pike *et al*. 2010). Nelitz and Porter (2009) described the projected changes to the Thompson and Chilcotin watersheds as a result of climate change. The general patterns of this analysis suggest that regional climate change impacts on Chinook Salmon may be mixed. In some areas, there may be benefits of habitat changes, while in others there may be constraints on production. For instance, stream habitats with temperatures optimal for Chinook Salmon rearing are predicted to decrease in northern areas of the study area and increase in southern areas. However, reductions in late summer/early fall flows will create challenges for rearing juveniles and for spring and summer spawners. As a result, Chinook Salmon populations are predicted to decrease more markedly in the north than in the south. In some of the more northern streams summer/fall flows are predicted to decline to such an extent that minimum flows to support successful spawning and rearing may not be reached consistently in the future.

The scope of change in southern BC watersheds is likely to be widespread. The severity of such impacts is unknown at present, but could be serious, particularly in those DUs already stressed by other anthropogenic activities. In a recent review of southern BC Chinook Salmon threats, climate change was identified as likely already affecting southern BC Chinook Salmon, but no definitive conclusions could be drawn from current evidence (Riddell *et al.* 2013).

FORMAT OF DESIGNATABLE UNIT-SPECIFIC CHAPTERS

In the following DU-specific chapters, the information covered for each DU will include:

1. Names, life-history type, run-timing and generation time
2. Extent of occurrence and area of occupancy
3. Habitat trends
4. Abundance
5. Fluctuations and trends
6. Threats and limiting factors

Names, life-history type, run-timing and generation time

Each DU chapter begins by listing the full DU name, the DU short name, the Joint Adaptive Zone (JAZ) short name, the life-history type (Ocean or Stream), the run-timing type (Fall, Spring, Summer), and generation time. Generation time is estimated as the average age of spawners in the absence of fishing mortality. These figures are based on CWT indicator stocks (listed below in Table 12). Where indicator stocks are not available within a DU, proxy indicator stocks are used (shown in Table 18). For southern BC Chinook Salmon DUs, all the CWT indicator stocks are integrated hatchery stocks. Since both natural and hatchery origin fish are used as brood stock and CWTs are applied to their progeny, it is assumed that other natural origin fish in the DU are represented reasonably by the indicator stocks. This assumption is often made with southern BC Chinook Salmon, but it is well known that these indicator stocks were chosen by convenience, and not by random selection or any other manner intended to accurately represent the characteristics of the conservation unit. These are currently the best data available for the purpose of estimating generation time (G. Brown, pers. comm.).

Extent of Occurrence and Area of Occupancy

For each DU, extent of occurrence and area of occupancy data are reported at the Designatable Unit (DU) level of analysis (see the **Designatable Unit Delineation** section of this report). The spatial extent of all DU boundaries is shown in Figure 30, this coverage represents the terrestrial (i.e., freshwater) extent of occurrence for the southern BC Chinook Salmon assessed in this report.

DU boundary delineations were adapted from CU Report Cards developed by Porter *et al.* (2013) which used third-order plus watersheds from the 1:50,000 British Columbia Watershed Atlas (www.env.gov.bc.ca/fish/watershed_atlas_maps/) as a base spatial scale of analysis. Prior to release of the Porter *et al.* report, some of these CU boundaries were modified to allow for DFO-defined changes; as a result, associated metrics were recalculated. Generally, DU boundaries used in this report correspond to CU boundaries. In the cases of DU12 and DU21, multiple CUs comprise the DU. For DU-specific chapters, individual DU areal extents are estimated in GIS software using geospatial shapefiles. The DU map in Figure 30 is confirmed as up-to-date and accurate as of 2012. However, after the report's release, the spatial extent of the CU areas were again redefined – in all cases they were expanded. At the time of writing, data were unavailable for these revised boundaries.

The marine extent of Chinook Salmon cannot be precisely defined geospatially due to lack of available data, but the extent of occurrence for all southern BC Chinook Salmon is known to be >20,000 km^2. According to harvest statistics, Chinook Salmon ocean ranges extend northward to Southeast Alaska (Riddell *et al.* 2013). Ranges specific to southern BC Chinook Salmon vary depending on life-history strategy with 'local' stocks moving as far north as central Queen Charlotte Islands and as far south as the Columbia River mouth (Bailey pers. comm. 2018). 'Offshore' stocks are believed to range as far north as the Bering Sea and into the North Pacific Gyre (Bailey pers. comm. 2018).

Following methods used for the COSEWIC Fraser Sockeye Salmon Status Report, the area of occupancy of each DU is calculated as two times the spawning length, and is reported in square-kilometres. This method is equivalent to overlaying a 2×2 km^2 grid over the stream, and adding up the total area. To assist in comparison across DUs, each DU description also states the proportion of spawning habitat within each DU relative to the total across all DUs. Chinook Salmon spawning extents were provided by the Province's Fisheries Information Summary System (FISS), and are meant to cover the total linear length of known Chinook Salmon spawning habitat within each DU. FISS presently represents the best available data in GIS format; however. the database is known to be incomplete due to a lack of comprehensive source information for southern BC Chinook Salmon distributions (Porter *et al.* 2013).

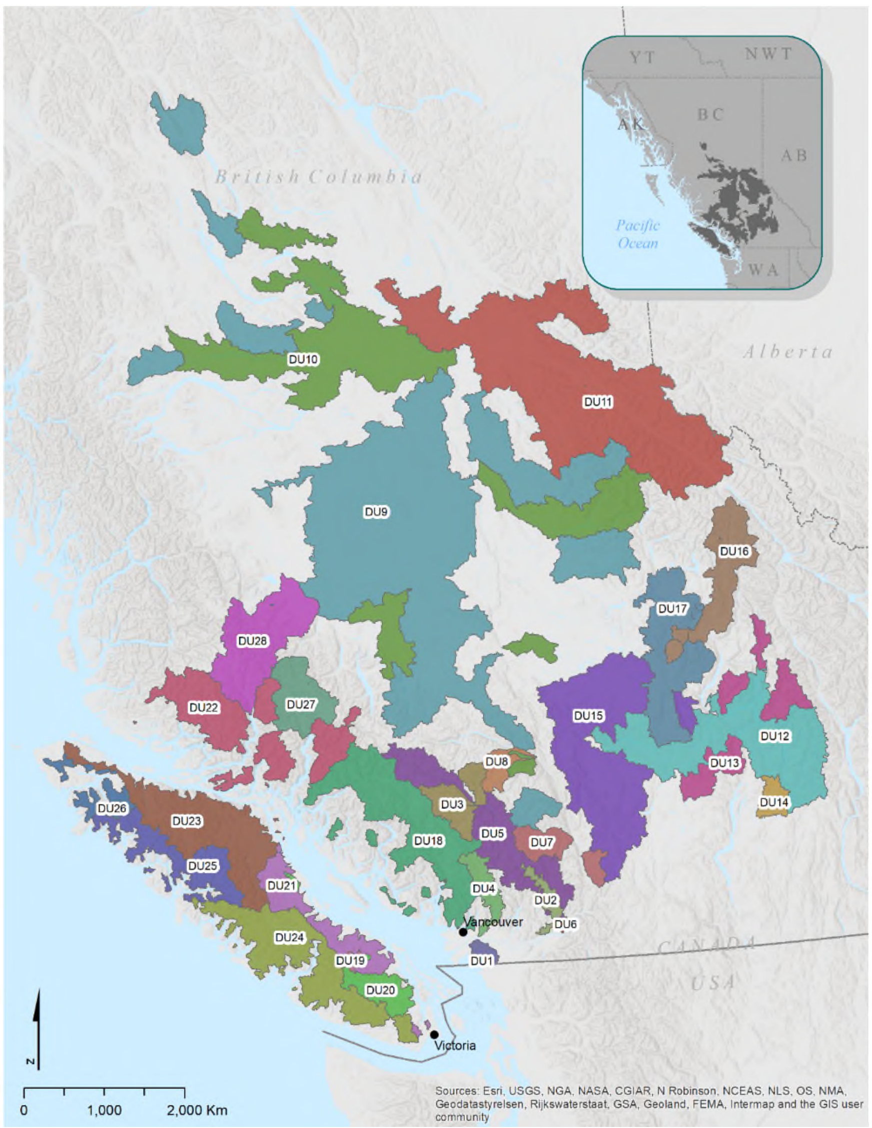


Figure 30. Spatial extent of the freshwater area for all southern BC Chinook Salmon Designatable Units (based on CU delineations, which are being regularly updated by DFO. These DU boundaries are up-to-date and accurate as of 2012. No official updates have been published since that date).

Habitat Trends

Habitat trends reported for each DU's freshwater-based area describe some of the known indicators adapted from the Porter *et al.* (2013) DFO Report Card data. Reported trends include land-based habitat alteration, urban development, rural development, mining, road density, the number of stream crossings, riparian habitat disturbance, forest disturbance and Mountain Pine Beetle-affected pine stands.

Sampling Effort and Methods

Abundance

While total abundance is the most desirable metric for this category, such data are unavailable for many DUs so this report relies on escapement data. Escapement data quality and quantity vary across DUs and over time. Escapement, defined as the number of fish arriving at a natal stream or river to spawn (also termed 'spawner abundance') can be assessed by presence/absence, relative abundance, or total ("true") abundance. The New Salmon Escapement Database System (NuSEDS) is a centralized database that holds adult salmon escapement data used by Fisheries and Oceans Canada (DFO). Escapement data used for the status metrics in this report originated from NuSEDS, with the understanding that not all escapement data from NuSEDS represent absolute abundances.

In 2013, DFO undertook a process to determine thresholds for data quality of escapement data that included a three-day workshop in February 2013. The NuSEDS Estimate Classification scheme (Table 11) was central to selecting data considered to be sufficient in quality and completeness to be used for calculation of status metrics. The process is described in greater detail in (Brown *et al.* 2013b), but it is also described briefly here. Data considered suitable for use were Type-1 through Type-4 estimates only ('true abundance' and 'relative abundance'). When using the NuSEDS Estimate Classification scheme, over 61% of escapement records between 1953 and 1995 were excluded due to missing Estimate Classification information, and therefore marked as 'unknown'. DFO identified the missing data as a high priority for 'data rescue'. The NuSEDS Estimate Classifications were further grouped into high, moderate, low and unknown categories: H (High) = True Abundance (Type 1 or 2), M (Mod) = Relative Abundance (Type 3 or 4), L (Low) = Relative Abundance (Type 5) or Presence/Absence (Type 6), and ? (Unknown) = Type Unknown is reported in the database or is blank.

Within a DU or, in the case of the WSP, within a CU, a key challenge is how to combine data for ‘true abundance’ (Type 1 or 2) with data for ‘relative abundance’ (Type 3 or 4). In many cases where multiple spawning sites existed, relative abundance estimates were summed with true abundance estimates to arrive at total abundance within the DU. In these cases, the entire DU was considered a ‘relative abundance index’. Under the WSP CUs, there were 4 CUs that were considered to provide actual abundance: CK-03, CK-15, CK-21, and CK-22. However, when combined into DUs, only DU2 (CK-03) was considered to provide actual abundance (CK-15 is combined into DU12 with CK-13; CK-21 and CK-22 are combined into DU 21 with CK-25 and CK-27). In both relative abundance index and actual abundance cases, all CUs/DUs had considerable past and current enhancement (Brown *et al.* 2013b).

Table 11. NuSEDS Estimate Classification scheme. SIL = Stream Inspection Log; SEN = Summary Estimate Narrative.

DFO Ranking	Estimate Type	Survey Method(s)	Analytical Method(s)	Reliability (within stock comparisons)	Units	Accuracy	Precision	Documentation
High (H)	Type-1, True Abundance, high resolution	total, seasonal counts through fence or fishway; virtually no bypass	simple, often single step	reliable resolution of between year differences >10% (in absolute units)	absolute abundance	actual, very high	infinite i.e.,+ or - zero%	detailed SIL(s), SEN, field notes or diaries, published report on methods
	Type-2, True Abundance, medium resolution	high effort (5 or more trips), standard methods (e.g., mark-recapture, serial counts for area under curve, etc.)	simple to complex multi-step, but always rigorous	reliable resolution of between year differences >25% (in absolute units)	absolute abundance	actual or assigned estimate and high	actual estimate, high to moderate	detailed SIL(s), SEN, field notes or diaries, published report on methods
Moderate (M)	Type-3, Relative Abundance, high resolution	high effort (5 or more trips), standard methods (e.g., equal effort surveys executed by walk, swim, overflight, etc.)	simple to complex multi-step, but always rigorous	reliable resolution of between year differences >25% (in absolute units)	relative abundance linked to method	assigned range and medium to high	assigned estimate, medium to high	detailed SIL(s), SEN, field notes or diaries, published report on methods
	Type-4, Relative Abundance, medium resolution	low to moderate effort (1-4 trips), known survey method	simple analysis by known methods	reliable resolution of between year differences >200% (in relative units)	relative abundance linked to method	unknown assumed fairly constant	unknown assumed fairly constant	complete SEN or equivalent with sufficient detail to verify both survey and analytical procedures

DFO Ranking	Estimate Type	Survey Method(s)	Analytical Method(s)	Reliability (within stock comparisons)	Units	Accuracy	Precision	Documentation
Low (L)	Type-5, Relative Abundance, low resolution	low effort (e.g., 1 trip), use of vaguely defined, inconsistent or poorly executed methods	unknown to ill defined; inconsistent or poorly executed	uncertain numeric comparisons, but high reliability for presence or absence	relative abundance, but vague or no identification of method	unknown assumed highly variable	unknown assumed highly variable	incomplete SEN, only reliable to confirm estimate is from an actual survey
	Type-6, Presence or Absence	any of above	not required	moderate to high reliability for presence/absence	(+) or (-)	medium to high	unknown	any of above sufficient to confirm survey and reliable species identification
Unknown (?)	Unknown	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Sample sites within a DU were assessed based on the quality and completeness of their time series. The full list of sample sites is presented in Table 43 (Appendix 2) of this report along with start/end dates for each estimation method. Note that sites with very low contributions are not included in the figures reported in Panels c and d of the ‘abundance, enhancement, and hatchery release’ data graphics (Figure 31) of each DU chapter (e.g., Wap Creek in DU12). The process is described in greater detail by Brown *et al.* (2013), and relied on the following criteria:

1. Sites must be ‘persistent’. ‘Persistent’ sites (‘P’) were defined as those having more than 50% high quality observations (Type-1 to Type-4) during the period Start Year to 2012, with no more than one generation of years missing in sequence. For example, for CUs with a start year of 1995, this translates into at least 10 years of high quality data from the period that was part of the in-depth data review, and no more than 3, 4 or 5 years in a row missing (depending on the average generation time for the CU) for each persistent census site in the CU.

2. For sites with marginal numbers of high quality observations during the Start Year to 2012 period, the pattern of missing data was investigated to determine if it could be infilled to provide a sufficiently complete time series (i.e., the pattern of missing observations for the census site did not include a full generation—based on the average generation time for the DU—at any point in the Start Year to 2012 period). Those that could meet the sufficiency criteria with infilling were identified as ‘P’, and the rest were classified as data deficient (‘DD’).

3. If a site had 50% or fewer high quality observations during the Start Year to 2012 period and could not be infilled to achieve a 50% level, it was categorized as ‘DD’.

When combining data from more than one site within a CU that contained years with missing data, infilling was performed by DFO. This process is described in greater detail in Brown *et al.* (2013b). Infilling followed the procedure outlined in English *et al.* (2006), whereby the average proportion (across years) each census site contributed to the total was calculated, and used to infill years with no escapement data. When the time series of several CUs within a DU were combined (i.e., DU12 and DU21), the same English *et al.* (2006) approach was adopted.

Within the DU-specific chapters, two pieces of information are presented when available:

1. The proportion of spawners originating from census sites of varying data quality.
2. The number of spawners above and below threshold abundances.

The calculation of the proportion of spawners originating from census sites of varying data quality combines the work on categorizing the data quality of abundance estimates with the work on categorizing the data quality from different census sites. The number of spawners above or below threshold abundance is based on COSEWIC quantitative criteria for the total number of mature individuals. The benchmarks are 10,000, 2,500, 1,000, and 250 individuals.

Coded-wire tags (CWT) are used as a source of detailed information for many populations of Chinook Salmon along the Pacific coast of North America (Hankin *et al.* 2005; Nandor *et al.* 2010). Chinook Salmon populations with consistent annual releases of CWTs are referred to as CWT indicator stocks and are used to represent naturally spawning wild stocks which exhibit the same adult and juvenile life-history patterns and are assumed to exhibit the same behavioural patterns within a similar geographic area. To produce sufficient CWTs for analysis, most of the CWT indicators are tied to hatchery programs, where fish are reared, tagged, and released. There are 11 Canadian CWT indicator stocks distributed among southern BC Chinook Salmon DUs (Table 12). Most of these stocks are from large-scale conventional hatchery facilities with five located within the Fraser River drainage (DU2, DU11, DU12, DU15, and the Chilliwack River) and six distributed around Vancouver Island (DU19, DU20, DU21, DU22, DU23, and DU24). Two hatcheries have been terminated in recent years (DU11 and DU21 – Nanaimo River) but funds administered by the Coded Wire Tag Improvement Team of the Pacific Salmon Commission (PSC) have been used recently to improve aspects of the others (PSC-CTC 2012a).

Information provided by CWTs includes ocean distribution (via catch of tagged fish vulnerable to fishing gear), exploitation, smolt survival, and mean age at maturity. The Pacific Salmon Treaty (PST) between Canada and the United States supports annual sampling programs to collect information from CWT indicator stocks using a consistent and unbiased design (Brown *et al.* 2013b). Information from CWT indicator stocks is obtained from the cohort analysis output files, which extend to the end of 2012, and were used to produce the Chinook Salmon Technical Committee (CTC) 2013 annual report (Brown *et al.* 2013b). The details of the cohort analysis procedure are described in PSC-CTC (1987).

Table 12. Summary coded-wire tag (CWT) release information for the southern BC Chinook Salmon CWT indicator stocks. Summary CWT release data are from the 2000-2009 brood years and CWT recovery data are from the 12-year period 2000-2011. Sample sizes are provided under 'n Broods' and 'n Years'. Under 'Release Information', 'Mean CWT' is the mean number of juveniles released per brood year with a CWT and marked by removal of the adipose fin. Values under 'Mean Associated non-CWT' are the mean number of untagged and unmarked fish released from the same brood years and associated to the tagged and marked release. The number of contributing brood years is given under 'n Broods'. Under 'Estimated CWT Information, 'Mean CWT' provides the total estimated number of CWTs represented in fishery catches and in the spawning escapement based on actual CWTs recovered in sampling programs. Mean percentages under the four right-most columns provide the proportional occurrence of the CWTs in all BC ocean fisheries (Ocean-CA), in all ocean fisheries in the U.S. (Ocean-US which includes Alaska, Washington or Oregon), in terminal marine or freshwater fisheries for a particular stock (the terminal area is stock-specific) and in the spawning escapement. These four percentages sum to 100%. The number of years of CWT recovery (n Years) includes only those years with at least two age classes of CWT releases available for capture. The CU associated with the Chilliwack River indicator stock (CK-9008) is not incorporated into the DUs assessed in this report as it is classified as hatchery stock. This classification excluded the stock from consideration in the Wild Salmon Policy status assessment. This table is adapted from Table 12 in Brown *et al.* 2013b.

				Release Information			Estimated CWT Information					
Indicator Stock Site/Name	Indicator Stock Acronym	DU Number	Run Type	n Broods	Mean CWT	Mean Associated Non-CWT	n Years	Mean CWT	Ocean-CA	Ocean-US	Terminal	Escapement
Chilliwack R	CHI	N/A	Fall	10	101,904	472,864	12	4153	9.2%	15.0%	7.4%	68.4%
Harrison R	HAR	DU2	Fall	9	149,096	804,461	12	1113	10.5%	20.9%	1.6%	66.9%
Dome Cr	DOM	DU11	Spring	3	83,602	3,718	8	155	1.8%	23.5%	50.1%	24.6%
Lower Shuswap R	SHU	DU12	Summer	10	186,708	370,005	12	1444	15.4%	26.8%	9.5%	48.3%
Nicola R	NIC	DU15	Spring	9	107,174	46,275	12	1089	1.2%	6.3%	10.3%	82.3%
Puntledge R	PPS	DU20	Summer	10	115,953	508,058	12	290	15.9%	23.4%	0.0%	60.7%
Cowichan R	COW	DU21	Fall	9	299,815	1,209,989	12	781	12.7%	48.0%	6.1%	33.2%
Nanaimo R	NAN	DU21	Fall	4	145,257	96,884	9	819	7.8%	33.7%	6.7%	51.8%

				Release Information			Estimated CWT Information					
Big Qualicum R	BQR	DU21	Fall	10	235,183	3,388,613	12	501	15.1%	26.3%	2.2%	56.4%
Quinsam R	QUI	DU23	Fall	10	287,024	1,842,503	12	814	22.6%	20.3%	0.1%	57.1%
Robertson Cr	RBT	DU24	Fall	10	256,807	6,153,023	12	2360	20.2%	16.0%	27.1%	36.7%

Enhancement

Wild-born fish cannot be distinguished from their hatchery counterparts with certainty unless mass marked. However, mass marking is not currently employed in Canada for Chinook Salmon (only hatchery Coho Salmon). Therefore the authors of the Pre-COSEWIC report adopted a higher-level approach based on categorizing sites by enhancement activity level (Brown *et al.* 2013b). Census sites within Designatable Units were assigned a level of enhancement based on a standardized procedure developed by DFO during the Pre-COSEWIC process (Brown *et al.* 2013b). The standardized rank classified the census sites as:

- Category 1. Unknown (no evidence of recent active enhancement) - no release records, brood records or enhanced contribution estimates during the period 2000-2011.
- Category 2. Low enhancement activity level - release records, brood records or enhanced contribution estimates exist prior to 2000 but there were none from 2000-2011.
- Category 3. Moderate enhancement activity level, defined as:
    - Number of release records is less than or equal to 4 out of 12 years (≤25% or roughly 1 per generation)
    - Number of brood take records are less than or equal to 4 out of 12 years (≤25% or roughly 1 per generation)
    - Hatchery-origin contribution estimate is available via expanded CWT data and 12-year mean is <25% (assessing adult contribution only)
- Category 4. High enhancement activity level, defined as:
    - Number of release records exceeds 4 out of 12 years (>25% or >1 per generation)

- Number of brood take records exceeds 4 out of 12 years (>25% or >1 per generation)
- Hatchery-origin contribution estimate is available via expanded CWT data and 12-year mean is ≥25% (assessing adult contribution only).

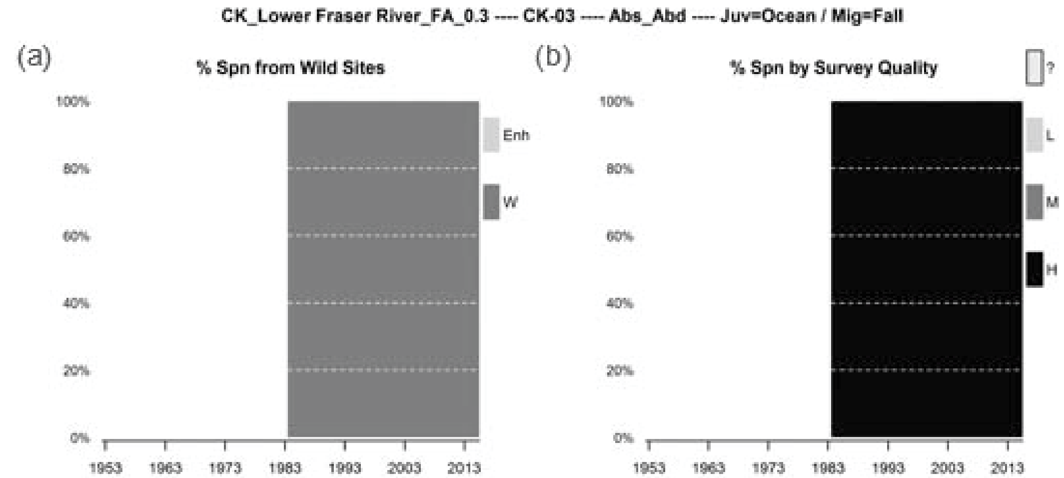
For each DU-specific chapter, a figure is presented showing the proportion of spawners originating from wild-born and enhanced census sites. These figures are updates to 2015 from the figures developed for the Pre-COSEWIC report (Brown *et al.* 2013b), and are adapted from CU-level time series of escapement for wild and enhanced sites. Where multiple CUs are combined within a DU (DU12, DU21), figures for each individual CU are included. In developing these figures, CU-level time series of escapement for the wild-born sites and the enhanced sites were created. Data were combined from sites with low or unknown levels of enhancement ('Low+Unk') and sites with moderate or high levels of enhancement ('Mod+High').

Hatchery Releases

For each DU, the time series of hatchery releases from within the DU and/or from outside the DU are presented. These are reproductions of the 'dashboard' graphics found in Brown *et al.* (2013b). When a DU is a combination of several CUs (DU12, DU21), the time series for each individual CU is included.

<u>Interpretation of abundance, enhancement and hatchery release data</u>

Data permitting, abundance, enhancement and hatchery release data are presented graphically for each DU as a six-panel figure (see example for DU2 below). Table 13 describes how to interpret each panel:



(c) Spn Range By Year

	Wild Sites - Spn Generational Average: All Years	Wild Sites - Spn Generational Average: Last 3 Gen	All Sites - Spn Generational Average: All Years	All Sites - Spn Generational Average: Last 3 Gen
# Obs	29	12	29	12
>=10k	29	12	29	12
<10k	0	0	0	0
<5k	0	0	0	0
<2.5k	0	0	0	0
<1k	0	0	0	0
<250	0	0	0	0

(d) Spn Range By Site

	Wild Sites - Spn (Low&Unk): Last Obs	Wild Sites - Spn (Low&Unk): Last Gen	All Sites - Spn: Last Obs	All Sites - Spn: Last Gen
# Sites	1	1	1	1
>=10k	1	1	1	1
<10k	0	0	0	0
<5k	0	0	0	0
<2.5k	0	0	0	0
<1k	0	0	0	0
<250	0	0	0	0
No Est	0	0	0	0

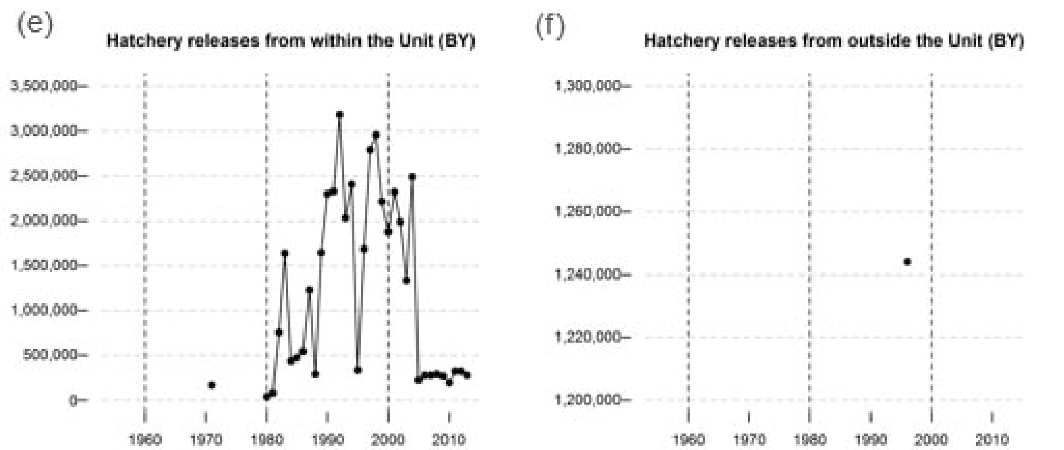


Figure 31. Example of graphical presentation for abundance, enhancement and hatchery release data.

The following table explains how to interpret each panel and can be used as a guide while reviewing each DU.

Table 13. Interpretation of abundance, enhancement and hatchery release data graphics.

Panel (a) %Spn From Wild Sites	Observed number of spawners in sites identified as wild as a proportion of spawners in all sites with data for this DU. When no data are available, no bars are present. If present, wild sites are represented in blue, and are defined as sites with unknown or low enhancement. Enhanced sites are represented in grey and are defined as sites with moderate to high enhancement. Note that this panel does not show annual estimates of enhanced contribution, it shows the proportion of spawner <u>estimates</u> for each year that come from sites CURRENTLY classified as either wild or enhanced. The plot is based on available site records, not on expanded estimates to account for non-surveyed populations
Panel (b) %Spn by Survey Quality	Percent of observed spawners in sites with different levels of survey quality as coded in NuSEDS. H (High) = True Abundance (Type 1 or 2); M (Mod) = Relative Abundance (Type 3 or 4); L (Low) = Relative Abundance (Type 5) or Presence/Absence (Type 6); and ? (Unknown) = Type Unknown is reported in the database or is blank. When no data are available, no bars are present.
Panel (c) Spn Range by Year	Number of years where spawner abundance (generational average) for the whole DU falls into different abundance bins, adapted from COSEWIC's absolute abundance criterion. The first row shows the total number of years that have spawner estimates. Subsequent rows show how many observations fall above or below various cut-off points.
Panel (d) Spn Range by Site	Number of sites where spawner abundance (generational average) for the whole DU falls into different abundance bins, adapted from COSEWIC's absolute abundance criterion. The first row shows the total number of sites that have spawner estimates. Subsequent rows show how many observations fall below various cut-off points. Note that sites with very low contributions are not included in the figures reported in Panels c and d of the 'abundance, enhancement, and hatchery release' data graphics of each DU chapter (e.g., Wap Creek in DU12).
Panels (e) & (f) Hatchery releases from within and outside Unit (BY)	The number of hatchery releases from within and outside the DU by brood year (BY). The left panel is the total number of hatchery-reared juveniles produced from broods collected from return sites within the DU and released at sites within the DU. The right panel is the total number of hatchery-reared juveniles produced from broods collected from return sites outside the DU and released at sites within the DU. When no data are available, no graph is present.

Fluctuations and Trends

For each DU, fluctuations and trends are presented in a summary table and a five-panel figure. The summary table provides two Bayesian estimates of changes in spawner abundance over the last three generations, one using the last three generations of data, and the other using entire time series of data. Probabilities of a 30%, 50% and 70% decline in spawner abundance over 3 generations are also presented for each of the two data samples. Data were available for most DUs up to the 2015 return year and were provided by DFO (Gayle Brown, pers. comm.).

The summary table for each DU has the following form (Table 14; categories described in Table 15):

Table 14. Summary table format for fluctuations and trends section.

DU Name	Generation length	Year range	Median % change	95% CI	p|30% decline	p|50% decline	p|70% decline	Number of observations
Example DU	4	3gen	-	-	-	-	-	-
		All years	-	-	-	-	-	-

Table 15.Description of fluctuation and trends table columns.

Table Column	Description
DU Name	**Full-name of each DU**
Generation length	Average generation time estimated as the average age of spawners in the absence of fishing mortality
Year range	Beginning and ending year of the data set used
Median % change	Median of the posterior distribution for the slope parameter outputs from Bayesian regression
95% CI	±95% credible interval of median % change
p|30% decline	Probability of a 30% or greater decline in abundance
p|50% decline	Probability of a 50% or greater decline in abundance
p|70% decline	Probability of a 70% or greater decline in abundance
Number of observations	Number of observations in the data set

Data permitting, trends in spawner abundance, exploitation rate and marine (smolt-to-adult) survival are presented graphically for each DU as a five-panel figure (see example for DU2 below). Table 16 describes how to interpret each panel:

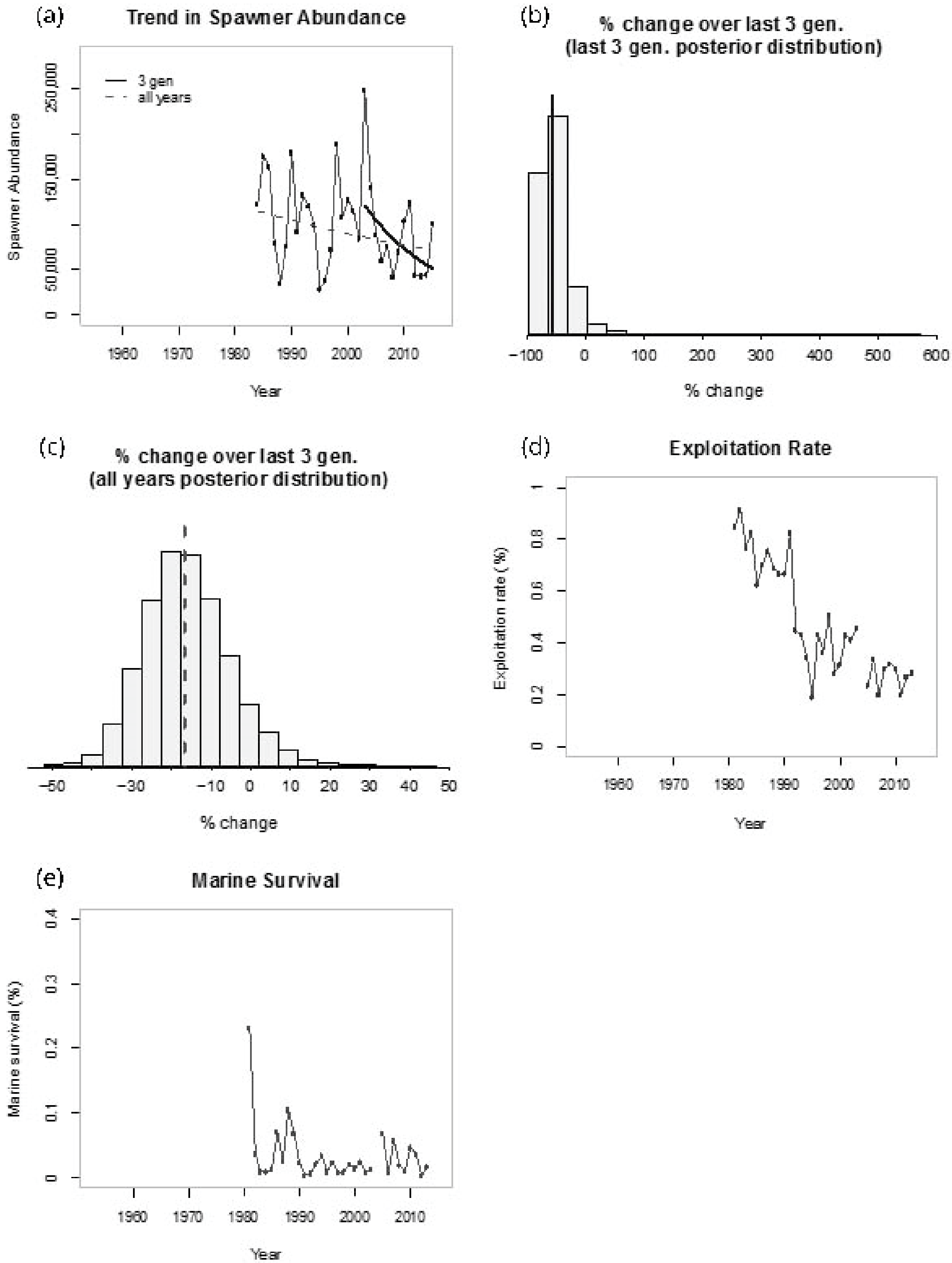


Figure 32. Example of graphical presentation for trends in spawner abundance, exploitation rate and marine (smolt-to-adult) survival.

Table 16. Interpretation of spawner abundance, exploitation rate and marine survival data graphics.

Panel (a) **Trend in Spawner Abundance**	**Trend in spawner abundance with two estimates of the linear rate of change in abundance through time: (1) rate of change over the last three generations based only on the last full three generations of data (i.e., 13 years for a DU with a 4 year generation time); (2) rate of change over the last three generations based on all available data. The latter is shown because indicators of changes in abundance based on the rate of change over entire time series have been shown to be more reliable than shorter time series (Porszt *et al*. 2010; d'Eon-Eggerston *et al*. 2012). Data used for the last three generations were calculated as the generation time + 1 data point such that the selected data spanned the latest three generations. If the 3-generation time was not a round number, it was rounded up** Rates of change were calculated using a Bayesian estimation framework. Doing so allowed the presentation of probabilities associated with estimated changes in abundance, which are more intuitive to interpret than frequentist confidence intervals. Bayesian modelling and parameter estimation was conducted in R using JAGS software (R Core Team 2017; Plummer 2011) with the package R2jags (Su and Yajima 2015). Uninformative priors were assumed for slope (β), intercept (α) and standard deviation (σ). The linear model for a single chain used a burn-in of 5,000 observations, and retaining 100,000 samples after burn-in. Only every 5th observation was saved to reduce autocorrelation (thin=5). These settings are the same as those used for the COSEWIC Fraser Sockeye Salmon status report.
Panel (b) **% change over last 3 gen. (last 3 gen. posterior distribution)**	**Posterior distribution and median estimate (as vertical line) of estimated percent change over last three generations based on a linear rate of change of spawner abundances over the most recent three generations of data.**
Panel (c) **% change over last 3 gen. (all years posterior distribution)**	**As for panel (b) but based on regression of data for entire time series.**
Panel (d) **Exploitation Rate**	**Total of coded-wire tagged fish of any age from a brood (breeding stock) estimated in coast wide pre-terminal and terminal fishery catches divided by the same total plus the total estimated in the escapement. Fishery impacts include an estimate of the non-landed (incidental) mortalities, which occur when fish escape from or are released from fishing gear but later die anyway. Pre-terminal fishery mortalities have been adjusted by a brood- and age-specific adult equivalency factor which accounts for the fact that even if there were no fisheries, fish may still die before reaching the spawning grounds but the probability of surviving to spawn increases at each age (e.g., a fish caught in the ocean at age 2 equates to a lower adult equivalent than a fish caught at age 4 because there is less of a chance of surviving and maturing at any possible future age compared to an older fish).**
Panel (e) **Marine Survival**	**Estimated cohort size of fish alive at the start of the youngest possible age of mature fish divided by the number of smolts released from the parental brood year.**

Where available, stock productivity data (recruits per spawner) are also presented. Stock productivity was calculated as the total number of adults recruiting to the population (i.e., spawners + catch) produced by the spawners from a given year (brood year). Only two time series of stock productivity data are available, for DU2 and DU22 (Brown *et al.* 2013b). The methods used to generate these productivity time series were based on Canadian Science Advisory Secretariat (CSAS) reports (Tompkins *et al.* 2005, G. Brown, DFO, unpublished data). Data used for these time series were provided by DFO (Cowichan River time series: M. Labelle, DFO, unpublished data; Harrison River time series: G. Brown, DFO, unpublished data).

Threats and Limiting Factors

Many DUs were assigned a general risk rating using the IUCN Threats Calculator (the Calculator), a fillable Excel spreadsheet that can be completed on a DU-by-DU basis to evaluate threats and limiting factors.

The Calculator characterizes threats to DUs based on scope, severity, and timing. *Scope* is defined as the percentage of the species reasonably expected to be affected by the threat within 10 years. *Severity* is the level of damage (percent population loss) to the species from the threat that can reasonably be expected within 10 years or three generations (whichever is longer), if current circumstances and trends continue. *Timing* is defined as the projected and estimated duration of the threat over the next 10 years or three generations (whichever is longer).

Scope, severity and timing rankings are assigned based on cumulative scores for eleven different threat categories comprised of forty different sub-categories. Main threat categories include:

1. Residential & commercial development
2. Agriculture & aquaculture
3. Energy production & mining
4. Transportation & service corridors
5. Biological resource use
6. Human intrusions & disturbance
7. Natural system modifications
8. Invasive & other problematic species & genes
9. Pollution
10. Geological events
11. Climate change & severe weather

Each sub-category is assigned a score ranging from Negligible to Pervasive (scope), Negligible to Extreme (severity), and Insignificant/Negligible to High-continuing (timing), with uncertainty ranges and Unknown or Neutral options also available. Once scores are assigned to each sub-category, the calculator provides a cumulative score for each main category. The roll-up of these main category threats is done manually to provide a grade for the population's overall threat impact, following the interpretations of Master *et al*. (2012). Threat impact grades include A-Very High; B-High; C-Medium; and D-Low.

Threats Calculators were produced for this report using a two-stage approach. The first stage relied on literature, document review and existing data (reported here). This method supplied relevant information regarding threats and limiting factors for each DU and permitted the production of a preliminary set of Threats Calculator results.

Some of the metrics used to evaluate threats (e.g., harvest, mortality) are based on information gathered from indicator stocks, which have coded-wire tag (CWT) individuals released from hatcheries. DUs with CWT indicator stocks are listed in Table 17. For those DUs without indicator stocks, proxy indicator stocks were used.

Table 17. Designatable Units (DUs) with indicator stocks and, where available, the first year of release of any hatchery fish released in the DU, including those originating from within the DU and from other DUs.

DU ID	Indicator Stock	Indicator Stock Code	Indicator Stock Used as Proxy	Year of First Release	Year of 1st release from DU	Year of 1st release from outside DU
DU1			SAM*	1984	1984	1991
DU2	HARRISON RIVER	HAR	HAR	1972	1972	1997
DU3			DOM	1978	1978	1989
DU4			DOM	1982	1982	
DU5			DOM	1982	1982	1982
DU6			SHU	1990	1990	
DU7			DOM			
DU8			DOM			
DU9			DOM	1983	1983	1995
DU10			DOM	1981	1981	
DU11	DOME CREEK	DOM	DOM	1981	1981	2014
DU12	SHUSWAP RIVER-LOWER	SHU	SHU	1982	1982	
DU12			SHU			
DU13			DOM	1984	1984	
DU14			NIC			
DU15	NICOLA RIVER	NIC	NIC	1981	1981	
DU16			DOM	1986	1986	
DU17			DOM	1985	1985	
DU18			BQR	1979	1979	1984
DU19			PPS			
DU20	PUNTLEDGE RIVER	PPS	PPS	1972	1972	
DU21			COW	1983	1983	1984
DU21	COWICHAN RIVER	COW	COW	1980	1980	
DU21	NANAIMO RIVER	NAN	NAN	1974	1974	
DU21	QUALICUM RIVER	BQR	BQR	1968	1968	1985
DU22			BQR	1989	1989	
DU23	QUINSAM RIVER	QUI	QUI	1971	1971	1999
DU24	SOMASS RIVER	RBT	RBT	1973	1973	
DU25			RBT	1980	1980	
DU26			RBT	1983	1983	
DU27			ATN			
DU28			ATN	1986	1986	

*The Nooksack River Fall Fingerling (NKF) indicator stock in Washington State, USA was used as the proxy indicator stock for DU1 (CU CK-02).

One challenge was quantifying severity because a direct causal link could not be established between most threats/limiting factors and impacts to populations. However, in some populations, metrics (e.g., harvest) could be quantified if there was an indicator stock present. This preliminary method did not provide sufficient depth and breadth to assign final Threats Calculator grades, but it did supply useful data informing the next stage.

For the second stage, a workshop of Chinook Salmon experts was convened in Nanaimo, BC in February 2017 to apply the IUCN Threats Calculator to Southern BC Chinook Salmon. This group of experts reviewed data supplied by the first stage and added new information based on expert knowledge of different DUs. The workshop provided a rich source of data, fleshing out the previous information and permitting the completion of Threats Calculator grading for several DUs as well as the assignment of proxy DUs for other DUs that could not be completed at the workshop. Table 18 shows the full list of DUs and indicates those that had Threats Calculators completed at the workshop as well as those that were assigned proxies. Where applicable, notes regarding status, priority levels, other relevant comments, and overall Threats Calculator grades are supplied.

Table 18. Designatable Unit Threats Calculator Results Completed at the IUCN Threats Calculator Workshop, February 2017. A = Very High; B = High; C = Medium; D = Low

DU ID	DU NAME	Status, Priority & Proxies	Comments	Overall Threats Calculator Results
DU1	Southern Mainland - Boundary Bay Ocean Fall	High Priority to be completed.	Small population, little quantitative info	
DU2	Lower Fraser Ocean Fall	Completed at Workshop		**High-high (B)**
DU3	Lower Fraser Stream Spring			
DU4	Lower River Stream Summer			
DU5	Lower Fraser Stream Summer			
DU6	Lower Fraser Ocean Summer	High Priority to be completed.	Unique DU, single spawning area	
DU7	Middle Fraser Stream	High Priority to be completed.	Unique DU, single spawning area	
DU8	Middle Fraser Stream Fall	High Priority to be completed.	Unique DU, single spawning area	
DU9	Middle Fraser Stream Spring	Completed at Workshop	Group used DU11 as starting point. Both Beringia origin fish, with similar habitats and run-timings	**High to Medium (B/C)**
DU10	Middle Fraser Stream Summer	Use results from DU17.	All are Beringia-origin summer Chinook Salmon, with similar habitats, but different and more stable habitats than the springs.	
DU11	Upper Fraser Stream Spring	Completed at Workshop		**High to Medium (B/C)**
DU12	South Thompson Ocean Summer	Not Complete, lower priority	Workshop considered this stock to be in good shape.	

DU ID	DU NAME	Status, Priority & Proxies	Comments	Overall Threats Calculator Results
DU13	South Thompson Stream Summer 1.3	Use results from DU15	Drought prone springs of the Southern Interior. DUs 13, 14, 15 could share same Threats Calculator Results	**High to Medium (B/C)**
DU14	South Thompson Stream Summer 1.2	Use results from DU15	Drought prone springs of the Southern Interior. DUs 13, 14, 15 could share same Threats Calculator Results	**High to Medium (B/C)**
DU15	Lower Thompson Stream Spring	Completed at Workshop	Drought prone springs of the Southern Interior. DUs 13, 14, 15 could share same Threats Calculator Results	**High to Medium (B/C)**
DU16	North Thompson Stream Spring	Use DU11 results here.	Beringia origin fish, with similar habitats and run-timings	**High to Medium (B/C)**
DU17	North Thompson Stream Summer		All are Beringia-origin summer Chinook Salmon, with similar habitats, but different and more stable habitats than the springs.	
DU18	South Coast - Georgia Strait Ocean Fall			
DU19	East Vancouver Island Stream Spring			
DU20	East Vancouver Island Ocean Summer	Completed at Workshop		**High (B)**
DU21	East Vancouver Island Ocean Fall	Completed at Workshop		**High (B)**
DU22	South Coast - Southern Fjords Ocean Fall			
DU23	East Vancouver Island Ocean Fall (EVI + SFj)	Completed at Workshop		**High to Medium (B/C)**
DU24	West Vancouver Island Ocean Fall (South)	Completed at Workshop		**High (B)**
DU25	West Vancouver Island Ocean Fall (Nootka & Kyuquot)	Completed at Workshop		**Medium (C)**
DU26	West Vancouver Island Ocean Fall (WVI + WQCI)			
DU27	Southern Mainland Ocean Summer	Use DU28 results here	Data Deficient DU	**Low (D)**
DU28	Southern Mainland Stream Summer	Completed at Workshop	Data Deficient DU	**Low (D)**

Designatable Unit 1: Southern Mainland Boundary Bay, Ocean, Fall population (not yet assessed)

Figures and tables to appear in Part Two:

Figure 33. Map of DU1 – Southern Mainland Boundary Bay Ocean Fall. To be in Part Two.

Figure 34. DU1 – Abundance, enhancement, and hatchery releases (see Table 13 for panel interpretation).

Table 19. Summary of estimated rate of change (±95% credible interval) in spawner abundance and probability of decline over the last three generations (>30%, >50%, >70%). Rates of change over the last three generations are provided based on analysis of the last three generations of data as well as the entire time series.

Figure 35. DU1 – Trends in spawner abundance, exploitation rate, and marine (smolt-to-adult) survival (see Table 16 for panel interpretation).

Designatable Unit 2: Lower Fraser, Ocean, Fall population (assessed November 2018)

DU Short Name	LFR+GStr/Ocean/Fall
Joint Adaptive Zone (JAZ)	LFR+GStr
Life History	Ocean
Run Timing	Fall

The average generation time for this DU is 3.8 years. These fish exhibit ocean-type life-history variants and fall run-timing.

To review methods pertaining to data reported within individual DU chapters, refer to the preliminary sections of this report.

<u>Extent of Occurrence and Area of Occupancy</u>

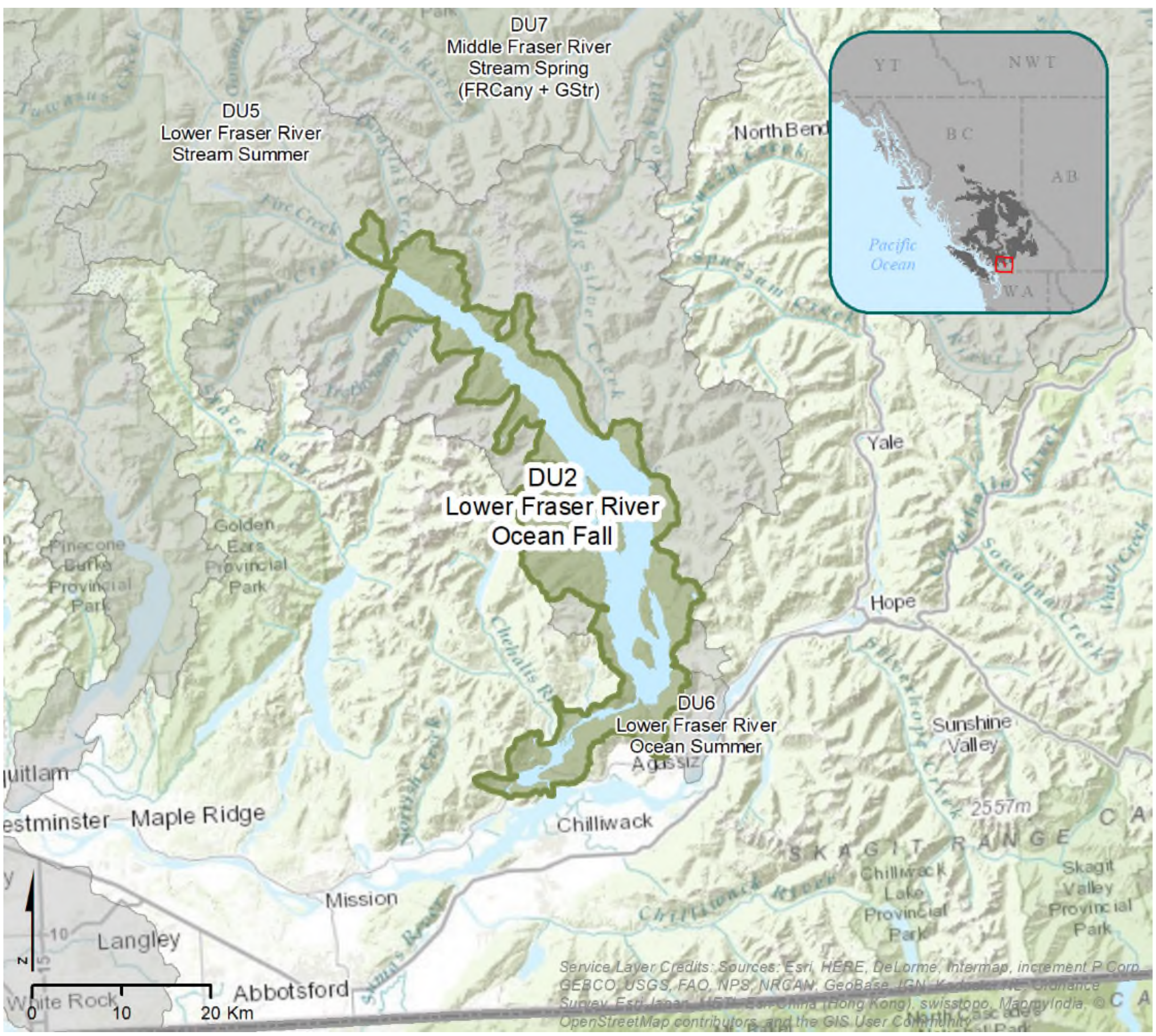


Figure 36. Map of DU2 – Lower Fraser River Ocean Fall.

DU2 overlaps DU5 – Lower Fraser River – Stream Summer. The DU stretches from Harrison River to the north (Lat. 49.79, Long. 122.18) to where the Harrison River merges into Fraser River at the south end (Lat. 49.22, Long. 121.94). The eastern extent of the DU reaches to Bear Creek at Lat. 49.56, Long. 121.69, and the westernmost extent is located at Twenty Mile Creek (Lat. 49.56, Long. 121.96). The DU's centroid is located at Lat. 49.22, Long. 121.95 and its total area is 715.85 km^2.

As for all DUs considered in this report, the extent of occurrence includes spawning streams as well as the ocean range, and is therefore >20,000 km^2. The IAO is 175 km^2 based on a total known spawning run length of 87 km, or 0.86% of the known spawning length across all DUs.

Habitat Trends

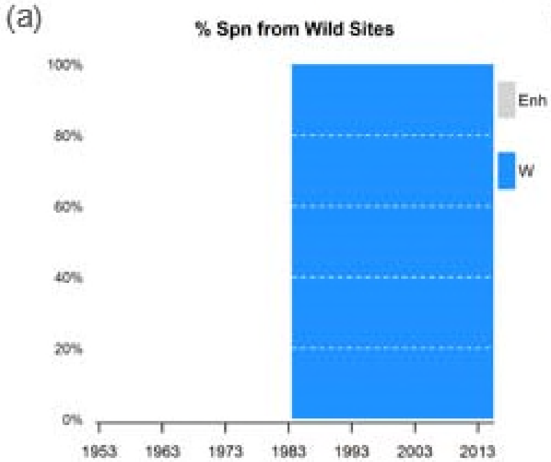
Land surrounding this DU's freshwater habitat is altered (10.4%), with 0.6% of the area dedicated to urban development, and 1.3% to agricultural / rural development. Road density in DU2 is 1.0 km/km^2 with an average of 0.3 stream crossings per km of fish accessible streams (the average across all DUs is 1.33 km/km^2 road density and 0.62 stream crossings per km of fish accessible streams). 15.2% of DU2's riparian habitat is disturbed. The DU contains no mining development nor pine stands affected by Mountain Pine Beetle.

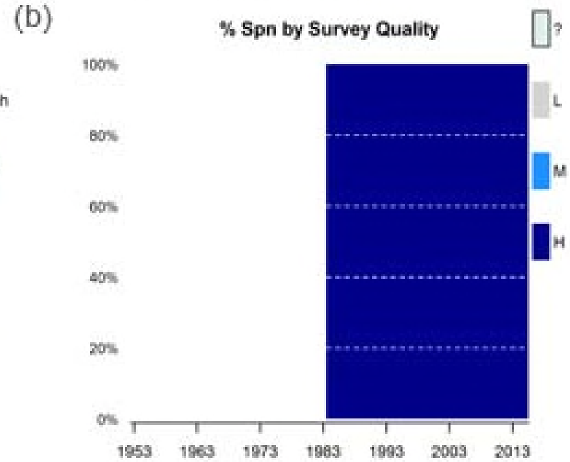
Abundance

All spawner estimates originated from a single site with true abundance data where sampling effort/survey quality was considered high (Figure 37b,d). Twenty-nine generational averages can be generated from relative index spawner time series data, with generational averages for all years estimated at 10,000 spawners or more (Figure 37c).

This DU is enhanced. Of the years where sampling occurred, mature individuals all originated from streams that had low or unknown levels of enhancement (Figure 37a). Hatchery releases increased from the early 1980s to a maximum of 3,184,390 fish annually in 1992 then declined to around 200,000 fish annually by 2005 (Figure 37e). Only one instance is reported of hatchery releases from outside the DU (Figure 37f). This release occurred when Harrison River-origin fish were brought from Chilliwack River due to insufficient brood stock at Harrison River (there is little differentiation between these stocks in accordance with their common origin – see Beacham *et al*. 2003). DU2 origin releases continue to occur at a number of sites outside the DU.

CK_Lower Fraser River_FA_0.3 ---- CK-03 ---- Abs_Abd ---- Juv=Ocean / Mig=Fall



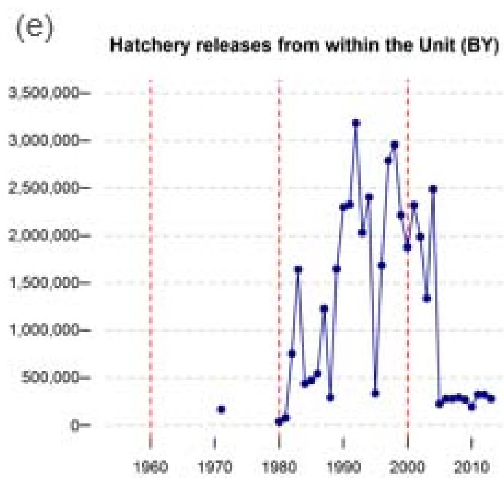


(c) Spn Range By Year

	Wild Sites - Spn Generational Average		All Sites - Spn Generational Average	
	All Years	Last 3 Gen	All Years	Last 3 Gen
# Obs	29	12	29	12
>=10k	29	12	29	12
<10k	0	0	0	0
<5k	0	0	0	0
<2.5k	0	0	0	0
<1k	0	0	0	0
<250	0	0	0	0

(d) Spn Range By Site

	Wild Sites - Spn (Low&Unk)		All Sites - Spn	
	Last Obs	Last Gen	Last Obs	Last Gen
# Sites	1	1	1	1
>=10k	1	1	1	1
<10k	0	0	0	0
<5k	0	0	0	0
<2.5k	0	0	0	0
<1k	0	0	0	0
<250	0	0	0	0
No Est	0	0	0	0



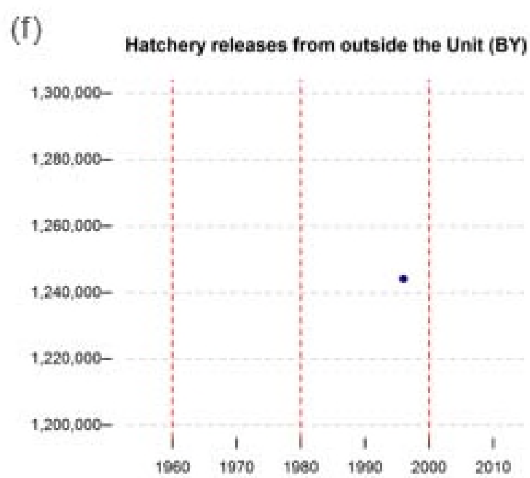


Figure 37. DU2 – Abundance, enhancement, and hatchery releases.

Fluctuations and Trends

Using the last three generations of data, the number of mature individuals changed by an estimated -57% (Upper 95% CI = 17%, Lower 95% CI = -84%) with the probability of a 30% decline at 0.85 (Table 20, Figure 38a,c). Using the entire time series of data, the number of mature individuals changed over the last three generations by an estimated -17% (Upper 95% CI = 7%, Lower 95% CI = -35%) with the probability of a 30% decline at 0.09.

The total exploitation rate declined from a maximum of ~0.9 in 1982 to ~0.3 by 2013 (Figure 38d). The trend from 2005 onward was relatively stable, with exploitation ranging from a rate of approximately 0.4 to 0.2. Marine (smolt-to-adult) survival declined from a maximum of ~0.23 in 1981 and fluctuated between 0.004 and 0.1 from 1982 onwards with a slight downward trend overall (Figure 38e). In 2013 the rate was 0.017. Stock productivity rose to a maximum of ~30 recruits per spawner in 1988 then declined, fluctuating between approximately 1 and 18 recruits per spawner until 2009 (Figure 39). In 2009, productivity was at ~6.5 recruits per spawner.

More recently, escapements to DU2 have declined for all but one brood cycle line. The cause of these declines is uncertain but likely linked to recent poor ocean conditions. Fishing mortality rates have also declined for this DU, and are thought not to be the primary reason for the declines in abundance. The preliminary escapement estimate for 2017 is the second lowest since high precision estimation started in the early 1980s, likely related to the ‘warm blob’ climate anomaly (Bailey pers. comm. 2018; M. Trudel, pers. comm.).

Table 20. Summary of estimated rate of change (±95% credible interval) in spawner abundance and probability of decline over the last three generations (>30%, >50%, >70%). Rates of change over the last three generations are provided based on analysis of the last three generations of data as well as the entire time series.

DU Name	Generation length	Year range	Median % change	95% CI	p|30% decline	p|50% decline	p|70% decline	Number of Observations
Lower Fraser River Ocean Fall	3.8	2003-2015	-57	-84,17	0.85	0.63	0.22	13
		1984-2015	-17	-35,7	0.09	0	0	32

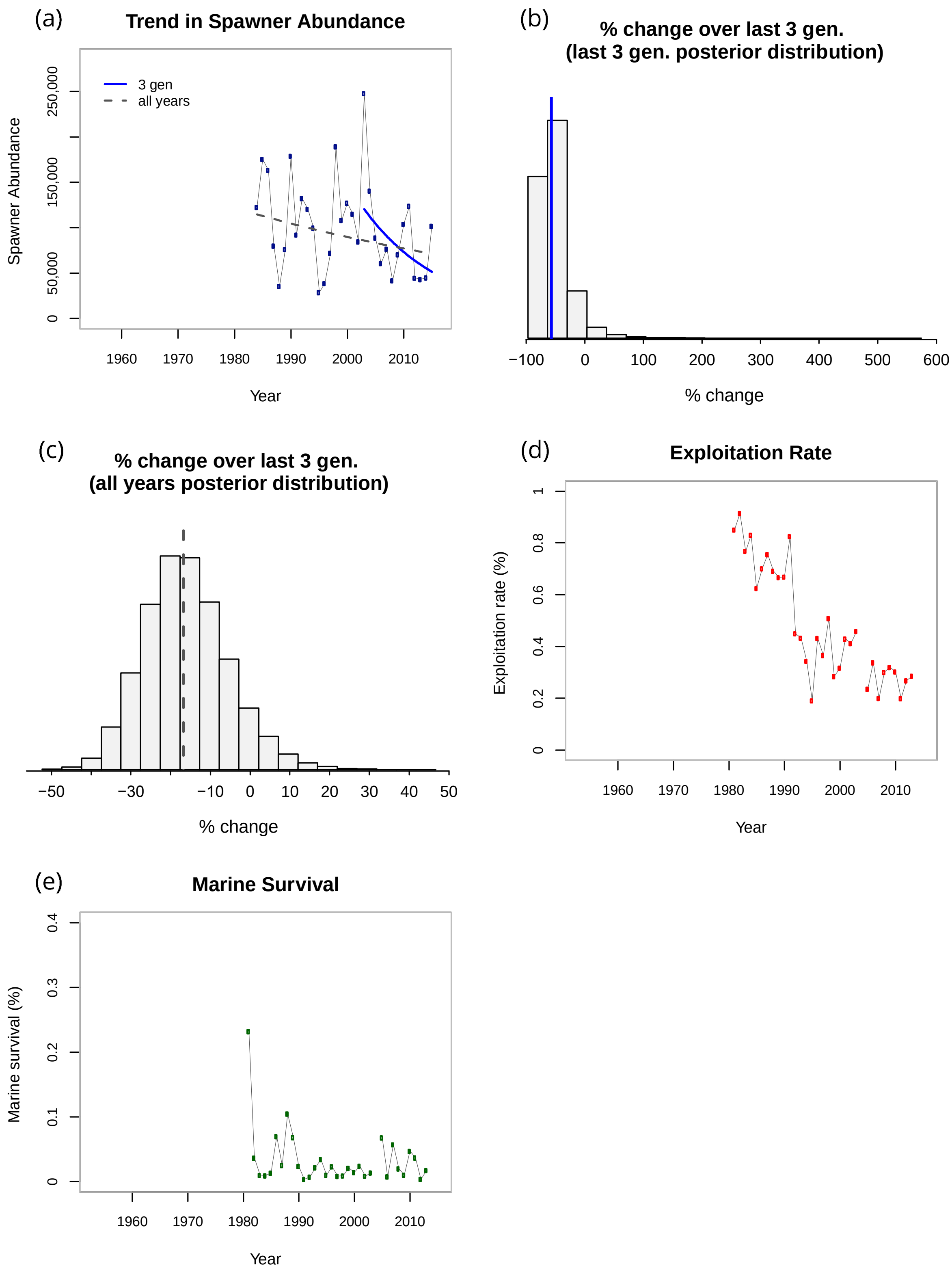


Figure 38. DU2 – Trends in spawner abundance, exploitation rate, and marine (smolt-to-adult) survival.

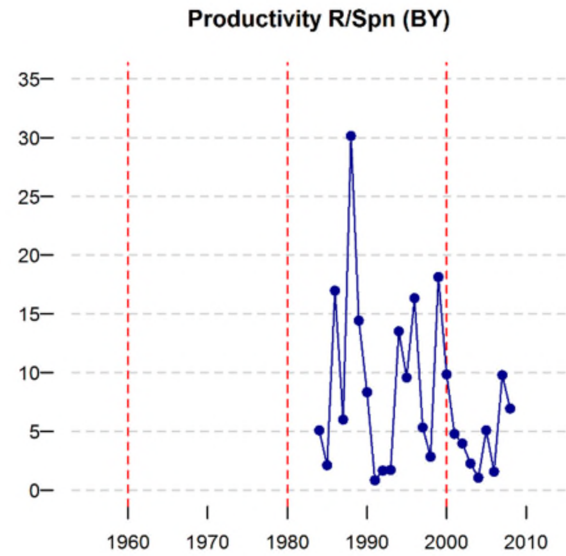


Figure 39. Stock productivity, as calculated as the total number of adults (R = natural origin spawners and natural origin catch) produced by spawners from a given year (brood year (BY)) divided by the number of spawners in the brood year. This figure is updated to 2015 from Brown *et al.* 2013.

Threats and Limiting Factors

For general threats and limiting factors applicable to all DUs, please refer to the **Threats and Limiting Factors** section in the introductory material. Chinook Salmon experts who participated in the IUCN Threats Calculator Workshop in February 2017 concluded that this DU should be assigned a threat impact of Medium (C). The most important threat specific to this DU is from harvest. The entire population is exposed to fishing. Exploitation rates have been at 20-30% for the last ten years and there is a possibility that this rate is higher than sustainable. Several low productivity years have occurred and it is unclear whether the exploitation rate is low enough to compensate. Ecosystem modifications are also relevant because a large portion of the Lower Fraser River and estuary are significantly altered, leading to a loss of critical tide marsh habitat.

Other less important threats include storms and flooding, habitat shifting and alteration, introduced genetic material, problematic native species, invasive species, channel dredging operations, recreational activities, and logging/shipping lanes (tugs and log booms move through spawning grounds and may disturb redds).

Threats Calculator spreadsheets are included with this report (see Appendix 1).

Designatable Unit 3: Lower Fraser, Stream, Spring population (assessed November 2018)

DU Short Name	LFR+GStr/Stream/Spring
Joint Adaptive Zone (JAZ)	LFR+GStr
Life History	Stream
Run Timing	Spring

The average generation time for this DU is 4.5 years. These fish exhibit stream-type life-history variants and spring run-timing.

To review methods pertaining to data reported within individual DU chapters, refer to the preliminary sections of this report.

<u>Extent of Occurrence and Area of Occupancy</u>

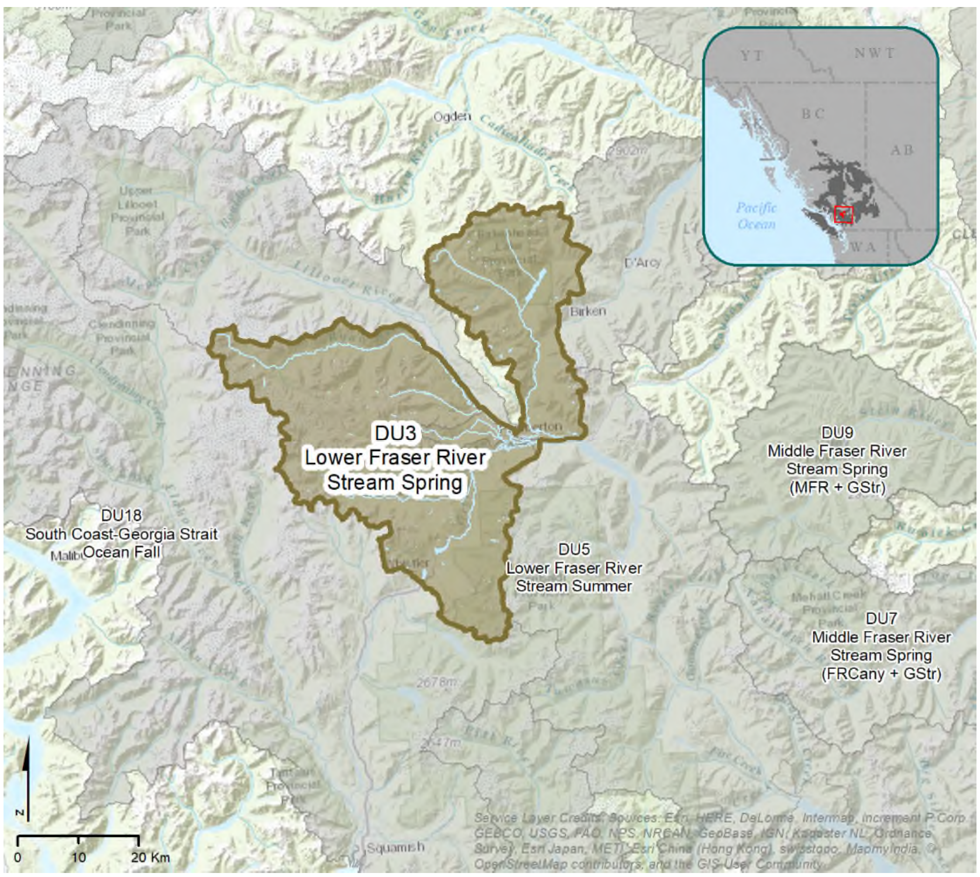


Figure 40. Map of DU3 – Lower Fraser River Stream Spring.

This DU is comprised of two connected sections draining into Lillooet Lake. The northernmost section extends south from Birkenhead Lake Provincial Park and the drainage of Birkenhead Lake (Lat. 50.65, Long. 122.71) to the confluence of the Birkenhead River with Lillooet Lake at Lat. 50.30, Long. 122.61. The southernmost section includes the Green River, Torrent Creek, Ipsoot Creek and Ryan River drainages. Its northernmost extent occurs at the headwaters of Ryan River (Lat. 50.49, Long. 123.44) and its southernmost extent occurs south of Whistler, BC near Russet Lake (Lat. 50.01, Long. 122.82). The DU's centroid occurs at Lat. 50.32, Long. 122.72, and its total area is 2030.28km^2.

As for all DUs considered in this report, the extent of occurrence includes spawning streams as well as the ocean range, and is therefore >20,000 km^2. The IAO is 105km^2 based on a total known spawning run length of 52km, or 0.52% of the known spawning length across all DUs.

<u>Habitat Trends</u>

Land surrounding this DU's freshwater habitat is altered (11.9%), with urban development covering 1.2% of the DU area, agricultural / rural development comprising 0.6%, and mining development comprising another 0.06% . Road density in DU3 is 1.0 km/km^2 with an average of 0.4 stream crossings per km of fish accessible streams (the average across all DUs is 1.33 km/km^2 road density and 0.62 stream crossings per km of fish accessible streams). 12.7% of the DU's riparian habitat is disturbed, 10.0% of the forest is disturbed, and 0.28% of pine stands are killed by Mountain Pine Beetle.

<u>Abundance</u>

No absolute abundance estimates are available for this DU, only relative abundance indices (Figure 41a and Figure 41b). Sampling effort/survey quality at all sample sites is rated moderate, with the exception of 1980, 1981, and 1983, where sampling effort is rated low. This DU is now classified as low enhancement, which means it is grouped into the wild data stream for assessment (Figure 41a). Twenty-nine generational averages can be generated from relative index spawner abundance time series data, with twenty-five indicating a generational average of 250 - 1,000 fish, and the remaining four estimated at less than 250 fish (Figure 41c)

Hatchery releases increased from 1980 to 1990, with a maximum release of ~240,000 in 1983 (Figure 41e). After 1990, hatchery releases stabilized at ~50,000 fish, with the last known hatchery release occurring in 2003. Only one instance is reported of hatchery releases from outside the DU (Figure 41f).

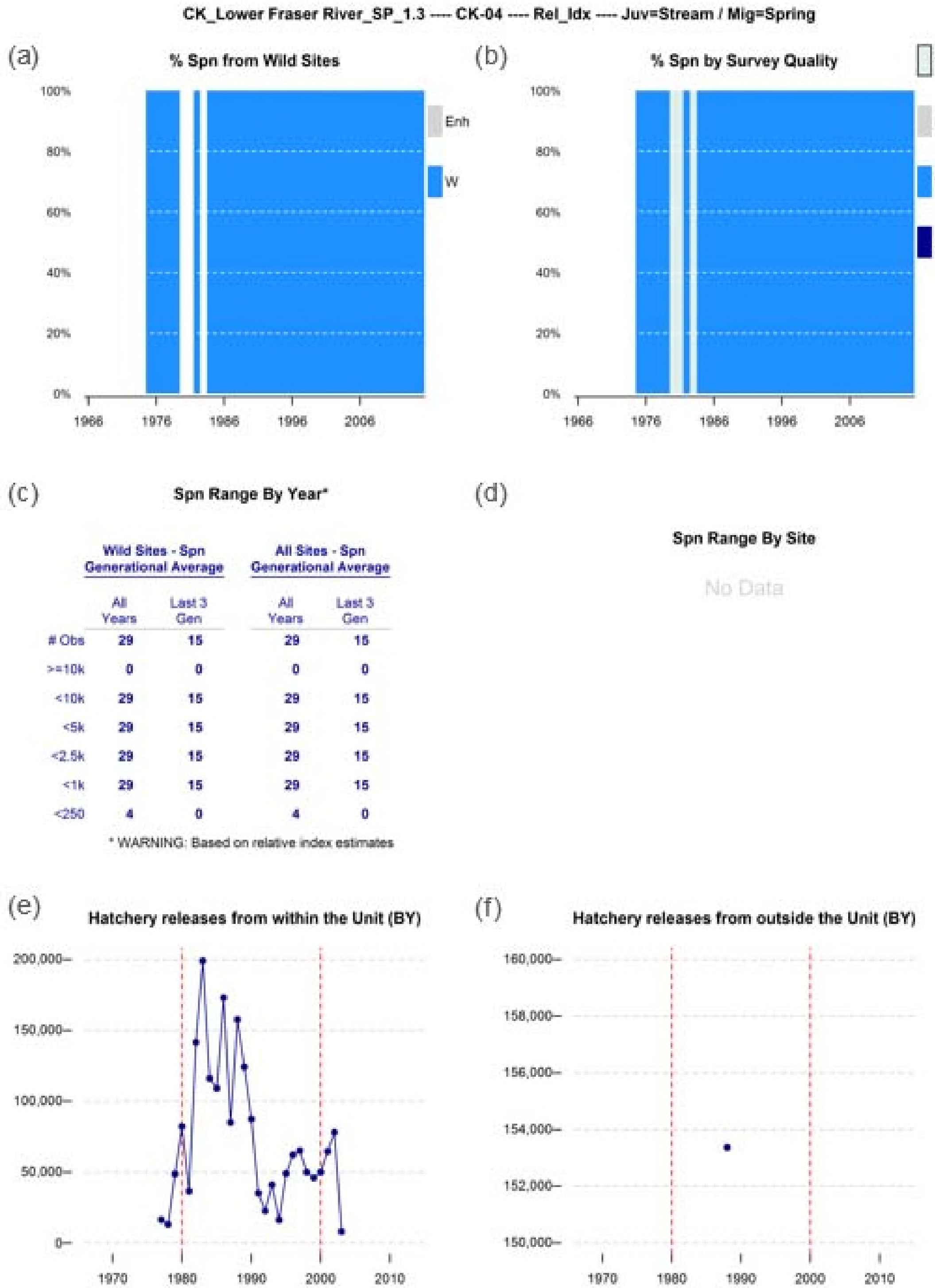


Figure 41. DU3 – Abundance, enhancement, and hatchery releases.

Fluctuations and Trends

Using the last three generations of data, the number of mature individuals changed by an estimated -16% (Upper 95% CI = 217%, Lower 95% CI = -77%) with the probability of a 30% decline at 0.38 (Table 21, Figure 42a,b). Using the entire time series of data, the number of mature individuals changed over the last three generations by an estimated 21% (Upper 95% CI = 60%, Lower 95% CI = -9%) with zero probability of a 30% decline.

Harvest, marine (smolt-to-adult) survival, and stock productivity data are unavailable for this DU because there is no coded-wire tag indicator stock.

Table 21. Summary of estimated rate of change (±95% credible interval) in spawner abundance and probability of decline over the last three generations (>30%, >50%, >70%). Rates of change over the last three generations are provided based on analysis of the last three generations of data as well as the entire time series.

DU Name	Generation length	Year range	Median % change	95% CI	p|30% decline	p|50% decline	p|70% decline	Number of Observations
Lower Fraser River Stream Spring	4.5	2000-2015	-16	-77,217	0.38	0.2	0.05	16
		1975-2015	21	-9,60	0	0	0	38

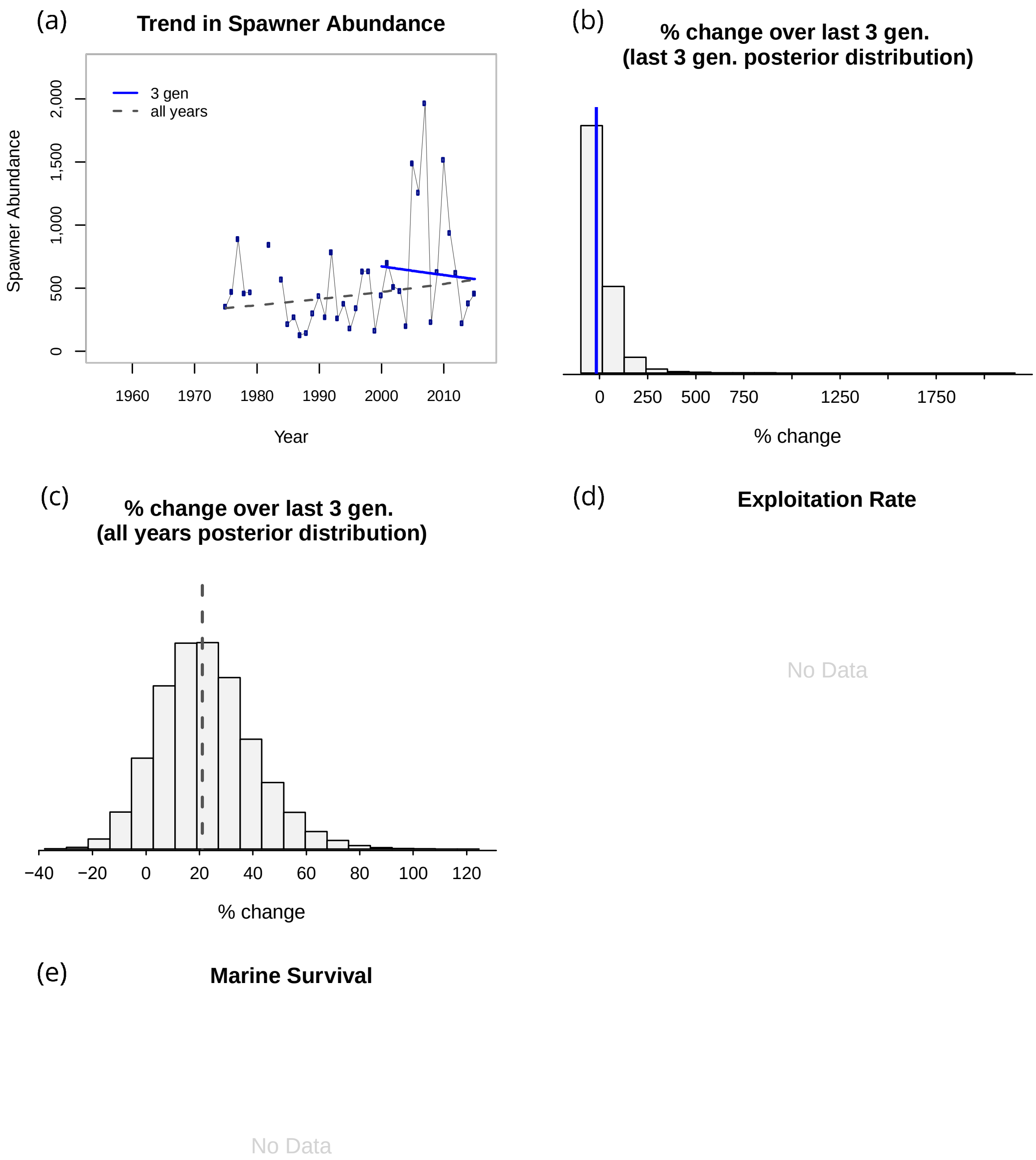


Figure 42. DU3 – Trends in spawner abundance, exploitation rate, and marine (smolt-to-adult) survival.

Threats and Limiting Factors

For general threats and limiting factors applicable to all DUs, please refer to the **Threats and Limiting Factors** section in the introductory material. This stock is far north migrating so most harvest occurs in Alaska. Further effort is required (e.g., by eliciting expert knowledge) to determine a threat grade using the IUCN Threats Calculator.

Designatable Unit 4: Lower Fraser, Stream, Summer (Upper Pitt) population (assessed November 2018)

DU Short Name	LFR+GStr/Stream/Summer (Upper Pitt)
Joint Adaptive Zone (JAZ)	LFR+GStr
Life History	Stream
Run Timing	Summer

The average generation time for this DU is 4.5 years. These fish exhibit stream-type life-history variants and summer run-timing.

To review methods pertaining to data reported within individual DU chapters, refer to the preliminary sections of this report.

<u>Extent of Occurrence and Area of Occupancy</u>

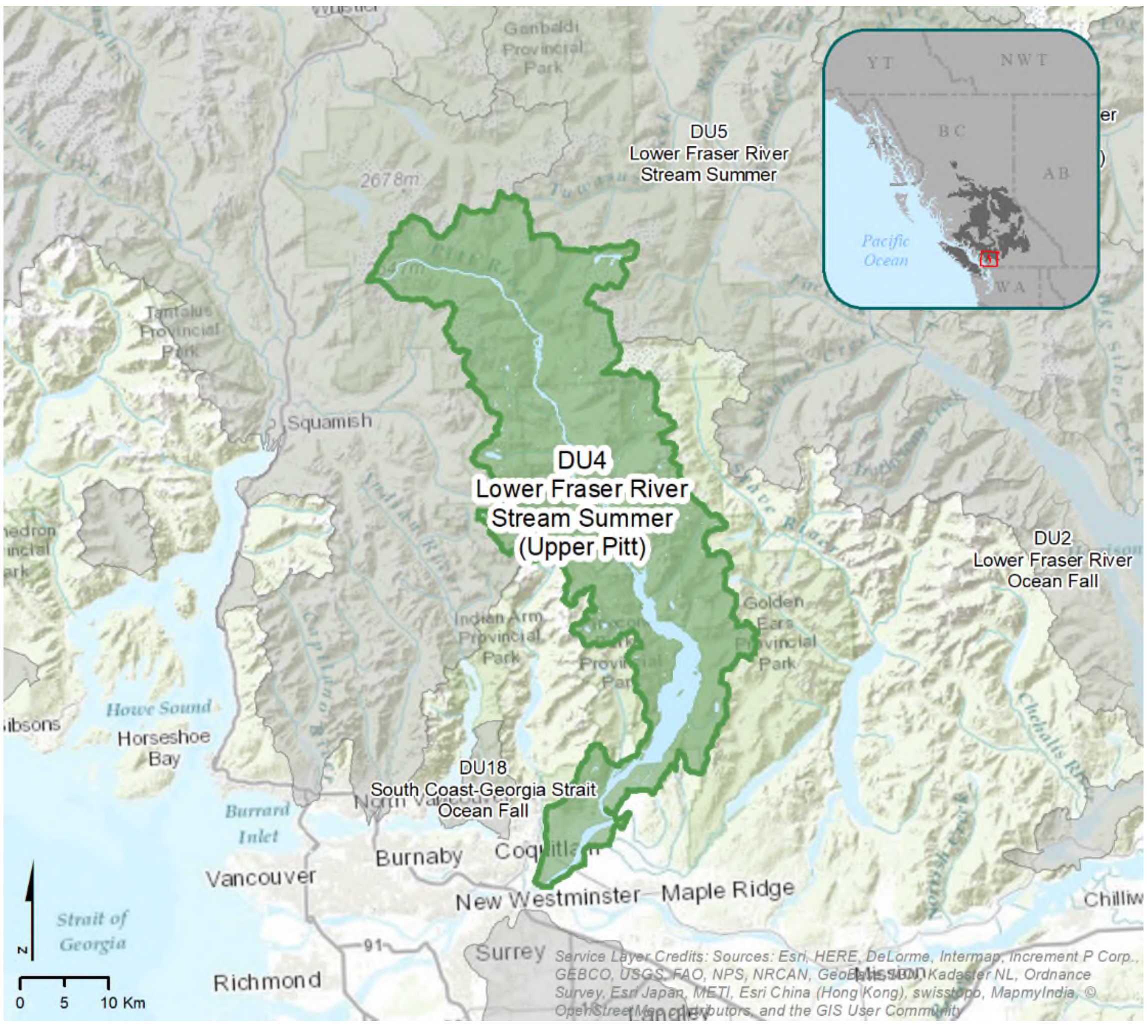


Figure 43. Map of DU4 – Lower Fraser River Stream Summer (Upper Pitt).

This DU extends along Pitt River from the north at Mount Carr (Lat. 49.64, Long. 122.68) to the south at the Fraser River confluence (Lat. 49.23, Long. 122.77). The easternmost extent is at Vickers Creek (Lat. 49.47, Long. 122.43) and the westernmost extent is at Homer Creek (Lat. 49.85, Long. 123.00). The DU's centroid occurs at Lat. 49.64, Long. 122.68, and its total area is 1217.71 km^2.

As for all DUs considered in this report, the Extent of Occurrence includes spawning streams as well as the ocean range, and is therefore <20,000 km^2. The IAO is 191km^2 based on a total known spawning run length of 95km giving or 0.94% of the known spawning length across all DUs.

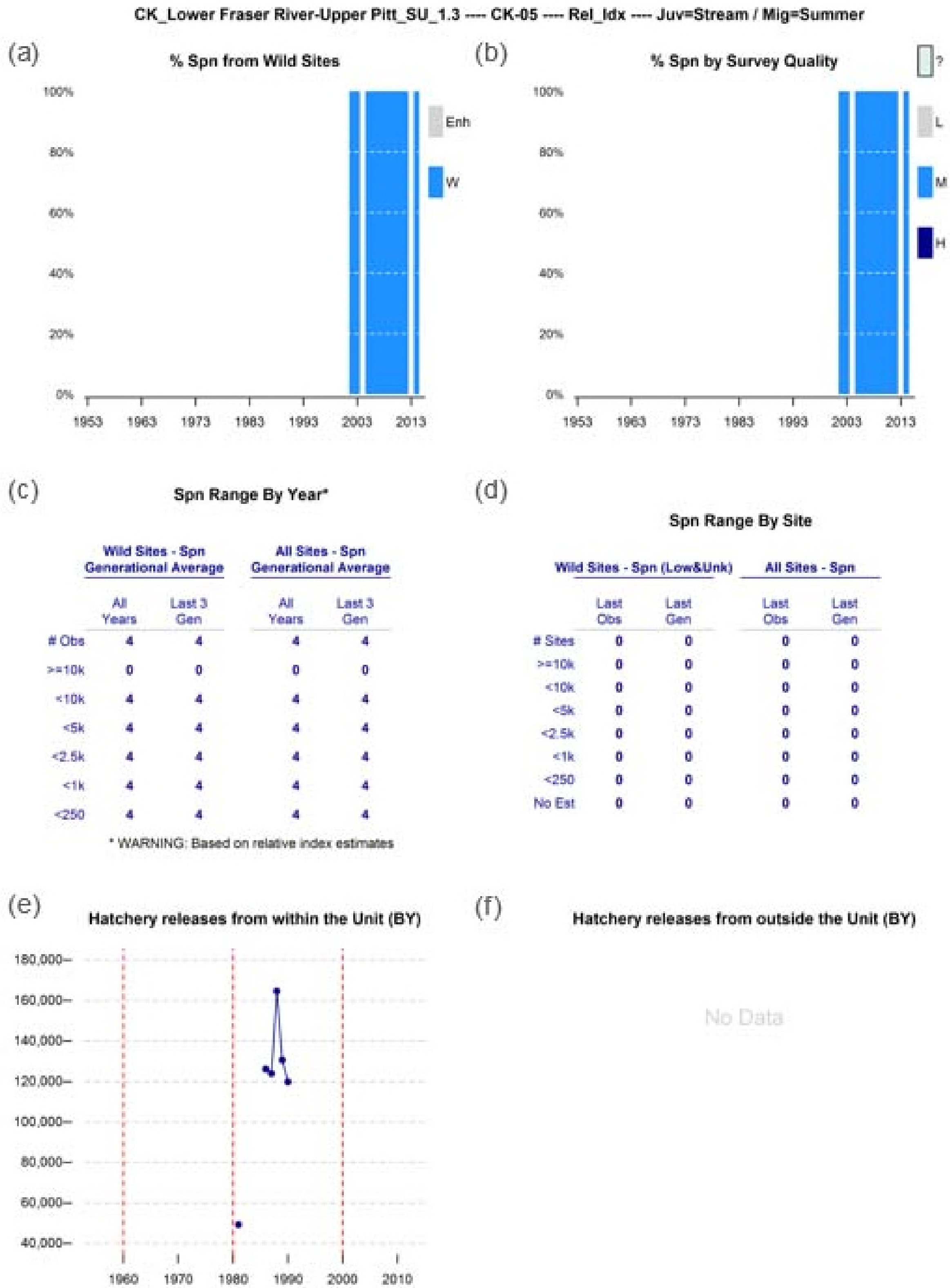
Habitat Trends

Land surrounding this DU's freshwater habitat is altered (10.6%), with urban development comprising 2.3% of the DU area, agricultural / rural development comprising 2.7%, and mining development comprising 0.06%. Road density in DU4 is 1.0 km/km^2 with an average of 0.2 stream crossings per km of fish accessible streams (the average across all DUs is 1.33 km/km^2 road density and 0.62 stream crossings per km of fish accessible streams). 11.0% of the DU's riparian habitat and 5.5% of the forest cover is disturbed. There are no pine stands in this DU affected by the Mountain Pine Beetle.

Abundance

No absolute abundance estimates are available for this DU, only relative abundance indices. All observed spawners originated from sample sites with moderate sampling effort/survey quality (Figure 44b). Four generational averages can be calculated from relative index spawner abundance time series data, each estimated at less than 250 spawners (Figure 44c).

Of the years where sampling occurred, mature individuals all originated from streams that had low or unknown levels of enhancement (Figure 44a). Hatchery releases ranging from ~40,000 to ~160,000 fish occurred in the 1980s, but no releases have taken place since 1990 (Figure 44e).



	Wild Sites - Spn Generational Average		All Sites - Spn Generational Average	
	All Years	Last 3 Gen	All Years	Last 3 Gen
# Obs	4	4	4	4
>=10k	0	0	0	0
<10k	4	4	4	4
<5k	4	4	4	4
<2.5k	4	4	4	4
<1k	4	4	4	4
<250	4	4	4	4

	Wild Sites - Spn (Low&Unk)		All Sites - Spn	
	Last Obs	Last Gen	Last Obs	Last Gen
# Sites	0	0	0	0
>=10k	0	0	0	0
<10k	0	0	0	0
<5k	0	0	0	0
<2.5k	0	0	0	0
<1k	0	0	0	0
<250	0	0	0	0
No Est	0	0	0	0

Figure 44. DU4 – Abundance, enhancement, and hatchery releases.

Fluctuations and Trends

The entire time series of data is within three generations. Based on these data, the number of mature individuals changed by an estimated -73% (Upper 95% CI = -32%, Lower 95% CI = -89 %) with the probability of a 30% decline at 0.98 (Table 22, Figure 45a,b). Note that in Figure 45a, the trend in the data is not necessarily representative of the entire DU. This is because it is a survey of a single tributary of a glacial river population. It is unknown if the tributary spawners form a consistent fraction of the total population.

Harvest, marine (smolt-to-adult) survival, and stock productivity data are unavailable for this DU because there is no coded-wire tag indicator stock.

Table 22. Summary of estimated rate of change (±95% credible interval) in spawner abundance and probability of decline over the last three generations (>30%, >50%, >70%). Rates of change over the last three generations are provided based on analysis of the last three generations of data.

<table>
<tr><th>DU Name</th><th>Generation length</th><th>Year range</th><th>Median % change</th><th>95% CI</th><th>p|30% decline</th><th>p|50% decline</th><th>p|70% decline</th><th>Number of Observations</th></tr>
<tr><td rowspan="2">Lower Fraser River Stream Summer (Upper Pitt)</td><td rowspan="2">4.5</td><td>2002-2014</td><td>-73</td><td>-89,-32</td><td>0.98</td><td>0.92</td><td>0.60</td><td>11</td></tr>
<tr><td colspan="7">As above</td></tr>
</table>

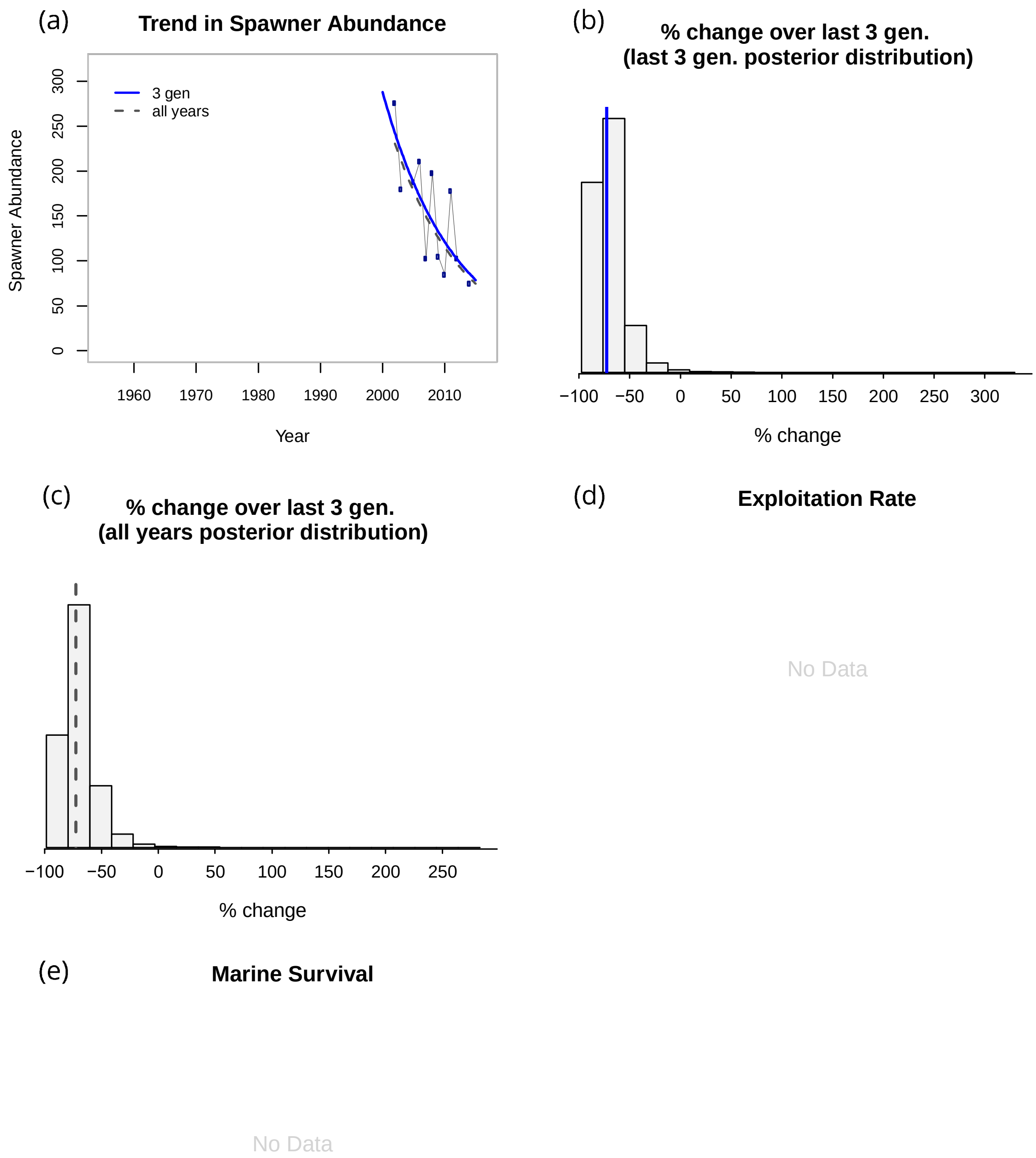


Figure 45. DU4 – Trends in spawner abundance, exploitation rate, and marine (smolt-to-adult) survival.

Threats and Limiting Factors

For general threats and limiting factors applicable to all DUs, please refer to the **Threats and Limiting Factors** section in the introductory material. Further effort is required (e.g., by eliciting expert knowledge) to determine a threat grade using the IUCN Threats Calculator. The ocean distribution for this DU is thought to be far north and therefore harvest likely occurs primarily in Alaska. However, due to a later return timing relative to DU3, some harvest also likely occurs in Georgia Strait.

Designatable Unit 5: Lower Fraser, Stream, Summer population (assessed November 2018)

DU Short Name	LFR+GStr/Stream/Summer
Joint Adaptive Zone (JAZ)	LFR+GStr
Life History	Stream
Run Timing	Summer

The average generation time for this DU is 4.5 years. These fish exhibit stream-type life-history variants and summer run-timing.

To review methods pertaining to data reported within individual DU chapters, refer to the preliminary sections of this report.

Extent of Occurrence and Area of Occupancy

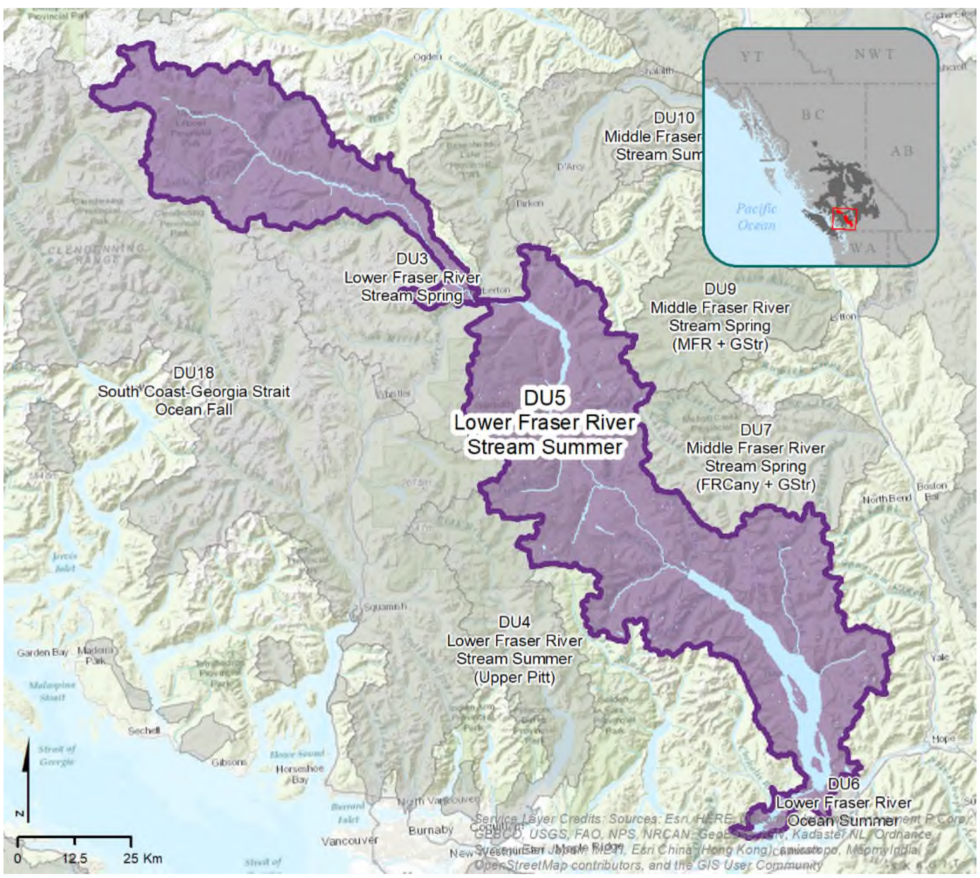


Figure 46. Map of DU5 – Lower Fraser River Stream Summer.

This DU is comprised of two sections extending from the Lillooet River headwaters in the north (Lat. 50.83, Long. 123.76) to the confluence of the Harrison and Fraser rivers in the south (Lat. 49.21, Long. 121.94). The westernmost extent occurs in the northern part along Meager Creek and runs south along Sirenia Mountain (Lat. 50.61, Long. 123.77), the easternmost extent occurs in the southern part east of Harrison Lake (Lat. 49.57, Long. 121.54). The DU's centroid is Lat. 49.70, Long. 122.13, and its total area is 5929.21km^2.

As for all DUs considered in this report, the extent of occurrence includes spawning streams as well as the ocean range, and is therefore >20,000 km^2. The IAO is 645 km^2 based on a total known spawning run length of 323 km, or 3.21% of the known spawning length across all DUs.

Habitat Trends

Land surrounding this DU's freshwater habitat is altered (10.0%), with urban development comprising of 0.09% of the DU area, agricultural / rural development comprising 1.2%, and mining development comprising 0.02% . Road density in DU5 is 1.0 km/km^2 with an average of 0.6 stream crossings per km of fish accessible streams (the average across all DUs is 1.33 km/km^2 road density and 0.62 stream crossings per km of fish accessible streams). 11.3% of the DU's riparian habitat is disturbed, 8.7% of the forest cover is disturbed, and 0.6% of pine stands are affected by Mountain Pine Beetle.

Abundance

No absolute abundance estimates are available for this DU, only relative abundance indices. All observed spawners originated from census sites with low and moderate sampling effort/survey quality (Figure 47b). Four generational averages can be calculated from relative index spawner abundance time series data, each with less than 250 spawners (Figure 47c). The available survey data, although considered to be of good quality, reflect relative abundance and it is not known how representative the survey information is of the entire DU.

The number of remaining mature individuals could be less than 1000, assuming that the spawning sites within the DU (Appendix 2) include a similar number as the surveyed population. This assumption cannot be tested.

Of the years where sampling occurred, all mature individuals originated from streams with low or unknown levels of enhancement (Figure 47a). Intermittent hatchery releases occurred both within and outside the DU during the 1980s. After 1990, the number of hatchery releases averaged ~450,000 fish (Figure 47e). The last recorded hatchery release was in 2013. However, DFO notes there is an annual release of hatchery summer Chinook Salmon into the Chehalis River, as well as releases into the Chilliwack River (not currently included within DU boundaries) (Bailey pers. comm. 2018).

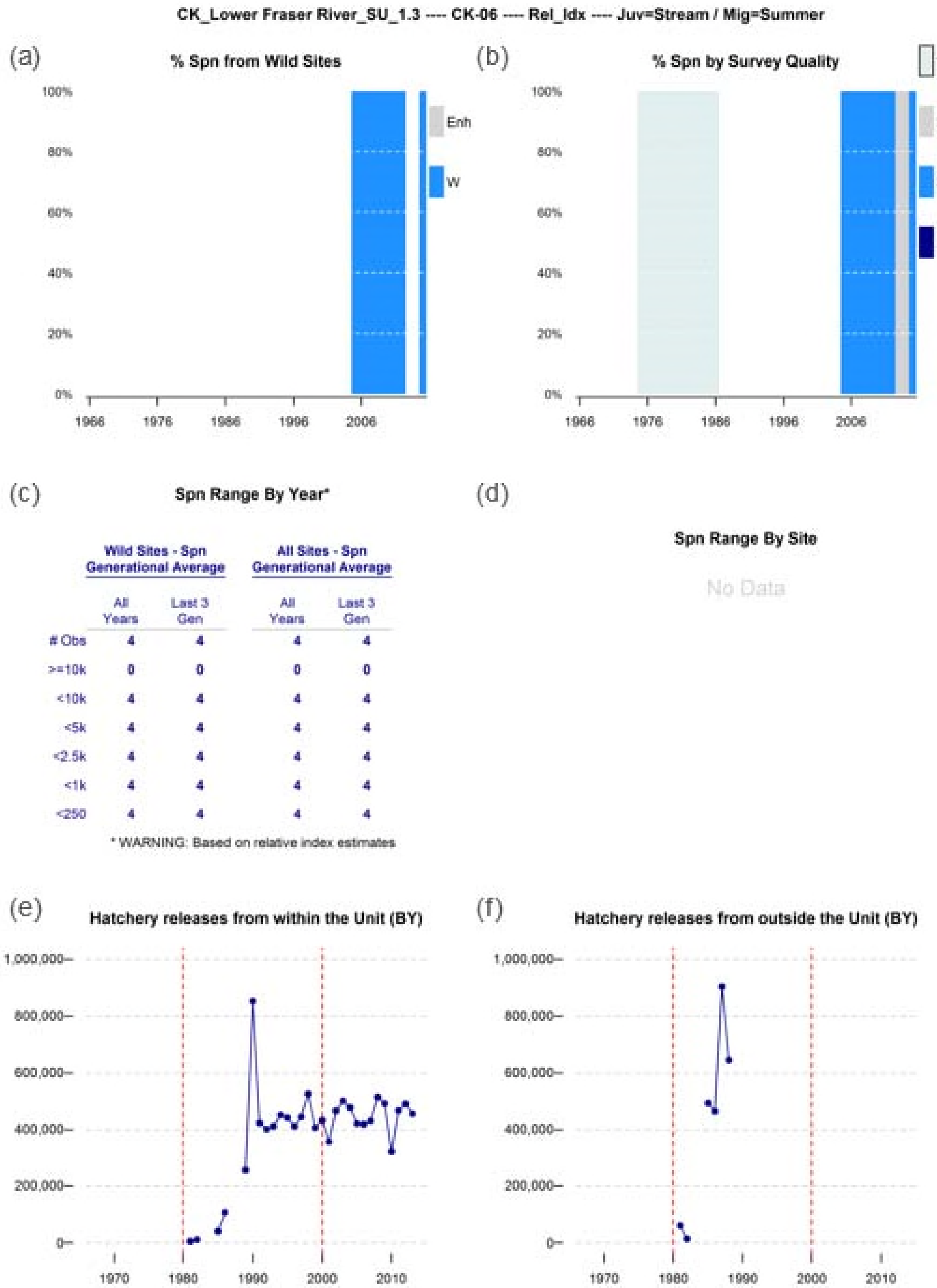


Figure 47. DU5 – Abundance, enhancement, and hatchery releases.

Fluctuations and Trends

The entire time series of data is within 3 generations. Based on these data, the number of mature individuals changed by an estimated -36% (Upper 95% CI = 1689%, Lower 95% CI = -98%) with the probability of a 30% decline at 0.52 (Table 23, Figure 48a,b).

Harvest, marine (smolt-to-adult) survival, and stock productivity data are unavailable for this DU because there is no coded-wire tag indicator stock.

Table 23. Summary of estimated rate of change (±95% credible interval) in spawner abundance and probability of decline over the last three generations (>30%, >50%, >70%). Rates of change over the last three generations are provided based on analysis of the last three generations of data.

DU Name	Generation length	Year range	Median % change	95% CI	p|30% decline	p|50% decline	p|70% decline	Number of Observations
Lower Fraser River Stream Summer	4.5	2005-2015	-36	-98,1689	0.52	0.43	0.30	9
		As above						

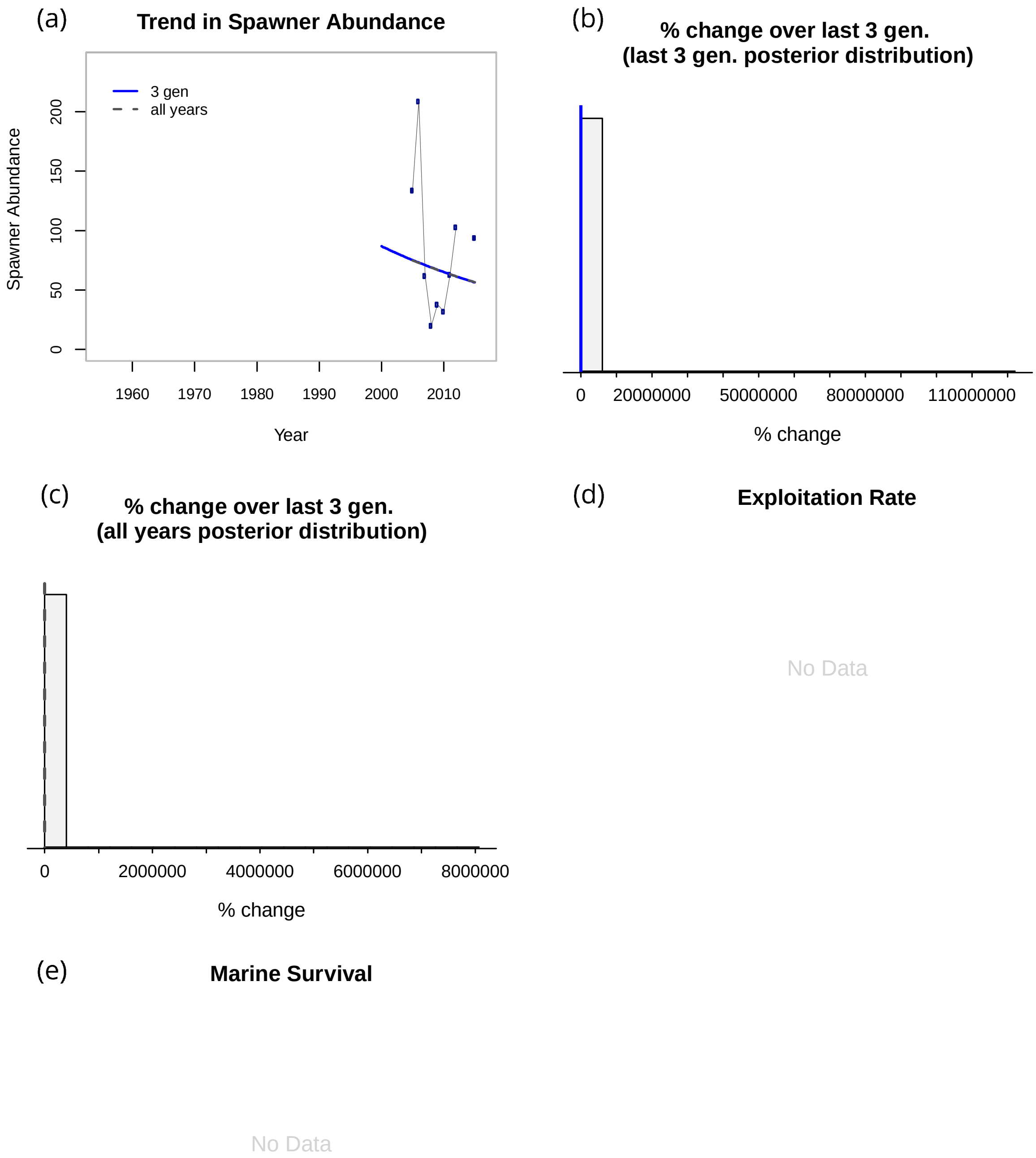


Figure 48. DU5 – Trends in spawner abundance, exploitation rate, and marine (smolt-to-adult) survival.

Threats and Limiting Factors

For general threats and limiting factors applicable to all DUs, please refer to the **Threats and Limiting Factors** section in the introductory material. Further effort is required (e.g., by eliciting expert knowledge) to determine a threat grade using the IUCN Threats Calculator. This DU experiences ongoing enhancement from releases of summer Chinook Salmon into the Chehalis and Chilliwack rivers. A significant habitat impact in this DU is the channelization and diking in the Lillooet River upstream of Lillooet Lake. Dredging occurs at the Lillooet Lake outlet and the lake’s elevation is lowered. Dredging likely removes prime spawning habitat because the lake outlet is formed by a glacial terminal moraine (Bailey pers. comm. 2018).

Designatable Unit 6: Lower Fraser, Ocean, Summer population (not yet assessed)

Tables and Figures to be in Part Two:

Figure 49. Map of DU6 – Lower Fraser River Ocean Summer.

Figure 50. DU6 – Abundance, enhancement, and hatchery releases.

Table 24. Summary of estimated rate of change (±95% credible interval) in spawner abundance and probability of decline over the last three generations (>30%, >50%, >70%). Rates of change over the last three generations are provided based on analysis of the last three generations of data as well as the entire time series.

Figure 51. DU6 – Trends in spawner abundance, exploitation rate, and marine (smolt-to-adult) survival.

Designatable Unit 7: Middle Fraser, Stream, Spring (FRCany+GStr) (assessed November 2018)

DU Short Name	FRCany+GStr/Stream/Spring
Joint Adaptive Zone (JAZ)	FRCany+GStr
Life History	Stream
Run Timing	Spring

The average generation time for this DU is 4.5 years. These fish exhibit stream-type life-history variants and spring run-timing.

To review methods pertaining to data reported within individual DU chapters, refer to the preliminary sections of this report.

<u>Extent of Occurrence and Area of Occupancy</u>

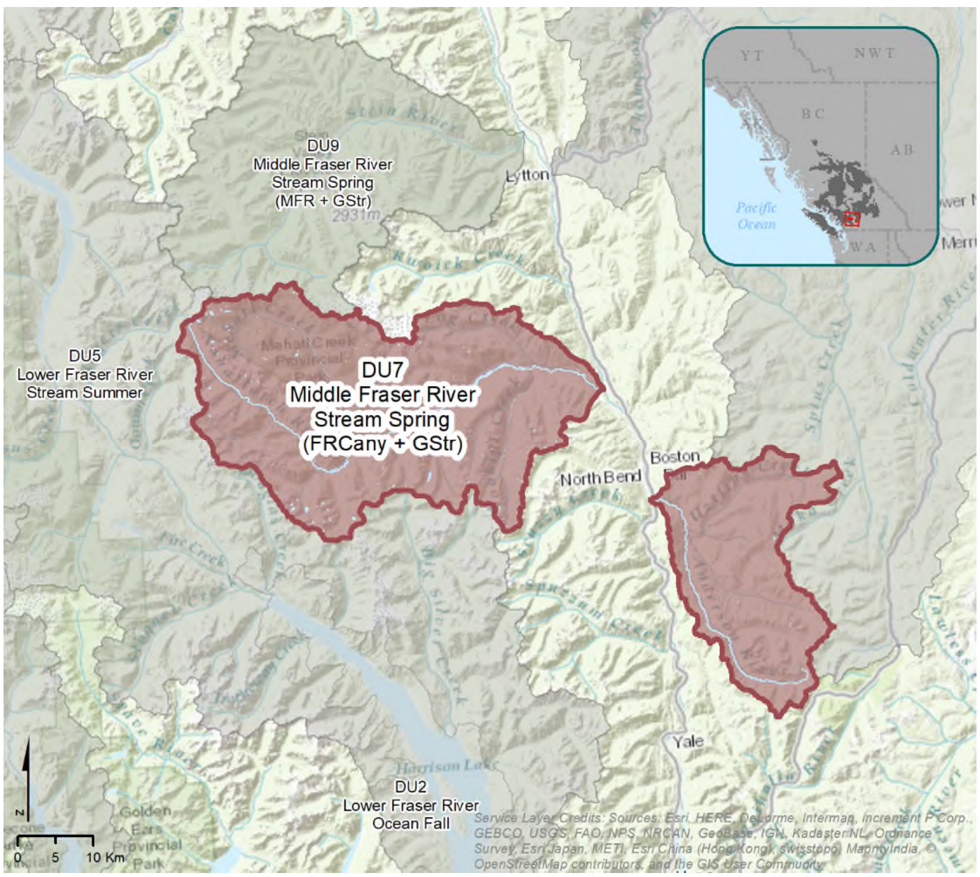


Figure 52. Map of DU7 – Middle Fraser River Stream Spring.

There are two geographically separated sections that combine to form this DU. The DU extends from the north at a mountain ridge close to Haynon Lake (Lat.50.12, Long. 122.07) to the south east of Anderson River at Lat. 49.57, Long. 121.23. The DU's western-most extent is at Nahatlatch River (Lat. 49.96, Long. 122.28) and the eastern-most extent occurs at Anderson River at Lat. 48.86, Long. 121.09. The DU's centroid is at Lat. 49.91, Long. 121.48, and its total area is 1705.57 km^2.

As for all DUs considered in this report, the extent of occurrence includes spawning streams as well as the ocean range and is therefore >20,000 km^2. The IAO is 103 km^2 based on a total known spawning run length of 52 km, or 0.52% of the known spawning length across all DUs.

Habitat Trends

Land surrounding this DU's freshwater habitat is altered (2.7%), with agricultural / rural development covering 0.03% of the area. Road density in DU7 is 0.3 km/km^2 with an average of 0.4 stream crossings per km of fish accessible streams (the average across all DUs is 1.33 km/km^2 road density and 0.62 stream crossings per km of fish accessible streams). 2.9% of the DU's riparian habitat and 2.7% of the forest cover is disturbed. 2.0% of the DU's pine stands are affected by Mountain Pine Beetle. There is no urban development, nor mining development within the DU area.

Abundance

Annual survey estimates for this wildlife species are available from 2009 to 2017, and range from 2 to 65. Even though these estimates are indices, it is not expected that expansion of the indices would result in population sizes greater than 250 mature individuals.

Fluctuations and Trends

Harvest, marine (smolt-to-adult) survival and stock productivity data are unavailable for this DU because there is no coded-wire tag indicator stock.

Threats and Limiting Factors

For general threats and limiting factors applicable to all DUs, please refer to the **Threats and Limiting Factors** section in the introductory material. Further effort is required (e.g., by eliciting expert knowledge) to determine a threat grade. This DU is considered a high priority for completion of an IUCN Threats Calculator.

Designatable Unit 8: Middle Fraser, Stream, Fall population (assessed November 2018)

DU Short Name	MFR+GStr/Stream/Fall
Joint Adaptive Zone (JAZ)	MFR+GStr
Life History	Stream
Run Timing	Fall

The average generation time for this DU is 4.5 years. These fish exhibit stream-type life-history variants and fall run-timing.

To review methods pertaining to data reported within individual DU chapters, refer to the preliminary sections of this report.

<u>Extent of Occurrence and Area of Occupancy</u>

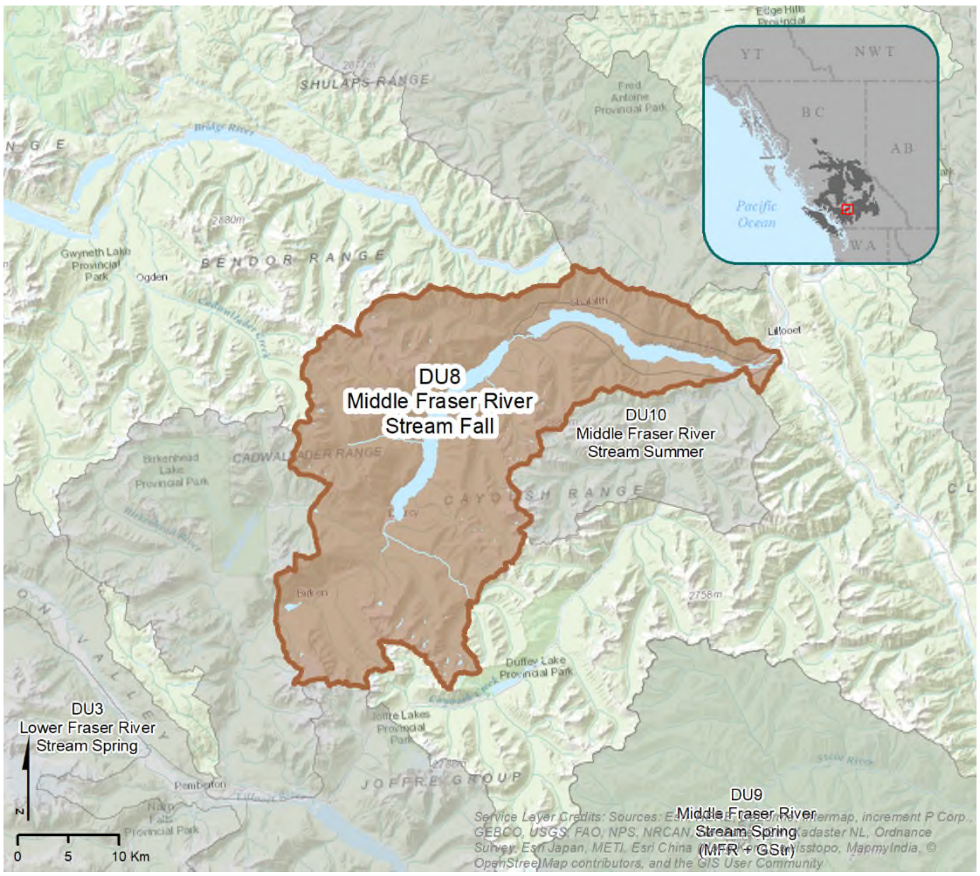


Figure 53. Map of DU8 – Middle Fraser River Stream Fall.

This DU extends from the north side of Whitecap Creek (Lat. 50.75, Long. 122.47) along Seton Lake and Anderson Lake to Haylmore Creek in the south at Lat. 50.41, Long. 122.40. The DU's western-most extent is at McGillivray Creek (Lat. 50.61, Long. 122.62) and the eastern-most extent is at the Seton River's confluence with the Fraser River (Lat. 50.67, Long. 121.92). The DU's centroid occurs at Lat. 50.71, Long. 122.27, and its total area is 981.85 km^2.

As for all DUs considered in this report, the extent of occurrence includes spawning streams as well as the ocean range, and is therefore >20,000 km^2. The IAO is 63 km^2 based on a total known spawning run length of 32 km, or 0.32% of the known spawning length across all DUs.

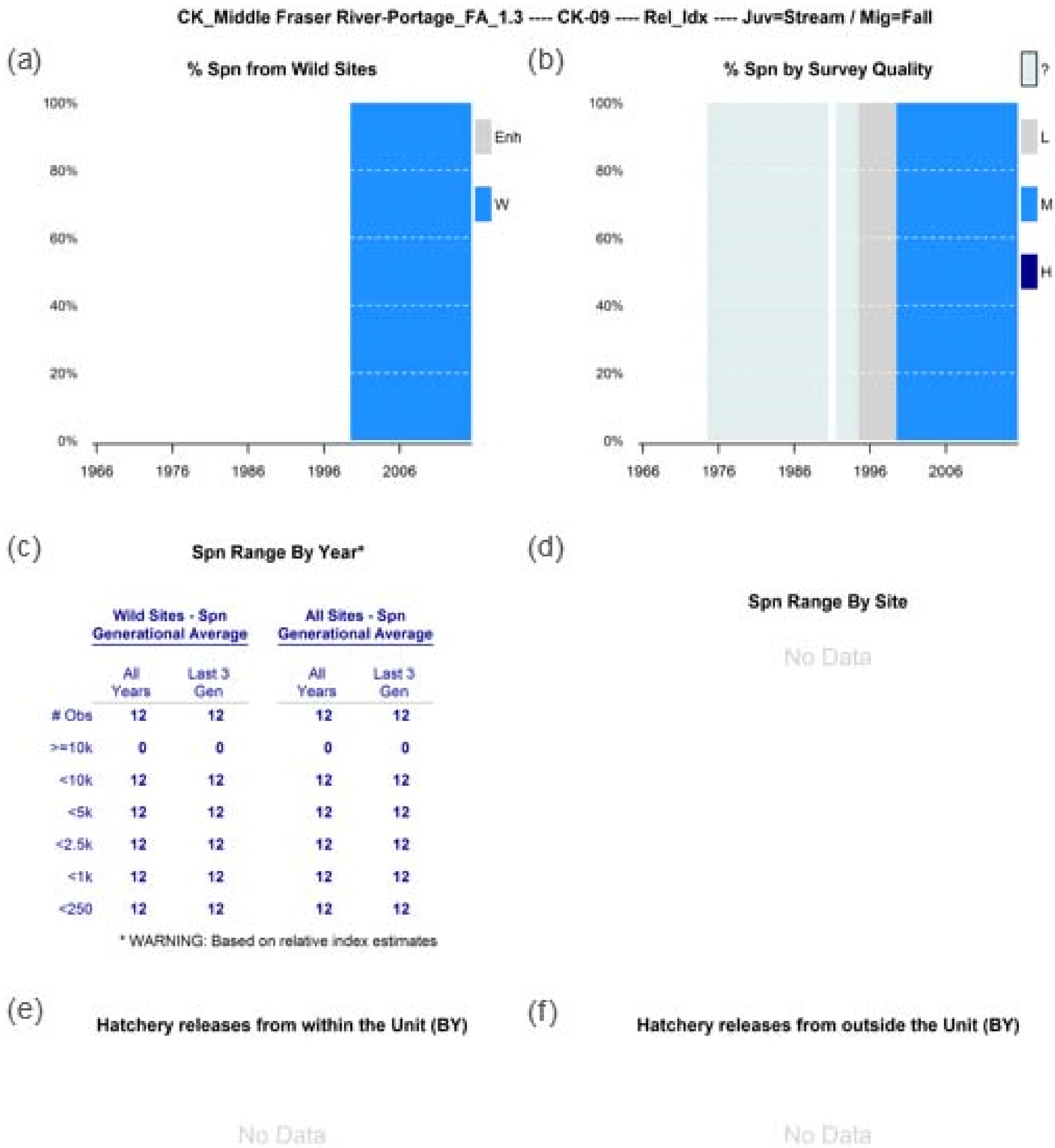
Habitat Trends

Land surrounding this DU's freshwater habitat is altered (5.0%), with agricultural / rural development comprising 0.1% of the DU area, and urban development comprising 0.9%. Road density in DU8 is 0.6km/km^2 with an average of 0.5 stream crossings per km of fish accessible streams (the average across all DUs is 1.33km/km^2 road density and 0.62 stream crossings per km of fish accessible streams). 4.5% of the DU's riparian habitat and 4.1% of its forest cover is disturbed. 3.0% of the DU's pine stands are affected by Mountain Pine Beetle. There is no mining development within the DU area. Seton Dam is within this DU and has resulted in degraded habitat below the dam (BC Hydro 2011a).

Abundance

No absolute abundance estimates are available for this DU, only relative abundance indices. All spawners originated from sample sites with low to moderate or unknown sampling effort/survey quality (Figure 54b). Twelve generational averages can be calculated from relative index spawner abundance time series data, all with less than 250 spawners (Figure 54c).

While the abundance data are indices, expert opinion indicates that the underestimate is not likely more than 50%. Of the years where sampling occurred, all mature individuals originated from a single stream (Portage Creek), that had low or unknown levels of enhancement (Figure 54a). No hatchery releases are on record.



	Wild Sites - Spn Generational Average		All Sites - Spn Generational Average	
	All Years	Last 3 Gen	All Years	Last 3 Gen
# Obs	12	12	12	12
>=10k	0	0	0	0
<10k	12	12	12	12
<5k	12	12	12	12
<2.5k	12	12	12	12
<1k	12	12	12	12
<250	12	12	12	12

* WARNING: Based on relative index estimates

Figure 54. DU8 – Abundance, enhancement, and hatchery releases.

Fluctuations and Trends

The entire time series of data is within 3 generations. Based on these data, the number of mature individuals changed by an estimated -67% (Upper 95% CI = 13%, Lower 95% CI = -90%) with the probability of a 30% decline at 0.90 (Table 25, Figure 54 a,b).

Harvest, marine (smolt-to-adult) survival and stock productivity data are unavailable for this DU because there is no coded-wire tag indicator stock.

Table 25. Summary of estimated rate of change (±95% credible interval) in spawner abundance and probability of decline over the last three generations (>30%, >50%, >70%). Rates of change over the last three generations are provided based on analysis of the last three generations of data.

DU Name	Generation length	Year range	Median % change	95% CI	p|30% decline	p|50% decline	p|70% decline	Number of Observations
Middle Fraser River Stream Fall	4.5	2000-2015	-67	-90,13	0.90	0.77	0.44	16
		As above						

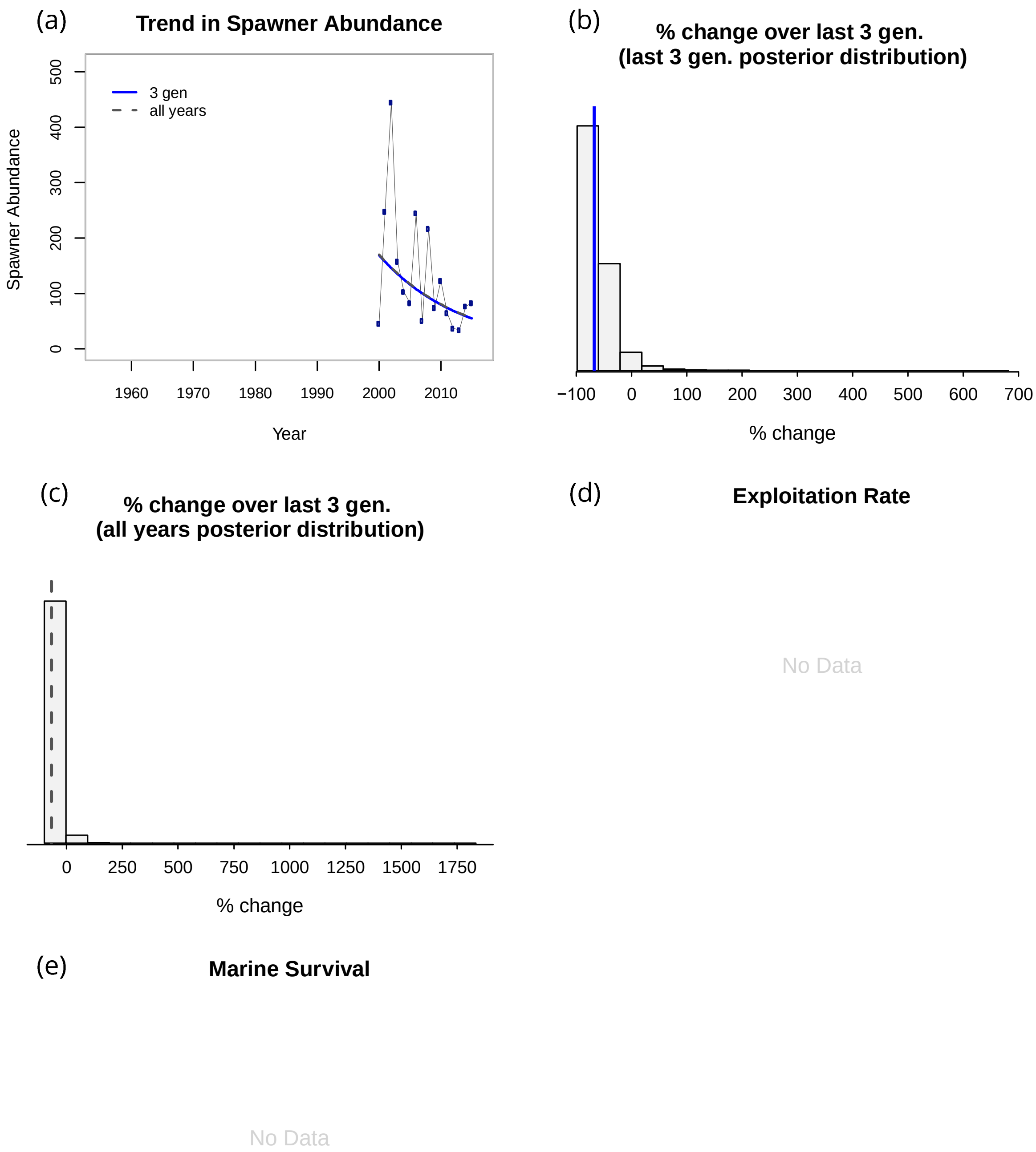


Figure 55. DU8 – Trends in spawner abundance, exploitation rate, and marine (smolt-to-adult) survival.

Threats and Limiting Factors

For general threats and limiting factors applicable to all DUs, please refer to the **Threats and Limiting Factors** section in the introductory material. Further effort is required (e.g., by eliciting expert knowledge) to determine a threat grade. This DU is considered a high priority for completion of an IUCN Threats Calculator because escapement began declining in 2000-2001 and is currently very low (under 20 fish in 2016 and 2017) (Bailey pers. comm. 2018). Chinook Salmon spawning occurred in the Seton Portage, but habitat below Seton Dam has been degraded and is likely limiting (BC Hydro 2011a). This DU also contains an abandoned mine in the lower Nahatlatch River where waste rock was discarded into the Nahatlatch Canyon (Bailey pers. comm. 2018).

Designatable Unit 9: Middle Fraser, Stream, Spring (MFR+GStr) population (assessed November 2018)

DU Short Name	MFR+GStr/Stream/Spring
Joint Adaptive Zone (JAZ)	MFR+GStr
Life History	Stream
Run Timing	Spring

The average generation time for this DU is 4.5 years. These fish exhibit stream-type life-history variants and spring run-timing.

To review methods pertaining to data reported within individual DU chapters, refer to the preliminary sections of this report.

Extent of Occurrence and Area of Occupancy

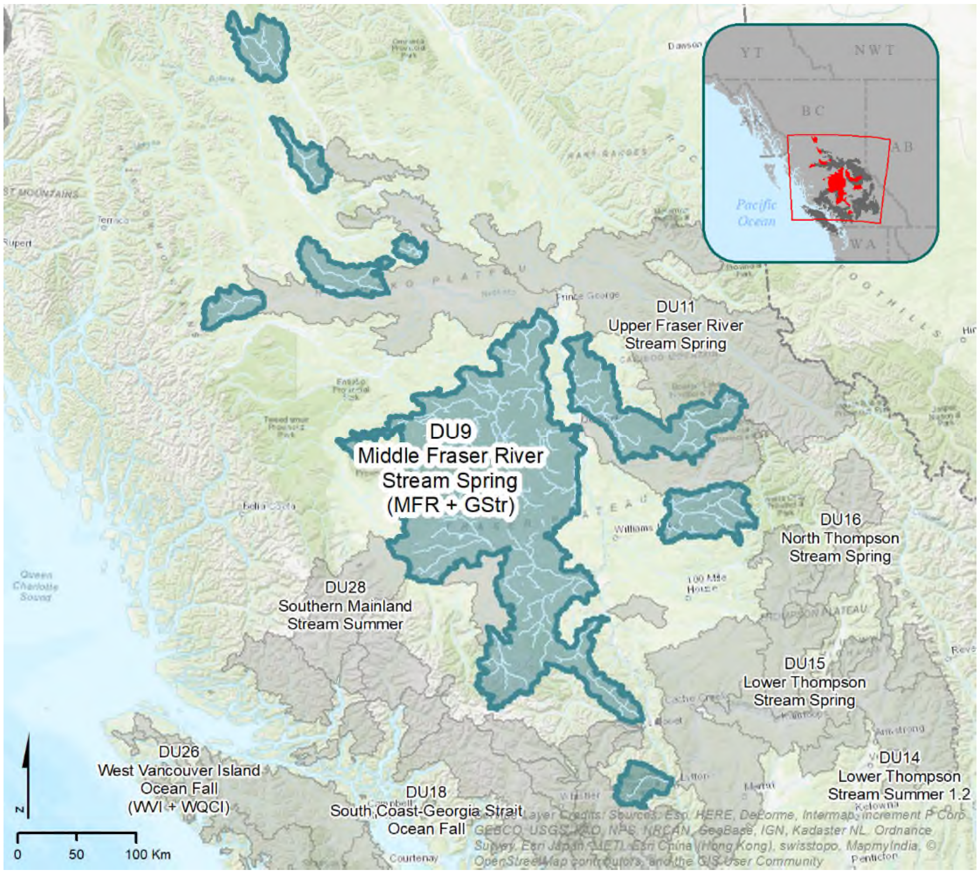


Figure 56. Map of DU9 – Middle Fraser River Stream Spring.

Comprised of nine separate sections, this DU has one of the largest extents in this report. DU9 stretches from Driftwood River close to Bear Lake in the north (Lat. 56.17, Long. 126.97) to Stein River close to Skihist Mountain in the south at Lat. 50.12, Long. 122.01. From the west, the DU extends from Nadina River (Lat. 53.78, Long. 127.27) to Cariboo River close to Mount Lunn in the east (Lat. 53.07, Long. 120.43). The DU's centroid occurs at Lat. 52.72, Long. 123.09 and its total area is 47965.10 km^2.

As for all DUs considered in this report, the extent of occurrence includes spawning streams as well as the ocean range, and is therefore >20,000 km^2. The IAO is 4490 km^2 based on a total known spawning run length of 2245 km, or 22.32% of the known spawning length across all DUs.

Habitat Trends

Land surrounding this DU's freshwater habitat is altered (16.1%), with urban development comprising 0.4% of the DU area, agricultural / rural development comprising 2.6% and mining development covering 0.1%. Road density in DU9 is 1.2 km/km^2 with an average of 0.5 stream crossings per km of fish accessible streams (the average across all DUs is 1.33 km/km^2 road density and 0.62 stream crossings per km of fish accessible streams). 13.5% of the riparian habitat and 13.0% of the forest cover is disturbed. 24.6% of the DU's pine stands are affected by Mountain Pine Beetle.

Chinook Salmon in the Bridge River are restricted to the lower river because of hydroelectric facilities. Prior to the installation of the Mission Dam at the outlet of Carpenter Lake, Chinook Salmon were present in the middle Bridge River and the tributaries Ferguson and Tyaughton creeks, where they were estimated at between 1 to 300 spawners, and 300 and 2,000 spawners respectively (BC Hydro 2011a). Spawning is now limited to areas downstream of the Terzaghi Dam (Komori 1997). Spawner abundance decreased in Yalakom River but increased in Bridge River when comparing the periods 1969-1980 to 1981-1992: the average number of spawners went from 136 to 23 in Yalakom River, and 125 to 529 in Bridge River (Komori 1997).

Abundance

For most years, no absolute abundance estimates are available for this DU, only relative abundance indices. Seventeen generational averages can be generated from relative index time series estimates, eight with 5,000 - 10,000 spawners and nine with less than 5,000 spawners (Figure 57c).

Most spawners originated from sample sites with moderate sampling effort/survey quality. Exceptions occurred in 2000 and 2015, when a small percentage of spawners came from high data quality sample sites (i.e., absolute abundance estimates) (Figure 57b). Fourteen sites provided data for seventeen generational averages of absolute abundance, one site with generational averages of 2,500 to 5,000 spawners, another with 1,000 to 2,500 spawners, seven with 250 to 1,000 spawners, and five with less than 250 spawners (Figure 57d).

Of the years where sampling occurred, mature individuals all originated from streams with low or unknown levels of enhancement (Figure 57a). However, hatchery releases did occur within the DU from 1980 to 2000, peaking at ~1,200,000 fish in 1986. From the mid-1990s to 2001, a very small number of releases occurred (Figure 57e). Three releases are reported outside the DU prior to 2000. No hatchery releases are reported after 2001.

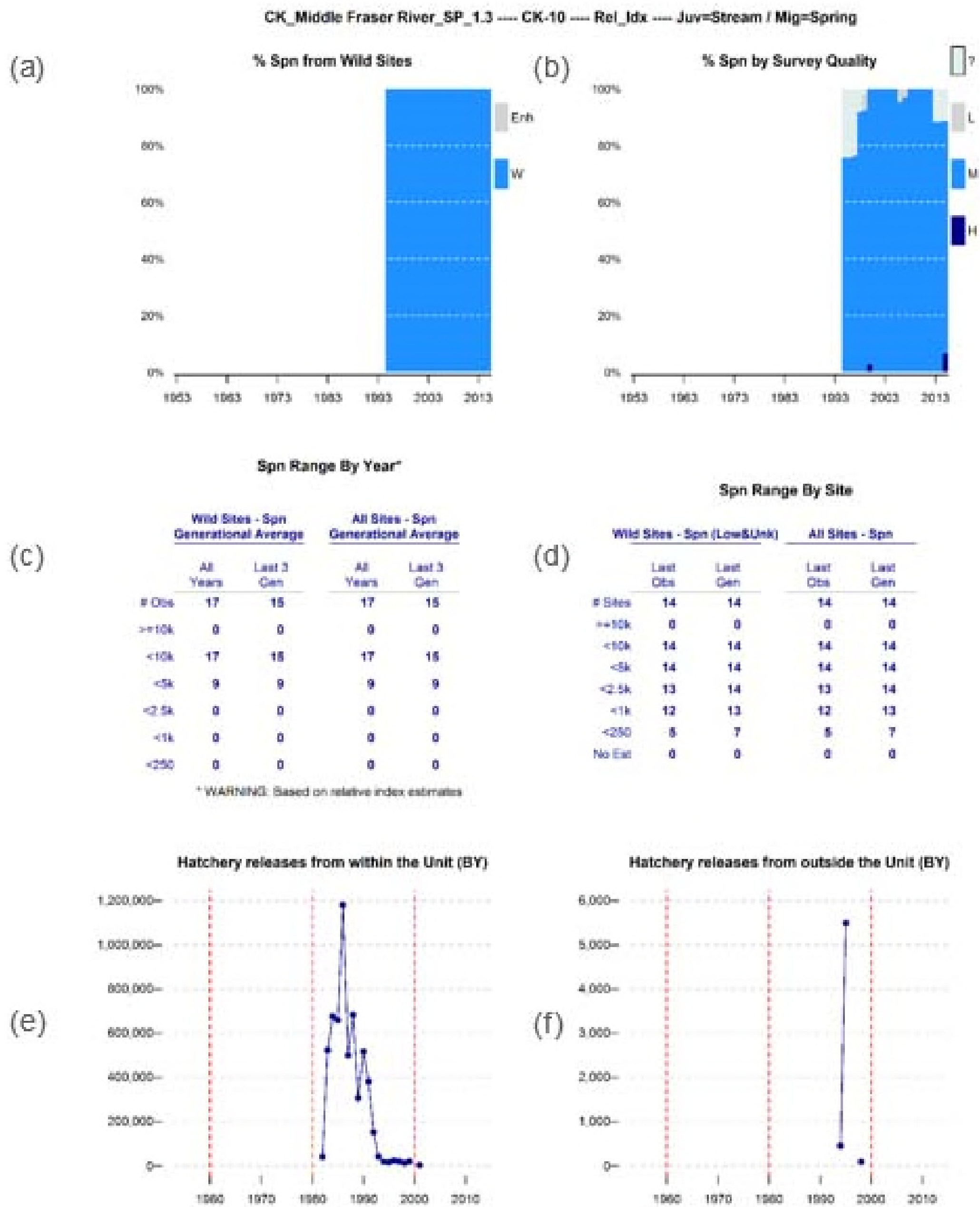


Figure 57. DU9 – Abundance, enhancement, and hatchery releases.

Fluctuations and Trends

Based on the last three generations of data, the number of mature individuals changed by an estimated -28% (Upper 95% CI = 97%, Lower 95% CI = -73%) with the probability of a 30% decline at 0.48 (Table 26, Figure 58a,b). Using the entire time series, the number of mature individuals changed over the last three generations by an estimated -49% (Upper 95% CI = -9%, Lower 95% CI = -72%) with the probability of a 30% decline at 0.87 (Figure 58c).

Harvest, marine (smolt-to-adult) survival and stock productivity data are unavailable for this DU because there is no coded-wire tag indicator stock.

Table 26. Summary of estimated rate of change (±95% credible interval) in spawner abundance and probability of decline over the last three generations (>30%, >50%, >70%). Rates of change over the last three generations are provided based on analysis of the last three generations of data as well as the entire time series.

DU Name	Generation length	Year range	Median % change	95% CI	p|30% decline	p|50% decline	p|70% decline	Number of Observations
Middle Fraser River Stream Spring	4.5	2000-2015	-28	-73,97	0.48	0.22	0.04	16
		1995-2015	-49	-72, -9	0.87	0.47	0.04	21

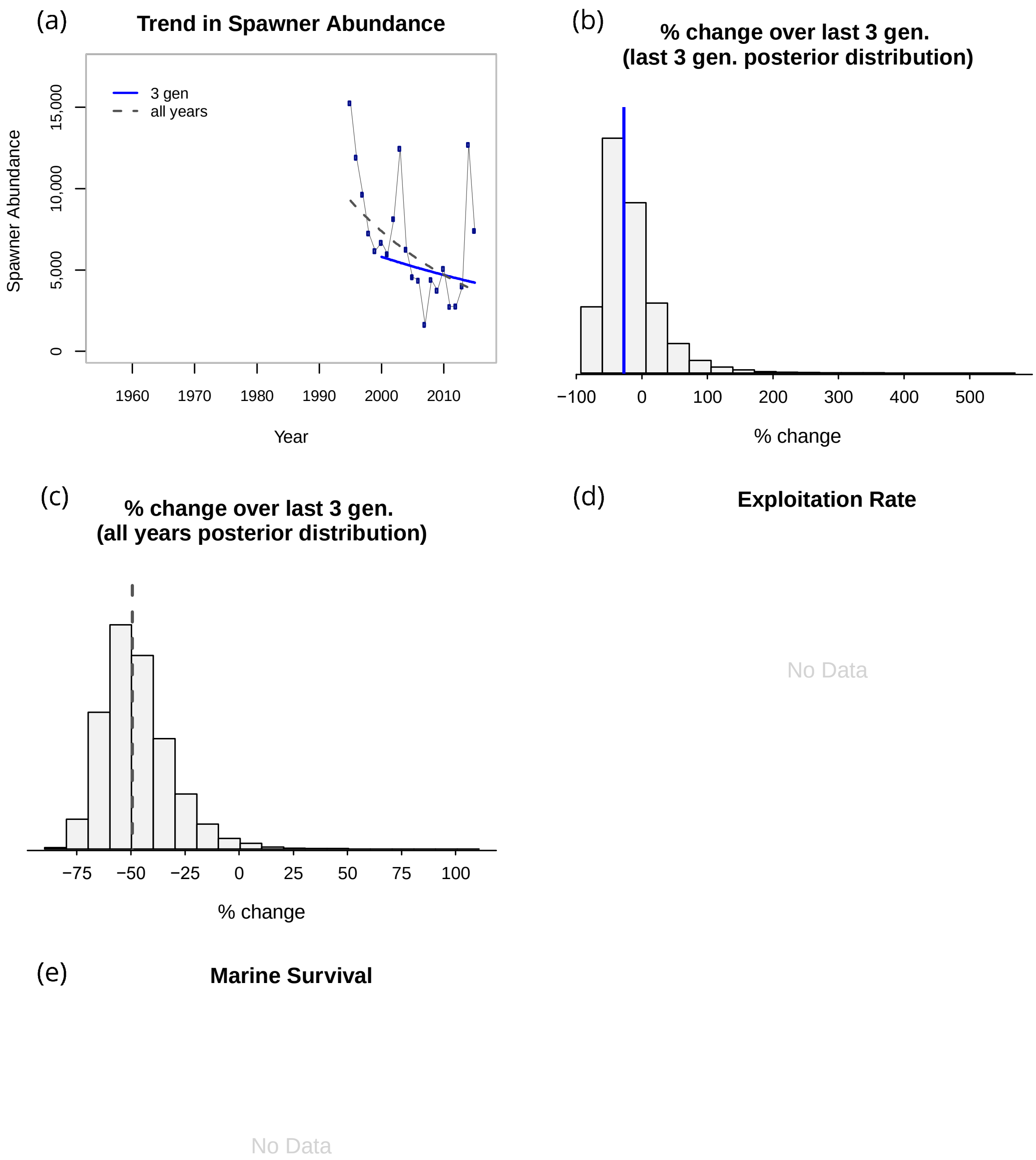


Figure 58. DU9 – Trends in spawner abundance, exploitation rate, and marine (smolt-to-adult) survival.

Threats and Limiting Factors

For general threats and limiting factors applicable to all DUs, please refer to the **Threats and Limiting Factors** section in the introductory material. Chinook Salmon experts who participated in the IUCN Threats Calculator Workshop in February 2017 concluded that this DU should be assigned a threat impact of High - Medium (B/C). The most important threats specific to this DU are from ecosystem modifications. Irrigation diking and ditching in the Lower Fraser Basin contributes to a loss of backwater and off-channel habitat. These practices are increasingly expanding upstream along the Fraser River (Bailey pers. comm. 2018). A loss of rearing and overwintering habitat is also occurring due to conversion of agricultural land use to residential/commercial land use. The DU is also impacted by snowpack and hydrologic regime changes. Placer and hard rock mining, evidence of acid mine drainage, and contaminant leaching exists at several sites in the Cottonwood River (Bailey pers. comm. 2018). Often the aquatic pollution that leaches from these sites is evident by the yellow ochre algae on the river bottom. Acid mine drainage is a serious threat with the potential for long-term devastating impacts to the aquatic community and reduced productive capacity of these rivers. Placer mining has also occurred in the Bridge River.

Other less critical threats include impacts from livestock and farm equipment entering stream habitat, dams and water management, invasive species, droughts, temperature extremes and harvest rates. For this DU, brood-over-brood increases in spawners were generally seen from 2012-2015, but there was high ocean mortality. In addition to resident Killer Whales, seals and sea lions are significant predators.

In 2005, the harvest rate for this DU was 60%. Attempts to reduce this rate to 30% have not been fully successful – a range of 20-40% is probably closer to actual.

Threats Calculator spreadsheets are included with this report (see Appendix 1).

Designatable Unit 10: Middle Fraser, Stream, Summer population (assessed November 2018)

DU Short Name	MFR+GStr/Stream/Summer
Joint Adaptive Zone (JAZ)	MFR+GStr
Life History	Stream
Run Timing	Summer

The average generation time for this DU is 4.5 years. These fish exhibit stream-type life-history variants and summer run-timing.

To review methods pertaining to data reported within individual DU chapters, refer to the preliminary sections of this report.

Extent of Occurrence and Area of Occupancy

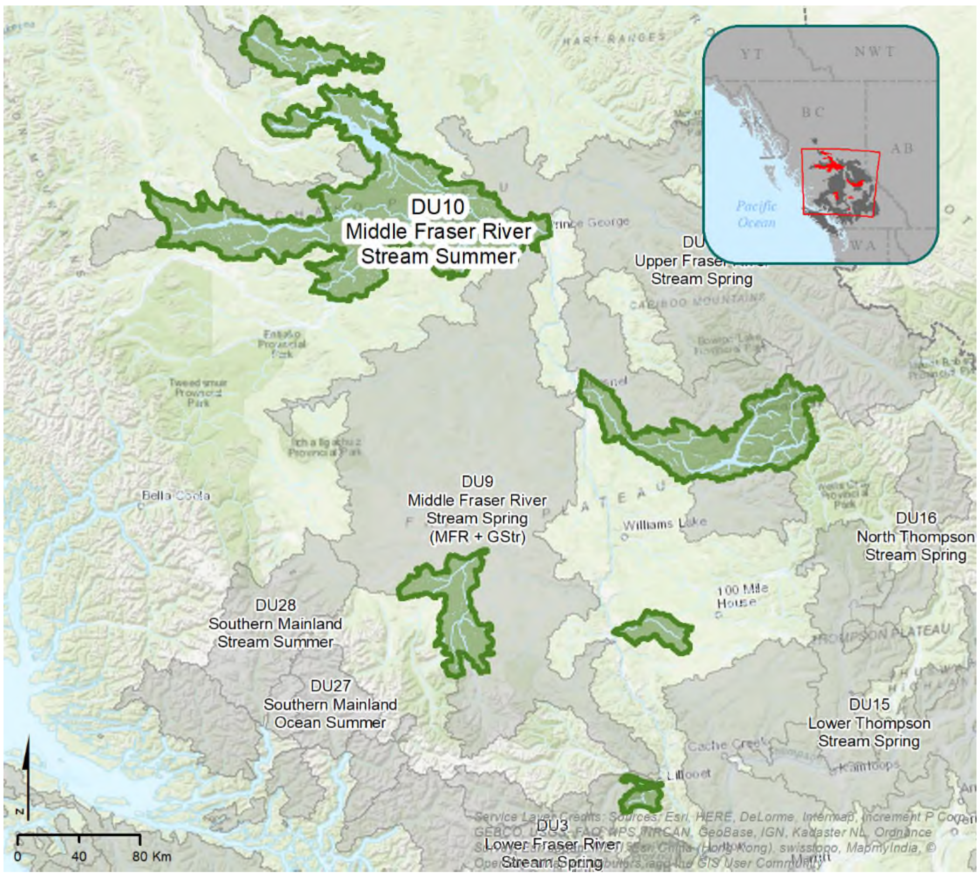


Figure 59. Map of DU10 – Middle Fraser River Stream Summer.

This DU consists of five geographically separated sections spanning from Middle River close to Nesabut Mountain in the north (Lat. 55.23, Long. 125.58) to Elkin Creek in the south (Lat. 51.39, Long. 123.51). The DU's western-most extent occurs at Stellako River close to Mount Parrott at Lat. 54.12, Long. 126.71 and the eastern-most point is at Niagara Creek close to Mount Sir Wilfrid Laurier (Lat. 52.88, Long. 120.16). The DU's centroid occurs at Lat. 53.50, Long. 123.72, and its total area is 22072.99 km^2.

As for all DUs considered in this report, the extent of occurrence includes spawning streams as well as the ocean range, and is therefore >20,000 km^2. The IAO is 2616km^2 based on a total known spawning run length of 1308km, or 13% of the known spawning length across all DUs.

Habitat Trends

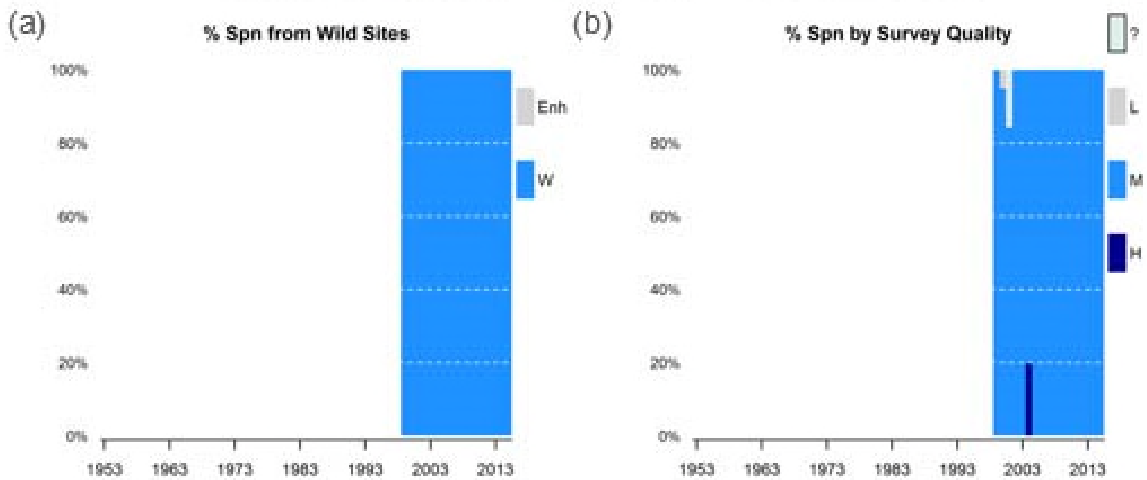
Land surrounding this DU's freshwater habitat is altered (11.6%), with urban development comprising 0.9% of the DU area, agricultural / rural development comprising 2.0% and mining development comprising 0.1%. Road density in DU10 is 1.0km/km^2 with an average of 0.32 stream crossings per km of fish accessible streams (the average across all DUs is 1.33km/km^2 road density and 0.62 stream crossings per km of fish accessible streams). 11.4% of the riparian habitat and 8.5% of the forest cover is disturbed. 21.0% of the DU's pine stands are affected by Mountain Pine Beetle.

Abundance

For most years no absolute abundance estimates are available for this DU, only relative abundance indices. Thirteen generational averages can be generated from relative index spawner time series data, all indicating abundances of 10,000 or more fish (Figure 60c). Most spawners originate from census sites with moderate sampling effort/survey quality. An exception occurred in 2004 when ~20% of spawners came from a site with high data quality (i.e., absolute abundance estimates) (Figure 60b). Six sites provide sufficient absolute abundance data to generate thirteen generational averages, one with 10,000 or more spawners, another with 5,000 and 10,000 spawners, one with 2,500 and 5,000 spawners, one with 1,000 and 2,500 spawners and two with less than 250 spawners (Figure 60d).

Of the years where sampling occurred, mature individuals all originated from streams with low or unknown levels of enhancement (Figure 60a). However, hatchery releases did occur from 1980 to 2013, peaking at about 2,200,000 fish then declining to a very small number of releases after 2000 (Figure 60e).

CK_Middle Fraser River_SU_1.3 ---- CK-11 ---- Rel_Idx ---- Juv=Stream / Mig=Summer



(c)

Spn Range By Year*

	Wild Sites - Spn Generational Average		All Sites - Spn Generational Average	
	All Years	Last 3 Gen	All Years	Last 3 Gen
# Obs	13	13	13	13
>=10k	13	13	13	13
<10k	0	0	0	0
<5k	0	0	0	0
<2.5k	0	0	0	0
<1k	0	0	0	0
<250	0	0	0	0

* WARNING: Based on relative index estimates

(d)

Spn Range By Site

	Wild Sites - Spn (Low&Unk)		All Sites - Spn	
	Last Obs	Last Gen	Last Obs	Last Gen
# Sites	6	6	6	6
>=10k	1	0	1	0
<10k	5	6	5	6
<5k	4	5	4	5
<2.5k	3	4	3	4
<1k	3	3	3	3
<250	2	2	2	2
No Est	0	0	0	0

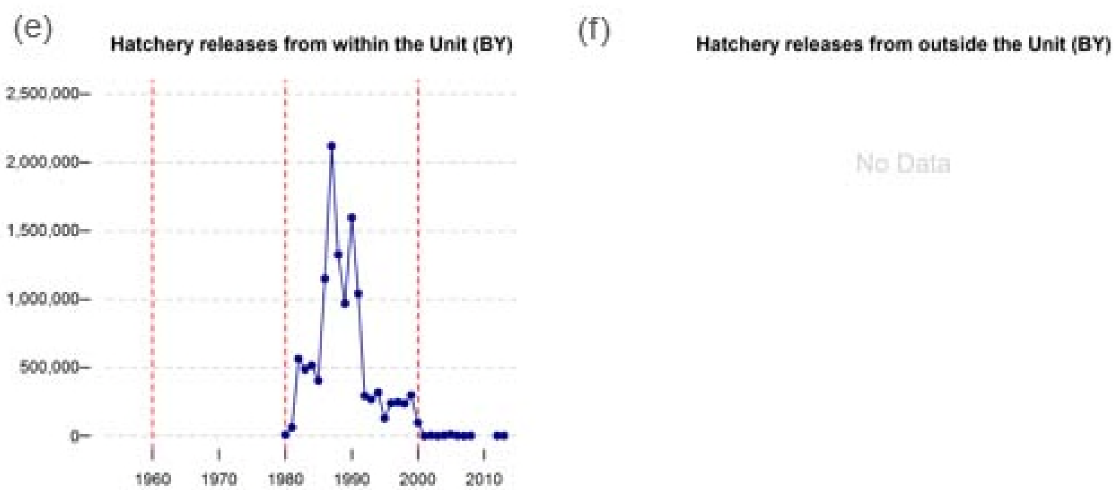


Figure 60. DU10 – Abundance, enhancement, and hatchery releases.

Fluctuations and Trends

Based on the last three generations of data, the number of mature individuals changed by an estimated -38% (Upper 95% CI = 28%, Lower 95% CI = -70%) with the probability of a 30% decline at 0.64 (Table 27, Figure 61a,b). Using the entire time series of data (one additional year), the number of mature individuals changed over the last three generations by an estimated -29% (Upper 95% CI = 39%, Lower 95% CI = -63%) with the probability of a 30% decline at 0.48 (Figure 61c).

Harvest, marine (smolt-to-adult) survival and stock productivity data are unavailable for this DU because there is no coded-wire tag indicator stock.

Table 27. Summary of estimated rate of change (±95% credible interval) in spawner abundance and probability of decline over the last three generations (>30%, >50%, >70%). Rates of change over the last three generations are provided based on analysis of the last three generations of data as well as the entire time series.

DU Name	Generation length	Year range	Median % change	95% CI	p|30% decline	p|50% decline	p|70% decline	Number of Observations
Middle Fraser River Stream Summer	4.5	2000-2015	-38	-70,28	0.64	0.26	0.03	16
		1999-2015	-29	-63,39	0.48	0.14	0.01	17

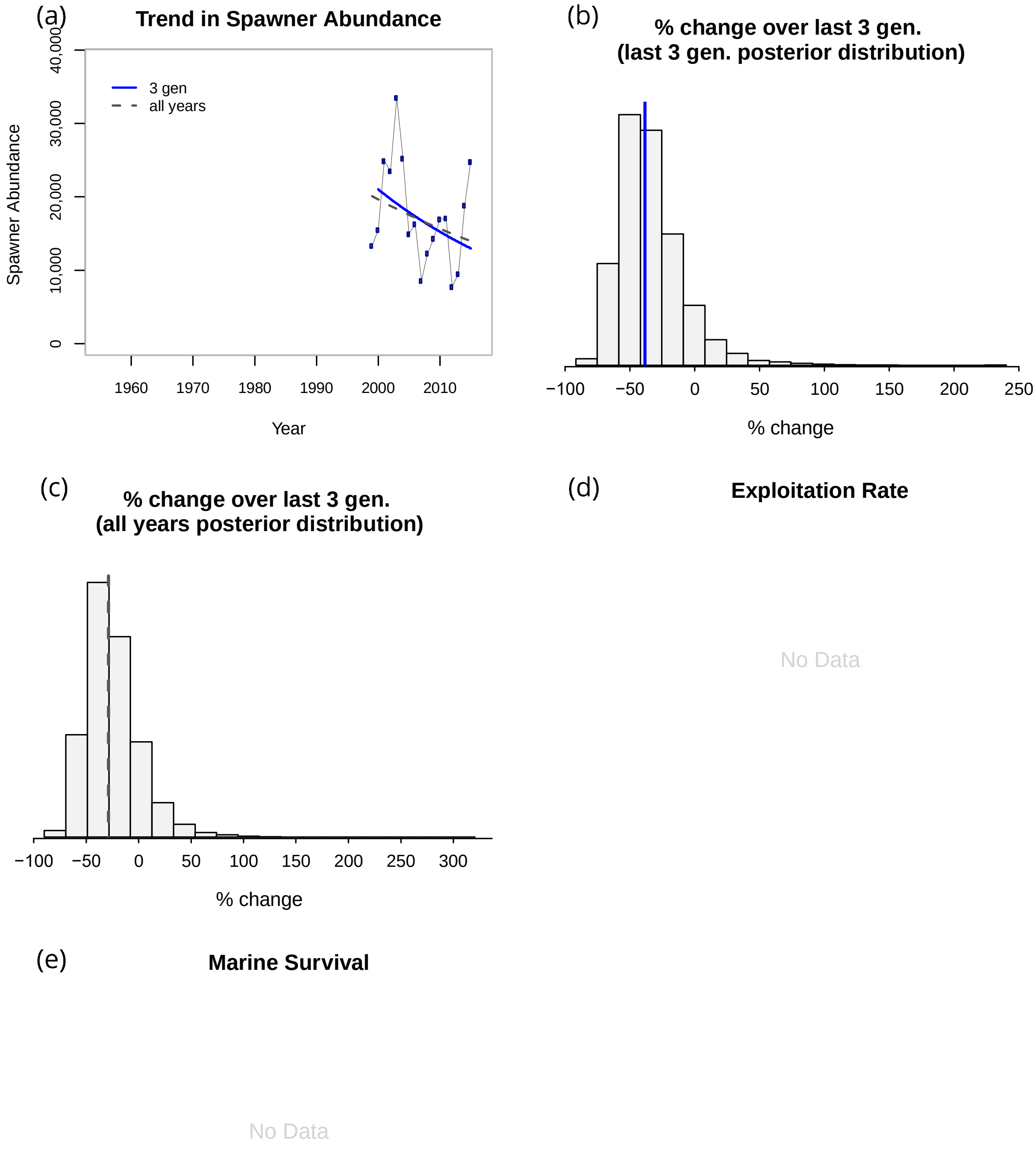


Figure 61. DU10 – Trends in spawner abundance, exploitation rate, and marine (smolt-to-adult) survival.

Threats and Limiting Factors

For general threats and limiting factors applicable to all DUs, please refer to the **Threats and Limiting Factors** section in the introductory material. Further effort is required (e.g., by eliciting expert knowledge) to determine a threat grade for this DU. Chinook Salmon experts who participated in the IUCN Threats Calculator Workshop in February 2017 recommended using the DU17 Threats Calculator as a proxy for DU10 (see Table 18), but DU17 was not completed at the workshop.

Expert knowledge indicates placer and hard rock mining, acid mine drainage, and contaminant leaching occurs at several locations in the Quesnel River and Cariboo River (Bailey pers. comm. 2018). Often the aquatic pollution that leaches from these sites is evident by the yellow ochre algae on the river bottom. Acid mine drainage has potential for long-term devastating impacts to the aquatic community and reduced productive capacity of these rivers. The 2014 Mount Polley mining disaster occurred in this DU and involved a breach of the copper/gold mine's tailings pond, discharging toxic mud and water into Polley Lake. The Kenney dam, which is outside the southernmost extent of the DU (approximate Lat. 53.58, Long. 124.95), may affect temperature and flow rates in the Nechako River, thereby changing the migration timing of Chinook Salmon smolts (Sykes *et al*. 2009).

Designatable Unit 11: Upper Fraser, Stream, Spring population (assessed November 2018

DU Short Name	UFR/Stream/Spring
Joint Adaptive Zone (JAZ)	UFR
Life History	Stream
Run Timing	Spring

The average generation time for this DU is 4.5 years. These fish exhibit stream-type life-history variants and spring run-timing.

To review methods pertaining to data reported within individual DU chapters, refer to the preliminary sections of this report.

<u>Extent of Occurrence and Area of Occupancy</u>

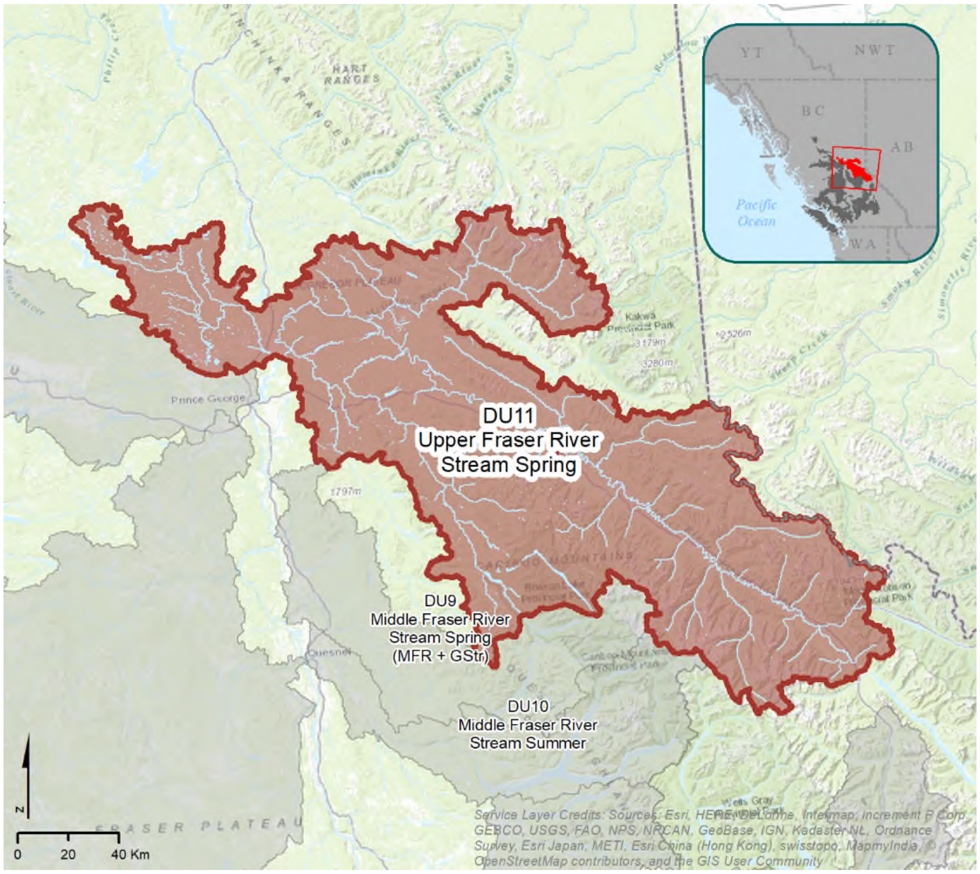


Figure 62. Map of DU11 – Upper Fraser River Stream Spring.

This DU extends from Salmon River around Mount MacKinnon in the north (Lat. 54.62, Long. 123.69) to Raush River at Mount Sir Wilfrid Laurier in the south (Lat. 52.69, Long. 119.73). The eastern-most extent occurs at Holmes River along Mount Robson at Lat. 53.36, Long. 119.41. The western-most extent also occurs in the north near Salmon River. Further south, the DU boundary extends west near Mount Burdett at Lat. 52.98, Long. 121.51. The DU's centroid is at Lat. 53.67, Long. 120.91, and its total area is 24431.59km^2.

As for all DUs considered in this report, the extent of occurrence includes spawning streams as well as the ocean range, and is therefore >20,000 km^2. The IAO is 4065 km^2 based on a total known spawning run length of 2033 km, or 20.21% of the known spawning length across all DUs.

Habitat Trends

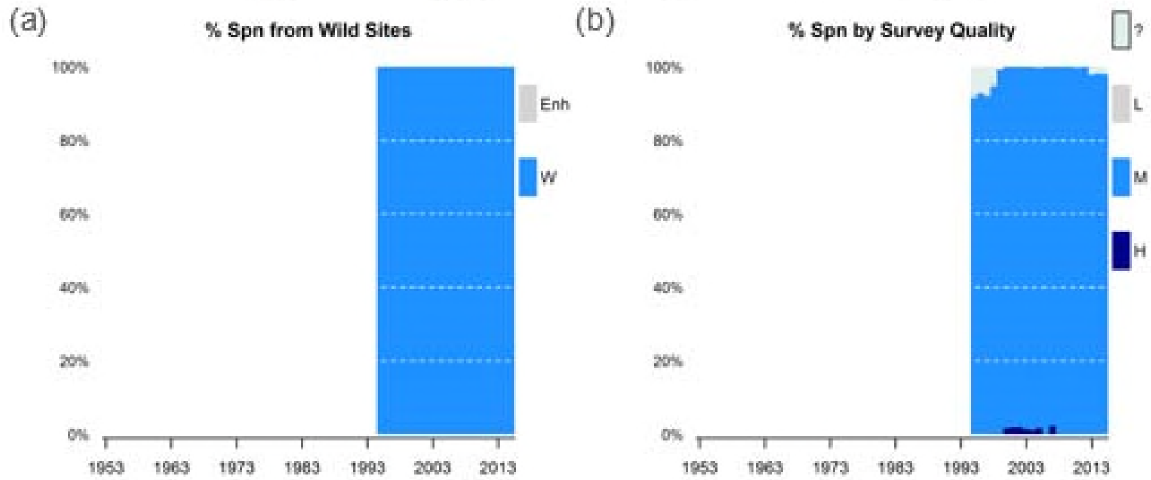
Land surrounding this DU's freshwater habitat is altered (17.5%), with urban development comprising 0.09% of the DU area, agricultural / rural development comprising 0.7%, and mining development comprising 0.01%. Road density in DU11 is 0.9 km/km^2 with an average of 0.5 stream crossings per km of fish accessible streams (the average across all DUs is 1.33 km/km^2 road density and 0.62 stream crossings per km of fish accessible streams). 15.5% of the riparian habitat and 16.6% of the forest cover is disturbed. 5.5% of the DU's pine stands are affected by Mountain Pine Beetle.

Abundance

Almost all data originate from sample sites with relative abundance indices of moderate sampling effort/survey quality. A small proportion of sample sites provided absolute abundance estimates between 1999 and 2007 (Figure 63b). Seventeen generational averages can be generated from spawner abundance time series data, all indicating abundances of 10,000 or more spawners (Figure 63c). Absolute abundance estimates were obtained from twenty-eight sites, over half of which had less than 250 spawners. One site had 5,000-10,000, another had 2,500-5,000, two sites had 1,000-2,500, and nine sites had 250-1,000 spawners.

Of the years where sampling occurred, almost all observed spawners originated from streams with low or unknown levels of enhancement (Figure 63a). A relatively high level of hatchery releases occurred in the 1980s, reaching a maximum of ~1,000,000 fish in 1984. After 1989, hatchery releases declined to ~50,000, before halting completely by 2005 (Figure 63e).

CK_Upper Fraser River_SP_1.3 ---- CK-12 ---- Rel_Idx ---- Juv=Stream / Mig=Spring



(c)

Spn Range By Year*

	Wild Sites - Spn Generational Average		All Sites - Spn Generational Average	
	All Years	Last 3 Gen	All Years	Last 3 Gen
# Obs	17	15	17	15
>=10k	17	15	17	15
<10k	0	0	0	0
<5k	0	0	0	0
<2.5k	0	0	0	0
<1k	0	0	0	0
<250	0	0	0	0

* WARNING: Based on relative index estimates

(d)

Spn Range By Site

	Wild Sites - Spn (Low&Unk)		All Sites - Spn	
	Last Obs	Last Gen	Last Obs	Last Gen
# Sites	28	28	28	28
>=10k	0	0	0	0
<10k	28	28	28	28
<5k	27	28	27	28
<2.5k	26	27	26	27
<1k	24	25	24	25
<250	15	16	15	16
No Est	0	0	0	0

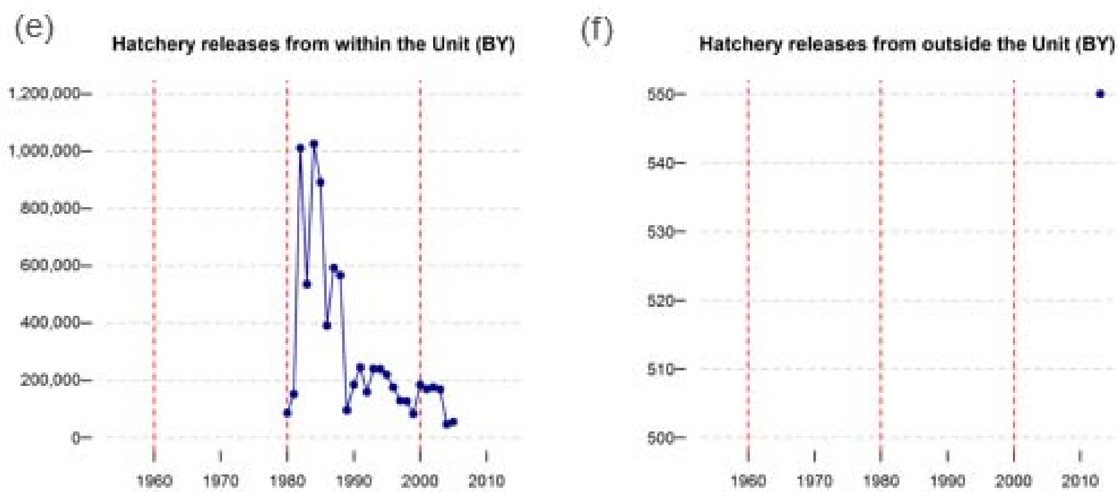


Figure 63. DU11 - Abundance, enhancement, and hatchery releases.

Fluctuations and Trends

Based on the last three generations of data, the number of mature individuals changed by an estimated -49% (Upper 95% CI = 15%, Lower 95% CI = -77%) with the probability of a 30% decline at 0.79 (Table 28, Figure 64a,b). Using the entire time series of data, the number of mature individuals changed over the last three generations by an estimated -43% (Upper 95% CI = -8%, Lower 95% CI = -64%) with the probability of a 30% decline at 0.81.

The total exploitation rate increased from a low of around 0.1 in 1986 to a high of 0.8 in 1996, but began to decline from 2000-2002 (Figure 64d). The last CWT data available in nuSEDS (shown here) are from brood year 2002 and indicate an exploitation rate of 0.4. More recently, in-river harvest was estimated using a run reconstruction model and was found to fluctuate between 10-20% (English *et al.* 2007). Marine (smolt-to-adult) survival averaged a rate of ~0.01 from 1986 to 2002, and fluctuated little in that time (Figure 64e). Marine survival data are not available past 2002. Stock productivity data are not available for this DU.

Table 28. Summary of estimated rate of change (±95% credible interval) in spawner abundance and probability of decline over the last three generations (>30%, >50%, >70%). Rates of change over the last three generations are provided based on analysis of the last three generations of data as well as the entire time series.

DU Name	Generation length	Year range	Median % change	95% CI	p|30% decline	p|50% decline	p|70% decline	Number of Observations
Upper Fraser River Stream Spring	4.5	2000-2015	-49	-77,15	0.79	0.48	0.09	16
		1995-2015	-43	-64, -8	0.81	0.28	0	21

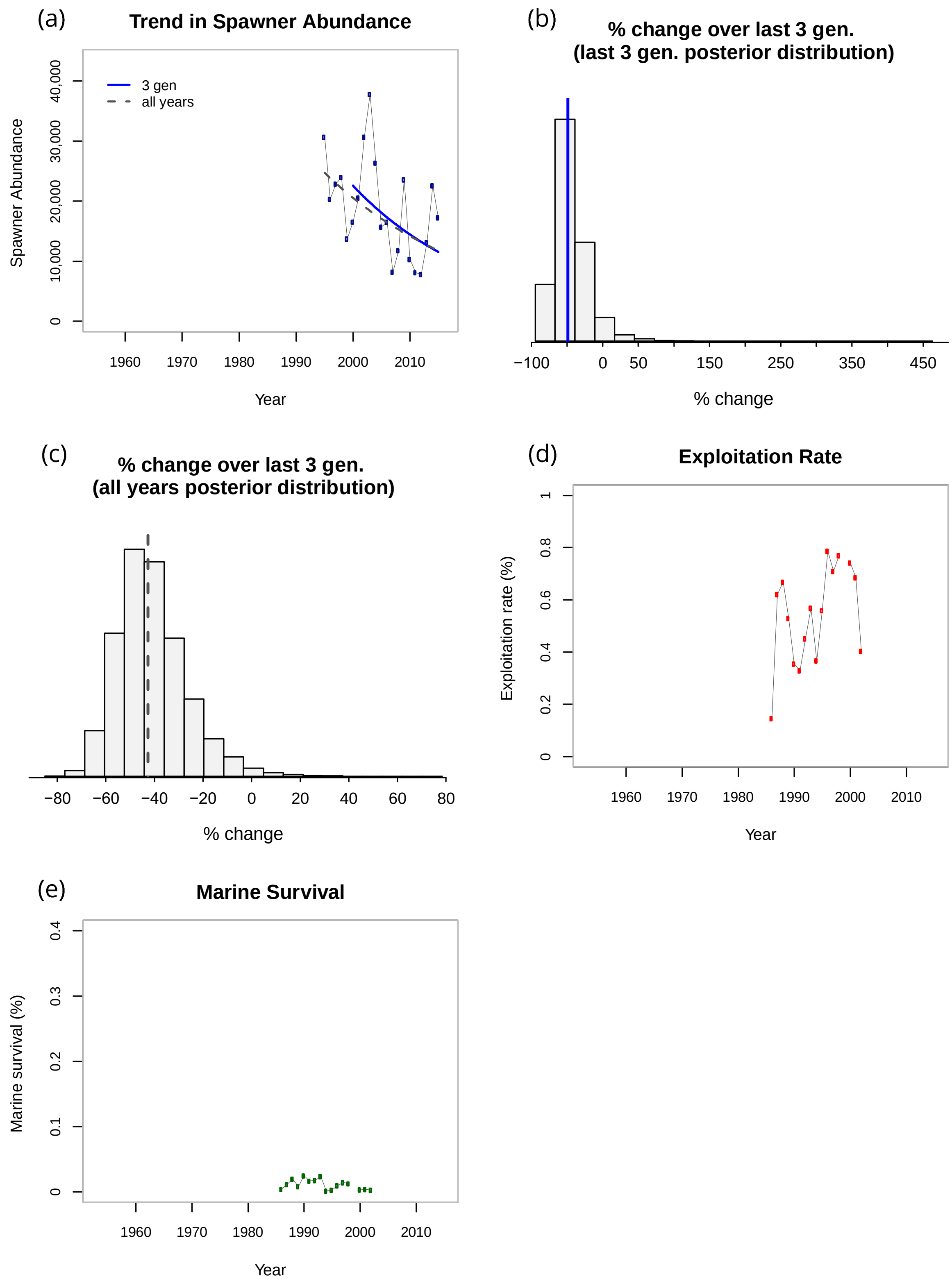


Figure 64. DU11 – Trends in spawner abundance, exploitation rate, and marine (smolt-to-adult) survival.

Threats and Limiting Factors

For general threats and limiting factors applicable to all DUs, please refer to the **Threats and Limiting Factors** section in the introductory material. Chinook Salmon experts who participated in the IUCN Threats Calculator Workshop in February 2017 concluded that this DU should be assigned a threat impact of High - Medium (B/C). Because females in fall actively seek a mix of groundwater and surface water when selecting redd sites, the most important threats specific to this DU are ecosystem modifications due to climate change, cyclical marine climate events (El Niño) and resulting shifts in groundwater availability caused by changes in the volume and timing of snowmelt. Another round of ocean survival impacts as in 2003 and 2007 could terminate groups of Chinook Salmon within the DU. Historic placer mining in the Bowron and Willow River systems also resulted in significant habitat alteration via large amounts of fine sediment washed into the river (Bailey pers. comm. 2018). Sedimentation can reduce egg-to-fry survival and adversely affect the aquatic insect community for rearing Chinook Salmon.

There has been limited success at maintaining a harvest target of 30% for this DU, with the most recent brood year at 40%. Chinook Salmon encounter nets all the way up the Fraser River and are exposed to constant fishing pressure exacerbated by slow migration speed from the river mouth to spawning grounds.

Other impacts include invasive species (esp. spiny rayed fish), avalanches/landslides, droughts, and temperature extremes.

Threats Calculator spreadsheets are included with this report (see Appendix 1).

Designatable Unit 12: South Thompson, Ocean, Summer population (assessed November 2018)

DU Short Name	ST+GStr/Ocean/Summer
Joint Adaptive Zone (JAZ)	STh+GStr
Life History	Ocean
Run Timing	Summer

The average generation time for this DU is 3.8 years. These fish exhibit ocean-type life-history variants and summer run-timing.

To review methods pertaining to data reported within individual DU chapters, refer to the preliminary sections of this report.

<u>Extent of Occurrence and Area of Occupancy</u>

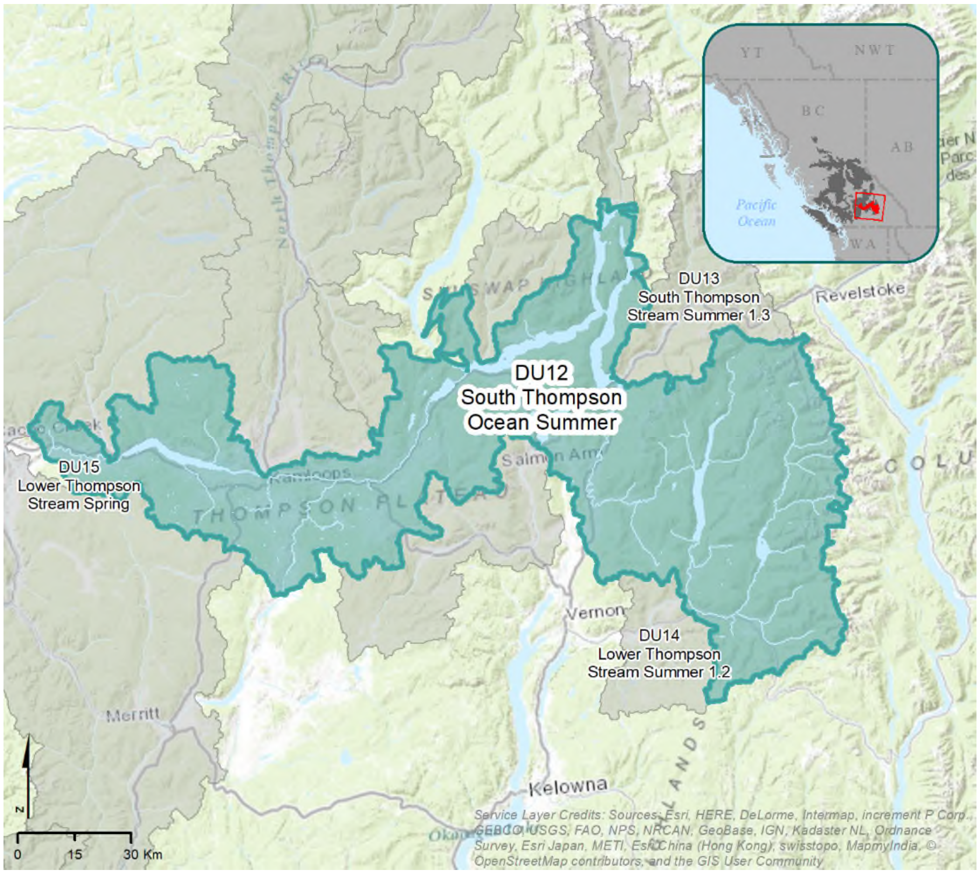


Figure 65. Map of DU12 – South Thompson Ocean Summer.

This DU extends west to east from Battle Creek around Mount Fehr (Lat. 50.84, Long. 121.20) to Spectrum Creek around Mount Odin in the southeast portion of the DU (Lat. 50.18, Long. 118.30). The northern-most extent occurs near Seymour Arm at the north end of Shuswap Lake (Lat. 51.25, Long. 118.99) and the southern-most extent occurs at Ferry Creek (Lat. 50.05, Long. 118.77). The DU's centroid is located at Lat. 50.67, Long. 119.34, and its total area is 10330.45 km^2.

As for all DUs considered in this report, the extent of occurrence includes spawning streams as well as the ocean range, and is therefore >20,000 km^2. The IAO is 1125 km^2 based on a total known spawning run length of 563 km, or 5.60% of the known spawning length across all DUs.

This DU is a combination of two Wild Salmon Policy Conservation Units: CK-13 and CK-15.

<u>Habitat Trends</u>

Land surrounding this DU's freshwater habitat is altered (20.3%), with agricultural / rural development comprising 6.4%, and urban development comprising 0.9% of the DU area. Road density in DU12 is 1.5km/km^2 with an average of 0.7 stream crossings per km of fish accessible streams (the average across all DUs is 1.33km/km^2 road density and 0.62 stream crossings per km of fish accessible streams). 20.5% of the DU's riparian habitat and 13.0% of the forest cover is disturbed. 2.5% of the pine stands are affected by Mountain Pine Beetle. No mining development is reported within the DU by Porter *et al* (2013). However, see comments in the Threats and Limiting Factors section below regarding potential risks associated with the Highland Valley Cooper and New Afton mines.

The South Thompson River and Little River were both dredged for shipping traffic. Spawning gravel was removed from the thalweg and or placed on shore or piled in mid-channel berms, which exceed the river level creating islands during spawning season (Bailey pers. comm. 2018). This activity reduced the spawning habitat and productive capacity of the DU.

<u>Abundance</u>

Most spawner data originated from sample sites with moderate sampling effort/survey quality except in the CK-15 portion of the DU, where from 2005 onward most spawner data originated from sites with high sampling effort/survey quality (Figure 67b). Sixteen generational averages can be calculated from spawner time series data available from CK-13 and thirty from CK-15. In both units, generational averages indicate 10,000 or more spawners (Figure 66c and Figure 67c). The average proportion of spawners contributed by each CK was 0.673 (CK-13), and 0.327 (CK-15). Six sites with absolute spawner data are identified (CK-13 and CK-15 combined). The four sites in CK-13 and one site in CK-15 are estimated at an average of 10,000 or more spawners. The remaining site (Shuswap River-Middle) is estimated at 2,500-5,000 spawners.

Of the years where sampling occurred, all spawners in CK-13 and most spawners in CK-15 originated from streams that had low or unknown levels of enhancement (Figure 66a and Figure 67a). Depending on the year, approximately 10-30% of spawners in CK-15 were from enhanced streams (Figure 67a). Hatchery releases within CK-15 started in 1980 and peaked at over 2 million fish before leveling off over the last fifteen years at around ~750,000 releases annually (Figure 67e). No hatchery releases are reported in CK-13.

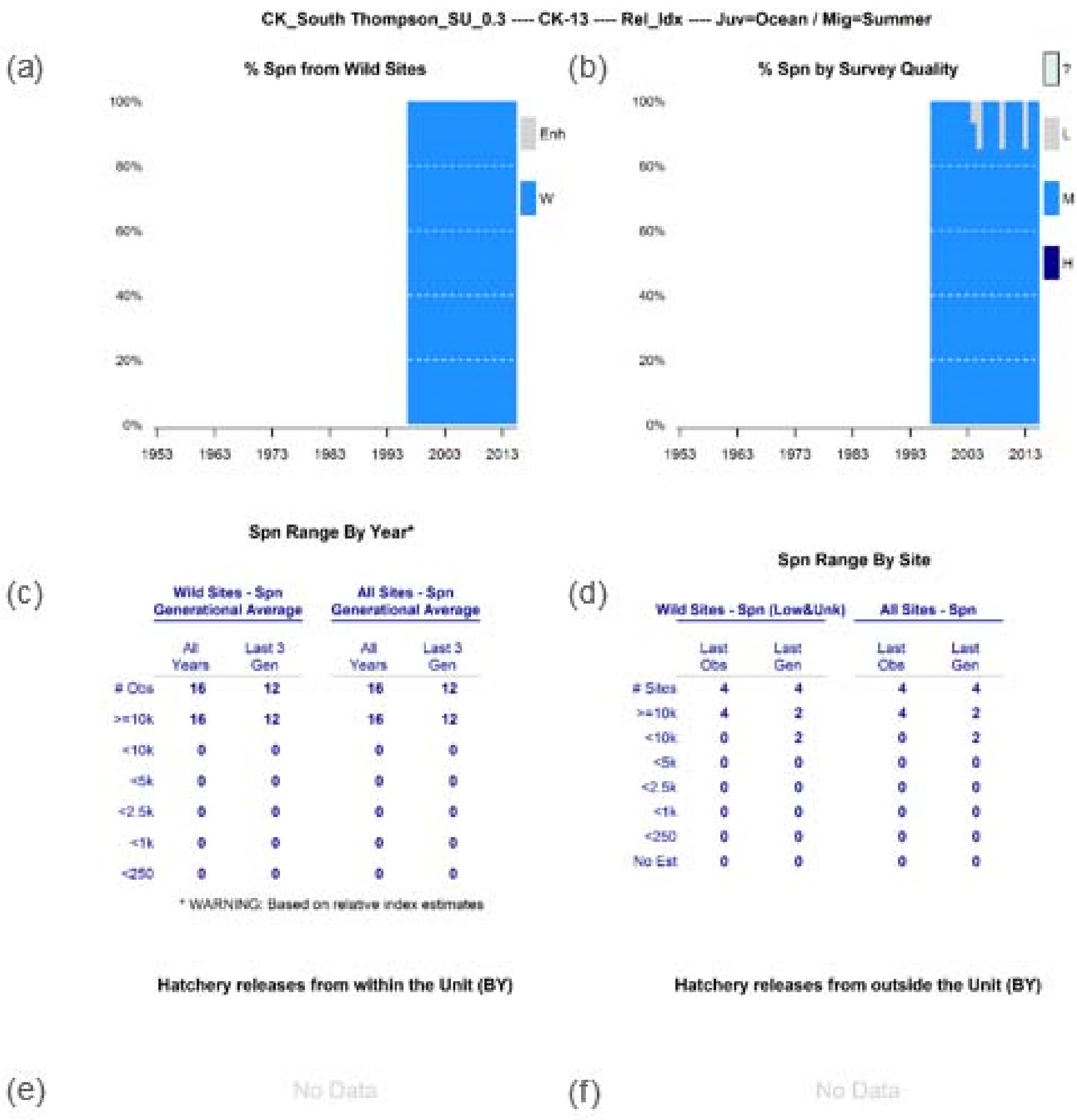
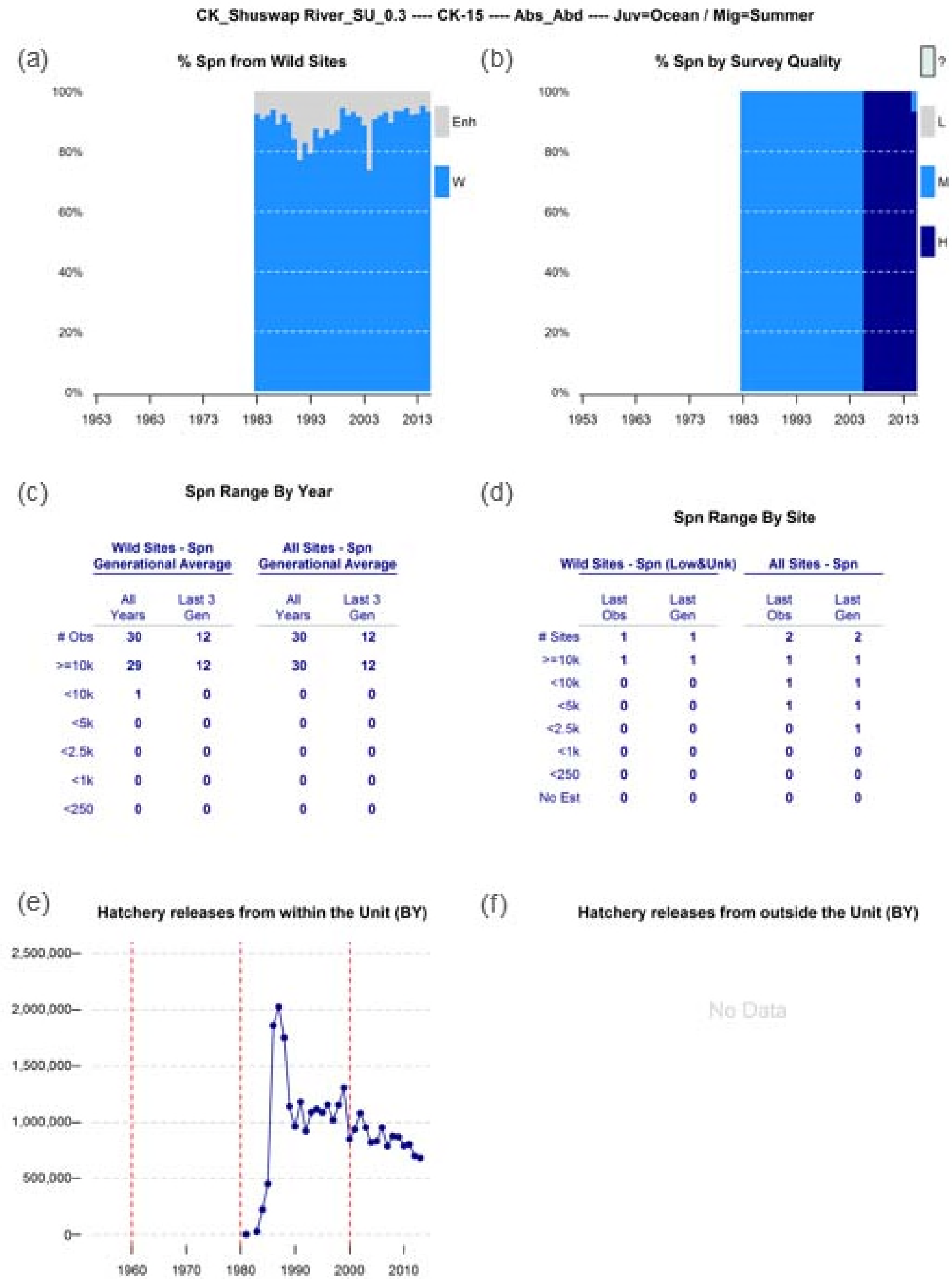


Figure 66. DU12 (CK – 13) – Abundance, enhancement, and hatchery releases.



	Wild Sites - Spn Generational Average		All Sites - Spn Generational Average	
	All Years	Last 3 Gen	All Years	Last 3 Gen
# Obs	30	12	30	12
>=10k	29	12	30	12
<10k	1	0	0	0
<5k	0	0	0	0
<2.5k	0	0	0	0
<1k	0	0	0	0
<250	0	0	0	0

	Wild Sites - Spn (Low&Unk)		All Sites - Spn	
	Last Obs	Last Gen	Last Obs	Last Gen
# Sites	1	1	2	2
>=10k	1	1	1	1
<10k	0	0	1	1
<5k	0	0	1	1
<2.5k	0	0	0	1
<1k	0	0	0	0
<250	0	0	0	0
No Est	0	0	0	0

Figure 67. DU12 (CK – 15) – Abundance, enhancement, and hatchery releases.

Fluctuations and Trends

Based on the last three generations of data, the number of mature individuals changed by an estimated 26% (Upper 95% CI = 195%, Lower 95% CI = -45%) with the probability of a 30% decline at 0.07 (Table 29, Figure 68a,b). Using the entire time series of data, the number of mature individuals changed over the last three generations by an estimated 64% (Upper 95% CI = 95%, Lower 95% CI = 38%) with zero probability of a 30% decline (Table 29, Figure 68a,c).

While coded-wire tag indicator stocks do exist, harvest, marine (smolt-to-adult) survival and stock productivity data are currently unavailable for this DU.

Table 29. Summary of estimated rate of change (±95% credible interval) in spawner abundance and probability of decline over the last three generations (>30%, >50%, >70%). Rates of change over the last three generations are provided based on analysis of the last three generations of data as well as the entire time series.

DU Name	Generation length	Year range	Median % change	95% CI	p|30% decline	p|50% decline	p|70% decline	Number of Observations
South Thompson Ocean Summer	3.8	2003-2015	26	-45,195	0.07	0.02	0	13
		1983-2015	64	38,95	0	0	0	33

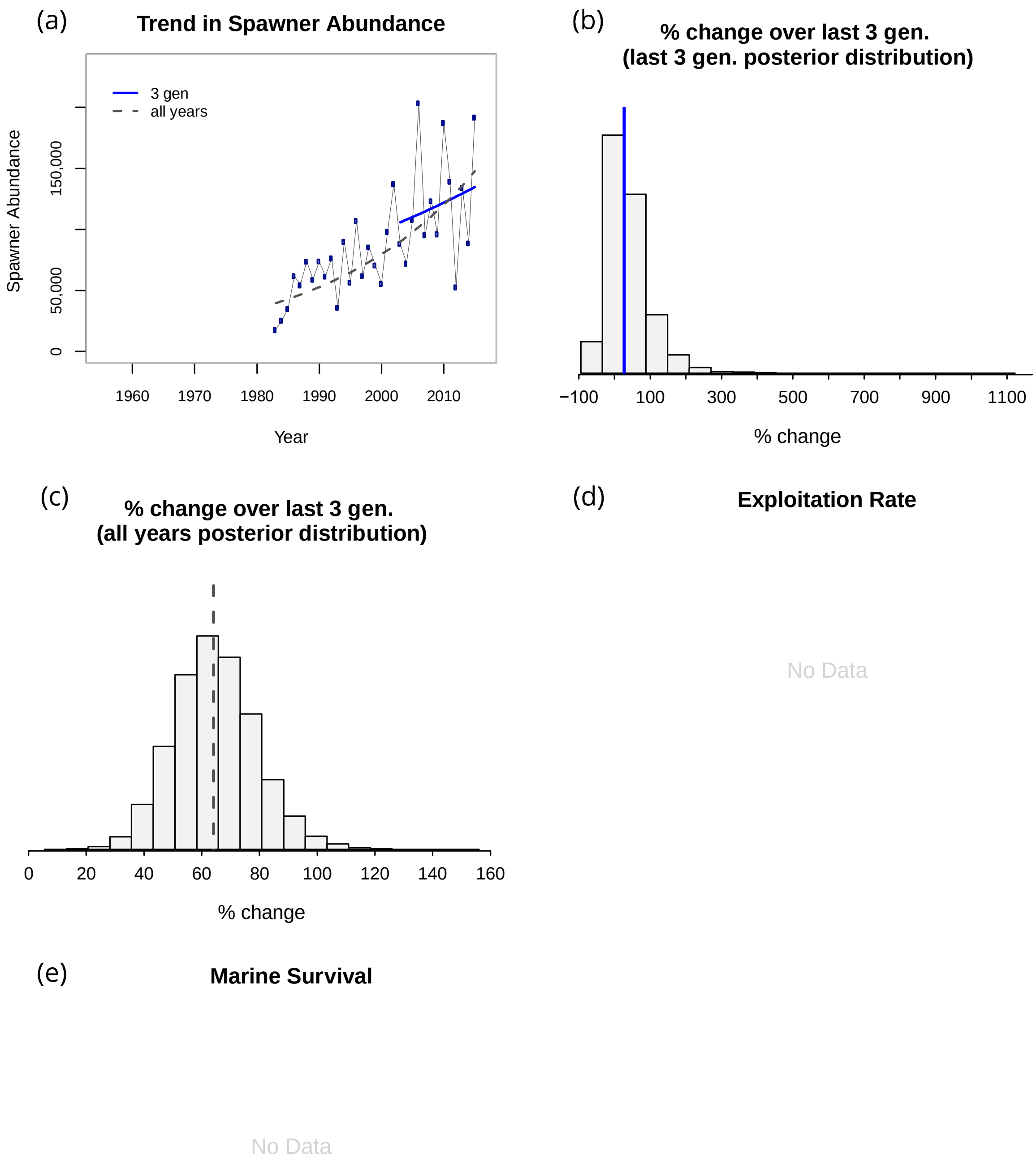


Figure 68. DU12 – Trends in spawner abundance, exploitation rate, and marine (smolt-to-adult) survival.

Threats and Limiting Factors

For general threats and limiting factors applicable to all DUs, please refer to the **Threats and Limiting Factors** section in the introductory material. Further effort is required (e.g., by eliciting expert knowledge) to determine a threat grade. This DU is considered a lower priority for completion of an IUCN Threats Calculator.

While Porter *et al*. (2013) report no mining development within the DU, the Highland Valley Cooper and New Afton mines have tailings ponds that, in the event of a failure, could result in toxic runoff entering the DU in the Thompson River (Bailey pers. comm. 2018).

Designatable Unit 13: South Thompson, Stream, Summer 1.3 population (not yet assessed)

Figures and tables to appear in Part Two:

Figure 69. Map of DU13 – South Thompson Stream Summer 1.3.

Figure 70. DU13 – Abundance, enhancement, and hatchery releases.

Table 30. Summary of estimated rate of change (±95% credible interval) in spawner abundance and probability of decline over the last three generations (>30%, >50%, >70%). Rates of change over the last three generations are provided based on analysis of the last three generations of data as well as the entire time series.

Figure 71. DU13 – Trends in spawner abundance, exploitation rate, and marine (smolt-to-adult) survival.

Designatable Unit 14: South Thompson, Stream, Summer 1.2 population (assessed November 2018)

DU Short Name	STh+GStr/Stream/Summer
Joint Adaptive Zone (JAZ)	STh+GStr
Life History	Stream
Run Timing	Summer

Unlike DU13, the average generation time for this DU at 3 years is atypical of Chinook Salmon (4.1yrs using Nicola River Spring as a proxy as stated in Table 17), like DU13, these fish exhibit stream-type life-history variants and summer run-timing – the title suffixes 1.2 and 1.3 are used to differentiate between these life-history strategies.

To review methods pertaining to data reported within individual DU chapters, refer to the preliminary sections of this report.

<u>Extent of Occurrence and Area of Occupancy</u>

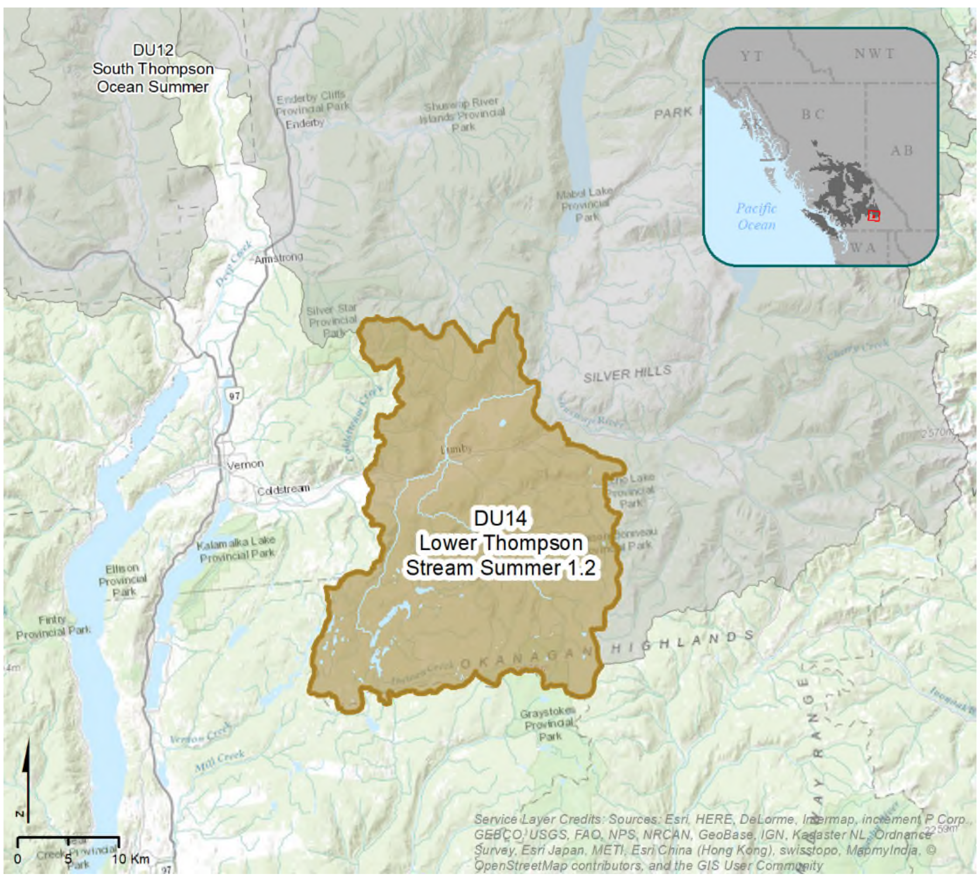


Figure 72. Map of DU14 – South Thompson Stream Summer 1.2.

This DU extends from Vance Creek in the northwest near Silver Star Provincial Park (Lat. 50.33, Long. 119.39) to Duteau Creek around Buck Mountain (Lat. 50.02, Long. 118.87). The DU's centroid is at Lat. 51.45, Long. 120.08, and its total area is 794.19 km^2.

As for all DUs considered in this report, the extent of occurrence includes spawning streams as well as the ocean range, and is therefore >20,000 km^2. The IAO is 70 km^2 based on a total known spawning run length of 35 km, or 0.35% of the known spawning length across all DUs.

<u>Habitat Trends</u>

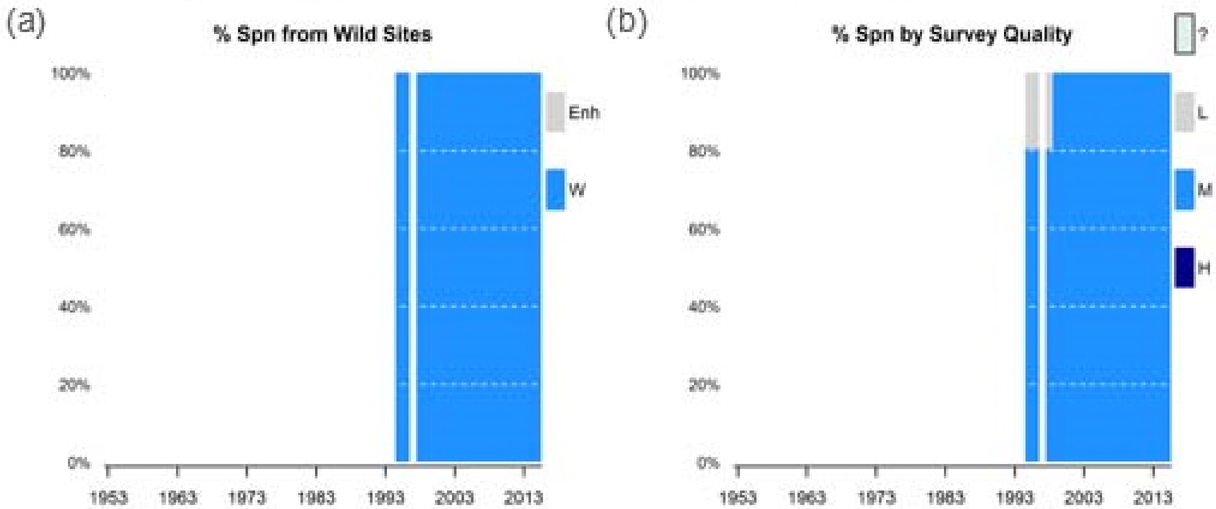
Land surrounding this DU's freshwater habitat is altered (24.0%), with agricultural / rural development comprising 8.0% and urban development 0.9% of the DU area. Road density in DU14 is 1.7 km/km^2 with an average of 0.7 stream crossings per km of fish accessible streams (the average across all DUs is 1.33 km/km^2 road density and 0.62 stream crossings per km of fish accessible streams). 20.4% of the DU's riparian habitat and 15.7% of its forest cover is disturbed. 5.3% of pine stands in the DU are affected by Mountain Pine Beetle. No mining development occurs within the DU boundaries.

<u>Abundance</u>

Most spawners originate from sample sites with moderate sampling effort/survey quality (Figure 73b). Fifteen generational averages can be calculated from available abundance time series data (Figure 73c), all but two with between 250 and 1,000 spawners. The remaining two generational averages indicate less than 250 spawners. Absolute abundance data are from two sites, each averaging less than 250 spawners (Figure 73d).

Of the years where sampling occurred, mature individuals all originate from streams with low or unknown levels of enhancement (Figure 73a). No hatchery releases are on record for this DU.

CK_South Thompson-Bessette Creek_SU_1.2 ---- CK-16 ---- Rel_Idx ---- Juv=Stream / Mig=Summer



(c) Spn Range By Year*

	Wild Sites - Spn Generational Average: All Years	Wild Sites - Spn Generational Average: Last 3 Gen	All Sites - Spn Generational Average: All Years	All Sites - Spn Generational Average: Last 3 Gen
# Obs	15	12	15	12
>=10k	0	0	0	0
<10k	15	12	15	12
<5k	15	12	15	12
<2.5k	15	12	15	12
<1k	15	12	15	12
<250	12	12	12	12

* WARNING: Based on relative index estimates

(d) Spn Range By Site

	Wild Sites - Spn (Low&Unk): Last Obs	Wild Sites - Spn (Low&Unk): Last Gen	All Sites - Spn: Last Obs	All Sites - Spn: Last Gen
# Sites	2	2	2	2
>=10k	0	0	0	0
<10k	2	2	2	2
<5k	2	2	2	2
<2.5k	2	2	2	2
<1k	2	2	2	2
<250	2	2	2	2
No Est	0	0	0	0

(e) Hatchery releases from within the Unit (BY)

No Data

(f) Hatchery releases from outside the Unit (BY)

No Data

Figure 73. DU14 – Abundance, enhancement, and hatchery releases.

Fluctuations and Trends

Based on the last three generations of data, the number of mature individuals changed by an estimated -47% (Upper 95% CI = 705%, Lower 95% CI = -96%) with the probability of a 30% decline at 0.59 (Table 31, Figure 74a,b). Using the entire time series of data, the number of mature individuals changed over the last three generations by an estimated -76% (Upper 95% CI = -31%, Lower 95% CI = -92%) with the probability of a 30% decline at 0.98 (Figure 74a,c).

Harvest, marine (smolt-to-adult) survival and stock productivity data are unavailable for this DU because there is no coded-wire tag indicator stock.

Table 31. Summary of estimated rate of change (±95% credible interval) in spawner abundance and probability of decline over the last three generations (>30%, >50%, >70%). Rates of change over the last three generations are provided based on analysis of the last three generations of data as well as the entire time series.

DU Name	Generation length	Year range	Median % change	95% CI	p|30% decline	p|50% decline	p|70% decline	Number of Observations
South Thompson Stream Summer 1.2	4	2003-2015	-47	-96,705	0.59	0.48	0.33	13
		1995-2015	-76	-92,-31	0.98	0.92	0.67	20

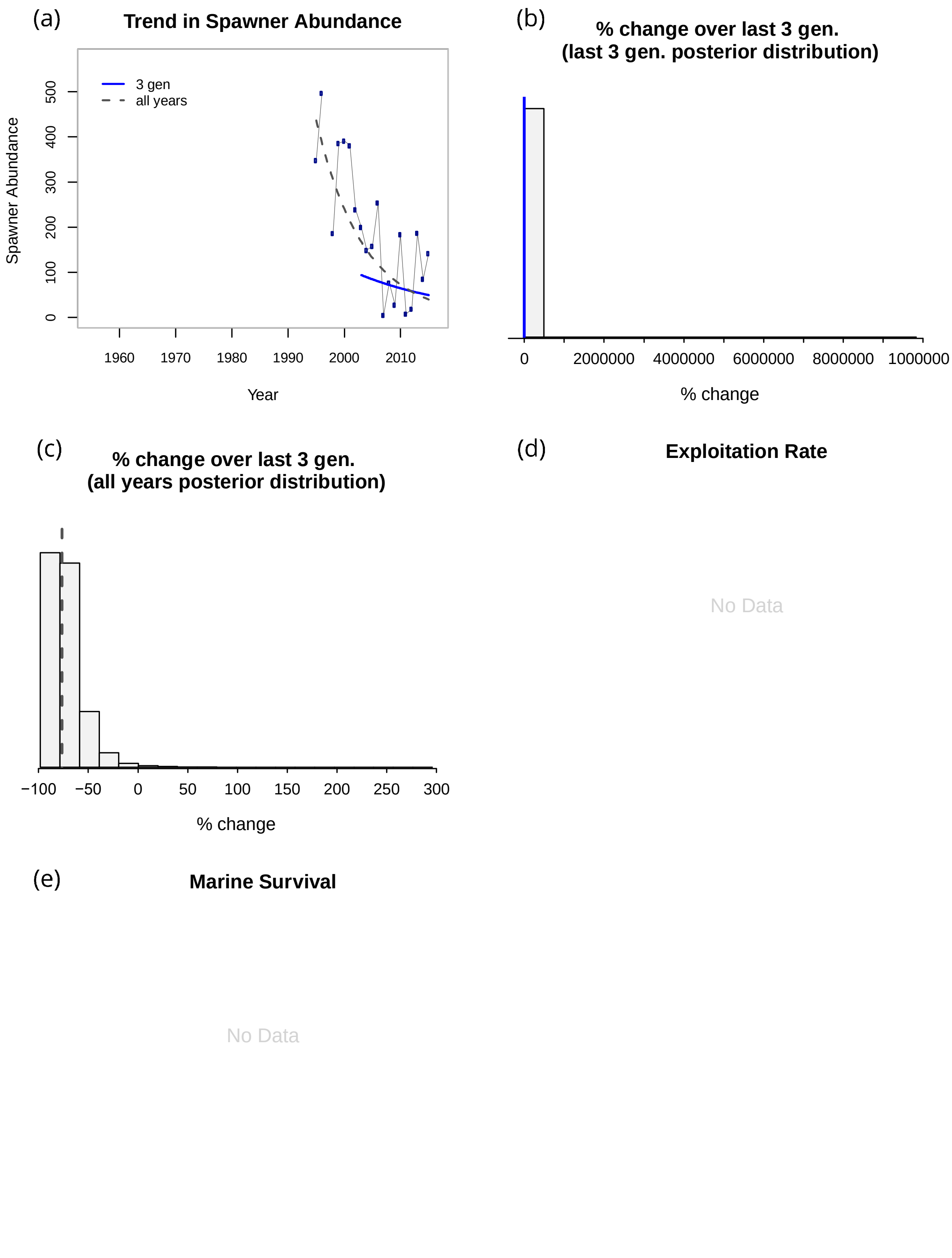


Figure 74. DU14 – Trends in spawner abundance, exploitation rate, and marine (smolt-to-adult) survival.

Threats and Limiting Factors

For general threats and limiting factors applicable to all DUs, please refer to the **Threats and Limiting Factors** section in the introductory material. Chinook Salmon experts who participated in the IUCN Threats Calculator Workshop in February 2017 recommended using the DU15 Threats Calculator as a proxy for this DU (see Table 18) with the main difference being that, as for DU13, juveniles in DU14 stay in freshwater for one year and utilize smaller rivers. These characteristics make the fish more vulnerable than DU15 Chinook Salmon to water management issues and increased development. In the Bessette and Duteau rivers, for example, Chinook Salmon contend with dewatering events, agricultural runoff and rising stream temperatures (Bailey pers. comm. 2018). Considerable agriculture occurs in the DU with cattle ranching and farming adversely affecting the amount and quality of the riparian habitat. Dams occur in the headwaters of this system, diverting water out of the drainage and affecting mean annual discharge and seasonal low discharge. Based on these points and DU15 results, participants concluded that DU14 should be assigned a threat impact of High-Medium (B/C). Because females in fall actively seek a mix of groundwater and surface water when selecting redd sites, the most important threats in this DU are ecosystem modifications due to climate change, cyclical marine climate events (El Niño) and resulting shifts in groundwater availability caused by changes in the volume and timing of snowmelt. Another round of ocean survival impacts as in 2003 and 2007 could terminate groups of Chinook Salmon within the DU. Other less critical impacts include invasive species (esp. spiny rayed fish), avalanches/landslides, droughts, and temperature extremes.

Threat calculator results for this population are based on those from DU15.

Designatable Unit 15: Lower Thompson, Stream, Spring population (not yet assessed)

<u>Figures and tables to appear in Part Two:</u>

Figure 75. Map of DU15 – Lower Thompson Stream Spring.

Figure 76. DU15 – Abundance, enhancement, and hatchery releases.

Table 32. Summary of estimated rate of change (±95% credible interval) in spawner abundance and probability of decline over the last three generations (>30%, >50%, >70%). Rates of change over the last three generations are provided based on analysis of the last three generations of data as well as the entire time series.

Figure 77. DU15 – Trends in spawner abundance, exploitation rate, and marine (smolt-to-adult) survival.

Designatable Unit 16: North Thompson, Stream, Spring population (assessed November 2018)

DU Short Name	NTh+GStr/Stream/Spring
Joint Adaptive Zone (JAZ)	NTh+GStr
Life History	Stream
Run Timing	Spring

The average generation time for this DU is 4.5 years. These fish exhibit stream-type life-history variants and spring run-timing.

To review methods pertaining to data reported within individual DU chapters, refer to the preliminary sections of this report.

<u>Extent of Occurrence and Area of Occupancy</u>

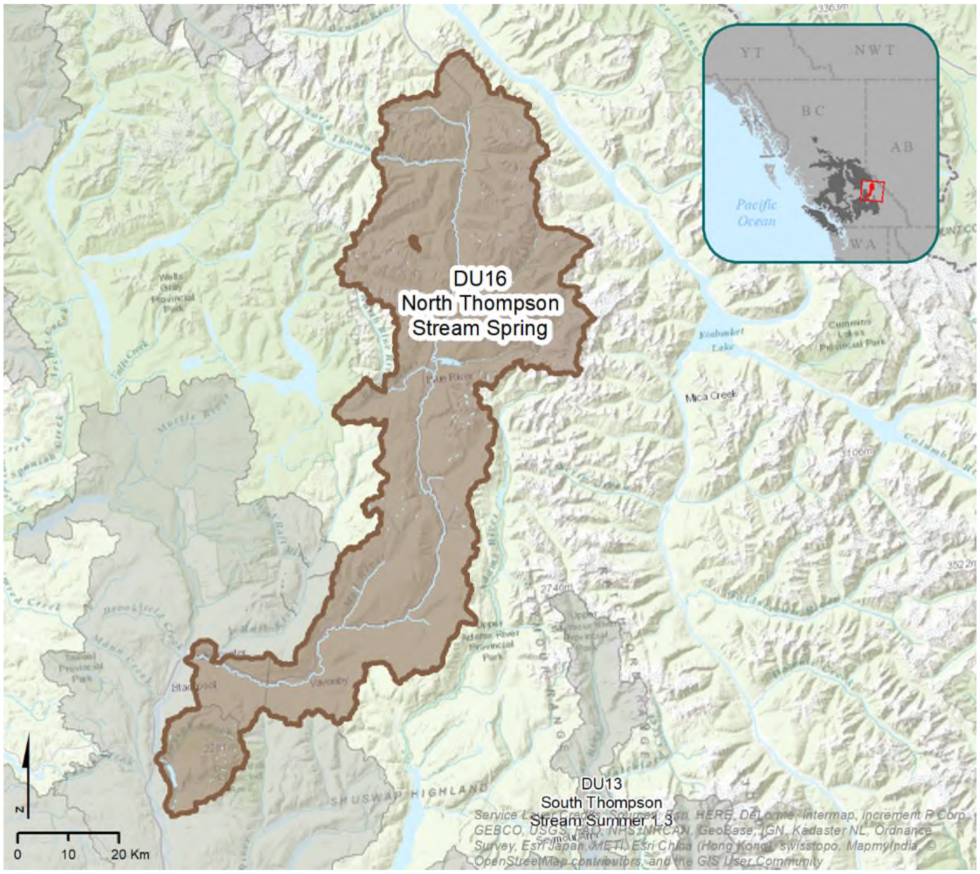


Figure 78. Map of DU16 – North Thompson Stream Spring.

This DU extends from Mt. Sir Allan McNab, Mt. Charlotte, and Albreda Mountain in the north, to Dunn Lake and Dunn Creek Protected Area in the south. The westernmost extent is located where Dunn Lake flows into the North Thompson River and the easternmost extent occurs at Mud Creek near Hallam Peak (N: Lat. 52.67, Long. 119.11; S: Lat. 51.38, Long. 120.10; W: Lat. 51.46, Long. 120.17; E: Lat. 52.18, Long. 118.80). The centroid of the DU area is at Lat. 51.88, Long. 119.51, and its total area is 4105.59 km^2.

As for all DUs considered in this report, the extent of occurrence includes spawning streams as well as the ocean range, and is therefore >20,000 km^2. The IAO is 291 km^2 based on a total known spawning run length of 146km, or 1.45% of the known spawning length across all DUs.

Habitat Trends

Land surrounding this DU's freshwater habitat is altered (17.8%), with agricultural / rural development comprising 0.4% and the urban development 0.2% of the DU area. Road density in DU16 is 1.2km/km^2 with an average of 0.6 stream crossings per km of fish accessible streams (the average across all DUs is 1.33 km/km^2 road density and 0.62 stream crossings per km of fish accessible streams). 15.4% of the DU's riparian habitat is disturbed and 17.2% of its forest cover is disturbed. 3.3% of pine stands in the DU are affected by Mountain Pine Beetle. No mining development occurs within the DU area.

Abundance

No absolute abundance estimates are available for this DU, only relative abundance indices. Almost all spawner data originate from sample sites with moderate sampling effort/survey quality (Figure 79b). Thirteen generational averages can be calculated from relative index spawner abundance time series estimates, with six years having generational averages between 250 and 1,000 spawners and 7 with less than 250 spawners (Figure 79c). Data originate from two sites, each with generational averages of less than 250 spawners.

Of the years where sampling occurred, mature individuals all originated from streams that had low or unknown levels of enhancement (Figure 79a). Only two hatchery releases in the 1980s are reported for this DU (Figure 79e). Finn Creek spawners were the brood source for these fish. Juveniles were released into Finn Creek as 0+ smolts during four separate releases in 1985, all with a CWT. An additional 0+ smolt release occurred from the same brood source in 1989 but was not tagged or clipped (G. Brown, pers. comm.).

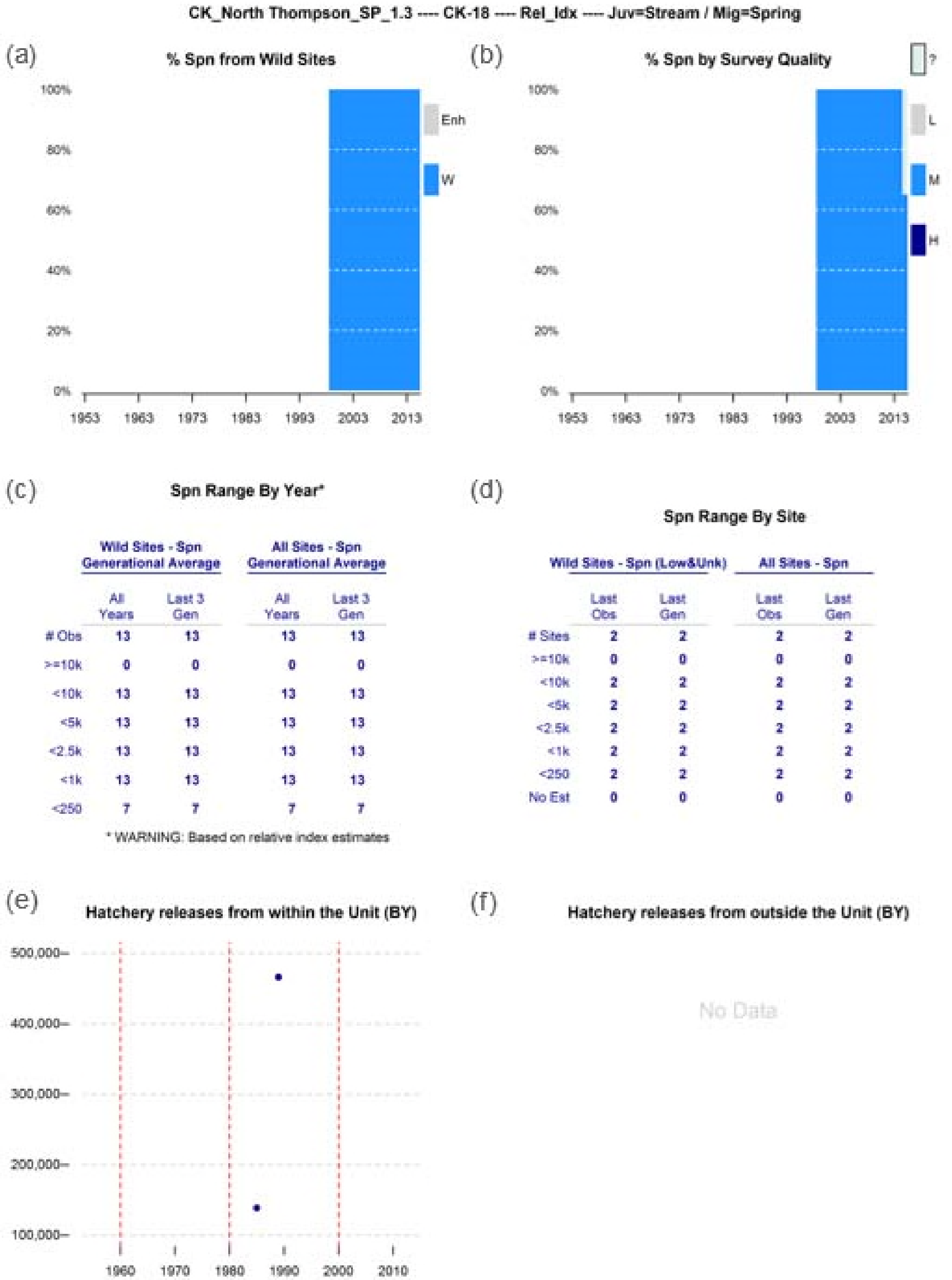


Figure 79. DU16 – Abundance, enhancement, and hatchery releases.

Fluctuations and Trends

Based on the last three generations of data, the number of mature individuals changed by an estimated -91% (Upper 95% CI = -81%, Lower 95% CI = -95%) with the probability of a 30% decline at 100% (Table 33, Figure 80a,b). Using the entire time series of data, the number of mature individuals changed over the last three generations by an estimated -88% (Upper 95% CI = -76%, Lower 95% CI = -94%) also with the probability of a 30% decline at 100% (Table 33, Figure 80a,c).

Harvest, marine (smolt-to-adult) survival and stock productivity data are unavailable for this DU because there is no coded-wire tag indicator stock.

Table 33. Summary of estimated rate of change (±95% credible interval) in spawner abundance and probability of decline over the last three generations (>30%, >50%, >70%). Rates of change over the last three generations are provided based on analysis of the last three generations of data as well as the entire time series.

DU Name	Generation length	Year range	Median % change	95% CI	p|30% decline	p|50% decline	p|70% decline	Number of Observations
North Thompson Stream Spring	4.5	2000-2015	-91	-95, -81	1	1	1	16
		1999-2015	-88	-94, -76	1	1	0.99	17

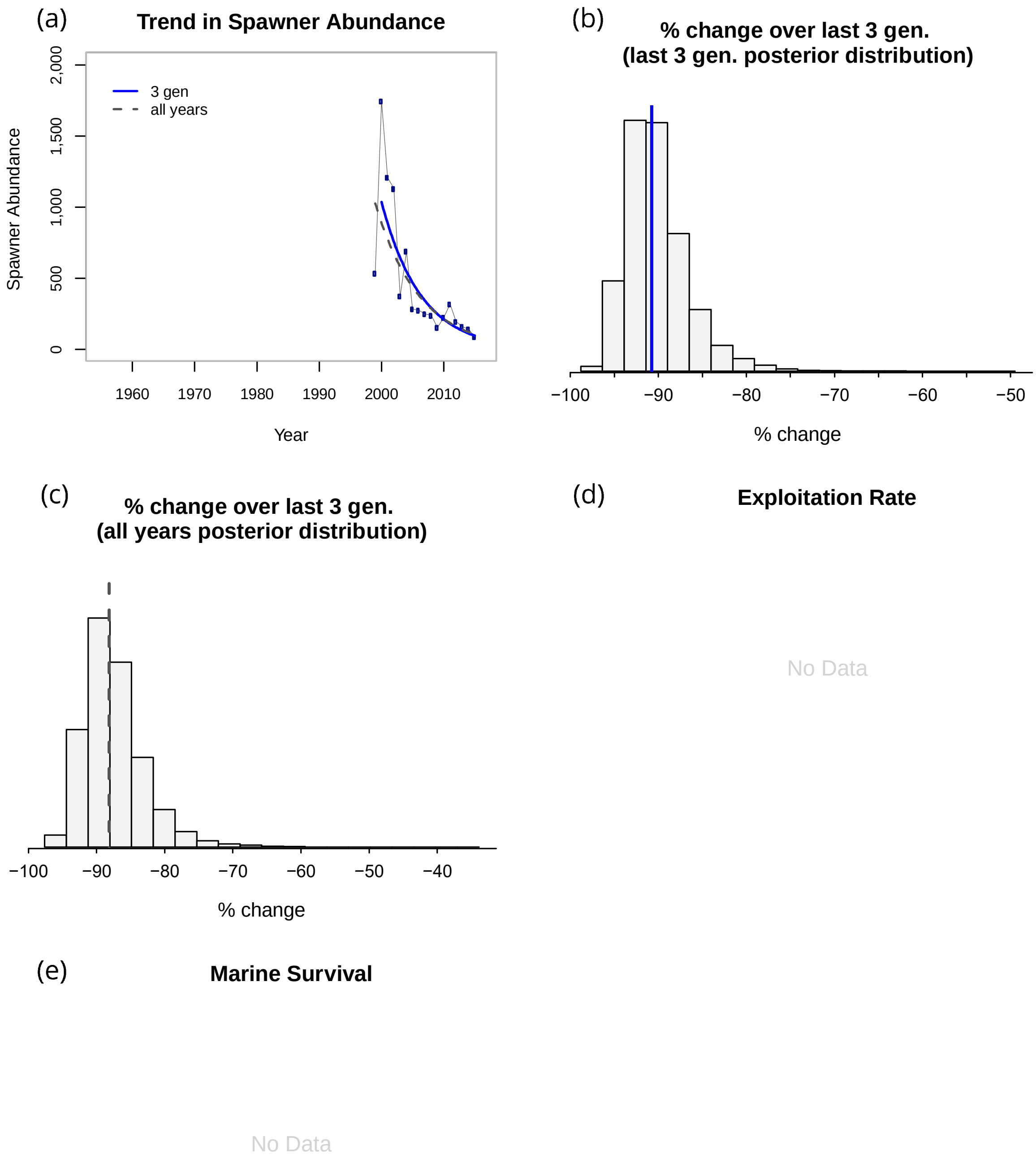


Figure 80. DU16 – Trends in spawner abundance, exploitation rate, and marine (smolt-to-adult) survival.

Threats and Limiting Factors

For general threats and limiting factors applicable to all DUs, please refer to the **Threats and Limiting Factors** section in the introductory material. Chinook Salmon experts who participated in the IUCN Threats Calculator Workshop in February 2017 recommended using the DU11 Threats Calculator as a proxy for this DU (see Table 18). Based on DU11 results DU16 should be assigned a threat impact of High - Medium (B/C). Because females in fall actively seek a mix of groundwater and surface water when selecting redd sites, the most important threats specific to this DU are ecosystem modifications due to climate change, cyclical marine climate events (El Niño) and resulting shifts in groundwater availability caused by changes in the volume and timing of snowmelt. Another round of ocean survival impacts as in 2003 and 2007 could terminate groups of Chinook Salmon within the DU.

Other impacts include invasive species (e.g., perch), avalanches/landslides, droughts, and temperature extremes.

Designatable Unit 17: North Thompson, Stream, Summer population (assessed November 2018)

DU Short Name	NTh+Gstr/Stream/Summer
Joint Adaptive Zone (JAZ)	NTh+GStr
Life History	Stream
Run Timing	Summer

The average generation time for this DU is 4.5 years. These fish exhibit stream-type life-history variants and summer run-timing.

To review methods pertaining to data reported within individual DU chapters, refer to the preliminary sections of this report.

Extent of Occurrence and Area of Occupancy

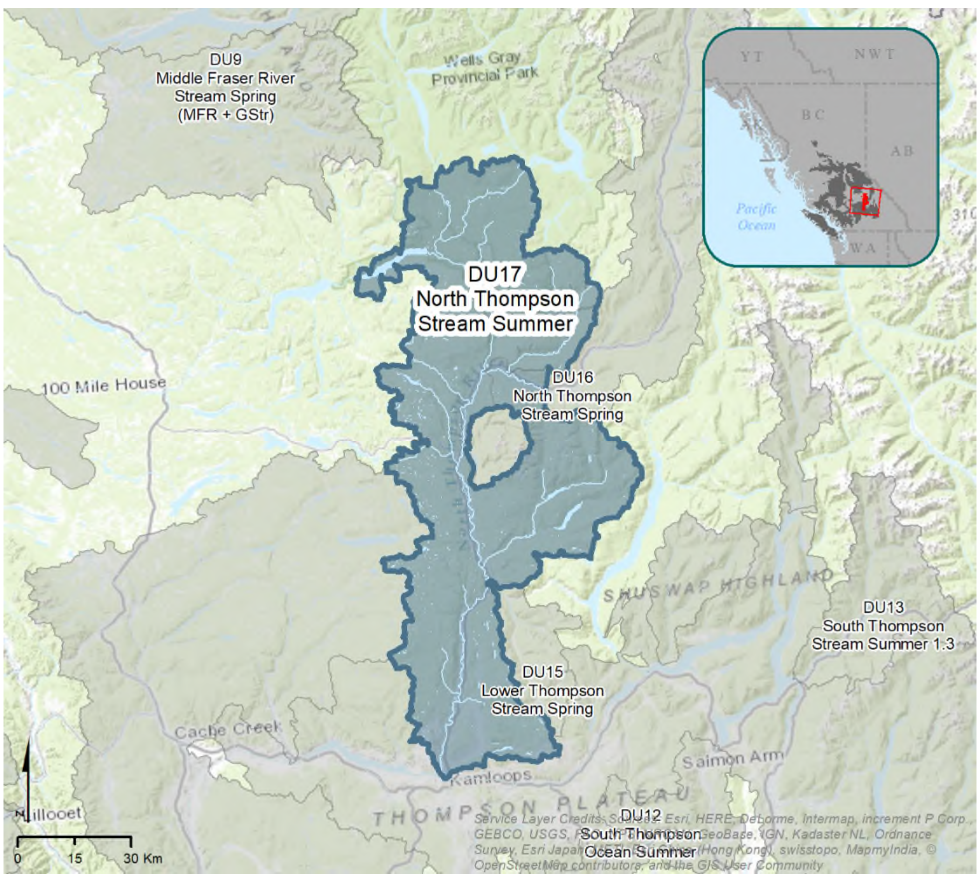


Figure 81. Map of DU17 – North Thompson Stream Summer.

This DU includes the drainage of the Clearwater River and the southern portion of the North Thompson River. The area extends southwest-ward from Murtle River around Kilpill Mountain to the North Thompson River's confluence with the Thompson near at Kamloops, BC. The westernmost extent is located near the west end of Mahood Lake and the easternmost extent is located at Bendelin Creek around Saskum Mountain (N: Lat. 52.14, Long. 119.90; S: Lat. 50.68, Long. 120.34; W: Lat. 51.85, Long. 120.53; E: Lat. 51.37, Long. 119.50). The DU's centroid is at Lat. 51.43, Long. 120.15, and its total area is 6168.43 km^2.

As for all DUs considered in this report, the extent of occurrence includes spawning streams as well as the ocean range, and is therefore >20,000 km^2. The IAO is 714km^2 based on a total known spawning run length of 357 km, or 3.55% of the known spawning length across all DUs.

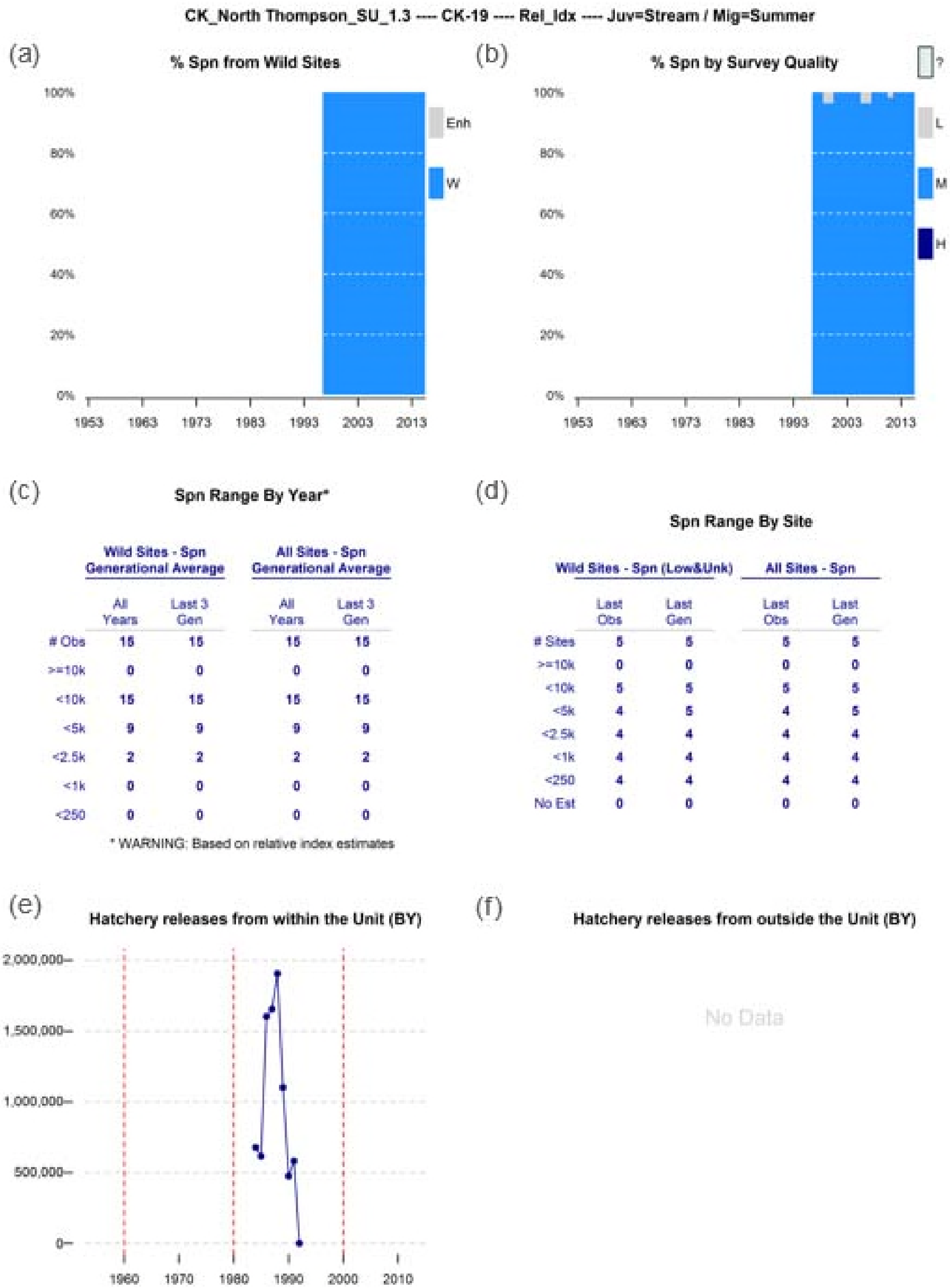
Habitat Trends

Land surrounding this DU's freshwater habitat is altered (15.2%), with urban development comprising 0.7% and agricultural / rural development 3.3% of the DU area. Road density in DU17 is 1.3 km/km^2, with an average of 0.7 stream crossings per km of fish accessible streams (the average across all DUs is 1.33 km/km^2 road density and 0.62 stream crossings per km of fish accessible streams). 12.8% of the DU's riparian habitat and 11.2% of its forest cover is disturbed. 6.8% of pine stands in the DU are affected by Mountain Pine Beetle. No mining development occurs in the DU area.

Abundance

No absolute abundance estimates are available for this DU, only relative abundance indices. Most spawners originate from sample sites with moderate sampling effort/survey quality (Figure 82b). Fifteen generational averages can be calculated from available relative index spawner abundance time series data, six with generational averages of 5,000-10,000 fish, seven with 2,500-5,000 fish and two with less than 2,500 fish (Figure 82c). Spawner abundance estimates originate from five sites (seven spawning sites are documented), one with 2,500-5,000 fish and the remaining four with less than 250 fish (Figure 82d). All five sites are showing declines.

Of the years where sampling occurred, mature individuals all originated from streams that had low to unknown levels of enhancement (Figure 82a). Hatchery releases occurred from 1984 to 1992, reaching a maximum of ~2,000,000 in 1988 before dropping to ~0 in 1992 (Figure 82e). Spawners from Clearwater River, Raft River and North Thompson River have been used as brood stock and 95% of all releases were 0+ smolts. The remaining 5% were split among fed fry and 1+ smolt releases (G. Brown, pers. comm.).



(c) Spn Range By Year*

	Wild Sites - Spn Generational Average		All Sites - Spn Generational Average	
	All Years	Last 3 Gen	All Years	Last 3 Gen
# Obs	15	15	15	15
>=10k	0	0	0	0
<10k	15	15	15	15
<5k	9	9	9	9
<2.5k	2	2	2	2
<1k	0	0	0	0
<250	0	0	0	0

* WARNING: Based on relative index estimates

(d) Spn Range By Site

	Wild Sites - Spn (Low&Unk)		All Sites - Spn	
	Last Obs	Last Gen	Last Obs	Last Gen
# Sites	5	5	5	5
>=10k	0	0	0	0
<10k	5	5	5	5
<5k	4	5	4	5
<2.5k	4	4	4	4
<1k	4	4	4	4
<250	4	4	4	4
No Est	0	0	0	0

Figure 82. DU17 – Abundance, enhancement, and hatchery releases.

Fluctuations and Trends

Based on the last three generations of data, the number of mature individuals changed by an estimated -62% (Upper 95% CI = -10%, Lower 95% CI = -84%), with the probability of a 30% decline at 0.93 (Table 34,Figure 83a,b). Using the entire time series of data, the number of mature individuals changed over the last three generations by an estimated -64% (Upper 95% CI = -33%, Lower 95% CI = -80%), with the probability of a 30% decline at 0.98 (Table 34,Figure 83a,c).

Harvest, marine (smolt-to-adult) survival and stock productivity data are unavailable for this DU because there is no coded-wire tag indicator stock.

Table 34. Summary of estimated rate of change (±95% credible interval) in spawner abundance and probability of decline over the last three generations (>30%, >50%, >70%). Rates of change over the last three generations are provided based on analysis of the last three generations of data as well as the entire time series.

DU Name	Generation length	Year range	Median % change	95% CI	p|30% decline	p|50% decline	p|70% decline	Number of Observations
North Thompson Stream Summer	4.5	2000-2015	-62	-84,-10	0.93	0.75	0.29	16
		1997-2015	-64	-80, -33	0.98	0.86	0.26	19

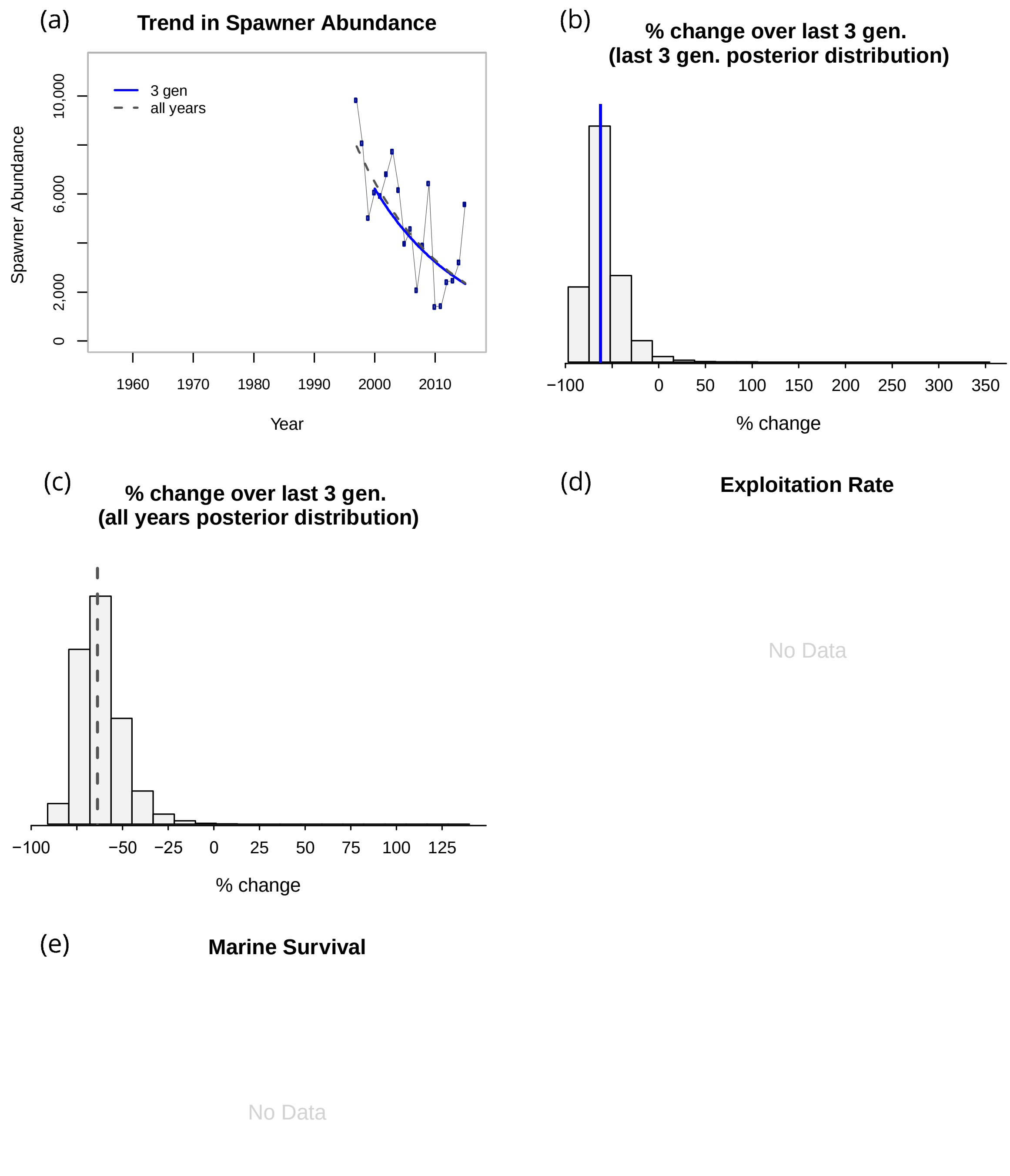


Figure 83. DU17 – Trends in spawner abundance, exploitation rate, and marine (smolt-to-adult) survival.

Threats and Limiting Factors

For general threats and limiting factors applicable to all DUs, please refer to the **Threats and Limiting Factors** section in the introductory material. Further effort is required (e.g., by eliciting expert knowledge) to determine an IUCN Threats Calculator threat grade.

Designatable Unit 18: South Coast - Georgia Strait, Ocean, Fall population (not yet assessed)

Figures and tables to appear in Part Two:

Figure 84. Map of DU18 – South Coast - Georgia Strait Ocean Fall.

Figure 85. DU18 – Abundance, enhancement, and hatchery releases.

Designatable Unit 19: East Vancouver Island, Stream, Spring population (assessed November 2018)

DU Short Name	EVI+GStr/Stream/Spring
Joint Adaptive Zone (JAZ)	EVI+GStr
Life History	Stream
Run Timing	Spring

The average generation time for this DU is 3.5 years. These fish exhibit stream-type life-history variants and spring run-timing.

To review methods pertaining to data reported within individual DU chapters, refer to the preliminary sections of this report.

<u>Extent of Occurrence and Area of Occupancy</u>

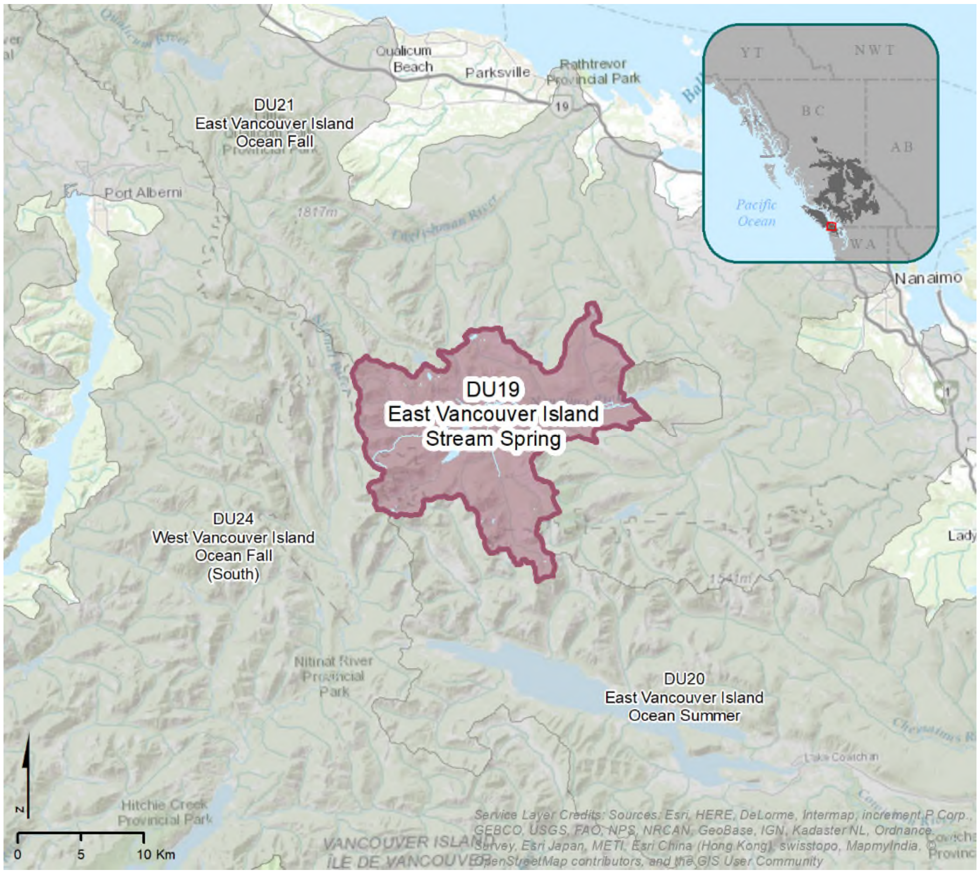


Figure 86. Map of DU19 – East Vancouver Island Stream Spring.

This DU extends eastward from Sadie Creek at Mount Moriarty to Nanaimo River around Mount Hooker. The northernmost extent occurs at Rush Creek around Okay Mountain, and the southernmost extent occurs at Green Creek close to Mount Buttle (N: Lat. 49.16, Long. 124.27; S: Lat. 48.96, Long. 124.33; W: Lat.49.12, Long. 124.52; E: Lat. 49.07, Long. 124.20). The DU's centroid is at Lat. 49.09, Long. 124.23, and its total area is 245.33 km^2.

As for all DUs considered in this report, the extent of occurrence includes spawning streams as well as the ocean range, and is therefore >20,000 km^2. The IAO is 41 km^2 based on a total known spawning run length of 21 km, or 0.21% of the known spawning length across all DUs.

Habitat Trends

Land surrounding this DU's freshwater habitat is altered (23.6%), with urban development comprising 3.6%, agricultural / rural development 2.7% and mining development 0.3% of the DU area. Road density in DU19 is 2.5 km/km^2 with an average of 0.9 stream crossings per km of fish accessible streams (the average across all DUs is 1.33 km/km^2 road density and 0.62 stream crossings per km of fish accessible streams). 20.9% of the DU's riparian habitat and 17.0% of its forest cover disturbed. This DU is not affected by Mountain Pine Beetle.

Abundance

This DU lacks consistent abundance, enhancement or hatchery release data. However, limited abundance data indicate that from 1987 to 2007, the maximum number of fish seen in any year was 25. In 1979, 166 fish were recorded, the highest value. More recently, in 2012 and 2013 only 2 and 5 fish were seen, respectively. While the recent survey information is an underestimate by an unknown amount, the number of mature fish is still likely less than the threshold of 250.

Fluctuations and Trends

Trends in abundance, harvest, marine (smolt-to-adult) survival and stock productivity data are unavailable.

Threats and Limiting Factors

For general threats and limiting factors applicable to all DUs, please refer to the **Threats and Limiting Factors** section in the introductory material. Further effort is required (e.g., by eliciting expert knowledge) to determine an IUCN Threats Calculator threat grade.

Designatable Unit 20: East Vancouver Island, Ocean, Summer population (not yet assessed)

Figures and tables to appear in Part Two:

Figure 87. Map of DU20 – East Vancouver Island Ocean Summer.

Figure 88. DU20 – Abundance, enhancement, and hatchery releases.

Table 35. Summary of estimated rate of change (±95% credible interval) in spawner abundance and probability of decline over the last three generations (>30%, >50%, >70%). Rates of change over the last three generations are provided based on analysis of the last three generations of data as well as the entire time series.

Figure 89. DU20 – Trends in spawner abundance, exploitation rate, and marine (smolt-to-adult) survival.

Designatable Unit 21: East Vancouver Island, Ocean, Fall population (not yet assessed)

<u>Figures and tables to appear in Part Two:</u>

Figure 90. Map of DU21 – East Vancouver Island Ocean Fall.

Figure 91. DU21 (CK-21) – Abundance, enhancement, and hatchery releases.

Figure 92. DU21 (CK-22) – Abundance, enhancement, and hatchery releases.

Figure 93. DU21 (CK-25) – Abundance, enhancement, and hatchery releases.

Figure 94. DU21 (CK-27) – Abundance, enhancement, and hatchery releases.

Table 36. Summary of estimated rate of change (±95% credible interval) in spawner abundance and probability of decline over the last three generations (>30%, >50%, >70%). Rates of change over the last three generations are provided based on analysis of the last three generations of data as well as the entire time series.

Figure 95. DU21 – Trends in spawner abundance, exploitation rate, and marine (smolt-to-adult) survival.

Figure 96. DU21 Stock productivity calculated as the total number of adults (spawners and catch) produced by spawners from a brood year (BY) divided by the number of spawners in the brood year. Productivity data are only available for CK-22. This figure is updated from Brown *et al*. 2013.

Designatable Unit 22: South Coast – Southern Fjords, Ocean, Fall (not yet assessed)

Figures and tables to appear in Part Two:

Figure 97. Map of DU22 – South Coast – Southern Fjords Ocean Fall.

Figure 98. DU22 – Abundance, enhancement, and hatchery releases.

Table 37. Summary of estimated rate of change (±95% credible interval) in spawner abundance and probability of decline over the last three generations (>30%, >50%, >70%). Rates of change over the last three generations are provided based on analysis of the last three generations of data.

Figure 99. DU22 – Trends in spawner abundance, exploitation rate, and marine (smolt-to-adult) survival.

Designatable Unit 23: East Vancouver Island, Ocean, Fall (EVI + SFj) population (not yet assessed)

Figures and tables to appear in Part Two:

Figure 100. Map of DU23 – East Vancouver Island Ocean Fall (EVI + SFj).

Figure 101. DU23 – Abundance, enhancement, and hatchery releases.

Table 38. Summary of estimated rate of change (±95% credible interval) in spawner abundance and probability of decline over the last three generations (>30%, >50%, >70%). Rates of change over the last three generations are provided based on analysis of the last three generations of data as well as the entire time series.

Figure 102. DU23 – Trends in spawner abundance, exploitation rate, and marine (smolt-to-adult) survival.

Designatable Unit 24: West Vancouver Island, Ocean, Fall (South) population (not yet assessed)

<u>Figures and tables to appear in Part Two:</u>

Figure 103. Map of DU24 – West Vancouver Island Ocean Fall (South).

Figure 104. DU24 – Abundance, enhancement, and hatchery releases.

Table 39. Summary of estimated rate of change (±95% credible interval) in spawner abundance and probability of decline over the last three generations (>30%, >50%, >70%). Rates of change over the last three generations are provided based on analysis of the last three generations of data as well as the entire time series.

Figure 105. DU24 – Trends in spawner abundance, exploitation rate, and marine (smolt-to-adult) survival.

Figure 106. DU24 – Disaggregated ocean and terminal exploitation rates 1970-2015.

Designatable Unit 25: West Vancouver Island, Ocean, Fall (Nootka & Kyuquot) population (not yet assessed)

Figures and tables to appear in Part Two:

Figure 107. Map of DU25 – West Vancouver Island Ocean Fall (Nootka & Kyuquot).

Figure 108. DU25 – Abundance, enhancement, and hatchery releases.

Table 40. Summary of estimated rate of change (±95% credible interval) in spawner abundance and probability of decline over the last three generations (>30%, >50%, >70%). Rates of change over the last three generations are provided based on analysis of the last three generations of data as well as the entire time series.

Figure 109. DU25 – Trends in spawner abundance, exploitation rate, and marine (smolt-to-adult) survival.

Designatable Unit 26: West Vancouver Island, Ocean, Fall (WVI + WQCI) population (not yet assessed)

Figures and tables to appear in Part Two:

Figure 110. Map of DU26 – West Vancouver Island Ocean Fall (WVU + WQCI).

Figure 111. DU26 – Abundance, enhancement, and hatchery releases.

Table 41. Summary of estimated rate of change (±95% credible interval) in spawner abundance and probability of decline over the last three generations (>30%, >50%, >70%). Rates of change over the last three generations are provided based on analysis of the last three generations of data as well as the entire time series.

Figure 112. DU26 – Trends in spawner abundance, exploitation rate, and marine (smolt-to-adult) survival.

Designatable Unit 27: Southern Mainland, Ocean, Summer population (assessed November 2018)

DU Short Name	HK+SFj/Ocean/Summer
Joint Adaptive Zone (JAZ)	HK+SFj
Life History	Ocean
Run Timing	Summer

The average generation time for this DU is 4.5 years. These fish exhibit ocean-type life-history variants and summer run-timing.

To review methods pertaining to data reported within individual DU chapters, refer to the preliminary sections of this report.

<u>Extent of Occurrence and Area of Occupancy</u>

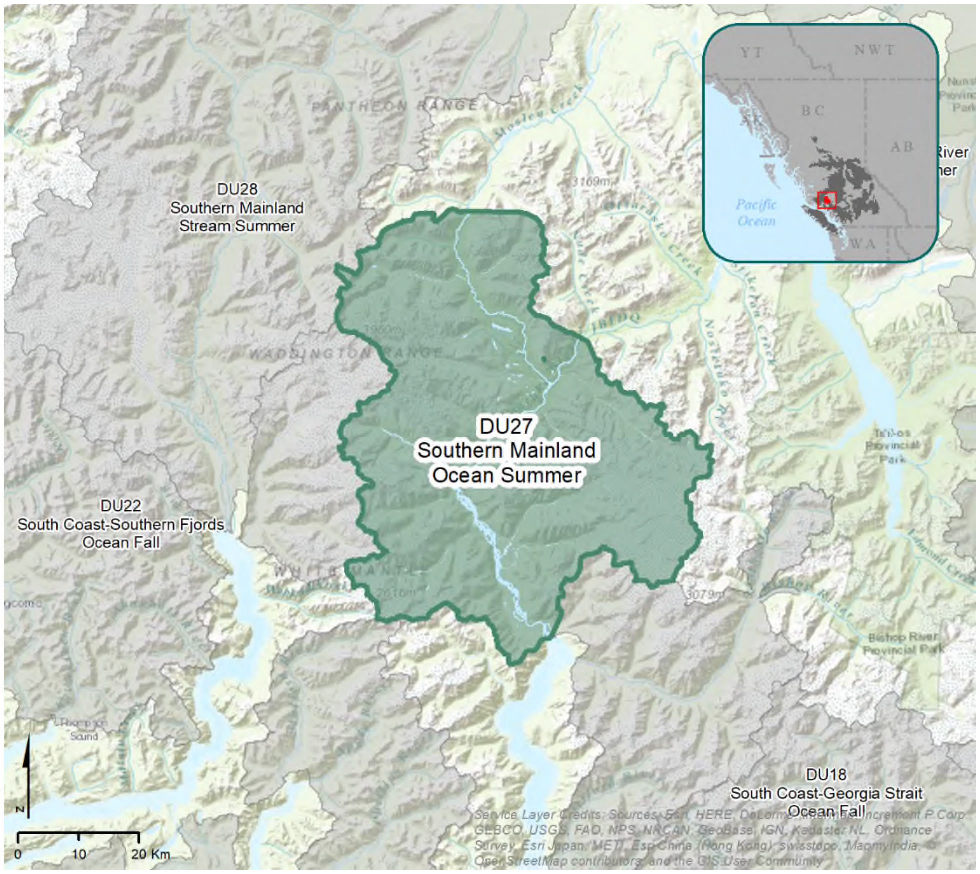


Figure 113. Map of DU27 – Southern Mainland Ocean Summer.

This DU contains the Homathko River drainage and extends south from Mosley Creek around West Branch Peaks to the Homathko River's outlet into Bute Inlet. The westernmost extent is located at Scar Creek close to Dauntless Mountain and the easternmost point occurs at Doran Creek close to Mount Queen Bess (N: Lat. 51.56, Long. 125.06; S: Lat. 50.89, Long. 124.93; W: Lat. 51.20, Long. 125.33; E: Lat. 51.20, Long. 124.46). The DUs centroid is at Lat. 50.93, Long. 124.86 and its total area is 2836.28 km^2.

As for all DUs considered in this report, the extent of occurrence includes spawning streams as well as the ocean range, and is therefore >20,000 km^2. The IAO is 154 km^2 based on a total known spawning run length of 77 km, or 0.77% of the known spawning length across all DUs.

Habitat Trends

Land surrounding this DU's freshwater habitat is altered (5.8%), with agricultural / rural development comprising 1.4% of the DU area. Road density in DU27 is 0.4 km/km^2 with an average of 0.4 stream crossings per km of fish accessible streams (the average across all DUs is 1.33 km/km^2 road density and 0.62 stream crossings per km of fish accessible streams). 5.4% of the DU's riparian habitat and 4.4% of its forest cover is disturbed. 11% of the DU area is affected by Mountain Pine Beetle. No urban development or mining development occurs within the DU.

Abundance

This DU has little information pertaining to abundance. Chinook Salmon within this DU occur in a large glacially turbid system within this remote area. Recent relative indices of spawners was zero and 267 fish in 2010 and 2011, respectively. In the past (1960s and 1970s), surveys indicated thousands of fish, but the quality of the surveys was uncertain and the comparability of the estimates between the periods is unknown.

Fluctuations and Trends

Trends in abundance, harvest, marine (smolt-to-adult) survival and stock productivity data are unavailable.

Threats and Limiting Factors

For general threats and limiting factors applicable to all DUs, please refer to the **Threats and Limiting Factors** section in the introductory material. Chinook Salmon experts who participated in the IUCN Threats Calculator Workshop in February 2017 concluded that this DU should be assigned a threat impact of Low (D). Some risk exists from ecosystem modifications due to independent power producers (minimal) and from avalanches/landslides due to the steep terrain in this system. Threat Calculator results for this population are based on those from DU28. Many issues need to be further investigated. There are a number of 'Unknown' Threat Calculator scores that, if populated, could change the overall threat rating.

While harvest is pervasive and continuing, it is not considered a threat because its severity is not expected to change much over the next three generations of Chinook Salmon. Thus, any harvest impacts on current population levels would be negligible.

Designatable Unit 28: Southern Mainland, Stream, Summer population (assessed November 2018)

DU Short Name	HK+SFj/Stream/Summer
Joint Adaptive Zone (JAZ)	HK+SFj
Life History	Stream
Run Timing	Summer

The average generation time for this DU is 4.5 years. These fish exhibit stream-type life-history variants and summer run-timing.

To review methods pertaining to data reported within individual DU chapters, refer to the preliminary sections of this report.

Extent of Occurrence and Area of Occupancy

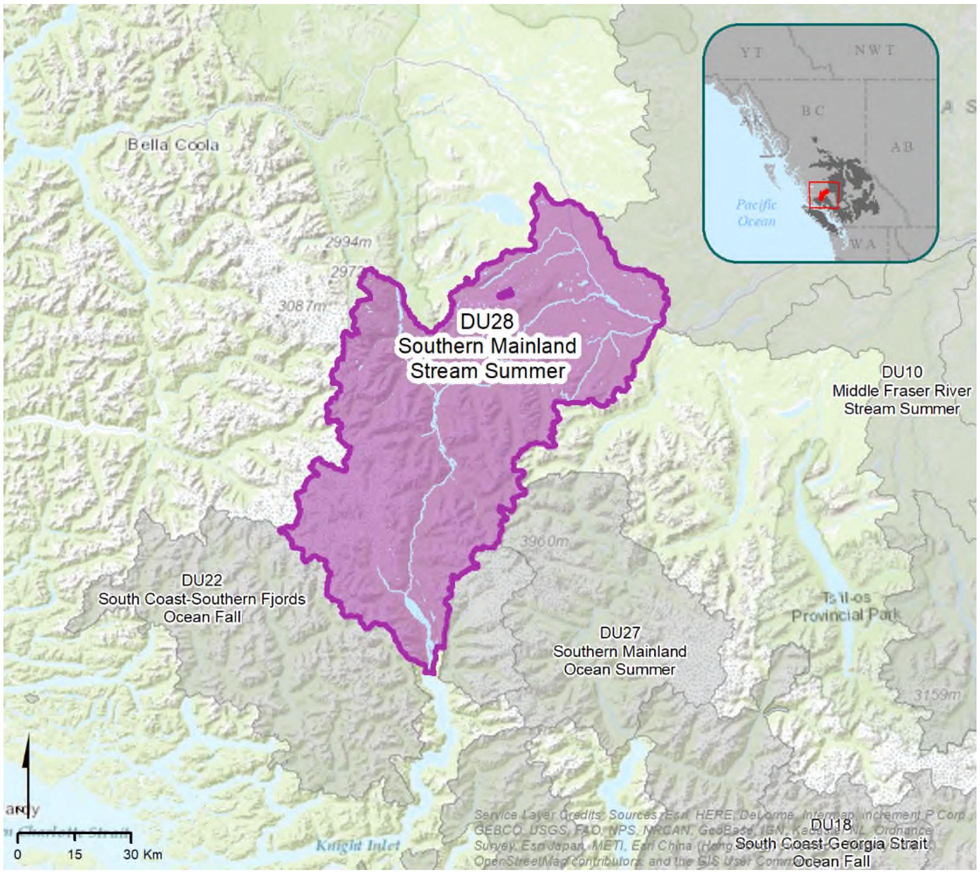


Figure 114. Map of inland DU area for DU28 – Southern Mainland Stream Summer.

This DU extends southwestward from McClinchy Creek close to Charlotte Lake to the Klinaklini River's outlet into Knight Inlet (N: Lat. 52.24, Long. 125.17; S: Lat. 51.10, Long. 125.61). The easternmost extent is located at Klinaklini River close to Martin Mountain (Lat. 51.96, Long. 124.68), and the west end is located at West Klinaklini River close to Silverthrone Mountain (Lat. 51.42, Long. 126.16). The DU's centroid is at Lat. 51.27, Long 125.61 and its total area is 5,848.22 km^2.

As for all DUs considered in this report, the extent of occurrence includes spawning streams as well as the ocean range, and is therefore >20,000 km^2. The IAO is 447 km^2 based on a total known spawning run length of 224 km, or 2.23% of the known spawning length across all DUs.

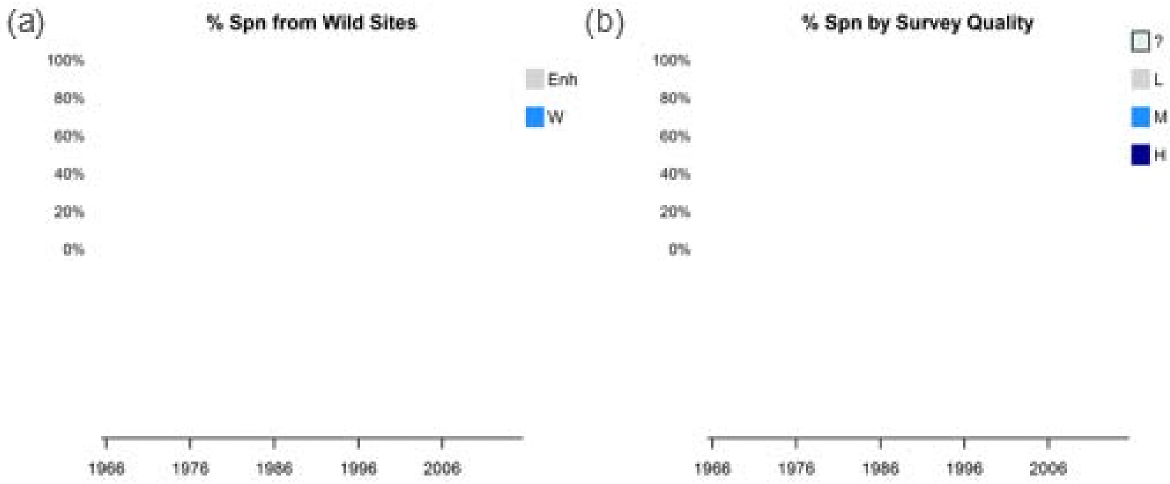
Habitat Trends

Land surrounding this DU's freshwater habitat is altered (5.4%), with urban development comprising 0.02%, and agricultural / rural development 0.6% of the DU area. Road density in DU28 is 0.3 km/km^2 with an average of 0.3 stream crossings per km of fish accessible streams (the average across all DUs is 1.33 km/km^2 road density and 0.62 stream crossings per km of fish accessible streams). 1.4% of the DU's riparian habitat and 4.7% of its forest cover is disturbed. 15.0% of pines stand are affected by Mountain Pine Beetle. No mining development within the DU.

Abundance

While historical estimates of abundance are available for this wildlife species, the methods have changed over time. The most recent estimate in 2003 was 13,365. No data exist over the past three generations. This DU is not considered enhanced, but one hatchery release of ~233,000 smolts did occur in 1985 (Figure 115e).

CK_Klinaklini_SU_1.3 ---- CK-35 ---- Rel_Idx ---- Juv=Stream / Mig=Summer



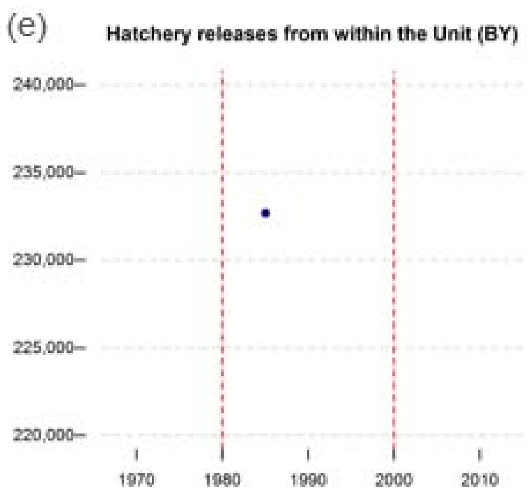
(c) Spn Range By Year*

	Wild Sites - Spn Generational Average		All Sites - Spn Generational Average	
	All Years	Last 3 Gen	All Years	Last 3 Gen
# Obs	0	0	0	0
>=10k	0	0	0	0
<10k	0	0	0	0
<5k	0	0	0	0
<2.5k	0	0	0	0
<1k	0	0	0	0
<250	0	0	0	0

* WARNING: Based on relative index estimates

(d) Spn Range By Site

No Data



(f) Hatchery releases from outside the Unit (BY)

No Data

Figure 115. DU28 – Abundance, enhancement, and hatchery releases.

Fluctuations and Trends

Trends in abundance, harvest, marine (smolt-to-adult) survival and stock productivity data are unavailable.

Threats and Limiting Factors

For general threats and limiting factors applicable to all DUs, please refer to the **Threats and Limiting Factors** section in the introductory material. Chinook Salmon experts who participated in the IUCN Threats Calculator Workshop in February 2017 concluded that this DU should be assigned a threat impact of Low (D). Some risk exists from ecosystem modifications due to independent power producers (minimal) and from avalanches/landslides due to the steep terrain in this system. Many issues need to be further investigated. There are a number of ‘Unknown’ Threat Calculator scores that, if populated, could change the overall threat rating.

While harvest is pervasive and continuing, it is not considered a threat because its severity is not expected to change much over the next three generations of Chinook Salmon. Thus, any harvest impacts on current population levels would be negligible.

Threats Calculator spreadsheets are included with this report (see Appendix 1).

PROTECTION, STATUS AND RANKS

Legal Protection and Status

In the United States of America, two Chinook Salmon Evolutionarily Significant Units (ESUs) are listed as Endangered, and seven ESUs are listed as Threatened (Table 42) (USFW 2014).

Table 42. Endangered Species Act Current Listing Status Summary for Chinook Salmon (ESU = Evolutionarily Significant Unit)

Status	Date Listed	Lead Region	Where Listed
Endangered	08/02/1999	National Marine Fisheries Service (Region 11)	Upper Columbia spring-run ESU
Endangered	04/06/1990	National Marine Fisheries Service (Region 11)	Sacramento River winter-run ESU
Threatened	12/29/1999	National Marine Fisheries Service (Region 11)	CA coastal
Threatened	12/29/1999	National Marine Fisheries Service (Region 11)	Central Valley spring-run ESU
Threatened	08/02/1999	National Marine Fisheries Service (Region 11)	Upper Willamette River ESU
Threatened	08/02/1999	National Marine Fisheries Service (Region 11)	Lower Columbia River ESU
Threatened	08/02/1999	National Marine Fisheries Service (Region 11)	Puget Sound ESU
Threatened	04/22/1992	National Marine Fisheries Service (Region 11)	Snake River spring/summer-run ESU
Threatened	04/22/1992	National Marine Fisheries Service (Region 11)	Snake River fall-run ESU

Non-Legal Status and Ranks

IUCN red list – Chinook Salmon has not yet been assessed.

ACKNOWLEDGEMENTS AND AUTHORITIES CONTACTED

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BIOGRAPHICAL SUMMARY OF REPORT WRITER(S)

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APPENDIX 1. IUCN Threat Calculator Tables for Some Designatable Unit.

THREATS ASSESSMENT WORKSHEET			
Species or Ecosystem Scientific Name	*Oncorhynchus tshawytscha* - Chinook Salmon		
Element ID	DU2 - Lower Fraser, Ocean, Fall population	**Elcode**	
Date (Ctrl + ";" for today's date):	22/02/2017		
Assessor(s):	Originally assessed by Brian O. Ma in November, 2014. Revised in February 2017 at a workshop and in December 2018 following assessment. Workshop attendees: Steve Baillie, Richard Bailey, Gayle Brown, Carolyn Churchland, Roger Gallant, Wilf Luedke, Cheryl Lynch, Jason Mahoney, Arlene Tompkins, Nicole Trouton, Greg Wilson, John Neilson (Marine Fishes SSC Co-chair), David Fraser (Facilitator), Bev McBride (COSEWIC Secretariat)		
References:	(Porter *et al*. 2013; Riddell et al. 2013; Brown *et al*. 2013, Pre-COSEWIC report, in-prep); Expert opinion from group identified above.		

Overall Threat Impact Calculation Help:		**Level 1 Threat Impact Counts**	
Threat Impact		**high range**	**low range**
A	Very High	0	0
B	High	0	0
C	Medium	3	3
D	Low	4	4
Calculated Overall Threat Impact:		High	High
Assigned Overall Threat Impact:		**B = High**	
Impact Adjustment Reasons:			
Overall Threat Comments		We assigned an overall impact rating of B (High). This rating was predominantly based on harvest and marine survival rate, while most other threats could not be assigned a severity rating. The indicator stock suggests that this DU has a 30 to 40% exploitation rate since 1995 (Riddell *et al*. 2013). Riddell *et al*. (2013) note that sustainable harvest is strongly tied to stock productivity. Stock productivity in the early 2000s has been lower than historical numbers, which may make the populations within the DU more susceptible to increases in harvest. However, stock productivity has increased since 2005, which may be linked to the increase in marine survival rate. Most sensitive of any conservation units to loss of wetlands in the estuary. Dec. 11th *(JDN revised overall threat to High, consistent with Dwayne Lepitzki's comments that rollup was incorrect.*	

Threat		**Impact (calculated)**		**Scope (next 10 Yrs)**	**Severity (10 Yrs or 3 Gen.)**	Timing	Comments
1	Residential & commercial development		Negligible	Negligible (<1%)	Negligible (<1%)	Low (Possibly in the long term, >10 yrs/3 gen)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1.1	Housing & urban areas		Negligible	Negligible (<1%)	Negligible (<1%)	Low (Possibly in the long term, >10 yrs/3 gen)	Urban develop is considered to be negligible in the land-based area of this DU (0.61%) (Porter *et al*. 2013). This urbanization is expected to continue at a low rate of timing because the DU area is surrounded by mountain ridge, but the severity of urbanization on Chinook salmon is unknown.
1.2	Commercial & industrial areas		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	Booming ground in one of the holding areas but has always been there; lower Fraser concerns;
1.3	Tourism & recreation areas		Negligible	Negligible (<1%)	Negligible (<1%)	Low (Possibly in the long term, >10 yrs/3 gen)	None. Jet boat central - suck fry through (this will come under recreational activities)
2	Agriculture & aquaculture		Unknown	Pervasive (71-100%)	Unknown	Moderate (Possibly in the short term, < 10 yrs/3 gen)	
2.1	Annual & perennial non-timber crops		Unknown	Pervasive (71-100%)	Unknown	Moderate (Possibly in the short term, < 10 yrs/3 gen)	Agricultural develop is considered at small scope (1.3% of the land-based area is agricultural) (Porter *et al*. 2013) and is expected to continue at a moderate rate. However, the severity of agricultural land on Chinook salmon is unknown. DU2: Cranberry & blueberry farms - farm development is increasing (impression). Need to verify with FLNRO habitat biologists
2.2	Wood & pulp plantations		Negligible	Negligible (<1%)	Unknown	Insignificant/Negligible (Past or no direct effect)	DU2: None
2.3	Livestock farming & ranching		Negligible	Small (1-10%)	Negligible (<1%)	Low (Possibly in the long term, >10 yrs/3 gen)	DU2: None
2.4	Marine & freshwater aquaculture		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	The risks of open net-pen salmon aquaculture on wild Chinook salmon is considered low but data are limited (Riddell et al. 2013). The risk of transmission from farmed Atlantic salmon to wild Chinook salmon is thought to be low because of differences in susceptibility to various diseases. Atlantic salmon farms are located higher north than the mouth of the Fraser River, so the scope is expected to be negligible. Given current practices, farming will continue into the future.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
3	Energy production & mining		Negligible	Negligible (<1%)	Negligible (<1%)	Insignificant/Negligible (Past or no direct effect)	
3.1	Oil & gas drilling		Negligible	Negligible (<1%)	Negligible (<1%)	Insignificant/Negligible (Past or no direct effect)	None
3.2	Mining & quarrying		Negligible	Negligible (<1%)	Negligible (<1%)	Insignificant/Negligible (Past or no direct effect)	The land-based coverage of mining area is 0% (Porter et al. 2013), the scope of mining is assumed to be negligible in this area. The severity of mining is unknown, and the likelihood of mining to continue in this area is unknown. DU2: need to investigate gravel mining in mainstem Fraser and impact on Harrison chinook
3.3	Renewable energy		Negligible	Negligible (<1%)	Negligible (<1%)	Insignificant/Negligible (Past or no direct effect)	None
4	Transportation & service corridors	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	
4.1	Roads & railroads		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	Road density in this area is 1.0 km/km2, and there are 0.3 stream crossings per km of fish accessible streams. Both of these are the lower values among the southern BC Chinook DUs. Road densities are presented in linear dimensions in Porter et al. (2013). If we assumed each road was 100m wide (0.1 km wide), which is almost certainly higher than the average, the percent of land covered by roads is still <1%. Therefore, we have assigned a scope of negligible <1% for this DU. The severity is unknown, but existing road infrastructure is expected to continue.
4.2	Utility & service lines		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	None
4.3	Shipping lanes	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	In-river log towing through spawning grounds throughout the year. R. Bailey. Large log booms and booming ground impact migrating and spawning Chinook.
4.4	Flight paths		Negligible	Negligible (<1%)	Negligible (<1%)	Insignificant/Negligible (Past or no direct effect)	None
5	Biological resource use	C	Medium	Pervasive (71-100%)	Moderate (11-30%)	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
5.1	Hunting & collecting terrestrial animals		Negligible	Negligible (<1%)	Negligible (<1%)	Insignificant/Negligible (Past or no direct effect)	None
5.2	Gathering terrestrial plants		Negligible	Negligible (<1%)	Negligible (<1%)	Insignificant/Negligible (Past or no direct effect)	None
5.3	Logging & wood harvesting	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	There is 8.5% of DU area is under forest disturbance (Porter *et al*. 2013). DU2: tugs, log booms right through spawning grounds. Need to look into severity. Potential for booms to disturb redds
5.4	Fishing & harvesting aquatic resources	C	Medium	Pervasive (71-100%)	Moderate (11-30%)	High (Continuing)	The total exploitation rate has declined. From 1980 to 1990, exploitation rate in this DU area is high around 0.7 to 0.8. From 1990 to 2005, average exploitation rate dropped to 0.4. Current trend from 2005 onward, the exploitation rate is decreasing approximately at range 0.4 to 0.2. Based on the exploitation rate within the last 3 generations, the scope of this threat is considered restricted
6	Human intrusions & disturbance	D	Low	Small (1-10%)	Serious (31-70%)	High (Continuing)	
6.1	Recreational activities	D	Low	Small (1-10%)	Serious (31-70%)	High (Continuing)	Jet boats suck in fish during spring and fall
6.2	War, civil unrest & military exercises		Negligible	Negligible (<1%)	Negligible (<1%)	Insignificant/Negligible (Past or no direct effect)	None
6.3	Work & other activities		Negligible	Negligible (<1%)	Negligible (<1%)	Insignificant/Negligible (Past or no direct effect)	None
7	Natural system modifications	C	Medium	Restricted (11-30%)	Serious (31-70%)	High (Continuing)	
7.1	Fire & fire suppression		Negligible	Negligible (<1%)	Negligible (<1%)	Insignificant/Negligible (Past or no direct effect)	
7.2	Dams & water management/ use		Negligible	Negligible (<1%)	Serious (31-70%)	High (Continuing)	According to Porter *et al*. (2013), 2357.3 m3/ha of water are allocated. No dams impede movement for this DU.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
7.3	Other ecosystem modifications	C	Medium	Restricted (11-30%)	Serious (31-70%)	High (Continuing)	15.2% of the riparian area within the DU has been disturbed (Porter *et al*. 2013), but the severity of this disturbance on the DU2 Chinook salmon population is unknown. We expect timing to be continuing because of continuing urbanization. Bailey: Also, a large portion of the Lower Fraser and estuary have been significantly altered, leading to loss of critical tide marsh habitat.
8	Invasive & other problematic species & genes	D	Low	Small (1-10%)	Moderate (11-30%)	High (Continuing)	
8.1	Invasive non-native/alien species	D	Low	Small (1-10%)	Moderate (11-30%)	High (Continuing)	Invasive spiny ray fish are present in Lower Fraser tributaries.
8.2	Problematic native species		Negligible	Negligible (<1%)	Unknown	High (Continuing)	There are no Mountain Pine Beetles reported in this area (Porter *et al*. 2013)
8.3	Introduced genetic material		Negligible	Negligible (<1%)	Slight (1-10%)	Low (Possibly in the long term, >10 yrs/3 gen)	Of the years where sampling occurred, mature individuals all originated from streams that had no low or unknown levels of enhancement. The number of hatchery releases from within DU2 increased from the mid-1980's to 2004, with the highest release of 3,184,390 in 1992. After 2005, the number of hatchery releases was at a steady rate around 200,000. There is only one instance of hatchery releases from outside the DU.
9	Pollution	D	Low	Small (1-10%)	Moderate (11-30%)	High (Continuing)	
9.1	Household sewage & urban waste water		Unknown	Unknown	Unknown	High (Continuing)	The average number of permitted waste water discharge locations within this DU is 25 (Porter *et al*. 2013). However, the scope, severity, and timing of the impact of this water discharge is unknown.
9.2	Industrial & military effluents		Unknown	Unknown	Unknown	Unknown	
9.3	Agricultural & forestry effluents	D	Low	Small (1-10%)	Moderate (11-30%)	High (Continuing)	
9.4	Garbage & solid waste		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	
9.5	Air-borne pollutants		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
9.6	Excess energy		Unknown	Unknown	Unknown	Unknown	
10	Geological events		Unknown	Unknown	Unknown	Unknown	
10.1	Volcanoes		Unknown	Unknown	Unknown	Unknown	
10.2	Earthquakes/tsunamis		Unknown	Unknown	Unknown	Unknown	
10.3	Avalanches/landslides		Negligible	Negligible (<1%)	Serious (31-70%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	Meager Creek landslide likely had a large impact on the Harrison River turbidity for three years and similar events may occur in the future.
11	Climate change & severe weather	C	Medium	Large (31-70%)	Moderate (11-30%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	
11.1	Habitat shifting & alteration	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	In a recent report evaluating threats to southern BC Chinook salmon by Riddell et al. (2013), the panel concluded that marine habitat conditions during the first year of marine residency were very likely a key driver in recent trends in survival and productivity. Shifting marine habitat will be experienced by all Chinook salmon in this DU (i.e., scope = pervasive). Based on indicator stock information, marine survival is estimated at 2-4%.
11.2	Droughts		Negligible	Negligible (<1%)	Serious (31-70%)	Unknown	
11.3	Temperature extremes		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	In predicted future, 10% change in air temperature over historical baseline in this DU area. Stream temperatures will continue to rise to critical levels (>18C) based on current projections, . (Porter et al. 2013). These increases in stream temperatures are expected to affect the entire population (i.e., the scope is pervasive). This impact is expected to be continuing into the future. However, the severity of this is unknown because of limited data (Riddell et al. 2013).
11.4	Storms & flooding	CD	Medium - Low	Large (31-70%)	Moderate - Slight (1-30%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	
Classification of Threats adopted from IUCN-CMP, Salafsky *et al.* (2008).							

THREATS ASSESSMENT WORKSHEET

Species or Ecosystem Scientific Name	*Oncorhynchus tshawytscha* - Chinook Salmon		
Element ID	DU9 Middle Fraser, Stream, Spring (MFR+GStr) population	**Elcode**	
Date (Ctrl + ";" for today's date):	22/02/2017		
Assessor(s):	Originally assessed by Brian O. Ma in November, 2014. Revised in February 2017 at a workshop and in December 2018 following assessment. Workshop attendees: Steve Baillie, Richard Bailey, Gayle Brown, Carolyn Churchland, Roger Gallant, Wilf Luedke, Cheryl Lynch, Jason Mahoney, Arlene Tompkins, Nicole Trouton, Greg Wilson, John Neilson (Marine Fishes SSC Co-chair), David Fraser (Facilitator), Bev McBride (COSEWIC Secretariat)		
References:	(Porter *et al*. 2013; Riddell *et al*. 2013; Brown *et al*. 2013, Pre-COSEWIC report, in-prep); Expert opinion from group identified above.		

Overall Threat Impact Calculation Help:

Threat Impact		Level 1 Threat Impact Counts high range	low range
A	Very High	0	0
B	High	1	0
C	Medium	1	0
D	Low	3	5
	Calculated Overall Threat Impact:	High	Medium

Assigned Overall Threat Impact:	**BC = High - Medium**
Impact Adjustment Reasons:	
Overall Threat Comments	Generation time = ~4.5 yrs. The major threats to this DU are from ecosystem modifications (dyking/ditching for irrigation in lower Fraser leads to a loss of backwater and off-channel habitat; snowpack/hydrologic regime changes). Other less critical challenges include: impacts from livestock and farm equipment entering stream habitat, harvest rates, dams and water management, invasive species, droughts and temperature extremes. A general harvest rate of 25 to 50% since 1995 is not specific to the populations within this DU. Riddell *et al.* (2013) note that sustainable harvest is strongly tied to stock productivity. There is no reliable estimate of stock productivity for this DU.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1	Residential & commercial development						
1.1	Housing & urban areas						Urban development comprises only 0.4% of the land-based area (Porter et al. 2013) and this trend is expected to continue.
1.2	Commercial & industrial areas						None
1.3	Tourism & recreation areas						None

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
2	Agriculture & aquaculture	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	
2.1	Annual & perennial non-timber crops						Agricultural development is minimal (2.6% of the land-based area) (Porter *et al*. 2013) and this trend is expected to continue.
2.2	Wood & pulp plantations						None
2.3	Livestock farming & ranching	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	Not a major impact but cattle do go into streams to drink and tractors cross streams. These impacts are likely increasing due to change in capacity for enforcement (habitat personnel).
2.4	Marine & freshwater aquaculture		Negligible	Large (31-70%)	Negligible (<1%)	High (Continuing)	Atlantic salmon farms are located higher north than the mouth of the Fraser River, but most wild Chinook pass these at some point so the scope is broad. The risks of open net-pen salmon aquaculture on wild Chinook Salmon are considered low in the literature but data are limited (Riddell *et al*. 2013). Fish aquaculture will likely continue to expand in the future, but in this category the proximal impact is from loss of habitat due to farm footprints. The issues of disease transfer & genetic enhancement will be dealt with in line item 8.3
3	Energy production & mining		Unknown	Small (1-10%)	Unknown	High (Continuing)	
3.1	Oil & gas drilling						None. Difficult to think about proximal impacts. Underwater pipe leaking methane? Some possible concerns about ocean impacts.
3.2	Mining & quarrying		Unknown	Small (1-10%)	Unknown	High (Continuing)	The land-based coverage of mining area is 0.1% (Porter *et al*. 2013), and assuming a random distribution of individuals within the watershed, the scope of mining is assumed to be minor in this area. However, some Placer mining occurs that is not reported. Not enough is known about Placer mining.
3.3	Renewable energy						None; no IPPs
4	Transportation & service corridors		Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
4.1	Roads & railroads		Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)	Road density in this area is 1.2 km/km2, and there are 0.5 stream crossings per km of fish accessible streams. Both of these are the moderate values among the southern BC Chinook DUs. Road densities are presented in linear dimensions in Porter et al. (2013). Road densities are presented in linear dimensions in Porter et al. (2013). Assuming each road is 100 m wide (0.1 km wide), which is an overestimate, the percent of land covered by roads is still <1%. Existing road infrastructure is expected to remain in place but development trend is unknown. Most effect of roads in this DU is from runoff of pollution (threat 9) . Roads themselves not an issue. A lot more roads here than in the upper Fraser (DU11), built to get pine beetle kill timber. Construction practices have improved - not working right in the stream.
4.2	Utility & service lines						None
4.3	Shipping lanes						None
4.4	Flight paths						None
5	Biological resource use	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	
5.1	Hunting & collecting terrestrial animals						None
5.2	Gathering terrestrial plants						None
5.3	Logging & wood harvesting		Negligible	Restricted (11-30%)	Negligible (<1%)	High (Continuing)	13.0% of forest is disturbed in this area (Porter et al. 2013). Pine beetle has resulted in a lot of dead forest. Most of this has now been clearcut (may need to update 2013 estimate). Proximal effect = forestry footprint.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
5.4	Fishing & harvesting aquatic resources	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Total exploitation of southern BC Chinook salmon has been between 25% to 50% in recent years (since 1995) (Riddell *et al*. 2013). Comparable rates of harvest are expected to continue for the foreseeable future. The levels of exploitation are typically compared to expected exploitation for Maximum Sustainable Yield (EMSY), and any level below this is considered sustainable. However, because there is no indicator stock for this DU, EMSY has not been estimated and there is no direct measurement of total exploitation specific to this DU. All fish from DU9 have to migrate through fisheries (e.g. lower Chilcotin). Brood over brood increases in spawners were generally seen until last year (2012-2015 was good but fish going to sea had high mortality). Evidence is less clear that the decline is fully halted. 2005 harvest rate was 60%, tried cutting to 30%. Assuming overall harvest for this DU is similar to the Nicola, 20-40% range is probably actual. These numbers are total in-river and marine harvest rate. Decline has flattened but not completely halted.
6	Human intrusions & disturbance						
6.1	Recreational activities						None
6.2	War, civil unrest & military exercises						None
6.3	Work & other activities						None
7	Natural system modifications	BD	High - Low	Pervasive (71-100%)	Serious - Slight (1-70%)	High (Continuing)	
7.1	Fire & fire suppression		Negligible	Negligible (<1%)	Moderate (11-30%)	High (Continuing)	Fires are a much bigger issue in this area but this is a natural part of the ecosystem. The proximal effect from fires is high short term temperatures in-stream. This is disaggregated here from the temperature section (11.3). Fire retardant may impact but no information. "Bucketing" could result in scooping up fish.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
7.2	Dams & water management/use	D	Low	Small (1-10%)	Serious - Moderate (11-70%)	High (Continuing)	According to Porter *et al*. (2013), 10803.3 m3/ha of water are allocated. The Bridge/Seton hydroelectric facilities negatively affect habitat in this DU. ~7% of Chinook in the DU spawn/rear right under the Bridge dam (expert opinion). The proximal effects of the dam include changes in timing and volume of flow, temperature regime, flushing/scouring and bed maintenance issues. Impact would never be 100% severity because not all spawners returning to the Bridge (alternate spawning habitat available). There is a Water Use Plan for Downton. Lower Fraser River dyking for irrigation is also a concern. All fish from this DU pass through the lower Fraser. Note the rating here is linked to impacts from Bridge dam. Lower Fraser impacts, which are pervasive in scope are dealt with in line item 7.3.
7.3	Other ecosystem modifications	BD	High - Low	Pervasive (71-100%)	Serious - Slight (1-70%)	High (Continuing)	13.5% of the riparian area within the DU has been disturbed (Porter et al. 2013). This stock migrates as juveniles through the lower Fraser (Hope to mouth of Fraser) so they experience significant impact from dyking and future dyking. Ongoing loss of overwintering and rearing habitat in lower Fraser due to conversion of agriculture to residential/commercial. Also new dyking in Chilliwack/Abbotsford so impacts are moving up Fraser. But if ocean survival could return to 5% it would reverse decline. In-stream, females in spring actively seek a mix of groundwater/runoff. Shifting snowmelt and snowpack means groundwater recharge is altered. NOTE: There are 2 separate effects here that impact to varying degrees a) dyking, ditching - loss of backwater/off channel habitat, b) snowpack and hydrologic regime changes.
8	Invasive & other problematic species & genes	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	
8.1	Invasive non-native/alien species	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	More spiny ray issues in mid Fraser than in upper. Tributary to Quesnel (Beaver Valley) has Large Mouth Bass. Potential for 'whirling disease' over next 12 yrs but unknown impact.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
8.2	Problematic native species		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	24.6% of pine stands were killed by Mountain Pine Beetles in this area (Porter et al. 2013) but the impact has already passed. All fish from this DU are affected by ocean predators (e.g. seals, sea lions). The impact is considered relatively stable (i.e. it's as bad as it's going to be and it's not likely to get worse).
8.3	Introduced genetic material						Of the years where sampling occurred, mature individuals all originated from streams that had low or unknown levels of enhancement. However, there were hatchery releases from within the DU from 1980 to 2000. A very small number of releases occurred until 2001. There are no known hatchery releases after 2001.
9	Pollution		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	
9.1	Household sewage & urban waste water		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	The average number of permitted waste water discharge points within this DU is 7.5 (Porter et al. 2013). Wastewater treatment plants exist all down the Fraser River. There is a pervasive domestic sewage impact. The volume will rise as the population is growing but directly linking this to a decline in this DU's Chinook populations over next 12yrs would be tough.
9.2	Industrial & military effluents		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	A lot of impact from industrial development throughout migration route in lower Fraser River
9.3	Agricultural & forestry effluents		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Definitely impacts from agricultural effluent in mid and lower Fraser River that affects all fish from this DU. There is forestry activity upstream that will move more upslope. Forestry causes changes in groundwater recharge. One interesting change with Pine Beetle - water table actually improved temporarily because the dead standing trees held the soil but they weren't consuming water. Siltation; Unknown range of impact.
9.4	Garbage & solid waste		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Fish consume plastic (micro and macro) - 2-7 microplastic particles per day. Research is ongoing (see Peter Ross work) so there may be data soon.
9.5	Air-borne pollutants						None
9.6	Excess energy						None

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
10	Geological events		Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)	
10.1	Volcanoes						None
10.2	Earthquakes/tsunamis						None
10.3	Avalanches/landslides		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	Only minor impacts
11	Climate change & severe weather	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	
11.1	Habitat shifting & alteration		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	In a recent report evaluating threats to southern BC Chinook salmon by Riddell et al. (2013), the panel concluded that marine habitat conditions during the first year of marine residency were very likely a key driver in recent trends in survival and productivity. Shifting marine habitat will be experienced by all Chinook salmon in this DU (i.e., scope = pervasive). However, the severity is unknown because there is no indicator stock available for this DU, so marine survival cannot be estimated. Major changes expected in ocean in terms of up-welling, anoxic areas ("the blob"). Also, another round of ocean survival impacts as in 2003/2007 would terminate this stock. Ranking here is based on potential marine survival impacts (e.g, El Nino). El Nino makes it worse La Nina makes it better.
11.2	Droughts	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	More susceptible to drought than DU11. These are challenging watersheds for Chinook. Frequency of droughts? Check Cariboo/Chilcotin report by Porter & Nelitz. Pervasive because if you have a drought it will affect a large portion of population.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
11.3	Temperature extremes	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	This DU is more susceptible to temp rises than DU11. More plateau landscape means more solar exposure and less water availability; dryer ecozone. Horsefly River is temperature sensitive. All through lower Fraser there is land loss and shade loss. Chinook don't have same problems as Sockeye. The group considered lower Fraser upstream migration but these fish travel through Fraser corridor before the high temperatures happen. This may shift as a result of CC but that will be at 100 yr time scale. Mainly in rearing areas where temperature effects are important.
11.4	Storms & flooding						None
Classification of Threats adopted from IUCN-CMP, Salafsky *et al*. (2008).							

THREATS ASSESSMENT WORKSHEET

Species or Ecosystem Scientific Name	*Oncorhynchus tshawytscha* - Chinook Salmon			
Element ID	DU11 - Upper Fraser, Stream, Spring population		**Elcode**	
Date (Ctrl + ";" for today's date):	06/11/2014			
Assessor(s):	Originally assessed by Brian O. Ma in November, 2014. Revised in February 2017 at a workshop and in December 2018 following assessment. Workshop attendees: Steve Baillie, Richard Bailey, Gayle Brown, Carolyn Churchland, Roger Gallant, Wilf Luedke, Cheryl Lynch, Jason Mahoney, Arlene Tompkins, Nicole Trouton, Greg Wilson, John Neilson (Marine Fishes SSC Co-chair), David Fraser (Facilitator), Bev McBride (COSEWIC Secretariat)			
References:	(Porter et al. 2013; Riddell et al. 2013; Brown et al. 2013, Pre-COSEWIC report, in-prep); Expert opinion from group identified above.			

Overall Threat Impact Calculation Help:		**Level 1 Threat Impact Counts**	
Threat Impact		**high range**	**low range**
A	Very High	0	0
B	High	1	0
C	Medium	1	0
D	Low	2	4
	Calculated Overall Threat Impact:	High	Medium

Assigned Overall Threat Impact:	**BC = High - Medium**
Impact Adjustment Reasons:	
Overall Threat Comments	Generation time = 4.5yrs.The major threats to this DU are ecosystem modifications due to cyclical marine climate events (El Nino) and groundwater/runoff mixing issues caused by shifting volume and timing of snowmelt. The harvest rate has increased while marine survival rate has declined. However, Riddell *et al*. (2013) note that sustainable harvest is strongly tied to stock productivity, and this DU does not have a reliable estimate of stock productivity. Other impacts include invasive species (esp. spiny rays), avalanches/landslides, droughts and temperature extremes.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1	Residential & commercial development						
1.1	Housing & urban areas						Urban development is considered low in the land-based area of this DU (0.09%) (Porter et al. 2013). This level of urbanization is expected to continue. No changes in proximal impacts on Chinook populations are expected.
1.2	Commercial & industrial areas						None
1.3	Tourism & recreation areas						None
2	Agriculture & aquaculture		Negligible	Large (31-70%)	Negligible (<1%)	High (Continuing)	
2.1	Annual & perennial non-timber crops						Agricultural development covers 0.7% of the land-base (Porter et al. 2013) and is expected to continue at this level. No changes in proximal impacts on Chinook populations are expected.
2.2	Wood & pulp plantations						None
2.3	Livestock farming & ranching						None
2.4	Marine & freshwater aquaculture		Negligible	Large (31-70%)	Negligible (<1%)	High (Continuing)	Atlantic salmon farms are located further north than the mouth of the Fraser River, but most wild Chinook pass these at some point so the scope is broad. The risks of open net-pen salmon aquaculture on wild Chinook salmon are considered low in the literature but data are limited (Riddell et al. 2013). Fish aquaculture will likely continue to expand in the future, but in this category the proximal impact is from loss of habitat due to farm footprints. The issues of disease transfer & genetic enhancement will be dealt with in line item 8.3
3	Energy production & mining		Unknown	Small (1-10%)	Unknown	High (Continuing)	
3.1	Oil & gas drilling						None
3.2	Mining & quarrying		Unknown	Small (1-10%)	Unknown	High (Continuing)	Mining covers 0.02% of the land-base (Porter et al. 2013), and assuming a random distribution of individuals within the watershed, the scope of mining is assumed to be minor in this DU. Some unreported Placer mining occurs but not much. They were mining in Summer. Not enough is known about Placer mining impacts. Need to approach Mike Bradford re: Placer impacts.
3.3	Renewable energy						None

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
4	Transportation & service corridors		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	
4.1	Roads & railroads		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	Road density in this area is 0.9 km/km2, and there are 0.5 stream crossings per km of fish accessible streams. These are the moderate values relative to other southern BC Chinook DUs. Road densities are presented in linear dimensions in Porter et al. (2013). Assuming each road is 100 m wide (0.1 km wide), which is an overestimate, the percent of land covered by roads is still <1%. Existing road infrastructure is expected to remain in place but development trend is unknown. Most effect of roads in this DU is from runoff of pollution (threat 9). Roads themselves not an issue.
4.2	Utility & service lines						None
4.3	Shipping lanes						None
4.4	Flight paths						None
5	Biological resource use		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	
5.1	Hunting & collecting terrestrial animals						None
5.2	Gathering terrestrial plants						None
5.3	Logging & wood harvesting		Negligible	Restricted (11-30%)	Negligible (<1%)	High (Continuing)	16.6% of forest was disturbed in this area (Porter et al. 2013), but any proximal effects due to logging footprint are from the past and are not likely to alter the population from its current state. The proximal effect is minor habitat reduction.
5.4	Fishing & harvesting aquatic resources		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	The total exploitation rate has increase from 1986 to 2002 by an estimated 118.7% from ~0.4 to ~0.7, but has remained relatively stable since 1995 at ~0.7 . Workshop participants indicated there has been limited success at maintaining the target rate of 30% harvest. Last BY the rate was still 40%. Fish encounter nets all the way up the Fraser. A lot of the fish are exposed to constant fishing pressure, being slow migrating from mouth of Fraser to end point in upper Fraser. DFO has been unsuccessful at getting First Nations groups in lower Fraser to restrain harvest. First Nations perspective is that this fish is their primary food source. Problem is trying to wind in all the harvest in the river ("700km of very difficult to control everything"); indications are that the marine harvest rate is about 20%.
6	Human intrusions & disturbance						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
6.1	Recreational activities						None
6.2	War, civil unrest & military exercises						None
6.3	Work & other activities						None
7	Natural system modifications	BD	High - Low	Pervasive (71-100%)	Serious - Slight (1-70%)	High (Continuing)	
7.1	Fire & fire suppression						None
7.2	Dams & water management/use		Unknown	Large (31-70%)	Unknown	High (Continuing)	According to Porter et al. (2013), 2695.9 m3/ha of water are allocated. No dams impede movement for this DU. Loss of Sumas Lake, diking and ditching has had a major impact on lower Fraser habitat which these fish pass through. Substantial numbers of Chinook rely on those habitats (e.g. rearing, overwintering) but it is unknown how many are affected.
7.3	Other ecosystem modifications	BD	High - Low	Pervasive (71-100%)	Serious - Slight (1-70%)	High (Continuing)	15.5% of the riparian area within the DU has been disturbed (Porter et al. 2013). This stock migrates as juveniles up along coast to Alaska. Another round of ocean survival impacts as in 2003/2007 would terminate it. It's not just ocean impacts, in-stream is also problematic. But if ocean survival could return to 5% it would reverse decline. In-stream, females in spring actively seek a mix of groundwater/runoff. Shifting snowmelt and snowpack means groundwater recharge is altered. Ranking here is based on a combination of potential marine survival impacts (e.g. El Nino) coupled with groundwater/runoff issues. El Nino makes it worse La Nina makes it better.
8	Invasive & other problematic species & genes	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	
8.1	Invasive non-native/alien species	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	Some impacts from spiny rays (bass, persids etc); small mouth bass & yellow perch in Quesnel. Possible future impacts of "whirling disease" - transmission vector not yet well known but thought to be related to anglers.
8.2	Problematic native species		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	5.5% of pine stands were killed by Mountain Pine Beetles in this area (Porter et al. 2013) but the impact has already passed. All fish from this DU are affected by ocean predators (e.g. seals, sea lions). The impact is considered relatively stable (i.e. it's as bad as it's going to be and it's not likely to get worse).

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
8.3	Introduced genetic material						Of the years where sampling occurred, almost all observed spawners originated from streams that had low or unknown levels of enhancement. There was a relatively high level of hatchery releases from within the DU in the 1980s. However, since 1989, the number of hatchery releases declined until stopping with the 2001/2002 Brood Year.
9	Pollution		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	
9.1	Household sewage & urban waste water		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	The average number of permitted waste water discharge locations within this DU is 1.2 (Porter et al. 2013). Wastewater treatment plants exist all down the Fraser River. There is a pervasive domestic sewage impact. The volume will rise as the population is growing but directly linking this to a decline in this DU's Chinook populations over next 12 yrs would be tough.
9.2	Industrial & military effluents		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	There is a pulp mill in Prince George, mine tailings in places. A lot of impact from industrial development throughout migration route in lower Fraser River
9.3	Agricultural & forestry effluents		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Definitely impacts from agricultural effluent in mid and lower Fraser River that affects all fish from this DU. There is forestry activity upstream that will move more upslope. Forestry causes changes in groundwater recharge. One interesting change with Pine Beetle - water table actually improved temporarily because the dead standing trees held the soil but they weren't consuming water.
9.4	Garbage & solid waste		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Fish consume plastic (micro and macro) - 2-7 microplastic particles per day. Research is ongoing (see Peter Ross work) so there may be data soon.
9.5	Air-borne pollutants						None; airborne pollutants need to become water pollution before impacting fish
9.6	Excess energy						None
10	Geological events	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	
10.1	Volcanoes						None
10.2	Earthquakes/tsunamis						None
10.3	Avalanches/landslides	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	Glacial system with high turbidity. Ongoing impact from avalanches & landslides.
11	Climate change & severe weather	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
11.1	Habitat shifting & alteration		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	In a recent report evaluating threats to southern BC Chinook salmon by Riddell et al. (2013), the panel concluded that marine habitat conditions during the first year of marine residency were very likely a key driver in recent trends in survival and productivity. Shifting marine habitat will be experienced by all Chinook salmon in this DU (i.e., scope = pervasive). Marine survival rate is ~0.02 from 1986 to 2002, and has changed -63.1% in that time. Marine survival rate data are not available past 2002.
11.2	Droughts	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	These fish are relatively resilient but there could be more than 10% severity over next 10-15yrs. Hard to predict. A lot would change if the Fraser becomes a migration barrier, but if that occurred there would be far worse problems than drought.
11.3	Temperature extremes	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Stream temperatures will continue to rise to critical levels (>18C) based on current projections (Porter et al. 2013). These increases in stream temperatures are expected to affect the entire population (i.e., the scope is pervasive). This impact is expected to be continuing into the future. However, the severity of this is unknown because of limited data (Riddell et al. 2013).
11.4	Storms & flooding						
Classification of Threats adopted from IUCN-CMP, Salafsky *et al.* (2008).							

THREATS ASSESSMENT WORKSHEET

Species or Ecosystem Scientific Name	*Oncorhynchus tshawytscha* - Chinook Salmon		
Element ID	DU28 Southern Mainland, Stream, Summer population	**Elcode**	
Date (Ctrl + ";" for today's date):	22/02/2017		
Assessor(s):	Originally assessed by Brian O. Ma in November, 2014. Revised in February 2017 at a workshop and in December 2018 following assessment. Workshop attendees: Steve Baillie, Richard Bailey, Gayle Brown, Carolyn Churchland, Roger Gallant, Wilf Luedke, Cheryl Lynch, Jason Mahoney, Arlene Tompkins, Nicole Trouton, Greg Wilson, John Neilson (Marine Fishes SSC Co-chair), David Fraser (Facilitator), Bev McBride (COSEWIC Secretariat)		
References:	(Porter *et al*. 2013; Riddell *et al*. 2013; Brown *et al*. 2013, Pre-COSEWIC report, in-prep); Expert opinion from group identified above.		

Overall Threat Impact Calculation Help:

Threat Impact		Level 1 Threat Impact Counts: high range	low range
A	Very High	0	0
B	High	0	0
C	Medium	0	0
D	Low	2	2
	Calculated Overall Threat Impact:	Low	Low

Assigned Overall Threat Impact:	**D = Low**
Impact Adjustment Reasons:	
Overall Threat Comments	Generation time: 4.5 years.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1	Residential & commercial development						
1.1	Housing & urban areas						
1.2	Commercial & industrial areas						
1.3	Tourism & recreation areas						
2	Agriculture & aquaculture		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	
2.1	Annual & perennial non-timber crops						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
2.2	Wood & pulp plantations						
2.3	Livestock farming & ranching						
2.4	Marine & freshwater aquaculture		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	
3	Energy production & mining						
3.1	Oil & gas drilling						
3.2	Mining & quarrying						
3.3	Renewable energy						
4	Transportation & service corridors		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	
4.1	Roads & railroads		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	
4.2	Utility & service lines						
4.3	Shipping lanes						
4.4	Flight paths						
5	Biological resource use		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	
5.1	Hunting & collecting terrestrial animals						
5.2	Gathering terrestrial plants						
5.3	Logging & wood harvesting		Unknown	Small (1-10%)	Unknown	High (Continuing)	
5.4	Fishing & harvesting aquatic resources		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	
6	Human intrusions & disturbance						
6.1	Recreational activities						
6.2	War, civil unrest & military exercises						
6.3	Work & other activities						
7	Natural system modifications	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	
7.1	Fire & fire suppression						
7.2	Dams & water management/use		Unknown	Unknown	Unknown	Unknown	Not thought of as a threat, but there is a lack of information.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
7.3	Other ecosystem modifications	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	There are some independent power producers but they in the upper reaches of streams so they may not have an impact. This threat also includes ecosystem changes leading to changes in food supply. This threat is less of an issue for this DU than for DU 25.
8	Invasive & other problematic species & genes		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	
8.1	Invasive non-native/alien species						
8.2	Problematic native species		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	Mackerel could be a factor as a predator, but it would be less so here than the west coast. Sea Lice impact also not negligible. Algal blooms also possible.
8.3	Introduced genetic material						
9	Pollution						
9.1	Household sewage & urban waste water						
9.2	Industrial & military effluents						Independent power producers are likely the only industrial activity. Log dumps likely biggest pollution issue. This should be reflected under logging and wood harvesting, above.
9.3	Agricultural & forestry effluents						
9.4	Garbage & solid waste						
9.5	Air-borne pollutants						
9.6	Excess energy						
10	Geological events	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	
10.1	Volcanoes						
10.2	Earthquakes/tsunamis						
10.3	Avalanches/landslides	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	Landslides do occur. It is a very steep system.
11	Climate change & severe weather		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	
11.1	Habitat shifting & alteration		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	See DU 11, a similar, glacial system.
11.2	Droughts						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
11.3	Temperature extremes						Not being on the Strait of Georgia but on more open ocean, in this DU temperature change would be harder to detect. It would be similar to West Vancouver Island.
11.4	Storms & flooding						Not expected in the next 10 years.
Classification of Threats adopted from IUCN-CMP, Salafsky *et al.* (2008).							

APPENDIX 2. Sample sites for southern BC Chinook Salmon Designatable Units.

Table 43. Sample sites for southern British Columbia Chinook Salmon Designatable Units with start and end dates shown for each estimation method. Note that not all sites are necessarily included in the figures reported in Panels c and d of the 'abundance, enhancement, and hatchery release' data graphics of each DU chapter. Inclusion/exclusion of sites depends on NuSEDS data quality filtering criteria implemented by DFO.

DU Number and Name	Site Name and Estimation Methods	Start Year	End Year
DU1 Southern Mainland - Boundary Bay Ocean Fall	**CAMPBELL RIVER**		
	NA	1980	2013
	RELATIVE ABUNDANCE (TYPE-4)	1979	2012
	NICOMEKL RIVER		
	NA	2012	2012
	RELATIVE: CONSTANT MULTI-YEAR METHODS	1997	1997
	UNKNOWN	1996	1996
	SERPENTINE RIVER		
	NA	2012	2012
	RELATIVE: CONSTANT MULTI-YEAR METHODS	1997	1997
	UNKNOWN	1996	1996
DU2 Lower Fraser Ocean Fall	**HARRISON RIVER**		
	TRUE ABUNDANCE (TYPE-2)	1984	2015
	UNKNOWN	1953	1983
DU3 Lower Fraser Stream Spring	**BIRKENHEAD RIVER**		
	RELATIVE ABUNDANCE (TYPE-3)	2015	2015
	RELATIVE ABUNDANCE (TYPE-4)	1975	2014
	UNKNOWN	1953	1983
	GREEN RIVER		
	UNKNOWN	1985	1985
DU4 Lower Fraser Stream Summer	**PITT RIVER-UPPER**		
	PRESENCE-ABSENCE (TYPE-6)	1984	1985
	RELATIVE ABUNDANCE (TYPE-4)	2002	2014
	UNKNOWN	1953	1993
DU5 Lower Fraser Stream Summer	**BIG SILVER CREEK**		
	RELATIVE ABUNDANCE (TYPE-3)	2015	2015
	RELATIVE ABUNDANCE (TYPE-4)	2005	2012
	RELATIVE ABUNDANCE (TYPE-5)	2013	2014
	UNKNOWN	1953	1986
	CHILLIWACK		

DU Number and Name	Site Name and Estimation Methods	Start Year	End Year
	RELATIVE ABUNDANCE (TYPE-4)	1990	2009
	UNKNOWN	1953	2015
	COGBURN CREEK		
	RELATIVE ABUNDANCE (TYPE-4)	2015	2015
	UNKNOWN	1954	1989
	DOUGLAS CREEK		
	RELATIVE ABUNDANCE (TYPE-4)	2002	2008
	UNKNOWN	1954	1983
	LILLOOET RIVER		
	UNKNOWN	1975	1992
	SLOQUET CREEK		
	PRESENCE-ABSENCE (TYPE-6)	1980	1980
	RELATIVE ABUNDANCE (TYPE-4)	2002	2008
	UNKNOWN	1953	2014
	TIPELLA CREEK		
	RELATIVE ABUNDANCE (TYPE-4)	2002	2008
	UNKNOWN	1958	1958
DU6 Lower Fraser Ocean Summer	**MARIA SLOUGH**		
	RELATIVE ABUNDANCE (TYPE-3)	2002	2009
	RELATIVE ABUNDANCE (TYPE-4)	1996	2015
	UNKNOWN	1953	2004
DU7 Middle Fraser Stream Spring (FRCany+GStr)	**ANDERSON RIVER**		
	UNKNOWN	1960	1964
	NAHATLATCH RIVER		
	RELATIVE ABUNDANCE (TYPE-4)	2012	2015
	RELATIVE ABUNDANCE (TYPE-5)	1996	2011
	UNKNOWN	1953	1994
DU8 Middle Fraser Stream Fall	**PORTAGE CREEK**		
	PRESENCE-ABSENCE (TYPE-6)	1995	1999
	RELATIVE ABUNDANCE (TYPE-4)	2000	2015
	UNKNOWN	1954	1994
DU9 Middle Fraser Stream Spring (MFR+GStr)	**AHBAU CREEK**		
	RELATIVE ABUNDANCE (TYPE-4)	1996	2011
	BAEZAEKO RIVER		
	INFILL	1995	1997

DU Number and Name	Site Name and Estimation Methods	Start Year	End Year
	RELATIVE ABUNDANCE (TYPE-4)	1998	2015
	RELATIVE ABUNDANCE (TYPE-5)	1999	1999
	UNKNOWN	1986	1986
	BAKER CREEK		
	INFILL	2004	2012
	RELATIVE ABUNDANCE (TYPE-3)	1995	2000
	RELATIVE ABUNDANCE (TYPE-4)	1996	2011
	UNKNOWN	1990	2015
	BRIDGE RIVER		
	INFILL	2003	2003
	RELATIVE ABUNDANCE (TYPE-3)	2005	2014
	RELATIVE ABUNDANCE (TYPE-4)	1999	2012
	TRUE ABUNDANCE (TYPE-1)	2015	2015
	UNKNOWN	1975	1998
	CARIBOO RIVER-UPPER		
	RELATIVE ABUNDANCE (TYPE-4)	2001	2015
	UNKNOWN	1986	1994
	CHILAKO RIVER		
	INFILL	2003	2003
	RELATIVE ABUNDANCE (TYPE-4)	2001	2015
	TRUE ABUNDANCE (TYPE-2)	2000	2000
	UNKNOWN	1953	1999
	CHILCOTIN RIVER-LOWER		
	RELATIVE ABUNDANCE (TYPE-4)	1995	2015
	UNKNOWN	1975	1994
	CHILCOTIN RIVER-UPPER		
	RELATIVE ABUNDANCE (TYPE-4)	1995	2015
	UNKNOWN	1953	1994
	CHURN CREEK		
	UNKNOWN	1985	1985
	COTTONWOOD RIVER-LOWER		
	RELATIVE ABUNDANCE (TYPE-4)	1998	2015
	UNKNOWN	1951	1997
	DRIFTWOOD RIVER		
	UNKNOWN	1958	1968
	ENDAKO RIVER		

DU Number and Name	Site Name and Estimation Methods	Start Year	End Year
	INFILL	2003	2004
	RELATIVE ABUNDANCE (TYPE-3)	2010	2012
	RELATIVE ABUNDANCE (TYPE-4)	1995	2015
	RELATIVE ABUNDANCE (TYPE-5)	2007	2007
	TRUE ABUNDANCE (TYPE-1)	2000	2000
	UNKNOWN	1959	1994
	HORSEFLY RIVER		
	RELATIVE ABUNDANCE (TYPE-3)	2011	2011
	RELATIVE ABUNDANCE (TYPE-4)	1998	2015
	UNKNOWN	1953	1997
	LIGHTNING CREEK		
	RELATIVE ABUNDANCE (TYPE-4)	1998	2015
	UNKNOWN	1995	1997
	MCKINLEY CREEK		
	RELATIVE ABUNDANCE (TYPE-3)	2015	2015
	RELATIVE ABUNDANCE (TYPE-4)	1999	2014
	TRUE ABUNDANCE (TYPE-1)	1998	1998
	UNKNOWN	1986	1986
	NARCOSLI CREEK		
	INFILL	2004	2012
	RELATIVE ABUNDANCE (TYPE-4)	1995	2011
	UNKNOWN	1987	2015
	NAVER CREEK		
	INFILL	2004	2012
	RELATIVE ABUNDANCE (TYPE-3)	2000	2000
	RELATIVE ABUNDANCE (TYPE-4)	1995	2009
	RELATIVE ABUNDANCE (TYPE-5)	2006	2006
	UNKNOWN	1985	2015
	NAZKO RIVER		
	INFILL	1995	1998
	RELATIVE ABUNDANCE (TYPE-4)	1997	2015
	UNKNOWN	1986	1986
	SHOVEL CREEK		
	RELATIVE ABUNDANCE (TYPE-4)	2002	2002
	RELATIVE: VARYING MULTI-YEAR METHODS	1999	1999
	STEIN RIVER		

DU Number and Name	Site Name and Estimation Methods	Start Year	End Year
	UNKNOWN	1977	1994
	SWIFT RIVER		
	NA	1995	1997
	RELATIVE ABUNDANCE (TYPE-4)	1998	2015
	UNKNOWN	1996	1996
	TASEKO LAKE		
	RELATIVE ABUNDANCE (TYPE-5)	1996	1998
	WEST ROAD (BLACKWATER) RIVER		
	RELATIVE ABUNDANCE (TYPE-3)	1999	1999
	RELATIVE ABUNDANCE (TYPE-4)	1995	2015
	UNKNOWN	1960	1994
	YALAKOM RIVER		
	UNKNOWN	1953	1994
DU10 Middle Fraser Stream Summer	**CARIBOO RIVER**		
	RELATIVE ABUNDANCE (TYPE-4)	1999	2015
	RELATIVE ABUNDANCE (TYPE-5)	1998	2000
	UNKNOWN	1981	1997
	CHILKO RIVER		
	RELATIVE ABUNDANCE (TYPE-3)	2010	2011
	RELATIVE ABUNDANCE (TYPE-4)	1998	2015
	UNKNOWN	1953	1997
	ELKIN CREEK		
	RELATIVE ABUNDANCE (TYPE-4)	1999	2003
	RELATIVE ABUNDANCE (TYPE-5)	1998	1998
	UNKNOWN	1967	1997
	KAZCHEK CREEK		
	PRESENCE-ABSENCE (TYPE-6)	1983	2011
	RELATIVE ABUNDANCE (TYPE-3)	2004	2009
	RELATIVE ABUNDANCE (TYPE-4)	2001	2015
	UNKNOWN	1953	2014
	KUZKWA RIVER		
	INFILL	1999	2001
	PRESENCE-ABSENCE (TYPE-6)	1984	2000
	RELATIVE ABUNDANCE (TYPE-3)	2004	2011
	RELATIVE ABUNDANCE (TYPE-4)	2002	2015
	UNKNOWN	1953	1998

DU Number and Name	Site Name and Estimation Methods	Start Year	End Year
	MIDDLE RIVER		
	UNKNOWN	1960	1988
	MITCHELL RIVER		
	PRESENCE-ABSENCE (TYPE-6)	2012	2012
	RELATIVE ABUNDANCE (TYPE-3)	2013	2014
	RELATIVE ABUNDANCE (TYPE-4)	2009	2010
	RELATIVE ABUNDANCE (TYPE-5)	2011	2011
	NECHAKO RIVER		
	RELATIVE ABUNDANCE (TYPE-3)	2000	2014
	RELATIVE ABUNDANCE (TYPE-4)	1999	2015
	RELATIVE ABUNDANCE (TYPE-5)	1998	1998
	TRUE ABUNDANCE (TYPE-2)	2004	2004
	UNKNOWN	1953	1997
	ORMOND CREEK		
	UNKNOWN	1959	1978
	PINCHI CREEK		
	PRESENCE-ABSENCE (TYPE-6)	1983	2002
	RELATIVE ABUNDANCE (TYPE-3)	2004	2012
	RELATIVE ABUNDANCE (TYPE-4)	2001	2015
	RELATIVE ABUNDANCE (TYPE-5)	1997	2000
	UNKNOWN	1967	1998
	QUESNEL RIVER		
	RELATIVE ABUNDANCE (TYPE-4)	1998	2015
	UNKNOWN	1953	2001
	SETON AND CAYOOSH CREEKS		
	RELATIVE ABUNDANCE (TYPE-4)	2002	2012
	UNKNOWN	1953	2000
	SETON RIVER		
	PRESENCE-ABSENCE (TYPE-6)	2012	2012
	RELATIVE ABUNDANCE (TYPE-4)	2001	2013
	UNKNOWN	1975	2000
	STELLAKO RIVER		
	PRESENCE-ABSENCE (TYPE-6)	1983	1990
	RELATIVE ABUNDANCE (TYPE-3)	2011	2011
	RELATIVE ABUNDANCE (TYPE-4)	2004	2015
	RELATIVE ABUNDANCE (TYPE-5)	1999	1999

DU Number and Name	Site Name and Estimation Methods	Start Year	End Year
	TRUE ABUNDANCE (TYPE-1)	2010	2010
	TRUE ABUNDANCE (TYPE-2)	2012	2012
	UNKNOWN	1953	2002
	STUART RIVER		
	RELATIVE ABUNDANCE (TYPE-3)	1998	2000
	RELATIVE ABUNDANCE (TYPE-4)	2001	2002
	UNKNOWN	1953	1997
	TACHIE RIVER		
	UNKNOWN	1953	1972
	TASEKO RIVER		
	RELATIVE ABUNDANCE (TYPE-4)	1953	1997
	RELATIVE ABUNDANCE (TYPE-5)	1998	1998
	UNKNOWN	1996	1996
DU11 Upper Fraser Stream Spring	**ANTLER CREEK**		
	INFILL	2002	2002
	RELATIVE ABUNDANCE (TYPE-4)	1995	2015
	UNKNOWN	1994	1994
	BAD RIVER (JAMES CREEK)		
	RELATIVE ABUNDANCE (TYPE-4)	1995	2015
	UNKNOWN	1979	1994
	BOWRON RIVER		
	RELATIVE ABUNDANCE (TYPE-4)	1995	2015
	UNKNOWN	1953	1994
	CAPTAIN CREEK		
	RELATIVE ABUNDANCE (TYPE-4)	1996	2015
	RELATIVE ABUNDANCE (TYPE-5)	1995	1997
	UNKNOWN	1994	1994
	DOME CREEK		
	INFILL	2009	2012
	RELATIVE ABUNDANCE (TYPE-3)	1998	1999
	RELATIVE ABUNDANCE (TYPE-4)	2006	2008
	TRUE ABUNDANCE (TYPE-1)	2003	2007
	TRUE ABUNDANCE (TYPE-2)	2000	2004
	UNKNOWN	1981	2015
	DRISCOLL CREEK		
	RELATIVE ABUNDANCE (TYPE-4)	2002	2002

DU Number and Name	Site Name and Estimation Methods	Start Year	End Year
	EAST TWIN CREEK		
	RELATIVE ABUNDANCE (TYPE-4)	1998	2015
	UNKNOWN	1975	2002
	FONTONIKO CREEK		
	RELATIVE ABUNDANCE (TYPE-4)	1995	2015
	UNKNOWN	1979	1994
	FORGETMENOT CREEK		
	RELATIVE ABUNDANCE (TYPE-4)	2000	2015
	UNKNOWN	1994	2013
	FRASER RIVER-ABOVE TETE JAUNE		
	RELATIVE ABUNDANCE (TYPE-3)	1994	1999
	RELATIVE ABUNDANCE (TYPE-4)	2000	2015
	UNKNOWN	1953	1993
	GOAT RIVER		
	RELATIVE ABUNDANCE (TYPE-4)	1999	2015
	RELATIVE ABUNDANCE (TYPE-5)	1998	1998
	UNKNOWN	1961	1997
	HAGGEN CREEK		
	RELATIVE ABUNDANCE (TYPE-4)	1995	2015
	UNKNOWN	1994	1994
	HERRICK CREEK		
	RELATIVE ABUNDANCE (TYPE-4)	1995	2000
	UNKNOWN	1979	1994
	HOLLIDAY CREEK		
	RELATIVE ABUNDANCE (TYPE-4)	1995	2015
	UNKNOWN	1994	1999
	HOLMES RIVER		
	RELATIVE ABUNDANCE (TYPE-3)	1995	1997
	RELATIVE ABUNDANCE (TYPE-4)	1998	2015
	UNKNOWN	1961	1994
	HORSEY CREEK		
	PRESENCE-ABSENCE (TYPE-6)	1977	1977
	RELATIVE ABUNDANCE (TYPE-3)	1996	1999
	RELATIVE ABUNDANCE (TYPE-4)	1995	2015
	UNKNOWN	1962	1994
	HUMBUG CREEK		

DU Number and Name	Site Name and Estimation Methods	Start Year	End Year
	RELATIVE ABUNDANCE (TYPE-4)	1996	2003
	ICE CREEK		
	INFILL	1995	1997
	RELATIVE ABUNDANCE (TYPE-4)	2000	2014
	RELATIVE ABUNDANCE (TYPE-5)	1998	1999
	UNKNOWN	1994	2015
	INDIANPOINT CREEK		
	RELATIVE ABUNDANCE (TYPE-4)	1995	2015
	RELATIVE ABUNDANCE (TYPE-5)	1987	1987
	UNKNOWN	1986	1994
	KENNETH CREEK		
	RELATIVE ABUNDANCE (TYPE-4)	2001	2003
	RELATIVE ABUNDANCE (TYPE-5)	1999	2000
	UNKNOWN	1986	1998
	MCGREGOR RIVER		
	RELATIVE: CONSTANT MULTI-YEAR METHODS	1998	2000
	RELATIVE: VARYING MULTI-YEAR METHODS	1997	1997
	UNKNOWN	1979	1991
	MCKALE RIVER		
	INFILL	1996	1997
	PRESENCE-ABSENCE (TYPE-6)	1999	1999
	RELATIVE ABUNDANCE (TYPE-4)	1995	2015
	UNKNOWN	1974	1994
	MORKILL RIVER		
	RELATIVE ABUNDANCE (TYPE-4)	1995	2015
	UNKNOWN	1961	1994
	NEVIN CREEK		
	RELATIVE ABUNDANCE (TYPE-4)	1995	2015
	UNKNOWN	1962	1994
	OTTER CREEK		
	UNKNOWN	1996	1997
	PTARMIGAN CREEK		
	NA	1995	1995
	RELATIVE ABUNDANCE (TYPE-4)	1999	2003
	RELATIVE ABUNDANCE (TYPE-5)	1997	2001
	UNKNOWN	1986	1998

DU Number and Name	Site Name and Estimation Methods	Start Year	End Year
	ROBSON RIVER		
	RELATIVE ABUNDANCE (TYPE-5)	2000	2000
	UNKNOWN	1996	1996
	SALMON RIVER		
	PRESENCE-ABSENCE (TYPE-6)	1984	1984
	RELATIVE ABUNDANCE (TYPE-4)	1999	2015
	UNKNOWN	1958	1998
	SEEBACH CREEK		
	RELATIVE ABUNDANCE (TYPE-4)	1995	2015
	UNKNOWN	1979	1994
	SLIM CREEK		
	RELATIVE ABUNDANCE (TYPE-4)	1995	2015
	UNKNOWN	1961	1994
	SMALL CREEK		
	RELATIVE ABUNDANCE (TYPE-4)	1995	2015
	UNKNOWN	1994	1994
	SNOWSHOE CREEK		
	RELATIVE ABUNDANCE (TYPE-4)	2002	2003
	RELATIVE ABUNDANCE (TYPE-5)	2000	2001
	UNKNOWN	1986	1991
	SPAKWANIKO CREEK		
	RELATIVE ABUNDANCE (TYPE-4)	2002	2003
	RELATIVE ABUNDANCE (TYPE-5)	1998	2000
	UNKNOWN	1996	1996
	SUS CREEK		
	UNKNOWN	1996	1996
	SWIFT CREEK		
	RELATIVE ABUNDANCE (TYPE-3)	1995	2014
	RELATIVE ABUNDANCE (TYPE-4)	2002	2015
	UNKNOWN	1970	1994
	TORPY RIVER		
	RELATIVE ABUNDANCE (TYPE-4)	1995	2015
	UNKNOWN	1961	1994
	TWIN CREEKS (COMBINED)		
	INFILL	1999	1999
	MERGED	2013	2015

DU Number and Name	Site Name and Estimation Methods	Start Year	End Year
	RELATIVE ABUNDANCE (TYPE-4)	1995	2012
	UNKNOWN	1971	1994
	WALKER CREEK		
	RELATIVE ABUNDANCE (TYPE-4)	1995	2015
	UNKNOWN	1971	1994
	WANSA CREEK		
	PRESENCE-ABSENCE (TYPE-6)	1995	1995
	RELATIVE ABUNDANCE (TYPE-4)	1996	2015
	UNKNOWN	1994	1994
	WEST TWIN CREEK		
	RELATIVE ABUNDANCE (TYPE-3)	2013	2014
	RELATIVE ABUNDANCE (TYPE-4)	1998	2015
	UNKNOWN	1996	2007
	WILLOW RIVER		
	RELATIVE ABUNDANCE (TYPE-4)	1995	2015
	UNKNOWN	1954	1994
DU12 South Thompson Ocean Summer	**ADAMS RIVER**		
	RELATIVE ABUNDANCE (TYPE-4)	1997	2015
	RELATIVE ABUNDANCE (TYPE-5)	2004	2004
	UNKNOWN	1953	1996
	LITTLE RIVER		
	RELATIVE ABUNDANCE (TYPE-3)	1998	1999
	RELATIVE ABUNDANCE (TYPE-4)	1997	2015
	UNKNOWN	1953	1996
	SHUSWAP RIVER-LOWER		
	RELATIVE ABUNDANCE (TYPE-3)	1983	2005
	TRUE ABUNDANCE (TYPE-2)	2006	2015
	UNKNOWN	1953	1982
	SHUSWAP RIVER-MIDDLE		
	RELATIVE ABUNDANCE (TYPE-3)	1983	2005
	RELATIVE ABUNDANCE (TYPE-4)	2015	2015
	TRUE ABUNDANCE (TYPE-2)	2006	2014
	UNKNOWN	1953	1982
	SOUTH THOMPSON RIVER		
	RELATIVE ABUNDANCE (TYPE-4)	1995	2015
	UNKNOWN	1953	1994

DU Number and Name	Site Name and Estimation Methods	Start Year	End Year
	THOMPSON RIVER		
	INFILL	1997	2003
	PRESENCE-ABSENCE (TYPE-6)	2005	2013
	RELATIVE ABUNDANCE (TYPE-4)	1999	2015
	UNKNOWN	1953	1996
	WAP CREEK		
	RELATIVE ABUNDANCE (TYPE-4)	1995	2015
DU13 South Thompson Stream Summer	**EAGLE RIVER**		
	RELATIVE ABUNDANCE (TYPE-4)	1999	2015
	UNKNOWN	1953	1997
	SALMON RIVER		
	RELATIVE ABUNDANCE (TYPE-4)	1999	2008
	TRUE ABUNDANCE (TYPE-1)	2012	2015
	TRUE ABUNDANCE (TYPE-2)	2002	2011
	UNKNOWN	1953	1998
	SCOTCH CREEK		
	PRESENCE-ABSENCE (TYPE-6)	1981	2012
	RELATIVE ABUNDANCE (TYPE-3)	2011	2014
	RELATIVE ABUNDANCE (TYPE-4)	2008	2015
	TRUE ABUNDANCE (TYPE-1)	2010	2010
	UNKNOWN	1967	1968
	SEYMOUR RIVER		
	PRESENCE-ABSENCE (TYPE-6)	1978	1983
	RELATIVE ABUNDANCE (TYPE-3)	2003	2015
	RELATIVE ABUNDANCE (TYPE-4)	2008	2012
	UNKNOWN	1954	1993
DU14 South Thompson Stream Summer	**BESSETTE CREEK**		
	PRESENCE-ABSENCE (TYPE-6)	1976	1987
	RELATIVE ABUNDANCE (TYPE-3)	2012	2015
	RELATIVE ABUNDANCE (TYPE-4)	1995	2011
	UNKNOWN	1962	1994
	CREIGHTON CREEK		
	PRESENCE-ABSENCE (TYPE-6)	2012	2012
	RELATIVE ABUNDANCE (TYPE-3)	2013	2014
	RELATIVE ABUNDANCE (TYPE-4)	2000	2015
	RELATIVE ABUNDANCE (TYPE-5)	1996	1998

DU Number and Name	Site Name and Estimation Methods	Start Year	End Year
	DUTEAU CREEK		
	RELATIVE ABUNDANCE (TYPE-3)	2012	2015
	RELATIVE ABUNDANCE (TYPE-4)	1999	2011
	RELATIVE ABUNDANCE (TYPE-5)	1995	1998
	HARRIS CREEK		
	PRESENCE-ABSENCE (TYPE-6)	2012	2012
	RELATIVE ABUNDANCE (TYPE-3)	2013	2015
	RELATIVE ABUNDANCE (TYPE-5)	1996	2011
DU15 Lower Thompson Stream Spring	**BONAPARTE RIVER**		
	TRUE ABUNDANCE (TYPE-1)	2012	2015
	TRUE ABUNDANCE (TYPE-2)	1995	2011
	UNKNOWN	1953	1994
	COLDWATER RIVER		
	RELATIVE ABUNDANCE (TYPE-4)	1999	2015
	RELATIVE ABUNDANCE (TYPE-5)	1995	1998
	UNKNOWN	1953	1994
	DEADMAN RIVER		
	TRUE ABUNDANCE (TYPE-1)	2012	2015
	TRUE ABUNDANCE (TYPE-2)	1995	2011
	UNKNOWN	1953	1994
	LOUIS CREEK		
	RELATIVE ABUNDANCE (TYPE-3)	2012	2015
	RELATIVE ABUNDANCE (TYPE-4)	2013	2013
	RELATIVE ABUNDANCE (TYPE-5)	1995	2011
	UNKNOWN	1953	1994
	NICOLA RIVER		
	TRUE ABUNDANCE (TYPE-2)	1995	2015
	UNKNOWN	1953	1994
	NICOLA RIVER-UPPER		
	RELATIVE ABUNDANCE (TYPE-4)	2008	2008
	RELATIVE: VARYING MULTI-YEAR METHODS	1999	1999
	UNKNOWN	1996	1996
	SPIUS CREEK		
	RELATIVE ABUNDANCE (TYPE-4)	1995	2015
	UNKNOWN	1953	1994

DU Number and Name	Site Name and Estimation Methods	Start Year	End Year
DU16 North Thompson Stream Spring	**ALBREDA RIVER**		
	UNKNOWN	2000	2000
	BLUE RIVER		
	INFILL	2005	2005
	PRESENCE-ABSENCE (TYPE-6)	1991	1997
	RELATIVE ABUNDANCE (TYPE-4)	1999	2014
	UNKNOWN	1979	2015
	FINN CREEK		
	RELATIVE ABUNDANCE (TYPE-3)	2001	2015
	RELATIVE ABUNDANCE (TYPE-4)	1999	2007
	RELATIVE ABUNDANCE (TYPE-5)	1997	1997
	UNKNOWN	1953	1998
	LYON CREEK		
	PRESENCE-ABSENCE (TYPE-6)	1981	2011
	RELATIVE ABUNDANCE (TYPE-4)	1999	2013
	UNKNOWN	1969	2002
	MAD RIVER		
	UNKNOWN	1995	1995
DU17 North Thompson Stream Summer	**BARRIERE RIVER**		
	INFILL	1997	1998
	PRESENCE-ABSENCE (TYPE-6)	1982	1999
	RELATIVE ABUNDANCE (TYPE-4)	2001	2015
	RELATIVE ABUNDANCE (TYPE-5)	2000	2007
	UNKNOWN	1953	1996
	CLEARWATER RIVER		
	RELATIVE ABUNDANCE (TYPE-4)	1995	2015
	UNKNOWN	1955	1994
	LEMIEUX CREEK		
	INFILL	1997	2003
	PRESENCE-ABSENCE (TYPE-6)	1975	2011
	RELATIVE ABUNDANCE (TYPE-3)	1999	2015
	RELATIVE ABUNDANCE (TYPE-4)	2001	2013
	UNKNOWN	1953	1996
	MAHOOD RIVER		
	RELATIVE ABUNDANCE (TYPE-3)	1997	2000
	RELATIVE ABUNDANCE (TYPE-4)	1999	2015

DU Number and Name	Site Name and Estimation Methods	Start Year	End Year
	UNKNOWN	1970	1996
	MANN CREEK		
	PRESENCE-ABSENCE (TYPE-6)	1987	2011
	RELATIVE ABUNDANCE (TYPE-3)	2012	2012
	RELATIVE ABUNDANCE (TYPE-4)	2008	2008
	RELATIVE ABUNDANCE (TYPE-5)	1999	2015
	UNKNOWN	1955	2013
	NORTH THOMPSON RIVER		
	RELATIVE ABUNDANCE (TYPE-4)	1997	2003
	UNKNOWN	1953	1998
	RAFT RIVER		
	RELATIVE ABUNDANCE (TYPE-3)	1999	2015
	RELATIVE ABUNDANCE (TYPE-4)	1997	2012
	UNKNOWN	1953	1996
DU18 South Coast - Georgia Strait Ocean Fall	**ASHLU CREEK**		
	UNKNOWN	1983	1993
	BROTHERS CREEK		
	UNKNOWN	1979	1993
	CHEAKAMUS RIVER		
	NA	2005	2013
	UNKNOWN	1983	1993
	DREW CREEK		
	UNKNOWN	1995	1997
	INDIAN RIVER		
	UNKNOWN	1977	1993
	KLITE RIVER		
	RELATIVE ABUNDANCE (TYPE-4)	2010	2010
	RELATIVE ABUNDANCE (TYPE-5)	2011	2011
	LYNN CREEK		
	UNKNOWN	1979	1993
	MAMQUAM RIVER		
	UNKNOWN	1985	1992
	MCKERCHER CREEK		
	UNKNOWN	1995	1995
	PENDER HARBOUR CREEK		
	UNKNOWN	1999	1999

DU Number and Name	Site Name and Estimation Methods	Start Year	End Year
	QUATAM RIVER		
	PRESENCE-ABSENCE (TYPE-6)	2000	2000
	RELATIVE ABUNDANCE (TYPE-3)	2009	2011
	RELATIVE ABUNDANCE (TYPE-4)	2002	2008
	UNKNOWN	1954	1967
	RICHARDS CREEK		
	UNKNOWN	1985	1993
	ROBERTS CREEK		
	UNKNOWN	2000	2000
	SEYMOUR RIVER		
	NA	1994	2011
	UNKNOWN	1976	1993
	SKWAWKA RIVER		
	PRESENCE-ABSENCE (TYPE-6)	1995	1998
	RELATIVE ABUNDANCE (TYPE-5)	2002	2002
	UNKNOWN	1962	1994
	SQUAMISH RIVER		
	NA	2012	2013
	RELATIVE ABUNDANCE (TYPE-5)	1994	2011
	TRUE ABUNDANCE (TYPE-1)	1997	1997
	UNKNOWN	1953	1993
	TENDERFOOT CREEK		
	NA	1999	2007
	UNKNOWN	1991	1991
	THEODOSIA RIVER		
	RELATIVE ABUNDANCE (TYPE-3)	2003	2013
	RELATIVE ABUNDANCE (TYPE-4)	2002	2015
	UNKNOWN	1967	1969
	TOBA RIVER		
	PRESENCE-ABSENCE (TYPE-6)	2010	2011
	RELATIVE ABUNDANCE (TYPE-5)	1984	1991
	UNKNOWN	1953	1988
	TZOONIE RIVER		
	UNKNOWN	1953	1994
	VANCOUVER RIVER		
	UNKNOWN	1995	1995

DU Number and Name	Site Name and Estimation Methods	Start Year	End Year
	WILSON CREEK		
	UNKNOWN	1998	1998
DU19 East Vancouver Island Stream Spring	**NANAIMO RIVER-UPPER**		
	RELATIVE ABUNDANCE (TYPE-4)	2012	2012
	RELATIVE ABUNDANCE (TYPE-5)	1979	2008
DU20 East Vancouver Island Ocean Summer	**NANAIMO RIVER**		
	RELATIVE ABUNDANCE (TYPE-4)	1995	2003
	RELATIVE ABUNDANCE (TYPE-5)	2004	2015
	UNKNOWN	1953	1994
	PUNTLEDGE RIVER		
	RELATIVE ABUNDANCE (TYPE-3)	2006	2015
	TRUE ABUNDANCE (TYPE-2)	1990	2012
	UNKNOWN	1967	1989
DU21 East Vancouver Island Ocean Fall	**BLACK CREEK**		
	TRUE ABUNDANCE (TYPE-1)	2002	2002
	CHEMAINUS RIVER		
	PRESENCE-ABSENCE (TYPE-6)	2014	2014
	RELATIVE ABUNDANCE (TYPE-3)	2002	2002
	RELATIVE ABUNDANCE (TYPE-4)	2004	2005
	RELATIVE ABUNDANCE (TYPE-5)	1995	2015
	UNKNOWN	1954	2013
	COWICHAN RIVER		
	RELATIVE ABUNDANCE (TYPE-3)	1965	2013
	RELATIVE ABUNDANCE (TYPE-4)	1978	1979
	TRUE ABUNDANCE (TYPE-1)	1988	2008
	TRUE ABUNDANCE (TYPE-2)	1997	2015
	UNKNOWN	1953	1987
	ENGLISHMAN RIVER		
	INFILL	2004	2004
	PRESENCE-ABSENCE (TYPE-6)	1994	2009
	RELATIVE ABUNDANCE (TYPE-3)	2005	2015
	RELATIVE ABUNDANCE (TYPE-4)	2000	2014
	RELATIVE ABUNDANCE (TYPE-5)	1997	2007
	TRUE ABUNDANCE (TYPE-1)	1999	1999
	TRUE ABUNDANCE (TYPE-2)	2001	2003
	UNKNOWN	1960	1993

DU Number and Name	Site Name and Estimation Methods	Start Year	End Year
	GOLDSTREAM RIVER		
	PRESENCE-ABSENCE (TYPE-6)	1995	1998
	RELATIVE ABUNDANCE (TYPE-4)	2000	2011
	RELATIVE ABUNDANCE (TYPE-5)	1999	2006
	TRUE ABUNDANCE (TYPE-1)	2007	2008
	TRUE ABUNDANCE (TYPE-2)	2004	2015
	UNKNOWN	1962	1994
	HASLAM CREEK		
	PRESENCE-ABSENCE (TYPE-6)	2000	2000
	RELATIVE ABUNDANCE (TYPE-3)	2002	2003
	UNKNOWN	1995	1998
	KOKSILAH RIVER		
	PRESENCE-ABSENCE (TYPE-6)	2003	2003
	RELATIVE ABUNDANCE (TYPE-5)	2002	2002
	UNKNOWN	1953	1992
	LITTLE QUALICUM RIVER		
	RELATIVE ABUNDANCE (TYPE-3)	1990	2013
	RELATIVE ABUNDANCE (TYPE-4)	2012	2014
	RELATIVE ABUNDANCE (TYPE-5)	2015	2015
	TRUE ABUNDANCE (TYPE-2)	2005	2005
	UNKNOWN	1953	1989
	MESACHIE CREEK		
	TRUE ABUNDANCE (TYPE-1)	1986	1986
	MORRISON CREEK		
	RELATIVE ABUNDANCE (TYPE-5)	2010	2010
	RELATIVE: VARYING MULTI-YEAR METHODS	1998	2001
	NANAIMO RIVER		
	RELATIVE ABUNDANCE (TYPE-3)	2004	2013
	RELATIVE ABUNDANCE (TYPE-4)	2012	2015
	RELATIVE ABUNDANCE (TYPE-5)	1980	1980
	TRUE ABUNDANCE (TYPE-1)	1995	2003
	TRUE ABUNDANCE (TYPE-2)	2005	2005
	UNKNOWN	1979	1994
	NANOOSE CREEK		
	PRESENCE-ABSENCE (TYPE-6)	2002	2002
	NAPOLEON CREEK		

DU Number and Name	Site Name and Estimation Methods	Start Year	End Year
	TRUE ABUNDANCE (TYPE-1)	1999	2000
	UNKNOWN	1996	2001
	OYSTER RIVER		
	PRESENCE-ABSENCE (TYPE-6)	2011	2011
	RELATIVE ABUNDANCE (TYPE-3)	2002	2002
	RELATIVE ABUNDANCE (TYPE-5)	1997	2003
	UNKNOWN	1953	2013
	PATRICIA CREEK		
	PRESENCE-ABSENCE (TYPE-6)	1990	1992
	RELATIVE: VARYING MULTI-YEAR METHODS	2001	2001
	PUNTLEDGE RIVER		
	NA	1953	1953
	RELATIVE ABUNDANCE (TYPE-3)	2006	2015
	RELATIVE ABUNDANCE (TYPE-4)	2007	2007
	RELATIVE ABUNDANCE (TYPE-5)	1975	1989
	TRUE ABUNDANCE (TYPE-2)	1990	2005
	UNKNOWN	1967	1974
	QUALICUM RIVER		
	RELATIVE ABUNDANCE (TYPE-3)	2006	2015
	TRUE ABUNDANCE (TYPE-1)	1990	2004
	TRUE ABUNDANCE (TYPE-2)	2005	2008
	UNKNOWN	1953	1989
	ROBERTSON RIVER		
	PRESENCE-ABSENCE (TYPE-6)	1990	2000
	ROSEWALL CREEK		
	PRESENCE-ABSENCE (TYPE-6)	2000	2000
	SHAW CREEK		
	PRESENCE-ABSENCE (TYPE-6)	1991	2003
	RELATIVE ABUNDANCE (TYPE-3)	2001	2001
	TRUE ABUNDANCE (TYPE-2)	2004	2004
	UNKNOWN	1999	1999
	SIMMS CREEK		
	TRUE ABUNDANCE (TYPE-1)	2007	2010
	TRUE ABUNDANCE (TYPE-2)	1999	2005
	UNKNOWN	1997	2004
	TOD CREEK		

DU Number and Name	Site Name and Estimation Methods	Start Year	End Year
	PRESENCE-ABSENCE (TYPE-6)	1987	1989
	TSABLE RIVER		
	TRUE ABUNDANCE (TYPE-1)	1999	1999
	UNKNOWN	1991	1993
	WILLOW CREEK		
	TRUE ABUNDANCE (TYPE-1)	1999	2000
	UNKNOWN	1995	2014
	WOODS CREEK		
	UNKNOWN	2001	2001
DU22 South Coast - Southern Fjords Ocean Fall	**AHNUHATI RIVER**		
	PRESENCE-ABSENCE (TYPE-6)	2004	2004
	RELATIVE ABUNDANCE (TYPE-3)	2014	2014
	RELATIVE ABUNDANCE (TYPE-4)	2002	2002
	RELATIVE ABUNDANCE (TYPE-5)	1995	2005
	UNKNOWN	1953	1994
	AHTA RIVER		
	RELATIVE ABUNDANCE (TYPE-3)	2014	2014
	UNKNOWN	1996	1999
	APPLE RIVER		
	PRESENCE-ABSENCE (TYPE-6)	1995	2000
	RELATIVE ABUNDANCE (TYPE-4)	2002	2011
	RELATIVE ABUNDANCE (TYPE-5)	2001	2009
	UNKNOWN	1967	1992
	FANNY BAY CREEK		
	UNKNOWN	1996	1996
	FRANKLIN RIVER		
	UNKNOWN	1953	1966
	FULMORE RIVER		
	UNKNOWN	1953	1984
	GLENDALE CREEK		
	RELATIVE: CONSTANT MULTI-YEAR METHODS	1998	1998
	HEYDON CREEK		
	TRUE ABUNDANCE (TYPE-1)	1999	2011
	TRUE ABUNDANCE (TYPE-2)	2001	2001
	UNKNOWN	1966	2002
	KAKWEIKEN RIVER		

DU Number and Name	Site Name and Estimation Methods	Start Year	End Year
	PRESENCE-ABSENCE (TYPE-6)	1995	2000
	RELATIVE ABUNDANCE (TYPE-3)	2011	2011
	RELATIVE ABUNDANCE (TYPE-4)	2002	2002
	RELATIVE ABUNDANCE (TYPE-5)	1996	1997
	UNKNOWN	1953	1994
	KINGCOME RIVER		
	RELATIVE ABUNDANCE (TYPE-3)	2004	2010
	RELATIVE ABUNDANCE (TYPE-4)	2002	2011
	RELATIVE ABUNDANCE (TYPE-5)	1995	2014
	UNKNOWN	1953	1994
	KWALATE CREEK		
	UNKNOWN	1953	1996
	ORFORD RIVER		
	RELATIVE ABUNDANCE (TYPE-3)	2011	2011
	RELATIVE ABUNDANCE (TYPE-5)	1996	2005
	UNKNOWN	1953	1994
	PHILLIPS RIVER		
	PRESENCE-ABSENCE (TYPE-6)	1995	2000
	RELATIVE ABUNDANCE (TYPE-3)	2006	2014
	RELATIVE ABUNDANCE (TYPE-4)	2002	2009
	RELATIVE ABUNDANCE (TYPE-5)	2001	2015
	TRUE ABUNDANCE (TYPE-2)	2012	2012
	UNKNOWN	1953	1994
	SIM RIVER		
	UNKNOWN	1953	1992
	SOUTHGATE RIVER		
	RELATIVE ABUNDANCE (TYPE-5)	1995	1995
	UNKNOWN	1953	1990
	STAFFORD RIVER		
	PRESENCE-ABSENCE (TYPE-6)	1995	1998
	RELATIVE ABUNDANCE (TYPE-4)	2002	2002
	UNKNOWN	1954	1993
	TEAQUAHAN RIVER		
	PRESENCE-ABSENCE (TYPE-6)	1987	1987
	UNKNOWN	1953	1980
	WAKEMAN RIVER		

DU Number and Name	Site Name and Estimation Methods	Start Year	End Year
	RELATIVE ABUNDANCE (TYPE-3)	2008	2010
	RELATIVE ABUNDANCE (TYPE-4)	2002	2011
	RELATIVE ABUNDANCE (TYPE-5)	1995	2014
	UNKNOWN	1953	1994
	WARNER BAY CREEK		
	UNKNOWN	1994	2003
DU23 East Vancouver Island Ocean Fall (EVI + SFj)	**ADAM RIVER**		
	PRESENCE-ABSENCE (TYPE-6)	1984	2000
	RELATIVE ABUNDANCE (TYPE-3)	2005	2014
	RELATIVE ABUNDANCE (TYPE-4)	2002	2015
	RELATIVE ABUNDANCE (TYPE-5)	2001	2001
	UNKNOWN	1953	1994
	AMOR DE COSMOS CREEK		
	RELATIVE ABUNDANCE (TYPE-3)	2009	2013
	RELATIVE ABUNDANCE (TYPE-4)	2015	2015
	RELATIVE ABUNDANCE (TYPE-5)	2005	2008
	UNKNOWN	1954	2004
	CAMPBELL RIVER		
	TRUE ABUNDANCE (TYPE-2)	1984	2015
	UNKNOWN	1953	1983
	CLUXEWE RIVER		
	NA	1988	1988
	UNKNOWN	1991	1998
	EVE RIVER		
	RELATIVE ABUNDANCE (TYPE-5)	2001	2001
	GRANITE BAY CREEK		
	UNKNOWN	2000	2000
	KOKISH RIVER		
	PRESENCE-ABSENCE (TYPE-6)	1997	2004
	RELATIVE ABUNDANCE (TYPE-3)	2012	2012
	RELATIVE ABUNDANCE (TYPE-4)	2015	2015
	RELATIVE ABUNDANCE (TYPE-5)	1996	1996
	UNKNOWN	1963	2014
	MENZIES CREEK		
	RELATIVE ABUNDANCE (TYPE-3)	2009	2013
	RELATIVE ABUNDANCE (TYPE-4)	2011	2014

DU Number and Name	Site Name and Estimation Methods	Start Year	End Year
	RELATIVE ABUNDANCE (TYPE-5)	2008	2015
	UNKNOWN	1995	2004
	MOHUN CREEK		
	PRESENCE-ABSENCE (TYPE-6)	1999	1999
	UNKNOWN	2000	2004
	NAHWITTI RIVER		
	UNKNOWN	1998	1998
	NIMPKISH RIVER		
	NA	2015	2015
	RELATIVE ABUNDANCE (TYPE-3)	2004	2014
	RELATIVE ABUNDANCE (TYPE-4)	2007	2008
	RELATIVE ABUNDANCE (TYPE-5)	1995	2006
	UNKNOWN	1953	1994
	QUATSE RIVER		
	RELATIVE ABUNDANCE (TYPE-5)	2001	2006
	UNKNOWN	1983	2004
	QUINSAM RIVER		
	TRUE ABUNDANCE (TYPE-2)	1984	2015
	UNKNOWN	1957	1983
	SALMON RIVER		
	PRESENCE-ABSENCE (TYPE-6)	1995	2000
	RELATIVE ABUNDANCE (TYPE-3)	2004	2014
	RELATIVE ABUNDANCE (TYPE-4)	2002	2015
	RELATIVE ABUNDANCE (TYPE-5)	2001	2003
	UNKNOWN	1953	1994
	TSITIKA RIVER		
	PRESENCE-ABSENCE (TYPE-6)	1998	1998
	UNKNOWN	1984	1992
	WHITE RIVER		
	UNKNOWN	1982	1996
	WOSS RIVER		
	NA	1985	2012
DU24 West Vancouver Island Ocean Fall (South)	**AYUM CREEK**		
	UNKNOWN	1997	1997
	BEDWELL SYSTEM		
	NA	1990	2015

DU Number and Name	Site Name and Estimation Methods	Start Year	End Year
	PRESENCE-ABSENCE (TYPE-6)	1985	1985
	RELATIVE ABUNDANCE (TYPE-3)	2012	2012
	TRUE ABUNDANCE (TYPE-2)	1995	2011
	UNKNOWN	1986	1994
	CARNATION CREEK		
	TRUE ABUNDANCE (TYPE-1)	1999	1999
	UNKNOWN	1982	1997
	CAYCUSE RIVER		
	RELATIVE ABUNDANCE (TYPE-5)	1998	2006
	UNKNOWN	1986	1992
	CHARTERS RIVER		
	RELATIVE ABUNDANCE (TYPE-5)	1999	1999
	UNKNOWN	1996	1997
	CHINA CREEK		
	RELATIVE ABUNDANCE (TYPE-5)	1989	1991
	UNKNOWN	1961	1990
	CLAYOQUOT RIVER-LOWER		
	UNKNOWN	1995	1996
	CLAYOQUOT RIVER-UPPER		
	RELATIVE ABUNDANCE (TYPE-4)	2002	2002
	RELATIVE: CONSTANT MULTI-YEAR METHODS	1999	1999
	TRUE ABUNDANCE (TYPE-1)	2001	2001
	UNKNOWN	1996	1996
	CLEMENS CREEK		
	NA	1985	2001
	PRESENCE-ABSENCE (TYPE-6)	2010	2010
	RELATIVE ABUNDANCE (TYPE-4)	2002	2015
	RELATIVE ABUNDANCE (TYPE-5)	2003	2014
	UNKNOWN	2004	2004
	COEUR D'ALENE CREEK		
	PRESENCE-ABSENCE (TYPE-6)	1995	1995
	RELATIVE ABUNDANCE (TYPE-5)	2001	2001
	UNKNOWN	1958	1994
	COLEMAN CREEK		
	UNKNOWN	1968	1984
	CONSINKA CREEK		

DU Number and Name	Site Name and Estimation Methods	Start Year	End Year
	UNKNOWN	1995	1995
	COUS CREEK		
	PRESENCE-ABSENCE (TYPE-6)	2012	2012
	UNKNOWN	1964	1990
	CYPRE RIVER		
	RELATIVE ABUNDANCE (TYPE-3)	2015	2015
	RELATIVE ABUNDANCE (TYPE-4)	2001	2014
	RELATIVE ABUNDANCE (TYPE-5)	1995	1999
	UNKNOWN	1953	1994
	DE MAMIEL CREEK		
	RELATIVE ABUNDANCE (TYPE-4)	1999	1999
	RELATIVE ABUNDANCE (TYPE-5)	2000	2012
	UNKNOWN	1995	1998
	DOOBAH CREEK		
	TRUE ABUNDANCE (TYPE-1)	1998	1998
	DRINKWATER CREEK		
	TRUE ABUNDANCE (TYPE-1)	2001	2001
	EFFINGHAM RIVER		
	PRESENCE-ABSENCE (TYPE-6)	1996	1999
	UNKNOWN	1953	1992
	FRANKLIN RIVER		
	PRESENCE-ABSENCE (TYPE-6)	1995	2015
	RELATIVE ABUNDANCE (TYPE-5)	2000	2001
	UNKNOWN	1956	1990
	GORDON RIVER		
	PRESENCE-ABSENCE (TYPE-6)	2015	2015
	RELATIVE ABUNDANCE (TYPE-3)	1996	2001
	RELATIVE ABUNDANCE (TYPE-5)	1995	2013
	UNKNOWN	1953	1994
	HARRIS CREEK		
	PRESENCE-ABSENCE (TYPE-6)	2011	2011
	RELATIVE ABUNDANCE (TYPE-4)	2003	2005
	RELATIVE ABUNDANCE (TYPE-5)	2008	2013
	UNKNOWN	1995	2001
	HENDERSON LAKE CREEK		
	RELATIVE ABUNDANCE (TYPE-4)	2002	2012

DU Number and Name	Site Name and Estimation Methods	Start Year	End Year
	RELATIVE ABUNDANCE (TYPE-5)	1995	2010
	UNKNOWN	1953	1994
	ICE RIVER		
	PRESENCE-ABSENCE (TYPE-6)	1995	2014
	RELATIVE ABUNDANCE (TYPE-5)	2001	2010
	UNKNOWN	1953	1991
	ITATSOO CREEK		
	UNKNOWN	1997	1997
	KENNEDY RIVER-LOWER		
	PRESENCE-ABSENCE (TYPE-6)	1995	2013
	RELATIVE ABUNDANCE (TYPE-4)	2000	2007
	RELATIVE ABUNDANCE (TYPE-5)	2008	2011
	UNKNOWN	1953	2012
	KENNEDY RIVER-UPPER		
	PRESENCE-ABSENCE (TYPE-6)	2010	2010
	RELATIVE ABUNDANCE (TYPE-3)	2002	2002
	RELATIVE ABUNDANCE (TYPE-4)	2003	2007
	RELATIVE ABUNDANCE (TYPE-5)	2008	2013
	TRUE ABUNDANCE (TYPE-1)	2000	2001
	UNKNOWN	1996	1999
	KLANAWA RIVER		
	PRESENCE-ABSENCE (TYPE-6)	2003	2012
	RELATIVE ABUNDANCE (TYPE-5)	2004	2006
	UNKNOWN	1975	1978
	LENS CREEK		
	RELATIVE ABUNDANCE (TYPE-5)	2012	2015
	UNKNOWN	1998	1998
	MACKTUSH CREEK		
	PRESENCE-ABSENCE (TYPE-6)	2012	2015
	UNKNOWN	1964	1995
	MAGGIE RIVER		
	UNKNOWN	1996	1996
	MEGIN RIVER		
	NA	1990	1990
	PRESENCE-ABSENCE (TYPE-6)	1985	2001
	RELATIVE ABUNDANCE (TYPE-3)	2002	2015

DU Number and Name	Site Name and Estimation Methods	Start Year	End Year
	RELATIVE ABUNDANCE (TYPE-4)	1995	2014
	RELATIVE ABUNDANCE (TYPE-5)	2000	2010
	UNKNOWN	1953	1994
	MERCANTILE CREEK		
	PRESENCE-ABSENCE (TYPE-6)	1995	2001
	RELATIVE ABUNDANCE (TYPE-5)	2002	2013
	UNKNOWN	1985	1994
	MOYEHA RIVER		
	INFILL	2012	2012
	NA	1986	1992
	PRESENCE-ABSENCE (TYPE-6)	1985	1988
	RELATIVE ABUNDANCE (TYPE-3)	1995	2005
	RELATIVE ABUNDANCE (TYPE-4)	2006	2011
	RELATIVE ABUNDANCE (TYPE-5)	2013	2014
	UNKNOWN	1953	2015
	NAHMINT RIVER		
	PRESENCE-ABSENCE (TYPE-6)	1987	1987
	RELATIVE ABUNDANCE (TYPE-3)	1995	2015
	RELATIVE ABUNDANCE (TYPE-4)	2003	2013
	TRUE ABUNDANCE (TYPE-2)	2014	2014
	UNKNOWN	1953	1994
	NITINAT RIVER		
	RELATIVE ABUNDANCE (TYPE-3)	2013	2013
	RELATIVE ABUNDANCE (TYPE-4)	2003	2015
	RELATIVE ABUNDANCE (TYPE-5)	2011	2012
	TRUE ABUNDANCE (TYPE-1)	1995	2001
	TRUE ABUNDANCE (TYPE-2)	2002	2008
	UNKNOWN	1953	2006
	PIPESTEM CREEK		
	UNKNOWN	1995	1995
	RENFREW CREEK		
	PRESENCE-ABSENCE (TYPE-6)	2007	2011
	RELATIVE ABUNDANCE (TYPE-4)	2005	2005
	RELATIVE ABUNDANCE (TYPE-5)	2013	2015
	UNKNOWN	1997	1998
	ROCKY CREEK		

DU Number and Name	Site Name and Estimation Methods	Start Year	End Year
	PRESENCE-ABSENCE (TYPE-6)	1999	1999
	UNKNOWN	1996	1997
	SAN JUAN RIVER		
	INFILL	2004	2004
	RELATIVE ABUNDANCE (TYPE-4)	1995	2015
	RELATIVE ABUNDANCE (TYPE-5)	2013	2013
	TRUE ABUNDANCE (TYPE-2)	2014	2014
	UNKNOWN	1953	1994
	SAND RIVER		
	PRESENCE-ABSENCE (TYPE-6)	2008	2011
	RELATIVE ABUNDANCE (TYPE-5)	2002	2004
	TRUE ABUNDANCE (TYPE-1)	2001	2001
	UNKNOWN	1996	1996
	SARITA RIVER		
	RELATIVE ABUNDANCE (TYPE-3)	1995	2012
	RELATIVE ABUNDANCE (TYPE-4)	2002	2015
	RELATIVE ABUNDANCE (TYPE-5)	1987	2011
	UNKNOWN	1953	1994
	SMITH CREEK		
	RELATIVE ABUNDANCE (TYPE-4)	2002	2002
	UNKNOWN	1996	2001
	SNUG BASIN CREEK		
	UNKNOWN	1995	1995
	SOMASS RIVER		
	NA	1977	2015
	RELATIVE ABUNDANCE (TYPE-4)	1997	2001
	RELATIVE ABUNDANCE (TYPE-5)	1998	1998
	UNKNOWN	1985	2008
	SOMASS-SPROAT-GC SYSTEM		
	RELATIVE ABUNDANCE (TYPE-3)	1985	1985
	TRUE ABUNDANCE (TYPE-1)	1990	2015
	TRUE ABUNDANCE (TYPE-2)	1986	2012
	UNKNOWN	1953	1984
	SOOKE RIVER		
	INFILL	2003	2008
	PRESENCE-ABSENCE (TYPE-6)	1995	2011

DU Number and Name	Site Name and Estimation Methods	Start Year	End Year
	RELATIVE ABUNDANCE (TYPE-3)	1996	2010
	RELATIVE ABUNDANCE (TYPE-4)	2007	2007
	RELATIVE ABUNDANCE (TYPE-5)	2005	2014
	UNKNOWN	1954	2015
	SUGSAW CREEK		
	UNKNOWN	1997	2001
	SYDNEY RIVER		
	PRESENCE-ABSENCE (TYPE-6)	1995	2015
	RELATIVE ABUNDANCE (TYPE-5)	2001	2010
	UNKNOWN	1953	1993
	THORNTON CREEK		
	RELATIVE ABUNDANCE (TYPE-4)	1997	2004
	RELATIVE ABUNDANCE (TYPE-5)	1985	2013
	UNKNOWN	1988	2014
	TOFINO CREEK		
	PRESENCE-ABSENCE (TYPE-6)	1996	1996
	RELATIVE ABUNDANCE (TYPE-5)	2009	2013
	UNKNOWN	1953	1994
	TOQUART RIVER		
	PRESENCE-ABSENCE (TYPE-6)	1995	1995
	RELATIVE ABUNDANCE (TYPE-3)	1998	2002
	RELATIVE ABUNDANCE (TYPE-4)	1996	2014
	RELATIVE ABUNDANCE (TYPE-5)	1997	2015
	UNKNOWN	1953	2011
	TRANQUIL CREEK		
	PRESENCE-ABSENCE (TYPE-6)	1988	1995
	RELATIVE ABUNDANCE (TYPE-3)	1996	2015
	RELATIVE ABUNDANCE (TYPE-5)	1992	1992
	UNKNOWN	1953	1994
	UCHUCK CREEK		
	UNKNOWN	1953	1984
	WARN BAY CREEK		
	PRESENCE-ABSENCE (TYPE-6)	1995	1996
	RELATIVE ABUNDANCE (TYPE-4)	2003	2003
	RELATIVE ABUNDANCE (TYPE-5)	2004	2015
	UNKNOWN	1983	1994

DU Number and Name	Site Name and Estimation Methods	Start Year	End Year
	WATTA CREEK		
	PRESENCE-ABSENCE (TYPE-6)	1995	2010
	UNKNOWN	1958	1991
DU25 West Vancouver Island Ocean Fall (Nootka and Kyuquot)	**AMAI CREEK**		
	PRESENCE-ABSENCE (TYPE-6)	2012	2015
	UNKNOWN	1954	1998
	ARTLISH RIVER		
	RELATIVE ABUNDANCE (TYPE-3)	1996	2015
	RELATIVE ABUNDANCE (TYPE-4)	1995	2014
	UNKNOWN	1953	1994
	BATTLE BAY RIVER		
	UNKNOWN	1953	1996
	BLACK CREEK		
	UNKNOWN	1995	1995
	BRODICK CREEK		
	UNKNOWN	1964	1992
	BURMAN RIVER		
	NA	2014	2015
	RELATIVE ABUNDANCE (TYPE-3)	1995	2013
	RELATIVE ABUNDANCE (TYPE-4)	2004	2008
	RELATIVE ABUNDANCE (TYPE-5)	2009	2009
	TRUE ABUNDANCE (TYPE-2)	2002	2002
	UNKNOWN	1953	1994
	CACHALOT CREEK		
	RELATIVE ABUNDANCE (TYPE-5)	2003	2003
	TRUE ABUNDANCE (TYPE-1)	2001	2001
	CANTON CREEK		
	RELATIVE ABUNDANCE (TYPE-3)	2011	2011
	RELATIVE ABUNDANCE (TYPE-5)	2007	2013
	TRUE ABUNDANCE (TYPE-1)	1996	2001
	UNKNOWN	1953	1995
	CHAMISS CREEK		
	RELATIVE ABUNDANCE (TYPE-5)	2003	2003
	UNKNOWN	1956	1991
	CHUM CREEK		
	PRESENCE-ABSENCE (TYPE-6)	2010	2012
	RELATIVE ABUNDANCE (TYPE-4)	2002	2002

DU Number and Name	Site Name and Estimation Methods	Start Year	End Year
	RELATIVE ABUNDANCE (TYPE-5)	2006	2006
	TRUE ABUNDANCE (TYPE-1)	1998	1998
	UNKNOWN	1966	1995
	CLANNINICK CREEK		
	UNKNOWN	1956	1989
	CONUMA RIVER		
	NA	2014	2015
	RELATIVE ABUNDANCE (TYPE-3)	1995	2009
	RELATIVE ABUNDANCE (TYPE-4)	2004	2013
	RELATIVE ABUNDANCE (TYPE-5)	2002	2011
	UNKNOWN	1953	1994
	DESERTED CREEK		
	PRESENCE-ABSENCE (TYPE-6)	1984	2012
	RELATIVE ABUNDANCE (TYPE-3)	1998	1998
	RELATIVE ABUNDANCE (TYPE-5)	2001	2006
	UNKNOWN	1958	1990
	EASY CREEK		
	RELATIVE ABUNDANCE (TYPE-4)	2003	2003
	RELATIVE ABUNDANCE (TYPE-5)	2012	2013
	UNKNOWN	1966	1998
	ELIZA CREEK		
	UNKNOWN	1962	1984
	ELIZA EAST RIVER		
	PRESENCE-ABSENCE (TYPE-6)	2008	2011
	TRUE ABUNDANCE (TYPE-1)	1998	1998
	UNKNOWN	1996	1996
	ESPINOSA CREEK		
	PRESENCE-ABSENCE (TYPE-6)	1984	2012
	RELATIVE ABUNDANCE (TYPE-5)	1998	2011
	UNKNOWN	1962	1989
	GOLD RIVER		
	NA	1999	2015
	PRESENCE-ABSENCE (TYPE-6)	1995	2010
	RELATIVE ABUNDANCE (TYPE-3)	1998	1998
	RELATIVE ABUNDANCE (TYPE-5)	1996	2013
	UNKNOWN	1953	2006

DU Number and Name	Site Name and Estimation Methods	Start Year	End Year
	HOISS CREEK		
	PRESENCE-ABSENCE (TYPE-6)	2010	2012
	RELATIVE ABUNDANCE (TYPE-4)	2002	2004
	RELATIVE ABUNDANCE (TYPE-5)	2006	2008
	TRUE ABUNDANCE (TYPE-1)	1998	1998
	UNKNOWN	1963	2001
	HOUSTON RIVER		
	UNKNOWN	1967	1984
	INNER BASIN RIVER		
	PRESENCE-ABSENCE (TYPE-6)	2010	2011
	JACKLAH RIVER		
	PRESENCE-ABSENCE (TYPE-6)	1984	1984
	UNKNOWN	1957	1991
	KAOUK RIVER		
	PRESENCE-ABSENCE (TYPE-6)	1988	1988
	RELATIVE ABUNDANCE (TYPE-3)	1995	2015
	RELATIVE ABUNDANCE (TYPE-4)	2005	2009
	UNKNOWN	1953	1994
	KAPOOSE CREEK		
	UNKNOWN	1997	1997
	KASHUTL RIVER		
	PRESENCE-ABSENCE (TYPE-6)	2011	2012
	UNKNOWN	1953	1998
	KAUWINCH RIVER		
	PRESENCE-ABSENCE (TYPE-6)	1996	2012
	RELATIVE ABUNDANCE (TYPE-4)	2015	2015
	RELATIVE ABUNDANCE (TYPE-5)	2001	2014
	UNKNOWN	1953	1994
	KLEEPTEE CREEK		
	PRESENCE-ABSENCE (TYPE-6)	1995	2012
	RELATIVE ABUNDANCE (TYPE-4)	2002	2004
	RELATIVE ABUNDANCE (TYPE-5)	2006	2011
	UNKNOWN	1961	1992
	LEINER RIVER		
	NA	2014	2015
	RELATIVE ABUNDANCE (TYPE-3)	2002	2013

DU Number and Name	Site Name and Estimation Methods	Start Year	End Year
	RELATIVE ABUNDANCE (TYPE-4)	1995	2000
	RELATIVE ABUNDANCE (TYPE-5)	2001	2001
	UNKNOWN	1953	1994
	LITTLE ZEBALLOS RIVER		
	PRESENCE-ABSENCE (TYPE-6)	1984	1999
	RELATIVE ABUNDANCE (TYPE-3)	1998	1998
	RELATIVE ABUNDANCE (TYPE-4)	2002	2008
	RELATIVE ABUNDANCE (TYPE-5)	2000	2013
	UNKNOWN	1953	1979
	MALKSOPE RIVER		
	PRESENCE-ABSENCE (TYPE-6)	1984	2001
	RELATIVE ABUNDANCE (TYPE-4)	2002	2015
	RELATIVE ABUNDANCE (TYPE-5)	2014	2014
	UNKNOWN	1954	1992
	MAMAT CREEK		
	UNKNOWN	1962	1984
	MARVINAS BAY CREEK		
	PRESENCE-ABSENCE (TYPE-6)	2011	2012
	RELATIVE ABUNDANCE (TYPE-4)	2002	2005
	UNKNOWN	1984	2001
	MCKAY COVE CREEK		
	UNKNOWN	1953	1996
	MOOYAH RIVER		
	PRESENCE-ABSENCE (TYPE-6)	1984	2012
	RELATIVE ABUNDANCE (TYPE-4)	2002	2004
	RELATIVE ABUNDANCE (TYPE-5)	1999	2011
	UNKNOWN	1953	1987
	MUCHALAT RIVER		
	NA	2003	2004
	RELATIVE ABUNDANCE (TYPE-5)	2002	2002
	TRUE ABUNDANCE (TYPE-1)	2001	2001
	UNKNOWN	2005	2005
	NARROWGUT CREEK		
	PRESENCE-ABSENCE (TYPE-6)	2011	2015
	UNKNOWN	1958	1998
	NASPARTI RIVER		

DU Number and Name	Site Name and Estimation Methods	Start Year	End Year
	UNKNOWN	1958	1995
	OKTWANCH RIVER		
	RELATIVE: CONSTANT MULTI-YEAR METHODS	1996	1996
	TRUE ABUNDANCE (TYPE-1)	2001	2001
	OUOUKINSH RIVER		
	PRESENCE-ABSENCE (TYPE-6)	1984	1996
	RELATIVE ABUNDANCE (TYPE-4)	2002	2002
	RELATIVE ABUNDANCE (TYPE-5)	2011	2011
	UNKNOWN	1953	1994
	PARK RIVER		
	PRESENCE-ABSENCE (TYPE-6)	1984	2012
	RELATIVE ABUNDANCE (TYPE-5)	2006	2006
	UNKNOWN	1953	1980
	POWER RIVER		
	UNKNOWN	1953	1992
	SILVERADO CREEK		
	UNKNOWN	1964	1991
	SUCWOA RIVER		
	NA	2006	2014
	PRESENCE-ABSENCE (TYPE-6)	1991	2010
	RELATIVE ABUNDANCE (TYPE-3)	2002	2011
	RELATIVE ABUNDANCE (TYPE-5)	2003	2013
	TRUE ABUNDANCE (TYPE-1)	1996	2001
	UNKNOWN	1958	2004
	TAHSIS RIVER		
	NA	2014	2015
	RELATIVE ABUNDANCE (TYPE-3)	2005	2013
	RELATIVE ABUNDANCE (TYPE-4)	1995	2011
	UNKNOWN	1953	1994
	TAHSISH RIVER		
	RELATIVE ABUNDANCE (TYPE-3)	1995	2015
	RELATIVE ABUNDANCE (TYPE-4)	1998	2014
	RELATIVE ABUNDANCE (TYPE-5)	2012	2012
	UNKNOWN	1953	1994
	TATCHU CREEK		
	UNKNOWN	1997	1997

DU Number and Name	Site Name and Estimation Methods	Start Year	End Year
	TLUPANA RIVER		
	NA	2014	2015
	PRESENCE-ABSENCE (TYPE-6)	2004	2007
	RELATIVE ABUNDANCE (TYPE-3)	1996	1998
	RELATIVE ABUNDANCE (TYPE-4)	1999	2003
	RELATIVE ABUNDANCE (TYPE-5)	2005	2013
	UNKNOWN	1953	1995
	TSOWWIN RIVER		
	PRESENCE-ABSENCE (TYPE-6)	2012	2012
	RELATIVE ABUNDANCE (TYPE-3)	1996	1997
	RELATIVE ABUNDANCE (TYPE-4)	1995	2008
	RELATIVE ABUNDANCE (TYPE-5)	1998	2013
	UNKNOWN	1953	1993
	ZEBALLOS RIVER		
	NA	2014	2015
	RELATIVE ABUNDANCE (TYPE-3)	1996	1999
	RELATIVE ABUNDANCE (TYPE-4)	1995	2013
	RELATIVE ABUNDANCE (TYPE-5)	2001	2012
	UNKNOWN	1953	1994
DU26 West Vancouver Island Ocean Fall (WVI + WQCI)	**BENSON RIVER**		
	PRESENCE-ABSENCE (TYPE-6)	2011	2011
	RELATIVE ABUNDANCE (TYPE-5)	2003	2003
	UNKNOWN	1998	1998
	CAYEGHLE SYSTEM		
	RELATIVE ABUNDANCE (TYPE-3)	1997	1998
	RELATIVE ABUNDANCE (TYPE-5)	1999	2010
	TRUE ABUNDANCE (TYPE-2)	2002	2002
	UNKNOWN	1955	1958
	DENAD CREEK		
	UNKNOWN	1992	1992
	EAST CREEK		
	UNKNOWN	1953	1993
	GOODSPEED RIVER		
	NA	2013	2013
	RELATIVE ABUNDANCE (TYPE-4)	2000	2000
	RELATIVE ABUNDANCE (TYPE-5)	1998	2001

DU Number and Name	Site Name and Estimation Methods	Start Year	End Year
	UNKNOWN	1955	2002
	KEITH RIVER		
	PRESENCE-ABSENCE (TYPE-6)	2000	2000
	UNKNOWN	1980	1980
	KLASKISH RIVER		
	PRESENCE-ABSENCE (TYPE-6)	1984	1984
	RELATIVE ABUNDANCE (TYPE-4)	1995	1998
	UNKNOWN	1953	1992
	KLOOTCHLIMMIS CREEK		
	PRESENCE-ABSENCE (TYPE-6)	2000	2000
	UNKNOWN	1998	2002
	MAHATTA CREEK		
	UNKNOWN	1953	1984
	MARBLE RIVER		
	PRESENCE-ABSENCE (TYPE-6)	1995	1995
	RELATIVE ABUNDANCE (TYPE-3)	2012	2012
	RELATIVE ABUNDANCE (TYPE-4)	1996	2015
	RELATIVE ABUNDANCE (TYPE-5)	2001	2013
	UNKNOWN	1954	1994
	STEPHENS CREEK		
	UNKNOWN	1991	1991
	WASHLAWLIS CREEK		
	UNKNOWN	1984	1993
DU27 Southern Mainland Ocean Summer	**CUMSACK CREEK**		
	UNKNOWN	1953	1970
	HOMATHKO RIVER		
	PRESENCE-ABSENCE (TYPE-6)	1995	1997
	RELATIVE ABUNDANCE (TYPE-4)	2011	2011
	UNKNOWN	1953	1993
DU28 Southern Mainland Stream Summer	**KLINAKLINI RIVER**		
	PRESENCE-ABSENCE (TYPE-6)	1995	1996
	RELATIVE ABUNDANCE (TYPE-3)	1997	2000
	TRUE ABUNDANCE (TYPE-2)	2001	2003
	UNKNOWN	1953	1994