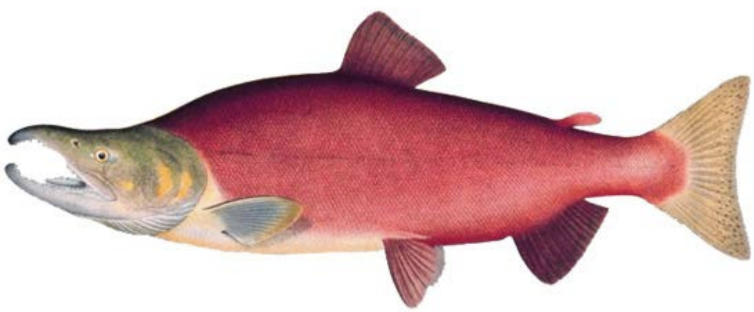
COSEWIC
Assessment and Status Report

on the

Sockeye Salmon
Oncorhynchus nerka

24 Designatable Units in the Fraser River Drainage Basin

in Canada



DU1: Anderson-Seton-ES population - NOT AT RISK
DU2: Bowron-ES population - ENDANGERED
DU3 and DU4: Chilko-ES population / Chilko-S population - NOT AT RISK
DU5: Chilliwack-ES population - NOT AT RISK
DU6: Cultus-L population - ENDANGERED
DU7: Francois-Fraser-S population - SPECIAL CONCERN
DU8: Nadina-Francois-ES population - NOT AT RISK
DU9: Harrison (D/S)-L population - SPECIAL CONCERN
DU10:Harrison (U/S)-L population - ENDANGERED
DU11: Kamloops-ES population - SPECIAL CONCERN
DU12: Lillooet-Harrison-L population - SPECIAL CONCERN
DU13: Nahatlatch-ES population - SPECIAL CONCERN
DU14: North Barriere-ES population - THREATENED
DU15: Pitt-ES population - NOT AT RISK
DU16: Quesnel-S population - ENDANGERED
DU17: Seton-L population - ENDANGERED
DU18: Shuswap Complex-L population - NOT AT RISK
DU19: Shuswap-ES population - NOT AT RISK
DU20: Takla-Trembleur-EStu population - ENDANGERED
DU21: Takla-Trembleur-Stuart-S population - ENDANGERED
DU22: Taseko-ES population - ENDANGERED
DU23: Harrison (River-Type) population - NOT AT RISK
DU24: Widgeon (River-Type) population - THREATENED
2017

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

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

COSEWIC. 2017. COSEWIC assessment and status report on the Sockeye Salmon *Oncorhynchus nerka,* 24 Designatable Units in the Fraser River Drainage Basin, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xli + 179 pp. (http://www.registrelep-sararegistry.gc.ca/default.asp?lang=en&n=24F7211B-1).

Previous report(s):

COSEWIC. 2016. COSEWIC assessment and status report on the Sockeye Salmon *Oncorhynchus nerka*, Sakinaw population, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. ix + 39 pp. (http://www.registrelep-sararegistry.gc.ca/default_e.cfm).

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

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

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

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COSEWIC
Assessment Summary

Designatable Unit 1: Anderson-Seton-ES population

Assessment Summary – November 2017

Common name
Sockeye Salmon - Anderson-Seton-ES population

Scientific name
Oncorhynchus nerka

Status
Not at risk

Reason for designation
The number of mature individuals in the population has been increasing since records were first taken in the mid-1950s, and the most recent numbers have been the highest on record.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Not at Risk in November 2017.

Designatable Unit 2: Bowron-ES population

Assessment Summary – November 2017

Common name
Sockeye Salmon - Bowron-ES population

Scientific name
Oncorhynchus nerka

Status
Endangered

Reason for designation
This anadromous species faces a number of threats in both freshwater and marine areas which are causing habitat quality to decline. The number of mature individuals in this population has been declining since the mid-1950s and there has been a large decline in the past 3 generations. The most recent numbers have been among the lowest in the time series. Annual exploitation rates have been in excess of 30% for many years while the population has been declining.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Endangered in November 2017.

Designatable Unit 3/4: Chilko-ES population / Chilko-S population

Assessment Summary – November 2017

Common name
Sockeye Salmon - Chilko-ES population / Chilko-S population

Scientific name
Oncorhynchus nerka

Status
Not at risk

Reason for designation
The number of mature individuals in the population has been increasing since records were first taken in the mid-1950s, and the most recent numbers have been among the highest on record.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Not at Risk in November 2017.

Designatable Unit 5: Chilliwack-ES population

Assessment Summary – November 2017

Common name
Sockeye Salmon - Chilliwack-ES population

Scientific name
Oncorhynchus nerka

Status
Not at Risk

Reason for designation
The number of mature individuals has only been monitored since 2001, resulting in considerable uncertainty about how the recent abundance compares to historical values. Nevertheless, there has been an increase in the number of mature individuals in the past 3 generations.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Not at Risk in November 2017.

Designatable Unit 6: Cultus-L population

Assessment Summary – November 2017

Common name
Sockeye Salmon - Cultus-L population

Scientific name
Oncorhynchus nerka

Status
Endangered

Reason for designation
Cultus Lake is one of the most heavily utilized lakes in BC and it has been developed for recreational, residential and agricultural purposes. The lake's water quality has been degraded as a result of seepage from septic systems, agricultural runoff and domestic use of fertilizers as well as by an introduced Eurasian water-milfoil (*Myriophyllum* sp.). The spawning population has declined steadily since 1950 and the current population size remains very small. This small population continues to face high exploitation rates as bycatch in other salmon fisheries.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Endangered in an emergency assessment in October 2002. Status re-examined and confirmed in May 2003 and November 2017.

Designatable Unit 7: Francois-Fraser-S population

Assessment Summary – November 2017

Common name
Sockeye Salmon - Francois-Fraser-S population

Scientific name
Oncorhynchus nerka

Status
Special Concern

Reason for designation
This anadromous species faces a number of threats in both freshwater and marine areas, which are causing habitat quality to decline. However, the number of mature individuals increased considerably during the period 1970-2000 and the most recent numbers have been among the highest on record. However, there has been a decline over the last three generations, and this fish may become Threatened if the factors contributing to this decline are not effectively managed.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Special Concern in November 2017.

Designatable Unit 8: Nadina-Francois-ES population

Assessment Summary – November 2017

Common name
Sockeye Salmon - Nadina-Francois-ES population

Scientific name
Oncorhynchus nerka

Status
Not at risk

Reason for designation
The number of mature individuals has steadily increased since 1950, and the most recent number is the highest on record.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Not at Risk in November 2017.

Designatable Unit 9: Harrison (D/S)-L population

Assessment Summary – November 2017

Common name
Sockeye Salmon - Harrison (D/S)-L population

Scientific name
Oncorhynchus nerka

Status
Special Concern

Reason for designation
The number of mature individuals in the population was very small from 1950-1995 and yet the population has persisted. However, the population may become Threatened if current threats are not managed and the population begins to decline. This anadromous species faces a number of threats in both freshwater and marine areas, which are causing habitat quality to decline.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Special Concern in November 2017.

Designatable Unit 10: Harrison (U/S)-L population

Assessment Summary – November 2017

Common name
Sockeye Salmon - Harrison (U/S)-L population

Scientific name
Oncorhynchus nerka

Status
Endangered

Reason for designation
This anadromous species faces a number of threats in both freshwater and marine areas which are causing habitat quality to decline. The number of mature individuals increased from a low level in 1960 to a peak in 1980. Since then, the numbers have fluctuated in a downward direction to reach an historical minimum in the most recent period.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Endangered in November 2017.

Designatable Unit 11: Kamloops-ES population

Assessment Summary – November 2017

Common name
Sockeye Salmon - Kamloops-ES population

Scientific name
Oncorhynchus nerka

Status
Special Concern

Reason for designation
This anadromous species faces a number of threats in both freshwater and marine areas, which are causing habitat quality to decline. However, the number of mature individuals in the population is currently greater than numbers observed 1960-1995. While there has been a decline in the number of mature individuals over the past 3 generations, this decline occurred from the maximum observed in the 65-year time period. However, there has been a decline over the last three generations, and these fish may become Threatened if the factors leading to this decline are not managed effectively.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Special Concern in November 2017.

Designatable Unit 12: Lillooet-Harrison-L population

Assessment Summary – November 2017

Common name
Sockeye Salmon - Lillooet-Harrison-L population

Scientific name
Oncorhynchus nerka

Status
Special Concern

Reason for designation
This anadromous species faces a number of threats in both freshwater and marine areas, which are causing habitat quality to decline. The population increased considerably in abundance between 1960-1990 after which it declined. Although the current abundance is above or similar to levels observed in the 1950-1970 period, the population may become Threatened if current threats are not managed and the population continues to decline.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Special Concern in November 2017.

Designatable Unit 13: Nahatlatch-ES population

Assessment Summary – November 2017

Common name
Sockeye Salmon - Nahatlatch-ES population

Scientific name
Oncorhynchus nerka

Status
Special Concern

Reason for designation
The number of mature individuals is small and, if the threats lead to a decline in the number of mature individuals, it could become Threatened. This anadromous species faces a number of threats in both freshwater and marine areas, which are causing habitat quality to decline.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Special Concern in November 2017.

Designatable Unit 14: North Barriere-ES population

Assessment Summary – November 2017

Common name
Sockeye Salmon - North Barriere-ES population

Scientific name
Oncorhynchus nerka

Status
Threatened

Reason for designation
After having been extirpated by dam construction in the 1920s, a new population was established through transplants. Although the population initially grew quickly, the fish now face a number of threats in both freshwater and marine areas which are causing habitat quality to decline. Since 1980, there has been a continuous decline to a low number today.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Threatened in November 2017.

Designatable Unit 15: Pitt-ES population

Assessment Summary – November 2017

Common name
Sockeye Salmon - Pitt-ES population

Scientific name
Oncorhynchus nerka

Status
Not at risk

Reason for designation
The number of mature individuals in the population is currently much higher than it was in the period 1950 to the late 1990s.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Not at Risk in November 2017.

Designatable Unit 16: Quesnel-S population

Assessment Summary – November 2017

Common name
Sockeye Salmon - Quesnel-S population

Scientific name
Oncorhynchus nerka

Status
Endangered

Reason for designation
The population faces a number of threats in both freshwater and marine areas, which are causing habitat quality to decline. A potential new threat to the population is the failure of a mining tailings pond that drained into Quesnel Lake in 2014. The population has declined consistently since 2000.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Endangered in November 2017.

Designatable Unit 17: Seton-L population

Assessment Summary – November 2017

Common name
Sockeye Salmon - Seton-L population

Scientific name
Oncorhynchus nerka

Status
Endangered

Reason for designation
This anadromous species faces a number of threats in both freshwater and marine areas which are causing habitat quality to decline. The number of mature individuals in this population was relatively high and stable from the mid-1970s to the late-1990s. Since then the numbers have declined considerably to very low abundance and are close to a historical minimum.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Endangered in November 2017.

Designatable Unit 18: Shuswap Complex-L population

Assessment Summary – November 2017

Common name
Sockeye Salmon - Shuswap Complex-L population

Scientific name
Oncorhynchus nerka

Status
Not at risk

Reason for designation
This population has extreme cyclic dominance where the dominant cycle line is on average 600 times larger than the smallest. While the number of mature individuals of the largest cycle line is highly variable, it has never been lower than 500,000 fish, it has exceeded 2.5 million twice (2002 and 2010), and there is no trend in its abundance.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Not at Risk in November 2017.

Designatable Unit 19: Shuswap-ES population

Assessment Summary – November 2017

Common name
Sockeye Salmon - Shuswap-ES population

Scientific name
Oncorhynchus nerka

Status
Not at risk

Reason for designation
The number of mature individuals in the population has increased since records were first taken in the mid-1950s. The population does not meet any risk criteria.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Not at Risk in November 2017.

Designatable Unit 20: Takla-Trembleur-EStu population

Assessment Summary – November 2017

Common name
Sockeye Salmon - Takla-Trembleur-EStu population

Scientific name
Oncorhynchus nerka

Status
Endangered

Reason for designation
This anadromous species faces a number of threats in both freshwater and marine areas which are causing habitat quality to decline. The number of mature individuals has been declining steadily for over 20 years despite reductions in fishing mortality. Productivity is currently very low.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Endangered in November 2017.

Designatable Unit 21: Takla-Trembleur-Stuart-S population

Assessment Summary – November 2017

Common name
Sockeye Salmon - Takla-Trembleur-Stuart-S population

Scientific name
Oncorhynchus nerka

Status
Endangered

Reason for designation
This anadromous species faces a number of threats in both freshwater and marine areas, which are causing habitat quality to decline. The number of mature individuals has been declining steadily for 3 generations yet removals by fishing remained high.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Endangered in November 2017.

Designatable Unit 22: Taseko-ES population

Assessment Summary – November 2017

Common name
Sockeye Salmon - Taseko-ES population

Scientific name
Oncorhynchus nerka

Status
Endangered

Reason for designation
This anadromous species faces a number of threats in both freshwater and marine areas which are causing habitat quality to decline. Poor data quality has caused a gap in population estimates in the middle of the time series (1960s-1990s). The number of mature individuals was relatively high in the late 1990s. Since then the numbers have declined considerably and are close to a historical minimum.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Endangered in November 2017.

Designatable Unit 23: Harrison (River-Type) population

Assessment Summary – November 2017

Common name
Sockeye Salmon - Harrison (River-Type) population

Scientific name
Oncorhynchus nerka

Status
Not at risk

Reason for designation
The number of mature individuals in the population has increased considerably over the past three generations and is now at a historical high.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Not at Risk in November 2017.

Designatable Unit 24: Widgeon (River–Type) population

Assessment Summary – November 2017

Common name
Sockeye Salmon - Widgeon (River–Type) population

Scientific name
Oncorhynchus nerka

Status
Threatened

Reason for designation
This is a naturally small population which faces a number of threats in both freshwater and marine areas which are causing habitat quality to decline. The number of mature individuals was relatively stable from 1950 to 1990, and then declined considerably to a minimum in 2000. Over the past 3 generations the number of fish has returned to pre-1990 abundances. However, the small population size makes them vulnerable to stochastic events and increasing threats.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Threatened in November 2017.

COSEWIC
Executive Summary

Sockeye Salmon
Oncorhynchus nerka

24 Designatable Units in the Fraser River Drainage Basin

Wildlife Species Description and Significance

Sockeye salmon is one of seven species of the genus *Oncorhynchus* native to North America. Adults have a slender, streamlined, silvery body with faint blue-green specking on the back and weigh an average of 3 kg (but in some cases over 6 kg). They undergo a distinctive transformation of external colour and body shape during their migration from the ocean to the freshwater ecosystem where they were born and grew as juveniles (usually a lake). The head becomes pale green in colour, the body can change to a brilliant scarlet, and the males develop large teeth and a sharply hooked jaw. The adults die soon after spawning and the developing embryos and then juveniles typically remain in freshwater for 1-2 years. Sockeye salmon exist as isolated populations and they evolve local adaptations to their freshwater environments.

Distribution

As a species, Sockeye salmon are distributed through the North Pacific Ocean and its tributary systems in both Asia and North America; however, they are particularly abundant in Alaska and British Columbia (BC). The Fraser River watershed is the largest Sockeye salmon complex in BC. For this status report, Sockeye Salmon from the Fraser River Drainage Basin have been subdivided into 24 designatable units (DUs) using methods based on COSEWIC guidelines and on work by Fisheries and Oceans Canada to identify conservation units under the Wild Salmon Policy. The DUs defined for this assessment represent distinct subpopulations of Fraser River Sockeye Salmon based on geographic distribution, life history variation, timing of adult spawning migrations and genetic data.

Habitat

Fraser River Sockeye Salmon typically spawn in lake tributaries or outflows, or along lake foreshores. Most juveniles rear in a nursery lake for one year before migrating rapidly out of their rearing lakes, downstream in the Fraser River, and northward through the Strait of Georgia. These Sockeye leave the Strait of Georgia in late June and July to enter the open ocean via Johnstone Strait to the north. They then migrate northwest along the coasts of British Columbia and central Alaska, until they reach wintering grounds in the Gulf of Alaska during late autumn.

Some Fraser River Sockeye migrate downstream to the Strait of Georgia shortly after emergence from the gravel. Most of these Sockeye migrate into the Strait of Georgia after mid-July and then remain in the Strait of Georgia for several months after all other Fraser Sockeye stocks have migrated out of this system. They largely migrate out into the northeast Pacific via the southern Juan de Fuca Strait route.

Fraser River Sockeye mature in the Gulf of Alaska for a variable number of years before returning to coastal BC and migrating up the Fraser River to the natal rivers or lakes where they were spawned.

Biology

Most Fraser River Sockeye Salmon become mature in their fourth year of life with spawning occurring most frequently in August and September. Fraser Sockeye return to the Fraser Basin to spawn in one of four general adult run timing groups (early Stuart, early summer, summer, and late). Adults typically spawn in lake tributaries or outflows, or along lake foreshores. Eggs are deposited in nests, termed redds, constructed by the female, fertilized by males, then covered with gravel by the female. Sockeye eggs are the smallest, on average, of any North American salmon and incubate in the gravel through the winter before emerging as alevins in the spring.

Most Fraser River Sockeye are lake-type fish which utilize lake rearing areas for one to two years, after which juvenile Sockeye emigrate to sea during the spring. Young sockeye remain at sea for one to four years, but more typically for two to three years, before the onset of maturation and the return to the natal area. There are also a few (River-Type) Sockeye populations in the Fraser which reside for a variable, often shorter, period of time in side channels and sloughs before migrating to sea. All Sockeye Salmon die after spawning.

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, fluctuations and trends, cyclic dominance and threats and limiting factors.

Threats and Limiting Factors

Overfishing, increases in mortality associated with early up-river migration, and reductions in marine survival all have contributed to declines in the abundance of Fraser River Sockeye Salmon. Ongoing threats for some DUs include: industrial effluents in freshwater, the Fraser River estuary and Strait of Georgia; the possibility of contaminant spills from derailments of trains passing beside nursery lakes; geological events such as landslides; and mixed stock fisheries. In addition, with the Fraser River expected to continue to warm throughout the 21st century, freshwater temperature extremes also pose a threat to Fraser River Sockeye. There is also a proposal for a pipeline expansion that will cross numerous streams in the Fraser watershed.

A number of other potential threats to Fraser River Sockeye exist including agricultural effluent, marine mammal predation, competition with other salmon at sea and pathogens from fish farms; however, their severity is currently unknown.

Protection, Status and Ranks

In addition to the current assessments, one Fraser River Sockeye population in Canada (the Cultus Lake population) has been assessed by COSEWIC as Endangered since 2002. COSEWIC has also assessed the Sakinaw Sockeye population (not part of the Fraser River group) as Endangered since 2006. Neither the Cultus nor Sakinaw populations of Sockeye Salmon are listed under the *Species at Risk Act*.

DU Naming Convention

Letters after each DU name refer to the four main run timing groups in the Fraser: “EStu” is Early Stuart, “ES” is Early Summer, “S” is Summer and “L” is Late; D/S is downstream, U/S is upstream.

TECHNICAL SUMMARIES

The Technical Summaries are provided in two parts. Part 1 contains the sections that have specific information for each DU. Part II shows the sections that have the same information for each DU. (See the final paragraph of the Executive Summary for naming convention.)

Technical Summaries, Part 1

Oncorhynchus nerka

Sockeye Salmon

Saumon rouge

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

Designatable Unit 1: Anderson-Seton-ES population
Population Anderson-Seton-DE

Demographic Information

1. Generation Time	4 years		
2. Is there a continuing decline in the number of mature individuals?	No		
4a. Change in number of mature individuals based on last 3 generations observations	+287%	p > 30% decline 0%	p > 50% decline 0%
4b. Change in number of mature individuals based on all observations	+116%	p > 30% decline 0%	p > 50% decline 0%
8. Are there extreme fluctuations in the number of mature individuals?	No		
10. Index of area of occupancy	16 km^2		
22. Number of mature individuals	24,527		

Threats

A threats calculator was completed. The main threats were climate change and severe weather, pollution, and geological events. The overall threat was Medium.

Status History:

Designated Not at Risk in November 2017.

Status and Reasons for Designation:

Status: Not at risk	Alpha-numeric codes: Not applicable.
Reasons for Designation: The number of mature individuals in the population has been increasing since records were first taken in the mid-1950s, and the most recent numbers have been the highest on record.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Does not meet criterion because the number of mature individuals is increasing
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 not extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Does not meet criterion because the number of mature individuals exceeds 10,000.
Criterion D (Very Small or Restricted Population): Does not meet criterion.
Criterion E (Quantitative Analysis): Not done.

Designatable Unit 2: Bowron-ES population
Population Bowron-DE

Demographic Information

1. Generation Time	4 years		
2. Is there a continuing decline in the number of mature individuals?	Yes.		
4a. Change in number of mature individuals based on last 3 generations observations	-60%	p > 30% decline 90%	p > 50% decline 71%
4b. Change in number of mature individuals based on all observations	-24%	p > 30% decline 2%	p > 50% decline 0%
8. Are there extreme fluctuations in the number of mature individuals?	No		
10. Index of area of occupancy	16 km^2		
22. Number of mature individuals	4,651		

Threats

A threats calculator was not completed.

Status History:

Designated Endangered in November 2017.

Status and Reasons for Designation:

Status: Endangered	Alpha-numeric codes: A2b
Reasons for Designation: This anadromous species faces a number of threats in both freshwater and marine areas which are causing habitat quality to decline. The number of mature individuals in this population has been declining since the mid-1950s and there has been a large decline in the past 3 generations. The most recent numbers have been among the lowest in the time series. Annual exploitation rates have been in excess of 30% for many years while the population has been declining.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets Endangered, A2b, because there has been a 60% decline in the number of mature individuals in the past 3 generations.
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 habitat is declining, but the population is not severely fragmented, locations does not apply, and there are not extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Does not meet criterion for Endangered. Meets Threatened, C2a(ii), because the number of mature individuals is less than 10,000, there is an estimated continuing decline, and more than 95% of mature individuals are in one subpopulation.
Criterion D (Very Small or Restricted Population): Does not meet criterion
Criterion E (Quantitative Analysis): Not done.

Designatable Unit 3/4: Chilko-ES population / Chilko-S population
Population Chilko-DE / Population Chilko-E

The Chilko-ES DU and Chilko-S DU cannot be assessed independently because escapement data for these CUs are aggregated (Grant *et al*. 2011). They are therefore presented here as one DU.

Demographic Information

1. Generation Time	4 years		
2. Is there a continuing decline in the number of mature individuals?	No		
4a. Change in number of mature individuals based on last 3 generations observations	+94%	p > 30% decline 0%	p > 50% decline 0%
4b. Change in number of mature individuals based on all observations	+41%	p > 30% decline 0%	p > 50% decline 0%
8. Are there extreme fluctuations in the number of mature individuals?	No		
10. Index of area of occupancy	160 km^2		
22. Number of mature individuals	767,329 combined for the two populations		

Threats

A threats calculator was not completed.

Status History:

Designated Not at Risk in November 2017.

Status and Reasons for Designation:

Status: Not at risk	Alpha-numeric codes: Not applicable.
Reasons for Designation: The number of mature individuals in the population has been increasing since records were first taken in the mid-1950s, and the most recent numbers have been among the highest on record.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Does not meet criterion because the number of mature individuals is increasing.
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 not extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Does not meet criterion because the number of mature individuals exceeds 10,000.
Criterion D (Very Small or Restricted Population): Does not meet criterion
Criterion E (Quantitative Analysis): Not done.

Designatable Unit 5: Chilliwack-ES population
Population Chilliwack-DE

Demographic Information

1. Generation Time	4 years		
2. Is there a continuing decline in the number of mature individuals?	No		
4a. Change in number of mature individuals based on last 3 generations observations	+64%	p > 30% decline 3%	p > 50% decline 1%
4b. Change in number of mature individuals based on all observations	Not calculated	p > 30% decline	p > 50% decline
8. Are there extreme fluctuations in the number of mature individuals?	No		
10. Index of area of occupancy	8 km^2		
22. Number of mature individuals	36,167		

Threats

A threats calculator was not completed.

Status History:

Designated Not at Risk in November 2017.

Status and Reasons for Designation:

Status: Not at Risk	Alpha-numeric codes: Not applicable.
Reasons for Designation: The number of mature individuals has only been monitored since 2001, resulting in considerable uncertainty about how the recent abundance compares to historical values. Nevertheless, there has been an increase in the number of mature individuals in the past 3 generations.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Does not meet criterion because the number of mature individuals is increasing.
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 not extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Does not meet criterion because the number of mature individuals exceeds 10,000.
Criterion D (Very Small or Restricted Population): Does not meet criterion.
Criterion E (Quantitative Analysis): Not done.

Designatable Unit 6: Cultus-L population
Population Cultus-T

Demographic Information:

1. Generation Time	4 years		
2. Is there a continuing decline in the number of mature individuals?	Yes		
4a. Change in number of mature individuals based on last 3 generations observations	-39%	p > 30% decline 64%	p > 50% decline 32%
4b. Change in number of mature individuals based on all observations	-56%	p > 30% decline 100%	p > 50% decline 100%
8. Are there extreme fluctuations in the number of mature individuals?	No		
10. Index of area of occupancy	4 km^2		
22. Number of mature individuals	1,536		

Threats

A threats calculator was not completed.

Status History:

Designated Endangered in an emergency assessment in October 2002. Status re-examined and confirmed in May 2003 and November 2017.

Status and Reasons for Designation:

Status: Endangered	Alpha-numeric codes: C2a(ii)
Reasons for Designation: Cultus Lake is one of the most heavily utilized lakes in BC and it has been developed for recreational, residential and agricultural purposes. The lake's water quality has been degraded as a result of seepage from septic systems, agricultural runoff and domestic use of fertilizers as well as by an introduced Eurasian water-milfoil (*Myriophyllum* sp.). The spawning population has declined steadily since 1950 and the current population size remains very small. This small population continues to face high exploitation rates as bycatch in other salmon fisheries.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Does not meet criterion for Endangered. Meets Threatened, A2b, because there has been a decline in the number of mature individuals of more than 30% in the last 3 generations.
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 not extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Meets Endangered, C2a(ii), because the number of mature individuals is less than 2,500, there is an estimated continuing decline in the number of mature individuals, and more than 95% of mature individuals are in one subpopulation.
Criterion D (Very Small or Restricted Population): Does not meet criterion.
Criterion E (Quantitative Analysis): Not done.

Designatable Unit 7: Francois-Fraser-S population
Population Francois-Fraser-E

Demographic Information

1. Generation Time	4 years		
2. Is there a continuing decline in the number of mature individuals?	No		
4a. Change in number of mature individuals based on last 3 generations observations	-34%	p > 30% decline 59%	p > 50% decline 16%
4b. Change in number of mature individuals based on all observations	+ 22%	p > 30% decline 0%	p > 50% decline 0%
8. Are there extreme fluctuations in the number of mature individuals?	No		
10. Index of area of occupancy	36 km^2		
22. Number of mature individuals	194,510		

Threats

A threats calculator was not completed.

Status History:

Designated Special Concern in November 2017.

Status and Reasons for Designation:

Status: Special Concern	Alpha-numeric codes: Not applicable.
Reasons for Designation: This anadromous species faces a number of threats in both freshwater and marine areas, which are causing habitat quality to decline. However, the number of mature individuals increased considerably during the period 1970-2000 and the most recent numbers have been among the highest on record. However, there has been a decline over the last three generations, and this fish may become Threatened if the factors contributing to this decline are not effectively managed.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Does not meet criterion. The number of mature individuals was estimated to have declined by 34% over the past 3 generations. However this was a decline from the second highest abundance observed and there has been an increase in the last generation. The long-term trend is an increase of 22%
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 not extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Does not meet criterion. The number of mature individuals is well above the threshold for Threatened.
Criterion D (Very Small or Restricted Population): Does not meet criterion.
Criterion E (Quantitative Analysis): Not done.

Designatable Unit 8: Nadina-Francois-ES population
Population Nadina-Francois-DE

Demographic Information

1. Generation Time	4 years		
2. Is there a continuing decline in the number of mature individuals?	No		
4a. Change in number of mature individuals based on last 3 generations observations	+74%	p > 30% decline 0%	p > 50% decline 0%
4b. Change in number of mature individuals based on all observations	+37%	p > 30% decline 0%	p > 50% decline 0%
8. Are there extreme fluctuations in the number of mature individuals?	No		
10. Index of area of occupancy	124 km^2		
22. Number of mature individuals	32,555		

Threats

A threats calculator was not completed.

Status History:

Designated Not at Risk in November 2017.

Status and Reasons for Designation:

Status: Not at risk	Alpha-numeric codes: Not applicable.
Reasons for Designation: The number of mature individuals has steadily increased since 1950, and the most recent number is the highest on record.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Does not meet criteria. The number of mature individuals has increased in the last 3 generations.
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 not extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Does not meet criterion.
Criterion D (Very Small or Restricted Population): Does not meet criterion
Criterion E (Quantitative Analysis): Not done.

Designatable Unit 9: Harrison (D/S)-L population
Population Harrison (aval)-T

Demographic Information

1. Generation Time	4 years		
2. Is there a continuing decline in the number of mature individuals?	No		
4a. Change in number of mature individuals based on last 3 generations observations	-73%	p > 30% decline 100%	p > 50% decline 99%
4b. Change in number of mature individuals based on all observations	+133%	p > 30% decline 0%	p > 50% decline 0%
8. Are there extreme fluctuations in the number of mature individuals?	No		
10. Index of area of occupancy	16 km^2		
22. Number of mature individuals	5,523		

Threats

A threats calculator was not completed.

Status History:

Designated Special Concern in November 2017.

Status and Reasons for Designation:

Status: Special Concern	Alpha-numeric codes: Not applicable.
Reasons for Designation: The number of mature individuals in the population was very small from 1950-1995 and yet the population has persisted. However, the population may become Threatened if current threats are not managed and the population begins to decline. This anadromous species faces a number of threats in both freshwater and marine areas, which are causing habitat quality to decline.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Does not meet criterion. While there was an estimated decline of 73% in the number of mature individuals over the past 3 generations, the 3-generation time period begins at the highest value in the 65-year time series. The current abundance is well above all observed abundances from 1952-1995.
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 not extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Does not meet criterion. While the number of mature individuals is less than 10,000 and more than 95% of mature individuals are in one subpopulation, and the number of mature individuals has been stable for the last 1-2 generations.
Criterion D (Very Small or Restricted Population): Does not meet criterion
Criterion E (Quantitative Analysis): Not done.

Designatable Unit 10: Harrison (U/S)-L population
Population Harrison (amont)-T

Demographic Information

1. Generation Time	4 years		
2. Is there a continuing decline in the number of mature individuals?	Yes		
4a. Change in number of mature individuals based on last 3 generations observations	-76%	p > 30% decline 100%	p > 50% decline 98%
4b. Change in number of mature individuals based on all observations	+8%	p > 30% decline 0%	p > 50% decline 0%
8. Are there extreme fluctuations in the number of mature individuals?	No		
10. Index of area of occupancy	4 km^2		
22. Number of mature individuals	14,558		

Threats

A threats calculator was not completed.

Status History:

Designated Endangered in November 2017.

Status and Reasons for Designation:

Status: Endangered	Alpha-numeric codes: A2b
Reasons for Designation: This anadromous species faces a number of threats in both freshwater and marine areas which are causing habitat quality to decline. The number of mature individuals increased from a low level in 1960 to a peak in 1980. Since then, the numbers have fluctuated in a downward direction to reach an historical minimum in the most recent period.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets Endangered, A2b. The estimated decline over the last 3 generations is 76%.
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 not extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Does not meet criteria because the number of mature individuals is greater than 10,000.
Criterion D (Very Small or Restricted Population): Does not meet criterion
Criterion E (Quantitative Analysis): Not done.

Designatable Unit 11: Kamloops-ES population
Population Kamloops-DE

Demographic Information

1. Generation Time	4 years		
2. Is there a continuing decline in the number of mature individuals?	No		
4a. Change in number of mature individuals based on last 3 generations observations	-52%	p > 30% decline 93%	p > 50% decline 55%
4b. Change in number of mature individuals based on all observations	+14%	p > 30% decline 0%	p > 50% decline 0%
8. Are there extreme fluctuations in the number of mature individuals?	No		
10. Index of area of occupancy	208 km^2		
22. Number of mature individuals	30,902		

Threats

A threats calculator was completed. The main threats were climate change and severe weather, pollution, and biological resource use. The overall threat impact was Medium.

Status History:

Designated Special Concern in November 2017.

Status and Reasons for Designation:

Status: Special Concern	Alpha-numeric codes: Not applicable.
Reasons for Designation: This anadromous species faces a number of threats in both freshwater and marine areas, which are causing habitat quality to decline. However, the number of mature individuals in the population is currently greater than numbers observed 1960-1995. While there has been a decline in the number of mature individuals over the past 3 generations, this decline occurred from the maximum observed in the 65-year time period. However, there has been a decline over the last three generations, and these fish may become Threatened if the factors leading to this decline are not managed effectively.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Does not meet criteria. While there was an estimated decline of 52% in the number of mature individuals over the past 3 generations, the 3-generation time period begins at the highest value in the 65-year time series. In addition, the numbers have increased over the last generation and are currently considerably higher than those observed 1960-1995.
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 not extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Does not meet criterion because the number of mature individuals exceeds the threshold for Threatened.
Criterion D (Very Small or Restricted Population): Does not meet criterion.
Criterion E (Quantitative Analysis): Not done.

Designatable Unit 12: Lillooet-Harrison-L population
Population Lillooet-Harrison-T

Demographic Information

1. Generation Time	4 years		
2. Is there a continuing decline in the number of mature individuals?	Yes		
4a. Change in number of mature individuals based on last 3 generations observations	-73%	p > 30% decline 100%	p > 50% decline 99%
4b. Change in number of mature individuals based on all observations	+26%	p > 30% decline 0%	p > 50% decline 0%
8. Are there extreme fluctuations in the number of mature individuals?	No		
10. Index of area of occupancy	84 km^2		
22. Number of mature individuals	49,048		

Threats

A threats calculator was not completed.

Status History:

Designated Special Concern in November 2017.

Status and Reasons for Designation:

Status: Special Concern	Alpha-numeric codes: Not applicable.
Reasons for Designation: This anadromous species faces a number of threats in both freshwater and marine areas, which are causing habitat quality to decline. The population increased considerably in abundance between 1960-1990 after which it declined. Although the current abundance is above or similar to levels observed in the 1950-1970 period, the population may become Threatened if current threats are not managed and the population continues to decline.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Does not meet criteria. While there was a decline in the number of mature individuals over the past 3 generations, this time period includes the downward side of a fluctuation. Based on IUCN guideline 4.5 on calculating a reduction, a longer time period was used to calculate the trend.
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 not extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Does not meet criterion because the number for mature individuals is estimated to be greater than 10,000.
Criterion D (Very Small or Restricted Population): Does not meet criterion
Criterion E (Quantitative Analysis): Not done.

Designatable Unit 13: Nahatlatch-ES population
Population Nahatlatch-DE

Demographic Information

1. Generation Time	4 years		
2. Is there a continuing decline in the number of mature individuals?	No		
4a. Change in number of mature individuals based on last 3 generations observations	-16%	p > 30% decline 31%	p > 50% decline 8%
4b. Change in number of mature individuals based on all observations	+9%	p > 30% decline 0%	p > 50% decline 0%
8. Are there extreme fluctuations in the number of mature individuals?	No		
10. Index of area of occupancy	12 km^2		
22. Number of mature individuals	2,946		

Threats

A threats calculator was not completed.

Status History:

Designated Special Concern in November 2017.

Status and Reasons for Designation:

Status: Special Concern	Alpha-numeric codes: Not applicable.
Reasons for Designation: The number of mature individuals is small and, if the threats lead to a decline in the number of mature individuals, it could become Threatened. This anadromous species faces a number of threats in both freshwater and marine areas, which are causing habitat quality to decline.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Does not meet criteria.
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 not extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Does not meet criterion. While the number of mature individuals is less than 10,000 and more than 95% of mature individuals are in one subpopulation, the number of mature individuals is not continuing to decline.
Criterion D (Very Small or Restricted Population): Does not meet criteria.
Criterion E (Quantitative Analysis): Not done.

Designatable Unit 14: North Barriere-ES population
Population North Barriere-DE

Demographic Information

1. Generation Time	4 years		
2. Is there a continuing decline in the number of mature individuals?	Yes		
4a. Change in number of mature individuals based on last 3 generations observations	-57%	p > 30% decline 95%	p > 50% decline 70%
4b. Change in number of mature individuals based on all observations	+113%	p > 30% decline 0%	p > 50% decline 0%
8. Are there extreme fluctuations in the number of mature individuals?	No		
10. Index of area of occupancy	20 km^2		
22. Number of mature individuals	4,416		

Threats

A threats calculator was not completed.

Status History:

Designated Threatened in November 2017.

Status and Reasons for Designation:

Status: Threatened	Alpha-numeric codes: C2a(ii)
Reasons for Designation: After having been extirpated by dam construction in the 1920s, a new population was established through transplants. Although the population initially grew quickly, the fish now face a number of threats in both freshwater and marine areas which are causing habitat quality to decline. Since 1980, there has been a continuous decline to a low number today.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Criterion does not apply because the decline may be part of a natural fluctuation.
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 not extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Meets Threatened, C2a(ii), because the number of mature individuals is less than 10,000, there is an estimated continuing decline in the number of mature individuals, and more than 95% of mature individuals are in one subpopulation.
Criterion D (Very Small or Restricted Population): Does not meet criteria.
Criterion E (Quantitative Analysis): Not done.

Designatable Unit 15: Pitt-ES population
Population Pitt-DE

Demographic Information

1. Generation Time	5 years		
2. Is there a continuing decline in the number of mature individuals?	Yes		
4a. Change in number of mature individuals based on last 3 generations observations	-48%	p > 30% decline 79%	p > 50% decline 45%
4b. Change in number of mature individuals based on all observations	+26%	p > 30% decline 0%	p > 50% decline 0%
8. Are there extreme fluctuations in the number of mature individuals?	No		
10. Index of area of occupancy	60 km^2		
22. Number of mature individuals	51,145		

Threats

A threats calculator was completed. The main threats were Climate change and severe weather, biological resource use, and geological events. The overall threat impact was Medium.

Status History:

Designated Not at Risk in November 2017.

Status and Reasons for Designation:

Status: Not at risk	Alpha-numeric codes: Not applicable.
Reasons for Designation: The number of mature individuals in the population is currently much higher than it was in the period 1950 to the late 1990s.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Does not meet criterion. While the population has declined over the last 3 generations, this appears to be part of a fluctuation. The population size is currently well above what it was in the first 40 years of the 65-year time series.

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 not extreme fluctuations.

Criterion C (Small and Declining Number of Mature Individuals): Does not meet criterion.

Criterion D (Very Small or Restricted Population): Does not meet criterion.

Criterion E (Quantitative Analysis): Not done.

Designatable Unit 16: Quesnel-S population
Population Quesnel-E

Demographic Information

1. Generation Time	4 years		
2. Is there a continuing decline in the number of mature individuals?	Yes		
4a. Change in number of mature individuals based on last 3 generations observations	-97%	p > 30% decline 100%	p > 50% decline 100%
4b. Change in number of mature individuals based on all observations	+272%	p > 30% decline 0%	p > 50% decline 0%
8. Are there extreme fluctuations in the number of mature individuals?	No		
10. Index of area of occupancy	352 km^2		
22. Number of mature individuals	260,974		

Threats

A threats calculator was completed. The main threats were climate change and severe weather, biological resource use, natural system modifications. The overall threat impact was High-Medium

Status History:

Designated Endangered in November 2017.

Status and Reasons for Designation:

Status: Endangered	Alpha-numeric codes: A2b+4b
Reasons for Designation: The population faces a number of threats in both freshwater and marine areas, which are causing habitat quality to decline. A potential new threat to the population is the failure of a mining tailings pond that drained into Quesnel Lake in 2014. The population has declined consistently since 2000.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): The number of mature individuals has declined by over 50% in the last 3 generations, and this is expected to continue.
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 in declining, but the population is not severely fragmented, locations do not apply, and there are not extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Does not meet criteria because the number of mature individuals exceeds 10,000.
Criterion D (Very Small or Restricted Population): Does not meet criteria.
Criterion E (Quantitative Analysis): Not done.

Designatable Unit 17: Seton-L population
Population Seton-T

Demographic Information

1. Generation Time	4 years		
2. Is there a continuing decline in the number of mature individuals?	Yes		
4a. Change in number of mature individuals based on last 3 generations observations	-88%	p > 30% decline 100%	p > 50% decline 100%
4b. Change in number of mature individuals based on all observations	+9%	p > 30% decline 0%	p > 50% decline 0%
8. Are there extreme fluctuations in the number of mature individuals?	No		
10. Index of area of occupancy	20 km^2		
22. Number of mature individuals	7,505		

Threats

A threats calculator was completed. The main threats were pollution, biological resource use, natural system modifications, and geological events. The overall threat impact was High-Medium

Status History:

Designated Endangered in November 2017.

Status and Reasons for Designation:

Status: Endangered	Alpha-numeric codes: A2b
Reasons for Designation: This anadromous species faces a number of threats in both freshwater and marine areas which are causing habitat quality to decline. The number of mature individuals in this population was relatively high and stable from the mid-1970s to the late-1990s. Since then the numbers have declined considerably to very low abundance and are close to a historical minimum.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets Endangered, A2b, because the number of mature individuals declined by more than 50% in the last 3 generations.
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 not extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Does not meet criterion for Endangered. Meets Threatened, C2a(ii), because the number of mature individuals is less than 10,000, there is an estimated continuing decline in the number of mature individuals, and more than 95% of mature individuals are in one subpopulation.
Criterion D (Very Small or Restricted Population): Does not meet criterion for Endangered. Meets Threatened D1 because the number of mature individuals is less than 1,000.
Criterion E (Quantitative Analysis): Not done.

Designatable Unit 18: Shuswap Complex-L population
Population Complexe Shuswap-T

Demographic Information

1. Generation Time	4 years
2. Is there a continuing decline in the number of mature individuals?	Yes
4a. Change in number of mature individuals based on last 3 generations observations	There is no trend in the number of mature individuals (see text for explanation).
4b. Change in number of mature individuals based on all observations	
8. Are there extreme fluctuations in the number of mature individuals?	No
10. Index of area of occupancy	652 km^2
22. Number of mature individuals	579,727

Threats

A threats calculator was completed. The main threats were climate change and severe weather, biological resource use, natural system modifications, and pollution. The overall threat impact was Medium.

Status History:

Designated Not at Risk in November 2017.

Status and Reasons for Designation:

Status: Not at risk	Alpha-numeric codes: Not applicable.
Reasons for Designation: This population has extreme cyclic dominance where the dominant cycle line is on average 600 times larger than the smallest. While the number of mature individuals of the largest cycle line is highly variable, it has never been lower than 500,000 fish, it has exceeded 2.5 million twice (2002 and 2010), and there is no trend in its abundance.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Does not meet criteria. There is no trend in the number of mature individuals.
Criterion B (Small Distribution Range and Decline or Fluctuation): Does not meet criteria. 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 not extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Does not meet criteria. The number of mature individuals exceeds 10,000.
Criterion D (Very Small or Restricted Population): Does not meet criteria.
Criterion E (Quantitative Analysis): Not done.

Designatable Unit 19: Shuswap-ES population
Population Shuswap-DE

Demographic Information

1. Generation Time	4 years		
2. Is there a continuing decline in the number of mature individuals?	No		
4a. Change in number of mature individuals based on last 3 generations observations	+30%	p > 30% decline 3%	p > 50% decline 1%
4b. Change in number of mature individuals based on all observations	+24%	p > 30% decline 0%	p > 50% decline 0%
8. Are there extreme fluctuations in the number of mature individuals?	No		
10. Index of area of occupancy	352 km^2		
22. Number of mature individuals	141,986		

Threats

A threats calculator was not completed.

Status History:

Designated Not at Risk in November 2017.

Status and Reasons for Designation:

Status: Not at risk	Alpha-numeric codes: Not applicable.
Reasons for Designation: The number of mature individuals in the population has increased since records were first taken in the mid-1950s. The population does not meet any risk criteria.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Does not meet criterion. The number of mature individuals is increasing.
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 not extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Does not meet criterion. The number of mature individuals exceeds 10,000.
Criterion D (Very Small or Restricted Population): Does not meet criterion.
Criterion E (Quantitative Analysis): Not done.

Designatable Unit 20: Takla-Trembleur-EStu population
Population Takla-Trembleur-à montaison hâtive dans la Stuart

Demographic Information

1. Generation Time	4 years		
2. Is there a continuing decline in the number of mature individuals?	Yes		
4a. Change in number of mature individuals based on last 3 generations observations	-54%	p > 30% decline 92%	p > 50% decline 61%
4b. Change in number of mature individuals based on all observations	+6%	p > 30% decline 0%	p > 50% decline 0%
8. Are there extreme fluctuations in the number of mature individuals?	No		
10. Index of area of occupancy	428 km^2		
22. Number of mature individuals	42,563		

Threats

A threats calculator was completed. The main threats were climate change and severe weather, biological resource use, natural system modifications. The overall threat impact was High-Medium.

Status History:

Designated Endangered in November 2017.

Status and Reasons for Designation:

Status: Endangered	Alpha-numeric codes: A2b+4b
Reasons for Designation: This anadromous species faces a number of threats in both freshwater and marine areas which are causing habitat quality to decline. The number of mature individuals has been declining steadily for over 20 years despite reductions in fishing mortality. Productivity is currently very low.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets Endangered, A2b+4b. The number of mature individuals has declined by 54% over the past 3 generations. This trend is expected to continue.
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 not extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Does not meet criterion. The number of mature individuals exceeds 10,000.
Criterion D (Very Small or Restricted Population): Does not meet criterion.
Criterion E (Quantitative Analysis): Not done.

Designatable Unit 21: Takla-Trembleur-Stuart-S population
Population Takla-Trembleur-Stuart-E

Demographic Information

1. Generation Time	4 years		
2. Is there a continuing decline in the number of mature individuals?	Yes		
4a. Change in number of mature individuals based on last 3 generations observations	-68%	p > 30% decline 100%	p > 50% decline 97%
4b. Change in number of mature individuals based on all observations	+60%	p > 30% decline 0%	p > 50% decline 0%
8. Are there extreme fluctuations in the number of mature individuals?	No		
10. Index of area of occupancy	164 km^2		
22. Number of mature individuals	66,073		

Threats

A threats calculator was not completed.

Status History:

Designated Endangered in November 2017.

Status and Reasons for Designation:

Status: Endangered	Alpha-numeric codes: A2b+4bd
Reasons for Designation: This anadromous species faces a number of threats in both freshwater and marine areas, which are causing habitat quality to decline. The number of mature individuals has been declining steadily for 3 generations yet removals by fishing remained high.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets Endangered, A2b+4bd. The decline over the last 3 generations was estimated to be 68%. This decline is projected to continue because fishing removals remain high.
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 not extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Does not meet criterion. The number of mature individuals exceeds 10,000.
Criterion D (Very Small or Restricted Population): Does not meet criterion.
Criterion E (Quantitative Analysis): Not done.

Designatable Unit 22: Taseko-ES population
Population Taseko-DE

Demographic Information

1. Generation Time	4 years		
2. Is there a continuing decline in the number of mature individuals?	Yes		
4a. Change in number of mature individuals based on last 3 generations observations	-84%	p > 30% decline 100%	p > 50% decline 99%
4b. Change in number of mature individuals based on all observations	-39%	p > 30% decline 99%	p > 50% decline 0%
8. Are there extreme fluctuations in the number of mature individuals?	No		
10. Index of area of occupancy	24 km^2		
22. Number of mature individuals	334		

Threats

A threats calculator was not completed.

Status History:

Designated Endangered in November 2017.

Status and Reasons for Designation:

Status: Endangered	Alpha-numeric codes: A2b; C2a(ii)
Reasons for Designation: This anadromous species faces a number of threats in both freshwater and marine areas which are causing habitat quality to decline. Poor data quality has caused a gap in population estimates in the middle of the time series (1960s-1990s). The number of mature individuals was relatively high in the late 1990s. Since then the numbers have declined considerably and are close to a historical minimum.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets Endangered, A2b, because the population has declined by over 50% in the past 3 generations.
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 not extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Meets Endangered, C2a(ii), because the number of mature individuals is less than 2,500, there is an estimated continuing decline, and more than 95% of mature individuals are in one subpopulation.
Criterion D (Very Small or Restricted Population): Does not meet criterion for Endangered. Meets Threatened D1 because the number of mature individuals is less than 1,000.
Criterion E (Quantitative Analysis): Not done.

Designatable Unit 23: Harrison (River-Type) population
Population Harrison - Rivière

Demographic Information

1. Generation Time	4 years		
2. Is there a continuing decline in the number of mature individuals?	No		
4a. Change in number of mature individuals based on last 3 generations observations	+2196%	p > 30% decline 0%	p > 50% decline 0%
4b. Change in number of mature individuals based on all observations	+38%	p > 30% decline 0%	p > 50% decline 0%
8. Are there extreme fluctuations in the number of mature individuals?	No		
10. Index of area of occupancy	20 km^2		
22. Number of mature individuals	205,975		

Threats

A threats calculator was not completed.

Status History:

Designated Not at Risk in November 2017.

Status and Reasons for Designation:

Status: Not at risk	Alpha-numeric codes: Not applicable.
Reasons for Designation: The number of mature individuals in the population has increased considerably over the past three generations and is now at a historical high.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Does not meet criteria. The number of mature individuals is estimated to be increasing.
Criterion B (Small Distribution Range and Decline or Fluctuation): Does not meet criteria. 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 not extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Does not meet criteria. The number of mature individuals exceeds 10,000
Criterion D (Very Small or Restricted Population): Does not meet criteria.
Criterion E (Quantitative Analysis): Not done.

Designatable Unit 24: Widgeon (River-Type) population
Population Widgeon - Rivière

Demographic Information

1. Generation Time	4 years		
2. Is there a continuing decline in the number of mature individuals?	No		
4a. Change in number of mature individuals based on last 3 generations observations	1145%	p > 30% decline 0%	p > 50% decline 0%
4b. Change in number of mature individuals based on all observations	-25%	p > 30% decline 20%	p > 50% decline 0%
8. Are there extreme fluctuations in the number of mature individuals?	No		
10. Index of area of occupancy	4 km^2		
22. Number of mature individuals	656		

Threats

A threats calculator was not completed.

Status History:

Designated Threatened in November 2017.

Status and Reasons for Designation:

Status: Threatened	Alpha-numeric codes: D1
Reasons for Designation: This is a naturally small population which faces a number of threats in both freshwater and marine areas which are causing habitat quality to decline. The number of mature individuals was relatively stable from 1950 to 1990, and then declined considerably to a minimum in 2000. Over the past 3 generations the number of fish has returned to pre-1990 abundances. However, the small population size makes them vulnerable to stochastic events and increasing threats.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Does not meet criterion. The number of mature individuals is increasing.
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 not extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Does not meet criterion. While the number of mature individuals is small, there is no continuing decline.
Criterion D (Very Small or Restricted Population): Meets Threatened D1 because the number of mature individuals is less than 1,000.
Criterion E (Quantitative Analysis): Not done.

Technical Summaries, Part II

The following are sections of the technical summary that have the same entries for each DU. These sections were removed from the DU-specific technical summaries above to reduce the document size.

Demographic Information

Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Not done
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Not done
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	Not done
Are the causes of the decline a. clearly reversible and b. understood and c. ceased?	a. No b. No c. No

Extent and Occupancy Information

Estimated extent of occurrence (EOO)	> 20,000 km²
Is the population "severely fragmented" i.e., is >50% of its total area of occupancy in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. No b. No
Number of "locations"* (use plausible range to reflect uncertainty if appropriate)	NA, known threats are insufficient to cause a rapid decline
Is there an [observed, inferred, or projected] decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	No
Is there an [observed, inferred, or projected] decline in number of subpopulations?	No
Is there an [observed, inferred, or projected] decline in number of "locations"*?	No
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Yes
Are there extreme fluctuations in number of subpopulations?	No
Are there extreme fluctuations in number of "locations"∗?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

* See Definitions and Abbreviations on COSEWIC web site and IUCN (Feb 2014) for more information on this term

Quantitative Analysis

Is the probability of extinction in the wild at least [20% within 20 years or 5 generations, or 10% within 100 years]?	Not done

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	NA, the DU is a Canadian endemic
Is immigration known or possible?	NA
Would immigrants be adapted to survive in Canada?	NA
Is there sufficient habitat for immigrants in Canada?	NA
Are conditions deteriorating in Canada?[+]	NA
Are conditions for the source (i.e., outside) population deteriorating?[+]	NA
Is the Canadian population considered to be a sink?[+]	NA
Is rescue from outside populations likely?	NA

Data Sensitive Species

Is this a data sensitive species?	No

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

PREFACE

This is a new assessment for all extant DUs of Sockeye Salmon in the Fraser River drainage with the exception of Cultus-L. Cultus-L was assessed as Endangered in an emergency assessment in 2002 and confirmed in 2003. These Sockeye populations in the Fraser have been very well monitored for many years. This report brings together an impressive amount of knowledge and experience regarding the conservation status of this important species.

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
(2017)

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

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

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

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

Environment and Climate Change Canada
Canadian Wildlife Service

Environnement et Changement climatique Canada
Service canadien de la faune

Canada

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

COSEWIC Status Report

on the

Sockeye Salmon
Oncorhynchus nerka

24 Designatable Units in the Fraser River Drainage Basin

in Canada

2017

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Class: Actinopterygii

Order: Salmoniformes

Family: Salmonidae

Latin binomial: *Oncorhynchus nerka* (Walbaum)

Designatable Unit: See DU section.

Common species names:

English – Sockeye Salmon (Hart 1973); red salmon (Alaska), blueback salmon (Columbia River) (Burgner 1991); Kokanee, little redfish, silver trout (non-anadromous form only)

French – saumon rouge (COSEWIC 2003), saumon Sockeye

First Nations – stheqi (Halq'emeylem), Talok (Wet'suwet'en), talo (Yekooche), ts'eman (Tsilhqot'in, talook (Lhatko Dene), Talukw (Carrier Sekani) and Samman or Saumo (Michif/Chinook) (COSEWIC 2012)

Other – nerka and krasnaya ryba (Russia), benizake and benimasu (Japan) (Burgner 1991); himemasu (Japan) for the non-anadromous form (Burgner 1991)

Morphological Description

Morphological aids to identification of Sockeye Salmon include: a dorsal fin with 11-16 rays; a small, slender and fleshy adipose fin; 13-18 anal fin rays; pelvic fins abdominal in position with 9-11 rays and a free-tipped fleshy appendage above the insertion point; pectoral fins with 11-21 rays; cycloid scales; gill rakers (29-43) that are long, rough, slender, and closely set on the first gill arch; and an elongate body with moderate lateral compression. In juveniles, the parr marks are oval, shorter than the diameter of the eye, and usually above the lateral line (Pauley *et al.* 1989).

Like other Pacific salmon, Sockeye develop secondary sexual characteristics as they return to freshwater spawning grounds. During maturation, male Sockeye develop large teeth, a pronounced “kype” (hooked jaw), and a small dorsal hump (less pronounced than in male Pink Salmon (*Oncorhynchus gorbuscha*)); females largely retain their marine body shape (Groot and Margulis 1991) (Figure 1). Both males and females undergo a distinctive transformation of external colour; the head and tail become olive green while the body changes to a brownish red that later becomes a brilliant scarlet, giving the species the common name of “red salmon”. Before developing their spawning colours, Sockeye are silver-blue in colour, with fine black speckling on the back but lacking large dark spots. Sockeye range from 2.2 to 3.1 kg in weight (averaging 3 kg, but in some cases over 6 kg) (COSEWIC 2003; Grant *et al.* 2011), and 50-60 cm in total length (Rand *et al.* 2012). Detailed morphological descriptions can be found in Foerster (1968), Hart (1973), Scott and Crossman (1973), and Burgner (1991).

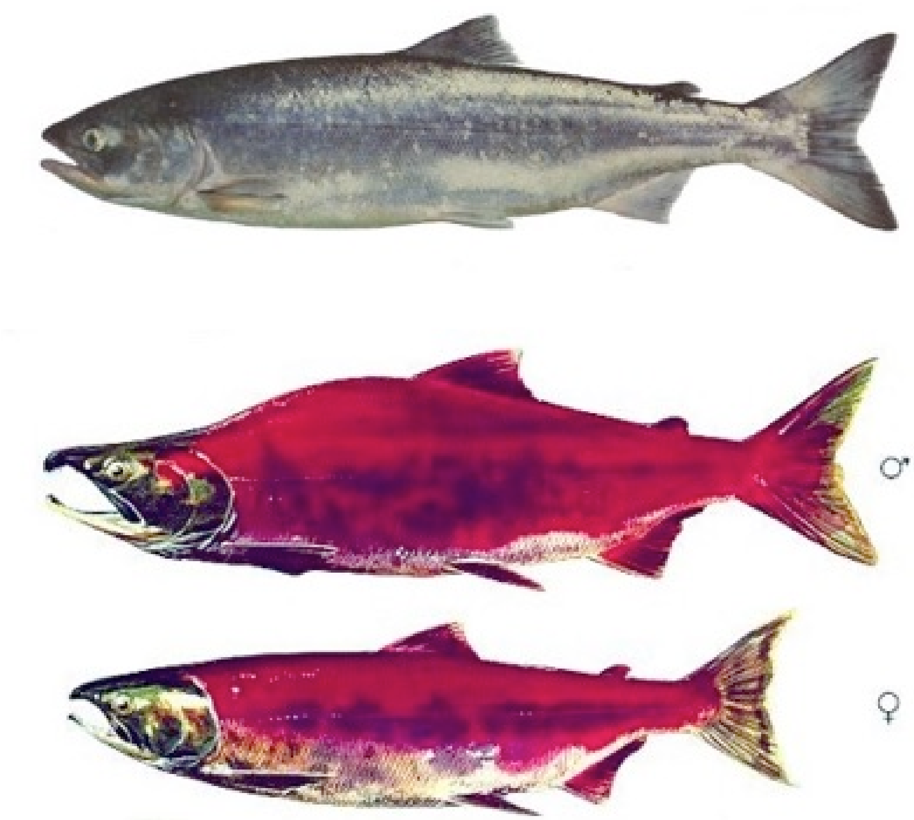


Figure 1. Sockeye Salmon ocean phase (top), freshwater phase adult male (middle), and freshwater phase adult female (bottom) (DFO 2017).

Population Spatial Structure and Variability

Information about population spatial structure and variability is addressed in the section below about designatable units.

Designatable Units

Background

The Sockeye Salmon species is composed of thousands of reproductively isolated populations that can be divided into three simple ecotypes based on their freshwater life history. The “lake-type” ecotype is most common. After spawning in freshwater, these fish rear for a year or more in a lake prior to migrating to sea (Burgner 1991). The “river-type” ecotype is also migratory (anadromous) but does not rear in a lake, instead residing for a variable, often shorter, period of time in side channels and sloughs before migrating to sea (Gilbert 1913). Lastly, the Kokanee ecotype does not go to sea (nonanadromous) and is found only in lakes (Nelson 1968). Because these ecotypes exploit very different niches they each have corresponding adaptations in attributes such as size at the stage when they become ready to go to sea (called “smolts”), morphology, fecundity, egg size, and size and age at maturity. The Kokanee ecotype was not considered in this COSEWIC assessment.

It is thought that river-type Sockeye gave rise to contemporary lake-type populations following the retreat of glaciers over the past 15,000 years, with Kokanee-type populations subsequently evolving from lake-type populations within drainages (Wood 1995; Wood *et al*. 2008). This is supported by four lines of evidence: (1) gene flow is greater among river-type than lake-type populations (Gustafson and Winans 1999), which suggests less fidelity to spawning sites than lake-type populations; (2) genetic diversity is as great or greater in river-type populations compared to the other two ecotypes and hence consistent with the river-type ecotype as the ancestral type; (3) river-type and lake-type populations appear to have been derived from more than one river-type ancestor multiple times (i.e., are polyphyletic) and typically do not appear as separate descendants from a common ancestor (i.e., a clade) within regions (Wood 1995; Gustafson and Winans 1999; Beacham *et al.* 2004; Wood *et al*. 2008); and (4) Kokanee populations appear to have evolved independently from lake-type populations on numerous, independent, occasions (reviewed by Wood and Foote 1996).

Comparison of Designatable Units with Conservation Units

The approach used to identify putative Fraser River Sockeye designatable units (DUs) is based upon COSEWIC guidelines (“*Appendix F5: Guidelines for Recognizing Designatable Units*”), the original identification of conservation units (CU) under the Wild Pacific Salmon Policy (WSP) by Fisheries and Oceans Canada (DFO) (Holtby and Ciruna 2007), and subsequent updates to Fraser River Sockeye CU designation described by Grant *et al*. (2011).

COSEWIC's DUs 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 (COSEWIC 2012). COSEWIC recognizes three different lines of evidence for "discreteness" and four different lines of evidence for "evolutionary distinctness". At least one line of evidence from each must be met to justify a DU designation:

Discreteness:

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

Evolutionary Significance:

1. Evidence that the discrete population differs markedly from others in genetic characteristics thought to reflect relatively deep phylogenetic divergence, e.g., based on relatively slow-evolving markers;
2. Persistence of the discrete population in a unique ecological setting that is likely or known to have given rise to local adaptations;
3. Evidence that the discrete population is the only surviving natural occurrence of a species that is only found elsewhere as an introduced species;
4. Evidence that loss of the discrete population would result in an extensive gap in the range of the species in Canada.

The Wild Salmon Policy's CUs are "a group of wild salmon sufficiently isolated from other groups that, if extirpated, are very unlikely to recolonize naturally in an acceptable timeframe", where an acceptable timeframe could correspond to a human lifetime or specified number of salmon generations (Fisheries and Oceans Canada 2005). Consideration of rates of colonization and adaptation led Waples *et al*. (2001) to conclude "local populations of Pacific salmon are not replaceable over ecological time frames. Empirical evidence indicates that if a local population is lost, it is not likely to be replaced (even with active human intervention) within a time span of interest to humans". When discussing the timeframe of local adaptation in their derivation of salmon CUs, Holtby and Ciruna (2007) note: "While in geological time, local adaptation has taken the proverbial blink of an eye, in human terms it has required a third of our species' recorded history." The Wild Salmon Policy notes: "Diversity includes the irreplaceable lineages of salmon evolved through time, the geographic distribution of these populations, the genetic differences and life history variations observed among them, and the habitats that support these differences. Diversity of Pacific salmon represents their legacy to-date and their potential for adaptation to future changes in climate, fishing, and habitat."

COSEWIC's DUs and DFO's CUs are therefore very similar. The goal of both CUs and DUs is to maintain genetic variability at the species level and as such isolation and distinctiveness are central defining characteristics. In addition, both CUs and DUs emphasize the probability of natural replacement or recolonization as crucial to defining a population though the DU definition does not dictate a timeframe while the CU definition states this should occur within an "acceptable" timeframe. Although DFO does not use COSEWIC's DU terminology, their designation of CUs, which is explained in more detail below, is based on both Discreteness (especially subcriteria 1 and 3), and Evolutionary Significance (subcriteria 1 and 2).

When considering salmon, an important aspect in which CUs and DUs differ is in how they treat enhanced populations (e.g., via a hatchery or spawning channel). Conservation units refer exclusively to naturally reproducing salmon while DUs can include enhanced populations if they are deemed to have a neutral or positive effect on the fitness of wild conspecifics.

<u>Methods and Results:</u>

Much effort has gone into the development and application of the CU methodology to Pacific salmon in Canada (Holtby and Ciruna 2007; DFO 2009) and its refinement for Fraser River Sockeye (Grant *et al.* 2011). We reviewed this work and evaluated the WSP derived CU designations from DFO through the lens of the COSEWIC lines of evidence for Distinctness and Evolutionary Significance for Fraser River Sockeye Salmon. This allowed us to evaluate whether the application of COSEWIC criteria would result in Fraser Sockeye DU designations that differ from the CU designations already arrived at through the application of WSP criteria (Grant *et al*. 2011). It was concluded that there is a direct 1:1 correspondence between the proposed Fraser River Sockeye DUs and existing DFO CUs. In the rest of this section, drawing upon the extensive work done by DFO as detailed in Holtby and Ciruna (2007), DFO (2009), and Grant *et al.* (2011), the process by which DFO scientists arrived at CU designations for Fraser River Sockeye Salmon is described as is how these designations meet COSEWIC criteria for distinctness and evolutionary significance.

Within the Fraser Basin, the methodologies used to enumerate the abundance of returning salmon and the number that spawn successfully have varied over time and among census sites. For details of enumeration methods for census sites within individual spawning populations see Grant *et al*. (2011).

Sockeye Salmon may have colonized the Fraser watershed from two directions after the last glaciation (Withler *et al*. 2000): from the north via connections to the Columbia and/or Skeena drainages (Wood 1995), and from the south. However, as noted below, there is more genetic variation *within* each of these putative original lineages than *between* them, so this pre-glacial division is not helpful for designating DUs.

Step 1: Division between river and lake-type ecotypes

There is clear evidence that river- and lake-type ecotypes are discrete (i.e., they naturally inhabit different environments during their freshwater rearing phase where they reproduce such that local adaptation is likely (discreteness subcriterion 2) and evolutionarily significant (i.e., they are markedly genetically different, significance subcriterion 1; Gustafson and Winans 1999). Therefore, to arrive at DUs, Fraser Sockeye populations can first be separated by these two life history types as was done for Sockeye CUs.

Step 2: Division among nursery lakes

Lake-type Sockeye populations that rear in a common nursery lake represent geographically distinct population units (discreteness subcriterion 1) which are likely to give rise to local adaptation owing to the unique ecological attributes of a given nursery lake (significance subcriteria 2 and 3). Population differentiation in lake-type Sockeye populations has been studied extensively and in most cases across their range. Sockeye reared in different nursery lakes are genetically distinct (reviewed in Wood 1995). For those nursery lakes that have been sampled in the Fraser Basin (over 13,000 Sockeye from 47 spawning populations) there is extensive evidence of genetic differentiation among most nursery lakes based on microsatellites and major histocompatibility complex loci (Wood *et al*. 1994; Withler *et al*. 2000; Beacham *et al*. 2006). Genetic variation among lakes within the upper and lower Fraser watershed is more than twice as large as variation between these two regions, despite evidence of separate colonization events from the north and south (Withler *et al*. 2000). DFO (2009) note that further evidence of adaptation is that "nearly all transplants of Sockeye between lakes have failed, sometimes despite decades of attempts", suggesting local adaptation to nursery lake of origin. This conclusion was based partly on an extensive review by Withler (1982), who summarized dozens of repeated attempts to transplant Sockeye over an 80-year period in BC. There have been two exceptions, where populations were extirpated, but transplanted fish became self-sustaining. These are described below, under Step 5**.**

As described in Grant *et al.* (2011), exceptions to grouping spawning populations by nursery lake included:

1. Sockeye that spawn in the Stellako River and that rear primarily in Fraser Lake but also to a limited extent in Francois Lake;
2. Sockeye that spawn in the Nadina River and tributaries to Nadina Lake and which rear in both Nadina and Francois Lakes;
3. Populations that rear in Quesnel, McKinley and Horsefly Lakes;
4. Sockeye that rear in lakes that are part of the Shuswap complex: Shuswap, Little Shuswap, Mara, Mabel, Adams, and Momich; and
5. Sockeye that rear in the Takla and Trembleur Lakes.

In these five cases nursery lakes are small (<~100 ha), close together geographically and / or tightly coupled hydrologically, and have little evidence of genetic differentiation among lakes (Beacham *et al*. 2004; Holtby and Ciruna 2007; Grant *et al*. 2011). They therefore lack evidence of evolutionary significance except in cases where there were significant differences in run timing among populations within each of the lake complexes (see below).

Step 3: Division according to run-timing

Patterns of genetic differentiation have also been observed within lake-type Sockeye populations, sometimes associated with differences in spawning timing and life history (e.g., Ramstad *et al*. 2003). Even in instances where genetic differentiation has not been quantified, significant differences in run-timing among life history variants can be considered evidence of evolutionary significance because these differences indicate local adaptation (e.g., adaptation to in-river thermal conditions experienced during upriver migration, as demonstrated for Fraser Sockeye Salmon by Eliason *et al*. 2011), (significance subcriterion 2).

Within the Fraser, the timing of upstream migration to spawning grounds is typically broken down into four run-timing groups: the Early Stuart Run, the Early Summer Run, Summer Run and Late Run, which historically have seen 50% of fish migrate through Hells Gate by July 14th, August 6th, August 17th and September 21st, respectively. These four groups are used for management purposes. There is considerable overlap in the timing of these groups, and they do not generally have strong congruence with geographical or phylogenetic distributions of the fish. Therefore, they cannot be used as a basal feature for dividing populations, but they can be used to make distinctions *within* populations.

As described in Grant *et al.* (2011), within some lake-type Sockeye population units there is evidence of significant differences in the timing of upstream migration to spawning sites:

1. Sockeye that rear in Chilko Lake and that originate from adults that return to spawn in two distinct run-timing groups (Early Summer and Summer) and that spawn in the south and north end of the lake, respectively;
2. Sockeye that rear in Francois Lake and that originate from spawners that return in the Early Summer and Summer run-timing groups;
3. Sockeye that rear in the lakes of the Shuswap complex and that originate from both Early Summer and Late run-timing spawners; and
4. Sockeye that rear in the Stuart, Takla and Trembleur Lakes and that originate from Early Stuart and Summer run-timing groups.

In each of these four cases, lake-type population units can be divided by run-timing groups because these local adaptations are considered evidence of evolutionarily significant differences among populations.

Step 4: Division between juvenile migration behavior

Within the Fraser there is also evidence of significant differences in the behaviour of juveniles from geographically nearby spawning sites (e.g., outlet and inlet spawners). This is the case for Sockeye that rear in Harrison Lake which have very distinct juvenile life histories depending on whether or not they originate from tributaries upstream (inlet spawners) or downstream (outlet spawners) of the lake. Sockeye fry from Weaver Creek migrate downstream to the Harrison River and then upstream to the lake, while those that spawn upstream of Harrison Lake migrate downstream to rear in it. These differences in fry behaviour associated with inlet versus outlet spawning can be considered important components of adaptive diversity in these systems (Burgner 1991; Holtby and Ciruna 2007) and so are considered evidence of an evolutionarily significant difference between the lake outlet and inlet spawner populations.

Step 5: Consideration of extinctions and new DUs from transplants

Seven lake-type Sockeye populations are believed to have been extirpated (Grant *et al*. 2011) including:

1. Early Summer run timed Sockeye that spawned in the upper Adams River and reared in Adams lake but which are thought to have become extinct due to the combined effects of the 1913 Fraser Canyon's Hells Gate landslide and splash damming (temporary damming of a river to raise the water level and float logs downstream to sawmills) on the upper Adams River from 1908-1940. The upper Adams River currently has a small population that originated from hatchery enhancement (fry releases) from the Seymour River and it is uncertain if this new hatchery-origin population will be self-sustaining without future hatchery supplementation;
2. Early Summer run timed Sockeye that spawned in the Momich and Cayenne Creeks and reared in Momich Lake but which are thought to have become extinct due to the combined effects of the 1913 Fraser Canyon's Hells Gate landslide and splash damming on the Upper Adams River from 1908-1940. Like the upper Adams River, the Momich and Cayenne currently has a small population that originated from hatchery enhancement from the Seymour River which are genetically distinct (due to founder effects; Withler *et al.* 2010). It is uncertain if this hatchery-origin population will be self-sustaining without future hatchery supplementation;

3. Early Summer run timed Sockeye that reared in Alouette Lake prior to the construction of a hydroelectric dam (1925) which blocked fish passage and extirpated the population. Kokanee that are resident in Alouette lake and that originated from pre-dam Sockeye have retained the ability to become anadromous again, as evidenced from juvenile Kokanee that have emigrated from the lake in an experimental spill over the dam and returned as adults (Mathews and Bocking 2007; Godbout *et al.* 2011);
4. Early Summer run timed Sockeye that reared in Coquitlam Lake prior to the construction of a hydroelectric dam (1925) which blocked fish passage and extirpated the population. Like Kokanee in Alouette lake, Coquitlam Kokanee have retained the ability to become anadromous again, as evidenced from juvenile Kokanee that have emigrated from the lake in experimental spill over the dam and returned as adults (Godbout *et al.* 2011);
5. Early Summer run timed Sockeye from the Endako and Ormonde rivers that reared in Fraser Lake but which have not been observed, despite monitoring, since the 1970s, for unknown reasons;
6. Early Summer run timed Sockeye that spawned in the Barriere River and reared in North Barriere Lake and became extinct following the damming of the river. The dam was decommissioned in 1952 and a population has been re-established due to hatchery transplants from the Raft River and has been self sustaining for at least the past 50 years (~10 generations); and
7. Summer run timed Sockeye that spawned in Portage Creek and reared in Seton Lake. This population became extinct as a result of early hatchery operations, the 1913 Hells Gate landslide and water diversion from Seton Lake. It has been replaced by a population that has been established by hatchery transplants from the lower Adams River and is now self-sustaining. The population has been self-sustaining for at least the past 30 years (~6 generations) and now has a late run-timing.

The two cases above where extinct populations have been re-established with transplants from other populations, North Barriere and Seton, were considered unique DUs. Though genetically similar to their donor populations (based on neutral loci), these populations were considered unique DUs because these populations have been self-sustaining since the 1960s and are geographically distinct from their donor populations, suggesting that local adaptation to their unique characteristics of their nursery lakes and migration routes is likely to have occurred.

Step 6: Division of river-type populations by Joint Adaptive Zones

As described by Holtby and Ciruna (2007), river-type Sockeye populations can be separated at first based on Joint Adaptive Zones (JAZs), which meet the COSEWIC criteria for discreteness of populations based on geographic range and eco-geographic regions. Joint Adaptive Zones represent distinct geographic ranges that are described by the intersection between a Freshwater Adaptive Zone and a Marine Adaptive Zone where local adaptation, and hence evolutionary significance, is likely (Holtby and Ciruna 2007). In five of six cases, there is only a single potential population within each JAZ and so each of these can be considered a possible river-type DU. In the one JAZ in the Fraser Basin that had more than one possible population unit, the populations (Lower Fraser and Fraser Canyon) have been further separated based on genetic evidence of local adaptation (Holtby and Ciruna 2007). However, of the resulting seven possible DUs, spawner observations in five DUs are suspected or confirmed dropouts from other DUs (i.e., spawners that spilled over from lake-type populations in years of high spawner abundance; “Lower Fraser”, “Middle Fraser”, “Upper Fraser”, “Thompson River” and “Fraser Canyon”) (Grant *et al*. 2011). Therefore, these are not considered unique CUs or DUs.

There was no information to further subdivide DUs into separate subpopulations. These DU exist at a relatively fine spatial scale that essentially precludes isolation of spawning components such that subpopulation structure could develop. For the purposes of this report it was assumed that each DU exists as a single subpopulation.

<u>Final list of DUs</u>

Based on the hierarchy of distinctions described above for lake- and river-type Sockeye in the Fraser basin, as used by DFO in their WSP CU designations (Grant *et al.* 2011), there is a total of 31 DU designations composed of 22 lake-type DUs, two river-type DUs and five extinct DUs, and two potentially extirpated DUs (see next paragraph) (Table 1 and Figure 2). This report uses the same names as those designated by DFO (Grant *et al.* 2011). In addition, there are six potential CUs identified by DFO that currently require validation (e.g., research to determine persistence of spawners, life-history types) (Grant *et al.* 2011). Because the status of these DUs is currently unknown we did not consider these populations further in our assessment.

Two of the DUs assumed to be extirpated (Alouette-ES and Coquitlam-ES) have had adult sockeye (re-anadromized Kokanee) return to spawn in recent years. However, due to a short history of returns (e.g., 8 years for Alouette-ES with none in 2014) and lack of data on population structure these DUs were not considered further in this assessment.

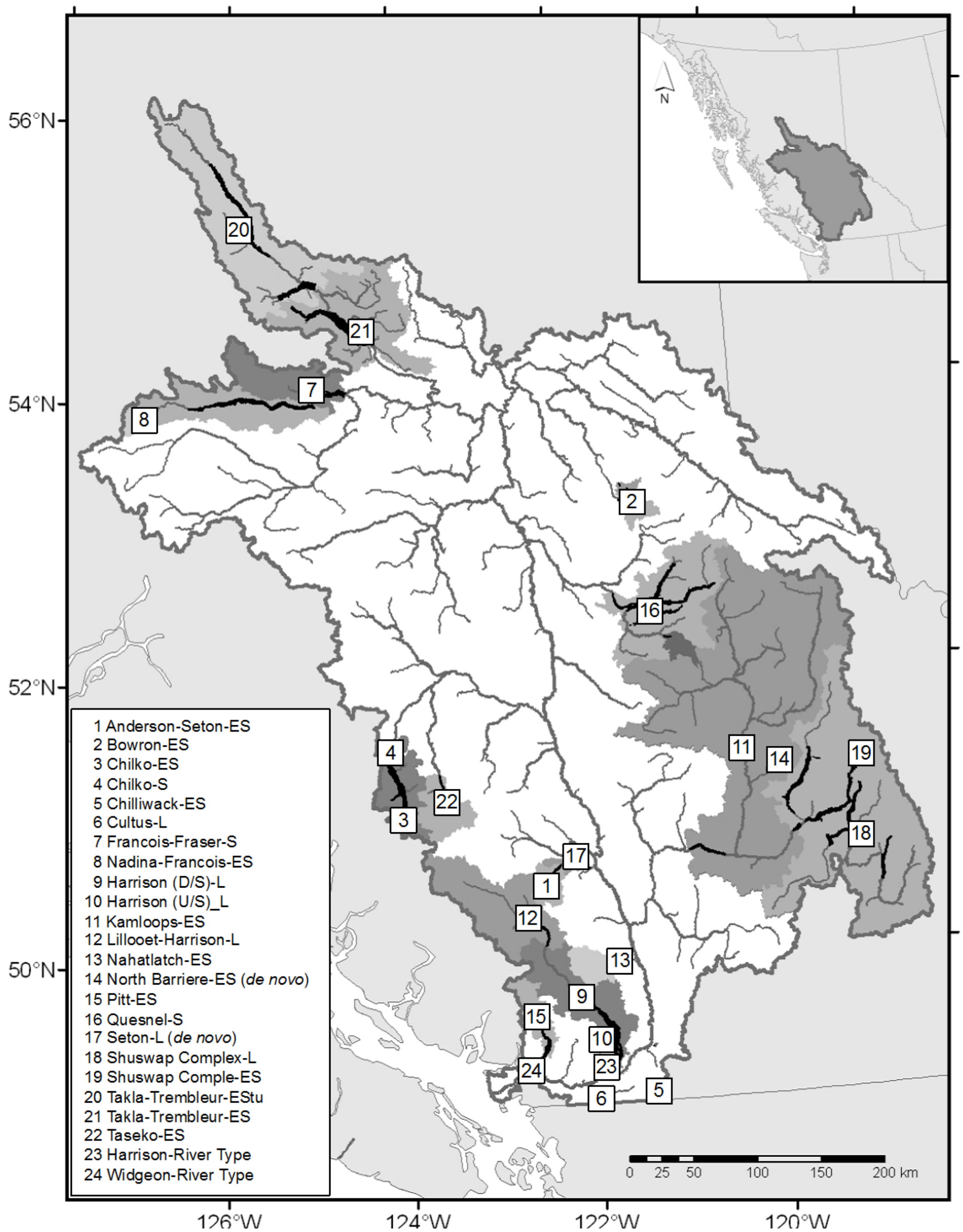


Figure 2: Fraser River basin, watershed boundaries (in shades of grey), and nursery lakes (in black) for all extant Sockeye Salmon designatable units (see legend for names and corresponding DU numbers). Note that different shades of grey are used to represent the upstream watershed boundaries for different DUs. In some cases several DUs overlap and as a result their boundaries only appear once. See Table 1 for additional details of each DU and corresponding Wild Salmon Policy Conservation Units.

Table 1: Originally proposed DUs for Fraser Sockeye Salmon. Note that these are identical to the CU names from the Government of Canada's Wild Salmon Policy and those described in Grant *et al.* (2011). Letters after each DU name refer to the four main run timing groups in the Fraser: "EStu" is Early Stuart, "ES" is Early Summer, "S" is Summer and "L" is Late. D/S means downstream and U/S means upstream.

Proposed DU Number	Proposed DU Name	Stock name	Rationale
1	Anderson-Seton-ES	Gates	Two nursery lakes in close proximity.
2	Bowron-ES	Bowron	Single nursery lake.
3	Chilko-ES	Chilko	Single nursery lake with DU separated from "Chilko Summer" DU by run timing and location of spawning.
4	Chilko-S	Chilko	Single nursery lake with DU separated from "Chilko Early Summer" DU by run timing and location of spawning.
5	Chilliwack-ES	Miscellaneous early summers	Single nursery lake.
6	Cultus-L	Cultus	Single nursery lake.
7	Francois-Fraser-S	Stellako	Two nursery lakes in close proximity. Francois Lake Sockeye further separated by "Summer" (grouped here) and "Early Summer" (Nadina-Francois-ES) run-timing.
8	Nadina-Francois-ES	Nadina	Two nursery lakes in close proximity (Francois and Nadina). Francois Lake Sockeye further separated by "Summer" (Francois-Fraser-S-S DU) and "Early Summer" (grouped here) run-timing. This DU currently requires validation, as described in Grant *et al.* (2011), to determine if it should be considered two separate CUs.
9	Harrison(D/S)-L	Miscellaneous Lates	Single nursery lake further separated from "Harrison Lake (upstream)" DU by spatial separation of spawners and unique fry migration (downstream to lake).
10	Harrison(U/S)-L	Weaver	Single nursery lake further separated from "Harrison Lake (downstream)" DU by spatial separation of spawners and unique fry migration (upstream from Weaver Creek to lake).
11	Kamloops-ES	Raft and miscellaneous Early Summers	Single nursery lake.
12	Lillooet-Harrison-L	Birkenhead	Two nursery lakes in close proximity.
13	Nahatlatch-ES	Miscellaneous Early Summers	Single nursery lake.

Proposed DU Number	Proposed DU Name	Stock name	Rationale
14	North Barriere-ES (*de novo*). Note, *'de novo'* was not included in the final DU name.	Upper Barriere and miscellaneous Early Summers	Single nursery lake. Self-sufficient introduced population from hatchery transplants from the Raft River.
15	Pitt-ES	Pitt	Single nursery lake.
16	Quesnel-S	Quesnel	Two nursery lakes (Quesnel and McKinley) in close proximity with vast majority of rearing occurring in Quesnel Lake.
17	Seton-L (*de novo*). Note, *'de novo'* was not included in the final DU name.	Portage	Single nursery lake. Self-sufficient introduced population from hatchery transplants from the Lower Adams River.
18	Shuswap Complex-L	Late Shuswap	Multiple closely coupled lakes further separated from the "Shuswap Early Summer" DU by run timing.
19	Shuswap -ES	Scotch, Seymour and miscellaneous Early Summers	Multiple closely coupled lakes further separated from the "Shuswap late" DU by run timing.
20	Takla-Trembleur-EStu	Early Stuart	Two closely coupled lakes further separated from the "Takla-Trembleur Summer" DU by run timing.
21	Takla-Trembleur-Stuart-S	Late Stuart	Multiple closely coupled lakes further separated from the "Takla-Trembleur Early Stuart" DU by run timing.
22	Taseko-ES	Miscellaneous Early Summers	Single nursery lake.
23	Harrison - (River-Type)	Harrison	Genetically and geographically distinct from other river-type Sockeye.
24	Widgeon - (River-Type)	Miscellaneous Summers	Genetically and geographically distinct from other river-type Sockeye.
25	Adams-ES	-	Single nursery lake. Became extinct because of Hells Canyon landslide and splash damming.
26	Alouette-ES	-	Single nursery lake. Extirpated by construction of dam but Kokanee in lake have retained the ability to become anadromous.
27	Coquitlam-ES	-	Single nursery lake. Extirpated by construction of dam but Kokanee in lake have retained the ability to become anadromous.

Proposed DU Number	Proposed DU Name	Stock name	Rationale
28	Fraser-ES	-	Single nursery lake. Extinct.
29	Momich-ES	-	Single nursery lake. Became extinct because of Hells Canyon Landslide and splash damming.
30	North Barriere-ES (Note, current DU in this location bears the same name.)	-	Single nursery lake. Became extinct because of construction of dam.
31	Seton-S	-	Single nursery lake. Became extinct because of construction of dam.

Special Significance

For a single river system, the Fraser River supports the largest abundance of Sockeye Salmon in the world (Northcote and Larkin 1989). These Sockeye are an icon in BC and an important species for human, marine, freshwater, and terrestrial communities.

Sockeye Salmon represent a cultural cornerstone providing food, social, and ceremonial values for First Nations throughout British Columbia (Nelitz *et al*. 2011; COSEWIC 2012). These fish are also central to First Nations spiritual beliefs about creation and the calendar (COSEWIC 2012). Fraser Sockeye have also historically been an important contributor to a multi-million dollar commercial salmon fishery in British Columbia (Nelson 2006; DFO 2008). In 2014, Fisheries and Oceans Canada awarded commercial licences for Sockeye to 22 First Nations groups along the Fraser River (Bennett 2014). In addition to their commercial value Fraser Sockeye support sport fisheries in the southern Strait of Georgia and lower Fraser River as well as ecotourism activities around Shuswap and Adams lakes.

Fraser Sockeye are also a significant component of the natural ecosystems in which they rear, migrate, and spawn. Fraser Sockeye are prey for numerous species throughout their life cycle and their return migrations deliver energy and nutrients from the North Pacific Ocean deep into the province of BC. This pulse of energy and nutrients directly and indirectly supports numerous components to their aquatic and terrestrial ecosystems (Gende *et al*. 2002; Naiman *et al.* 2002; Nelitz *et al*. 2006).

DISTRIBUTION

Global Range

As a species, Sockeye Salmon occur in the temperate and sub-arctic waters of the North Pacific Ocean, the Bering Sea, and the Sea of Okhotsk (Figure 3) (Burgner 1991). In Asia, the spawning distribution extends to the Kamchatka Peninsula and the northern part of the Sea of Okhotsk. In North America, they range from the Columbia River in the south to Kotzebue Sound in Alaska, and to the western tip of the Aleutian Islands (Augerot *et al.* 2005).

North America supports most (~90%) of the world's wild Sockeye Salmon biomass, with nearly 50% from the Bristol Bay region of Alaska. The species often exhibits a freshwater life history form known as Kokanee, but demographic data on Kokanee are limited (Rand *et al*. 2012).

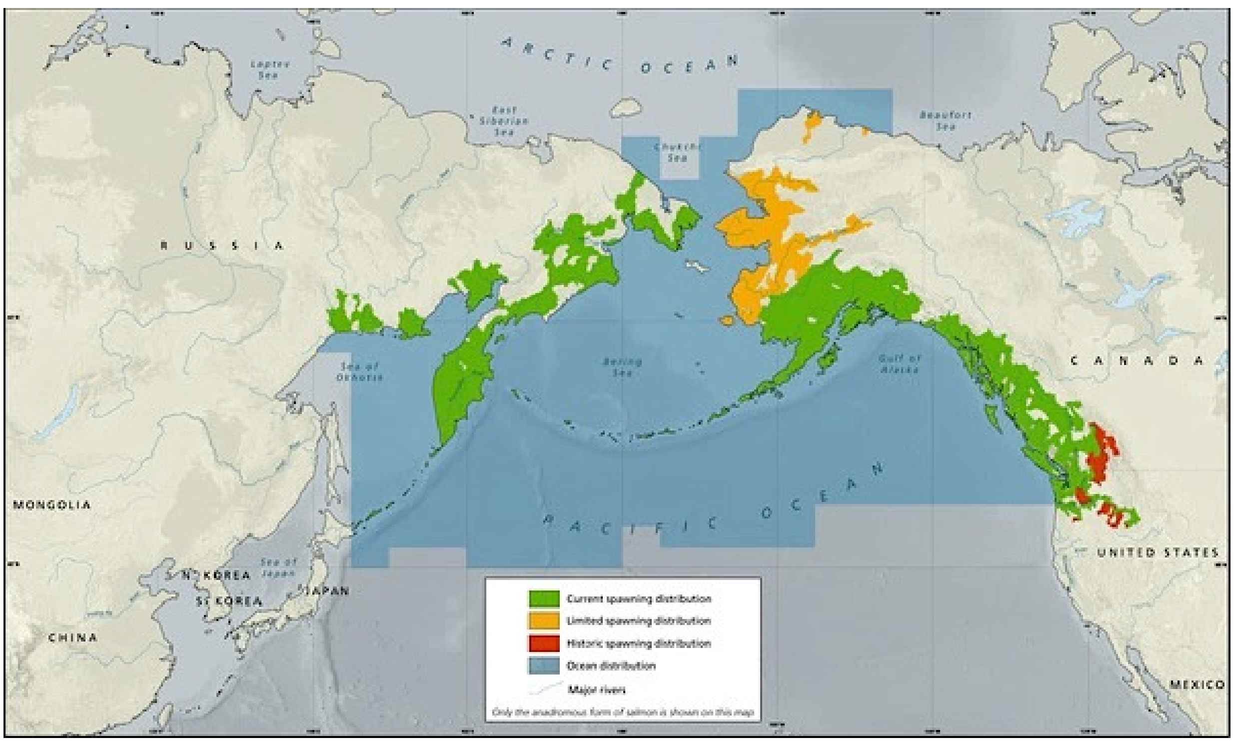


Figure 3: Map of the North Pacific Ocean and Bering Sea, showing the current (green), limited (orange), and historical (red) distribution of Sockeye spawning populations. Reproduced from Augerot *et al.* (2005).

Canadian Range

Sockeye Salmon occur throughout British Columbia (Holtby and Ciruna 2007) and have been reported to occur in Canada's high Arctic, with specimens collected in 1993 from the Sachs River estuary at Sachs Harbour, Banks Island, Northwest Territories (NT) (Babaluk *et al.* 2000). Sockeye are absent from the Canadian portion of the Yukon River (Burgner 1991).

The largest spawning Sockeye populations occur in areas with an abundance of large lakes that are accessible to the Pacific Ocean. In British Columbia, this includes the Fraser River in the southwest and the Skeena and Nass rivers on the north coast. Sockeye also return in significant numbers on the central coast of British Columbia but are less abundant in the coastal streams around the Strait of Georgia and much of Haida Gwaii (Holtby and Ciruna 2007).

The Fraser is the largest river in western Canada, and it supports more than 150 Sockeye spawning populations (Northcote and Larkin 1989) that, for management purposes, have been divided into four groups based on the timing of the adult migration in the lower river: the early run (late June to late July); the early summer run (mid-July to mid-August); the summer run (mid-July to early September); and the late run (early September to mid-October).

Extent of Occurrence and Area of Occupancy

Information about extent of occurrence and area of occupancy for Fraser Sockeye Salmon is presented for each designatable unit.

Definition and application of quantitative measures of population distribution have been covered extensively for Fraser River Sockeye Salmon populations (see de Mestral Bezanson *et al.* 2012).

HABITAT

Habitat Requirements

The Sockeye Salmon is primarily an anadromous species that depends on freshwater environments for spawning, egg incubation, juvenile rearing and smoltification, and marine environments for growth and maturation (Burgner 1991). Adults typically spawn in lake tributaries and outflows in coarse sediments where groundwater upwellings occur, or along lake foreshores among wave-aerated boulders.

Successful incubation of salmon eggs depends on physical characteristics at the nest site, the most important being water temperature, oxygenation, and sedimentation. Optimum spawning temperatures range from 10.6 and 12.2°C, incubation temperatures for successful hatching range from 4.4 to 13.3°C (Reiser and Bjornn 1979), and at least 5.0 mg/L dissolved oxygen is required for successful incubation of eggs (Reiser and Bjornn 1979). Excessive amounts of sand and silt in the gravel can hinder fry emergence, even though the embryos may develop and hatch normally (COSEWIC 2003). Low or high flows, freezing temperatures, siltation, predation and disease can reduce egg survival.

After emergence, most Sockeye fry migrate to freshwater foraging and rearing areas where they spend one to three years. Newly emerged Sockeye fry occupy the littoral zone from early June through mid-July before moving offshore where they remain in the open water of the lake until they migrate to sea as smolts.

Most Fraser Sockeye smolts migrate to sea through the Strait of Georgia, Discovery Islands and Johnstone Strait (Tucker *et al.* 2009; Welch *et al.* 2009) and then along the continental shelf until the fall or winter at which point they migrate out into the Gulf of Alaska. In contrast, Sockeye from the Harrison (River-Type) and Widgeon DUs have unique ocean migration timing and migration routes.

Fraser River Sockeye mature in the ocean for one to three years. During this marine phase of the life cycle, Sockeye occur east of Kodiak Island and south to about 46º N latitude (Burgner 1991; McKinnell *et al*. 2011), ranging northward to winter feeding areas where the waters are less than 7°C and southward to summer feeding areas in about 12°C water (McKinnell *et al*. 2011).

Habitat Trends

Trends in habitat are discussed under the section on **Threats.**

BIOLOGY

The general biology of Sockeye Salmon in North America has been well documented. The following sections draw heavily from Burgner (1991), Grant *et al*. (2011) and COSEWIC (2003), and from the references therein.

Life Cycle and Reproduction

Most Fraser River Sockeye are lake-type Sockeye (Burgner 1991; Grant *et al*. 2011) and are found in lakes at higher elevations, several hundred metres above sea level, in the extensive area of the Upper Fraser (Burgner 1991). The extensive and varied terrain in this region presents diverse habitat for spawners which may explain, in part, the great diversity in run timing exhibited by Fraser Sockeye stocks. The only confirmed river-type Sockeye in the Fraser system are the Harrison River and Widgeon Creek populations (Grant *et al*. 2011). Harrison Sockeye are thought to stage in sloughs for a few months prior to their downstream migration to the Strait of Georgia where they rear for up to six months before migrating through the southern Juan de Fuca Strait (Taylor *et al*. 1996; Tucker *et al*. 2009). Widgeon Creek Sockeye are adapted to the tidal conditions of Widgeon Slough, moving into the slough on high tides to spawn and moving into Pitt Lake on low tides. Unlike Harrison Sockeye, Widgeon Creek Sockeye migrate to the ocean shortly after emergence from spawning gravels (Grant *et al*. 2011).

The Sockeye breeding period ranges from July to January, but spawning occurs most frequently in August and September. Adult return migrations to spawning grounds vary across four general adult run timing groups (early Stuart, early summer, summer, and late). Adults typically spawn in lake tributaries or outflows, or along lake foreshores. Eggs are deposited in nests, termed redds, constructed by the female, fertilized by a chosen male (or an opportunistic sneaker male), then covered with gravel by the female. Sockeye eggs are the smallest, on average, of any North American salmon (Burger 1991) and incubate in the gravel through the winter before emerging as alevins in the spring.

Most Fraser Sockeye rear in lakes for zero to two years, after which juveniles smoltify and emigrate to sea during the spring (typically from March to June). Young Sockeye remain at sea for one to four years, but more typically for two to three years, before the onset of maturation and the return to the natal area. Most Fraser Sockeye return to spawn as four year old fish (Grant *et al*. 2011) and like other Pacific salmon species, Sockeye die after spawning.

Dispersal and Migration

Juvenile Sockeye typically emerge from the gravel after nightfall, often at high densities, and migrate to rearing lakes (Quinn 2005). Newly emerged Sockeye fry occupy the littoral zone of lakes from early June through mid-July before moving offshore where they remain in the open water of the lake until they migrate to sea as smolts. Seaward migration typically occurs over a period of one to two months (Burgner 1991; DFO 2016) and can be influenced by the timing of ice break-up on the lake and subsequent water temperatures; extent and direction of wind action on the lake; and size, age, and physiological readiness of the smolts. Lake-type Sockeye from the Fraser River migrate rapidly out of their rearing lakes, downstream in the Fraser River, and northward through the Strait of Georgia. Most leave the Strait of Georgia in late June and July to enter the open ocean via Johnstone Strait to the north. They then migrate northwest along the coast in a band within 35 km off the coasts of British Columbia and central Alaska, until they reach wintering grounds in the Gulf of Alaska during late autumn and early December (Tucker *et al.* 2009; Welch *et al.* 2009).

In contrast to lake-type Sockeye, river-type Fraser Sockeye migrate downstream to the Strait of Georgia shortly after emergence from the gravel. Most of these Sockeye migrate into the Strait of Georgia after mid-July and then remain in the Strait of Georgia for several months after all other Fraser Sockeye stocks have migrated out of this system (Beamish *et al*. 2016). They largely migrate out into the northeast Pacific via the southern Juan de Fuca Strait route, although a small proportion also migrates out the northern Johnstone Strait route (Beamish *et al*. 2016).

Interspecific Interactions

During the freshwater rearing period, young Sockeye may compete with Kokanee as well as other species such as Redside Shiner (*Richardsonius balteatus*) and Threespine Stickleback (*Gasterosteus aculeatus*) for planktonic crustacean and aquatic insect foods (COSEWIC 2003).

Once at sea Sockeye Salmon compete for a limited pool of resources with other salmon and fishes. Fraser Sockeye and Pink and Chum (*O. keta*) salmon from distant regions are broadly distributed and overlap in the North Pacific Ocean (Myers *et al*. 1996; Beacham *et al*. 2014). Sockeye Salmon are vulnerable to competition with Pink Salmon because they share common prey at sea (Pearcy *et al*. 1988; Kaeriyama *et al*. 2000; Bugaev *et al*. 2001; Davis *et al*. 2005) and because adult Pink Salmon returning from the North Pacific Ocean are exceptionally abundant, averaging approximately 4.7 times more adults than Sockeye Salmon during 1952–2005 (Ruggerone *et al*. 2010). Abundant Pink Salmon can influence the diet, growth, distribution, age at maturation, and survival of other Pacific salmon (Ruggerone and Nielsen 2004) and there is evidence that competition with Pink Salmon has led to reduced growth, delayed maturation and depressed survival in Fraser Sockeye (McKinnell and Reichardt 2012; Ruggerone and Connors 2015).

Sockeye Salmon serve as prey for a number of species, both aquatic and terrestrial. In the freshwater environment, piscivorous fish (e.g., trout, char, cyprinids, cottids) and birds (gulls, terns, loons, mergansers, dippers) take Sockeye eggs during the spawning season and emergent fry thereafter, despite the latter’s nocturnal migratory strategy (Burgner 1991; Quinn 2005; Christensen and Trites 2011). In the Strait of Georgia and Queen Charlotte Sound, predators on Sockeye include Spiny Dogfish (*Squalus acanthias*), Coho Salmon (*O. kisutch*), Chinook Salmon (*O. tshawytscha*), and juvenile Sablefish (*Anoplopoma fimbria*) (Christensen and Trites 2011). In the open ocean, Sockeye are consumed by a variety of predators including sharks, Daggertooth (*Anotopterus nikparini*), Humboldt Squid (*Dosidicus gigas*), and a number of marine mammals such as sea lions, seals, resident Killer Whales (*Orcinus orca*), Humpback Whales (*Megaptera novaeangliae*), porpoises, and White-sided Dolphins (*Lagenorhynchus obliquidens*) (Christensen and Trites 2011). Adult Sockeye are taken during the spawning season by a variety of predators, including Bald Eagles (*Haliaeetus leucocephalus*), Osprey (*Pandion haliaetus*), Grizzly Bears (*Ursus arctos horribilis*), and Black Bears (*Ursus americanus*) (Burgner 1991; Christensen and Trites 2011).

POPULATION SIZES AND TRENDS

Information about Population Sizes and Trends is presented for each DU separately in a series of DU-specific chapters. Each chapter includes information on extent of occurrence and area of occupancy, habitat trends, sampling effort and methods, 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

Salmonid enhancement programs employ a variety of techniques to either (1) mitigate declines in wild salmon populations caused by environmental and human factors and restore populations to their historical levels of abundance or (2) increase production above natural levels. Enhancement for Sockeye can include lake enrichment, spawning channels, and hatcheries (Stephen *et al*. 2011).

Although enrichment was once carried out on a limited basis in Chilko Lake and Adams Lake, it is no longer a part of the Sockeye enhancement program (Cohen Commission 2012b). Today, virtually all enhanced Fraser River Sockeye originate from spawning channels (97%) with a small additional contribution from hatcheries (3%) (Stephen *et al*. 2011).

Salmon spawning channels encompass manned and unmanned structures fed by natural waterways created to increase the available area of suitable spawning habitat and increase egg to fry survival. Four Sockeye spawning channels have been built in the Fraser River drainage and are in Weaver Creek, Nadina River, Horsefly River, and Gates Creek. Of these, Weaver Creek is responsible for the majority (67%) of Fraser River Sockeye produced via enhancement (Stephen *et al*. 2011).

In addition to spawning channels, hatchery activities took place in the Upper Adams River between 1988 and 2001 and two Sockeye hatchery programs are still active for the Upper Pitt River and Cultus Lake stocks (Cohen Commission 2012b). Between 2006 and 2009, it is estimated that enhancement activities in the Fraser River system produced an average of 40 million Sockeye per year (Cohen Commission 2012b).

COSEWIC guidelines on manipulated populations state that hatchery produced fish which may have “reduced fitness or genetic characteristics that may corrupt local adaptations” should not be considered when applying quantitative criteria to abundance estimates to determine status (Guideline 7). Because hatchery produced fish can adversely affect the local populations they are introduced into they were removed from estimates of abundance for the Cultus-L and Pitt-ES DUs. However, it should be noted that there is some uncertainty about the contributions of hatchery fish to these DUs. More details on the approach taken to remove hatchery contributions are provided in each DU-specific chapter.

Fish that originate from artificial spawning channels and lake fertilization were included in estimates of abundance for other DUs when applying quantitative criteria to determine status because they are unlikely to have reduced fitness or genetic characteristics that may adversely affect local adaptations.

THREATS AND LIMITING FACTORS

Threats to Fraser River Sockeye include fisheries, environmental conditions in the freshwater and marine environments, en-route and pre-spawn mortality, habitat alteration, and pathogens and disease. These threats and their supporting evidence have been summarized in Grant *et al*. (2011), and were formally assessed for seven DUs using the IUCN Threat Calculator at a workshop in February 2017.

Freshwater Habitat

Forestry-related activities including road construction and upslope harvesting can reduce freshwater Sockeye habitat and survival by interfering with natural patterns of water flow through a watershed and increasing sediment inputs into streams. Sedimentation can cover spawning redds, smother incubating eggs and reduce egg to fry survival (Levasseur *et al*. 2006; Greig *et al*. 2007). In addition, stream crossings can obstruct fish passage and interfere with access to habitats. From 2000 to 2005, the density of roads in the Southern Interior and Central Interior of British Columbia increased by 18% and 10%, respectively and the density of road-stream crossings increased by 21% and 10%, respectively (BC MOE 2008). Over the same time period the level of forest harvesting in the Fraser River watershed has been less than 10% in the areas used by Sockeye, although it varies widely across DUs and habitat types (Nelitz *et al*. 2011). Drainages upstream of spawning areas and nursery lakes tend to be more heavily disturbed than spawning areas downstream of lakes or along migration corridors and sharp increases in harvesting in the Takla-Trembleur-EStu, Takla-Trembleur-Stuart-S, and Quesnel-S DUs have occurred in recent years likely due to increases in salvage harvesting associated with Mountain Pine Beetle (*Dendroctonus ponderosae*) outbreaks.

Agriculture, urbanization and related water use also have the potential to affect Fraser Sockeye freshwater habitat and survival through reductions in water quality (e.g., Schendel *et al*. 2004; Schindler *et al*. 2006; Jokinen *et al*. 2010), riparian vegetation (e.g., Radomski *et al*. 2010), and reduced instream flows which, at critical times of the year, can constrain access to spawning habitats and even dewater redds (Nelitz *et al*. 2011). Although the extent of land in agricultural production and number of farms has remained relatively stable in recent decades, the intensity of use on these lands (e.g., number of livestock) has increased. Urbanization and water withdrawals have both also increased in recent decades in some parts of the Fraser River Basin. While these increases in agricultural intensity, urbanization and water withdrawals all have the potential to translate into changes in Sockeye habitat quantity and quality, their consequences for Fraser Sockeye population trends are currently unknown, but likely negative.

Adult survival during the spawning migration can be affected by both short-term and cumulative exposure to high water temperatures. High water temperatures alter the rates of physiological processes in fish (Fry 1971; Marcogliese 2001; Crockett and Londraville 2006) and can reduce "aerobic scope" in Sockeye, reducing the ability to allocate energy to critical tissues for migration (Eliason *et al*. 2011). Elevated water temperatures in streams and rivers within the Fraser Basin create stressful, sometimes lethal, conditions for migrating Pacific salmon as they return to their natal spawning grounds (Eliason *et al*. 2011). Higher than normal water temperatures correlate with elevated mortality rates (Morrison *et al*. 2002). Recent years of high summer river temperatures have already been associated with extremely high levels of migration mortality in some Fraser River Sockeye Salmon stocks (MacDonald *et al*. 2000; Williams 2005; Farrell *et al*. 2008). The current warming trend in the Fraser River (1.9°C over the past 60 years) is expected to continue (Ferrari *et al*. 2007), and the timing and magnitude of those increases will be critically important for survival during the annual spawning migration (Morrison *et al*. 2002). For example, a 9 to 16% decrease in survival by the end of this century is predicted for Quesnel-S, Francois-Fraser-S, and Shuswap Complex-L DUs if the Fraser River continues to warm as expected (Martins *et al*. 2011). If warming trends continue as anticipated, Fraser River Sockeye populations are generally expected to experience increased mortality during adult spawning migrations (Martins *et al*. 2011) and possibly also basin-wide declines in egg and fry survival (McDaniels *et al*. 2010).

Marine Environment

A number of studies have highlighted the broad scale influence of ocean climate variation, over annual and decadal scales, on Sockeye Salmon survival (e.g., Mantua *et al*. 1997; Beamish *et al*. 1997, 1999, 2004b; Mueter *et al*. 2002b; Malick *et al*. 2016). In general, these ocean climate effects are believed to be most important during early marine life. Fraser River Sockeye Salmon productivity (recruits-per-spawner) has been shown to be inversely related to increasing sea-surface-temperature (SST) during early marine life (e.g., Mueter *et al*. 2002b; Connors *et al*. 2012) and to the strength and location of the bi-furcation of the North Pacific Current (Malick *et al*. 2016). Though relationships between marine temperature and oceanography have been identified, the underlying causal mechanisms driving the relationships are poorly understood. Ocean temperatures have warmed an average of 0.5°C over the past two decades and have likely contributed to declining survival of Fraser Sockeye smolts and postsmolts (Hinch and Martins 2011). Ocean temperatures in the Gulf of Alaska where Fraser River Sockeye spend much of their marine life are predicted to increase 1-2°C by the 2040s (Abdul-Aziz *et al*. 2011).

In addition to marine climate conditions, the productivity of Fraser Sockeye may also be influenced by competitive interactions with other salmonids at sea. During the two years Fraser Sockeye spend feeding at sea off the coast of Alaska, their range overlaps with that of North American and Asian stocks of Pink Salmon that compete for similar prey and recent work has shown that lower growth and survival of Sockeye in their second year at sea coincides with peaks in the population cycles of Pink Salmon, and this trend has become more pronounced as stocks of Pink Salmon have increased over time (Ruggerone and Connors 2015). It is unclear whether the substantial increases in total salmon abundance seen across the North Pacific in recent decades will continue.

Early Migration and Pre-Spawn Mortality

Since 1995, late run Sockeye have been entering the Fraser River three to six weeks earlier than the historical average (Lapointe *et al*. 2003; Cooke *et al*. 2004; Hinch and Martins 2011; though in recent years the timing has shifted closer to the long-term average). Consequently, the fish are being exposed to higher (up to 5°C) enroute migration temperatures for longer periods of time than if they had held in the Strait of Georgia for the full four to six weeks (Grant *et al*. 2011; Hinch and Martins 2011). Even for short periods of time, exposure to high water temperatures increases metabolic rates, expedites the growth of bacteria and fungi, reduces reproductive hormone synthesis and the energy available for migration and reproduction, decreases swimming performance, and delays gonadal maturation. All of these effects can contribute to increased pre-spawning mortality and reduced spawning success but the causes of early entry behaviour are unknown, and likely to be complex (Hinch 2009; Hinch *et al*. 2012). It is considered likely that pre-spawn mortality and reduced spawning success will persist into the future though the magnitude of it will likely continue to vary from year to year and among DUs.

Pre-spawn mortality is a phenomenon whereby adult female salmon die on the spawning grounds with most of their eggs unshed. The historical pre-spawn mortality rate for Fraser River Sockeye populations averages between 10 and 15%, with episodic extreme events (>40%) (Grant *et al*. 2011). Multiple factors are thought to contribute to pre-spawn mortality, including pathogens, high stress and low energy, migration timing, length of time on the spawning grounds, and spawning ground temperatures (Gilhousen 1990; Macdonald *et al*. 2000, 2007; Crossin *et al*. 2008; Bradford *et al*. 2010a,b). There is evidence that pre-spawn mortality has been higher and more variable in recent years for late run stocks (Hinch 2009; Hinch *et al*. 2012).

Fisheries

The abundance of Fraser Sockeye Salmon is dominated by a few large and productive stocks which can co-migrate with “weaker” less productive ones. Weak stocks are often harvested when they co-migrate with the strong stocks that are the target of the fishery. As a result, weak stocks can become endangered (e.g., Cultus Lake stock, see COSEWIC 2003). For this reason, Fraser Sockeye management decisions frequently involve trade-offs between harvest and escapement objectives whereby some fraction of the harvest may be forgone to protect weaker stocks with similar migration timing (Grant *et al*. 2011).

Based on available estimates of abundance and exploitation rate, English *et al*. (2011) concluded that overharvesting (harvest at rates greater than the population can sustain) likely occurred for Early Stuart Sockeye in the period 1984-2000 and for Early Summer Sockeye in the period 1960-89. No evidence of overharvesting was detected for the other two run-timing groups as a whole but there was clear evidence that at least one component of the late-run group (Cultus Lake Sockeye) was overharvested during the late 1980s and early 1990s.

The current fisheries management system for Fraser River Sockeye salmon relies on in-season information on run-size and timing to determine when and where to prosecute fisheries. This allows fishery managers to respond to information near real-time to determine when and where fisheries can occur. For example, in 2016 in-season information indicated that returns were well below pre-season forecasts and so harvest opportunities were severely constrained and total exploitation rates for Fraser River Sockeye were kept to relatively low levels (19%, with 17% associated with First Nations fisheries in Canada). However, because of the mixed-DU nature of Fraser Sockeye Salmon fisheries some fishing mortality will occur even in year of low abundance which could pose a moderate to high threat to depressed or declining DUs.

Pathogens and Disease

Sockeye Salmon are hosts to a multitude of pathogens including viruses, bacteria, fungi, and parasites (Kent 2011, Miller *et al*. 2014). Pathogens are a natural component of all ecosystems and not all infections cause disease.

A number of pathogens have been identified as posing a high risk of causing significant disease in Fraser Sockeye (Kent 2011). Infectious hematopoietic necrosis virus is endemic to wild Fraser River Sockeye and infects all life history stages, although the disease is manifested primarily in freshwater and so affects mostly fry (Miller *et al*. 2014). *Ichthyophthirius multifiliis* causes a disease called “ich” or “white spot disease” (Grant *et al*. 2011). White spot disease is most likely to occur where conditions favour high numbers of the pathogen, e.g., warm water, reduced flows, and adult crowding. *Parvicapsula minibicornis* infects adult and juvenile Sockeye as they migrate through the Fraser estuary. Adult salmon holding in the river under elevated river temperatures are at higher risk of more severe infections (e.g., early migrating late run stocks such as Cultus Sockeye (COSEWIC 2003)). *P. minibicornis* infects kidneys and gills, and is linked to increased pre-spawning mortality (Grant *et al*. 2011).

Pathogen transmission frequently occurs where host populations are concentrated (Nese and Enger 1993; Daszak *et al*. 2000). Marine salmon farming is an example of how concentrated reservoir populations can alter natural transmission dynamics in salmonid host-parasite systems (Costello 2009; Fraser 2009; Marty *et al*. 2010). A major migration corridor for juvenile Fraser River Sockeye (the Discovery Islands corridor) runs through the region with the highest density of salmon farms in British Columbia. Recent research has found that juvenile Fraser Sockeye migrating through this corridor carried up to an order of magnitude more sea lice than did Sockeye migrating through a region without farms (Price *et al.* 2010, 2011). Though it is unlikely that low levels of infestation (2-3 lice per fish) would cause direct mortality these burdens have been shown to reduce the competitive ability of juvenile Sockeye in feeding trials by up to 20% in comparison to lightly infected fish (Godwin *et al*. 2015). Moreover, the impact of sea lice on juvenile Sockeye survival and ecology may be exacerbated in the presence of additional stressors (Finstad *et al*. 2007, Miller *et al*. 2014).

The severity of the threat posed to Fraser Sockeye by pathogens from salmon farms or other sources is currently unknown. Fisheries and Oceans Canada, under the *Sustainable Aquaculture Program,* has recently launched the *Aquaculture Science Environmental Risk Assessment Initiative* to assess the risks of aquaculture activities to wild fish and the environment. The first series of risk assessments to be conducted under the initiative focus on the risks to Fraser River Sockeye salmon due to pathogen transfer from marine Atlantic Salmon (*Salmo salar*) farms located in the Discovery Islands in British Columbia.

In addition to pathogens and disease, harmful algal blooms (HABs) occur on an annual basis in BC waters, particularly within the Strait of Georgia. HABs can cause mortality in salmon by diminishing respiratory function. Blooms have been found to coincide with the timing of the smolt migration through the Strait, and may pose a threat to Fraser Sockeye (Cohen Commission 2012b).

General Comments on the Completed Threats Calculators

The following are general notes on how seven threats calculators were completed during a workshop held February 22-23, 2017. Threats were reviewed for these DUs:

DU 1 Anderson-Seton-ES population

DU 11 Kamloops-ES population

DU 15 Pitt-ES population

DU 16 Quesnel-S population

DU 17 Seton-L population

DU 18 Shuswap Complex-L population

DU 20 Takla-Trembleur-Estu population

Few DUs had scores assigned for threats in the main categories 1 Residential & commercial development, 2 Agriculture & aquaculture, 3 Energy production & mining, 6 Human intrusions & disturbance. An exception is Shuswap Complex L where development along the lake justified entries under 1 & 2. And there are a couple of other examples.

For threats in category 4 Transportation & service corridors, the threats related to maintenance were scored. Where there was evidence that new construction would occur, for example for the Trans-mountain pipeline, a score was assigned to 4.2.

Threat 5.4 Fishing & harvesting aquatic resources was scored for all DUs. All were scope Pervasive and timing High because the entire population is exposed to fishing. For DUs where the population was declining, the severity was scored > negligible and the degree of effect was related to how much of a decline was occurring. Separate rationales for each DU are given in the comments cells of the workbooks.

Threats under category 7 Natural system modifications were scored differently depending on local knowledge of what was going on in the DU. 7.3 Other system modifications is where marine survival was scored. Scores of Slight or Moderate-Slight were only assigned where population size was declining. Scores are justified in the comments cells.

There was a common answer for 8.2 Problematic native species/diseases related to predation and exposure to sea pens. The severity was always scored Unknown. 8.1 Invasive non-native species was scored a couple of times based on observations of Yellow Perch (*Perca flavescens*) and Small-mouthed Bass (*Micropterus dolomieu*). The severity was always score Unknown or Negligible.

Threats related to pollution were scored under 9.1 Domestic and urban wastewater, 9.2 Industrial and military effluents, and 9.3 Agriculture and forestry effluents. Most of the severity scores were Unknown except in the case where railroads followed rearing lakes. Based on recent experience with derailed train cars falling into lakes and streams, these were sometimes scored Slight or Moderate-Slight.

Only 10.3 Avalanches/landslides were scored under 10 Geological events. This threat was only scored in steep sided areas known to have had such events in the past.

Three threats were scored under 11 Climate change & severe weather. 11.1 Habitat shifting & alteration is where threats related to changing hydrology related to climate change were scored. The effect was considered more severe for DUs migrating early in the year during freshet. Increasing temperatures in freshwater during migration which have been shown to cause in-river mortality were scored in 11.3 Temperature extremes. These were thought to be more severe for later migrating DUs and DUs with longer migration routes. Increasing temperatures in marine waters could also be included here. 11.4 Storms and flooding was scored in the same manner was for all DUs.

Having regional experts at the workshop was vital to the progress made. Once it was determined where specific proximal threats would be scored, there was good success assigning scores for scope and timing. Severity, on the other hand, was difficult to score. There is very good quantitative information on trends in many demographic indicators, for example number of mature individuals, exploitation rate, and marine survival. However, the ability to accurately predict how the various threats would affect the future status of each population (i.e., severity) was very difficult. On a number of occasions the assigned severity scores were revised for populations where the recent population trend had been upwards. Following the threats workshop and during review of this report one SSC member pointed out several inconsistencies in the threats scoring. He noted a lack of explicit models for how individual threats would affect the future trajectory of a given DU.

The threats workshop on Sockeye Salmon led to two main conclusions.

1. Evidence is mounting that climate change will likely be degrading both the freshwater and marine habitats of the species. Warmer winters will lead to lower snow pack, as well as reduced runoff and earlier freshet. This will have the most effect on early run DUs. Warmer summer temperatures will have a negative impact on late-run DUs. Warmer marine waters will negatively affect juveniles and adults (Hinch and Martins 2011).
2. Current knowledge of these various threats was insufficient to invoke “locations” for any DU. There are two main reasons. Pacific Salmon are broadly distributed throughout their lives. In freshwater, spawning sites are separate from rearing sites. In-river migrations may be relatively short or very long. In the marine environment the juveniles and returning adults are distributed through thousands of square kilometres. At any one time only one quarter of the DU will be in one place. There are management measures in place to mitigate localized threats related to fishing, logging, agriculture, and mining. Given these considerations, it was concluded the “locations” would not apply to any DU.

DESIGNATABLE UNIT-SPECIFIC CHAPTERS

In the following DU-specific chapters, the information covered for each extant DU includes:

1. Extent of occurrence and area of occupancy
2. Habitat trends
3. Abundance
4. Fluctuations and trends
5. Threats and limiting factors

Extent of Occurrence and Area of Occupancy

DFO Stock Assessment began collecting data on the spatial distribution of spawning Fraser River Sockeye in 2001 and since 2008 spatial data on spawning distribution have been collected annually for all Sockeye DUs in the Fraser Basin. These data are described in detail in de Mestral Benzanson *et al*. (2012) and have been used to quantify spatial distribution metrics for Fraser Sockeye and to evaluate whether relationships among these metrics are like those found for other taxa assessed by COSEWIC (de Mestral Benzanson and Bradford 2014). For many DUs, water clarity and depth of spawning likely impair observations of habitat use by the fish, and so estimates of the spatial extent of spawning based on these observations should be considered minimum estimates.

For Fraser River Sockeye Salmon, the extent of occurrence for all DUs is greater than 20,000 km^2 because high seas monitoring programs have demonstrated that their ocean migration extends at least as far north as 60^0 and west as 180^0 (Myers *et al*. 1996). DU-specific migration patterns were not available, so this minimum estimate is given for all DUs.

The index of area of occupancy (IAO) for each DU was calculated by overlaying the extent of spawner occurrence within a given DU with a grid of 2 x 2 km cells, with the grid cell beginning on the edge of one of the spawning observation points. The IAO was then calculated as the sum of the 2 x 2 km grid cells in which spawning was observed between 2008 and 2011 (de Mestral Benzanson *et al*. 2012).

The estimated number of spawning sites over three time periods (1992-1995, 2000-2003, 2008-2011), after excluding inconsistently surveyed sites, was used to illustrate to what extent spawning distribution has changed over time (de Mestral Benzanson *et al*. 2012). Sites are defined "as individual streams or lakeshores used regularly by spawning salmon" (de Mestral Benzanson *et al*. 2012).

Habitat Trends

For each DU we present available information on landscape-level changes in freshwater spawning and rearing habitat and human stressors over recent years. These indicators include such metrics as human population density, forest harvesting, Mountain Pine Beetle disturbance, mining, road density, and water extraction, and are adapted from Nelitz *et al*. (2011). Qualitative ratings of the relative intensity and trend (where available) of these potential disturbances are provided (where available) as described in Nelitz *et al*. (2011).

Sampling Effort and Methods

The number of adult Sockeye Salmon that return to spawn after having escaped fisheries (typically referred to as escapement) have been estimated to a varying extent in the Fraser River for over a century. Early approaches to estimating escapement were overseen by the Government of Canada's Fishery Agency and were visual and opportunistic. In 1938, the International Pacific Fisheries Commission assumed responsibility for management of Fraser River Sockeye and implemented improved enumeration techniques including a two-tiered approach whereby small populations were enumerated with lower precision visual surveys and larger populations (e.g., greater than 25,000 fish) were enumerated with higher precision approaches like counting fences and mark-recapture studies. DFO took over responsibility for enumerating spawning Sockeye in 1985 with the signing of the Pacific Salmon Treaty. Enumeration now includes a combination of fence, mark-recapture studies, sonar systems and visual surveys conducted by air, boat and foot. The details of the methods used to enumerate Fraser Sockeye are provided in numerous technical reports (Houtman and Cone 1995; Schubert and Tadey 1997; Schubert and Fanos 1997a,b; Schubert 1998; Cone 1999; Houtman *et al*. 2000; Schubert 2000, 2007; Schubert and Houtman 2007) and are summarized in Grant *et al*. (2011).

For most DUs, spawner assessments prior to 1950 were typically opportunistic visual surveys not specifically tailored to estimate abundance in a given DU. As a result, DFO's methodology was followed and all-time series presented in this assessment were truncated to only include estimates of escapement since 1950, when available. In addition to total escapement estimates, the abundance of males and females in a given year are available as well as estimates of female spawning success based on the proportion of eggs (0%, 50% or 100%) successfully spawned as determined through carcass surveys.

The overall quality of the spawner assessments can vary among enumeration sites and years. Grant *et al.* (2011) assigned one of five data quality classifications to the estimates of spawner abundance from each DU:

1. Poor: an estimate with poor accuracy due to poor counting conditions, few surveys (one or two in a given year), incomplete time series, etc.;
2. Fair: an estimate using two or more visual inspections that occur during peak spawning where fish visibility is reasonable; methodology and data quality varies across the time series in terms of good to poor quality;
3. Good: four or more visual inspections with good visibility;
4. Very good: an estimate of high reliability using mark recapture methods, DIDSON methods, or near-complete fence counts that have relatively high accuracy and precision. Visual surveys that have been calibrated with local fence programs;
5. Excellent: an unbreached fence estimate with extremely high accuracy given an almost complete census of counts.

The estimated quality of the spawner abundance estimates is reported according to this five-point classification in each DU chapter.

Not all spawning sites have been surveyed consistently since the 1950s. To generate time series of spawner abundance within a DU that were comparable through time, DFO has considered only those sites that have been relatively consistently assessed through time and has employed a gap filling approach to correct DU level estimates of abundance for missing observations in a limited number of years where there were missing observations. This gap filling method has been subject to external review and the specific approach to fill gaps for each DU time series considered in this assessment are provided in Grant *et al*. (2011). The need for infilling was uncommon and in most instances when it was employed was for enumeration sites that made up a small portion (e.g., less than 5%) of total estimated spawners in each year. There were, however, three DUs that consisted of a single enumeration site that had one or more weak (i.e., non-dominant) years infilled (Lillooet-Harrison-L: 1 year; Taseko-ES: 5 years; Widgeon - (River-Type): 3 years). In these instances, infilled years were excluded from analyses of the rate of change in abundance over time (see next Section).

Fluctuations and Trends

The status of Fraser River Sockeye Salmon conservation units (CUs in DFO terminology, which are equivalent to the Fraser Sockeye Salmon DUs recognized by the COSEWIC) as well as their habitats, has been the focus of several assessments in recent years (Grant *et al*. 2011; Grant and Pestel 2012; de Mestral Bezanson *et al*. 2012). These assessments have included analyses based on COSEWIC criteria as well as those based on Wild Salmon Policy biologically based criteria (e.g., benchmarks based on stock-recruitment relationships) and integrated status based on expert judgment.

The figures, tables and analyses prepared for each DU are described below. These elements were chosen primarily to inform specific COSEWIC classification criteria (e.g., trends in abundance, area of occupancy, number of mature individuals) and then secondarily to provide additional information to aid interpretation of the trends in abundance for each DU.

Estimates of total effective female spawners (EFS; the product of the number of female spawners and spawner success - the proportion of eggs [0%, 50%, or 100%] successfully spawned, based on spawning ground carcass surveys) plus male spawners was used as the metric of mature individuals for each DU. Given the cyclic nature of the dynamics of a number of the Fraser Sockeye DUs (Ricker 1950), the number of mature individuals was calculated as the arithmetic mean of the most recent four years of data. A geometric mean was not used because it is inherently biased low and the bias increases as the variance of the data increases.

The number of effective females spawners was used to estimate trends in mature individuals. The annual data were initially smoothed using a 4-year running geometric mean. Such smoothed data have been shown to be a more statistically reliable metric to detect population decline with salmon than unsmoothed abundance (d'Eon-Eggertson *et al*. 2015). This is also the method proposed and used by DFO in their assessment of Fraser River Sockeye status based on trends in abundance (Grant *et al*. 2011).

Some DUs with strong cyclic dominance can exhibit changes in spawner abundance from one year to the next that are close to or greater than an order of magnitude, which COSEWIC defines as extreme fluctuations. However, these fluctuations have a regular pattern spanning one generation and in such cases IUCN recommends that the entire population abundance should be considered and not just the mature individuals in any one year (guideline 4.7 IUCN 2016). There were no extreme fluctuations in DUs that did not have cyclic dominance.

For each DU, data permitting, a six-panel graphic is presented which includes:

Panel (a): Escapement (males and females arriving at the spawning areas), catch (at sea and in river), and en-route loss, which is an estimate of the number of fish that perished in the river en-route to the spawning grounds for reasons other than fishing, such as predation, disease, and warm water temperatures. We also show the percentage of total returns that were caught in a fishery (exploitation rate as estimated from catch composition of target and non-target fisheries) on a secondary y-axis.

Panel (b): The total number of effective female spawners, female pre-spawn mortality and male spawners in a given year. Pre-spawn mortality includes those fish that made it to the spawning grounds but did not successfully spawn.

Panel (c): Total recruits (age 2, 3, 4, 5 and 6 year old spawners and catch) per effective female spawner (on $\log_e$ scale) as a measure of lifetime productivity.

Panel (d): Four-year running average of $\log_e$ transformed effective female spawners with two estimates of the rate of change in abundance through time (equation 1): (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 four year generation time[1]) and (2) rate of change based on all available data. The latter is shown because indicators of changes in abundance for Sockeye Salmon estimated based on the rate of change over entire time series have been shown to be more reliable than those based on the last three generations only (Porszt *et al*. 2012; d'Eon-Eggertson *et al.* 2015). D'Eon-Eggertson *et al*. (2015) show in the presence of random variability in recruitment (i.e., process errors) at levels similar to those found for Sockeye Salmon, long-term indicators of change are more reliable than short-term indicators, even in the absence of extreme fluctuations (~an order of magnitude, as defined by COSEWIC).

Panel (e): Frequency distribution of the posterior distribution (and median estimate as vertical line) of estimated percent change over last three generations based on a linear rate of change of smoothed $\log_e$-transformed effective female spawner abundances over most recent three generations of data.

Panel (f): Same as panel (e), but based on estimated rate of change from the entire time series.

[1] this differs from the approached used by COSEWIC in the 2003 assessments of Cultus and Sakinaw Sockeye, which used 12 years of data, and DFO's current approach for estimating short-term trends, but is consistent with COSEWIC's reassessment of Sakinaw Sockeye in 2017.

To estimate rates of change, a log-linear model was fit to the data:

$y_i = \alpha + \beta x_i + \varepsilon_i$ (equation 1)

where, y is the four-year running average of $\log_e$ transformed effective female spawner abundance, x is year, β is the per time step rate of change in $\log_e$ abundance, α is the intercept and ε is residual error assumed to be $N(0, \sigma^2)$.

The model in equation 1 was fit to both the entire time series of available data or the last 13 years and then the percent change in abundance over the last full three generations of data was estimated as:

$$\lambda = (e^{(\beta \cdot (13-1))} - 1) \cdot 100 \qquad \text{(equation 2)}$$

where, λ is the percent change in smoothed effective female spawner abundance and β is estimated rate of change in $\log_e$ abundance from equation 1.

The model in equation 1 was fit in a Bayesian estimation framework as opposed to ordinary least squares linear regression. In so doing, the probabilities associated with estimated changes were derived. Uninformative normal (0, 1000) prior probability distributions were assigned to α and β. Posterior probability distributions were generated for the parameters in equation 1 using a Markov chain Monte Carlo procedure in the JAGS package in R (Plummer 2003). We ran three chains for 100 000 iterations, and thinned every five iterations with a burn-in of 5000 iterations. Convergence was assessed by examining the potential scale reduction factor ($\hat{R}$); convergence was assumed to have occurred if $\hat{R}$ was less than 1.1 (Gelman and Rubin 1992). It should be noted that the probability distribution of the change in abundance estimated with smoothed data is more restricted than if the unsmoothed data were used. The estimated slope using the smoothed data was unbiased (Whitehead pers. comm. 2017).

When available, a two-panel plot is presented that includes (a) a freshwater survival index which is fry or smolts per effective female spawner and (b) a marine survival index which is recruits per smolt or fry depending on which juvenile life stage (fry or smolt) an abundance estimate is available for in a given DU. Note that while they are referred to generally as a “marine” when they are calculated from fry to recruits the index includes both freshwater and marine survival.

Each DU chapter includes a summary table which provides the estimated change in abundance over the last three generations based on the rate of change in abundance estimated from either just the last three generations or the entire time series as well as the probability that the observed change in abundance is greater than a 30%, 50% and 70% decline over 3 generations.

Data on the total number of mature individuals and effective female spawners were available for most DUs up to the 2015 return year and provided by DFO (Grant pers. comm. 2016) and the Pacific Salmon Commission (PSC) (Lapointe pers. comm. 2016). Data on escapement, en-route loss, exploitation and total recruits per effective female spawner were provided by DFO and the PSC up to the 2013 return year.

Threats and Limiting Factors

To provide a general risk rating for each DU, the IUCN Threats Calculator was used. Threats were characterized based on scope, severity, and timing. Scope is defined as the percentage of the species that can reasonably be expected to be affected by the threat within 10 years if current circumstances and trends continue. Severity is the level of damage (percent population loss) to the species from the threat that can reasonably be expected if current circumstances and trends continue over the next 10 years or three generations, whichever is longer. Timing is defined as the projected and estimated time duration of the threat.

An IUCN Threat Calculator is provided for seven of the DUs electronically (Appendix 1). The threat calculator was completed by Dwayne Lepitzki, Alan Sinclair, John Reynolds, Sue Grant, Sean MacConnachie, Mike Staley, Mike Hawkshaw, Jason Mahoney, and Scott Decker February 21st and 22nd, 2017.

Designatable Unit 1: Anderson-Seton-ES population

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

The Anderson-Seton-ES DU is composed of Sockeye that primarily spawn in Gates Channel and Gates Creek (Figure 4). The extent of occurrence for this DU includes the North Pacific Ocean and so is estimated to be greater than 20,000 km^2. The most recent estimate of the IAO for the Anderson-Seton-ES DU is 16 km^2. The number of consistently assessed sites where spawning has occurred has remained the same over the past 19 years (1992-95: 2, 2000-03: 2, 2008-11: 2; de Mestral Bezanson *et al.* 2012).

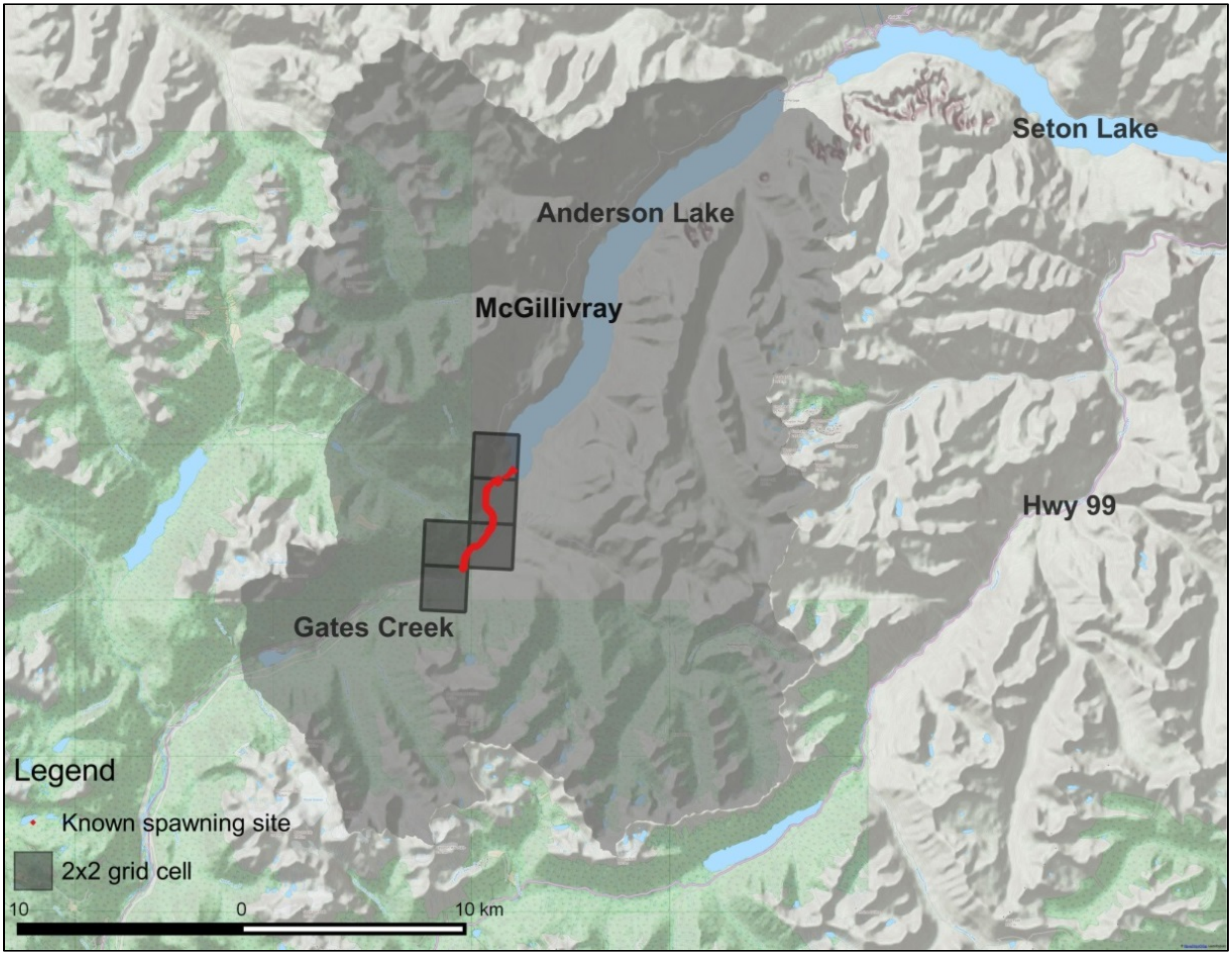


Figure 4: Anderson-Seton-ES DU and known spawning sites within it.

Habitat Trends

There is a low intensity of Mountain Pine Beetle disturbance in the DU which has increased in recent years (Nelitz *et al*. 2011). Forest harvesting, agriculture, road density and water allocation all occur at relatively low intensities (Nelitz *et al*. 2011).

The Seton dam and the associated works have been a concern since construction in the early 1950s because they have led to changes in Seton Lake limnology, issues with the attraction of adult fish to the river, the passage of fish through the dam, and the mortality of smolts downstream through the powerhouse. There have been some recent efforts to mitigate some of these effects.

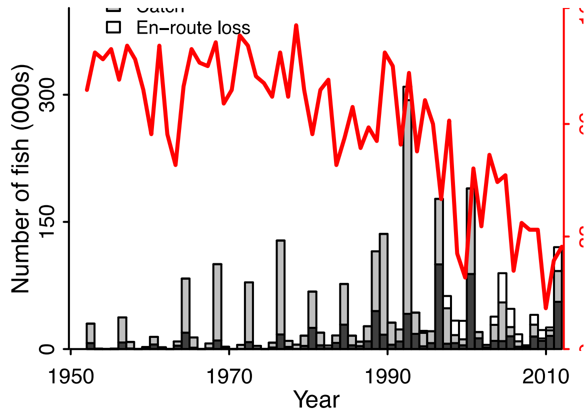
Female pre-spawn mortality in this DU is typically higher on most years than other DUs in the Fraser; the average (1954-2015) pre-spawn mortality in the DU was 27% compared to an average of approximately 11% for all other DUs.

Abundance

Spawner abundance for Anderson-Seton-ES DU is estimated based on counts of Sockeye at 2 sites, Gates Creek and Gates Channel, using a combination of peak live cumulative dead and mark recapture methods in the channel (Grant *et al.* 2011). The overall quality of these spawner estimates is considered “Good”. The most recent estimate of spawner abundance was 24,527 mature individuals.

Fluctuations and Trends

This DU historically exhibited strong cyclic dominance. From the 1950s to 1970s, the number of fish escaping fisheries to spawn remained relatively stable before increasing steadily from the 1970s to the 1990s coincident with the construction of a spawning channel in 1967-1968.



(e)

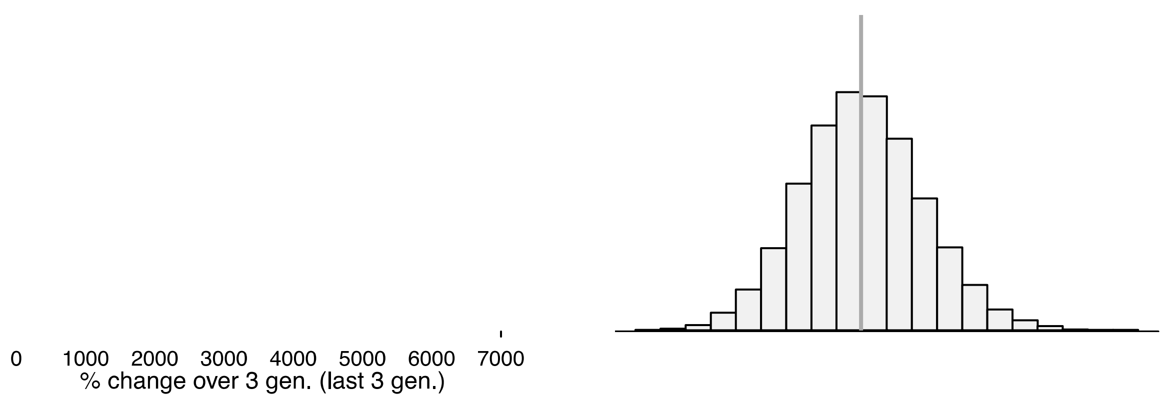


Figure 5: Historical trends in abundance, catch, recruits-per-spawner and estimated rates of change for DU 1: Anderson-Seton-ES, (a) total escapement, catch, en-route loss and exploitation rate (red line) by return year; (b) escapement separated by sex and female pre-spawn mortality (PSM); (c) recruits per effective female spawner ($\log_e$ scale); (d) 4-year running average of effective female spawners with estimated rates of change based on last 3 generations and full time series; and posterior distributions (and median estimate as vertical line) of estimated percent change over last three generations based on a linear rate of change of smoothed $\log_e$ effective female spawner abundances over (e) most recent three generations of data or (f) full time series.

Using data for the last 3 generations, the Anderson-Seton-ES DU has increased by an estimated 287% (Upper 95% CI = 997%, Lower 95% CI = 31%) (Table 2). The probability that there has been a decline of >30% is 0.00. When change in abundance is calculated based on the entire time series, the DU has increased by an estimated 116% (Upper 95% CI = 143%, Lower 95% CI = 93%). The probability that there has been a decline of >30% is 0.00.

Table 2: Summary of estimated rate of change (+/- 95% credible interval) in effective female spawner abundance as well as the probability DU 1: Anderson-Seton-ES has declined by more than 30%, 50% or 70% over the last three generations. Rates of change are provided based on analysis of just the last 3 generations of data or the entire time series (see corresponding year range).

DU	Generation length	Year range	Median % change	95% CI	p>30% decline	p>50% decline	p>70% decline	Number of observations
Anderson-Seton-ES	4 yrs	2002-2015	+287%	+31% / +997%	0	0	0	13
		1954-2015	+116%	+93% / +143%	0	0	0	13

Threats and Limiting Factors

Based on the IUCN threat calculator, this DU was assigned a threat impact of Medium (C). Threats to Sockeye from this DU include pollution because they are exposed to industrial effluents in freshwater, the Fraser River estuary and Strait of Georgia. There is also the possibility of contaminant spills from derailments of trains passing beside the nursery lakes. Based on this, the severity was scored moderate-slight. Geological events such as landslides are also considered a threat and there have been two landslides in the past 2 years at Portage Creek. The slides have been cleared but more slides are possible. If this occurs the severity is estimated to be slight to moderate. Lastly, freshwater temperature extremes pose a threat with the Fraser River expected to continue to warm throughout the 21st century. This could lead to severe losses during adult migrations en route to spawning grounds.

Several other potential threats exist for this DU (e.g., agricultural effluent, marine mammal predation, competition with abundant Pink Salmon at sea and pathogens) but could not be assigned a severity rating.

Designatable Unit 2: Bowron-ES population

Extent of Occurrence and Area of Occupancy

The Bowron-ES DU is composed of Sockeye that spawn in five sites (Figure 6): Antler Creek, Bowron River, Pomeroy Creek, Huckey Creek, and Sus Creek (Grant *et al.* 2011). The extent of occurrence for this DU includes the North Pacific Ocean and so is estimated to be greater than 20,000 km^2. The most recent estimate of the IAO for the Bowron-ES DU is 16 km^2. The number of consistently assessed sites where spawning has occurred has remained the same over the past 19 years (1992-95: 1, 2000-03: 1, 2008-11: 1; de Mestral Bezanson *et al*. 2012).

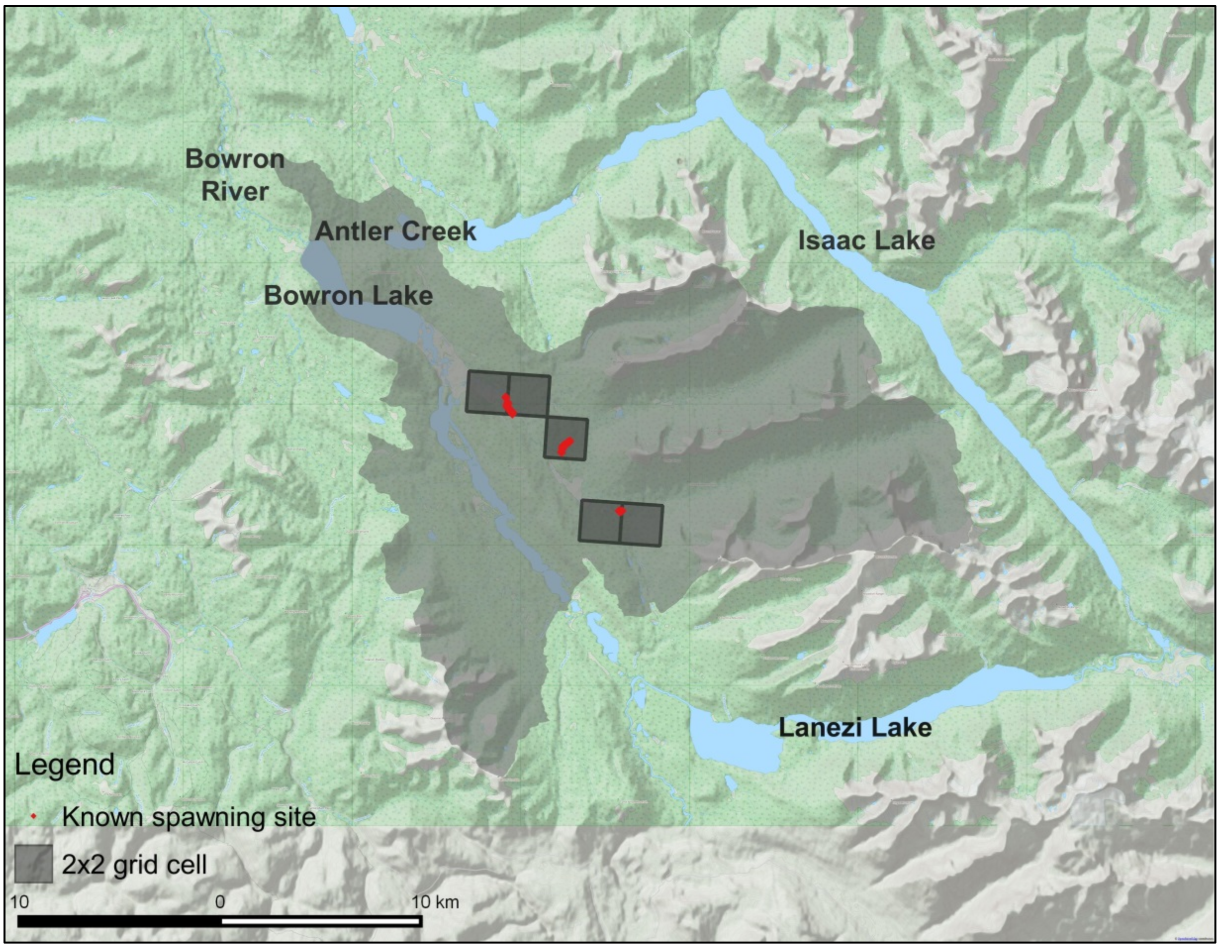


Figure 6: Bowron-ES DU and known spawning sites within it.

Habitat Trends

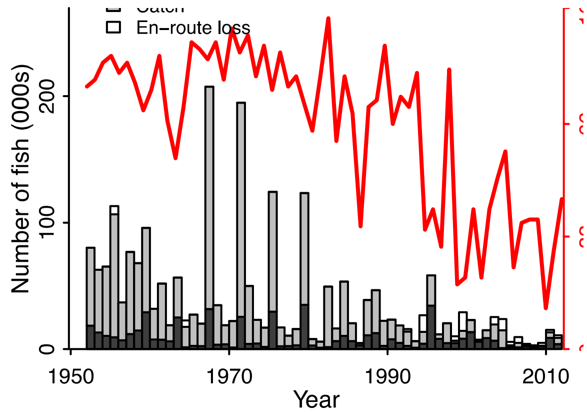
There is a moderate intensity of Mountain Pine Beetle disturbance in the Bowron-ES DU which has increased in recent years. Forest harvesting occurs at low intensity in the DU and has remained stable in recent years (Nelitz *et al*. 2011).

Abundance

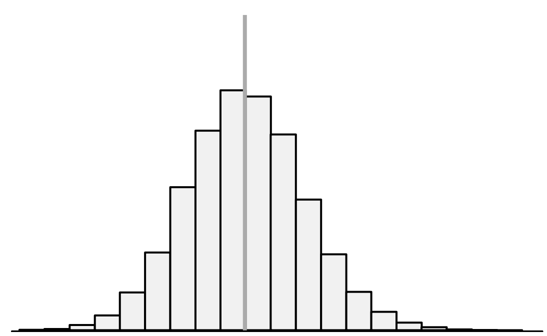
Spawner abundance for the Bowron-ES DU is estimated based on counts of Sockeye at five sites, the Bowron River, and Pomeroy, Huckey, Antler and Sus creeks, using a combination of helicopter visual surveys and fence count survey methods in the river and creeks (Grant *et al.* 2011). The overall quality of these spawner estimates is considered “Good”. The most recent estimate of spawner abundance was 4,651 mature individuals.

Fluctuations and Trends

From the 1950s to 1960s, the Bowron-ES DU exhibited relatively high escapement relative to the remainder of time series. From the mid-1960 to the late 1990s escapement was relatively stable before declining again (Figure 7). The estimated exploitation rate for the Bowron-ES DU has declined since the early 1980s from highs of 97% to rates typically below 50% from the mid-1980s to late 1990s and in the 30% range in recent years. Recruits-per-spawner in the Bowron-ES DU have not exhibited a systematic change over time. There are no data on trends in early freshwater or post-fry survival for this DU.



(e)



00 0 50 150 250 350 450
% change over 3 gen. (last 3 gen.)

Figure 7: Historical trends in abundance, catch, recruits-per-spawner and estimated rates of change for DU 2: Bowron-ES, (a) total escapement, catch, en-route loss and exploitation rate (red line) by return year; (b) escapement separated by sex and female pre-spawn mortality (PSM); (c) recruits per effective female spawner ($\log_e$ scale); (d) 4-year running average of effective female spawners with estimated rates of change based on last 3 generations and full time series; and posterior distributions (and median estimate as vertical line) of estimated percent change over last three generations based on a linear rate of change of smoothed $\log_e$ effective female spawner abundances over (e) most recent three generations of data or (f) full time series.

Using data for the last 3 generations, the Bowron-ES DU has decreased by an estimated 60% (Upper 95% CI = -2%, Lower 95% CI = -84%) (Table 3). The probabilities that the decline has been greater than 30%, 50% and 70% respectively are 0.90, 0.71, and 0.25. When change in abundance is calculated based on the entire time series, the DU has decreased by an estimated 24% (Upper 95% CI = -18%, Lower 95% CI = -30%). The probabilities that the decline has been greater than 30%, 50% and 70% respectively are 0.02, 0.00, and 0.00.

Table 3: Summary of estimated rate of change (+/- 95% credible interval) in effective female spawner abundance as well as the probability DU 2: Bowron-ES has declined by more than 30%, 50% or 70% over the last three generations. Rates of change are provided based on analysis of just the last 3 generations of data or the entire time series (see corresponding year range).

DU	Generation length	Year range	Median % change	95% CI	p>30% decline	p>50% decline	p>70% decline	Number of observations
Bowron-ES	4 yrs	2003-2015	-60%	-84% /-2%	0.9	0.71	0.25	13
		1954-2015	-24%	-30% / -18%	0.02	0	0	13

<u>Threats and Limiting Factors</u>

A threats calculator was not completed for this DU.

Designatable Units 3 and 4: Chilko-ES population / Chilko-S population

The Chilko-ES DU and Chilko-S DU cannot be assessed independently because escapement data for these CUs are aggregated (Grant *et al*. 2011). They are therefore presented here as one DU.

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

The Chilko-ES/S DUs are composed of Sockeye that spawn in numerous sites (Figure 8) including the Chilko River, Chilko Channel, Chilko Lake North, and Chilko Lake South (Grant *et al*. 2011). The extent of occurrence for the DUs includes the North Pacific Ocean and so is estimated to be greater than 20,000 km^2. The most recent estimate of the IAO for the Chilko-S DU is 60 km^2 and Chilko-ES DU is 100 km^2. The number of consistently assessed streams or lakes where early summer spawning has occurred has remained the same over the past 19 years (1992-95: 1, 2000-03: 1, 2008-11: 1; de Mestral Bezanson *et al*. 2012). The number of consistently assessed streams or lakes where summer spawning has occurred has varied slightly over the past 19 years (1992-95: 3, 2000-03: 3, 2008-11: 2; de Mestral Bezanson *et al*. 2012).

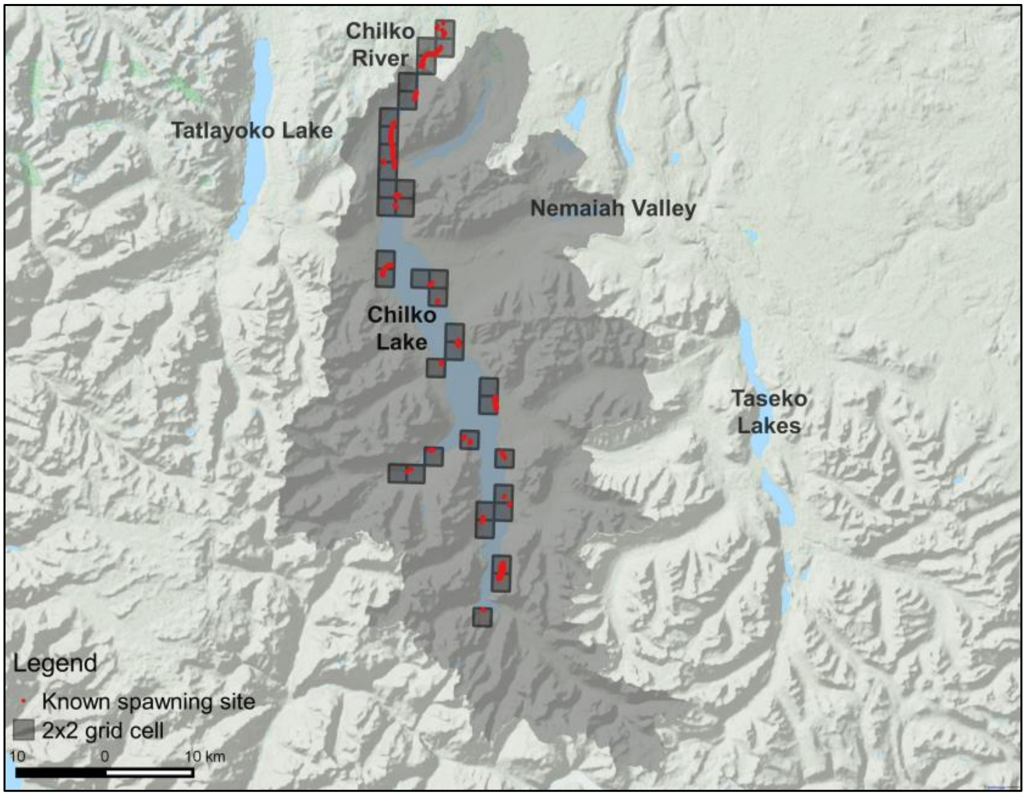


Figure 8: Chilko DU and known spawning sites within it.

<u>Habitat Trends</u>

There are no known human stressors on habitat within this DU (Nelitz *et al.* 2011).

<u>Abundance</u>

Spawner abundance for Chilko-ES/S DUs is estimated using either sonar or mark-recapture methods along with visual surveys in the river, channel and lake (Grant *et al*. 2011). The overall quality of these spawner estimates is considered "Very good". The most recent estimate of spawner abundance for the two DUs was 767,329 mature individuals.

<u>Fluctuations and Trends</u>

From the 1950s to 1990s, the number of fish escaping fisheries to spawn in the DUs remained relatively constant before increasing through much of the 1990s. Escapement in recent years, particularly in 2010, has been high (Figure 9). The estimated exploitation rate for the Chilko-ES/S DUs historically averaged in excess of 80% before declining through the 1990s to rates around 30% in recent years. Recruits-per-spawner in the Chilko-ES/S DUs declined in the early 1990s and has been highly variable in recent years. Freshwater survival (smolts/EFS), though variable, decreased from the mid-1960s through to the mid-1990s before increasing dramatically in recent years (Figure 10). Marine survival in contrast has declined consistently since the early 1990s.

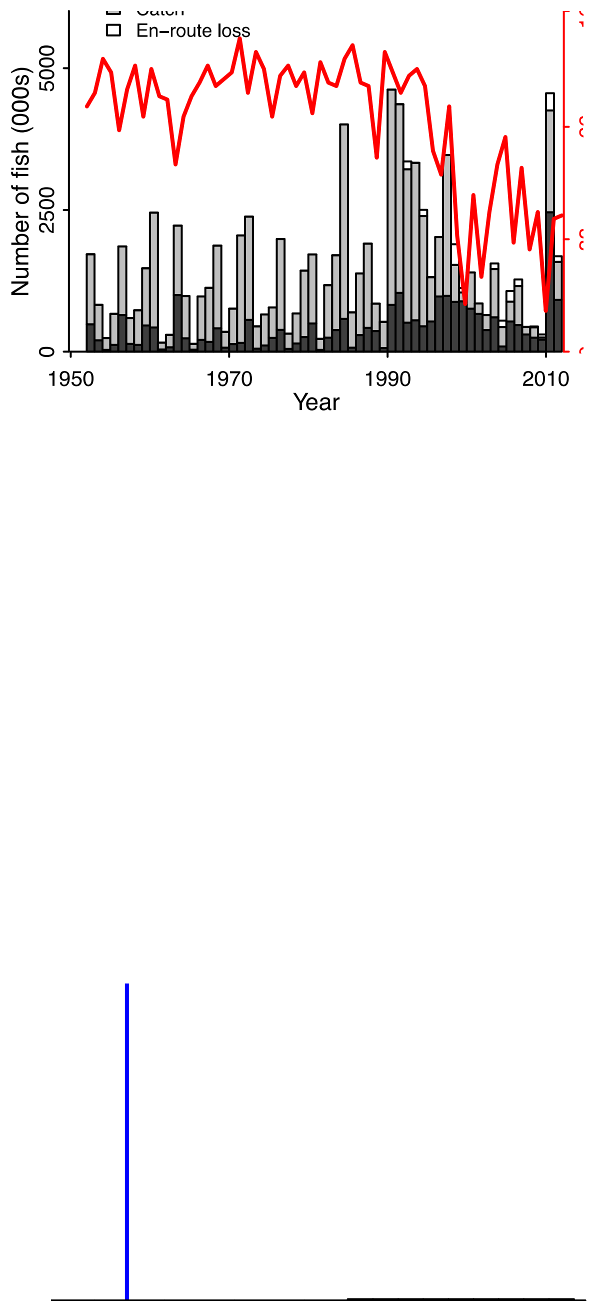
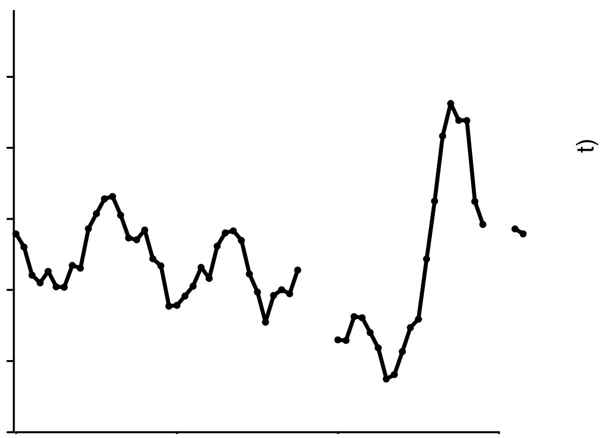


Figure 9: Historical trends in abundance, catch, recruits-per-spawner and estimated rates of change for DU 3/4: Chilko-ES/S, (a) total escapement, catch, en-route loss and exploitation rate (red line) by return year; (b) escapement separated by sex and female pre-spawn mortality (PSM); (c) recruits per effective female spawner ($\log_e$ scale); (d) 4-year running average of effective female spawners with estimated rates of change based on last 3 generations and full time series; and posterior distributions (and median estimate as vertical line) of estimated percent change over last three generations based on a linear rate of change of smoothed $\log_e$ effective female spawner abundances over (e) most recent three generations of data or (f) full time series.

(b)



Brood year

Figure 10: Historical trends in (a) freshwater (smolt per effective female spawner) and (b) marine (recruits per smolt) survival.

Using data for the last 3 generations, the Chilko-ES/S DUs have increased by an estimated 94% (Upper 95% CI = 267%, Lower 95% CI = +1%) (Table 4). The probability that there has been a decline of >30% is 0.00. When change in abundance is calculated based on the entire time series, the DUs have increased by an estimated 41% (Upper 95% CI = 51%, Lower 95% CI = 32%). The probability that there has been a decline of >30% is 0.00.

Table 4: Summary of estimated rate of change (+/- 95% credible interval) in effective female spawner abundance as well as the probability DU 3/4: Chilko-ES/S has declined by more than 30%, 50% or 70% over the last three generations. Rates of change are provided based on analysis of just the last 3 generations of data or the entire time series (see corresponding year range).

DU	Generation length	Year range	Median % change	95% CI	p>30% decline	p>50% decline	p>70% decline	Number of observations
Chilko-ES/S	4 yrs	2003-2015	+94%	+1% / +267%	0	0	0	13
		1954-2015	+41%	+32 / +51%	0	0	0	13

Threats and Limiting Factors

A threat calculator was not completed for these DUs.

Designatable Unit 5: Chilliwack-ES population

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

The Chilliwack-ES DU is composed of Sockeye that primarily spawn in Chilliwack Lake and Dolly Varden Creek (Figure 11) (Grant *et al*. 2011). The extent of occurrence for this DU includes the North Pacific Ocean and so is estimated to be greater than 20,000 km^2. The most recent estimate of the IAO for the Chilliwack-ES DU is 8 km^2. The number of consistently assessed sites where spawning has occurred has remained the same over the past 19 years (1992-95: 2, 2000-03: 2, 2008-11: 2; de Mestral Bezanson *et al.* 2012).

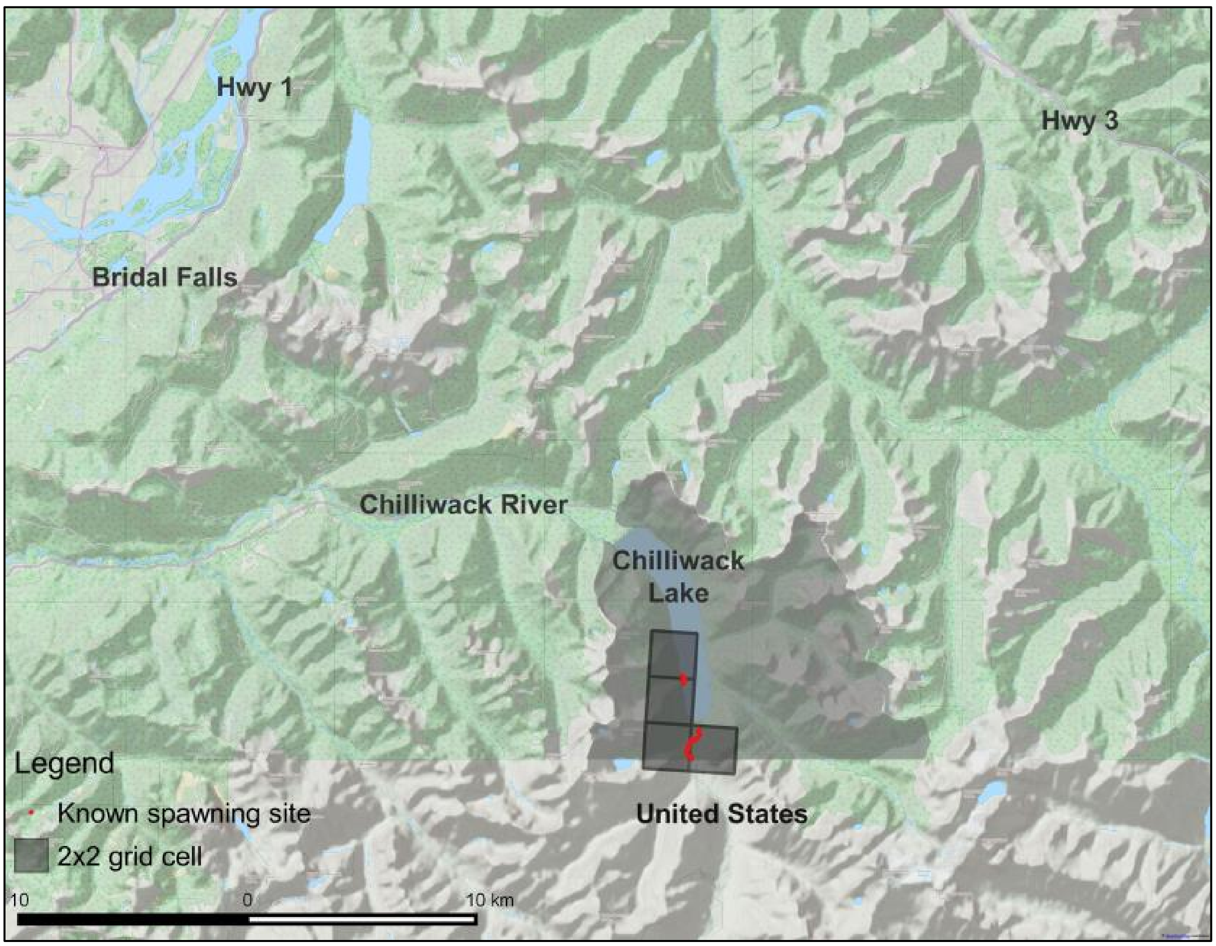


Figure 11: Chilliwack-ES DU and known spawning sites within it.

Habitat Trends

There is a relatively moderate road density in the Chilliwack-ES DU as well as relatively low intensity of Mountain Pine Beetle disturbance which has been increasing in recent years (Nelitz *et al*. 2011). Forest harvesting, agriculture and water allocation all occur at relatively low intensities (Nelitz *et al*. 2011). Increasing global temperatures and associated decrease in glacial mass have led to increasing water temperature in Chilliwack Lake (Grant *et al*. 2011).

Abundance

Spawner abundance for Chilliwack-ES DU is estimated based on counts of Sockeye at two sites, Chilliwack Lake and Dolly Varden Creek, using either visual surveys (peak live plus cumulative dead) or sonar methods in the creek and carcass counts in the lake (Grant *et al*. 2011). The lake assessment is considered an index of abundance only based on carcass surveys on the lake, and so is a lower quality escapement estimate and should be considered a minimum estimate. In 2016, a sonar system operated at the outlet of the lake to provide a more accurate estimate of total spawners to the system. Prior to 2001 the full extent of spawning was not estimated and so trends in abundance have only been estimated since 2001. The overall quality of these spawner estimates is considered “Good”. The most recent estimate of spawner abundance was 36,167 mature individuals.

Fluctuations and Trends

From the 1970s to 2000s, the number of fish in the Chilliwack-ES DU was relatively low but has increased in recent years (Figure 12; note beginning in 2000 escapement to Dolly Varden Creek is included). The Chilliwack-ES DU experienced relatively high abundances of female spawners in 2001, 2004, 2008 and 2013 compared to other years with data. Escapement has remained relatively stable over the short period of time for which good data are available (since 2001). Exploitation rates and recruits-per-spawner could not be estimated for the Chilliwack-ES DU as there are no corresponding data available. There are also no data on trends in early freshwater or post-fry survival for this DU.

No Corresponding Data for this DU

(f)

0 500 1000 1500 2000 2500 3000

% change over 3 gen. (all years)

Figure 12: Historical trends in abundance, catch, recruits-per-spawner and estimated rates of change for DU 5: Chilliwack-ES, (a) total escapement, catch, en-route loss and exploitation rate (red line) by return year; (b) escapement separated by sex and female pre-spawn mortality (PSM); (c) recruits per effective female spawner ($\log_e$ scale); (d) 4-year running average of effective female spawners with estimated rates of change based on last 3 generations and full time series; and posterior distributions (and median estimate as vertical line) of estimated percent change over last three generations based on a linear rate of change of smoothed $\log_e$ effective female spawner abundances over (e) most recent three generations.

Using data for the last 3 generations, the Chilliwack-ES DU has increased by an estimated 64% (Upper 95% CI = 287%, Lower 95% CI = -32%) (Table 5). The probabilities that the decline has been greater than 30%, 50% and 70% respectively are 0.03, 0.01, and 0.00.

Table 5: Summary of estimated rate of change (+/- 95% credible interval) in effective female spawner abundance as well as the probability DU 5: Chilliwack-ES has declined by more than 30%, 50% or 70% over the last three generations. Rates of change are provided based on analysis of just the last 3 generations of data or the entire time series (see corresponding year range).

DU	Generation length	Year range	Median % change	95% CI	p>30% decline	p>50% decline	p>70% decline	Number of observations
Chilliwack-ES	4 yrs	2003-2015	+64%	-32% / +287%	0.03	0.01	0	13

Threats and Limiting Factors

A threat calculator was not completed for this DU.

Designatable Unit 6: Cultus-L population

Extent of Occurrence and Area of Occupancy

The Cultus-L DU is composed of Sockeye that spawn in Cultus Lake (Figure 13). The extent of occurrence for this DU includes the North Pacific Ocean and so is estimated to be greater than 20,000 km^2. The most recent estimate of the IAO for the Cultus-L DU is 4 km^2. The number of consistently assessed sites where spawning has occurred has remained the same over the past 19 years (1992-95: 1, 2000-03: 1, 2008-11: 1; de Mestral Bezanson *et al*. 2012).

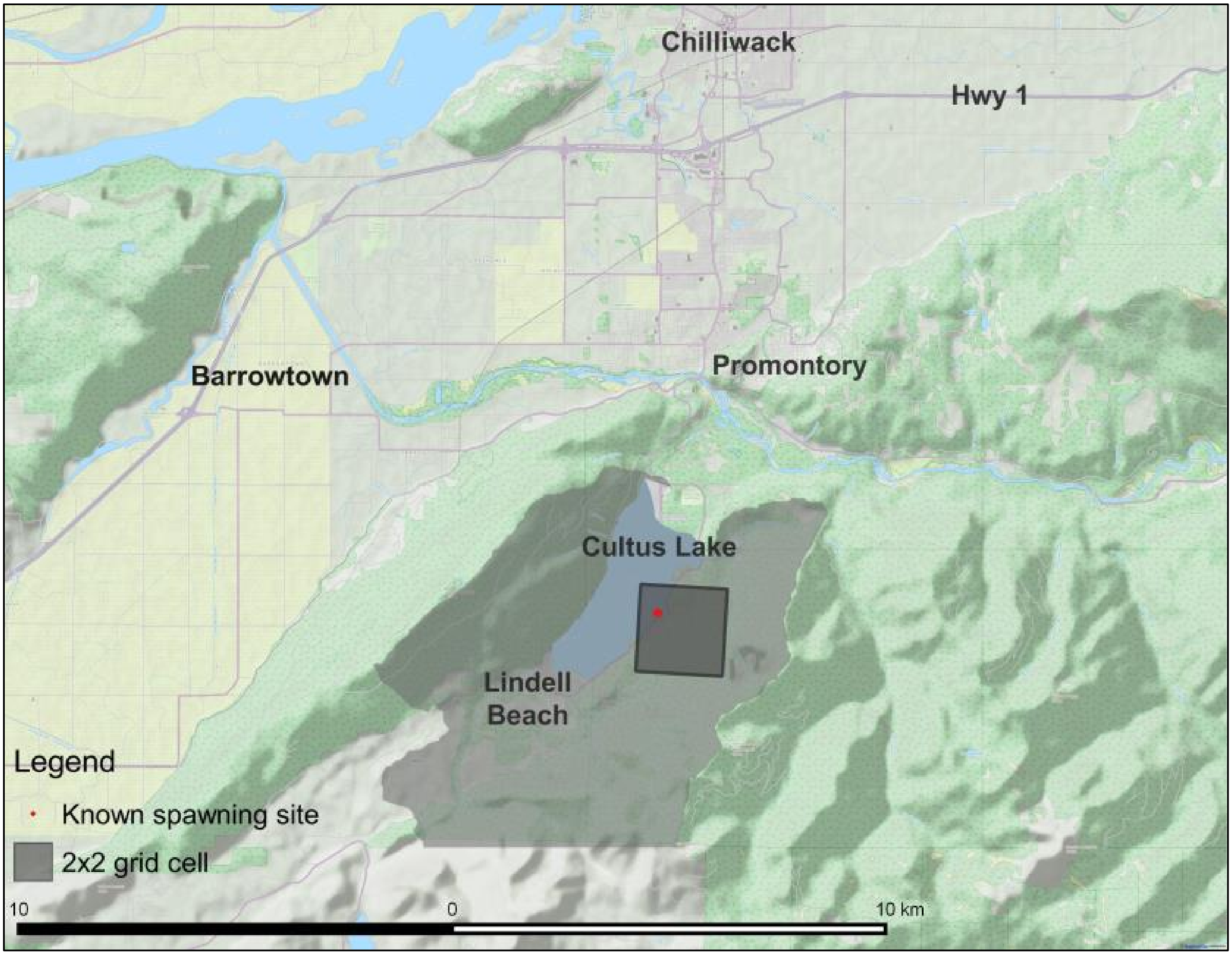


Figure 13: Cultus-L DU and known spawning sites within it.

Habitat Trends

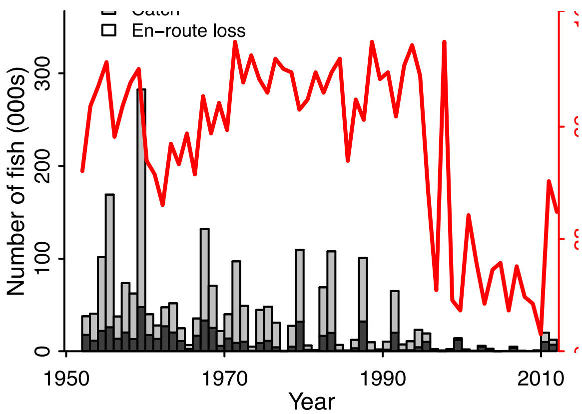
The Cultus-L DU receives over 1.5 million visitors annually making it one of the most utilized lakes in BC. The DU is extensively developed for recreational, residential and agricultural purposes which has led to degradation to tributary and outlet streams and lake foreshore habitat (COSEWIC 2003). Cultus Lake's water quality has potentially been degraded as a result of seepage from septic systems, agricultural runoff and domestic use of fertilizers (COSEWIC 2003). The lake is heavily impacted by Eurasian Watermilfoil (*Myriophyllum spicatum*) which has spread widely and rapidly, despite attempts to control it, since its introduction in the late 1970s (Cultus Sockeye Recovery Team 2009).

Abundance

Spawner abundance for this DU is estimated based on counts of Sockeye at Cultus Lake using a combination of enumeration fence and carcass recovery methods in the lake (Grant *et al*. 2011). Sex identification is not possible at the fence and so the data presented in Figure 14 are total spawners, with hatchery (clipped) fish removed. The overall quality of these spawner estimates is considered “Excellent”, though determining the number of effective female spawners is problematic. The most recent estimate of spawner abundance was 1,536 total spawners.

Fluctuations and Trends

From the 1950s to 1970s, the number of fish that returned to spawn in the Cultus-L DU was relatively high and stable but then steadily declined though the 1970 to 1990s. By the 2000s the abundance of Cultus-L DU Sockeye was very depressed (i.e., less than 2,000 total effective spawners in most years) (Figure 14). The DU experienced very high (>80%) exploitation rates in most years from the 1950s to late 1990s. The exploitation rate declined in the mid-1990s and was relatively low until 2010. However, the exploitation rate in the last two years was greater than 40%. There are no data on trends in early freshwater or post-fry survival available for this DU.



(e)

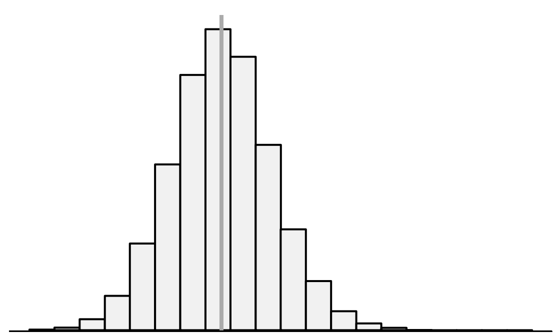


Figure 14: Historical trends in abundance, catch and estimate of rate of change for DU 6: Cultus-L, (a) total escapement, catch, en-route loss and exploitation rate (red line) by return year; (b) total spawners (males plus females); (c) recruits per effective female spawner ($\log_e$ scale); (d) 4-year running average of effective total spawners with estimated rates of change based on last 3 generations and full time series; and posterior distributions (and median estimate as vertical line) of estimated percent change over last three generations based on a linear rate of change of smoothed $\log_e$ effective total spawner abundances over (e) most recent three generations of data (f) or full time series.

Using data for the last 3 generations, the Cultus-L DU has declined by an estimated 39% (Upper 95% CI = 48%, Lower 95% CI = -76%) (Table 6). The probabilities that the decline has been greater than 30%, 50% and 70% respectively are 0.64, 0.32, and 0.05. When change in abundance is calculated based on the entire time series, the DU has decreased by an estimated 56% (Upper 95% CI = -53%, Lower 95% CI = -59%). The probabilities that the decline has been greater than 30%, 50% and 70% respectively are 1.00, 1.00, and 0.00.

Table 6: Summary of estimated rate of change (+/- 95% credible interval) in effective female spawner abundance as well as the probability DU 6: Cultus-L has declined by more than 30%, 50% or 70% over the last three generations. Rates of change are provided based on analysis of just the last 3 generations of data or the entire time series (see corresponding year range).

DU	Generation length	Year range	Median % change	95% CI	p>30% decline	p>50% decline	p>70% decline	Number of observations
Cultus-L	4 yrs	2003-2015	-39%	-76% / + 48%	0.64	0.32	0.05	13
		1950-2015	-56%	-59% / -53%	1	1	0	13

Threats and Limiting Factors

A threat calculator was not completed for this DU.

Designatable Unit 7: Francois-Fraser-S population

Extent of Occurrence and Area of Occupancy

The Francois-Fraser-S DU is composed of Sockeye that spawn in three sites (Figure 15): the Stellako River, and Uncha and Ormonde creeks (Grant *et al*. 2011). The extent of occurrence for this DU includes the North Pacific Ocean and so is estimated to be greater than 20,000 km^2. The most recent estimate of the IAO for the Francois-Fraser-S DU is 36 km^2. The number of consistently assessed sites where spawning has occurred has remained the same for the past 19 years (1992-95: 1, 2000-03: 1, 2008-11: 1; de Mestral Bezanson *et al.* 2012).

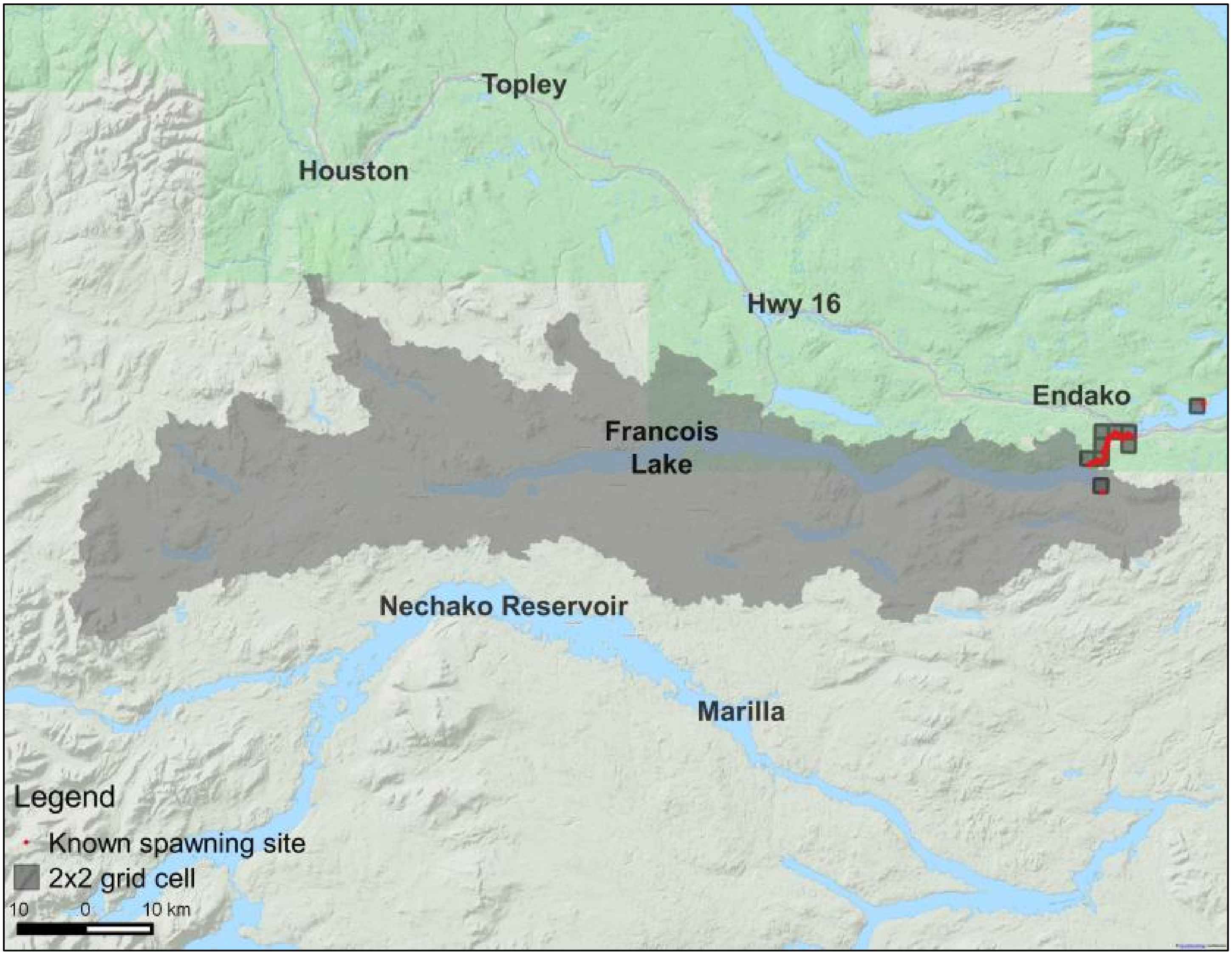


Figure 15: Francois-Fraser-S DU and known spawning sites within it.

Habitat Trends

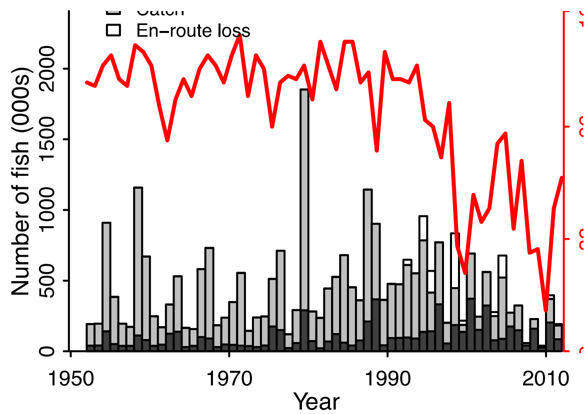
There are no known human stressors on habitat within this DU (Nelitz *et al.* 2011).

Abundance

Spawner abundance for Francois-Fraser-S DU is estimated based on counts of Sockeye at Stellako River using a combination of fence counts and mark recapture methods in the river (Grant *et al*. 2011). The overall quality of these spawner estimates is considered “Very good”. The most recent estimate of spawner abundance was 194,510 mature individuals.

Fluctuations and Trends

Escapement to the spawning grounds in the Francois-Fraser-S DU remained relatively constant from the 1950s to the mid-1970s before increasing through to the late 1990s and then declining to present (Figure 16). The estimated exploitation rate for the DU remained very high through the early 1990s (as high as 95%) before declining to around 30% in recent years. The Francois-Fraser-S DU has exhibited systematic declines in recruits-per-spawner since the 1990s with particularly low recruits-per-spawner in the 2005 brood year. There are very little data on trends in early freshwater or post-fry survival for this DU and so they are not presented.



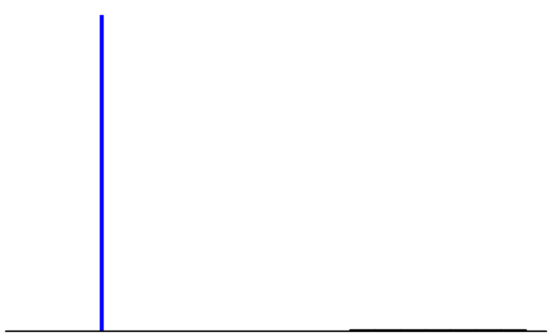


Figure 16: Historical trends in abundance, catch and recruits-per-spawner and estimate of rate of change for DU 7: Francois-Fraser-S, (a) total escapement, catch, en-route loss and exploitation rate (red line) by return year; (b) escapement separated by sex and female pre-spawn mortality (PSM); (c) recruits per effective female spawner ($\log_e$ scale); (d) 4-year running average of effective female spawners with estimated rates of change based on last 3 generations and full time series; and posterior distributions (and median estimate as vertical line) of estimated percent change over last three generations based on a linear rate of change of smoothed $\log_e$ effective female spawner abundances over (e) most recent three generations of data (f) or full time series.

Using data for the last 3 generations, the Francois-Fraser-S DU has decreased by an estimated 34% (Upper 95% CI = 19%, Lower 95% CI = -64%) (Table 7). It should be noted that this was a decline from the second highest value in the time series and that there has been an increase in the last generation. The most recent estimate is among the highest in the time series. The probabilities that the decline has been greater than 30%, 50% and 70% respectively are 0.59, 0.16, and 0.01. When change in the abundance is calculated based on the entire time series, the DU has increased by an estimated 22% (Upper 95% CI = 28%, Lower 95% CI = 16%). The probability that there has been a decline of >30% is 0.00.

Table 7: Summary of estimated rate of change (+/- 95% credible interval) in effective female spawner abundance as well as the probability DU 7: Francois-Fraser-S has declined by more than 30%, 50% or 70% over the last three generations. Rates of change are provided based on analysis of just the last 3 generations of data or the entire time series (see corresponding year range).

DU	Generation length	Year range	Median % change	95% CI	p>30% decline	p>50% decline	p>70% decline	Number of observations
Francois-Fraser-S	4 yrs	2003-2015	-34%	-64 / +19%	0.59	0.16	0.01	13
		1954-2015	22%	+16 / +28%	0	0	0	13

Threats and Limiting Factors

A threat calculator was not completed for this DU.

Designatable Unit 8: Nadina-Francois-ES population

Extent of Occurrence and Area of Occupancy

The Nadina-Francois-ES DU is composed of Sockeye that spawn in numerous sites including Glacier Creek, Nadina River, Nadina Channel, and Tagetochlain Creek (Figure 17). The extent of occurrence for this DU includes the North Pacific Ocean and so is estimated to be greater than 20,000 km^2. The most recent estimate of the IAO for the Nadina-Francois-ES DU is 124 km^2. The number of consistently assessed sites where spawning has occurred has remained the same for the past 19 years (1992-95: 2, 2000-03: 2, 2008-11: 2; de Mestral Bezanson *et al*. 2012).

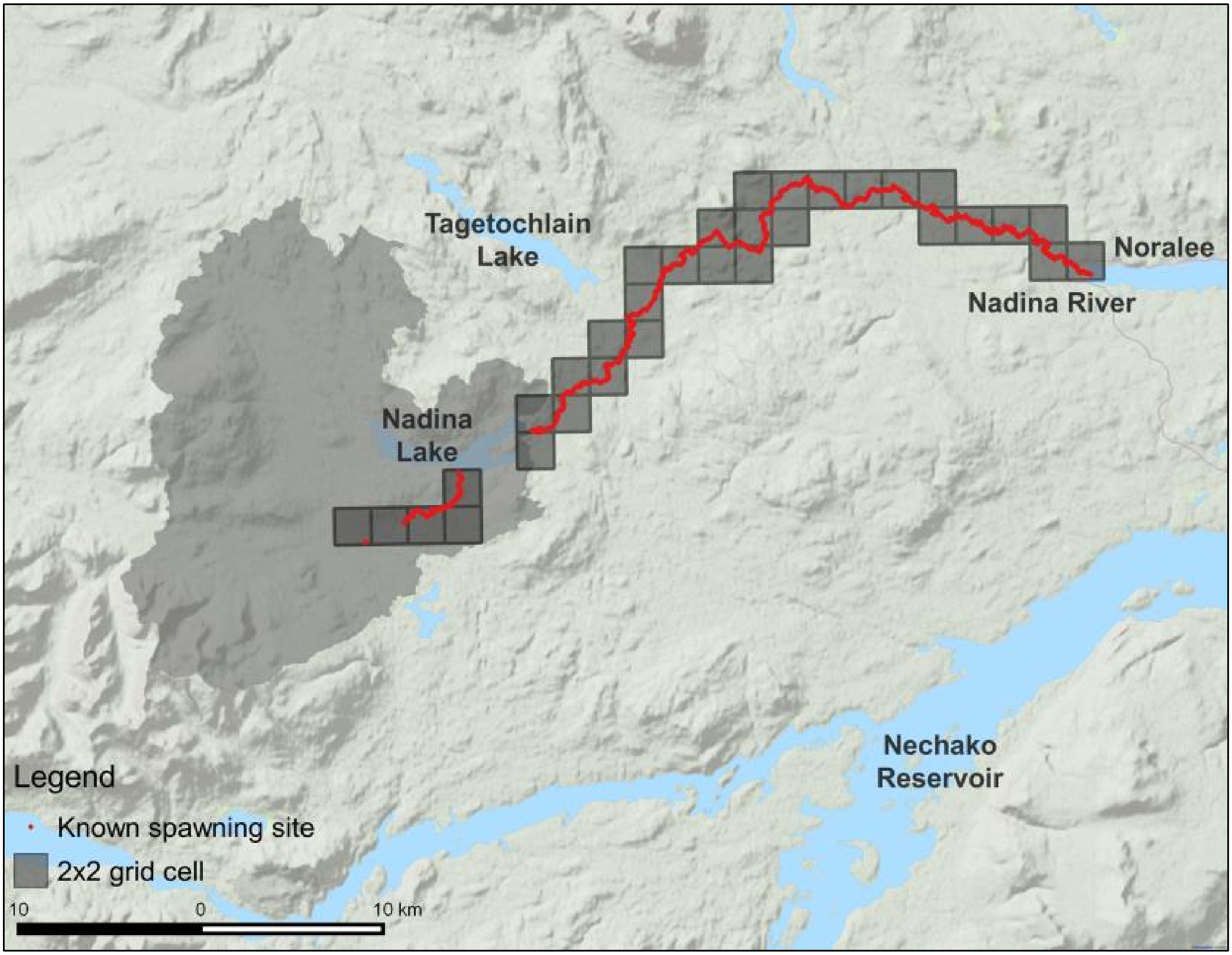


Figure 17: Nadina-Francois-ES DU and known spawning sites within it.

Habitat Trends

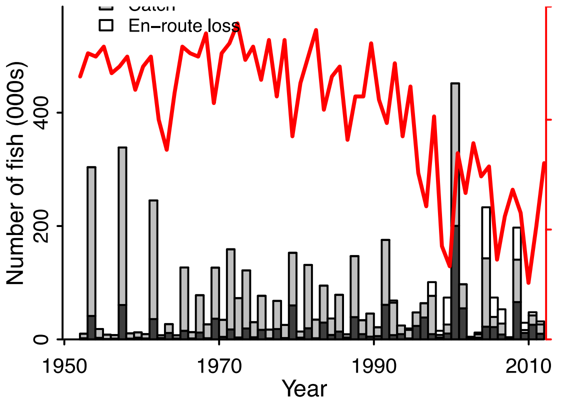
There are no known human stressors on habitat within this DU (Nelitz *et al.* 2011). The Nadina Sockeye spawning channel was built in 1973 next to the Nadina River at the outlet of Nadina Lake. The channel was built to augment Nadina Sockeye and increase utilization of the Francois Lake rearing area by juveniles (Grant *et al*. 2011). Nadina Channel Sockeye experienced several years of elevated pre-spawn mortality associated with *Ichthyophthirius multifiliis,* particularly in 1978, 1987 and 1995 (Grant *et al*. 2011).

Abundance

Spawner abundance for Nadina-Francois-ES DU is estimated based on annual counts in the Nadina River and Channel (Grant *et al.* 2011). The overall quality of these spawner estimates is considered “Good”. The most recent estimate of spawner abundance was 32,555 mature individuals.

Fluctuations and Trends

Escapement to the Nadina-Francois-ES DU increased in the early 1970s with the construction of the spawning channel and then remained relatively constant through time with higher average escapement in odd years than in even ones (Figure 18). The estimated exploitation rate for the Nadina-Francois-ES DU declined sharply in the early 1990s from rates as high as 90% to rates typically below 50% since the 2000s. The Nadina-Francois-ES DU has exhibited a general decline in recruits-per-spawner since the early 1970s (note the time series is truncated to exclude years before the spawning channel). Early freshwater survival (fall fry/EFS) declined from the early 1970s to the early 1990s and has then been increasing ever since (Figure 19) while post-fry survival, which includes a period of freshwater survival and marine survival, has remained relatively constant with the exception of almost a decade of elevated survival in the 1990s.



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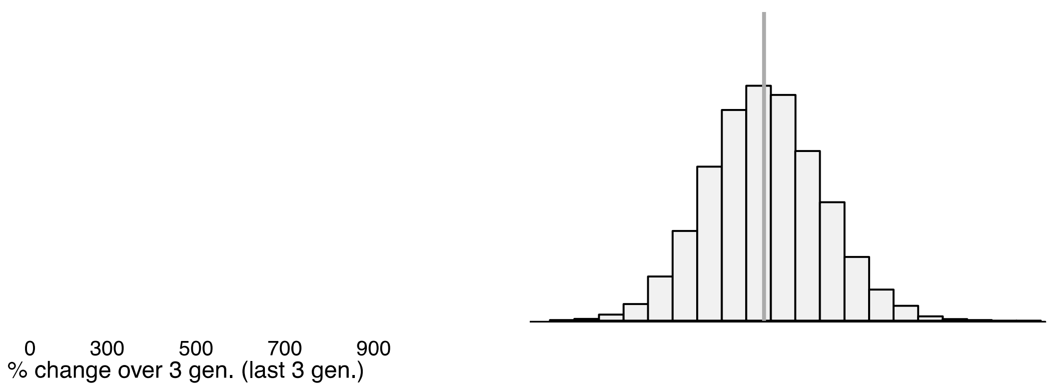


Figure 18: Historical trends in abundance, catch, recruits-per-spawner and estimate of rate of change for DU 8: Nadina-Francois-ES, (a) total escapement, catch, en-route loss and exploitation rate (red line) by return year; (b) escapement separated by sex and female pre-spawn mortality (PSM); (c) recruits per effective female spawner ($\log_e$ scale); (d) 4-year running average of effective female spawners with estimated rates of change based on last 3 generations and full time series; and posterior distributions (and median estimate as vertical line) of estimated percent change over last three generations based on a linear rate of change of smoothed $\log_e$ effective female spawner abundances over (e) most recent three generations of data (f) or full time series. Note that data pre spawning channel (i.e., before 1973) are not comparable to those after it.

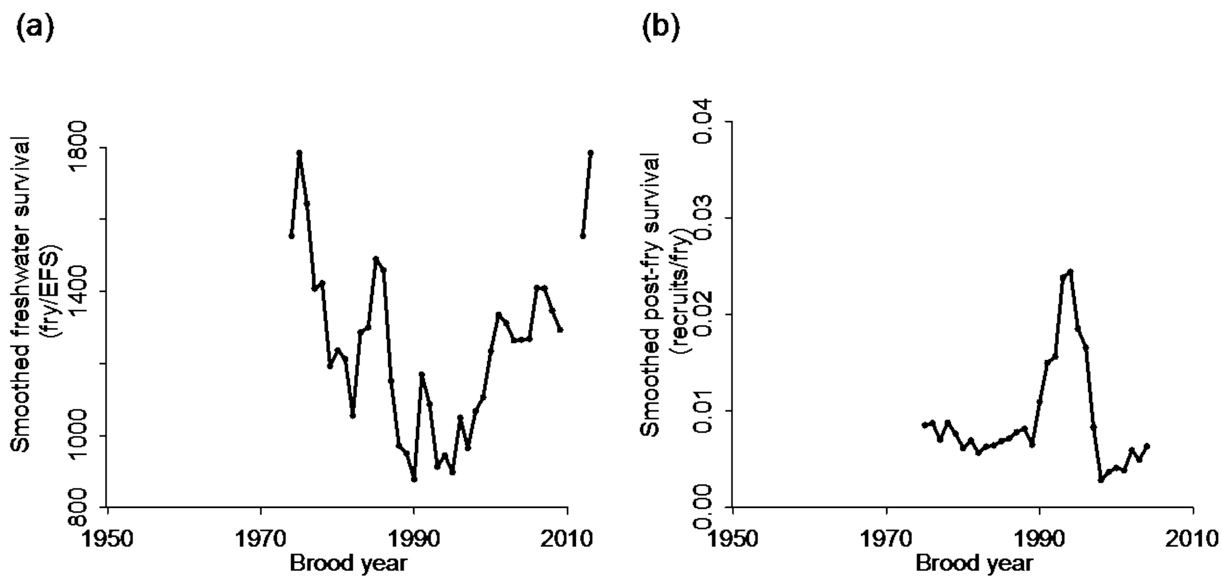


Figure 19: Historical trends in (a) early freshwater (fry per effective female spawner) and (b) post-fry/marine (recruits per fry) survival.

Using data for the last 3 generations, the Nadina-Francois-ES DU has increased by an estimated 74% (Upper 95% CI = 225%, Lower 95% CI = -8%) (Table 8). The probability that there has been a decline of >30% is 0.00. When change in abundance is calculated based on the entire time series, the DU has increased by an estimated 37% (Upper 95% CI = 45%, Lower 95% CI = 29%). The probability that there has been a decline of >30% is 0.00.

Table 8: Summary of estimated rate of change (+/- 95% credible interval) in effective female spawner abundance as well as the probability DU 8: Nadina-Francois-ES has declined by more than 30%, 50% or 70% over the last three generations. Rates of change are provided based on analysis of just the last 3 generations of data or the entire time series (see corresponding year range).

DU	Generation length	Year range	Median % change	95% CI	p>30% decline	p>50% decline	p>70% decline	Number of observations
Nadina-Francois-ES	4 yrs	2003-2015	+74%	-8 /+ 225%	0	0	0	13
		1954-2015	+37%	+29 / + 45%	0	0	0	13

Threats and Limiting Factors

A threat calculator was not completed for this DU.

Designatable Unit 9: Harrison (D/S)-L population

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

The Harrison (D/S)-L DU is composed of Sockeye that spawn in numerous sites including Bear Creek, Big Silver Creek, Cogburn Creek, Crazy Creek, Douglas Creek, Hatchery Creek, Sloquet Creek, Tipella Creek, and Tipella Slough (Figure 20). The extent of occurrence for this DU includes the North Pacific Ocean and so is estimated to be greater than 20,000 km^2. The most recent estimate of the IAO for the Harrison (D/S)-L DU is 36 km^2. The number of consistently assessed sites where spawning has occurred has remained the same for the past 19 years (1992-95: 1, 2000-03: 1, 2008-11: 1; de Mestral Bezanson *et al*. 2012).

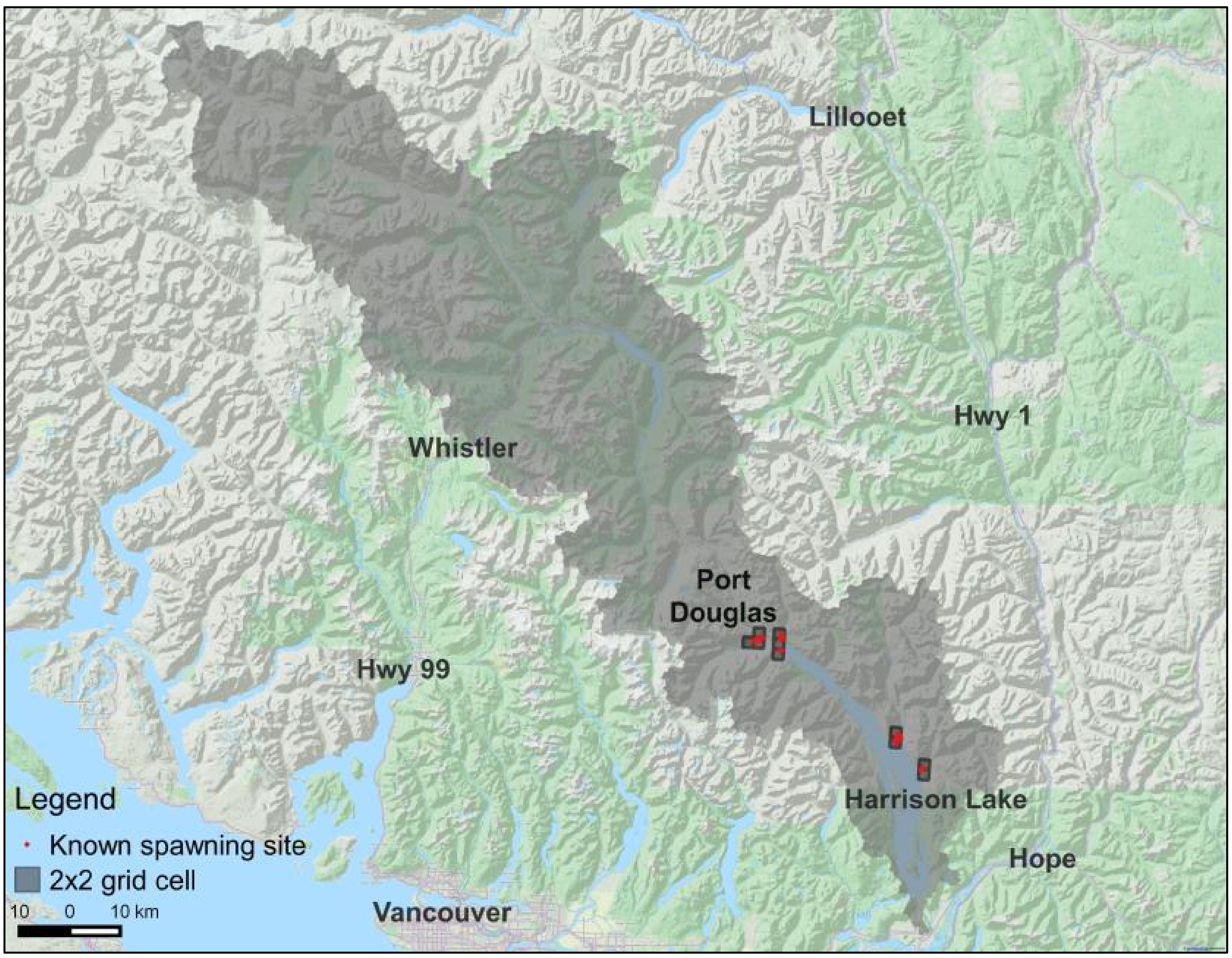


Figure 20: Harrison (D/S)-L DU and known spawning sites within it.

Habitat Trends

There is a relatively high intensity of forest harvesting in the Harrison (D/S)-L DU though it has decreased in recent years. There is a relatively low intensity Mountain Pine Beetle disturbance in the DU which has increased in recent years (Nelitz *et al*. 2011). Placer mines occur at relatively moderate intensity in the DU while road density and small scale hydro dams occur at relatively low intensities in the DU (Nelitz *et al*. 2011).

Abundance

Spawner abundance for Harrison (D/S)-L DU is estimated based on counts of Sockeye at nine sites: Bear Creek, Big Silver Creek, Cogburn Creek, Crazy Creek, Douglas Creek, Hatchery Cree, Sloquet Creek, Tipella Creek, and Tipella Slough (Grant *et al*. 2011). The overall quality of these spawner estimates is considered “Good”. The most recent estimate of spawner abundance was 5,523 mature individuals.

Fluctuations and Trends

From the 1950s to the early 1990s escapement to the DU was relatively low, it then rapidly increased in the early 2000s, and has subsequently declined but still remained above the long-term average (Figure 21). Exploitation and recruits-per-spawner could not be estimated for the Harrison (D/S)-L DU. There are no data on trends in early freshwater or post-fry survival for this DU.

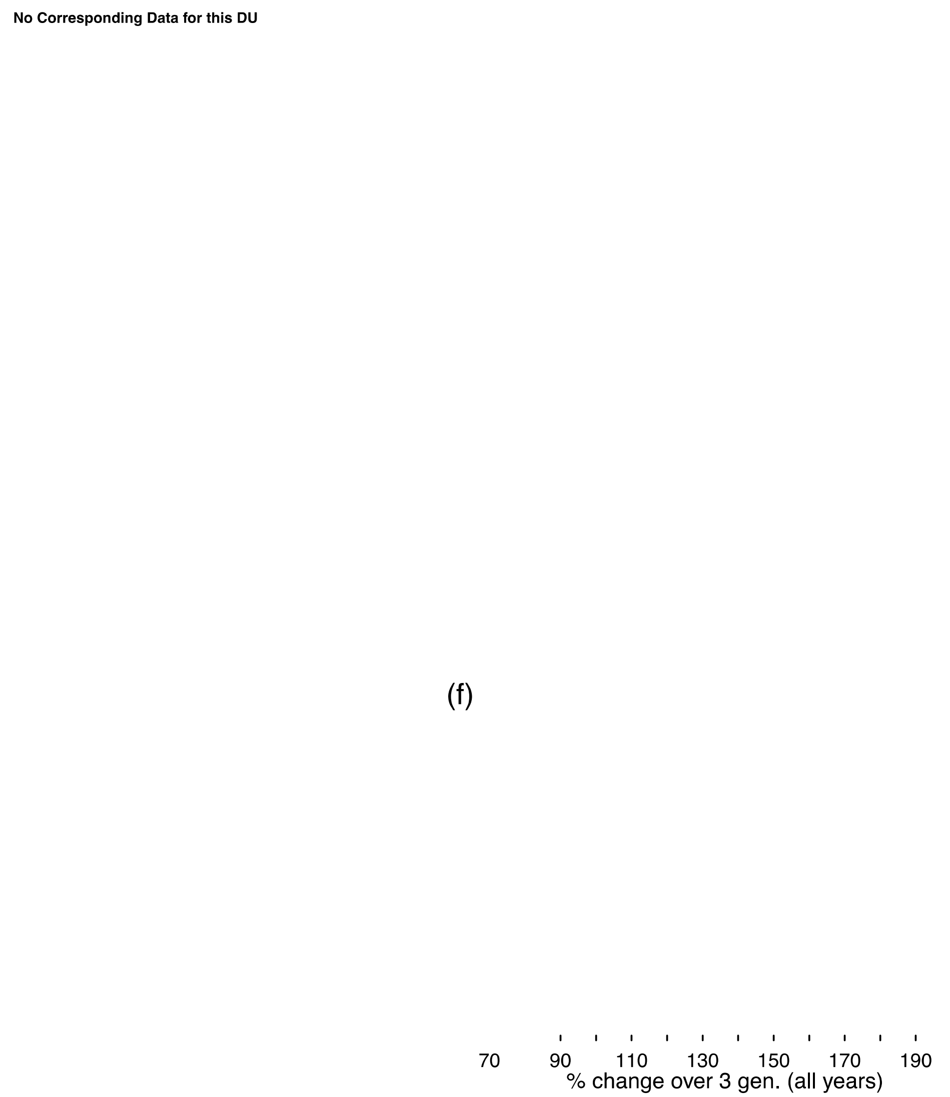


Figure 21: Historical trends in abundance, catch and estimate of rate of change for DU 9: Harrison (D/S)-L, (a) total escapement, catch, en-route loss and exploitation rate (red line) by return year; (b) escapement separated by sex and female pre-spawn mortality (PSM); (c) recruits per effective female spawner ($\log_e$ scale); (d) 4-year running average of effective female spawners with estimated rates of change based on last 3 generations and full time series; and posterior distributions (and median estimate as vertical line) of estimated percent change over last three generations based on a linear rate of change of smoothed $\log_e$ effective female spawner abundances over (e) most recent three generations of data (f) or full time series.

Using data for the last 3 generations, the Harrison (D/S)-L DU has decreased by an estimated 73% (Upper 95% CI = -56%, Lower 95% CI = -83%) (Table 9). It should be noted that this decline was from the highest value in the time series, and that the current abundance is well above that observed from 1952-1995. The probabilities that the decline has been greater than 30%, 50% and 70% respectively are 1.00, 0.99, and 0.68. When change in abundance is calculated based on the entire time series, the DU has increased by an estimated 133% (Upper 95% CI = 169%, Lower 95% CI = 101%). The probability that there has been a decline of >30% is 0.00.

Table 9: Summary of estimated rate of change (+/- 95% credible interval) in effective female spawner abundance as well as the probability DU 9: Harrison (D/S)-L has declined by more than 30%, 50% or 70% over the last three generations. Rates of change are provided based on analysis of just the last 3 generations of data or the entire time series (see corresponding year range).

DU	Generation length	Year range	Median % change	95% CI	p>30% decline	p>50% decline	p>70% decline	Number of observations
Harrison (D/S)-L	4 yrs	2003-2015	-73%	-83 / -56%	1	0.99	0.68	13
		1954-2015	+133%	+101% / +169%	0	0	0	13

Threats and Limiting Factors

A threat calculator was not completed for this DU.

Designatable Unit 10: Harrison (U/S)-L population

Extent of Occurrence and Area of Occupancy

The Harrison (U/S)-L DU (Figure 22) is composed of Sockeye that spawn in site across East Creek, Weaver Channel, and Weaver Creek. The extent of occurrence for this DU includes the North Pacific Ocean and so is estimated to be greater than 20,000 km^2. The most recent estimate of the IAO for the Harrison (U/S)-L DU is 4 km^2. The number of consistently assessed sites where spawning has occurred has remained the same for the past 19 years (1992-95: 2, 2000-03: 2, 2008-11: 2; de Mestral Bezanson *et al*. 2012).

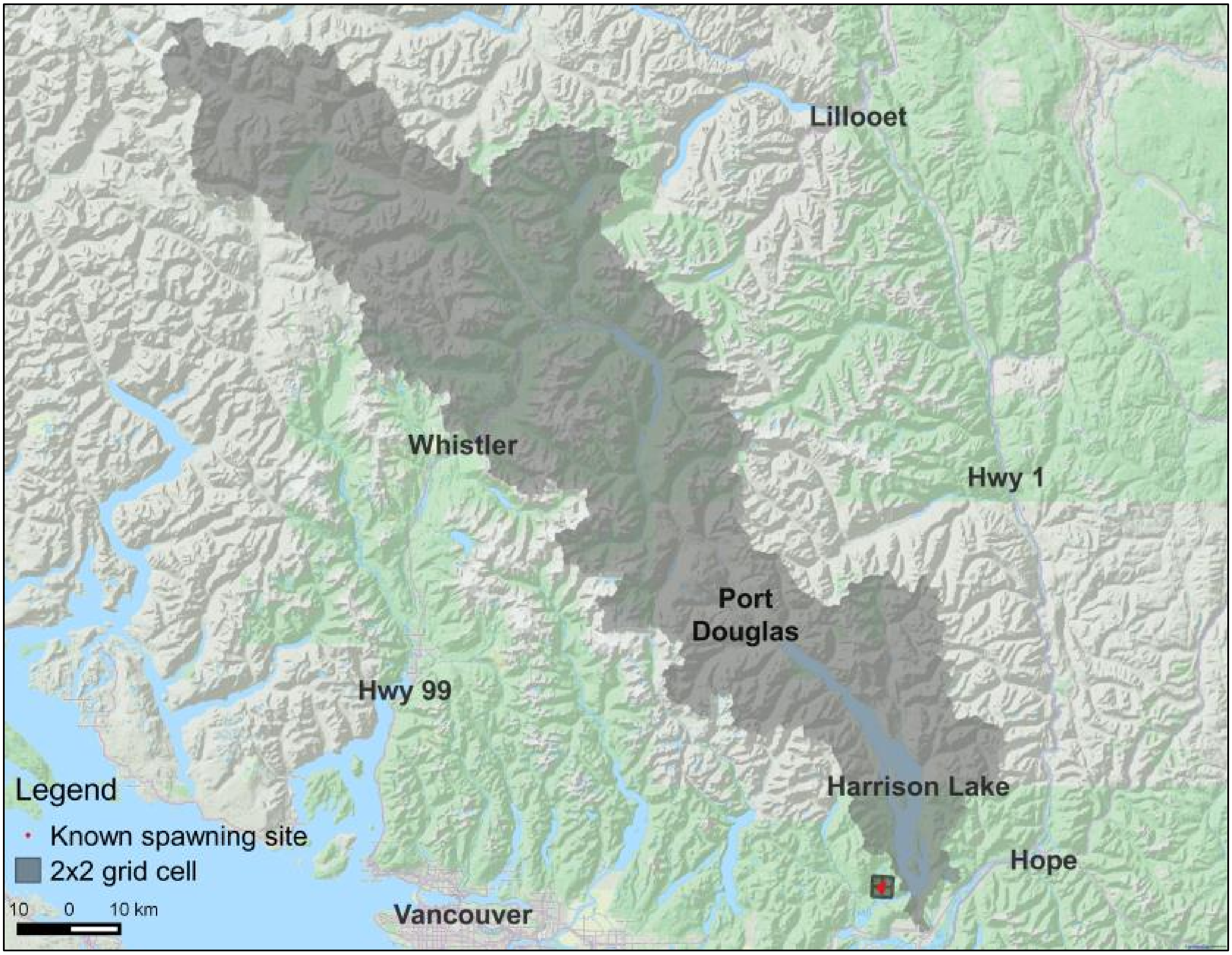


Figure 22: Harrison (U/S)-L DU and known spawning sites within it.

Habitat Trends

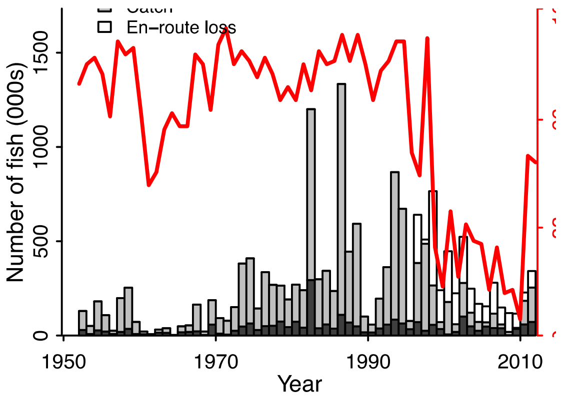
There is currently a relatively high road density in the Harrison (U/S)-L DU. There is moderate intensity of forest harvesting in the DU area which has increased in recent years (Nelitz *et al*. 2011). Water allocation occurs at relatively moderate intensity in the DU and there are several small hydro-electric dams in the DU (Nelitz *et al*. 2011).

Abundance

Spawner abundance for Harrison (U/S)-L DU is estimated based on counts of Sockeye at three sites, Weaver Creek, Weaver Channel and East Creek, using a combination of peak live cumulative dead and mark recapture methods as well as carcasses surveys and an enumeration fence in Weaver channel which was built in the early 1960s (Grant *et al*. 2011). The overall quality of these spawner estimates is considered "Good". The most recent estimate of spawner abundance was 14,558 mature individuals.

Fluctuations and Trends

Prior to the completion of the Weaver Creek spawning channel escapement to the DU was relatively low but then increased dramatically in the early 1970s. Since the early 1980s, the population has fluctuated in a downward direction until the present (Figure 23). Exploitation rates for the DU were variable but high (i.e., > 70%) through most of the 1960s to 1980s and then were reduced significantly in the mid-1990s to rates less than 30% in most years since. Recruits-per-spawner in the Harrison (U/S)-L DU have been variable but relatively stable over the time period for which data are available. Early freshwater survival (fall fry/EFS), though variable, has generally increased since the 1970s while post-fry survival, which includes a period of freshwater survival and marine survival, has generally declined over the same time period.



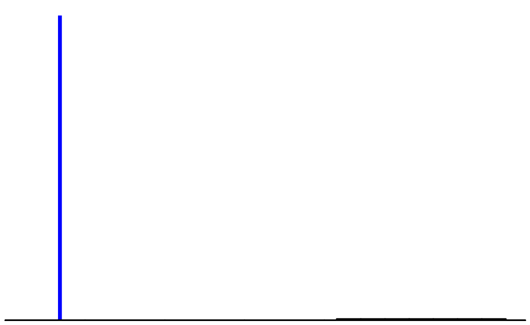


Figure 23: Historical trends in abundance, catch, recruits-per-spawner and estimate of rate of change for DU 10: Harrison (U/S)-L, (a) total escapement, catch, en-route loss and exploitation rate (red line) by return year; (b) escapement separated by sex and female pre-spawn mortality (PSM); (c) recruits per effective female spawner ($\log_e$ scale); (d) 4-year running average of effective female spawners with estimated rates of change based on last 3 generations and full time series; and posterior distributions (and median estimate as vertical line) of estimated percent change over last three generations based on a linear rate of change of smoothed $\log_e$ effective female spawner abundances over (e) most recent three generations of data (f) or full time series.

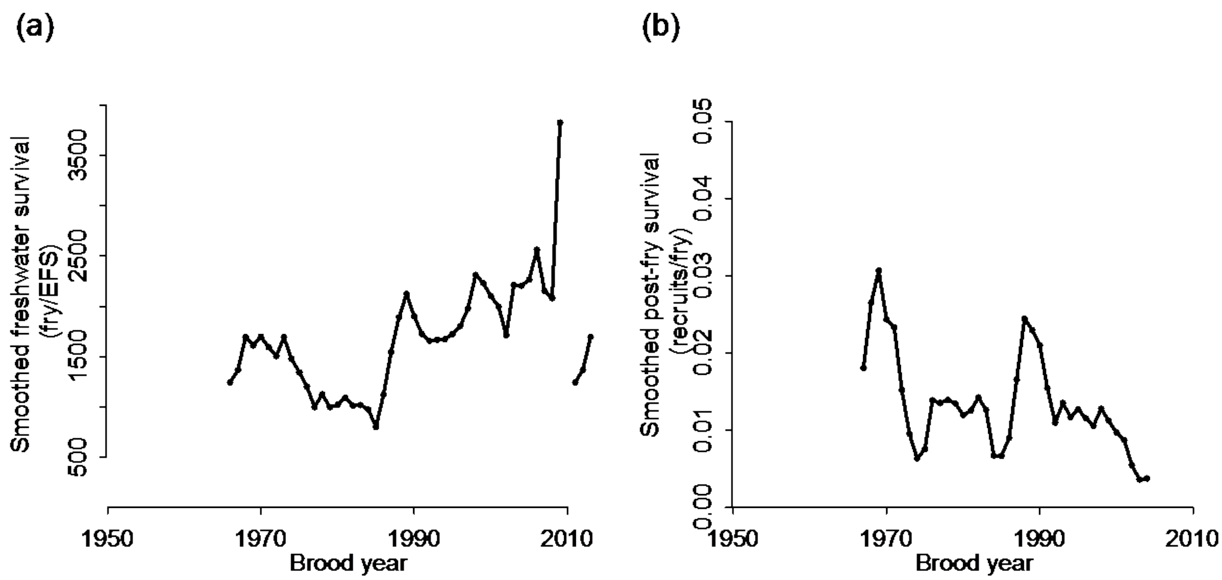


Figure 24: Historical trends in (a) early freshwater (fry per effective female spawner) and (b) post-fry/marine (recruits per fry) survival.

Using data for the last 3 generations, the Harrison (U/S)-L DU has decreased by an estimated 76% (Upper 95% CI = -52%, Lower 95% CI = -88%) (Table 10). The probabilities that the decline has been greater than 30%, 50% and 70% respectively are 1.00, 0.98, and 0.76. When change in abundance is calculated based on the entire time series, the DU has increased by an estimated 8% (Upper 95% CI = 21%, Lower 95% CI = -4%).

Table 10: Summary of estimated rate of change (+/- 95% credible interval) in effective female spawner abundance as well as the probability DU 10: Harrison (U/S)-L has declined by more than 30%, 50% or 70% over the last three generations. Rates of change are provided based on analysis of just the last 3 generations of data or the entire time series (see corresponding year range).

DU	Generation length	Year range	Median % change	95% CI	p>30% decline	p>50% decline	p>70% decline	Number of observations
Harrison (U/S)-L	4 yrs	2003-2015	-76%	-88% / -52%	1	0.98	0.76	13
		1954-2015	8%	-4% / +21%	0	0	0	13

<u>Threats and Limiting Factors</u>

In recent years pre-spawn mortality of Weaver Creek Sockeye has been relatively high due to the *Parvicapsula* parasite (Grant *et al.* 2011).

A threat calculator was not completed for this DU.

Designatable Unit 11: Kamloops-ES population

Extent of Occurrence and Area of Occupancy

The Kamloops-ES DU is composed of Sockeye that spawn in over ten sites including the Clearwater River, North Thompson River, and Barriere River (Figure 25). The extent of occurrence for this DU includes the North Pacific Ocean and so is estimated to be greater than 20,000 km^2. The most recent estimate of the IAO for the Kamloops-ES DU is 208 km^2. The number of consistently assessed sites where spawning has occurred has remained the same over the past 19 years (1992-95: 3, 2000-03: 3, 2008-11: 3; de Mestral Bezanson *et al*. 2012).

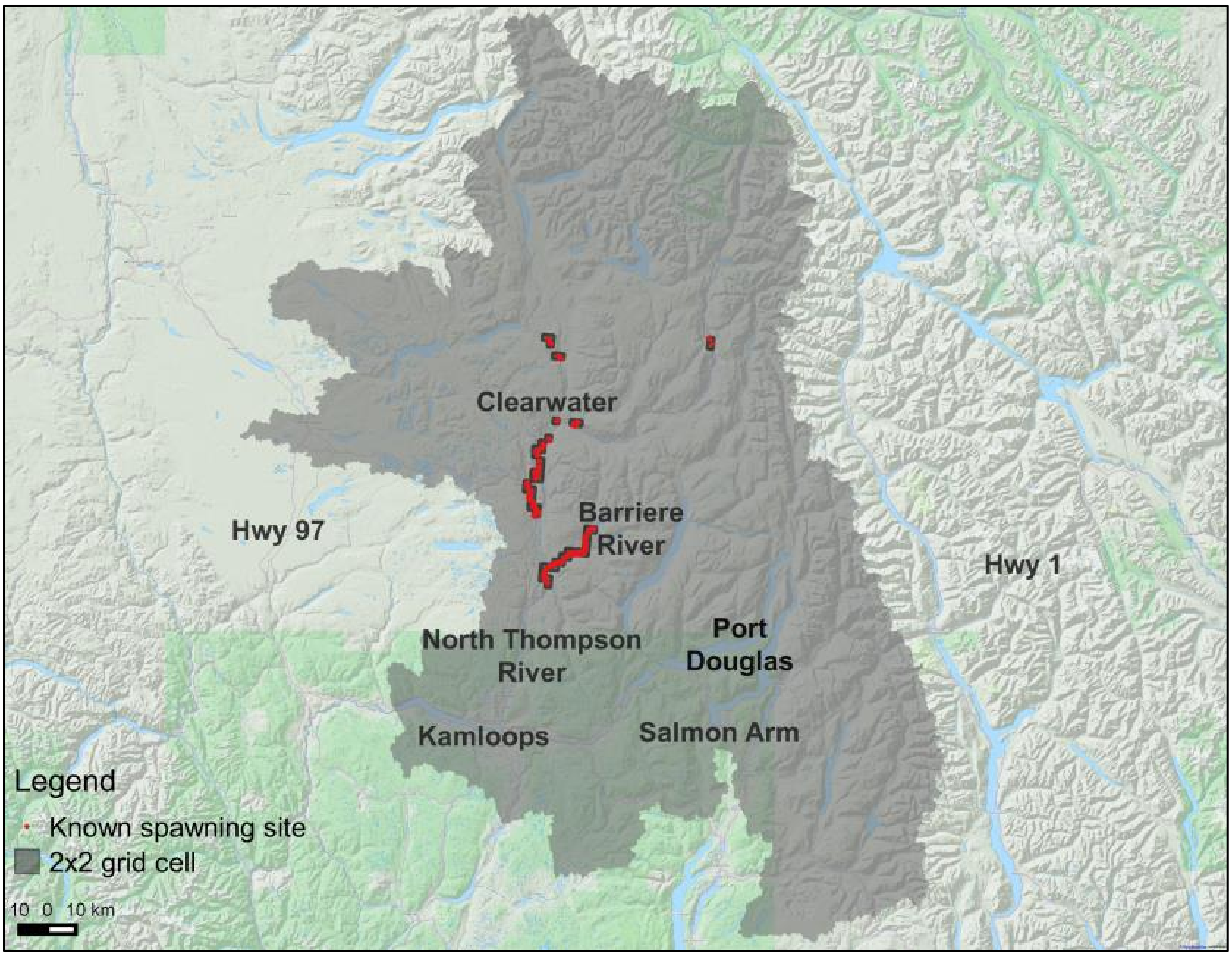


Figure 25: Kamloops-ES DU and known spawning sites within it.

Habitat Trends

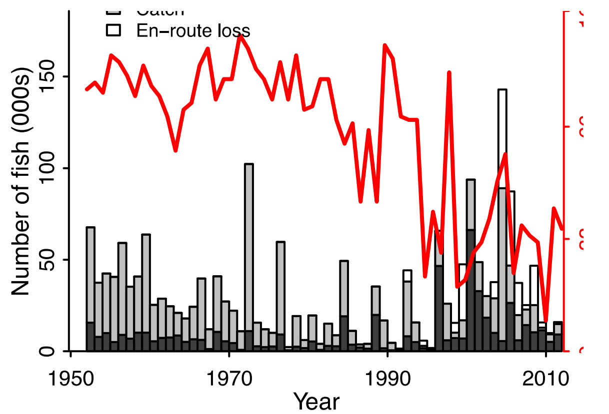
There is a relatively high intensity of forest harvesting and a moderate intensity of Mountain Pine Beetle disturbance in the DU (Nelitz *et al*. 2011). Road density and placer mines occur at relatively moderate intensities while urban area, agricultural area, water allocation, and water restriction occur at low intensities in the DU (Nelitz *et al*. 2011).

Abundance

Spawner abundance for Kamloops-ES DU is estimated based on counts of Sockeye in the Raft River using a combination of visual survey and mark recapture methods in the river (Grant *et al.* 2011). The overall quality of these spawner estimates is considered “Good”. The most recent estimate of spawner abundance was 30,902 mature individuals.

Fluctuations and Trends

The Kamloops-ES DU exhibited relatively low abundance from the 1950s to the early 1990s before increasing through to the mid-2000s and declining since then, though remaining above the long-term average (Figure 26). Exploitation rates for the DU averaged 60-70% for most of the 1950s through the early 1990s before being reduced to 30% on average ever since. The recruits-per-spawner of the Kamloops-ES DU has exhibited a general decline beginning in the mid-1990s with recruits-per-spawner in the 2003 to 2005 brood years being particularly low. There are no data on trends in early freshwater or post-fry survival for this DU.



(e)

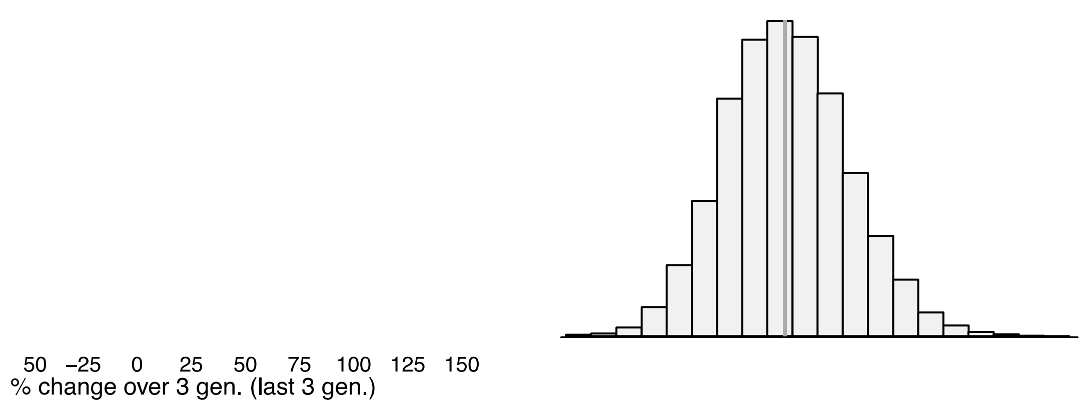


Figure 26: Historical trends in abundance, catch, recruits-per-spawner and estimated rates of change for DU 11: Kamloops-ES, (a) total escapement, catch, en-route loss and exploitation rate (red line) by return year; (b) escapement separated by sex and female pre-spawn mortality (PSM); (c) recruits per effective female spawner ($\log_e$ scale); (d) 4-year running average of effective female spawners with estimated rates of change based on last 3 generations and full time series; and posterior distributions (and median estimate as vertical line) of estimated percent change over last three generations based on a linear rate of change of smoothed $\log_e$ effective female spawner abundances over (e) most recent three generations of data or (f) full time series.

Using data for the last 3 generations, the Kamloops-ES DU has decreased by an estimated 52% (Upper 95% CI = -19%, Lower 95% CI = -71%) (Table 11). It should be noted that this decline was from the highest value in the time series, there has been an increase in the last generation and the current value is considerably higher than those observed from 1960-1995. The probabilities that the decline has been greater than 30%, 50% and 70% respectively are 0.93, 0.55, and 0.03. When change in abundance is calculated based on the entire time series, the DU has increased by an estimated 14% (Upper 95% CI = 27%, Lower 95% CI = 2%). The probability that there has been a decline of >30% is 0.00.

Table 11: Summary of estimated rate of change (+/- 95% credible interval) in effective female spawner abundance as well as the probability DU 11: Kamloops-ES has declined by more than 30%, 50% or 70% over the last three generations. Rates of change are provided based on analysis of just the last 3 generations of data or the entire time series (see corresponding year range).

DU	Generation length	Year range	Median % change	95% CI	p>30% decline	p>50% decline	p>70% decline	Number of observations
Kamloops-ES	4 yrs	2003-2015	-52%	-71% / -19%	0.93	0.55	0.03	13
		1954-2015	+14%	+2% / +27%	0	0	0	13

Threats and Limiting Factors

Based on the IUCN threat calculator, this DU was assigned a threat impact of Medium (C). Threats to Sockeye from this DU include pollution because they are exposed to industrial effluents in freshwater, the Fraser River estuary and Strait of Georgia. There is also the possibility of contaminant spills from derailments of trains passing beside Kamloops Lake. Based on this, the severity was scored moderate-slight. Freshwater temperature extremes pose a threat to Sockeye from this DU with the Fraser River expected to continue to warm throughout the 21st century. This could lead to severe losses during adult migrations en route to spawning grounds.

Several other potential threats exist for this DU (e.g., new and existing roads and railroads, marine mammal predation, competition with abundant Pink Salmon at sea and pathogens) but could not be assigned a severity rating.

Designatable Unit 12: Lillooet-Harrison-L population

Extent of Occurrence and Area of Occupancy

The Lillooet-Harrison-L DU is composed of Sockeye that spawn in ten sites: Birkenhead River, Green River, Lillooet Slough, Miller Creek, Poole Creek, Railroad Creek, Ryan Creek, Sampson Creek, John Sandy, and 25 Mile Creek (Figure 27). The extent of occurrence for this DU includes the North Pacific Ocean and so is estimated to be greater than 20,000 km^2. The most recent estimate of the IAO for the Lillooet-Harrison-L DU is 84 km^2. The number of consistently assessed sites where spawning has occurred has remained the same for the past 19 years (1992-95: 3, 2000-03: 3, 2008-11: 3; de Mestral Bezanson *et al*. 2012).

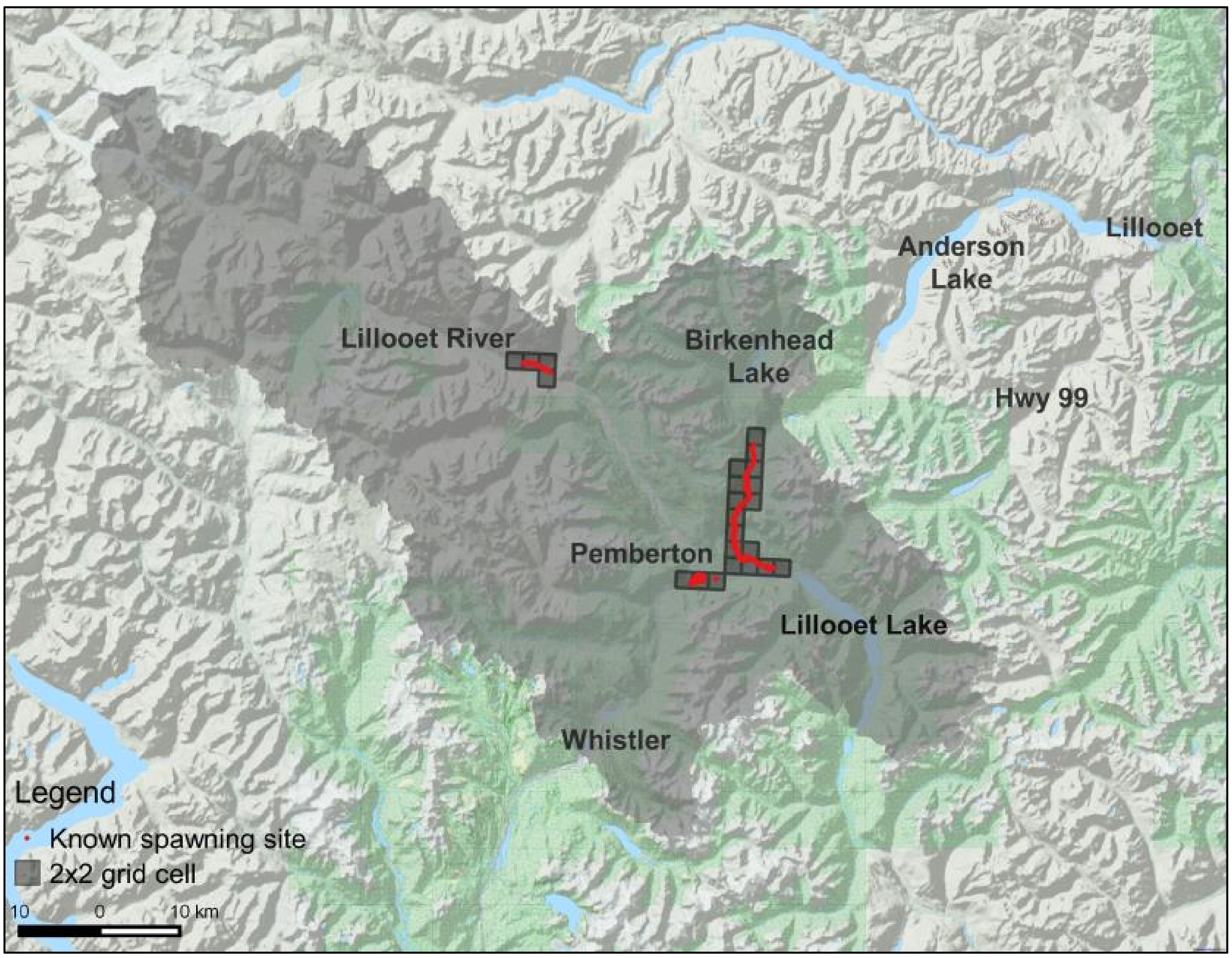


Figure 27: Lillooet-Harrison-L DU and known spawning sites within it.

Habitat Trends

There is a relatively high intensity of forest harvesting in the Lillooet-Harrison-L DU but it has decreased in recent years. There is a low intensity of Mountain Pine Beetle disturbance in the DU area which has increased in recent years (Nelitz *et al*. 2011). Agriculture area, road density, urban area and water allocation all occur at relatively low intensities within the DU (Nelitz *et al*. 2011).

Abundance

Spawner abundance for Lillooet-Harrison-L DU is estimated based on counts of Sockeye at Birkenhead River using a combination of visual surveys and mark recapture methods as well as an enumeration fence and a counting tower on the river (Grant *et al*. 2011). In recent years sonar methods have also been used. The overall quality of these spawner estimates is considered “Very good”. The most recent estimate of spawner abundance was 49,048 mature individuals.

Fluctuations and Trends

Escapement to the Lillooet-Harrison-L DU increased from 1950 until the early-1990s. Since then escapement has been variable with a declining trend variable (Figure 28). Exploitation rates for the DU were variable but high (i.e., > 70%) through most of the 1960s to 1980s and then were reduced significantly in the mid-1990s to rates less than 30% in most years since. Lillooet-Harrison-L DU exhibited a decline in recruits-per-spawner in the late 1980s which has remained depressed ever since, with exceptionally low recruits-per-spawner in the 2005 brood year. There are no data on trends in early freshwater or post-fry survival for this DU.

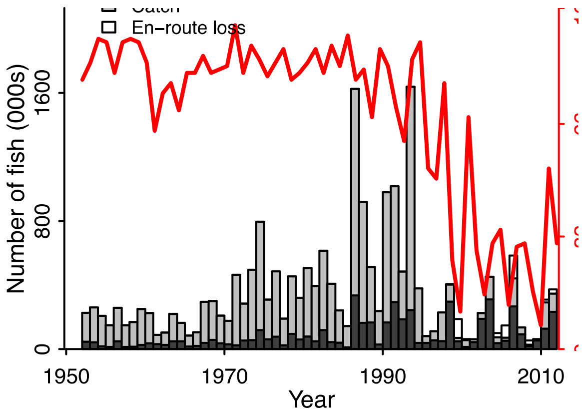


Figure 28: Historical trends in abundance, catch, recruits-per-spawner and estimated rates of change for DU 12: Lillooet-Harrison-L, (a) total escapement, catch, en-route loss and exploitation rate (red line) by return year; (b) escapement separated by sex and female pre-spawn mortality (PSM); (c) recruits per effective female spawner ($\log_e$ scale); (d) 4-year running average of effective female spawners with estimated rates of change based on last 3 generations and full time series; and posterior distributions (and median estimate as vertical line) of estimated percent change over last three generations based on a linear rate of change of smoothed $\log_e$ effective female spawner abundances over (e) most recent three generations of data or (f) full time series.

Using data for the last 3 generations, the Lillooet-Harrison-L DU has decreased by an estimated 73% (Upper 95% CI = -56%, Lower 95% CI = -83%) (Table 12). The probabilities that the decline has been greater than 30%, 50% and 70% respectively are 1.00, 0.99, and 0.67. When change in abundance is calculated based on the entire time series, the DU has increased by an estimated 26% (Upper 95% CI = 36%, Lower 95% CI = 17%). The probability that there has been a decline of >30% is 0.00.

Table 12: Summary of estimated rate of change (+/- 95% credible interval) in effective female spawner abundance as well as the probability DU 12: Lillooet-Harrison-L has declined by more than 30%, 50% or 70% over the last three generations. Rates of change are provided based on analysis of just the last 3 generations of data or the entire time series (see corresponding year range).

DU	Generation length	Year range	Median % change	95% CI	p>30% decline	p>50% decline	p>70% decline	Number of observations
Lillooet-Harrison-L	4 yrs	2003-2015	-73%	-83% / -56%	1	0.99	0.67	13
		1954-2015	+26%	+17 / +36%	0	0	0	13

Threats and Limiting Factors

In the late 1940s the course of the Birkenhead River was altered for flood control. In more recent years parts of the Birkenhead and upper Lillooet rivers have been dyked, and much of the floodplain has been ditched or filled, which has degraded salmon habitat (Grant *et al.* 2011).

A threat calculator was not completed for this DU.

Designatable Unit 13: Nahatlatch-ES population

Extent of Occurrence and Area of Occupancy

The Nahatlatch-ES DU is composed of Sockeye that spawn in Nahatlach Lake and Nahatlach River (Figure 29). The extent of occurrence for this DU includes the North Pacific Ocean and so is estimated to be greater than 20,000 km^2. The most recent estimate of the IAO for the Nahatlatch-ES DU is 12 km^2. The number of consistently assessed sites where spawning has occurred has remained the same over the past 19 years (1992-95: 2, 2000-03: 2, 2008-11: 2; de Mestral Bezanson *et al.* 2012).

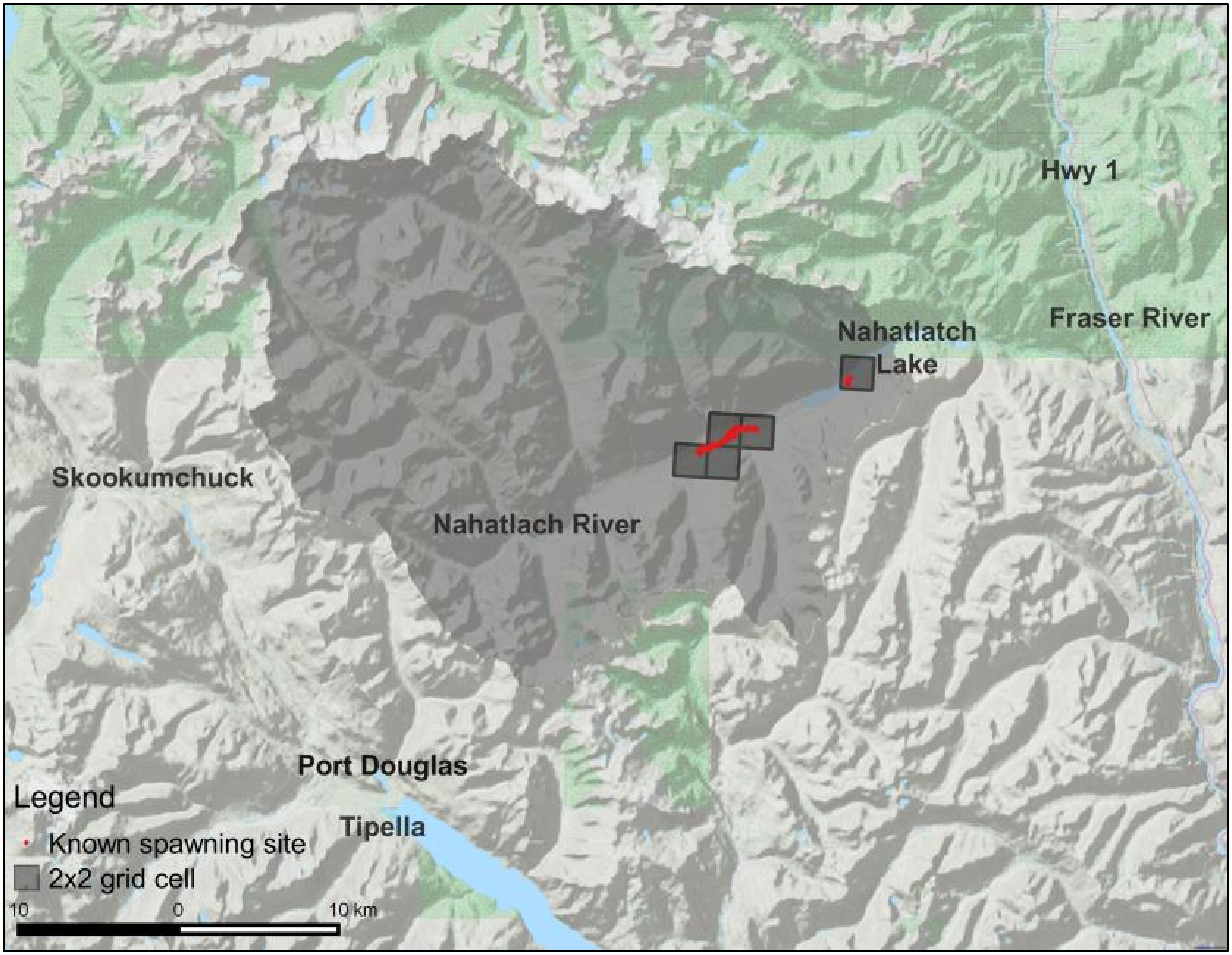


Figure 29: Nahatlatch-ES DU and known spawning sites within it.

Habitat Trends

There is relatively high intensity of forest harvesting in the Nahatlatch-ES DU area which has decreased in recent years. There is a low intensity of Mountain Pine Beetle disturbance in the DU that has increased in recent years (Nelitz *et al*. 2011). Road density occurs at relatively low intensity in the DU (Nelitz *et al*. 2011). Extensive forest fires have also occurred in the Nahatlatch-ES DU area in the last 20 years, and may have affected stream temperatures and channel stability.

Abundance

Spawner abundance for the Nahatlatch-ES DU is estimated based on visual survey methods (peak live plus cumulative dead) in the river and carcass counts in the lake and so is considered an index of abundance and a minimum estimate (Grant *et al.* 2011). The overall quality of these spawner estimates is considered "Good". The most recent estimate of spawner abundance was 2,946 mature individuals.

Fluctuations and Trends

Escapement to the Nahatlatch-ES DU was relatively low in the 1970s and 1980s, increased in the 1990s and early 2000s and has declined since (Figure 30). Exploitation and recruits-per-spawner could not be estimated for the Nahatlatch-ES DU. There are also no data on trends in early freshwater or post-fry survival for this DU.

No Corresponding Data for this DU

(f)

0 10 20 30 40 50 60 70

% change over 3 gen. (all years)

Figure 30: Historical trends in abundance, catch, recruits-per-spawner and estimate of rate of change for DU 13: Nahatlatch-ES, (a) total escapement, catch, en-route loss and exploitation rate (red line) by return year; (b) escapement separated by sex and female pre-spawn mortality (PSM); (c) recruits per effective female spawner (log_e scale); (d) 4-year running average of effective female spawners with estimated rates of change based on last 3 generations and full time series; and posterior distributions (and median estimate as vertical line) of estimated percent change over last three generations based on a linear rate of change of smoothed log_e effective female spawner abundances over (e) most recent three generations of data (f) or full time series.

Using data for the last 3 generations, the Nahatlatch-ES DU has decreased by an estimated 16% (Upper 95% CI = 87%, Lower 95% CI = -61%) (Table 13). The probabilities that the decline has been greater than 30%, 50% and 70% respectively are 0.31, 0.08, and 0.00. When change in abundance is calculated based on the entire time series, the DU has increased by an estimated 9% (Upper 95% CI = 37%, Lower 95% CI = -12%). The probability that there has been a decline of >30% is 0.00.

Table 13: Summary of estimated rate of change (+/- 95% credible interval) in effective female spawner abundance as well as the probability DU 13: Nahatlatch-ES has declined by more than 30%, 50% or 70% over the last three generations. Rates of change are provided based on analysis of just the last 3 generations of data or the entire time series (see corresponding year range).

DU	Generation length	Year range	Median % change	95% CI	p>30% decline	p>50% decline	p>70% decline	Number of observations
Nahatlatch-ES	4 yrs	2003-2015	-16%	-61% / +87%	0.31	0.08	0.01	13
		1954-2015	+9%	-12% / +37%	0	0	0	13

Threats and Limiting Factors

A threat calculator was not completed for this DU.

Designatable Unit 14: North Barriere-ES population

Extent of Occurrence and Area of Occupancy

The North Barriere DU is composed of Sockeye that spawn in the Upper Barriere River and Harper Creek (Figure 31). Sockeye in this system became extinct because of dam construction. After the dam was removed in 1952 various attempts were made to re-establish Sockeye (Grant *et al.* 2011). Transplants from a donor population from the Raft River established in Fennell Creek (Withler *et al.* 2000; Beacham *et al.* 2004). The extent of occurrence for this DU includes the North Pacific Ocean and so is estimated to be greater than 20,000 km^2. The most recent estimate of the IAO for the North Barriere DU is 20 km^2. The number of consistently assessed locations where spawning has occurred has remained the same for the past 19 years (1992-95: 2, 2000-03: 2, 2008-11: 2; de Mestral Bezanson *et al.* 2012).

Figure 31: North Barriere-ES DU and known spawning sites within it.

Habitat Trends

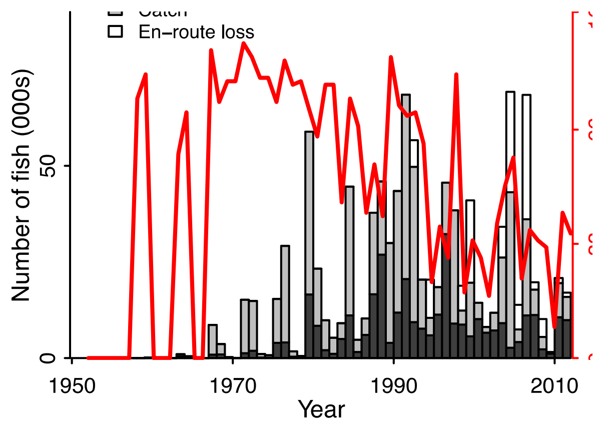
There is a relatively high intensity of forest harvesting in the North Barriere DU area which has been increasing in recent years. There is a moderate intensity of Mountain Pine Beetle disturbance in the DU which has also increased in recent years (Nelitz *et al*. 2011). Road density and placer mines occur at relatively moderate intensities while agriculture area, urban area, water allocation and water restriction all occur at relatively low intensities in the DU (Nelitz *et al*. 2011).

Abundance

Spawner abundance for the North Barriere DU is estimated based on visual counts at the Upper Barriere River using the peak live plus cumulative dead method (Grant *et al.* 2011). The overall quality of these spawner estimates is considered “Good”. The most recent estimate of spawner abundance was 4,416 mature individuals.

Fluctuations and Trends

From the late 1960s through the 1990s escapement for the North Barriere DU steadily increased and has declined ever since (Figure 32). Exploitation rates for the DU have gradually declined from as high as 90% plus in the late 1960s to around 30% in recent years. The DU has experienced systematic declines in recruits-per-spawner over the course of the time series of available data. There are no data on trends in early freshwater or post-fry survival for this DU. The interpretation of the trend in abundance is made difficult by the fact that this is essentially a newly established population that may be naturally fluctuating around its carrying capacity. For this reason it was decided that the A criterion would not apply (see IUCN Guideline 4.5, IUCN 2016).



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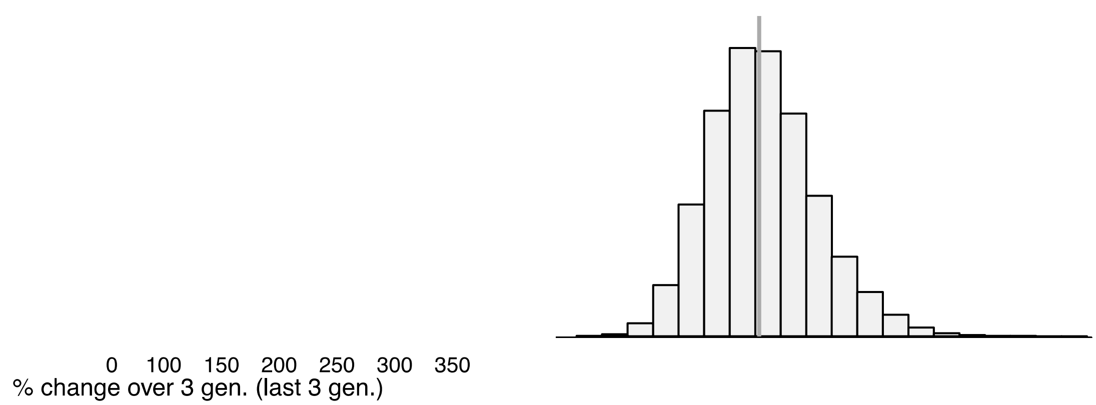


Figure 32: Historical trends in abundance, catch, recruits-per-spawner and estimate of rate of change for DU 14: North Barriere-ES population, (a) total escapement, catch, en-route loss and exploitation rate (red line) by return year; (b) escapement separated by sex and female pre-spawn mortality (PSM); (c) recruits per effective female spawner (log_e scale); (d) 4-year running average of effective female spawners with estimated rates of change based on last 3 generations and full time series; and posterior distributions (and median estimate as vertical line) of estimated percent change over last three generations based on a linear rate of change of smoothed log_e effective female spawner abundances over (e) most recent three generations of data (f) or full time series.

Using data for the last 3 generations, the North Barriere DU has decreased by an estimated 57% (Upper 95% CI = -22%, Lower 95% CI = -76%) (Table 14). The probabilities that the decline has been greater than 30%, 50% and 70% respectively are 0.95, 0.70, and 0.10. When change in abundance is calculated based on the entire time series, the DU has increased by an estimated 113% (Upper 95% CI = 181%, Lower 95% CI = 63%). The probability that there has been a decline of >30% is 0.00.

Table 14: Summary of estimated rate of change (+/- 95% credible interval) in effective female spawner abundance as well as the probability DU 14: North Barriere has declined by more than 30%, 50% or 70% over the last three generations. Rates of change are provided based on analysis of just the last 3 generations of data or the entire time series (see corresponding year range).

DU	Generation length	Year range	Median % change	95% CI	p>30% decline	p>50% decline	p>70% decline	Number of observations
North Barriere-ES	4 yrs	2003-2015	-57%	-76% / -22%	0.95	0.7	0.1	13
		1954-2015	+113%	+63% / +181%	0	0	0	13

Threats and Limiting Factors

A threat calculator was not completed for this DU.

Designatable Unit 15: Pitt-ES population

Extent of Occurrence and Area of Occupancy

The Pitt-ES DU is composed of Sockeye that spawn in the Upper Pitt River and its tributaries (Figure 33). The extent of occurrence for this DU includes the North Pacific Ocean and so is estimated to be greater than 20,000 km^2. The most recent estimate of the IAO for the Pitt-ES DU is 60 km^2. The number of consistently assessed sites where spawning has occurred has remained the same over the past 19 years (1992-95: 2, 2000-03: 2, 2008-11: 2; de Mestral Bezanson *et al.* 2012).

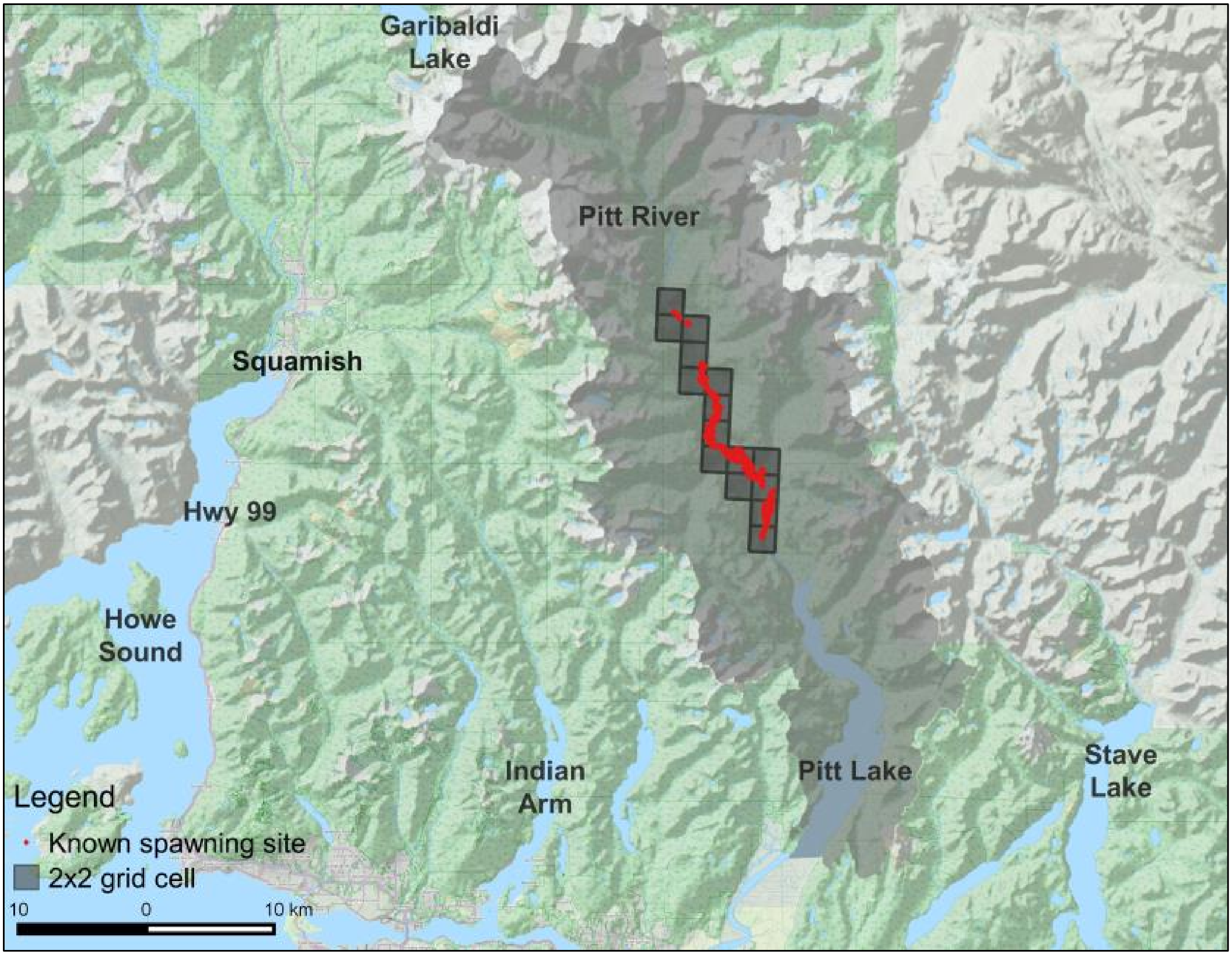


Figure 33: Pitt-ES DU and known spawning sites within it.

Habitat Trends

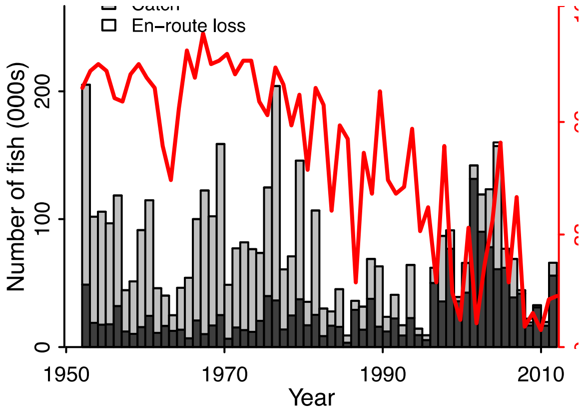
There is a relatively high intensity of forest harvesting in the Pitt-ES DU but it has decreased in recent years (Nelitz *et al*. 2011). Road density, urban area and water allocation all occur at relatively low intensities in the DU (Nelitz *et al*. 2011).

Abundance

Spawner abundance for the Pitt-ES DU is estimated based on counts of Sockeye using mark recapture methods in the river (Grant *et al.* 2011). Visual survey methods (peak live plus cumulative dead) have been used to estimate abundance in recent years. The Pitt DU is subject to some enhancement and the time series used has had females that were captured prior to natural spawning for use in the hatchery program removed. Current work on otoliths is occurring to determine that proportion of total escapement is represented by enhanced fish; as a result estimates of total abundance and trends in abundance should be interpreted with caution as they may be confounded by hatchery production. The overall quality of these spawner estimates is considered “Very good”. The most recent estimate of spawner abundance was 51,145 mature individuals.

Fluctuations and Trends

From the 1950s to mid-1990s, escapement in the Pitt-ES DU was relatively stable before increasing steadily in the mid-1990s and then declining slightly in recent year (Figure 34). Exploitation rates for the Pitt-ES DU were high in the 1950s to 1970s and then have declined steadily to less than 20% in recent years. Recruits-per-spawner in the DU were high in the 1960s, lower in the 1980s, and have systematically declined from the early 1990s to present. There are no data on trends in early freshwater or post-fry survival for this DU.



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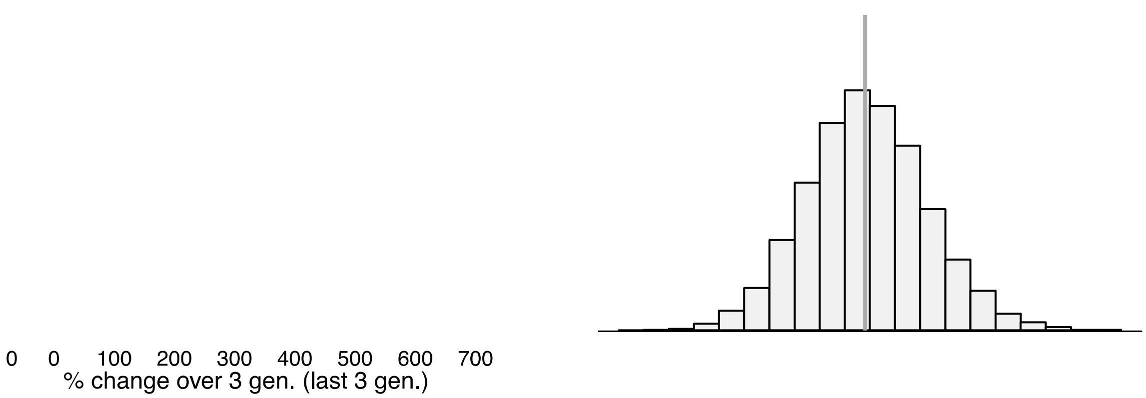


Figure 34: Historical trends in abundance, catch and recruits-per-spawner and estimate of rate of change for DU 15: Pitt-ES, (a) total escapement, catch, en-route loss and exploitation rate (red line) by return year; (b) escapement separated by sex and female pre-spawn mortality (PSM); (c) recruits per effective female spawner ($\log_e$ scale); (d) 4-year running average of effective female spawners with estimated rates of change based on last 3 generations and full time series; and posterior distributions (and median estimate as vertical line) of estimated percent change over last three generations based on a linear rate of change of smoothed $\log_e$ effective female spawner abundances over (e) most recent three generations of data (f) or full time series.

Using data for the last 3 generations, the Pitt-ES DU has decreased by an estimated 48% (Upper 95% CI = 16%, Lower 95% CI = -76%) (Table 15). The probabilities that the decline has been greater than 30%, 50% and 70% respectively are 0.79, 0.45, and 0.08. It should be noted that the decline has been from the maximum value in the time series and there has been an increase in the last generation. When change in abundance is calculated based on the entire time series, the DU has increased by an estimated 26% (Upper 95% CI = 38%, Lower 95% CI = 16%). The probability that there has been a decline of >30% is 0.00.

Table 15: Summary of estimated rate of change (+/- 95% credible interval) in effective female spawner abundance as well as the probability DU 15: Pitt-ES has declined by more than 30%, 50% or 70% over the last three generations. Rates of change are provided based on analysis of just the last 3 generations of data or the entire time series (see corresponding year range).

DU	Generation length	Year range	Median % change	95% CI	p>30% decline	p>50% decline	p>70% decline	Number of observations
Pitt	4[1] yrs	2003-2015	-48%	-76% / +16%	0.79	0.45	0.08	13
		1954-2015	+26%	+16 / +38%	0	0	0	13

[1]Sockeye from the Pitt-ES DU have a higher proportion of 5 year olds than any other Fraser Sockeye DU. On average, approximately 65% of Pitt Sockeye mature at 5 years of age. However, for the purposes of maintaining consistency in the number of years of data used to calculate trends in abundance across all DUs, the estimated rate of change was calculated over the past 12 years.

Threats and Limiting Factors

Based on the IUCN threat calculator, this DU was assigned a threat impact of Medium (C). Fisheries pose a threat to Sockeye from this DU because the DU has been declining in abundance and harvest, even if only at slight severity (i.e., 1-10% over next 3 generations), will continue. Depressed marine survival also poses a low-medium level of threat to this DU. Lastly, both frequent landslides due to steep terrain and scouring of spawning habitat due to high flows pose low impact threats to this DU.

Several other potential threats exist for this DU (e.g., siltation from forestry upstream of Pitt Lake, marine mammal predation, competition with abundant Pink Salmon at sea and pathogens) but could not be assigned a severity rating.

Designatable Unit 16: Quesnel-S population

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

The Quesnel-S DU is composed of Sockeye that spawn in over 100 sites, including the Horsefly River, and that rear in Quesnel and McKinley Lakes (Figure 35). The extent of occurrence for this DU includes the North Pacific Ocean and so is estimated to be greater than 20,000 km^2. The most recent estimate of the IAO for the Quesnel-S DU is 352 km^2. The number of consistently assessed sites where spawning has occurred has varied slightly over the past 19 years (1992-95: 20, 2000-03: 23, 2008-11: 18; de Mestral Bezanson *et al*. 2012).

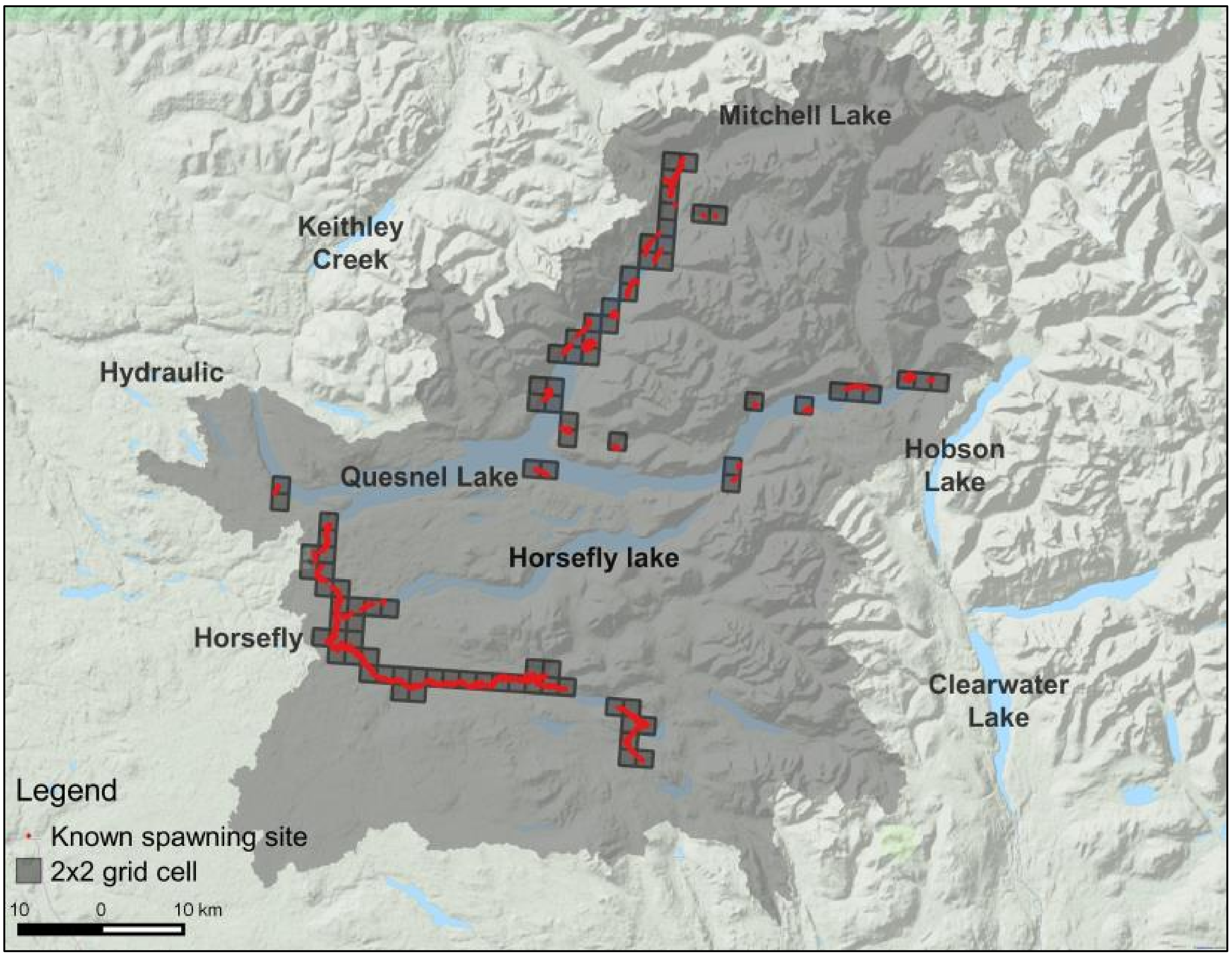


Figure 35: Quesnel-S DU and known spawning sites within it.

Habitat Trends

There is currently a relatively moderate intensity of forest harvesting and Mountain Pine Beetle disturbance in the Quesnel-S DU which has increased in recent years (Nelitz *et al*. 2011). Placer mines, agriculture, and water allocation and restrictions all occur at relatively low intensities while road density occurs at a relatively high intensity in the DU (Nelitz *et al*. 2011). In August of 2014 a tailings dam at the Mount Polley mine failed, releasing sediment containing potentially toxic metals into Quesnel Lake. The potential effects of this spill on the population are being monitored and it is still too early to determine what these might be.

Abundance!

Spawner abundance for this DU is estimated based on counts of Sockeye at 11 sites including in the Horsefly and Mitchell rivers and McKinley and Penfold creeks using a combination of peak live cumulative dead and mark recapture methods as well as counting fences on McKinley Creek (Grant *et al.* 2011). The overall quality of these spawner estimates is considered “Very good”. The most recent estimate of spawner abundance was 260,974 mature individuals.

Fluctuations and Trends

The Quesnel DU was probably the largest summer run timed DU in BC in the late 1800s with escapement reported to be several millions in the dominant cycle years. Dam construction at the outlet of Quesnel lake in the late 1800s, placer mining, and the Hell’s Gate landslide in 1913 all contributed to the massive decline in run size in the early 1900s (as reported in Grant *et al.* 2011). The dam was removed in 1903 and a fishway was constructed. However, placer mining continued until 1945 and tailings were dumped on the spawning grounds rendering them unusable. Once mining ceased escapement increased from the 1950s to 1980s. Escapement then increased markedly in the 1980s and 1990s and subsequently declined until the present (Figure 36). The estimated exploitation rate for the Quesnel-S DU has declined since the late 1990s from highs of 80% plus to rates typically below 50% since the early 2000s. The Quesnel-S DU appears to have exhibited systematic declines in recruits-per-spawner from the late 1980s brood years to the mid-2000s brood years. However, there is strong statistical evidence of delayed density dependence in the Quesnel DU and when this is accounted for there are no apparent trends in recruits-per-spawner for the DU (Peterman and Dorner 2012). Early freshwater survival (fall fry/EFS), though variable, decreased from the mid-1970s brood years, and has subsequently increased slightly while post-fry survival, which includes a period of freshwater survival and marine survival, increased in the 1990s and subsequently decreased (Figure 37).

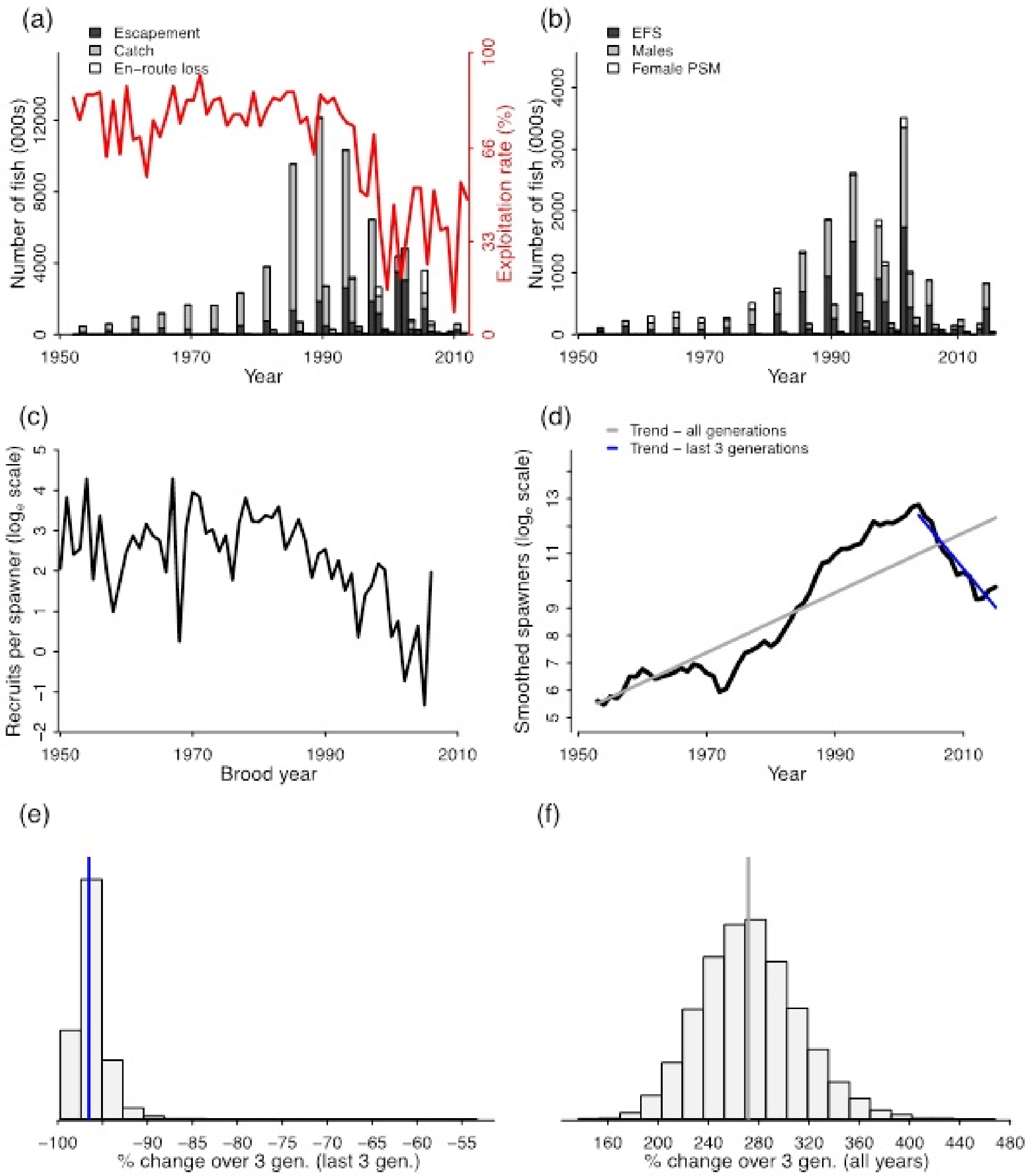


Figure 36: Historical trends in abundance, catch, recruits-per-spawner and estimated rates of change for DU 16: Quesnel-S, (a) total escapement, catch, en-route loss and exploitation rate (red line) by return year; (b) escapement separated by sex and female pre-spawn mortality (PSM); (c) recruits per effective female spawner (log$_e$ scale); (d) 4-year running average of effective female spawners with estimated rates of change based on last 3 generations and full time series; and posterior distributions (and median estimate as vertical line) of estimated percent change over last three generations based on a linear rate of change of smoothed log$_e$ effective female spawner abundances over (e) most recent three generations of data or (f) full time series.

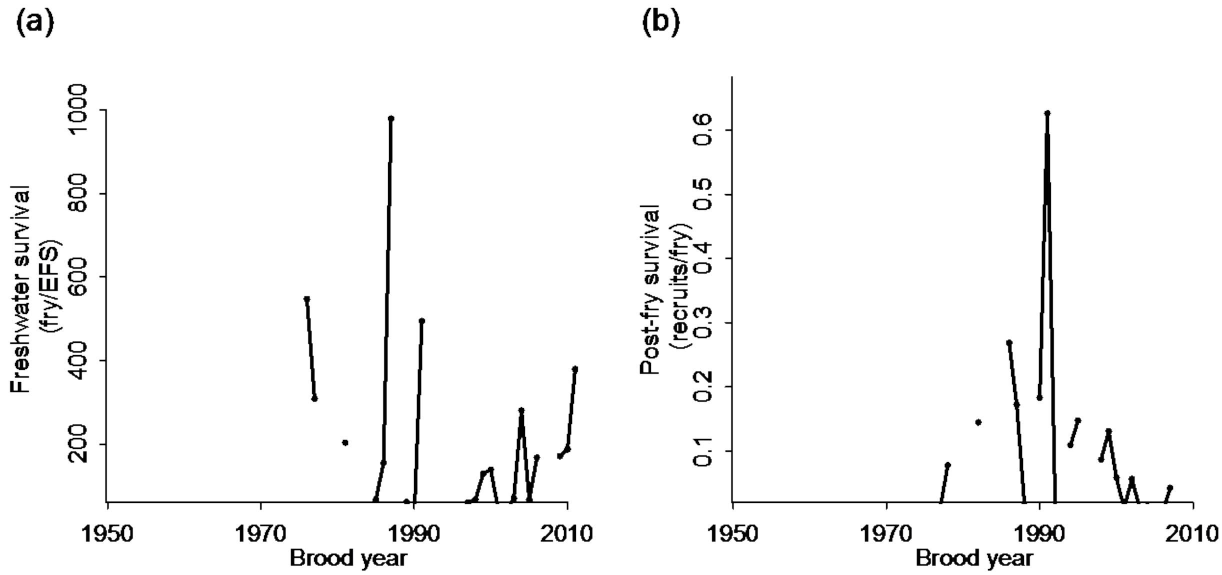


Figure 37: Historical trends in (a) early freshwater (fry per effective female spawner) and (b) post-fry/marine (recruits per fry) survival

Using data for the last 3 generations, the Quesnel-S DU has declined by an estimated 97% (Upper 95% CI = -92%, Lower 95% CI = -98%) (Table 16). The probabilities that the decline has been greater than 30%, 50% and 70% respectively are all 1.00. When change in abundance is calculated based on the entire time series, the DU has increased by an estimated 272% (Upper 95% CI = 356%, Lower 95% CI = 202%). The probability that there has been a decline of >30% is 0.00.

Table 16: Summary of estimated rate of change (+/- 95% credible interval) in effective female spawner abundance as well as the probability DU 16: Quesnel-S has declined by more than 30%, 50% or 70% over the last three generations. Rates of change are provided based on analysis of just the last 3 generations of data or the entire time series (see corresponding year range).

DU	Generation length	Year range	Median % change	95% CI	p>30% decline	p>50% decline	p>70% decline	Number of observations
Quesnel-S	4 yrs	2003-2015	-97%	-98 / -92%	1	1	1	13
		1954-2015	+272%	+202% / +356%	0	0	0	13

Threats and Limiting Factors

Based on the IUCN threat calculator, this DU was assigned a threat impact of High - Medium (BC). Threats to Sockeye from this DU include fisheries because the Sockeye population from this DU has been declining in abundance and harvest, even if only at slight to moderate severity (i.e., 1-30% over next 3 generations), will continue. Depressed marine survival and modifications to the freshwater ecology of Quesnel Lake related to fisheries management actions directed at changing cyclic dominance may also pose a threat to this DU. Their severity was scored as moderate-slight. Freshwater temperature extremes also pose a threat to Sockeye from this DU with the Fraser River expected to continue to warm throughout the 21st century. This could lead to severe losses during adult migrations en route to spawning grounds.

Several other potential threats exist for this DU (e.g., potential lingering effects of contaminants spilled into Quesnel Lake from the Mt. Polley mine, marine mammal predation, competition with abundant Pink Salmon at sea and pathogens) but could not be assigned a severity rating.

Designatable Unit 17: Seton-L population

Extent of Occurrence and Area of Occupancy

The Seton-L DU is composed of late run Sockeye that spawn in Portage Creek (Figure 38). A combination of poor husbandry techniques in a nearby hatchery in the early 1900s, the Hell's Gate slide in 1913, and water diversion from the Bridge River into Seton Lake in 1934 led to the extinction of the original Portage Sockeye summer run population (see Grant *et al.* for a more complete history of this DU). There were numerous attempts in the first half of the 20th century to replace the population with Sockeye from other regions. Genetically, the current Seton-L population is similar to the Lower Adams River indicating that transplants from this area were the most successful. The new population has been established for several decades and it is an important contributor to the Fraser Sockeye late run aggregate.

The extent of occurrence for this DU includes the North Pacific Ocean and so is estimated to be greater than 20,000 km^2. The most recent estimate of the IAO for the Anderson-Seton-ES DU is 20 km^2. The number of consistently assessed sites where spawning has occurred has remained the same for the past 19 years (1992-95: 1, 2000-03: 1, 2008-11: 1; de Mestral Bezanson *et al.* 2012).

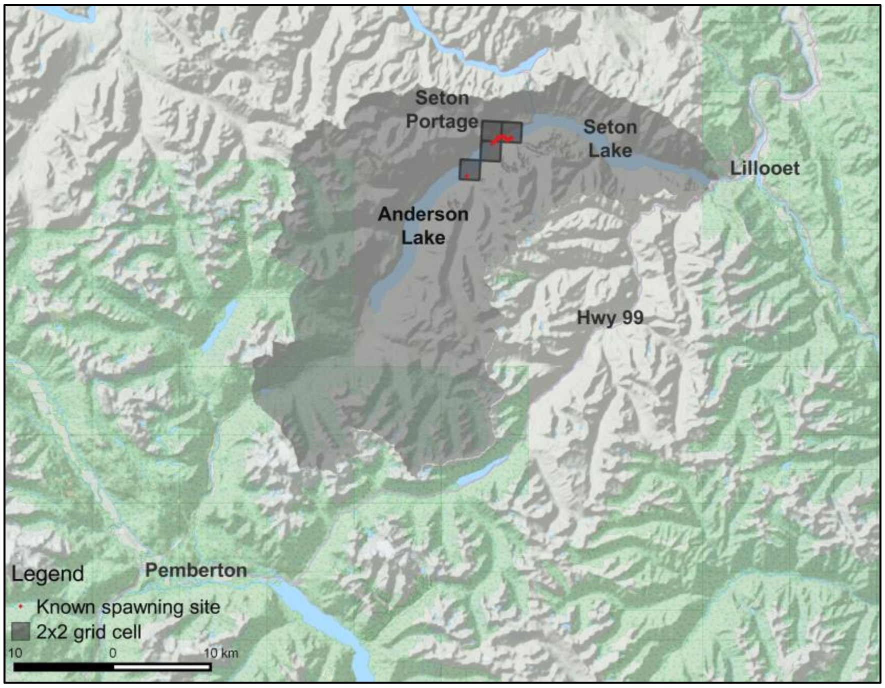


Figure 38: Seton-L DU and known spawning sites within it.

Habitat Trends

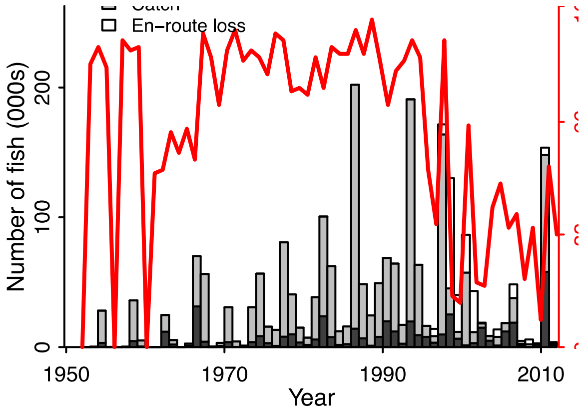
There is a relatively high density of water allocation restrictions in the Anderson-Seton-ES DU. There is a low intensity of Mountain Pine Beetle disturbance in the DU which has increased in recent years (Nelitz *et al*. 2011). Forest harvesting, agriculture, road density and water allocation all occur at relatively low intensities (Nelitz *et al*. 2011). These general trends suggest that there have not been extensive changes in habitat required in the DU.

Abundance

Spawner abundance for Seton-L DU is estimated based on visual counts of Sockeye at Portage Creek (Grant *et al.* 2011). The overall quality of these spawner estimates is considered “Good”. The most recent estimate of spawner abundance was 7505 mature individuals.

Fluctuations and Trends

Escapement has been variable but relatively stable in the Seton-L DU for most of the time series but, with the exception of record escapement in 2010, has declined in recent years (Figure 39). Exploitation rates for the Seton-L DU were maintained at high levels (i.e., > 70%) through most of the 1970s to 1990s before being reduced to rates around 30% over the past two decades. Recruits-per-spawner in the Seton-L DU have declined since the 1970s. There are no data on trends in early freshwater or post-fry survival for this DU.



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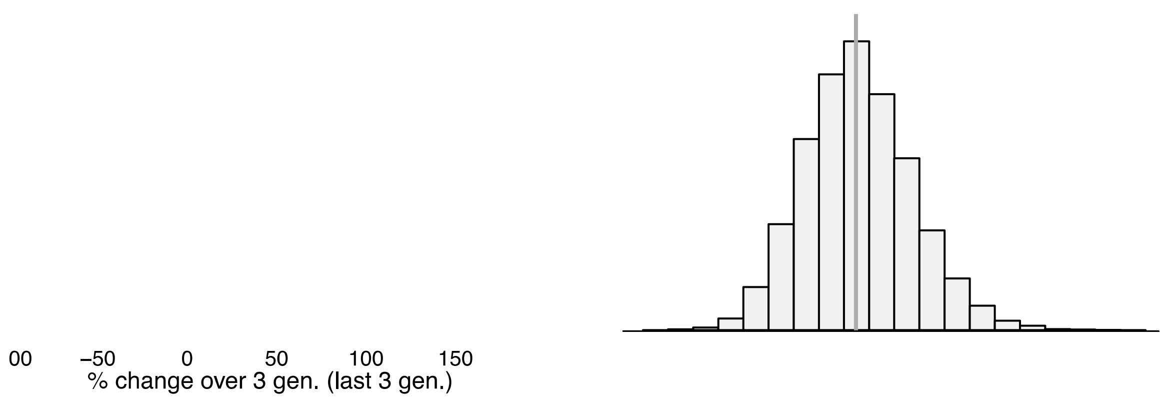


Figure 39: Historical trends in abundance, catch, recruits-per-spawner and estimated rates of change for DU 17: Seton-L, (a) total escapement, catch, en-route loss and exploitation rate (red line) by return year; (b) escapement separated by sex and female pre-spawn mortality (PSM); (c) recruits per effective female spawner ($\log_e$ scale); (d) 4-year running average of effective female spawners with estimated rates of change based on last 3 generations and full time series; and posterior distributions (and median estimate as vertical line) of estimated percent change over last three generations based on a linear rate of change of smoothed $\log_e$ effective female spawner abundances over (e) most recent three generations of data or (f) full time series.

Using data for the last 3 generations, the Seton-L DU has decreased by an estimated 88% (Upper 95% CI = -76%, Lower 95% CI = -94%) (Table 17). The probabilities that the decline has been greater than 30%, 50% and 70% respectively are 1.00, 1.00, and 0.99. When change in abundance is calculated based on the entire time series, the DU has increased by an estimated 9% (Upper 95% CI = 33%, Lower 95% CI = -11%). The probability that there has been a decline of >30% is 0.00.

Table 17: Summary of estimated rate of change (+/- 95% credible interval) in effective female spawner abundance as well as the probability DU 17: Seton-L has declined by more than 30%, 50% or 70% over the last three generations. Rates of change are provided based on analysis of just the last 3 generations of data or the entire time series (see corresponding year range).

DU	Generation length	Year range	Median % change	95% CI	p>30% decline	p>50% decline	p>70% decline	Number of observations
Seton-L	4 yrs	2003-2015	-88%	-94% / -76%	1	1	0.99	13
		1954-2015	+9%	-11% / +33%	0	0	0	13

Threats and Limiting Factors

Based on the IUCN threat calculator, this DU was assigned a threat impact of High - Medium (BC). Threats to Sockeye from this DU include fisheries because they can be harvested in a mixed stock fishery with the very large Shuswap Complex L DU and may experience high exploitation in dominant cycle years for the Shuswap complex. Pollution also poses a threat to Sockeye from this DU because they are exposed to industrial effluents in freshwater, the Fraser River estuary and Strait of Georgia and there is the possibility of contaminant spills from derailments of trains passing beside the lakes. Based on this, the severity was scored moderate-slight. Lastly, there have been 2 landslides in the past 2 years at Portage Creek. The slides have been cleared but more slides are possible and if this occurs the severity is estimated to be slight to moderate.

Several other potential threats exist for this DU (e.g., exposure to agricultural effluent, marine mammal predation, competition with abundant Pink Salmon at sea and pathogens) but could not be assigned a severity rating.

Designatable Unit 18: Shuswap Complex-L population

Extent of Occurrence and Area of Occupancy

The Shuswap Complex-L DU is composed of Sockeye that spawn in over 50 sites concentrated around in five lakes: Adams Lake, Shuswap Lake, Little Shuswap Lake, Mara Lake and Mabel Lake (Figure 40). The extent of occurrence for this DU includes the North Pacific Ocean and so is estimated to be greater than 20,000 km^2. The most recent estimate of the IAO for the Shuswap Complex-L DU is 652 km^2. The number of consistently assessed sites where spawning has occurred has increased over the past 19 years (1992-95: 24, 2000-03: 27, 2008-11: 29; de Mestral Bezanson *et al.* 2012).

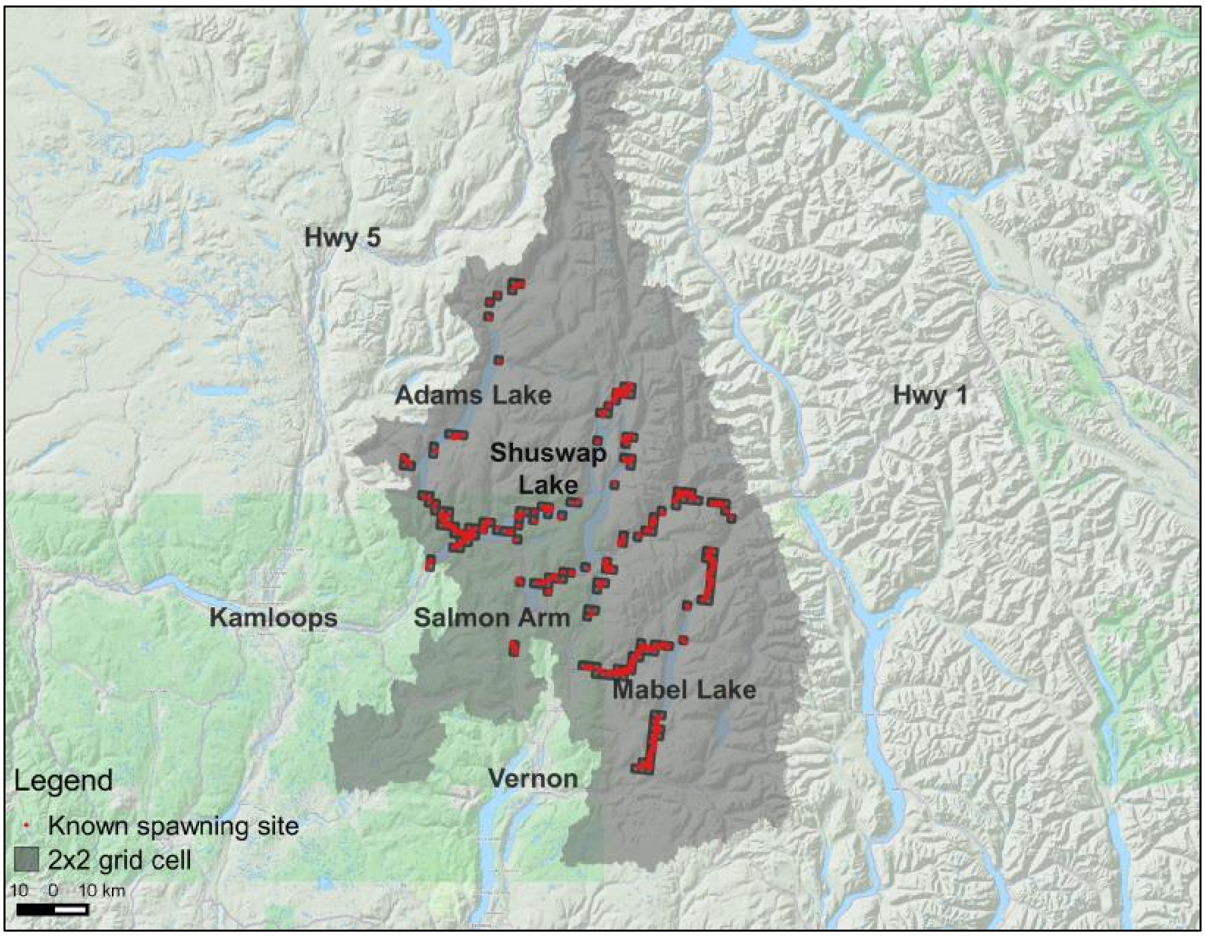


Figure 40: Shuswap Complex-L DU and known spawning sites within it.

Habitat Trends

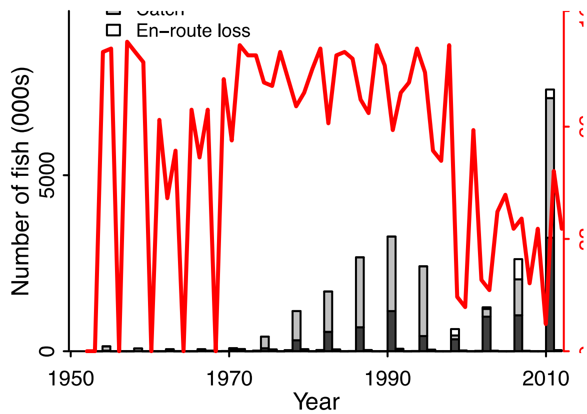
There is currently a relatively low intensity of Mountain Pine Beetle disturbance in the Shuswap Complex-L DU which has increased in recent years. There is a relatively low intensity of forest harvesting which has decreased in the recent years (Nelitz *et al*. 2011). Urban area, water allocation and placer mines all occur at relatively high intensities while road density, agricultural area, and water restriction all occur at relatively moderate intensities in the DU (Nelitz *et al*. 2011).

Abundance

Spawner abundance for Shuswap Complex-L DU is estimated based on counts of Sockeye at 28 sites. River sites surveyed were the Adams River, Anstey River, Eagle River, Little River, Lower Shuswap River, Middle Shuswap Rive, Momich River, Pass Creek, Scotch Creek, and South Thompson River. Lake sites were Shuswap Lake, Adams River-Shore, Anstey Arm, Anstey River-Shore, Cruikshank Point-West-Shore, Hlina Creek-Shore, Lee Creek-Shore, Shuswap Lake-Main Arm, Shuswap Lake-Main Arm North, Shuswap Lake-Main Arm South, Onyx Creek-Shore, Ross Creek-Shore, Shuswap Lake-Salmon Arm, Shuswap Lake-Salmon Arm East, Shuswap Lake-Salmon Arm North, Shuswap Lake-Salmon Arm South, Scotch Creek-Shore, and Seymour Arm. Sockeye in this DU are enumerated using a combination of peak live cumulative dead and mark recapture methods as well as an enumeration fence on Eagle River. In 2014 sonar methods were also used. The overall quality of these spawner estimates is considered “Very good”. The most recent estimate of spawner abundance was 579,727 mature individuals.

Fluctuations and Trends

From the 1950s to 1990 the geometric mean escapement to the Shuswap Complex-L DU was relatively constant (Figure 41). There was a decline in the late 1990s to a minimum in 2000 followed by an increase to 2005 and then a decline to the most recent value. The estimated exploitation rate for the Shuswap Complex-L DU has declined since the late 1990s from highs of 90% to rates typically below 50% since the early 2000s. Recruits-per-spawner in the Shuswap Complex-L DU have not exhibited any persistent trends through time. Early freshwater survival (fall fry/EFS) was relatively stable throughout the time series with the exception of high survival in 1990 (Figure 42) while post-fry survival, which includes a period of freshwater survival and marine survival, has been variable but relatively stable throughout the time series.



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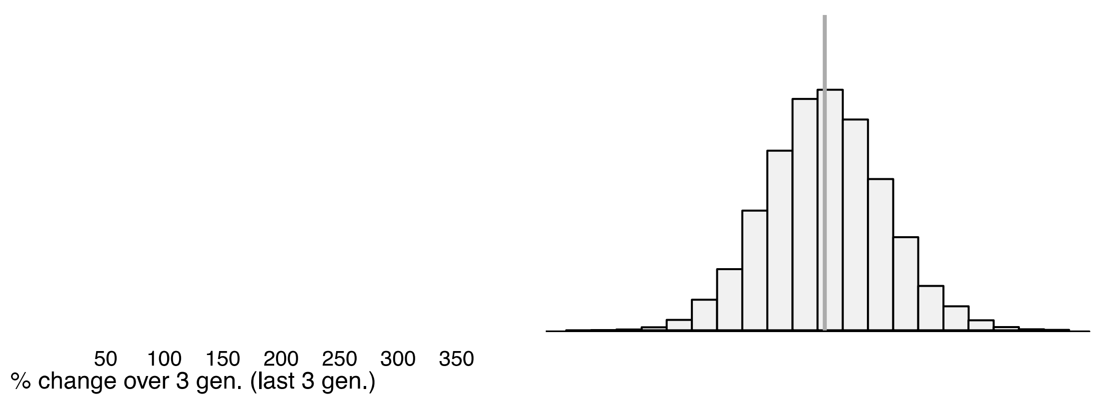


Figure 41: Historical trends in abundance, catch, recruits-per-spawner and estimated rates of change for DU 18: Shuswap Complex-L, (a) total escapement, catch, en-route loss and exploitation rate (red line) by return year; (b) escapement separated by sex and female pre-spawn mortality (PSM); (c) recruits per effective female spawner ($\log_e$ scale); (d) 4-year running average of effective female spawners with estimated rates of change based on last 3 generations and full time series; and posterior distributions (and median estimate as vertical line) of estimated percent change over last three generations based on a linear rate of change of smoothed $\log_e$ effective female spawner abundances over (e) most recent three generations of data or (f) full time series.

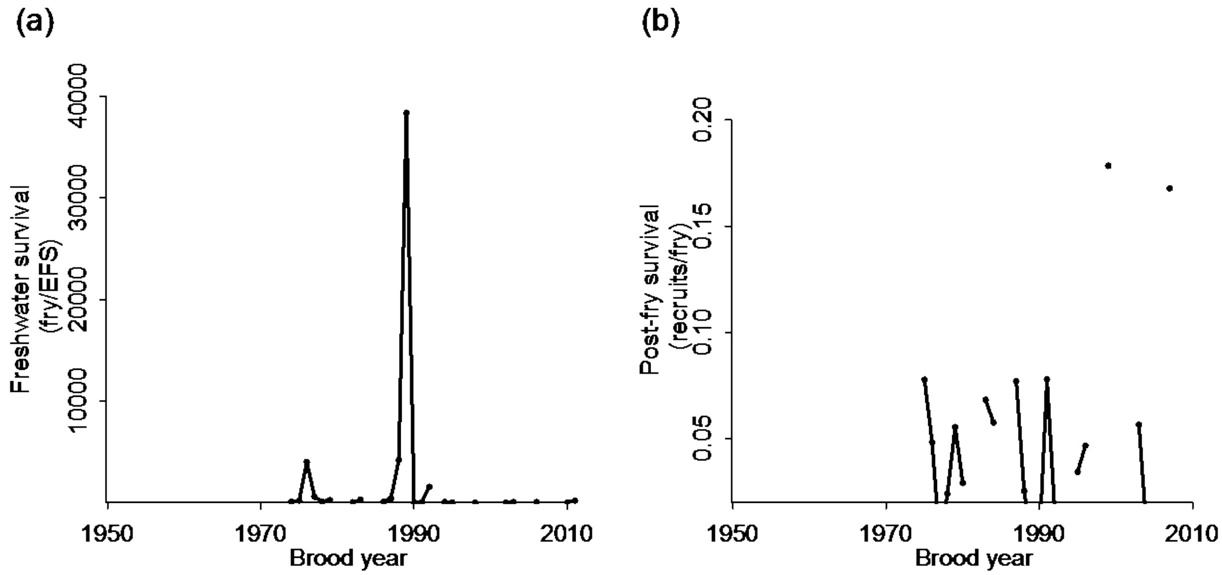


Figure 42: Historical trends in (a) early freshwater (fry per effective female spawner) and (b) post-fry/marine (recruits per fry) survival.

Using data for the last 3 generations, the Shuswap Complex-L DU has decreased by an estimated 78% (Upper 95% CI = -46%, Lower 95% CI = -91%) based on the geometric mean regression (Table 18). The probabilities that the decline has been greater than 30%, 50% and 70% respectively are 0.99, 0.97, and 0.76. When change in abundance is calculated based on the entire time series, the DU has decreased by an estimated 2% (Upper 95% CI = 6%, Lower 95% CI = -9%) . The probability that there has been a decline of >30% is 0.00.

Table 18: Summary of estimated rate of change (+/- 95% credible interval) in effective female spawner abundance as well as the probability DU 18: Shuswap Complex-L has declined by more than 30%, 50% or 70% over the last three generations. Rates of change are provided based on analysis of just the last 3 generations of data or the entire time series (see corresponding year range).

DU	Generation length	Year range	Median % change	95% CI	p>30% decline	p>50% decline	p>70% decline	Number of observations
Shuswap Complex-L	4 yrs	2003-2015	-78%	-91% / -46%	0.99	0.97	0.76	13
		1954-2015	-2%	-9% / +6%	0	0	0	13

This DU exhibits very strong cyclical dominance and the geometric mean time series is severely biased. The run cycle that returned to breed in 1950, 1954, and every 4 years subsequently has always dominated the population (Figure 43). While the number of effective female spawners of the largest cycle is highly variable, it has never been lower than 500,000 individuals, it has exceeded 2.5 million on two recent occasions (2002 and 2010), and there is a long term upward trend in its abundance. Estimates of the abundance of off-cycle lines in this DU are highly uncertain (survey effort is very low on these lines), and the recent low estimates are responsible for the downward trend in the geometric mean. The 2012 estimate was 12 fish, but this could be as high as 1000 (Benner pers. comm. 2017), in which case the short-term trends would likely be less than a 30% decline. For the purpose of this assessment, the trend in the number of mature individuals is based on the trend in the dominant cycle. There is no trend in the number of mature individuals over the last 3 generations.

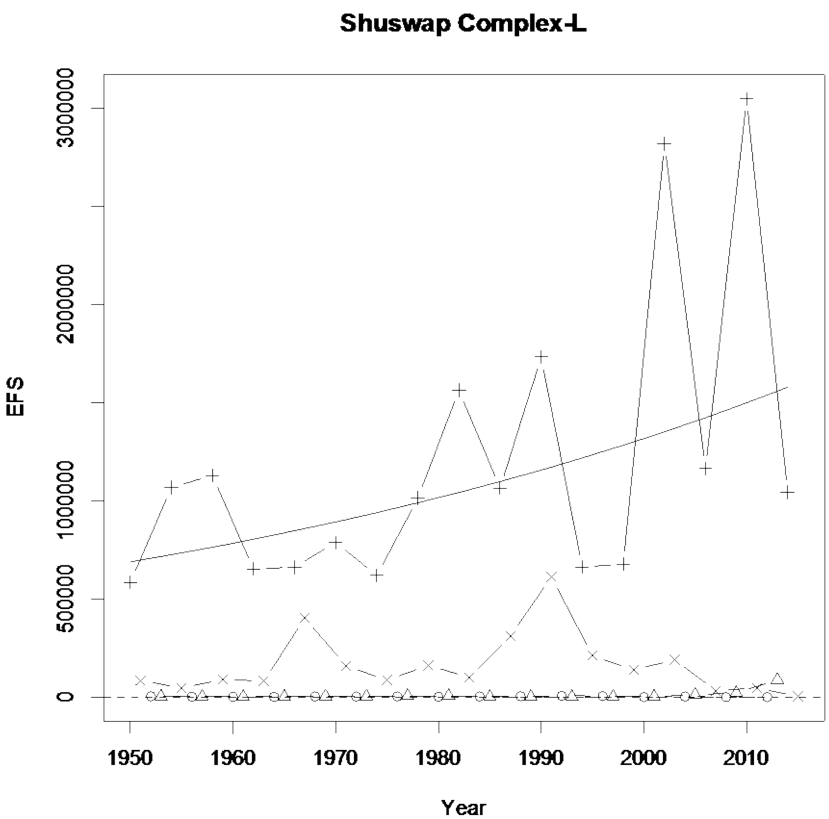


Figure 43: Effective female spawners (EFS) for each cycle line in DU 18 Shuswap Complex-L. The fitted line is a log-linear regression for the dominant cycle.

Threats and Limiting Factors

Based on the IUCN threat calculator, this DU was assigned a threat impact of Medium (C). Threats to Sockeye from this DU include fisheries because the Sockeye population from this DU, though well managed on the dominant cycle, can pose a low threat on off cycle runs. Depressed marine survival also poses a low level of threat to this DU. Lastly, Sockeye from the DU are exposed to industrial effluents during migration in freshwater, the Fraser estuary and Strait of Georgia and there is the possibility of contaminant spills from train derailments into Shuswap Lake. Based on this, the severity was scored slight.

Several other potential threats exist for this DU (e.g., agricultural effluent, marine mammal predation, competition with abundant Pink Salmon at sea and pathogens) but could not be assigned a severity rating.

Designatable Unit 19: Shuswap-ES population

Extent of Occurrence and Area of Occupancy

The Shuswap-ES DU is composed of Sockeye that spawn in 23 sites including the Adams River, Eagle River, Seymour River, and Scotch Creek (Figure 44). The extent of occurrence for this DU includes the North Pacific Ocean and so is estimated to be greater than 20,000 km^2. The most recent estimate of the IAO for the Shuswap-ES DU is 352 km^2. The number of consistently assessed sites where spawning has occurred has varied slightly over the past 19 years (1992-95: 16, 2000-03: 15, 2008-11: 17; de Mestral Bezanson *et al*. 2012).

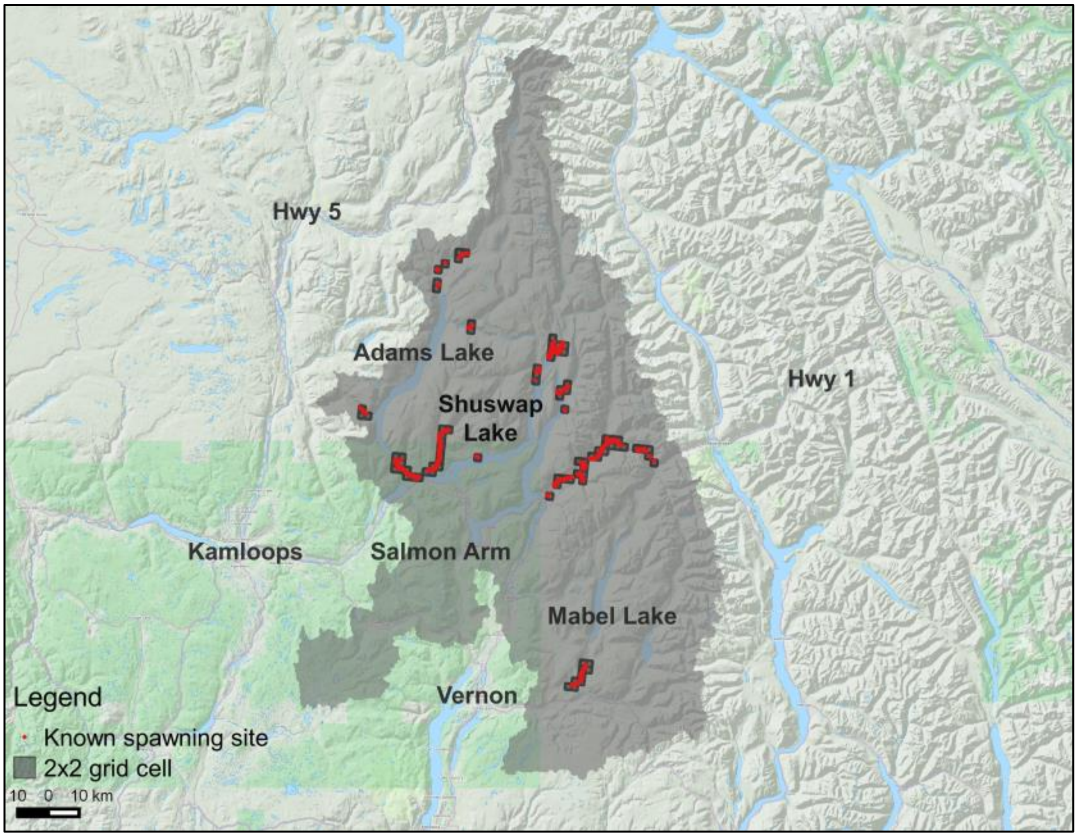


Figure 44: Shuswap-ES DU and known spawning sites within it.

Habitat Trends

There is a relatively low intensity of forest harvesting and Mountain Pine Beetle disturbance in the Shuswap -ES DU both of which have increased in recent years (Nelitz *et al*. 2011). Urban area occurs at relatively high intensity in the DU while road density, agricultural area, water restriction, and placer mines all occur at relatively moderate intensities (Nelitz *et al*. 2011).

Abundance

Spawner abundance for Shuswap-ES DU is estimated based on counts of Sockeye at three sites including Seymour River and Scotch and McNomee creeks using a combination of peak live cumulative dead and mark recapture methods as well as an enumeration fence on Scotch Creek (Grant *et al.* 2011). The overall quality of these spawner estimates is considered “Very good”. The most recent estimate of spawner abundance was 141,986 mature individuals.

Fluctuations and Trends

From the 1950s to 1990s, escapement in the Shuswap-ES DU was relatively low before increasing gradually through to the present (Figure 45). Recruits-per-spawner in the Shuswap-ES DU have declined somewhat from highs in the 1980s. There are no data on trends in early freshwater or post-fry survival for this DU.

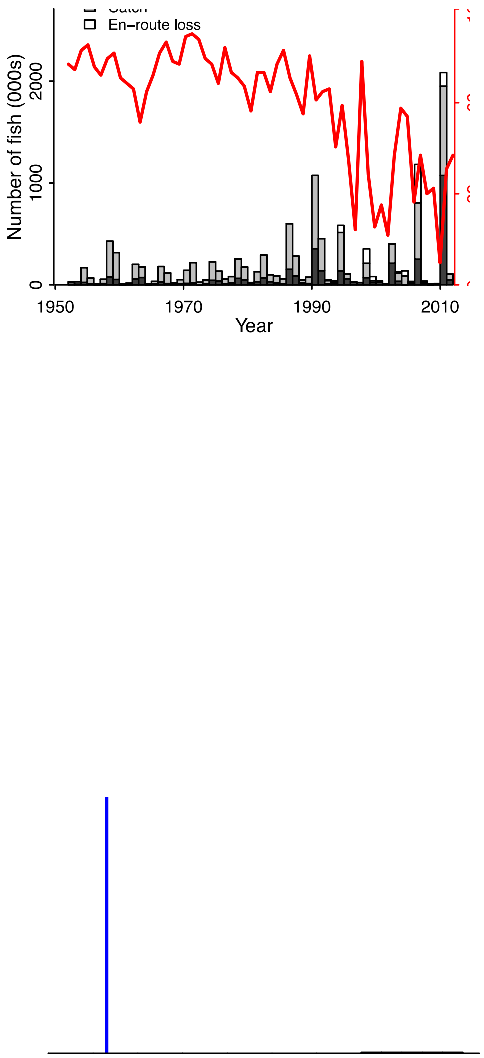


Figure 45: Historical trends in abundance, catch, recruits-per-spawner and estimated rates of change for DU 19: Shuswap-ES, (a) total escapement, catch, en-route loss and exploitation rate (red line) by return year; (b) escapement separated by sex and female pre-spawn mortality (PSM); (c) recruits per effective female spawner (log_e scale); (d) 4-year running average of effective female spawners with estimated rates of change based on last 3 generations and full time series; and posterior distributions (and median estimate as vertical line) of estimated percent change over last three generations based on a linear rate of change of smoothed log_e effective female spawner abundances over (e) most recent three generations of data or (f) full time series.

Using data for the last 3 generations, the Shuswap-ES DU has increased by an estimated 30% (Upper 95% CI = 161%, Lower 95% CI = -34%) (Table 19). The probabilities that the decline has been greater than 30%, 50% and 70% respectively are 0.03, 0.01, and 0.00. When change in abundance is calculated based on the entire time series, the DU has increased by an estimated 24% (Upper 95% CI = 33%, Lower 95% CI = 16%). The probability that there has been a decline of >30% is 0.00.

Table 19: Summary of estimated rate of change (+/- 95% credible interval) in effective female spawner abundance as well as the probability DU 19: Shuswap -ES has declined by more than 30%, 50% or 70% over the last three generations. Rates of change are provided based on analysis of just the last 3 generations of data or the entire time series (see corresponding year range).

DU	Generation length	Year range	Median % change	95% CI	p>30% decline	p>50% decline	p>70% decline	Number of observations
Shuswap - ES	4 yrs	2003-2015	+30%	-34% / +161%	0.03	0.01	0	13
		1954-2015	+24%	+16% / +33%	0	0	0	13

Threats and Limiting Factors

A threat calculator was not completed for this DU.

Designatable Unit 20: Takla-Trembleur-EStu population

Extent of Occurrence and Area of Occupancy

The Takla-Trembleur-EStu DU is composed of Sockeye that spawn in over 50 sites including Takla Lake, Middle River, Driftwood River, Sakeniche River, Rossette (Van Decar), Paula and Sydney (Felix) creeks (Figure 46). The extent of occurrence for this DU includes the North Pacific Ocean and so is estimated to be greater than 20,000 km^2. The most recent estimate of the IAO for the Takla-Trembleur-EStu DU is 428 km^2. The number of consistently assessed sites where spawning has occurred has varied slightly over the past 19 years (1992-95: 39, 2000-03: 38, 2008-11: 35; de Mestral Bezanson *et al.* 2012).

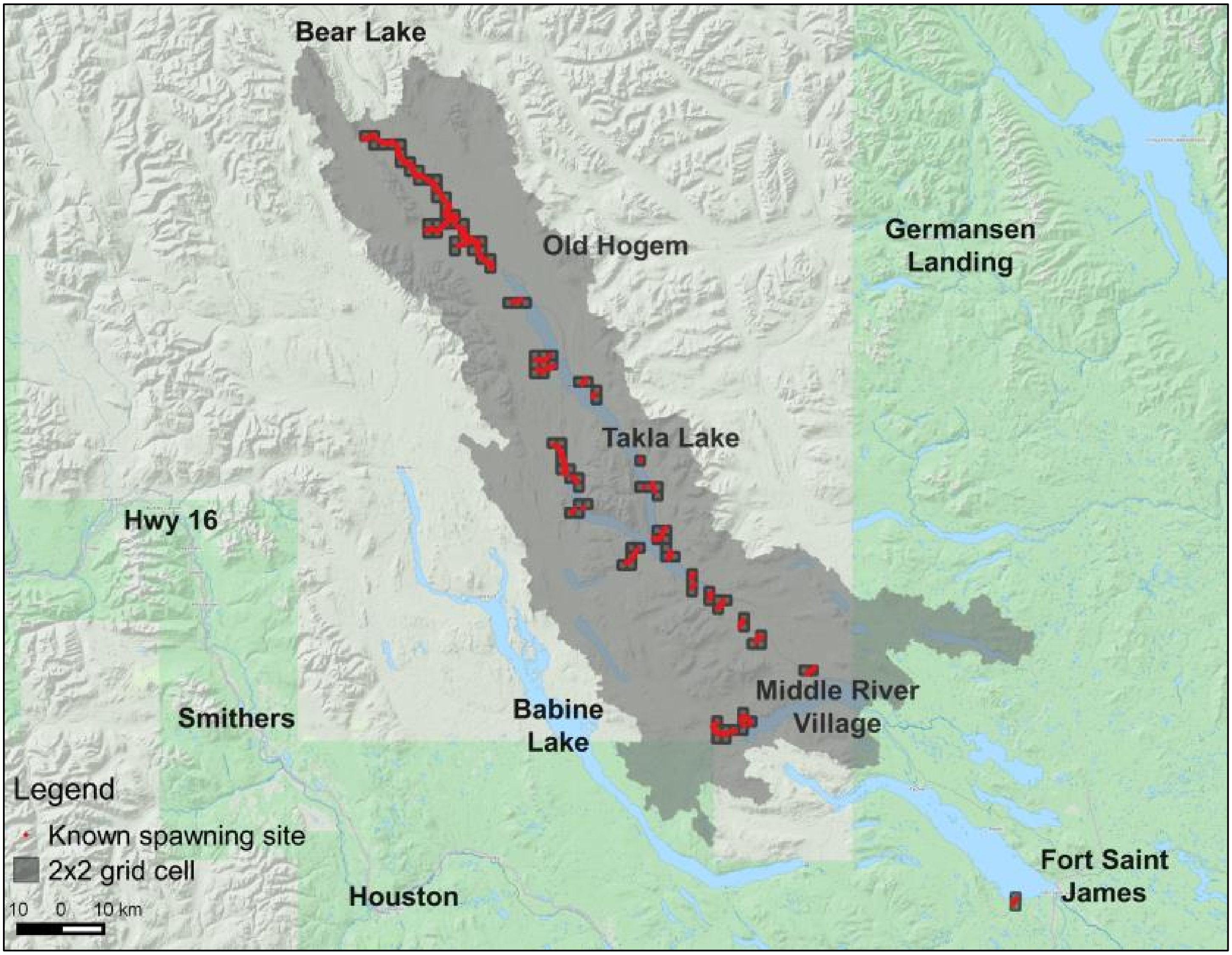


Figure 46: Takla-Trembleur-EStu DU and known spawning sites within it.

Habitat Trends

There is relatively moderate intensity of Mountain Pine Beetle disturbance in the Takla-Trembleur-EStu DU which has increased in recent years. There is a relatively low intensity of forest harvesting that has decreased in the recent years (Nelitz *et al*. 2011). Road density and water allocation all occur at relatively low intensities while placer mining occurs at relatively moderate intensity in the DU (Nelitz *et al*. 2011).

Abundance

Spawner abundance for Takla-Trembleur-EStu DU is estimated based on four sites that were enumerated consistently throughout the time series, including Forfar, Gluske, Kynoch (O'Ne-ell), and Rossette (Van Decar) creeks using a combination of peak live cumulative dead and mark recapture methods as well as a fences program in the Forfar, Gluske and Kynoch (O'Ne-ell) creeks (Grant *et al*. 2011). The overall quality of these spawner estimates is considered "Very good". The most recent estimate of spawner abundance was 42,563 mature individuals.

Fluctuations and Trends

Escapement to the Takla-Trembleur-EStu DU increased from the 1970s to 1990s and has been declining since (Figure 47). Estimated exploitation rates for the DU have steadily declined since the late 1970s and have been below 20% in recent years. The Takla-Trembleur-EStu DU has exhibited a gradual and systematic decline in recruits-per-spawner since highs observed in the late 1960s. There are no data on trends in early freshwater or post-fry survival for this DU.

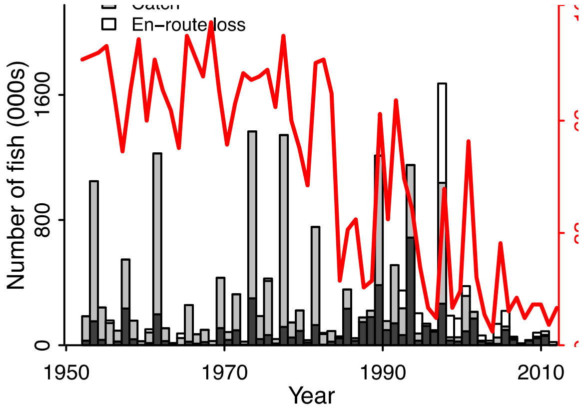


Figure 47: Historical trends in abundance, catch, recruits-per-spawner and estimate of rate of change for DU 20: Takla-Trembleur-EStu, (a) total escapement, catch, en-route loss and exploitation rate (red line) by return year; (b) escapement separated by sex and female pre-spawn mortality (PSM); (c) recruits per effective female spawner (log_e scale); (d) 4-year running average of effective female spawners with estimated rates of change based on last 3 generations and full time series; and posterior distributions (and median estimate as vertical line) of estimated percent change over last three generations based on a linear rate of change of smoothed log_e effective female spawner abundances over (e) most recent three generations of data (f) or full time series.

Using data for the last 3 generations, the Takla-Trembleur-EStu DU has decreased by an estimated 54% over 3 generations (Upper 95% CI = -16%, Lower 95% CI = -74%) (Table 20). The probabilities that the decline has been greater than 30%, 50% and 70% respectively are 0.92, 0.61, and 0.06. When change in abundance is calculated based on the entire time series, the DU has increased by an estimated 6% (Upper 95% CI = 20%, Lower 95% CI = -7%). The probability that there has been a decline of >30% is 0.00.

Table 20: Summary of estimated rate of change (+/- 95% credible interval) in effective female spawner abundance as well as the probability DU 20: Takla-Trembleur-EStu has declined by more than 30%, 50% or 70% over the last three generations. Rates of change are provided based on analysis of just the last 3 generations of data or the entire time series (see corresponding year range).

DU	Generation length	Year range	Median % change	95% CI	p>30% decline	p>50% decline	p>70% decline	Number of observations
Takla-Trembleur-EStu	4 yrs	2003-2015	-54%	-74% / -16%	0.92	0.61	0.06	13
		1954-2015	+6%	-7% / +20%	0	0	0	13

<u>Threats and Limiting Factors</u>

Based on the IUCN threat calculator, this DU was assigned a threat impact of High - Medium (BC). Threats to Sockeye from this DU include fisheries because the Sockeye population from this DU is declining and fishing is likely contributing to the decline. Depressed marine survival also poses a medium to low level of threat to this DU. Freshwater temperature extremes also pose a threat to Sockeye from this DU with the Fraser River expected to continue to warm throughout the 21st century. This could lead to severe losses during adult migrations en route to spawning grounds. Lastly, with warmer winters and earlier snow melt expected with climate change, changes in the timing of the freshet pose a medium threat to this early run time DU.

Several other potential threats exist for this DU (e.g., industrial effluent, marine mammal predation, competition with abundant Pink Salmon at sea and pathogens) but could not be assigned a severity rating.

Designatable Unit 21: Takla-Trembleur-Stuart-S population

Extent of Occurrence and Area of Occupancy

The Takla-Trembleur-Stuart-S DU is composed of Sockeye that spawn in the area around Middle River, Sakeniche River, Stuart River, and Tachie River (Figure 48). The extent of occurrence for this DU includes the North Pacific Ocean and so is estimated to be greater than 20,000 km^2. The most recent estimate of the IAO for the Takla-Trembleur-Stuart DU is 164 km^2. The number of consistently assessed sites where spawning has occurred has remained the same over the past 19 years (1992-95: 7, 2000-03: 7, 2008-11: 7; de Mestral Bezanson *et al*. 2012).

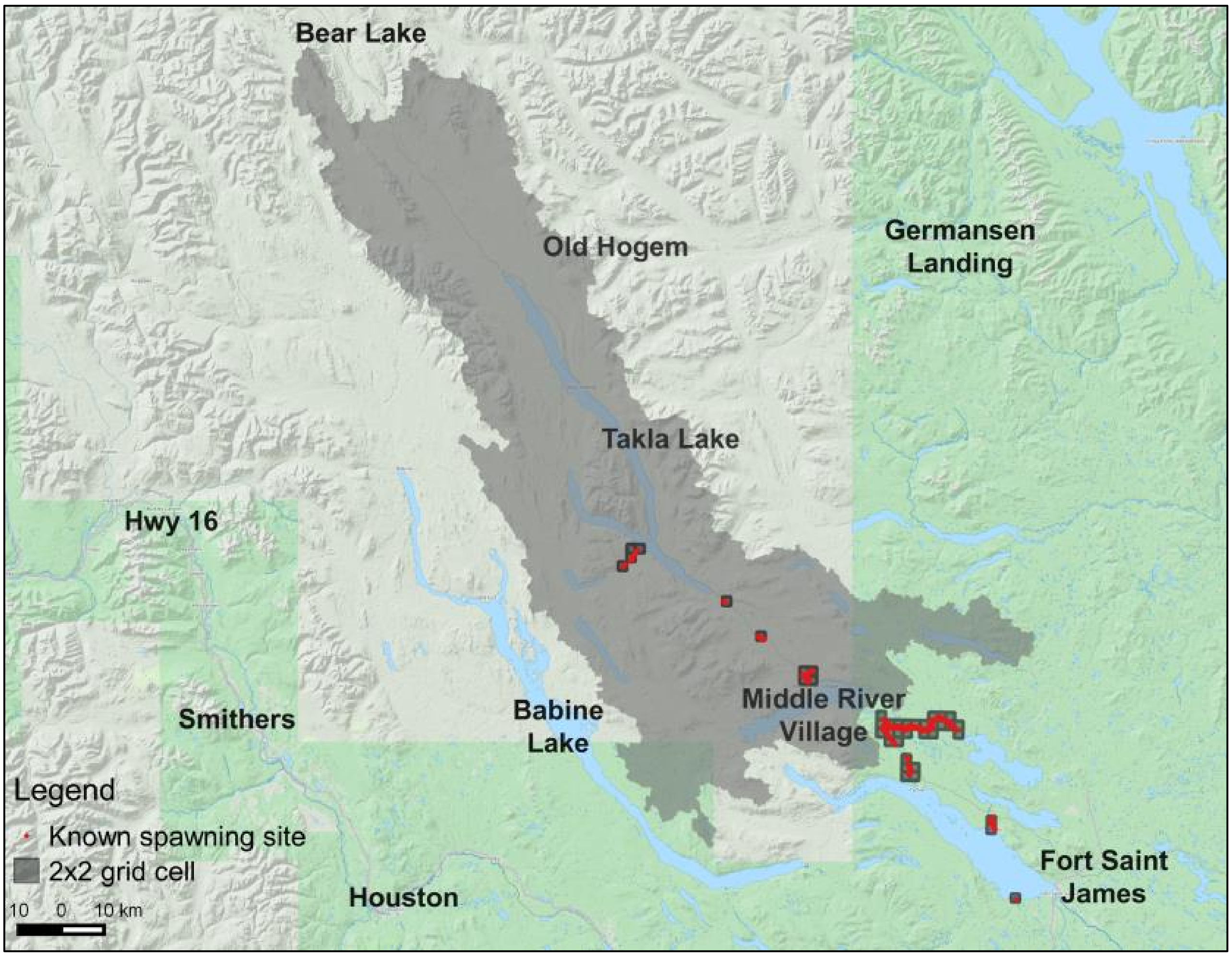


Figure 48: Takla-Trembleur-Stuart-S DU and known spawning sites within it.

Habitat Trends

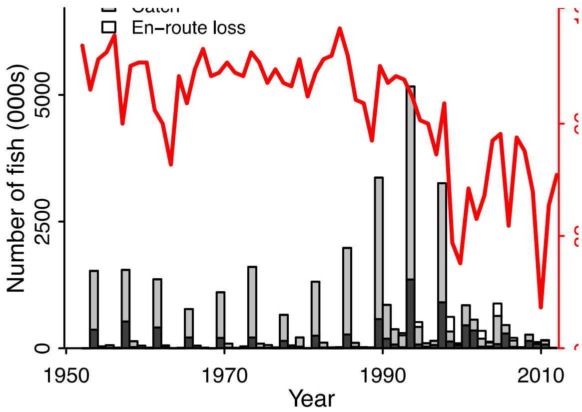
There is relatively high intensity Mountain Pine Beetle disturbance in the Takla-Trembleur-Stuart-S DU which has increased in recent years. There is a relatively low intensity of forest harvesting which has decreased in the recent years (Nelitz *et al*. 2011). Placer mines and road density occur at relatively moderate intensities in the DU (Nelitz *et al*. 2011).

Abundance

Spawner abundance for Takla-Trembleur-Stuart-S DU is estimated based on counts of Sockeye at four sites including Middle and Tachie rivers and Kazchek and Kuzkwa creeks using a combination of peak live cumulative dead, fence and mark recapture methods (Grant *et al*. 2011). The overall quality of these spawner estimates is considered “Very good”. The most recent estimate of spawner abundance was 66,073 mature individuals.

Fluctuations and Trends

This DU exhibits strong cycle dominance. From the 1950s to 1990s, escapement was relatively constant before increasing during the 1990s and early 2000s and then declining to present (Figure 49). Exploitation rates remained high (i.e., > 70%) in this DU through the early 1990s. There was a decline thereafter; however, there are a number of years when the exploitation rate was above 50% in recent years. The Takla-Trembleur-Stuart DU has exhibited a decline in recruits-per-spawner since the late 1980s. There are no data on trends in early freshwater or post-fry survival for this DU.



d)

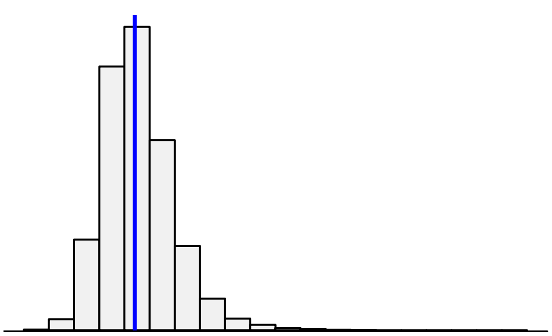


Figure 49: Historical trends in abundance, catch, recruits-per-spawner and estimated rates of change for DU 21: Takla-Trembleur-Stuart-S, (a) total escapement, catch, en-route loss and exploitation rate (red line) by return year; (b) escapement separated by sex and female pre-spawn mortality (PSM); (c) recruits per effective female spawner ($\log_e$ scale); (d) 4-year running average of effective female spawners with estimated rates of change based on last 3 generations and full time series; and posterior distributions (and median estimate as vertical line) of estimated percent change over last three generations based on a linear rate of change of smoothed $\log_e$ effective female spawner abundances over (e) most recent three generations of data or (f) full time series.

Using data for the last 3 generations, the Takla-Trembleur-Stuart-S DU has decreased by an estimated 68% over 3 generations (Upper 95% CI = -48%, Lower 95% CI = -81%) (Table 21). The probabilities that the decline has been greater than 30%, 50% and 70% respectively are 1.00, 0.97, and 0.41. When change in abundance is calculated based on the entire time series, the DU has increased by an estimated 60% (Upper 95% CI = 83%, Lower 95% CI = 40%). The probability that there has been a decline of >30% is 0.00.

Table 21: Summary of estimated rate of change (+/- 95% credible interval) in effective female spawner abundance as well as the probability DU 21: Takla-Trembleur-Stuart-S has declined by more than 30%, 50% or 70% over the last three generations. Rates of change are provided based on analysis of just the last 3 generations of data or the entire time series (see corresponding year range).

DU	Generation length	Year range	Median % change	95% CI	p>30% decline	p>50% decline	p>70% decline	Number of observations
Takla-Trembleur-Stuart-S	4 yrs	2003-2015	-68%	-81% / -48%	1	0.97	0.41	13
		1954-2015	+60%	+40% / +83%	0	0	0	13

Threats and Limiting Factors

A threat calculator was not completed for this DU.

Designatable Unit 22: Taseko-ES population

Extent of Occurrence and Area of Occupancy

The Taseko DU is composed of Sockeye that spawn in Taseko Lake (Figure 50). The extent of occurrence for this DU includes the North Pacific Ocean and so is estimated to be greater than 20,000 km^2. The most recent estimate of the IAO for the Taseko-ES DU is 24 km^2. The number of consistently assessed sites where spawning has occurred has remained the same for the past 19 years (1992-95: 1, 2000-03: 1, 2008-11: 1; de Mestral Bezanson *et al*. 2012).

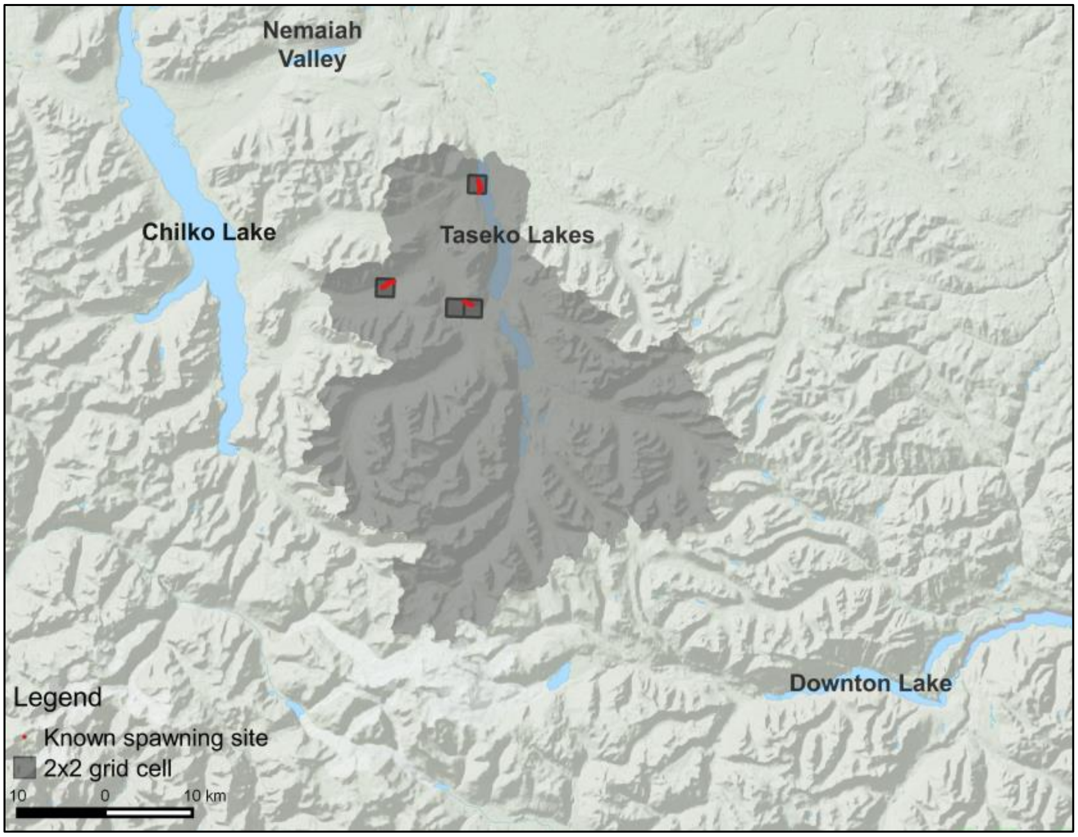


Figure 50: Taseko DU and known spawning sites within it.

Habitat Trends

There are no known human stressors on habitat within this DU (Nelitz *et al.* 2011).

Abundance

Spawner abundance for this DU is estimated based on carcass counts in Taseko-ES Lake and so is considered an index of abundance (Grant *et al*. 2011). The overall quality of these spawner estimates is considered “Fair”. The most recent estimate of spawner abundance was 334 mature individuals.

Fluctuations and Trends

Recruits-per-spawner and survival could not be estimated for Taseko-ES DU as there are no corresponding data available for this DU. From 1950s to mid-1960s escapement was relatively high in the DU and has declined since then (Figure 51). Exploitation and recruits-per-spawner could not be estimated for the Taseko DU. There are also no data on trends in early freshwater or post-fry survival for this DU.

No Corresponding Data for this DU

(f)

20

% change over 3 gen. (all years)

Figure 51: Historical trends in abundance, catch, recruits-per-spawner and estimated rates of change for DU 22: Taseko-ES, (a) total escapement, catch, en-route loss and exploitation rate (red line) by return year; (b) escapement separated by sex and female pre-spawn mortality (PSM); (c) recruits per effective female spawner (log_e scale); (d) 4-year running average of effective female spawners with estimated rates of change based on last 3 generations and full time series; and posterior distributions (and median estimate as vertical line) of estimated percent change over last three generations based on a linear rate of change of smoothed log_e effective female spawner abundances over (e) most recent three generations of data or (f) full time series.

Using data for the last 3 generations, the Taseko-ES DU has decreased by an estimated 84% (Upper 95% CI = -59%, Lower 95% CI = -94%) (Table 22). The probabilities that the decline has been greater than 30%, 50% and 70% respectively are 1.00, 0.99, 0.92. When change in abundance is calculated based on the entire time series, the DU has decreased by an estimated 39% (Upper 95% CI = -31%, Lower 95% CI = -46%). The probabilities that the decline has been greater than 30%, 50% and 70% respectively are 0.99, 0.00, and 0.00.

Table 22: Summary of estimated rate of change (+/- 95% credible interval) in effective female spawner abundance as well as the probability DU 22: Taseko-ES has declined by more than 30%, 50% or 70% over the last three generations. Rates of change are provided based on analysis of just the last 3 generations of data or the entire time series (see corresponding year range).

DU	Generation length	Year range	Median % change	95% CI	p>30% decline	p>50% decline	p>70% decline	Number of observations
Taseko-ES	4 yrs	2003-2015	-84%	-94% / -59%	1	0.99	0.92	13
		1954-2015	-39%	-31% / -46%	0.99	0	0	13

Threats and Limiting Factors

A threat calculator was not completed for this DU.

Designatable Unit 23: Harrison - (River-Type) population

Extent of Occurrence and Area of Occupancy

The Harrison – (River-Type) DU is composed of Sockeye that spawn in the Harrison River (Figure 52). The extent of occurrence for this DU includes the North Pacific Ocean and so is estimated to be greater than 20,000 km^2. The most recent estimate of the IAO for the Harrison – (River-Type) DU is 20 km^2. The number of consistently assessed sites where spawning has occurred has remained the same for the past 19 years (1992-95: 1, 2000-03: 1, 2008-11: 1; de Mestral Bezanson *et al.* 2012).

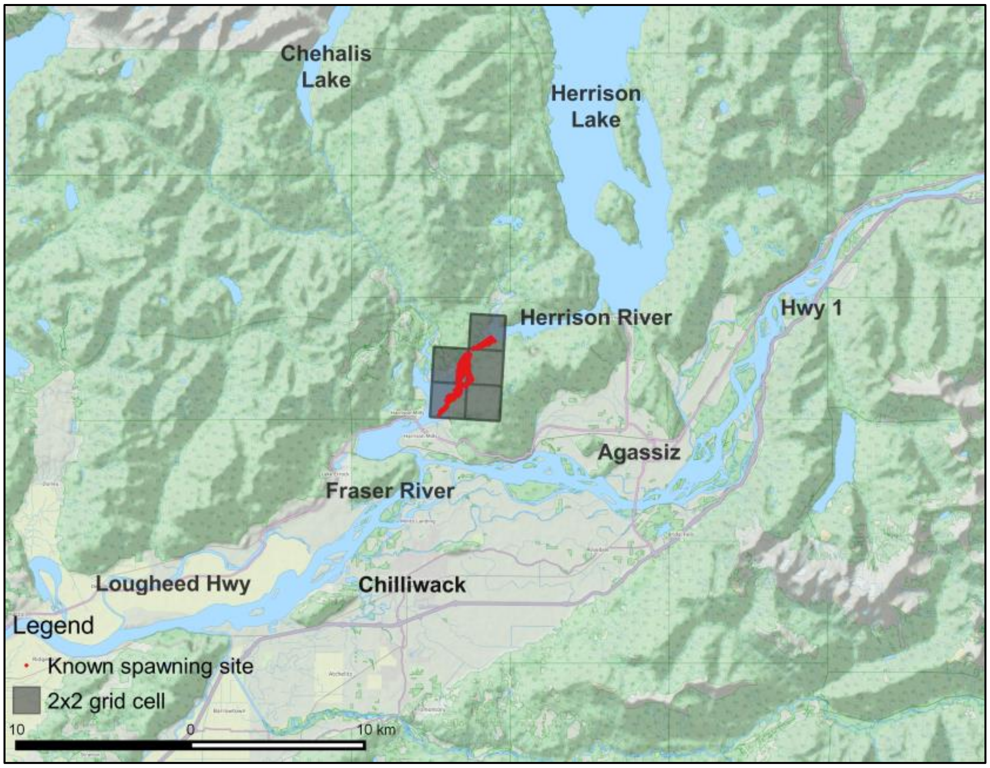


Figure 52: Harrison – (River-Type) DU and known spawning sites within it.

Habitat Trends

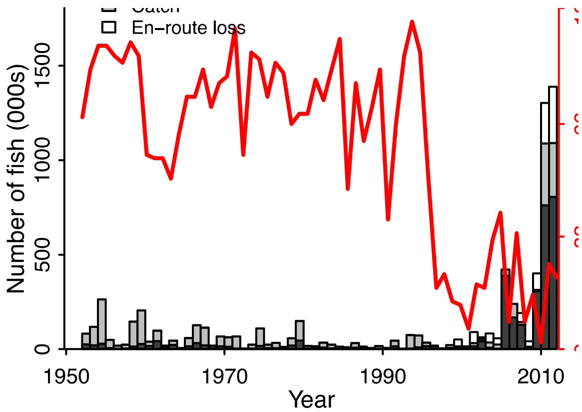
There is a relatively low intensity of Mountain Pine Beetle disturbance in the DU which has increased in recent years (Nelitz *et al*. 2011). Forest harvesting, agriculture, road density and water allocation all occur at relatively low intensities while urban area, small hydro-electric dams, and placer mines remain stable in the DU (Nelitz *et al*. 2011).

Abundance

Spawner abundance for this DU is estimated based on counts of Sockeye at Harrison River using a combination of peak live cumulative dead and mark recapture methods (Grant *et al.* 2011). The overall quality of these spawner estimates is considered “Good”. The most recent estimate of spawner abundance was 205,975 mature individuals.

Fluctuations and Trends

From the 1950s to the mid-2000s escapement in the Harrison River DU was relatively low but then experienced a sharp increase in escapement over the past decade (Figure 53). Exploitation rates for the DU were high until the early 1990s when they were reduced sharply and have been maintained at less than 40% ever since. The Harrison River DU has experienced a variable but increasing trend in recruits-per-spawner over time. There are no data on trends in early freshwater or post-fry survival for this DU.



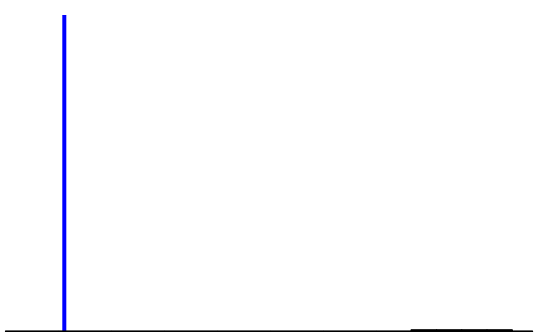


Figure 53: Historical trends in abundance, catch and recruits-per-spawner and estimated rates of change for DU 23: Harrison - (River-Type), (a) total escapement, catch, en-route loss and exploitation rate (red line) by return year; (b) escapement separated by sex and female pre-spawn mortality (PSM); (c) recruits per effective female spawner ($\log_e$ scale); (d) 4-year running average of effective female spawners with estimated rates of change based on last 3 generations and full time series; and posterior distributions (and median estimate as vertical line) of estimated percent change over last three generations based on a linear rate of change of smoothed $\log_e$ effective female spawner abundances over (e) most recent three generations of data or (f) full time series.

Using data for the last 3 generations, the Harrison River DU has increased by an estimated 2196% (Upper 95% CI = 5496%, Lower 95% CI = 862%) (Table 23). The probability that there has been a decline of >30% is 0.00. When change in abundance is calculated based on the entire time series, the DU has increased by an estimated 38% (Upper 95% CI = 66%, Lower 95% CI = 16%) (Table 23). The probability that there has been a decline of >30% is 0.00.

Table 23: Summary of estimated rate of change (+/- 95% credible interval) in effective female spawner abundance as well as the probability DU 23: Harrison - (River-Type) has declined by more than 30%, 50% or 70% over the last three generations. Rates of change are provided based on analysis of just the last 3 generations of data or the entire time series (see corresponding year range).

DU	Generation length	Year range	Median % change	95% CI	p>30% decline	p>50% decline	p>70% decline	Number of observations
Harrison River	4 yrs	2003-2015	+2196%	+862% / +5496%	0	0	0	13
		1954-2015	+38%	+16% / +66%	0	0	0	13

Threats and Limiting Factors

A threat calculator was not completed for this DU.

Designatable Unit 24: Widgeon - (River-Type) population

Extent of Occurrence and Area of Occupancy

The Widgeon – (River-Type) DU is composed of Sockeye that spawn in Widgeon Creek (Figure 54). The extent of occurrence for this DU includes the North Pacific Ocean and so is estimated to be greater than 20,000 km^2. The most recent estimate of the IAO for the Widgeon – (River-Type) DU is 4 km^2. The number of consistently assessed sites where spawning has occurred has remained the same over the past 19 years (1992-95: 1, 2000-03: 1, 2008-11: 1; de Mestral Bezanson *et al*. 2012).

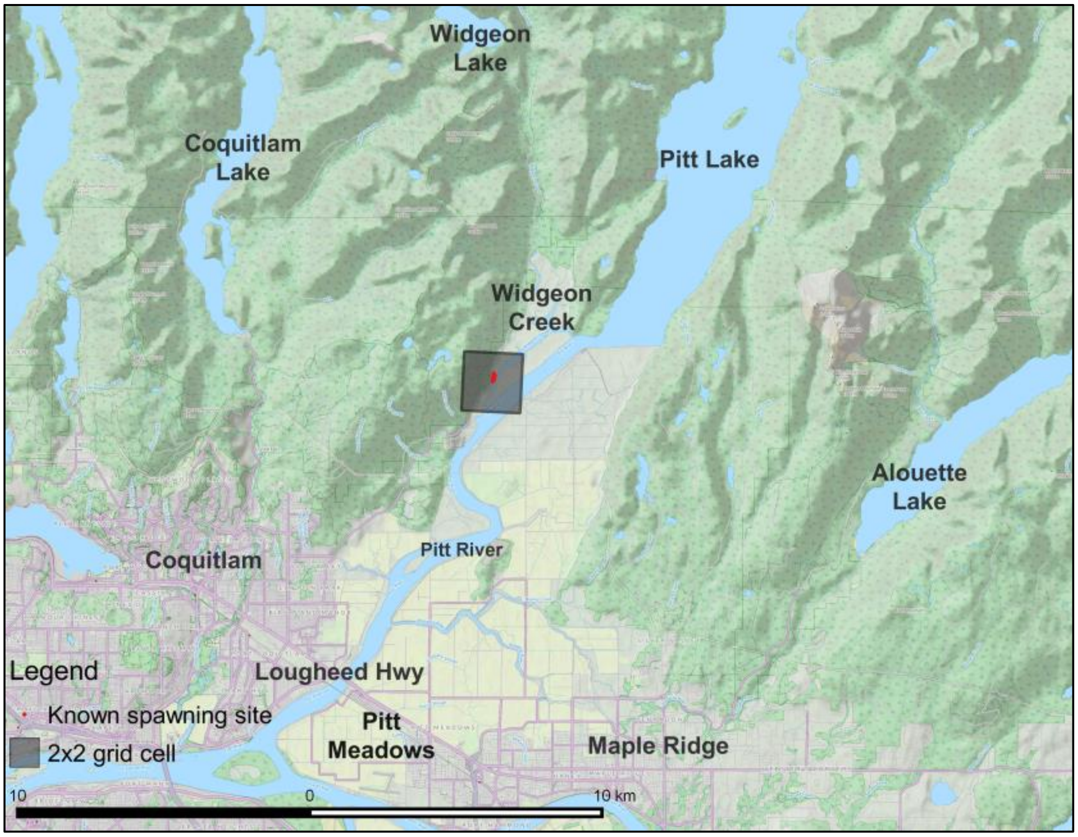


Figure 54: Widgeon – (River-Type) DU and known spawning sites within it.

Habitat Trends

There are no known human stressors on habitat within this DU (Nelitz *et al.* 2011); however, this DU is highly vulnerable to any development that would alter ground water flow from upslope areas into Widgeon Slough.

Abundance

Spawner abundance for the Widgeon – (River-Type) DU is estimated based on counts of Sockeye at Widgeon Slough using a peak live plus cumulative dead methodology. The overall quality of these spawner estimates is considered “Good”. The most recent estimate of spawner abundance was 656 mature individuals.

Fluctuations and Trends

Escapement in the Widgeon – (River-Type) DU remained relatively constant from the 1950s to the late 1980s before being depressed for 20 years and then increasing again in the 2010s (Figure 55). Estimates of exploitation and recruits-per-spawner are not available for this DU. There are also no data on trends in early freshwater or post-fry survival for this DU.

No Corresponding Data for this DU

(f)

5 −25 −15 −5 0 5

% change over 3 gen. (all years)

Figure 55: Historical trends in abundance, catch and estimate of rate of change for DU 24: Widgeon - (River-Type), (a) total escapement, catch, en-route loss and exploitation rate (red line) by return year; (b) escapement separated by sex and female pre-spawn mortality (PSM); (c) recruits per effective female spawner ($\log_e$ scale); (d) 4-year running average of effective female spawners with estimated rates of change based on last 3 generations and full time series; and posterior distributions (and median estimate as vertical line) of estimated percent change over last three generations based on a linear rate of change of smoothed $\log_e$ effective female spawner abundances over (e) most recent three generations of data (f) or full time series.

Using data for the last 3 generations, the Widgeon – (River-Type) DU has increased by an estimated 1145% (Upper 95% CI = 5809%, Lower 95% CI = +145%) (Table 24). The probability that there has been a decline of >30% is 0.00. When change in abundance is calculated based on the entire time series, the DU has decreased by an estimated 25% (Upper 95% CI = -13%, Lower 95% CI = -36%). The probabilities that the decline has been greater than 30%, 50% and 70% respectively are 0.20, 0.00, and 0.00.

Table 24: Summary of estimated rate of change (+/- 95% credible interval) in effective female spawner abundance as well as the probability for DU 24: Widgeon - (River-Type) has declined by more than 30%, 50% or 70% over the last three generations. Rates of change are provided based on analysis of just the last 3 generations of data or the entire time series (see corresponding year range).

DU	Generation length	Year range	Median % change	95% CI	p|30% decline	p|50% decline	p|70% decline	Number of observations
Widgeon – (River-Type)	4 yrs	2003-2015	+1145%	+145% / +5809%	0	0	0	13
		1954-2015	-25%	-36% / -13%	0.2	0	0	13

Threats and Limiting Factors

A threat calculator was not completed for this DU.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

In Canada, one Fraser River Sockeye population (the Cultus Lake population) underwent an emergency assessment in October 2002 by COSEWIC and was found to be Endangered. COSEWIC confirmed the status in 2003 (COSEWIC 2003a) and again in 2017. A *National Conservation Strategy for Cultus Lake Sockeye Salmon* was published in 2009 (Cultus Sockeye Recovery Team 2009). COSEWIC has also assessed the Sakinaw population of Sockeye (not part of the Fraser River group) as Endangered in an emergency assessment in October 2002. That status was confirmed by COSEWIC in 2003, 2006, and in 2016 (COSEWIC 2003b, 2006, 2016). Neither the Cultus nor Sakinaw populations of Sockeye Salmon are listed under the *Species at Risk Act* (SARA) (SARA 2015). Canada's decision not to list these populations under SARA took into account public input from more than 50 responses, including submissions from the Sierra Club, British Columbia Aboriginal Fisheries Commission, Soowahlie First Nation, and many individuals and associations from the fishing industry (Cohen Commission 2012b). Canada determined that listing these two populations of Sockeye would result in "unacceptably high social and economic costs" for the commercial and recreational fishing sectors, and for some Aboriginal peoples and coastal communities.

Globally, *O. nerka* as a species is considered to be demonstrably widespread, abundant, and secure (BC Conservation Data Centre 2015). In British Columbia, the species is considered to be “apparently secure and not at risk of extinction” (BC Conservation Data Centre 2015). This status equates to a Provincial Conservation Status rating of ‘4’ (reviewed in 2000) which puts *O. nerka* on the BC List in the ‘Yellow’ category. The conservation priority assigned to Sockeye in BC is nevertheless high (BC Conservation Data Centre 2015).

In the United States, one population of Sockeye Salmon (Snake River ESU) is listed as Endangered, and one population (Ozette Lake ESU) is listed as Threatened under the *Endangered Species Act* (see Table 25) (NOAA 2015).

Table 25: Endangered Species Act Current Listing Status Summary for Sockeye Salmon (after NOAA 2015).

Common Name	Description of listed entity	ESA Listing
Salmon, Sockeye (Snake River ESU)	Naturally spawned anadromous and residual Sockeye Salmon originating from the Snake River basin. Also, Sockeye Salmon from one artificial propagation program: the Redfish Lake Captive Broodstock Program.	**Endangered**
Salmon, Sockeye (Ozette Lake ESU)	Naturally spawned Sockeye Salmon originating from the Ozette River and Ozette Lake and its tributaries. Also, Sockeye Salmon from two artificial propagation programs: the Umbrella Creek Hatchery Program; and the Big River Hatchery Program.	**Threatened**

An extensive framework of international commitments and domestic legislation and policies exist to protect Pacific salmon populations, including: the UN Convention on Biological Diversity; the *Fisheries Act*; federal-provincial agreements; the 1998 New Directions Policy of Fisheries and Oceans Canada; the Wild Salmon Policy; and provincial legislation such as the *BC Water Sustainability Act*. Additionally, the *Canada Oceans Act* (1996) requires that marine resources be managed to conserve biological diversity and commits Canada to the application of the Precautionary Principle for wildlife, including fishes.

In March of 1985, Canada and the United States agreed to co-operate in the management, research and enhancement of Pacific salmon stocks of mutual interest by ratifying the Pacific Salmon Treaty. Since then, the Fraser River Panel (FRP) of the Pacific Salmon Commission (PSC) has regulated management of Fraser Sockeye fisheries in Panel Area waters off Vancouver Island (Grant *et al*. 2011: Figure 8). The purpose of the FRP, which is composed of Canadian and US representatives, is to ensure that spawning escapement targets are met (Fisheries and Oceans Canada 1998). Under the Pacific Salmon Treaty, the US share of the Fraser Sockeye harvest has gradually decreased; the present level is 16.5% of international Total Allowable Catch (GC and GUSA 2014). DFO manages the Canadian catch outside of Panel Area waters, ensuring that escapement and allocation objectives are met there (Grant *et al*. 2011).

Non-Legal Status and Ranks

The IUCN Red List of Threatened Species lists 22 distinct populations of Fraser River Sockeye. The IUCN classifies Fraser River Cultus Lake, Chilko (summer), Gates Creek and Channel (early summer), Nahatlatch (early summer), Stuart (early summer), Stuart (summer), and Bowron (early summer) Sockeye populations as Endangered. Four Fraser populations are classified as Data Deficient, and the other 11 Fraser River populations as Least Concern (IUCN 2014). The IUCN identified a total of 75 extant and five extinct 'subpopulations' across the natural range of *O. nerka* in its 2008 assessment. In a 2011 amendment, several of these subpopulations were further subdivided based on additional input from salmon specialists (PSC and DFO), resulting in a total of 98 subpopulations, of which 93 are extant.

At the range-wide species level, Sockeye Salmon have been assigned a Red List status of Least Concern. The median and mean rate of change across assessed populations were 9.0 and 72.4 % increase, respectively, over the past three generations, suggesting there is no evidence of risk to the species under Red List A2 criterion. At 1.9 million km^2 of freshwater basin area, there is no evidence of threat to the current area of occupancy. The IUCN has therefore concluded the species is not threatened globally (IUCN 2014).

Habitat Protection and Ownership

There are many forms of legislation and regulation in place to protect Pacific salmon habitat, both freshwater and marine, in Canada and the United States. An excellent summary of these, along with related policies and programs, is provided in Volume 1 of the Cohen Commission final report (Cohen Commission 2012b: Chapter 6). The following information comes largely from that report and the exhibits referenced therein.

The regulation and management of Sockeye habitat falls primarily under the federal *Fisheries Act*. Historically, the *Fisheries Act* (Section 35) was interpreted by the 1986 Habitat Policy which has a guiding principle to achieve “no net loss” in fish habitat, which sought to balance unavoidable habitat losses to development with habitat replacement on a project-by-project basis. However, the *Fisheries Act* was amended in June 2012 to have decision making related to prohibitions of activities be guided by Section 6.1: “to provide for the sustainability and ongoing productivity of commercial, recreational and Aboriginal fisheries”. The federal government is currently developing policies to address these changes, with a focus on significant threats to fisheries and the habitats that support them, while setting clear standards and guidelines for routine projects.

At the provincial level, the *Fish Riparian Areas Protection Act* and *Water Sustainability Act* provide for the designation of streams as sensitive when this designation will help protect a population of fish at risk due to inadequate water flow or habitat degradation. Designated sensitive streams in the Fraser River watershed include Kanaka Creek, Nathan Creek, Salmon River (near Prince George), Silverdale Creek, West Creek, and Whonnock Creek. As of July 2011, no further streams had been designated. The *Fish Protection Act* also prevents the construction of new bank-to-bank dams on the Fraser River. The Riparian Areas Regulation (RAR), developed under the *Fish Protection Act*, directs local governments to improve the protection of fish and fish habitat in British Columbia in riparian areas.

The provincial *Water Act* is the primary statute for managing works in and about a body of water and the diversion of water. It vests in the Province the right to use and regulate flow of all stream water except where private rights have been established. The Water Regulation sets out works permitted under the *Water Act's* notification process, including the restoration and maintenance of fish habitat. A new *Water Act* was passed in 2014.

The availability of information about salmon habitat protection measures taken by First Nations in Canada is limited. In the St'át'imc territory, a cultural fish protection area extending one kilometre on either side of all fish streams has been established; this includes the St'át'imc Water Protection Areas which cover 50 metres on either side of fish streams and are full protection areas. Essential riparian functions such as bank integrity, litterfall (nutrient input), coarse woody debris recruitment, and moderation of sediment yield and stream temperatures can be maintained by retaining the forest in these full protection areas (COSEWIC 2012).

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BIOGRAPHICAL SUMMARY OF REPORT WRITER

Brendan Connors received his B.Sc. (with Distinction) from the University of Victoria in 2004 and his Ph.D. in Ecology from Simon Fraser University in 2011. From 2011-2013 he was a postdoctoral fellow in the School of Resource and Environmental Management at Simon Fraser University. Brendan is currently a Senior Systems Ecologist and Fisheries and Aquatic Science Team Lead at ESSA Technologies Ltd. in Vancouver. He is also an Adjunct Professor in the Department of Biological Sciences at Simon Fraser University. Most of Brendan's work and research has focused on Pacific salmon including evaluating fisheries management, restoration, climate change, hydro-electric, and hatchery effects on Chinook, Sockeye, Coho, Chum and steelhead in Western North America from Oregon through to the Yukon and Alaska. Brendan has served as an expert witness for the Government of Canada's Inquiry into the Decline of Sockeye Salmon in the Fraser River and the House of Commons Standing Committee on Fisheries and Oceans. Brendan's research has been featured in both popular and scientific media and he routinely gives seminars, guest lectures and public presentations on the ecology, management and conservation of Pacific Salmon.

Appendix 1. IUCN threat calculator tables for representative designatable units.

1) Anderson-Seton-ES population (DU 1)

THREATS ASSESSMENT WORKSHEET			
Species or Ecosystem Scientific Name	Sockeye Salmon – Anderson-Seton-ES population (DU 1)		
Element ID		**Elcode**	
Date (Ctrl + ";" for today's date):	22/02/2017		
Assessor(s):	Dwayne Lepitzki (Facilitator), Alan Sinclair (co-chair), John Reynolds, Sue Grant, Sean MacConnachie, Mike Staley, Mike Hawkshaw, Jason Mahoney, Scott Decker		
References:	Draft Report Threats Workshop		

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	2	1
D	Low	1	2
Calculated Overall Threat Impact:		Medium	Medium

Assigned Overall Threat Impact:	**C = Medium**
Impact Adjustment Reasons:	
Overall Threat Comments	

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						
2.1	Annual & perennial non-timber crops						
2.2	Wood & pulp plantations						
2.3	Livestock farming & ranching						
2.4	Marine & freshwater aquaculture						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
3	Energy production & mining						
3.1	Oil & gas drilling						
3.2	Mining & quarrying						
3.3	Renewable energy						
4	Transportation & service corridors		Negligible	Pervasive (71-100%)	Negligible (<1%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	
4.1	Roads & railroads		Negligible	Pervasive (71-100%)	Negligible (<1%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	Road and railway along both lakes. Expansion plans unknown. Road maintenance and bridge repair because of flooding underway.
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						
5.4	Fishing & harvesting aquatic resources		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	Fishing is continuous but the population is increasing. Thus negligble threat from fishing.
6	Human intrusions & disturbance						
6.1	Recreational activities						
6.2	War, civil unrest & military exercises						
6.3	Work & other activities						
7	Natural system modifications		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	
7.1	Fire & fire suppression		Not Calculated (outside assessment timeframe)	Restricted (11-30%)	Slight (1-10%)	Low (Possibly in the long term, >10 yrs/3 gen)	There is only one spawning stream and a fire would affect that part of the population in the area at the time. Timing scored low based on frequency of fire.
7.2	Dams & water management/use		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	There is a hydro dam at the entrance to Seton Lake. Returning fish ascend in a fishway, Smolts descend through turbines. There is a mitigation program. There is some mortality but negligible effect on population abundance over next 3 gens.
7.3	Other ecosystem modifications		Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)	Negligible severity of changes in marine survival because the population in increasing. Rip rapping makes scope small.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
8	Invasive & other problematic species & genes		Unknown	Large (31-70%)	Unknown	High (Continuing)	
8.1	Invasive non-native/alien species/diseases						
8.2	Problematic native species/diseases		Unknown	Large (31-70%)	Unknown	High (Continuing)	Seal and sea lion predation, competition with herring in Strait of Georgia and pink salmon in the Gulf of Alaska, exposure to sea lice and disease while passing net pens.
8.3	Introduced genetic material						
8.4	Problematic species/diseases of unknown origin						
8.5	Viral/prion-induced diseases						
8.6	Diseases of unknown cause						
9	Pollution	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	
9.1	Domestic & urban waste water		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Fish are exposed to domestic and urban waste water in freshwater, the Fraser estuary and Strait of Georgia. Contaminants are many including micro-plastics. The severity of the threat is unknown.
9.2	Industrial & military effluents	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	Fish are exposed to industrial effluents in freshwater, the Fraser estuary and Strait of Georgia. There is also the possibility of contaminant spills from train derailments into the lakes. Based on this, the severity was scored moderate-slight.
9.3	Agricultural & forestry effluents		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Fish are exposed to agricultural effluents in the lower Fraser and Fraser estuary. The severity is unknown.
9.4	Garbage & solid waste						
9.5	Air-borne pollutants						
9.6	Excess energy						
10	Geological events	D	Low	Restricted (11-30%)	Moderate (11-30%)		
10.1	Volcanoes						
10.2	Earthquakes/tsunamis						
10.3	Avalanches/landslides	CD	Medium - Low	Restricted (11-30%)	Moderate - Slight (1-30%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	There have been 2 landslides in the past 2 years at Portage Creek. The slides have been cleared but more slides are possible. If this occurs the severity is estimated to be slight to moderate.
11	Climate change & severe weather	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
11.1	Habitat shifting & alteration	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Warmer winters and earlier snow melt are expected with climate change. This will result in earlier freshet conditions and interact with run timing.
11.2	Droughts						
11.3	Temperature extremes	C	Medium	Pervasive (71-100%)	Moderate (11-30%)	High (Continuing)	The Fraser river is expected to continue to warm throughout the 21st century. This could lead to severe losses during adult migration.
11.4	Storms & flooding		Negligible	Negligible (<1%)	Unknown	High (Continuing)	Scouring from high-precipitation events. Severity unknown.
11.5	Other impacts						
Classification of Threats adopted from IUCN-CMP, Salafsky et al. (2008).							

2) Kamloops-ES population (DU 11)

THREATS ASSESSMENT WORKSHEET			
Species or Ecosystem Scientific Name	Sockeye Salmon – Kamloops-ES population (DU 11)		
Element ID		**Elcode**	
Date (Ctrl + ";" for today's date):	22/02/2017		
Assessor(s):	Dwayne Lepitzki (Facilitator), Alan Sinclair (co-chair), John Reynolds, Sue Grant, Sean MacConnachie, Mike Staley, Mike Hawkshaw, Jason Mahoney, Scott Decker, Kim Hyatt		
References:	Draft Report Threats Workshop		

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	2	1
	D	Low	1	2
		Calculated Overall Threat Impact:	Medium	Medium
		Assigned Overall Threat Impact:	**C = Medium**	
		Impact Adjustment Reasons:		
		Overall Threat Comments		

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						
2.1	Annual & perennial non-timber crops						
2.2	Wood & pulp plantations						
2.3	Livestock farming & ranching						
2.4	Marine & freshwater aquaculture						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
3	Energy production & mining						
3.1	Oil & gas drilling						
3.2	Mining & quarrying						
3.3	Renewable energy						
4	Transportation & service corridors		Negligible	Restricted (11-30%)	Negligible (<1%)	High (Continuing)	
4.1	Roads & railroads		Unknown	Unknown	Unknown	High (Continuing)	No information available on new road and railroad construction or maintenance of existing roads in this area
4.2	Utility & service lines		Negligible	Restricted (11-30%)	Negligible (<1%)	High (Continuing)	Trans Mountain pipeline passes through this area and pipeline expansion might occur over the next 10 years. Severity of construction/maintenance negligible provided mitigation is effective
4.3	Shipping lanes						
4.4	Flight paths						
5	Biological resource use	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	
5.1	Hunting & collecting terrestrial animals						
5.2	Gathering terrestrial plants						
5.3	Logging & wood harvesting						
5.4	Fishing & harvesting aquatic resources	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Fishing is ongoing and there has been a decline in mature numbers over the past 3 generations but from the highest level observed. Severity scored slight.
6	Human intrusions & disturbance						
6.1	Recreational activities						
6.2	War, civil unrest & military exercises						
6.3	Work & other activities						
7	Natural system modifications		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	
7.1	Fire & fire suppression		Not Calculated (outside assessment timeframe)	Small (1-10%)	Slight (1-10%)	Low (Possibly in the long term, >10 yrs/3 gen)	Fire relatively infrequent in this moist forest. Only a small part of the population would be exposed to fire at any one time and the severity of fire was scored slight.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
7.2	Dams & water management/use						Rearing in Kamloops Lake not susceptible to water use. No related threat
7.3	Other ecosystem modifications		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	Negligible severity of changes in marine survivall because the population is relatively abundant.
8	Invasive & other problematic species & genes		Unknown	Large (31-70%)	Unknown	High (Continuing)	
8.1	Invasive non-native/alien species/diseases		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	Yellow Perch present in system but at low abundance.
8.2	Problematic native species/diseases		Unknown	Large (31-70%)	Unknown	High (Continuing)	Seal and sea lion predation, competition with herring in Strait of Georgia and pink salmon in the Gulf of Alaska, exposure to sea lice and disease while passing net pens.
8.3	Introduced genetic material						
8.4	Problematic species/diseases of unknown origin						
8.5	Viral/prion-induced diseases						
8.6	Diseases of unknown cause						
9	Pollution	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	
9.1	Domestic & urban waste water		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Fish are exposed to domestic and urban waste water in freshwater, the Fraser estuary and Strait of Georgia. Contaminants are many including micro-plastics. The severity of the threat is unknown.
9.2	Industrial & military effluents	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	Fish are exposed to industrial effluents in freshwater, the Fraser estuary and Strait of Georgia. There is also the possibility of contaminant spills from train derailments into Kamloops Lake. Based on this, the severity was scored moderate-slight.
9.3	Agricultural & forestry effluents		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Fish are exposed to agricultural effluents in Kamloops Lake, the lower Fraser and Fraser estuary. The severity is unknown.
9.4	Garbage & solid waste						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
9.5	Air-borne pollutants						
9.6	Excess energy						
10	Geological events						
10.1	Volcanoes						
10.2	Earthquakes/tsunamis						
10.3	Avalanches/landslides						
11	Climate change & severe weather	C	Medium	Pervasive (71-100%)	Moderate (11-30%)	High (Continuing)	
11.1	Habitat shifting & alteration	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Warmer winters and earlier snow melt are expected with climate change. This will result in earlier freshet conditions and interact with run timing.
11.2	Droughts						
11.3	Temperature extremes	C	Medium	Pervasive (71-100%)	Moderate (11-30%)	High (Continuing)	The Fraser river is expected to continue to warm throughout the 21st century. This could lead to severe losses during adult migration.
11.4	Storms & flooding		Unknown	Small (1-10%)	Unknown	High (Continuing)	Scouring from high-precipitation events
11.5	Other impacts						

3) Pitt-ES population (DU 15)

THREATS ASSESSMENT WORKSHEET

Species or Ecosystem Scientific Name	Sockeye Salmon - Pitt-ES population (DU 15)		
Element ID		**Elcode**	
Date (Ctrl + ";" for today's date):	22/02/2017		
Assessor(s):	Dwayne Lepitzki (Facilitator), Alan Sinclair (co-chair), John Reynolds, Sue Grant, Sean MacConnachie, Mike Staley, Mike Hawkshaw, Jason Mahoney, Scott Decker		
References:	Draft Report Threats Workshop		

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	4	4
	Calculated Overall Threat Impact:	Medium	Medium

Assigned Overall Threat Impact:	**C = Medium**
Impact Adjustment Reasons:	
Overall Threat Comments	

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						
2.1	Annual & perennial non-timber crops						
2.2	Wood & pulp plantations						
2.3	Livestock farming & ranching						
2.4	Marine & freshwater aquaculture						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
3	Energy production & mining						
3.1	Oil & gas drilling						
3.2	Mining & quarrying						
3.3	Renewable energy						
4	Transportation & service corridors						
4.1	Roads & railroads						
4.2	Utility & service lines						
4.3	Shipping lanes						
4.4	Flight paths						
5	Biological resource use	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	
5.1	Hunting & collecting terrestrial animals						
5.2	Gathering terrestrial plants						
5.3	Logging & wood harvesting						
5.4	Fishing & harvesting aquatic resources	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Escapement has declined over last 3 generations and fishing is likely part of the cause. Severity scored slight.
6	Human intrusions & disturbance		Negligible	Negligible (<1%)	Unknown	High (Continuing)	
6.1	Recreational activities		Negligible	Negligible (<1%)	Unknown	High (Continuing)	There is some recreational activity in the river (jet boats) but scope negligible and severity unknown.
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		Not Calculated (outside assessment timeframe)	Small (1-10%)	Slight (1-10%)	Low (Possibly in the long term, >10 yrs/3 gen)	Water heated by fire, fire retardant entering waterways, erosion of riparian area. Fire may also bring benefits.
7.2	Dams & water management/use						
7.3	Other ecosystem modifications	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Escapement has declined over last 3 generations and low marine survival is likely part of the cause. Severity scored slight.
8	Invasive & other problematic species & genes		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	
8.1	Invasive non-native/alien species/diseases		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	There may be warm water non-native species in the system but the severity is unknown.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
8.2	Problematic native species/diseases		Unknown	Large (31-70%)	Unknown	High (Continuing)	Seal and sea lion predation, competition with herring in Strait of Georgia and pink salmon in the Gulf of Alaska, exposure to sea lice and disease while passing net pens.
8.3	Introduced genetic material						
8.4	Problematic species/diseases of unknown origin						
8.5	Viral/prion-induced diseases						
8.6	Diseases of unknown cause						
9	Pollution		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	
9.1	Domestic & urban waste water		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Fish are exposed to domestic and urban waste water in freshwater, the Fraser estuary and Strait of Georgia. Contaminants are many including micro-plastics. The severity of the threat is unknown.
9.2	Industrial & military effluents		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Fish are exposed to industrial effluents in freshwater, the Fraser estuary and Strait of Georgia. The severity is unknown.
9.3	Agricultural & forestry effluents		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Siltation from forestry upstream of the lake is occurring and logs are boomed at the southern end of the lake. Severity is unknown.
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%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	
10.1	Volcanoes						
10.2	Earthquakes/tsunamis						
10.3	Avalanches/landslides	D	Low	Small (1-10%)	Slight (1-10%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	Steep terrain with frequent landslides. A hatchery program is maintained to compensate for losses caused by landslides.
11	Climate change & severe weather	D	Low	Large (31-70%)	Slight (1-10%)	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
11.1	Habitat shifting & alteration		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	The spawning area is close to the Fraser River mouth and changes in hydrology would not affect this DU.
11.2	Droughts						
11.3	Temperature extremes		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	Exposure to high and increasing temperatures in freshwater during migration considered a negligible threat.
11.4	Storms & flooding	D	Low	Large (31-70%)	Slight (1-10%)	High (Continuing)	Scouring effects common in this area and a hatchery program is maintained to compensate for losses, However, slight loss in mature numbers is still expected.
11.5	Other impacts						
Classification of Threats adopted from IUCN-CMP, Salafsky et al. (2008).							

4) Quesnel-S population (DU 16)

THREATS ASSESSMENT WORKSHEET

Species or Ecosystem Scientific Name	Sockeye Salmon - Quesnel-S population (DU 16)		
Element ID		**Elcode**	
Date (Ctrl + ";" for today's date):	22/02/2017		
Assessor(s):	Dwayne Lepitzki (Facilitator), Alan Sinclair (co-chair), John Reynolds, Sue Grant, Sean MacConnachie, Mike Staley, Mike Hawkshaw, Jason Mahoney, Scott Decker		
References:	Draft Report Threats Workshop		

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	3	1
D	Low	0	2
	Calculated Overall Threat Impact:	High	Medium

Assigned Overall Threat Impact:	**BC = High - Medium**
Impact Adjustment Reasons:	
Overall Threat Comments	

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						
2.1	Annual & perennial non-timber crops						
2.2	Wood & pulp plantations						
2.3	Livestock farming & ranching						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
2.4	Marine & freshwater aquaculture						
3	Energy production & mining		Negligible	Negligible (<1%)	Negligible (<1%)	Insignificant/Negligible (Past or no direct effect)	
3.1	Oil & gas drilling						
3.2	Mining & quarrying		Negligible	Negligible (<1%)	Negligible (<1%)	Insignificant/Negligible (Past or no direct effect)	The Mt. Polley mine tailings pond failed in August 2014. As a result, a small sediment wedge formed where Hazeltine Creek enters Quesnel Lake. This is not expected to occur again and lingering effects to the habitat structure are a negligible threat.
3.3	Renewable energy						
4	Transportation & service corridors		Negligible	Negligible (<1%)	Unknown	High (Continuing)	
4.1	Roads & railroads		Negligible	Negligible (<1%)	Unknown	High (Continuing)	Some road construction is expected to occur in this area but the effect is unknown.
4.2	Utility & service lines						
4.3	Shipping lanes						
4.4	Flight paths						
5	Biological resource use	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	
5.1	Hunting & collecting terrestrial animals						
5.2	Gathering terrestrial plants						
5.3	Logging & wood harvesting						
5.4	Fishing & harvesting aquatic resources	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	The population is declining and fishing is continuous. The severity was scored slight-moderate.
6	Human intrusions & disturbance		Negligible	Negligible (<1%)	Unknown	High (Continuing)	
6.1	Recreational activities		Negligible	Negligible (<1%)	Unknown	High (Continuing)	There is jet boatactivity in Mitchell River but the severity is unknown.
6.2	War, civil unrest & military exercises						
6.3	Work & other activities						
7	Natural system modifications	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	
7.1	Fire & fire suppression		Not Calculated (outside assessment timeframe)	Small (1-10%)	Slight (1-10%)	Low (Possibly in the long term, >10 yrs/3 gen)	Water heated by fire, fire retardant entering waterways, erosion of riparian area. Fire may also bring benefits.
7.2	Dams & water management/use						No threats in this category

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
7.3	Other ecosystem modifications	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	A reduction in marine survival and modifications to the freshwater ecology related to fisheries management actions directed at changing cyclic dominance may have contributed to reductions in population size. Severity scored moderate-slight.
8	Invasive & other problematic species & genes		Unknown	Large (31-70%)	Unknown	High (Continuing)	
8.1	Invasive non-native/alien species/diseases						Some Smallmouth Bass have been reported in watershed but not in streams where Sockeye are found. Not scored
8.2	Problematic native species/diseases		Unknown	Large (31-70%)	Unknown	High (Continuing)	Seal and sea lion predation, competition with herring in Strait of Georgia and pink salmon in the Gulf of Alaska, exposure to sea lice and disease while passing net pens.
8.3	Introduced genetic material						
8.4	Problematic species/diseases of unknown origin						
8.5	Viral/prion-induced diseases						
8.6	Diseases of unknown cause						
9	Pollution		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	
9.1	Domestic & urban waste water		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Fish are exposed to domestic and urban waste water in freshwater, the Fraser estuary and Strait of Georgia. Contaminants are many including micro-plastics. The severity of the threat is unknown.
9.2	Industrial & military effluents		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Fish are exposed to industrial effluents in freshwater, the Fraser estuary and Strait of Georgia. There are potential lingering effects of contaminants spilled into Quesnel Lake from the Mt. Polley mine. The severity of these effects is unknown.
9.3	Agricultural & forestry effluents		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	The main exposure impacts the juvenile stage in spring-fall. Forest harvesting is high in this area but measures are taken to reduce the impact on riparian areas. The severity of the threat is unknown.
9.4	Garbage & solid waste						
9.5	Air-borne pollutants						
9.6	Excess energy						
10	Geological events		Negligible	Negligible (<1%)	Slight (1-10%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	
10.1	Volcanoes						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
10.2	Earthquakes/tsunamis						
10.3	Avalanches/landslides		Negligible	Negligible (<1%)	Slight (1-10%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	Landslide and avalanche has happened in the past and might happen again.
11	Climate change & severe weather	C	Medium	Pervasive (71-100%)	Moderate (11-30%)	High (Continuing)	
11.1	Habitat shifting & alteration	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Given run timing, this Du is less susceptible to changes in the freshet caused by climate change.
11.2	Droughts						
11.3	Temperature extremes	C	Medium	Pervasive (71-100%)	Moderate (11-30%)	High (Continuing)	The Fraser River is expected to continue to warm throghout the 21st century. This could lead to losses during adult migration.
11.4	Storms & flooding		Negligible	Negligible (<1%)	Unknown	High (Continuing)	Scouring may occur related to high precipitation events. Severity unknown.
11.5	Other impacts						
Classification of Threats adopted from IUCN-CMP, Salafsky et al. (2008).							

5) Seton-L population (DU 17)

THREATS ASSESSMENT WORKSHEE

Species or Ecosystem Scientific Name	Sockeye Salmon – Seton-L population (DU 17)			
Element ID			**Elcode**	
Date (Ctrl + ";" for today's date):	22/02/2017			
Assessor(s):	Dwayne Lepitzki (Facilitator), Alan Sinclair (co-chair), John Reynolds, Sue Grant, Sean MacConnachie, Mike Staley, Mike Hawkshaw, Jason Mahoney, Scott Decker			
References:	Draft Report Threats Workshop			

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	2	0
D	Low	2	4
	Calculated Overall Threat Impact:	High	Medium

Assigned Overall Threat Impact:	**BC = High - Medium**
Impact Adjustment Reasons:	
Overall Threat Comments	

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						
2.1	Annual & perennial non-timber crops						
2.2	Wood & pulp plantations						
2.3	Livestock farming & ranching						
2.4	Marine & freshwater aquaculture						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
3	Energy production & mining						
3.1	Oil & gas drilling						
3.2	Mining & quarrying						
3.3	Renewable energy						
4	Transportation & service corridors		Negligible	Pervasive (71-100%)	Negligible (<1%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	
4.1	Roads & railroads		Negligible	Pervasive (71-100%)	Negligible (<1%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	Road and railway along both lakes. Expansion plans unknown. Road maintenance and bridge repair because of flooding underway.
4.2	Utility & service lines						
4.3	Shipping lanes						
4.4	Flight paths						
5	Biological resource use	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	
5.1	Hunting & collecting terrestrial animals						
5.2	Gathering terrestrial plants						
5.3	Logging & wood harvesting						
5.4	Fishing & harvesting aquatic resources	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	Fishing is ongoing. This DU is taken in mixed stock fishery with the very large Shuswap Complex L DU and may experience high exploitation in dominant cycle years for Shuswap.
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		Not Calculated (outside assessment timeframe)	Restricted (11-30%)	Slight (1-10%)	Low (Possibly in the long term, >10 yrs/3 gen)	There is only one spawning stream and a fire would effect that part of the population in the area at the time. Timing scored low based on frequency of fire.
7.2	Dams & water management/use		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	There is a hydro dam at the entrance to Seton Lake. Returning fish ascend in a fishway, Smolts descend through turbines. There is a mitigation program. There is some mortality but negligible effect on population abundance over next 3 gens.

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)	The population is declining and low marine survival may be a contributing factor.
8	Invasive & other problematic species & genes		Unknown	Large (31-70%)	Unknown	High (Continuing)	
8.1	Invasive non-native/alien species/diseases						
8.2	Problematic native species/diseases		Unknown	Large (31-70%)	Unknown	High (Continuing)	Seal and sea lion predation, competition with herring in Strait of Georgia and pink salmon in the Gulf of Alaska, exposure to sea lice and disease while passing net pens.
8.3	Introduced genetic material						
8.4	Problematic species/diseases of unknown origin						
8.5	Viral/prion-induced diseases						
8.6	Diseases of unknown cause						
9	Pollution	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	
9.1	Domestic & urban waste water		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Fish are exposed to domestic and urban waste water in freshwater, the Fraser estuary and Strait of Georgia. Contaminants are many including micro-plastics. The severity of the threat is unknown.
9.2	Industrial & military effluents	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	Fish are exposed to industrial effluents in freshwater, the Fraser estuary and Strait of Georgia. There is also the possibility of contaminant spills from train derailments into the lakes. Based on this, the severity was scored moderate-slight.
9.3	Agricultural & forestry effluents		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Fish are exposed to agricultural effluents in the lower Fraser and Fraser estuary. The severity is unknown.
9.4	Garbage & solid waste						
9.5	Air-borne pollutants						
9.6	Excess energy						
10	Geological events	D	Low	Restricted (11-30%)	Moderate (11-30%)		Fix bug in scoring moderate-slight severity
10.1	Volcanoes						
10.2	Earthquakes/tsunamis						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
10.3	Avalanches/landslides	CD	Medium - Low	Restricted (11-30%)	Moderate - Slight (1-30%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	There have been 2 landslides in the past 2 years at Portage Creek. The slides have been cleared but more slides are possible. If this occurs the severity is estimated to be slight to moderate.
11	Climate change & severe weather		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	
11.1	Habitat shifting & alteration		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	Migration is not affected by expected changes in hydrology due to climate change.
11.2	Droughts						
11.3	Temperature extremes		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	Migration not affected by warmer waters.
11.4	Storms & flooding		Negligible	Negligible (<1%)	Unknown	High (Continuing)	Scouring from high-precipitation events. Severity unknown.
11.5	Other impacts						
Classification of Threats adopted from IUCN-CMP, Salafsky et al. (2008).							

6) Shuswap Complex-L population (DU 18)

THREATS ASSESSMENT WORKSHEET

Species or Ecosystem Scientific Name	Sockeye Salmon - Shuswap Complex-L population (DU 18)		
Element ID		**Elcode**	
Date (Ctrl + ";" for today's date):	22/02/2017		
Assessor(s):	Dwayne Lepitzki (Facilitator), Alan Sinclair (co-chair), John Reynolds, Sue Grant, Sean MacConnachie, Mike Staley, Mike Hawkshaw, Jason Mahoney, Scott Decker		
References:	Draft Report Threats Workshop		

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	0	0
D	Low	4	4
	Calculated Overall Threat Impact:	Medium	Medium

Assigned Overall Threat Impact:	**C = Medium**
Impact Adjustment Reasons:	
Overall Threat Comments	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1	Residential & commercial development		Unknown	Small (1-10%)	Unknown	High (Continuing)	
1.1	Housing & urban areas		Unknown	Small (1-10%)	Unknown	High (Continuing)	High degree of foreshore development on Shuswap Lake that has expanded over several decades and will likely continue. Scope small and severity unknown.
1.2	Commercial & industrial areas						
1.3	Tourism & recreation areas		Negligible	Negligible (<1%)	Unknown	High (Continuing)	Marina development ongoing. Scope negligible and severity unknown.
2	Agriculture & aquaculture		Negligible	Negligible (<1%)	Negligible (<1%)		
2.1	Annual & perennial non-timber crops						
2.2	Wood & pulp plantations						
2.3	Livestock farming & ranching		Negligible	Negligible (<1%)	Negligible (<1%)	Moderate - Low	Cattle have trampled spawning redds and this is likely to continue
2.4	Marine & freshwater aquaculture						
3	Energy production & mining						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
3.1	Oil & gas drilling						
3.2	Mining & quarrying						
3.3	Renewable energy						
4	Transportation & service corridors		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	
4.1	Roads & railroads		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	Road development will likely continue as human population increases. Twinning of Hwy 1 along Shuswap Lake likely. Mitigation measures should make impacts negligible
4.2	Utility & service lines						
4.3	Shipping lanes						
4.4	Flight paths						
5	Biological resource use	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	
5.1	Hunting & collecting terrestrial animals						
5.2	Gathering terrestrial plants						
5.3	Logging & wood harvesting						
5.4	Fishing & harvesting aquatic resources	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Fishery on dominant cycle runs well managed to ensure sufficient escapement. Management less effective on off cycle runs. Severity on these runs slight.
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		Negligible	Restricted (11-30%)	Negligible (<1%)	Low (Possibly in the long term, >10 yrs/3 gen)	Fires have occurred in this area but they have been fought aggressively because of high human population. Scope restricted and the severity negligible.
7.2	Dams & water management/use		Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)	There are few dams in the system. Negligible severity.
7.3	Other ecosystem modifications	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Low marine survival scored slight severity
8	Invasive & other problematic species & genes		Negligible	Large (31-70%)	Negligible (<1%)	High (Continuing)	
8.1	Invasive non-native/alien species/diseases		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	Yellow Perch in Shuswap Lake at low abundance.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
8.2	Problematic native species/diseases		Unknown	Large (31-70%)	Unknown	High (Continuing)	Seal and sea lion predation, competition with herring in Strait of Georgia and pink salmon in the Gulf of Alaska, exposure to sea lice and disease while passing net pens.
8.3	Introduced genetic material						
8.4	Problematic species/diseases of unknown origin						
8.5	Viral/prion-induced diseases						
8.6	Diseases of unknown cause						
9	Pollution	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	
9.1	Domestic & urban waste water		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Fish are exposed to domestic and urban waste water in freshwater, the Fraser estuary and Strait of Georgia. Contaminants are many including micro-plastics. The severity of the threat is unknown.
9.2	Industrial & military effluents	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Fish are exposed to industrial effluents during migration in freshwater, the Fraser estuary and Strait of Georgia. There is also the possibility of contaminant spills from train derailmentsinto Shuswap Lake. Based on this, the severity was scored slight (less than Kamloops).
9.3	Agricultural & forestry effluents		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Fish are exposed to agricultural effluents in Shuswap Lake, the lower Fraser and Fraser estuary. The severity is unknown.
9.4	Garbage & solid waste						
9.5	Air-borne pollutants						
9.6	Excess energy						
10	Geological events		Negligible	Negligible (<1%)	Negligible (<1%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	
10.1	Volcanoes						
10.2	Earthquakes/tsunamis						
10.3	Avalanches/ landslides		Negligible	Negligible (<1%)	Negligible (<1%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	There have been recent landslides
11	Climate change & severe weather	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	
11.1	Habitat shifting & alteration		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	Changes in Fraser River hydrology predicted because of climate change will have negligible effect on this DU because of late run timing.
11.2	Droughts						

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)	The Fraser river is expected to continue to warm throughout the 21st century. This could lead to losses during adult migration. Severity scored slight.
11.4	Storms & flooding		Unknown	Small (1-10%)	Unknown	High (Continuing)	Scouring from high-precipitation events.
11.5	Other impacts						
Classification of Threats adopted from IUCN-CMP, Salafsky et al. (2008).							

7) Takla-Trembleur-EStu population (DU 20)

THREATS ASSESSMENT WORKSHEET				
Species or Ecosystem Scientific Name	Sockeye Salmon – Takla-Trembleur-EStu population (DU 20)			
Element ID		Elcode		
Date (Ctrl + ";" for today's date):	22/02/2017			
Assessor(s):	Dwayne Lepitzki (Facilitator), Alan Sinclair (co-chair), John Reynolds, Sue Grant, Sean MacConnachie, Mike Staley, Mike Hawkshaw, Jason Mahoney, Scott Decker, Kim Hyatt			
References:	Draft Report Threats Workshop			

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	1
D	Low	0	2
Calculated Overall Threat Impact:		High	Medium

Assigned Overall Threat Impact:	BC = High - Medium
Impact Adjustment Reasons:	
Overall Threat Comments	

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						
2.1	Annual & perennial non-timber crops						
2.2	Wood & pulp plantations						
2.3	Livestock farming & ranching						
2.4	Marine & freshwater aquaculture						
3	Energy production & mining						
3.1	Oil & gas drilling						
3.2	Mining & quarrying						
3.3	Renewable energy						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
4	Transportation & service corridors		Negligible	Negligible (<1%)	Unknown	High (Continuing)	
4.1	Roads & railroads		Negligible	Negligible (<1%)	Unknown	High (Continuing)	Road and railroad construction negligible in this area. Severity unknown.
4.2	Utility & service lines						
4.3	Shipping lanes						
4.4	Flight paths						
5	Biological resource use	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	
5.1	Hunting & collecting terrestrial animals						
5.2	Gathering terrestrial plants						
5.3	Logging & wood harvesting						
5.4	Fishing & harvesting aquatic resources	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	The mature population numbers are declining. Fishing is ongoing and likely contributing to the decline.
6	Human intrusions & disturbance						
6.1	Recreational activities						
6.2	War, civil unrest & military exercises						
6.3	Work & other activities						
7	Natural system modifications	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	
7.1	Fire & fire suppression		Not Calculated (outside assessment timeframe)	Small (1-10%)	Slight (1-10%)	Low (Possibly in the long term, >10 yrs/3 gen)	Spawning is dispersed over a broad area making scope small. Impact on exposed portion of population scored slight. Timing is low based on past experience with fire in this area.
7.2	Dams & water management/use		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	The portion of the Fraser River below the Nechako Dam can be affected by water release. Severity unknown.
7.3	Other ecosystem modifications	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	The population is declining and low marine survival may be a contributing factor.
8	Invasive & other problematic species & genes						
8.1	Invasive non-native/alien species/diseases						
8.2	Problematic native species/diseases		Unknown	Large (31-70%)	Unknown	High (Continuing)	Seal and sea lion predation, competition with herring in Strait of Georgia and pink salmon in the Gulf of Alaska, exposure to sea lice and disease while passing net pens.
8.3	Introduced genetic material						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
8.4	Problematic species/diseases of unknown origin						
8.5	Viral/prion-induced diseases						
8.6	Diseases of unknown cause						
9	Pollution		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	
9.1	Domestic & urban waste water		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Fish are exposed to domestic and urban waste water in freshwater, the Fraser estuary and Strait of Georgia. Contaminants are many including micro-plastics. The severity of the threat is unknown.
9.2	Industrial & military effluents		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Fish are exposed to industrial effluents in freshwater, the Fraser estuary and Strait of Georgia. The severity is unknown.
9.3	Agricultural & forestry effluents		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Forest harvesting has been low and decreasing in recent years. There is no agriculture in this area. Severity is unknown.
9.4	Garbage & solid waste						
9.5	Air-borne pollutants						
9.6	Excess energy						
10	Geological events						
10.1	Volcanoes						
10.2	Earthquakes/tsunamis						
10.3	Avalanches/landslides						
11	Climate change & severe weather	C	Medium	Pervasive (71-100%)	Moderate (11-30%)	High (Continuing)	
11.1	Habitat shifting & alteration	C	Medium	Pervasive (71-100%)	Moderate (11-30%)	High (Continuing)	Warmer winters and earlier snow melt are expected with climate change. This will result in earlier freshet conditions and interact with run timing. This is an early run DU and the severity was scored moderate.
11.2	Droughts						
11.3	Temperature extremes	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	The Fraser river is expected to continue to warm throughout the 21st century. This could lead to losses during adult migration.
11.4	Storms & flooding		Negligible	Negligible (<1%)	Unknown	High (Continuing)	Scouring from high-precipitation events. Severity unknown.
11.5	Other impacts						
Classification of Threats adopted from IUCN-CMP, Salafsky et al. (2008).							

Appendix 2. Census sites for Fraser Sockeye Salmon designatable units.

Table 26: Census sites for proposed Fraser Sockeye Salmon DU. List of census sites is taken from Grant *et al*. (2011).

DU Number	DU Name	Census Sites
1	Anderson-Seton-ES	Gates Channel, Gates Creek
2	Bowron-ES	Antler Creek, Bowron River, Pomeroy Creek, Huckey Creek, Sus Creek
3	Chilko-ES	Chilko River, Chilko Channel, Chilko Lake North, Chilko Lake South
4	Chilko-S	Chilko River, Chilko Channel, Chilko Lake North, Chilko Lake South
5	Chilliwack-ES	Chilliwack Lake, Dolly Varden Creek
6	Cultus-L	Cultus Lake
7	Francois-Fraser-S	Stellako River, Uncha Creek, Ormonde Creek
8	Nadina-Francois-ES	Glacier Creek, Early Nadina River, Late Nadina River, Nadina Channel, Tagetochlain Creek
9	Harrison(D/S)-L	Bear Creek, Big Silver Creek, Cogburn Creek, Crazy Creek, Douglas Creek, Hatchery Creek, Sloquet Creek, Tipella Creek, Tipella Slough
10	Harrison(U/S)-L	East Creek, Weaver Channel, Weaver Creek
11	Kamloops-ES	Barriere River, Clearwater River, Dunn Creek, Finn Creek, Grouse Creek, Hemp Creek, Lemieux Creek, Lion Creek, Mann Creek, Moul Creek, North Thompson River, Raft River
12	Lillooet-Harrison-L	Birkenhead River, Green River, Lillooet Slough, Miller Creek, Poole Creek, Railroad Creek, Ryan Creek, Sampson Creek, John Sandy, 25 Mile Creek
13	Nahatlatch-ES	Nahatlach Lake, Nahatlach River
14	North Barriere-ES (*de novo*)	Fennell Creek, Harper Creek
15	Pitt-ES	Upper Pitt River
16	Quesnel-S	Abbott Creek, Amos Creek, Archie Creek, Baxter Beach, Bear Beach – shore, Betty Frank's – shore, Big Slide – shore, Big Slide – shore 1km West, Bill Miner Creek, Bill Miner Creek – shore, Bill Miner Creek – shore 3km West, Blue Lead Creek, Blue Lead Creek – shore, Bouldery Creek, Bouldery Creek – shore, Bouldery Creek – shore 2km East, Bowling Point, Buckingham Creek, Cameron Creek, Clearbrook Creek, Deception Point, Devoe Creek, Devoe Creek – shore, Double T – shore, East Arm – shore (Rock Slide – Penninsula Pt), East arm – unnamed creek 1, East arm – unnamed creek 2 – shore, East arm – unnamed point, Elysia – shore, Elysia – shore 1km West, Franks Creek, Franks Creek – shore, Goose Creek, Goose Point – shore, Goose Point – shore 8km South, Grain Creek, Grain Creek – shore, Hazeltine Creek, Horsefly Channel, Horsefly Lake, Horsefly River, Horsefly River – Above Falls, Horsefly River – Lower, Horsefly River – Upper, Hurricane Point, Isaiah Creek, Junction Creek, Junction Creek – shore, Killdog Creek, Killdog Creek – shore, Lester Shore, Limestone Creek, Limestone Point – shore, Limestone Point – shore 5km South, Little Horsefly River, Logger Landing, Long Creek, Long Creek – shore, Lynx Creek, Lynx Creek – shore, Marten Creek, Marten Creek – shore, McKinley Creek, McKinley Creek – Lower, McKinley Creek – Upper, Mitchell River, Moffat Creek, Niagara Creek, North Arm – shore (Bowling-Goose Pt.), North Arm – shore (Roaring-Deception Pt.), North Arm – unnamed cove, Opa Beach, Penfold Camp Shore, Penfold Creek, Quartz Point, Quesnel Lake, Raft Creek, Roaring Point Roaring River, Roaring River – shore, Rock Slide, Service Creek, Slate Bay, Slate Bay 1km East, Spusks Creek, Sue Creek, Summit Creek, Taku Creek, Tasse Creek, Tasse Creek – shore, Tisdall Creek, Trickle Creek, Wasko Creek, Wasko Creek – shore, Watt Creek, Watt Creek – shore, Whiffle Creek, Winkley Creek
17	Seton-L (*de novo*)	Portage Creek

DU Number	DU Name	Census Sites
18	Shuswap Complex-L	5 Mile Creek, Adams Channel, Adams Lake, Adams Lake – East, Adams Lake – North, Adams Lake – South, Adams River, Adams River – shore, Anstey River, Anstey River – shore, Hiuhill (Bear) Creek, Bessette Creek, Bush Creek, Bush Creek – shore, Canoe Creek, Celista Creek, Cook Creek, Crazy Creek, Cruikshank Pt. W. – shore, Eagle River, Four Mile Creek – shore, Nikwikwaia (Gold) Creek, Hlina Creek – shore, Hunakwa Creek, Kingfisher Creek, Knight Creek – shore, Lee Creek – shore, Little River, Loftus Creek, Lower Shuswap River, Mara Lake – shore, McNomee Creek, Middle Shuswap River, Momich River, Momich River – shore, Noisy Creek, Onyx Creek, Onyx Creek – shore, Pass Creek, Pass Creek – shore, Perry River, Queest Creek – shore, Reinecker Creek, Reinecker Creek – shore, Ross Creek, Ross Creek – shore, Salmon Arm – shore, Salmon River, Scotch Creek, Scotch Creek – shore, Seymour River, Shuswap Lake, Shuswap Lake – Anstey Arm, Shuswap Lake – Main Arm, Shuswap Lake – Main Arm North, Shuswap Lake – Main Arm South, Shuswap Lake – Salmon Arm, Shuswap Lake – Salmon Arm East, Shuswap Lake – Salmon Arm North, Shuswap Lake – Salmon Arm South, Shuswap Lake – Seymour Arm, South Thompson River, Tappen Creek, Trinity Creek, Tsikwustum Creek, Tsuius Creek, Upper Adams River, Vanishing Creek – shore, Wap Creek, Yard Creek
19	Shuswap -ES	Adams Channel, Adams River, Anstey River, Burton Creek, Bush Creek, Celista Creek, Craigellachie Creek, Crazy Creek, Eagle River, Huihill (Bear) Creek, Hunakwa Creek, Loftus Creek, McNomee Creek, Middle Shunswap River, Nikwikwaia (Gold) Creek, Onyx Creek, Pass Creek, Perry River, Ross Creek, Salmon River, Scotch Creek, Seymour River, Yard Creek
20	Takla-Trembleur-EStu	5 Mile Creek, 10 Mile Creek, 15 Mile Creek, 25 Mile Creek, Ankwill Creek, Baptiste Creek, Bates Creek, Bivouac Creek, Blackwater Creek, Blanchette Creek, Casamir Creek, Consolidated Creek, Crow Creek, Driftwood River, Dust Creek, Felix Creek, Fleming Creek, Forfar Creek, Forsythe Creek, French Creek, Frypan Creek, Gluske Creek, Hooker Creek, Hudson Bay Creek, Kastberg Creek, Kazchek Creek, Kotesine Creek, Kynock Creek, Leo Creek, Lion Creek, McDougall Creek, Middle River (Rosette), Nancut Creek, Narrows Creek, Paula Creek, Point Creek, Porter Creet, Rosette Creek, Sakeniche River, Sandpoint Creek, Shale Creek, Sinta Creek, Takla Lake – shore, Takla Lake – unnamed, Tanezell Creek, Tildesley Creek, Tliti Creek, Unnamed Creek
21	Takla-Trembleur-Stuart-S	Kazchek Creek, Kuzkwa Creek, Middle River, Pinchi Creek, Sakeniche River, Sowchea Creek, Stuart Lake, Stuart River, Tachie River
22	Taseko-ES	Taseko Lake
23	Harrison - (River-Type)	Harrison River
24	Widgeon - (River-Type)	Widgeon Creek