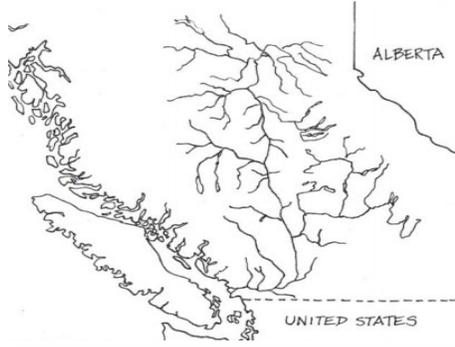


# State of the Fraser River at Kanaka Bar



Prepared for:

**Kanaka Bar Band  
2693 Siwash Road  
Kanaka Bar, BC, V0K 1Z0**

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Prepared by:

**Ecofish Research Ltd.**



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## EXECUTIVE SUMMARY

Food sovereignty and security are one of the pillars of the Kanaka Bar Band's community vision and form part of their climate change adaptation strategy (Kanaka Bar Band 2020). Salmon and steelhead (*Oncorhynchus mykiss*) are traditional foods for the Kanaka Bar Band and it is no secret that stocks are in decline (DFO 2020a; Baker 2020; Taylor 2020). One of the Kanaka Bar Band's goals is to have healthy salmon and steelhead stocks available for their future generations (Michell 2020, pers. comm.). To that end, the Kanaka Bar Band retained Ecofish Research Ltd. (Ecofish) to conduct an overview assessment report of the state of Fraser River salmon and provide suggestions for mitigation and monitoring opportunities for the Kanaka Bar Band based on the findings.

24 fish species are potentially present in the Fraser River at Kanaka Bar. This includes four species of Pacific salmon: Chinook Salmon (*O. tshawytscha*), Coho Salmon (*O. kisutch*), Pink Salmon (*O. gorbuscha*) and Sockeye Salmon (*O. nerka*), and steelhead which migrate through Kanaka Bar territory twice each year. Coho Salmon have been documented spawning in at least one tributary stream within Kanaka Bar territory; given habitat constraints this is unlikely to be the case for the other salmonid species (with the possible exception of steelhead).

The five species of Pacific salmon and steelhead migrating through Kanaka Bar are made up of numerous unique populations, each with their own life history strategy and run timing. With few exceptions, these populations have seen steep declines in abundance over the past few decades, and many populations are in serious risk of extinction. The causes of these declines are numerous and interconnected, but can be summarized as follows:

- Climate change, which has induced or worsened water temperature changes, food web changes (particularly in the marine environment), flow changes, frequency of forest fires, pine beetle infestation of forests, and an expansion of range for southern species of fish, wildlife, and vegetation.
- Habitat loss and fragmentation related to human impacts, including forestry, mining, urban development, hydroelectric facilities, agriculture, roads, and other land uses.
- Predation by humans (i.e., fishing pressure) and others (e.g., pinnipeds, such as seals), which has a disproportionate effect on small salmon populations. In particular, overfishing during the 1980s and 1990s negatively impacted many populations.
- Disease, parasites, and competition related to aquaculture and hatcheries.
- Natural disasters such as the recent Big Bar landslide, which has impacted early-spawning populations with home streams upstream of the obstruction.

With the likely exception of climate change, none of these causes on their own are enough to produce the current declines in Fraser River salmon and steelhead, although previous overfishing played a large role in decreasing some populations to a point where they lack the resilience to withstand other pressures. Unfortunately, mitigation of these causes will take large-scale and, in some cases, global

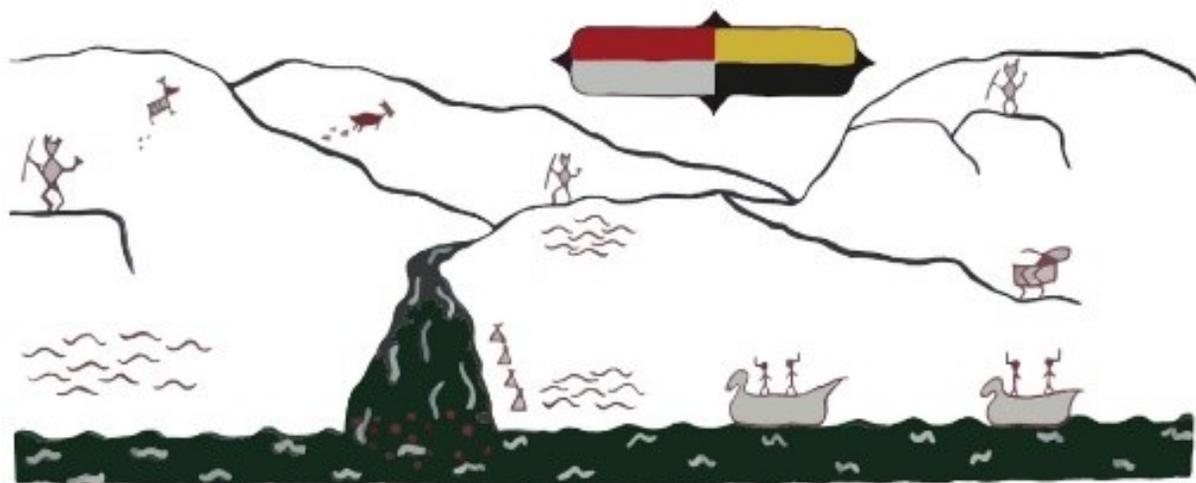
efforts at the individual, community and government level. However, the Kanaka Bar Band has the opportunity to both lead by example and to exert political pressure on others. The mitigation and monitoring efforts described below are a drop in the bucket when compared to the enormity of the problems faced by Fraser River salmon and steelhead, but many drops fill a bucket. At an individual and community level these drops include:

- Continue to reduce the community's greenhouse gas emissions through use of renewable energy, retrofitting buildings to improve energy efficiency, and encouraging sustainable transportation choices (Kanaka Bar Band 2018, 2020).
- Implement the recommendations in the Kanaka Bar Indian Band Climate Change Vulnerability Assessment (Kanaka Bar Band 2018).
- Improve stormwater runoff management. Capture and treat rainfall and road runoff through natural infrastructure (e.g., swales, phytoremediation) and design (e.g., permeable hard surfaces), particularly for new developments.
- Ensure local wastewater is being treated to a high standard prior to discharge and encourage upstream and downstream communities to do the same.
- Investigate potential point sources of pollution (e.g., historical railcar derailment, creosote associated with railway line) and remediate if necessary.
- Enforce high standards for future construction and land clearing within Kanaka Bar territory with regards to erosion and sediment control, changes in stormwater runoff patterns, and protection of riparian vegetation.
- Enforce sustainable forestry practices within Kanaka Bar territory, including restoration of degraded habitat.
- Continue to refrain from fishing until stocks are restored and join with other First Nations in pressuring the Fisheries and Oceans Canada (DFO) for even more stringent fish harvest limits for all users.
- Investigate salmon and steelhead enhancement opportunities in Kanaka Bar territory, as well as aquaculture to meet immediate food needs.
- Implement a water quality monitoring program intended to measure conditions in the Fraser River and tributary streams within Kanaka Bar territory.
- Implement a water quality monitoring program intended to measure the impacts of point and non-point source pollution in Kanaka Bar territory and track the effectiveness of any mitigation of those pollution sources.
- Monitor numbers of migrating salmon and steelhead (adults and/or smolts) to better understand survivorship and timing of stocks.

- Implement an aquatic invasive species monitoring program, educating community members in fish identification, and set up a protocol for preserving samples and reporting any new species encountered.

Monitoring will be more effective if it is coordinated with other groups, particularly if data collection and analysis methods are designed to integrate with ongoing monitoring (e.g., the provincial Environmental Monitoring System (EMS) and existing Water Survey of Canada (WSC) monitoring programs). The University of British Columbia's (UBC) Centre for Indigenous Fisheries was launched in 2021 with the intent of "building a community of Indigenous scholars and allies that engage in community-based research" that aims to "support the management and protection of culturally significant fish and fisheries in ways that uphold and respect Indigenous rights, values, practices, and knowledge systems" (UBC 2021). This UBC program may be a good starting place for coordination of monitoring efforts.

The majority of Pacific salmon and steelhead populations that pass through Kanaka Bar territory are suffering serious declines, which is the result of numerous and interrelated causes, chief among them climate change. Mitigation possible on Kanaka Bar territory is small in comparison to the scope of these causes, but that does not mean such actions are futile. Small actions by the many, and big actions by elected officials, will be necessary in order to tackle such problems. Kanaka Bar Band can lead by example when it comes to carbon emissions, non-point source pollution, and sustainable land and resource use, and can monitor conditions in their territory to encourage others to take both the small and large actions required.



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## 1. INTRODUCTION

Food sovereignty and security is one of the pillars of the Kanaka Bar Band's community vision and form part of their climate change adaptation strategy (Kanaka Bar Band 2020). Salmon and steelhead are a traditional food for the Kanaka Bar Band and it is no secret that stocks are in decline (DFO 2020a; Baker 2020; Taylor 2020). One of the Kanaka Bar Band's goals is to have healthy salmon and steelhead stocks available for their future generations (Michell 2020, pers. comm.). As environmental stewards, the Kanaka Bar Band look to mitigate and monitor impacts to salmon stocks in their territory. The Kanaka Bar Band retained Ecofish Research Ltd. (Ecofish) to conduct an overview assessment report of the state of Fraser River salmon and steelhead and provide suggestions for mitigation and monitoring opportunities for the Kanaka Bar Band based on the findings of the overview assessment.

The objective of this report is to identify what the Kanaka Bar Band can do to slow Fraser River salmon and steelhead declines. To that end, it contains the following parts:

- A description of the salmon and steelhead (“travellers”) and other fish species resident to Kanaka Bar territory.
- Timelines of population trends for salmon and steelhead that travel through Kanaka Bar territory.
- A summary of stressors contributing to declines in those salmon and steelhead, both throughout their life cycle and specifically in Kanaka Bar territory.
- Potential mitigation and monitoring programs in Kanaka Bar Band's traditional territory (“Kanaka Bar territory”) that could contribute to the goal of Fraser River salmon and steelhead recovery.

## 2. METHODS

Map 1 shows the general study area for this report, showing the Fraser River watershed and the portions of the Pacific Ocean used by Fraser River salmon and steelhead. Map 2 illustrated the detailed study area of this report, Kanaka Bar territory.

This study was based on a literature review of available data on environmental conditions in the Fraser River watershed and on Fraser River salmon and steelhead. The literature review included maps, publicly available online databases, salmon escapement data, Department of Fisheries and Oceans Canada (DFO) population forecasts, and species-specific status reports and research. Appendix A contains an annotated list of major sources reviewed for this report. A site visit to Kanaka Bar territory is recommended for summer 2021 to assess site-specific conditions. The visit will involve visual inspection, interviews with community members, and possibly, soil and water quality sample collection and scoping of enhancement opportunities. The results of the site visit will inform a future amended version of this report.

Interpretation of the data presented in the available literature requires an understanding of fish management and abundance descriptors in use in British Columbia (BC). The following sub-sections provide context on the groups involved in the management and study of Fraser River salmon and steelhead, and how these different groups measure and describe populations and abundance.

## 2.1. Salmon Management

Fraser River salmon and steelhead are managed and/or studied by multiple organizations (Figure 1). DFO is primarily responsible for management of Pacific salmon<sup>1</sup> (including Fraser River salmon), and steelhead are managed by the Province of BC (the Province)<sup>2</sup>. Groups such as the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) are concerned with all wildlife (including fish) species.

COSEWIC uses a process based on science, Aboriginal Traditional Knowledge, and community knowledge to assess the risk of extinction for wildlife species in Canada. The Government of Canada then decides whether to legally protect those species by listing them under Schedule 1 of the *Species at Risk Act*. Currently, a number of Fraser River salmon and steelhead populations are listed by COSEWIC, but have not yet been legally protected by listing under the *Species at Risk Act* (COSEWIC 2019a; Government of Canada 2021).

DFO's management of Fraser River salmon is complex, but a simplified summary is that the Pacific Salmon Commission and DFO's fisheries management groups are concerned with predicting and setting fisheries management targets, and DFO's programs associated with the Wild Salmon Policy (WSP) are concerned with more holistic conservation and recovery strategies for wild salmon, including preservation of genetic diversity. While some changes to the internal structure of DFO have occurred in the decade since the Cohen Report was published, Volume 1 still provides a good overview of the various organizations concerned with Fraser River salmon management and their individual responsibilities (Cohen 2012a). DFO's annual integrated fisheries management plan reporting (e.g., DFO 2020b) also provides a description of the stock assessment process.

The Province's management of steelhead occurs through recreational fishing regulations, hatchery enhancement, and cooperation with DFO on habitat protection and enhancement and by-catch

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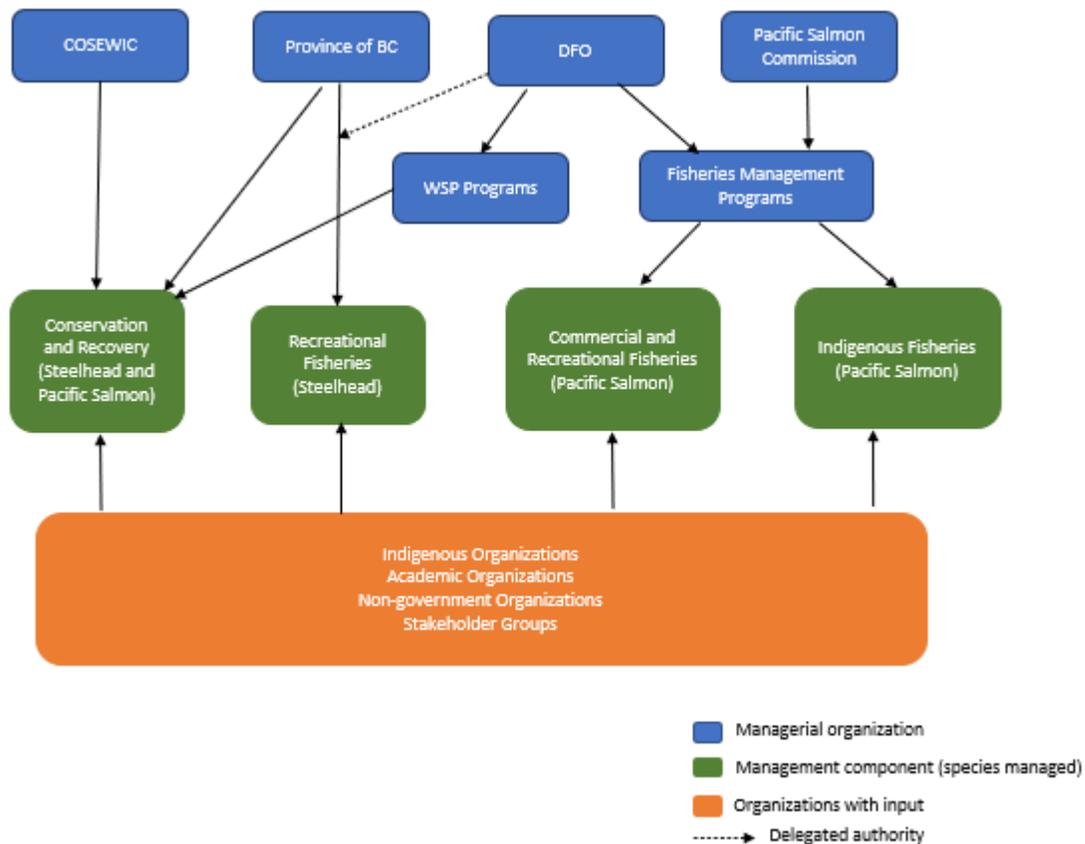
<sup>1</sup> Pacific salmon species found in BC are: Chinook Salmon (*Oncorhynchus tshawytscha*), Chum Salmon (*O. keta*), Coho Salmon (*O. kisutch*), Pink Salmon (*O. gorbuscha*) and Sockeye Salmon (*O. nerka*). Steelhead (*O. mykiss*) are a trout species, although they are closely related to salmon. Collectively salmon and trout, along with whitefish and char, are referred to as salmonids. Chum Salmon do not migrate past Kanaka Bar and so are not considered in this report.

<sup>2</sup> The Government of Canada has delegated management of recreational freshwater sport fisheries (including sea-run trout and wholly freshwater fish) to the Province, retaining regulation of recreational, commercial and Indigenous salmon fisheries (marine and freshwater) through DFO (MFLNRO 2016). What this means is that DFO manages Pacific salmon, and the Province manages steelhead, although there are aspects of steelhead management (i.e., marine factors) that fall outside of the Province's scope of influence.

management. The Provincial Framework for Steelhead Management in British Columbia (MFLNRO 2016) describes the Province's approach.

Indigenous organizations (e.g., the Fraser River Aboriginal Fisheries Secretariat) and governments, academic institutions, non-governmental organizations (e.g., the Pacific Salmon Foundation, the Steelhead Society of British Columbia), and stakeholder groups such as commercial and recreational fishers also participate in, and contribute to, management of Fraser River salmon and steelhead.

**Figure 1. Management of steelhead and Pacific salmon in BC.**



## 2.2. Population Names

### 2.2.1. Salmon

Fraser River salmon are grouped in different management units by the various government organizations managing their survival and production.

- COSEWIC and the *Species at Risk Act* describe species in terms of designatable units (DUs): “units of a taxonomic species, whereby the unit is important to the evolutionary legacy of the species, and likely could not be replaced by natural dispersion” (ECCC 2019a).

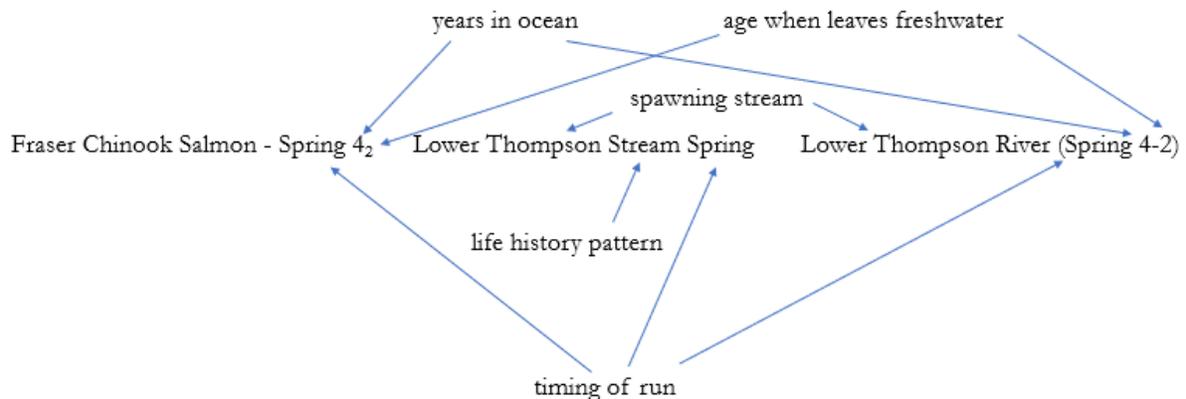
- DFO's WSP (DFO 2005) describes salmon in terms of conservation units (CUs). A CU is defined slightly differently and can sometimes be a smaller aggregate than a DU, forming a group of wild salmon sufficiently isolated from other groups that, if extirpated<sup>3</sup>, is very unlikely to naturally recolonize (DFO 2013).
- Stock management units (SMUs, also referred to as fisheries management units, or stocks) are groups of one or more CUs that are managed together by DFO for harvest planning and reporting (DFO 2020b).

Table 1 illustrates some of these potential unit relationships with two Chinook Salmon SMU examples (complete lists of SMUs, DUs, and CUs passing through Kanaka Bar territory are presented in Appendix B). SMU, DU and CU names also provide information about life cycle and spawning location (Figure 2).

**Table 1. Examples of possible relationships between SMUs, DUs and CUs.**

SMU	DU	CU
Fraser Chinook Salmon - Spring 4 <sub>2</sub>	South Thompson, Stream, Summer 1.2	South Thompson River - Bessette Creek (Spring 4-2)
	Lower Thompson Stream Spring	Lower Thompson River (Spring 4-2)
Fraser Chinook Salmon - Summer 4 <sub>1</sub>	South Thompson Ocean Summer	South Thompson River (Summer 4-1)
		Shuswap River (Summer 4-1)
		South Thompson - Adams River Upper

<sup>3</sup> Common terms to describe the status of species at risk include: Special Concern = a wildlife species that may become threatened or endangered because of a combination of biological characteristics and identified threats; Threatened = a wildlife species that is likely to become endangered if nothing is done to reverse the factors leading to its extirpation or extinction; Endangered = a wildlife species facing imminent extirpation or extinction; Extirpated = a wildlife species that no longer exists in the wild in Canada but exists elsewhere; Extinct = a wildlife species that no longer exists. (COSEWIC 2019b). Note that these categories can also be used to refer to a population on a smaller geographical scale (e.g., extirpated may be used to describe a CU that no longer exists in the wild in its original range; members of a different population of that species may still be present in the wild elsewhere in BC or Canada).

**Figure 2. Life history information in SMU, DU and CU names.**

### 2.2.2. Steelhead

Steelhead are managed by the Province and are described in different terms than are salmon. Populations that have been assessed by COSEWIC are described in terms of DUs, however, as steelhead do not form part of a commercial fishery they have not been assigned to SMUs. Similarly, as they do not fall within the scope of the WSP, CUs have not been designated for steelhead. Rather, the Province has identified approximately 30 steelhead stocks in BC, which are assessed on a regular basis to maintain an index of abundance (MFLNRO 2016). The Province uses the term 'stock' to describe a population unit more similar to a CU than an SMU, as it references a group of fish using the same spawning stream.

The terms populations, runs and stocks<sup>4</sup> are frequently used to describe fish groupings, but it is not always clear what specific management unit is being referred to when using these terms. For this reason, in this report, salmon will primarily be described in terms of SMUs, as those are the most common management units used in communications and literature regarding Indigenous fisheries, and to avoid confusion with the Province's definition of stock. However, the terms DU or CU will be used where those are the most accurate or relevant descriptor. Similarly, DU or the Province's definition of stock will be used when describing steelhead.

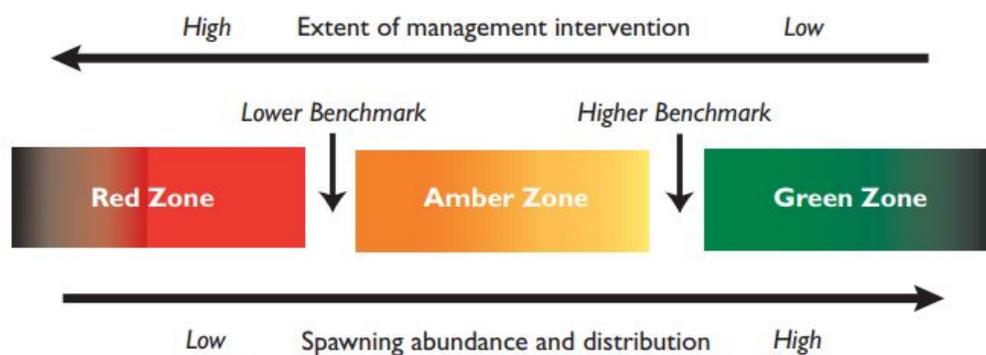
### 2.3. Abundance Descriptors

The different organizations responsible for managing salmon also describe and measure salmon abundance in different ways.

<sup>4</sup> Population = a group of individuals of the same species living and interbreeding within a given area run = the time when salmon enter freshwater and migrate upstream to their spawning grounds stock = subpopulation of a species of fish, more or less isolated from other stocks of the same species and hence self-sustaining (Krebs 2009)

Both COSEWIC and the WSP are concerned with population unit (i.e., DU or CU) recovery and health, but their terms are not directly comparable. COSEWIC uses common endangered species terms of Special Concern, Threatened or Endangered to describe at-risk species and DUs. The WSP uses a colour coded system (Figure 3) to categorize CUs and is more conservative than COSEWIC. That is, a red categorization by the WSP may occur before a population unit has declined to the point of being considered Endangered by COSEWIC. This is a deliberate strategy by the WSP, intended to sound the alarm before a population unit has declined to the point where it becomes difficult to repair (DFO 2005; PSF 2020a). The Pacific Salmon Foundation, a non-governmental organization, also ranks biological status of CUs using a similar process to the WSP (PSF 2020b).

**Figure 3. WSP benchmarks and biological status (from DFO 2005).**



The fish abundance measurement most often used when discussing population health is escapement: the number of fish that “escape” the fishery and reach their spawning grounds. Escapement is measured by a variety of methods, including visual spawner surveys and carcass recovery surveys, hydroacoustic programs, mark-recapture programs, and enumeration fences. These methods vary in cost and in precision (Gomez and Scroggie 2021).

### 3. RESULTS

#### 3.1. Freshwater Environment at Kanaka Bar

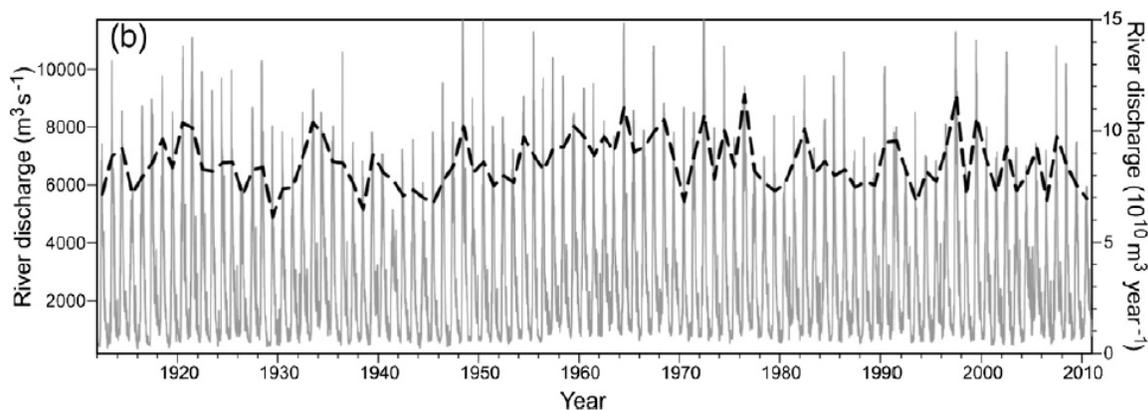
The Fraser River is 1,600 km long, with a watershed size of 223,000 km<sup>2</sup>. It is the largest undammed river on the west coast of North America and is Canada’s most productive salmon river (Cohen 2012a; WSC 2017). A 15 km long stretch of the Fraser River runs through Kanaka Bar territory. The Fraser River’s largest tributary, the Thompson River, enters the Fraser River approximately 10 km upstream. In Kanaka Bar territory, 28 tributary streams drain into the Fraser River (Map 2). These streams climb steeply from the Fraser River, with limited accessible habitat for anadromous salmonids to potentially spawn and rear.

### 3.1.1. River Flow

The Water Survey of Canada (WSC), in partnership with the Province, maintains and operates 142 active hydrometric stations throughout the Fraser River watershed<sup>5</sup>; an additional 672 discontinued stations provide historical data. The “Fraser River at Hope” station, located 100 km downstream of Kanaka Bar, is the most relevant to Kanaka Bar conditions, given its relative proximity and long dataset. This station has been recording flow data continuously since 1912, and water level data since 1996 (WSC 2021). The upstream “Fraser River above Texas Creek station” is closer (just south of Lillooet, located 60 km upstream of Kanaka Bar), but, as it is located upstream of the Thompson River (a major tributary to the Fraser River), it is less representative of Fraser River flows at Kanaka Bar than is the Fraser River at Hope station.

Based on data collected at the Fraser River at Hope station over the past one hundred years, the discharge in the Fraser River is trending toward larger fluctuations between years (Déry *et al.* 2012), although average annual flow has remained roughly constant (Riche *et al.* 2014; Figure 3). The river transports approximately 18 million tonnes/year of sediment, including 3 million tonnes/year of coarse sand bed material load (NHC 2002).

**Figure 4.** Fraser River stream flow, measured at Hope (from Riche *et al.* 2014). Grey line shows stream flow over time (left axis); black dashed line shows mean annual flow (right axis).



The Fraser River has shown a shift from predominantly snow-fed (spring/summer freshet) toward predominantly rain-fed (multiple autumn and winter peaks) over the past 100 years, a trend that is likely to result in an entirely rain-fed hydrograph by the end of the 21<sup>st</sup> century (Riche *et al.* 2014). Freshet timing is also shifting to earlier than previously, a result of warming temperatures and earlier snow-melt (Johannessen and McCarter 2010).

<sup>5</sup> [Real-Time Hydrometric Data Map Search - Water Level and Flow - Environment Canada \(ec.gc.ca\)](https://www.ec.gc.ca/real-time-hydrometric-data-map-search-water-level-and-flow)

### 3.1.2. Water Quality

The provincial government publishes water quality data through the Environmental Monitoring System (EMS)<sup>6</sup>, an online portal that allows the public to access water quality data collected by federal and provincial staff, permit holders, and authorized third parties for long-term monitoring programs. While a number of such stations are present in relative proximity to Kanaka Bar, the majority are located on tributary streams rather than on the Fraser River, and most are associated with discharge permits and monitor a relatively small suite of parameters. The closest (current) Fraser River EMS sample sites to Kanaka Bar are a cluster of three sites in Lillooet associated with municipal wastewater discharge permitting that have been operated since November 1998. Parameters monitored at these sites include biological oxygen demand, sediment, pH, and coliforms. The closest tributary sites to Kanaka Bar are historical sites (i.e., last sampled 20 years or more ago) at Nekliptum Creek, Siska Creek, and Mowhokam Creek, where parameters associated with municipal wastewater (i.e., nutrients, coliforms, physical parameters) were measured (Province of British Columbia 2021).

The federal and provincial governments collaborate to monitor water quality across Canada<sup>7</sup>, with the data publicly available through the EMS website. These water quality sites include 14 sites in the Fraser River basin, sampled for 15 years or more for nutrients, metals, major ions and other physical-chemical variables (ECCC 2019b). The downstream-most of these, located at Hope, is the most representative of conditions at Kanaka Bar. This site has been sampled since 1979 and is intended to represent water quality effects from discharges to the upper and middle reaches of the Fraser River and to the Thompson River (ECCC 2014).

An assessment of water quality in the Fraser River at Hope between 1979 and 2004 showed fluctuating turbidity and conductivity levels with a general increasing trend in turbidity over this time period. Most metals fluctuated with turbidity levels, and on occasion exceeded guidelines and objectives, while chloride concentrations showed steady decline since early 1992 (Swain 2007). More recent raw water quality data is available at the Hope site. The interpretation and analysis of this data set is outside the scope of this project but would provide a more current and accurate overview of water quality conditions.

DFO's Environmental Watch (EWatch) program<sup>8</sup> collects water temperature data in the Fraser River throughout the summer at a number of data loggers operated by EWatch and WSC (Figure 5). This data is used to forecast salmon migratory success and mortality (DFO 2020c).

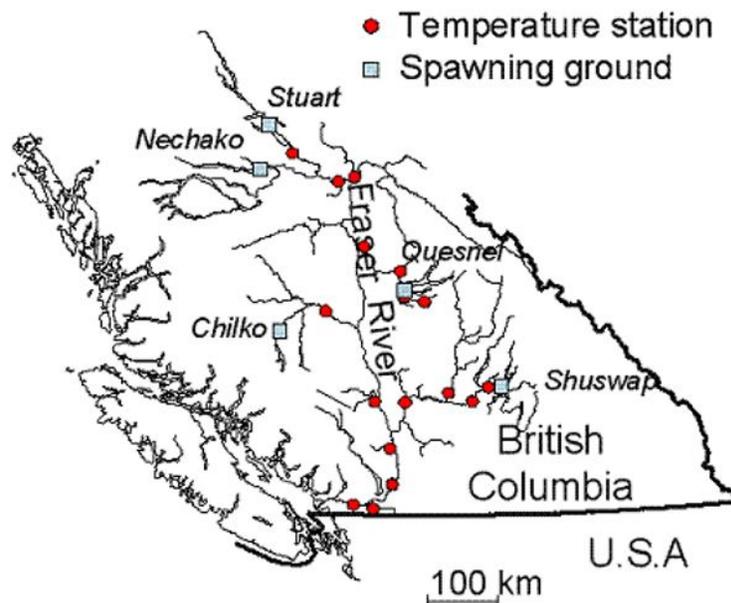
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<sup>6</sup> [Environmental Monitoring System - Province of British Columbia \(gov.bc.ca\)](https://www2.gov.bc.ca/gov/content/monitoring-and-reporting/ems)

<sup>7</sup> [Freshwater quality monitoring: online data - Canada.ca](https://www.ec.gc.ca/freshwater-quality-monitoring)

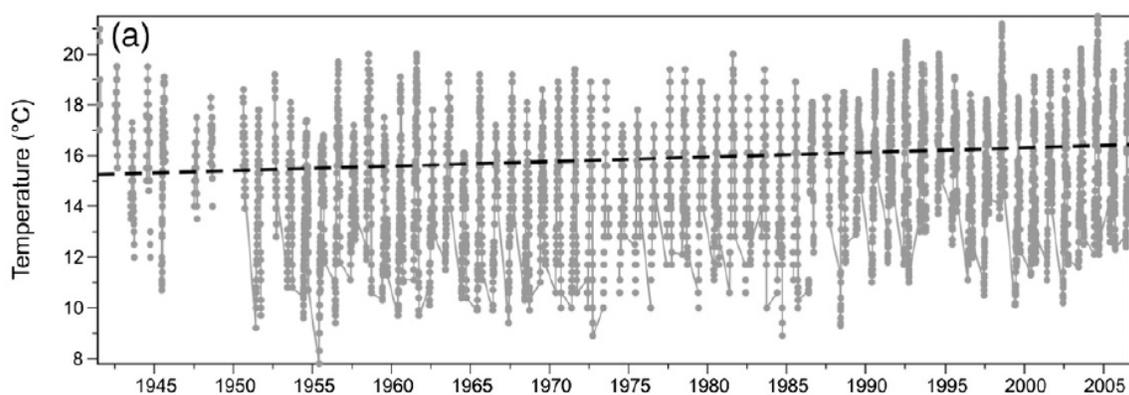
<sup>8</sup> [Fraser River environmental watch | Pacific Region | Fisheries and Oceans Canada \(dfo-mpo.gc.ca\)](https://www.dfo-mpo.gc.ca/fisheries-environmental-watch)

**Figure 5.** EWatch and WSC water temperature data logger locations.



Fraser River water temperatures at Hell's Gate, located approximately 40 km downstream of Kanaka Bar, were recorded between the early 1940s until 1998. The highest summer water temperature recorded during this time period was 21.2°C (recorded in August 1998), and the lowest temperature at this site was 11°C (recorded in July 1955). Summer mean temperatures between 1953 and 1998 ranged between 15°C to 19°C, with a high of 21.2°C (recorded in August 1998), and a low of 11°C (recorded in July 1955) (Morrison *et al.* 2002). More recent raw water temperature data is available for the Fraser River at Hope through the EWatch and WSC websites. Summer high temperatures in the Fraser River are on a rising trend, in recent years often reaching temperatures stressful to salmon and steelhead (i.e., > 20°C) (Cohen 2012b; Riche *et al.* 2014; DFO 2020c; MacDonald *et al.* 2021).

**Figure 6.** Water temperature trends in the Fraser River, measured at Hope (from Riche *et al.* 2014).



A limited number of short-term water quality monitoring studies have also occurred in Kanaka Bar territory. A train derailment in 1997 resulted in a spill of sulphur (the train cargo), hydrocarbons (fuel and lubricants for the train itself), and fluoride compounds (from fire retardant employed after the crash) into the Fraser River. Monitoring immediately following the incident found localized exceedances for fluoride and hydrocarbons in the Fraser River in the vicinity of the derailment site. However, a month later concentrations of these parameters had returned to below the provincial criteria for protection of aquatic life (AGRA 1997). An undetermined quantity of insoluble sulphur remains in river sediments and upland soils in and around the derailment site. Because the sulphur remains in an inert form it was determined not to create a hazard to aquatic life or human health (TSB 1997). Environmental assessments done in support of proposed hydroelectric projects on two tributary streams in Kanaka Bar territory included water quality baseline studies (Golder 2007; Green Valley Power 2013). Measurements of physical parameters and nutrients were typical for high gradient coastal streams. Kwoiek Creek exceeded the criteria for protection of aquatic life for aluminum, cadmium, and silver due to naturally high background levels; Siwash Creek was not tested for metals.

### 3.2. Kanaka Bar Fish Species

#### 3.2.1. Anadromous Salmonids

Five<sup>9</sup> anadromous salmonid species pass through Kanaka Bar territory: Chinook Salmon, Coho Salmon, Pink Salmon, Sockeye Salmon, and steelhead. Coho Salmon and Rainbow Trout<sup>10</sup> are present in tributary streams (Province of British Columbia 2020; Map 2) but there are no established runs for any of these species in Kanaka Bar territory as little suitable spawning habitat is available (see Section 3.2.1.1).

##### 3.2.1.1. Life History and Habitat Use

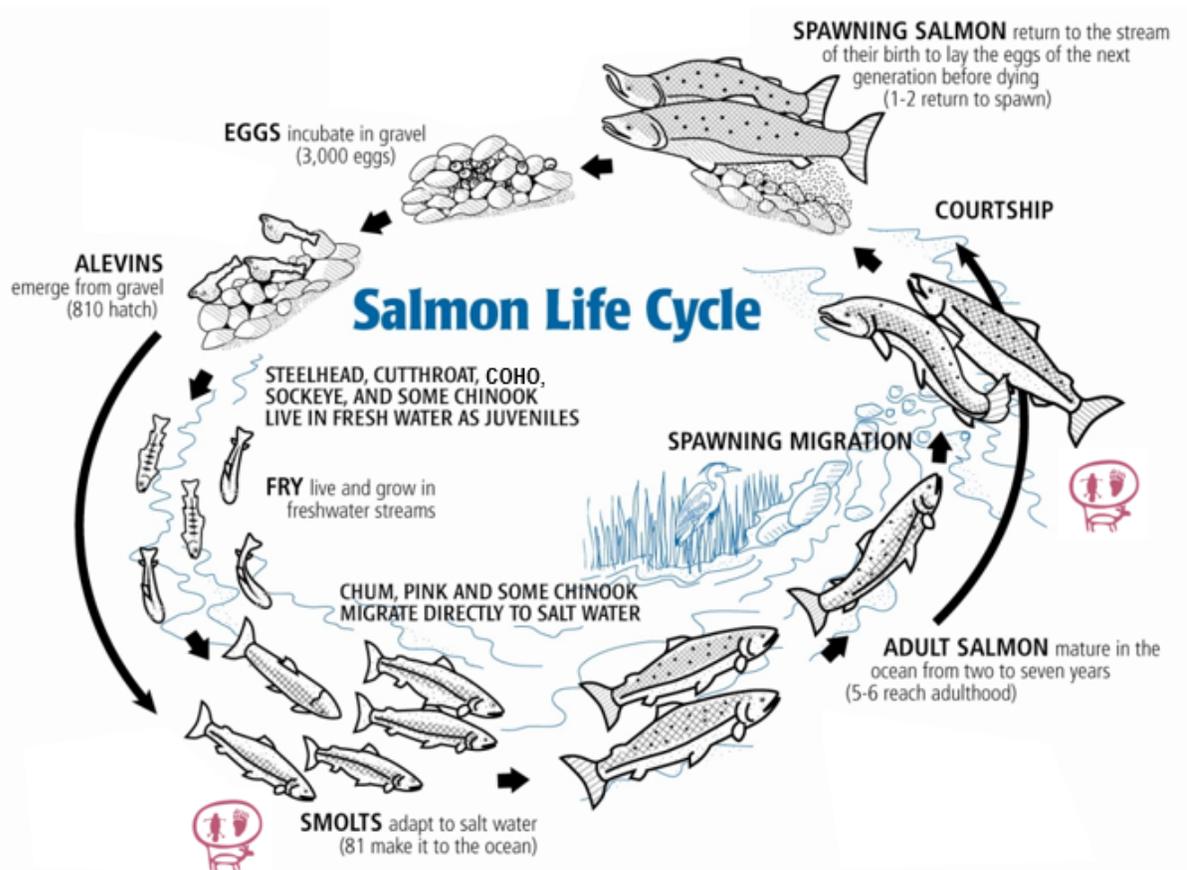
Details of the life history, habitat requirements and abundance of each of these species are described in Appendix B. An overview of these topics is provided below. Figure 7 shows the anadromous salmonid life cycle, along with typical survival rates at each stage.

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<sup>9</sup> Chum Salmon are not present this far upstream in the Fraser River (McPhail 2007).

<sup>10</sup> Steelhead and Rainbow Trout fry cannot be differentiated by field observations and have similar habitat requirements; hence presence of Rainbow Trout may indicate presence of steelhead.

Figure 7. Salmonid life cycle<sup>11</sup> (adapted from SFEG 2021).



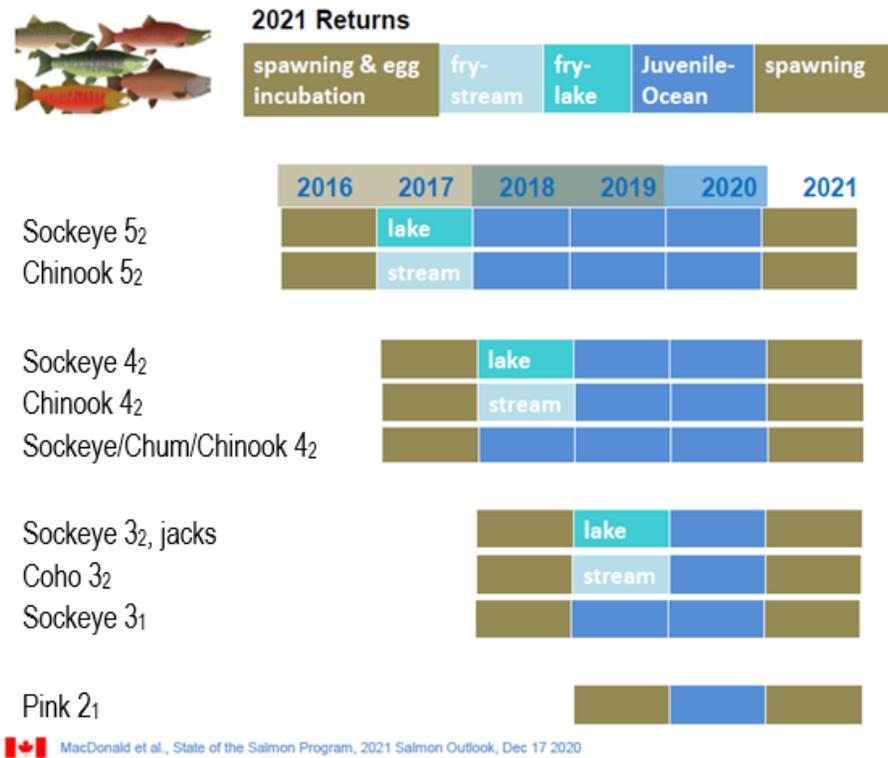
Anadromous salmonids start their lives in freshwater, rearing there for anywhere from a few days to a few years depending on species, before migrating to the ocean and completing their growth to adulthood. Upon maturity, which occurs after two to five years at sea, depending on species, adults return to the stream where they were born to spawn. All the salmon species described here die after spawning; steelhead, a trout species, returns to the ocean. Steelhead can repeat this cycle the following year, spawning up to three times in total.

Figure 8 illustrates the life history patterns of Fraser River salmon stocks, showing when those returning in 2021 would have been born and how long they would have spent in freshwater and in the ocean. Steelhead are not shown, but spend one to three years in freshwater, and two to three years at

<sup>11</sup>  indicates passing through Kanaka Bar territory

sea before spawning for the first time<sup>12</sup>, after which they return to the ocean and then back to freshwater to spawn again on an annual basis.

**Figure 8. Life history patterns of Fraser River salmon.**



Salmonids vary somewhat in their specific habitat requirements (see Table 2 and Appendix B), but generally require a steady stream flow and cool and clean water for all their freshwater life stages. Eggs and alevin need a well-oxygenated gravel streambed; juveniles require food, cover from predators and refuge from high flows (Figure 9). Stable water levels, cover and access are all important for up and down-stream migration. Estuary rearing requires food and a steady flow of clean water to allow smolts to acclimate to saltwater. In the ocean food becomes the primary “habitat” requirement.

<sup>12</sup> Thompson River steelhead have a 3<sub>2</sub> pattern; Chilcotin River steelhead 3<sub>3</sub> (COSEWIC 2018); other Fraser River steelhead may differ.

**Table 2. General habitat preferences of Fraser River salmon and steelhead (adapted from VIU 2009).**

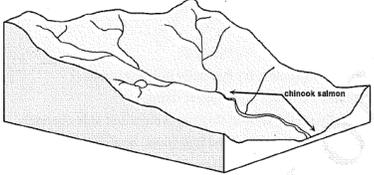
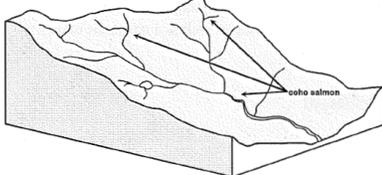
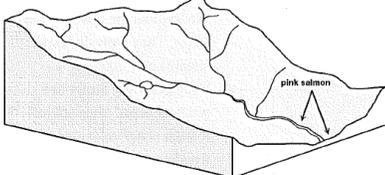
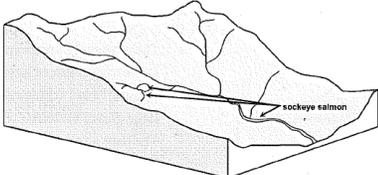
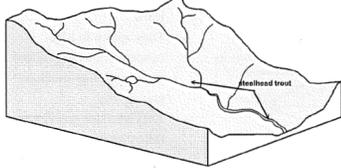
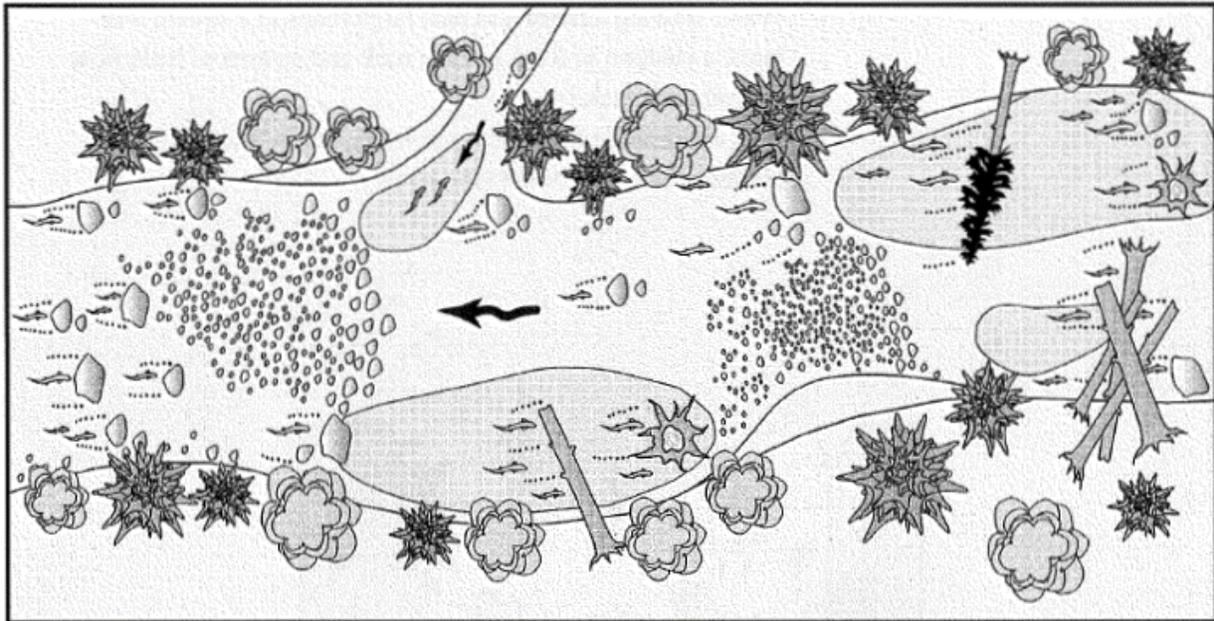
Species	Spawning Habitat	Rearing Habitat
Chinook Salmon		Stream/Lake/Estuary/Ocean. Versatile, but often deeper/faster water than other species.
Coho Salmon		Stream. Versatile, but prefer slow-moving water and side channels.
Pink Salmon		Estuary (little or no freshwater residence).
Sockeye Salmon		Lake most common, but stream possible.
Steelhead		Stream/lake. Versatile: boulders, pools and turbulence important as cover.

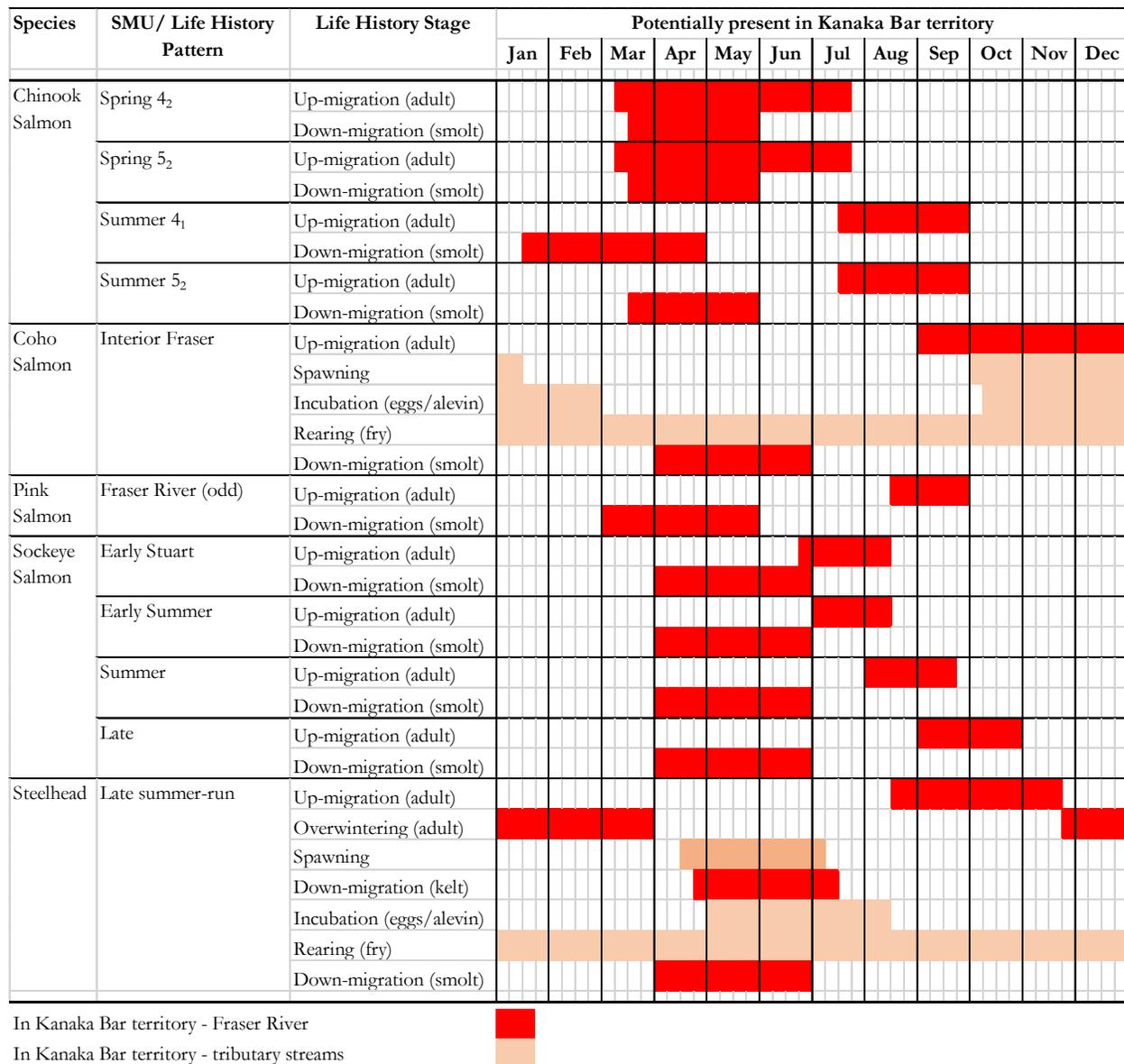
Figure 9. Salmonid distribution in a typical stream (from VIU 2009).



Kanaka Bar territory primarily provides habitat for up- and down-migration, in the Fraser River, although it may also provide overwintering habitat for summer-run steelhead returning to the Stein and Nahatlatch rivers. Most of the tributary streams in Kanaka Bar territory have very limited accessible habitat for spawning and rearing, although small numbers<sup>13</sup> of Coho Salmon have been observed spawning in the first 400 m of Kwoiek Creek (Griffith 1997; Chambers and Faulkner 2021). Given their habitat preferences (see Appendix B) and the documented presence of Rainbow Trout in Kwoiek Creek and other tributary streams (Triton 2012; Province of British Columbia 2020; Chambers and Faulkner 2021; Map 2), some steelhead spawning and juvenile rearing may also be occurring in tributary streams. Figure 10 shows when salmon and steelhead may be present in Kanaka Bar territory. Note that Pink Salmon are only present in odd years.

<sup>13</sup> No spawner surveys have been done, but based on observations and limited habitat availability (Chambers and Faulkner 2021) likely fewer than 20.

**Figure 10. Timing of salmon and steelhead in Kanaka Bar territory (MELP and DFO 1998; Cooke *et al.* 2004; McPhail 2007; VIU 2009; COSEWIC 2016, 2017, 2018; DFO 2018a; ECCC 2019a; CDC 2021; Gomez and Scroggie 2021).**



### 3.2.1.2. Populations and Abundance

Generally, all five species have suffered declines in both abundance (COSEWIC 2016, 2017, 2018, 2020; Malick and Cox 2016; DFO 2018a; ECCC 2019a; Gomez and Scroggie 2021; MacDonald *et al.* 2021) and body size at maturity (Oke *et al.* 2020) over the past few decades. 2020 returns were among the worst on record for many populations, with 2021 predicted to be similar (Davis and Xu 2021; Gomez and Scroggie 2021; MacDonald *et al.* 2021; Scroggie 2021). Populations

that spend less time in freshwater, including river-type Sockeye Salmon, ocean-type Chinook Salmon, and Pink Salmon populations, have been the exception to these trends (Grant *et al.* 2019), although even some of these populations are beginning to show the impact of poor marine survivorship (Davis and Xu 2021). Details are provided below.

### *Chinook Salmon*

Chinook Salmon from four Fraser River SMUs (Spring 4<sub>2</sub>, Spring 5<sub>2</sub>, Summer 4<sub>1</sub>, and Summer 5<sub>2</sub>) travel through Kanaka Bar territory, including 11 DUs and 13 CU<sup>14</sup>s (a complete list of these population units is provided in Appendix B). Most of these population units are suffering low enough abundance to be considered at risk (Table 3), and the 2020 Fraser River Chinook Salmon returns were the lowest on record (Davis and Xu 2021). The exception is the Spring 4<sub>1</sub> SMU; this SMU consists of ocean-type Chinook Salmon while the other Fraser River Chinook Salmon populations are all stream-type<sup>15</sup>. Abundance trends for these SMUs<sup>16</sup> for the past 45 years are shown in Figure 11.

**Table 3. At-risk status of Chinook Salmon potentially at Kanaka Bar.**

SMU	COSEWIC status	WSP status
Spring 4 <sub>2</sub>	2 DUs: both Endangered	2 CUs: both red
Spring 5 <sub>2</sub>	4 DUs: 3 Endangered, 1 Threatened	4 CUs: 3 red, 1 data deficient
Summer 4 <sub>1</sub>	1 DU: Not at Risk	3 CUs: 1 green, 2 not assessed (both PSF data deficient)
Summer 5 <sub>2</sub>	4 DUs: all Endangered	4 CUs: 2 red, 1 amber/red, 1 amber

**Notes:**

Only DUs and CUs passing through Kanaka Bar listed; SMU may contain additional downstream DUs and CUs.  
PSF ranking provided where not yet assessed by DFO through WSP

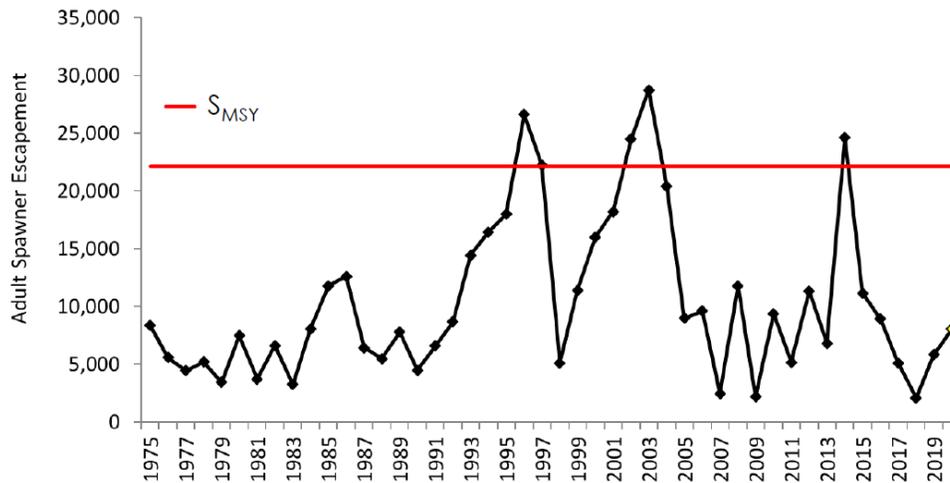
<sup>14</sup> Includes Fraser Canyon – Nahatlatch CU, which is downstream of Kanaka Bar but close enough that straying is possible.

<sup>15</sup> Ocean-type Chinook Salmon spend only a few weeks to a few months in freshwater before heading to estuaries and the ocean to rear, whereas stream-type Chinook Salmon spend at least one winter in freshwater.

<sup>16</sup> Amalgamated data for all Fraser River Chinook Salmon was not available.

Figure 11. Fraser River Chinook Salmon abundance by SMU for a) Spring 4<sub>2</sub>, b) Spring 5<sub>2</sub>, c) Summer 4<sub>1</sub>, d) Summer 5<sub>2</sub>. “S<sub>MSY</sub>” in the figures refers to the spawning abundance needed to produce the maximum sustained yield, as calculated by DFO (Gomez and Scroggie 2021).

a) Spring 4<sub>2</sub>



b) Spring 5<sub>2</sub>

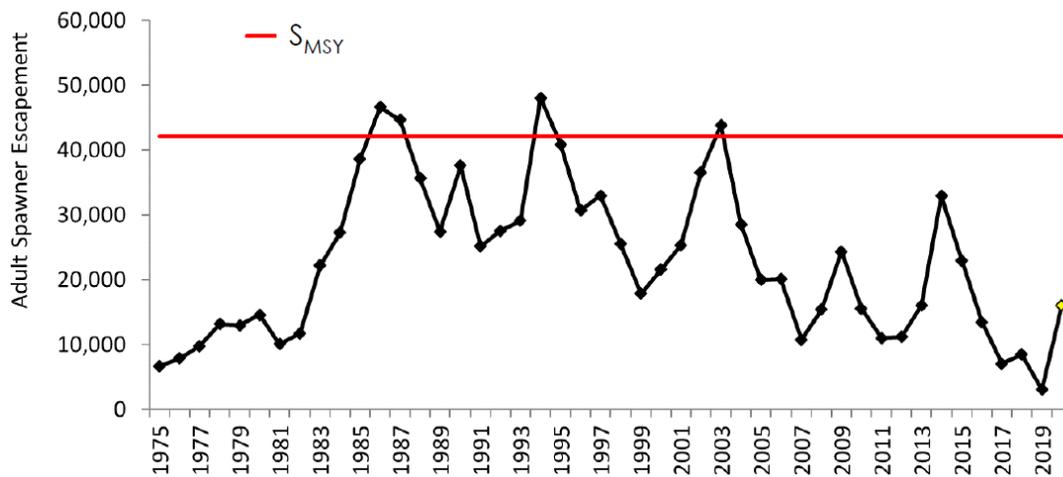
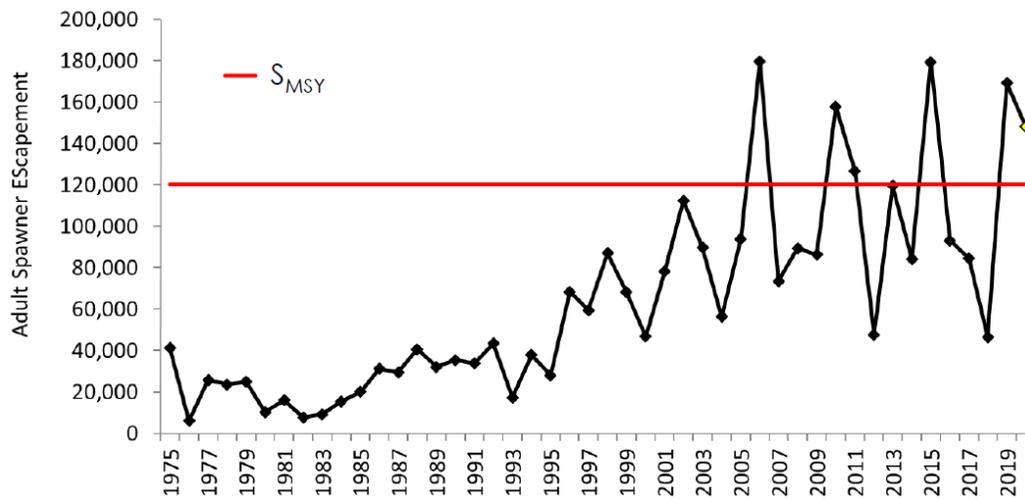
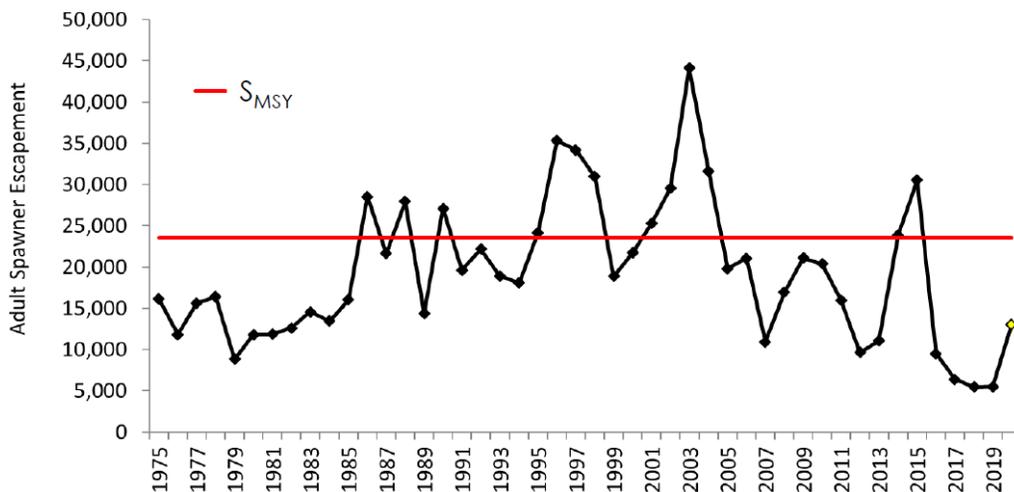


Figure 11. Continued.

c) Summer 4<sub>1</sub>



d) Summer 5<sub>2</sub>.



*Coho Salmon*

Coho Salmon from one SMU (Interior Fraser) travel through Kanaka Bar territory. This SMU contains one DU and five CUs that travel through Kanaka Bar. The Coho Salmon documented in Kwoiek Creek likely belong to the Interior Fraser CU, assessed as amber by the WSP.

**Table 4 At-risk status of Coho Salmon potentially at Kanaka Bar**

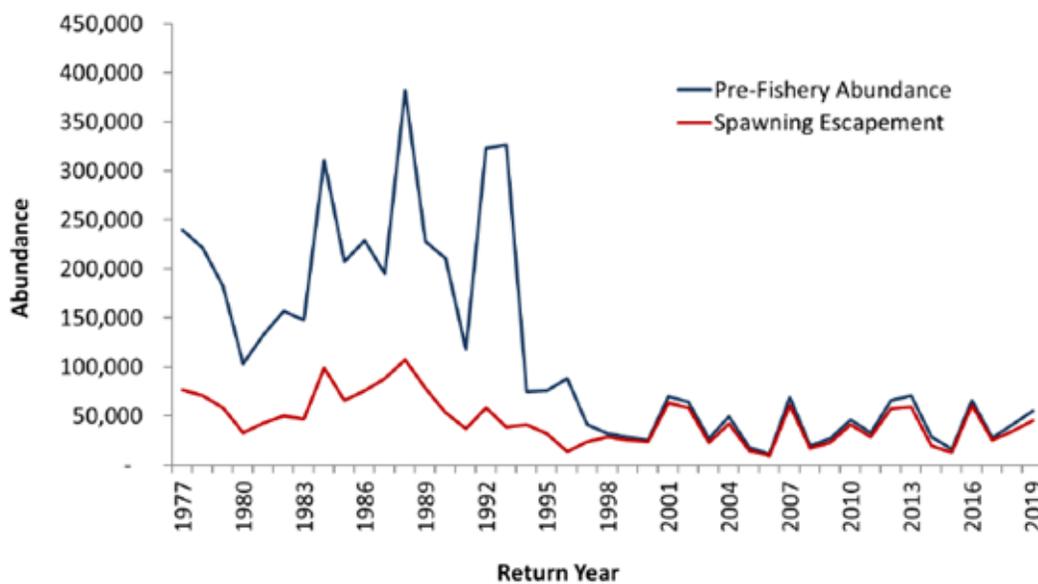
SMU	COSEWIC status	WSP status
Interior Fraser	1 DU: Threatened	5 CUs: 2 green/amber, 3 amber

**Notes:**

Only DUs and CUs passing through Kanaka Bar listed; SMU may contain additional downstream DUs and CUs. PSF ranking provided where not yet assessed by DFO through WSP

Figure 12, below, shows Interior Fraser Coho Salmon abundance over the past 40 years, both as escapement to spawning grounds and as numbers prior to fishing take. Numbers have declined dramatically from peak abundances observed in the 1980s (Gomez and Scroggie 2021). Note that after 1998 the fishery take reduced substantially, and has remained low since (COSEWIC 2016).

**Figure 12. Trends in abundance of Interior Fraser River Coho Salmon (Gomez and Scroggie 2021).**

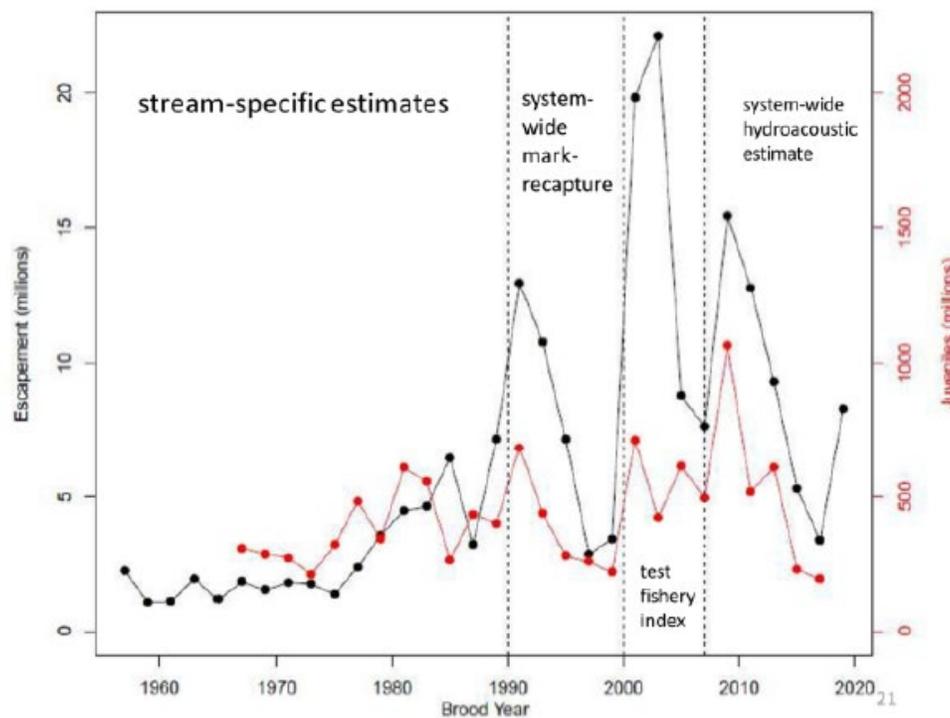


*Pink Salmon*

One SMU of Pink Salmon, forming a single CU (Fraser River (odd)), travels through Kanaka Bar territory. COSEWIC has not listed this species, and so no DUs have been established. This CU has not been assessed by DFO through the WSP, however the Pacific Salmon Foundation has rated it as having a poor (roughly equivalent to the WSP “red”) biological status using a methodology similar to that of the WSP (PSF 2020b).

Figure 13, below, shows Fraser River Pink Salmon (odd) abundance both in terms of adult escapement to spawning grounds and juvenile out-migration<sup>17</sup> over the past 60 years. While Fraser River Pink Salmon have not suffered the steep declines of other Fraser River salmon species in recent years (Grant *et al.* 2019; DFO 2020b), they have not been unaffected (Malick and Cox 2016), and evidence shows the most recent brood year (2019) is showing the same poor marine survival afflicting other species (Davis and Xu 2021).

**Figure 13. Fraser River Pink Salmon abundance. Black text indicates different methods for calculating escapement over time (Davis and Xu 2021).**



### *Sockeye Salmon*

Sockeye Salmon from four Fraser River SMUs (Early Stuart, Early Summer, Summer, and Late) travel through Kanaka Bar territory, encompassing 14 DUs and 15 CUs potentially present at Kanaka Bar. A complete list of these population units is provided in Appendix B. Almost half of Fraser River Sockeye Salmon CUs have been assessed as red by WSP (with most of the corresponding DUs listed as Endangered by COSEWIC) (Table 5). River-type Sockeye Salmon, which spend less time in

<sup>17</sup> Unlike other salmon species, enumeration of Fraser River Pink Salmon has previously favoured counting juveniles out-migrating rather than adult escapement to spawning grounds, due to data quality issues (Grant *et al.* 2014; Davis and Xu 2021).

freshwater than lake-type life history forms, seem to be doing better, with many of these CUs ranked as green by WSP (Grant *et al.* 2019).

**Table 5. At-risk status of Sockeye Salmon travelling through Kanaka Bar territory.**

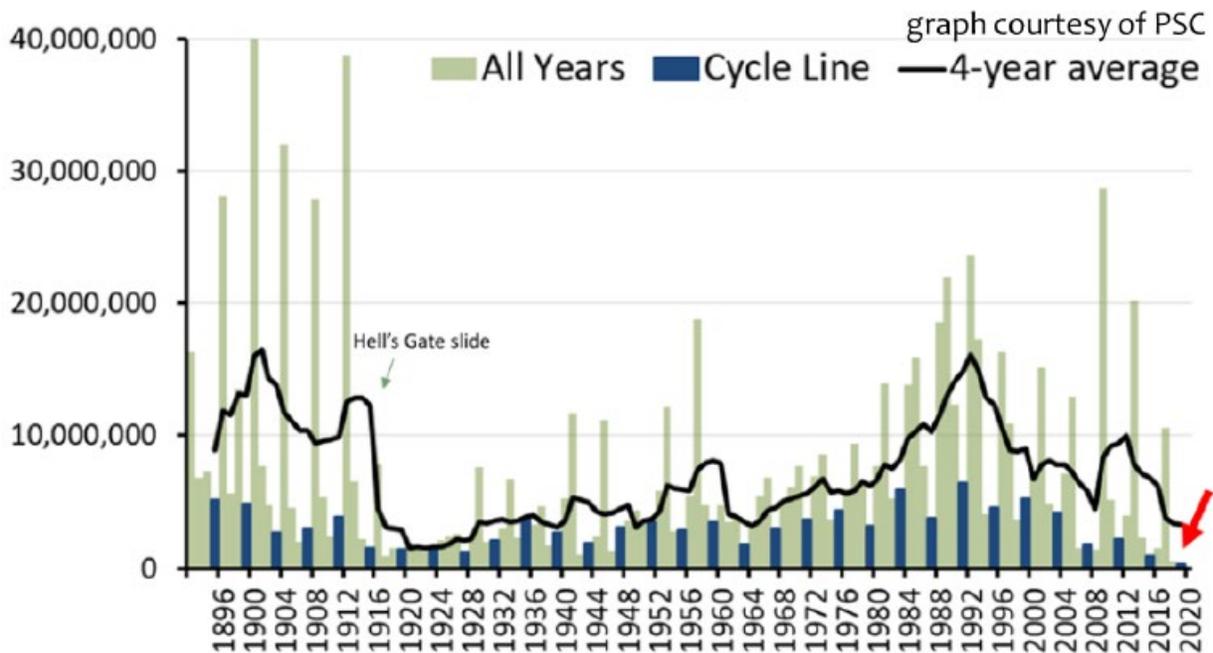
SMU	COSEWIC status	WSP status
Early Stuart	1 DU: Endangered	1 CU: red
Early Summer	8 DUs: 2 Endangered, 1 Threatened, 1 Special Concern, 4 Not at Risk	8 CUs: 2 red, 3 amber, 2 green/amber, 1 green
Summer	4 DUs: 1 Not at Risk, 1 Special Concern, 2 Endangered	4 CUs: 1 green, 2 amber/green, 1 amber/red
Late	2 DUs: 1 Endangered, 1 Not at Risk	2 CUs: 1 red, 1 green/amber

**Notes:**

Only DUs and CUs passing through Kanaka Bar listed; SMU may contain additional downstream DUs and CUs. PSF ranking provided where not yet assessed by DFO through WSP

Figure 14, below, shows Fraser River Sockeye Salmon abundance over the past 100 years. Fraser River Sockeye Salmon abundance declined sharply after the Hell’s Gate slide in 1913, and then began slowly recovering (Figure 14). However, in 1989 productivity began to decline again (Davis and Xu 2021). The red arrow shows preliminary 2020 escapement estimate; this is the smallest escapement since 1893 (Scroggie 2021).

**Figure 14. Fraser River Sockeye Salmon Abundance (Scroggie 2021).**



### Steelhead

One provincial run, Interior Fraser (all late-run summer steelhead), travels through Kanaka Bar territory, comprised of 11 stocks in total, all of which are potentially present at Kanaka Bar. The Province considers Interior Fraser steelhead populations to be in a state of Extreme Conservation Concern (i.e., stocks at less than 10% of habitat capacity) (MOE 2005; Bison 2020). COSEWIC has assessed two DUs (Thompson and Chilcotin) that pass through Kanaka Bar territory as Endangered; these two DUs encompass six of the stocks within the Interior Fraser run (Bison 2012; COSEWIC 2018; DFO 2018a). Other stocks of steelhead belonging to the Interior Fraser run pass through Kanaka Bar territory but have not been assessed by COSEWIC. There are no documented stocks of steelhead specific to tributary streams in Kanaka Bar territory; the two nearest stocks are Nahatlatch and Stein (Bison 2012; PSF 2020b). Figure 15 shows Thompson River and Chilcotin River steelhead abundance over the past 40 years; data for other Interior Fraser steelhead was not available (Bison 2020).

**Figure 15. Thompson River (a) and Chilcotin River (b) Steelhead Abundance (Bison 2020).**

#### a) Thompson River

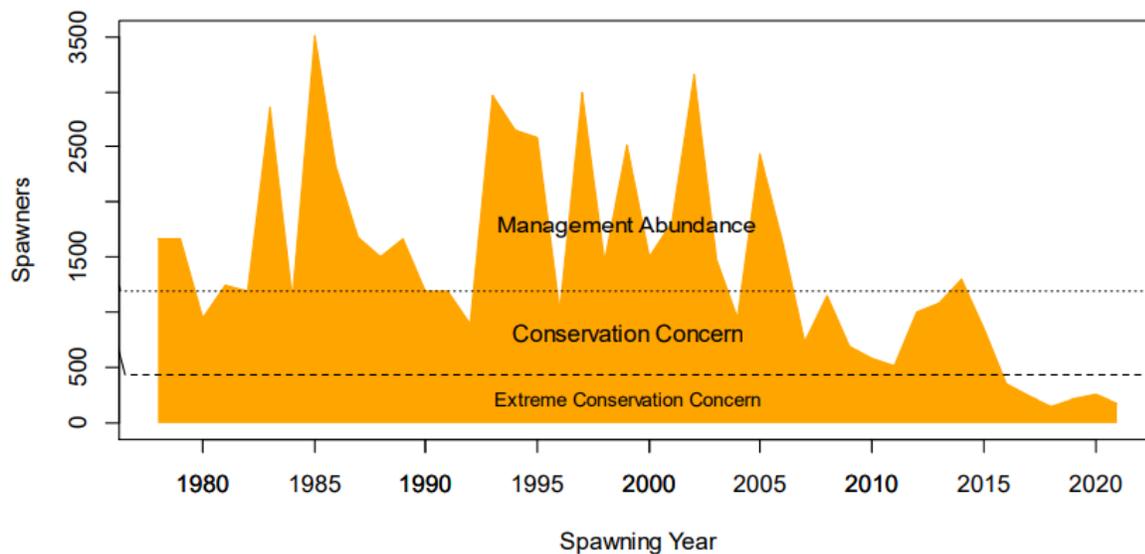
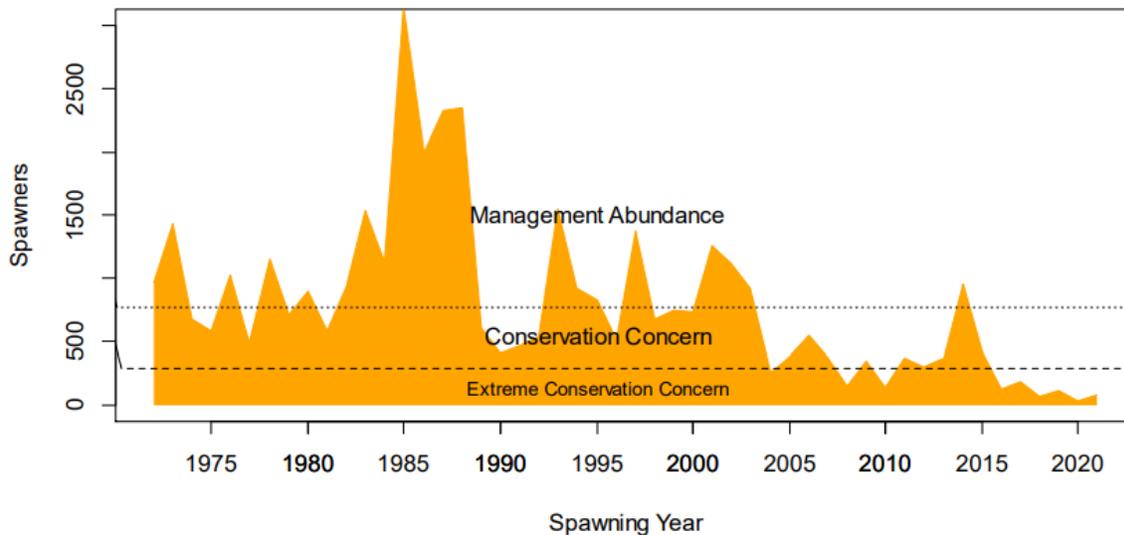


Figure 15. Continued.

## b) Chilcotin River



## 3.2.2. Other Fish Species

In addition to salmon and steelhead, there are at least 19 other documented fish species potentially present in the Fraser River at Kanaka Bar (Figure 16). All of these species are of traditional value in Nlaka’pamux culture. Resident species provide food, as do the five anadromous species when they pass through Kanaka Bar territory as adults. These five species are not just food sources but also define the community’s culture and life-ways. Several of the species potentially present are considered at risk: Bull Trout (*Salvelinus confluentus*) and Mountain Sucker (*Catostomus platyrhynchus*) are both blue listed<sup>18</sup> by the Province, listed as Special Concern by COSEWIC and legally protected under SARA. Coastal Cutthroat Trout (*O. clarkii clarkii*) is also provincially blue-listed, but not by COSEWIC. White Sturgeon (*Acipenser transmontanus*) is provincially red-listed and listed as Threatened by COSEWIC.

While there are words in the Nlaka’pamux language for these fish species, their anatomy, their uses, and the tools used to catch, process, and store them, this report has not provided direct translations as English spelling conventions for Nlaka’pamux words are contested. Kanaka Bar is advancing a language program that features an image, the English spelling, and a clickable sound bar that plays an audio clip of the word in the Nlaka’pamux language. More information is available at [Our Language — Kanaka Bar Band 2020](#).

<sup>18</sup> Blue-listed = Special Concern; red-listed = Threatened, Endangered or Extirpated (CDC 2021).

**Figure 16. Fish species potentially present in Fraser River at Kanaka Bar.**

Group	Common Name	Scientific Name
Lamprey	Pacific Lamprey	<i>L. tridentate</i>
Minnow	Brassy Minnow	<i>Hybognathus hankinsoni</i>
	Carp spp.*	<i>Cyprinus spp.</i>
	Leopard Dace	<i>Rhinichthys falcatus</i>
	Longnose Dace	<i>R. cataractae</i>
	Northern Pikeminnow	<i>Ptychocheilus oregonensis</i>
	Peamouth	<i>Mylocheilus caurinus</i>
	Redside Shiner	<i>Richardsonius balteatus</i>
Salmon, trout, char and whitefish	Bull Trout	<i>Salvelinus confluentus</i>
	Chinook Salmon	<i>Oncorhynchus tshawytscha</i>
	Coastal Cutthroat Trout	<i>O. clarkii</i>
	Coho Salmon	<i>O. kisutch</i>
	Mountain Whitefish	<i>Prosopium williamsoni</i>
	Pink Salmon	<i>O. gorbuscha</i>
	Sockeye Salmon	<i>O. nerka</i>
Sculpin	Steelhead (Rainbow) Trout	<i>O. mykiss</i>
	Aleutian Sculpin	<i>Cottus aleuticus</i>
Sturgeon	Prickly Sculpin	<i>C. asper</i>
	White Sturgeon	<i>A. transmontanus</i>
Sucker	Bridgelip Sucker	<i>Catostomus columbianus</i>
	Largescale Sucker	<i>C. macrocheilus</i>
	Longnose Sucker	<i>C. catostomus</i>
	Mountain Sucker	<i>C. platyrhynchus</i>
Sunfish	Largemouth Bass*	<i>Micropterus salmoides</i>

Asterisk (\*) indicates an introduced species

### 3.3. Causes of Fraser Salmon Decline

There is no one cause for the decline in Fraser River salmon and steelhead, although evidence suggests that marine survival is the main driver of productivity (MacDonald *et al.* 2021). Instead, a complex and interconnected set of causes and interactions have created the current situation<sup>19</sup>. In understanding causes of decline it can be useful to think about impacts to salmon in terms of stressors, then working

<sup>19</sup> For more detail, DFO's "State of Canadian Pacific Salmon 2019" e-book provides an interactive overview of many of the stressors described in the sub-sections below, particularly those related to climate change. [E-book: State of the Canadian Pacific salmon: Responses to changing climate and habitats \(dfo-mpo.gc.ca\)](https://www.dfo-mpo.gc.ca/state-of-the-canadian-pacific-salmon-responses-to-changing-climate-and-habitats)

backwards to the causes of those stressors, as it is the causes that must be addressed to effectively mitigate stressors.

Cause -> stressor -> effect

An example of a cause would be climate change, which results in warmer air temperatures. Warmer air temperatures create warmer water, which is the stressor to fish. The stressor of warmer water results in fish having a higher metabolism, creating the effect of reduced fat reserves for the migration to spawning habitat. Climate change > warmer air temperatures > warmer water > higher metabolism in fish > reduced fat reserves

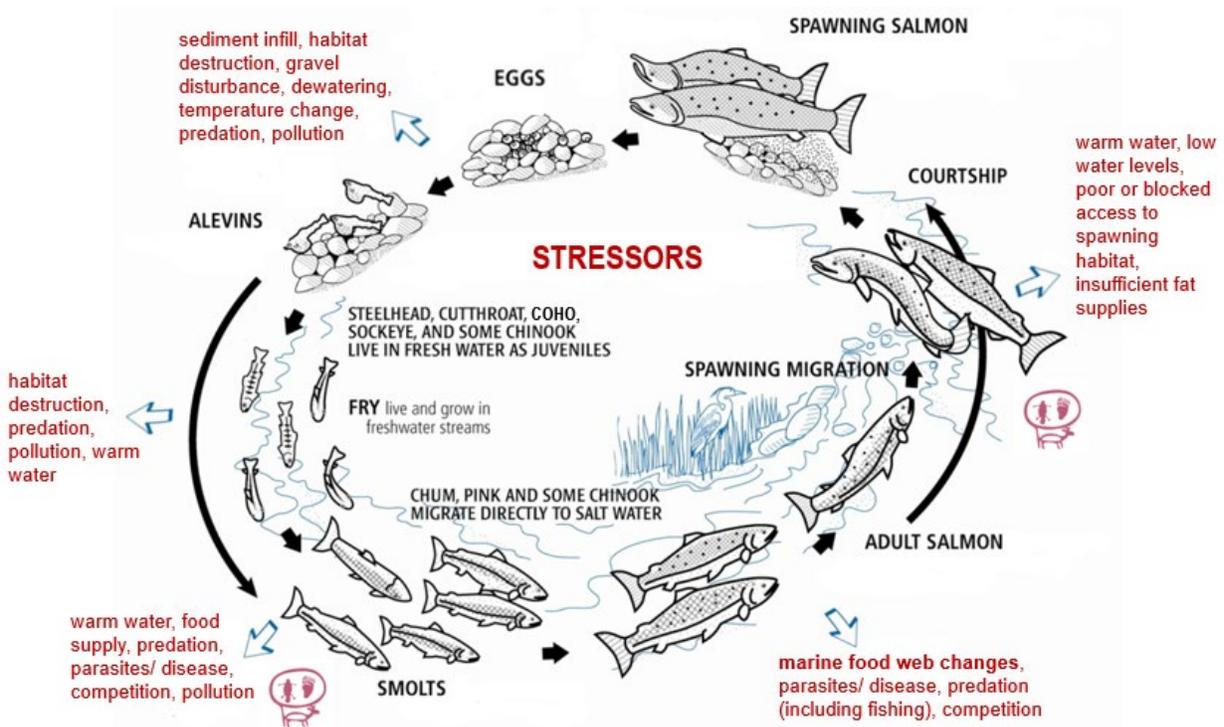
More than one cause can result in the same stressor. For example, loss of shade after clearing of riparian vegetation can also result in warmer water. A single cause can also result in multiple stressors. For example, warmer air temperatures can also create drought, which may lead to water levels too low for salmon to access spawning habitat. A single stressor can also have more than one effect. For example, warmer water can also result in creating an environment where invasive species can thrive, potentially competing with or preying on salmon and steelhead.

Figure 17 shows the major stressors known to negatively affect Fraser River salmonids during their different life stages<sup>20</sup>. The sub-sections below describe how stressors impact salmon and steelhead and identify the causes that create these stressors, including a summary of the causes that are potentially occurring at Kanaka Bar.

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<sup>20</sup> As different species and populations spend different amounts of time in freshwater versus marine environments, the importance of different stressors will vary accordingly.

Figure 17. Stressors at various stages of salmonid life cycle (adapted from SFEG 2021).



### 3.3.1. Freshwater Stressors

The freshwater stressors<sup>21</sup> described below all occur in the Fraser River watershed, and primarily impact eggs, alevin, rearing fry and out-migrating smolts. Returning spawners (adults) are also impacted by some of these stressors, although their larger size provides some additional resilience and, as they do not feed while up-migrating, food-related stressors do not apply to this life stage.

#### 3.3.1.1. Habitat loss and fragmentation

Habitat destruction (including lost access to habitat), fragmentation and degradation reduce the quantity and quality of the habitat available to salmonids. This stressor can result in insufficient quantity of specific habitat types (e.g., spawning, rearing, overwintering), creating a bottleneck for a population. Insufficient cover increases vulnerability to predators. Lack of shelter from high flows results in increased energy expenditure and can impact growth. Habitat degradation causes other stressors such as sedimentation, water quality changes, food web changes, flow changes and water temperature changes. After stressors associated with climate change, the cumulative impacts of habitat

<sup>21</sup> A good tool for viewing the relative importance of stressors to various CUs in the Fraser River watershed is the publicly available [Pacific Salmon Explorer](#), which maps the intensity of activities such as mining or road density for individual CUs (PSF 2020b).

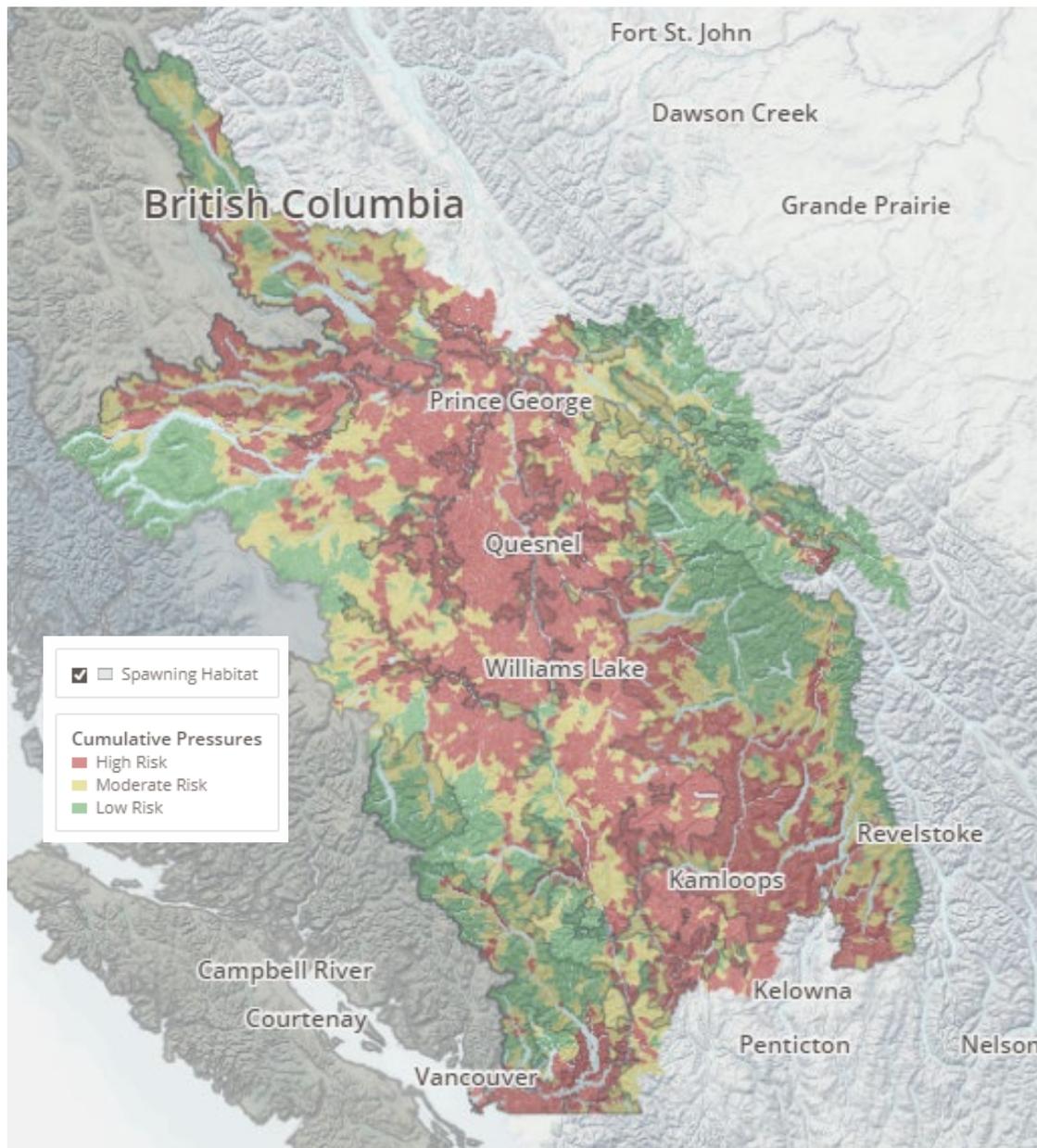
loss and alteration are likely the next most important freshwater influence on salmon and steelhead populations.

Direct habitat destruction, fragmentation and degradation is caused by infill and channelization of watercourses, clearing of riparian vegetation, placement of structures in watercourses, armouring of watercourse banks, trampling by livestock, and use of machinery in and around water. Logging, construction activities, poorly designed roads, and placer mining can cause sedimentation, affecting habitat (see Section 3.2.1.1). Dams, poorly installed culverts, and dikes can block or limit upstream fish passage, as can natural events such as the recent Big Bar rockslide. Climate change, forestry, forest fires and the pine beetle epidemic all impact the likelihood and frequency of landslides, due to heavy rain events and reduced slope stability. Barriers such as dams can also prevent the movement of gravel and other materials through a system, changing downstream habitat. The reservoirs that form upstream of dams have different habitat attributes to the streams they replaced, which can result in changed food webs, temperature, and contaminant concentrations in the reservoirs and in downstream habitat. All of these activities are occurring in the Fraser River watershed, many of which are captured by the indicators<sup>22</sup> shown in Figure 18.

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<sup>22</sup> Habitat pressure indicators include: forest disturbance, equivalent clearcut area, insect and disease defoliation, riparian disturbance, road development, water licenses, stream crossings, total land cover alteration, impervious surfaces, linear development, mining development, waste water discharges (PSF 2020b).

Figure 18 Cumulative habitat pressure indicators in the Fraser River watershed (PSF 2020b).



Construction activities can also directly kill or injure fish and eggs through crushing or sound impacts, however common mitigation measures for these impacts are generally effective. The cumulative effects of habitat loss and degradation have played a role in the decline of Fraser River salmon and steelhead (COSEWIC 2016, 2018; DFO 2018a; ECCC 2019a). Recently, the Big Bar rockslide has had

a dramatic negative impact on Fraser River salmon, particularly early spawners<sup>23</sup>, as it has blocked or impeded upstream passage to multiple at-risk CUs of Chinook Salmon and Sockeye Salmon (Government of British Columbia 2019; Scroggie 2021). Loss of forest canopy due to logging, fire and pine beetle has contributed to slope destabilization in recent years (MacDonald *et al.* 2021), which may result in more incidents similar to Big Bar in future.

Causes of habitat loss or degradation that occur in Kanaka Bar territory include historical and current logging, pine beetle infestation, and more frequent forest fires. While limited in area and magnitude, impacts associated with road development, culverts, impermeable surfaces, and construction may also be occurring in and around Highway 1 and Kanaka Bar itself. A site visit planned for summer 2021 is intended to assess any such impacts. The severity of habitat loss and degradation potentially resulting from construction and operation of the Kwoiek Creek Hydroelectric Project was assessed during that project's environmental assessment along with recommended mitigation and offsetting; to date operational monitoring has not shown negative impacts to fish populations in Kwoiek Creek (Focus 2008; Associated Environmental 2019; Chambers and Faulkner 2021). Greenhouse gas emissions contributing to climate change are also occurring in Kanaka Bar, although these inputs are quite small in a relative sense.

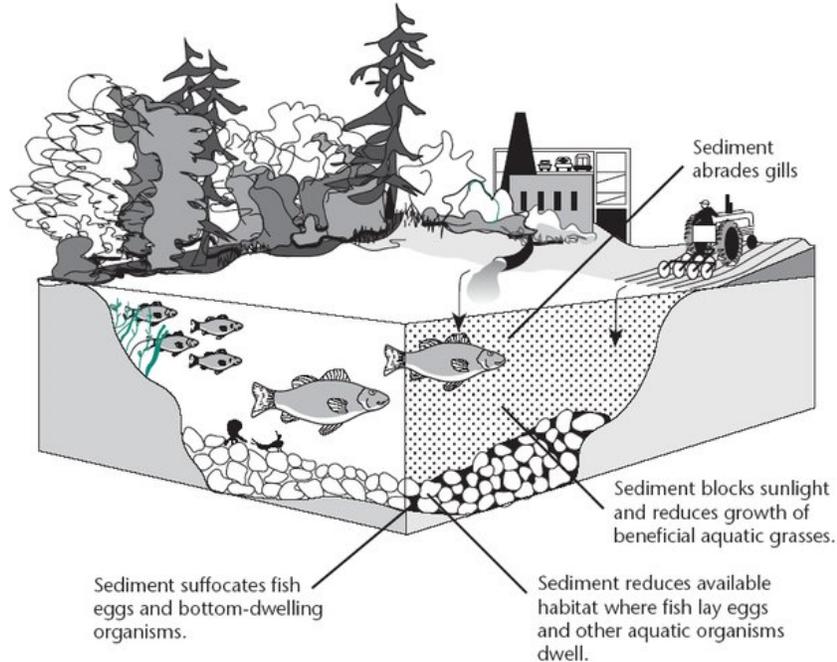
#### 3.3.1.2. Sedimentation

Physical effects of sedimentation include abrasion of gills and stress resulting in reduced growth rate and increased susceptibility to disease, with early life stages of fish more sensitive to these effects than later life stages. Sediment can also smother eggs and alevin (DFO 2000). Elevated levels of suspended sediment can disrupt feeding and cause avoidance of affected habitats, altered territoriality, and impaired homing and migration (DFO 2000). Sediment deposition can infill spawning gravel and alter habitat structures. Sediment can create food web effects, such as effects to prey (e.g., invertebrates) and their habitats, or reduced light penetration and photosynthesis (Kjelland *et al.* 2015). Figure 19 illustrates these effects.

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<sup>23</sup> Lower flows later in the summer increase passability.

Figure 19. Impacts of sediment on fish (from Lakel *et al.* 2006).



Causes of sedimentation include upland deforestation (due to logging, forest fires, and/or pine beetle disturbance), which can result in more intense runoff and hence more erosion and result in reduced slope stability. When slopes fail, large inputs of sediment can result. Poorly constructed roads or culverts and activities such as logging, construction and mining can also reduce slope stability, as well as directly disturbing soils resulting in sediment-laden runoff entering streams (Figure 20). Indirectly, more intense rain events related to climate change can increase erosion and sedimentation. Conversion of vegetation in a watershed to impermeable surfaces results in sediment-laden runoff directly entering watercourses rather than infiltrating into the ground. Similarly, conversion of riparian vegetation from trees and shrubs to mowed grass reduces the amount of runoff that can infiltrate into the ground, removing sediment and other contaminants.

**Figure 20.** Erosion and sediment transport on a deforested construction site.



Causes of sedimentation that may be occurring in Kanaka Bar territory are similar to those described in Section 3.3.1.1 above, including logging, forest fire frequency, pine beetle infestation, and, to a lesser extent, impermeable surfaces and other human development activities. A site visit planned for summer 2021 is intended to assess any such impacts.

#### 3.3.1.3. Flow Changes

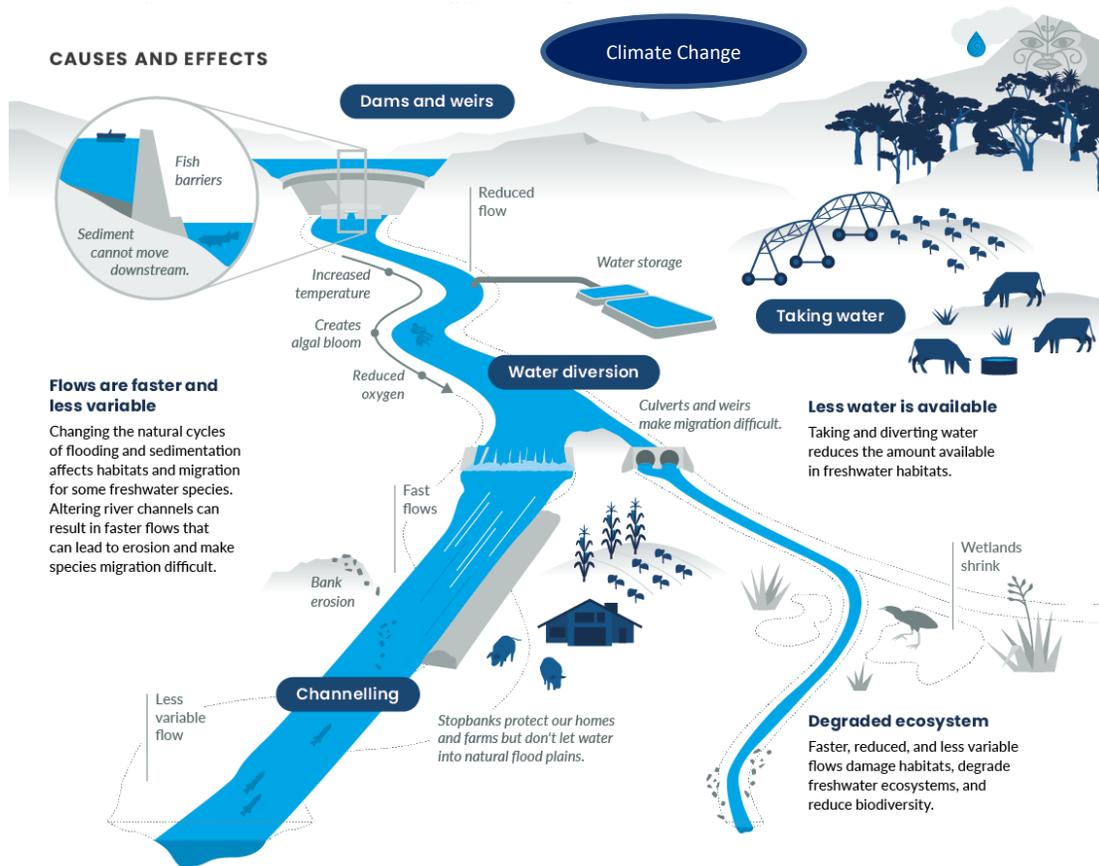
Reduced flows can reduce the total amount of fish habitat available (Figure 21). Depending upon the species and life stage, fish are more often found in a certain range of depths, velocities, substrates, and cover types, and the availability of these preferred habitat conditions varies with stream flow. Reduced flows can reduce connectivity and can result in water depths too shallow to support passage by returning adult fish, or even incubation and spawning. In extreme cases, dewatering can kill eggs and alevin. Low water levels can also leave fish at all freshwater life stages more vulnerable to predation.

Reduced flows can also result in warmer water (see Section 3.3.1.4) and/or slower, more stagnant water, both of which can lead to reduced dissolved oxygen. Changes in timing of freshet can create a mismatch with biological cycles and create repercussions in the marine environment (see Section 3.3.2.2). On controlled watercourses (i.e., with dams and controlled releases of flow), smaller freshet flows may not be sufficient to flush sediment and other materials downstream, affecting fish habitat.

Conversely, extreme weather events, increased impermeability (e.g., paved streets), and deforestation resulting from forest fires, logging, or pine beetle infestation in a watershed may result in flashier

streams. The result is both more frequent high velocity scouring flows directly affecting eggs and alevin, altering fry habitat, and reducing groundwater. Extraction of groundwater for irrigation and drinking water can also affect groundwater levels. Many of the important salmon streams in the Fraser River watershed rely on groundwater inputs to maintain summer flows and temperature.

**Figure 21. Flow change impacts (adapted from New Zealand Ministry for the Environment 2020).**

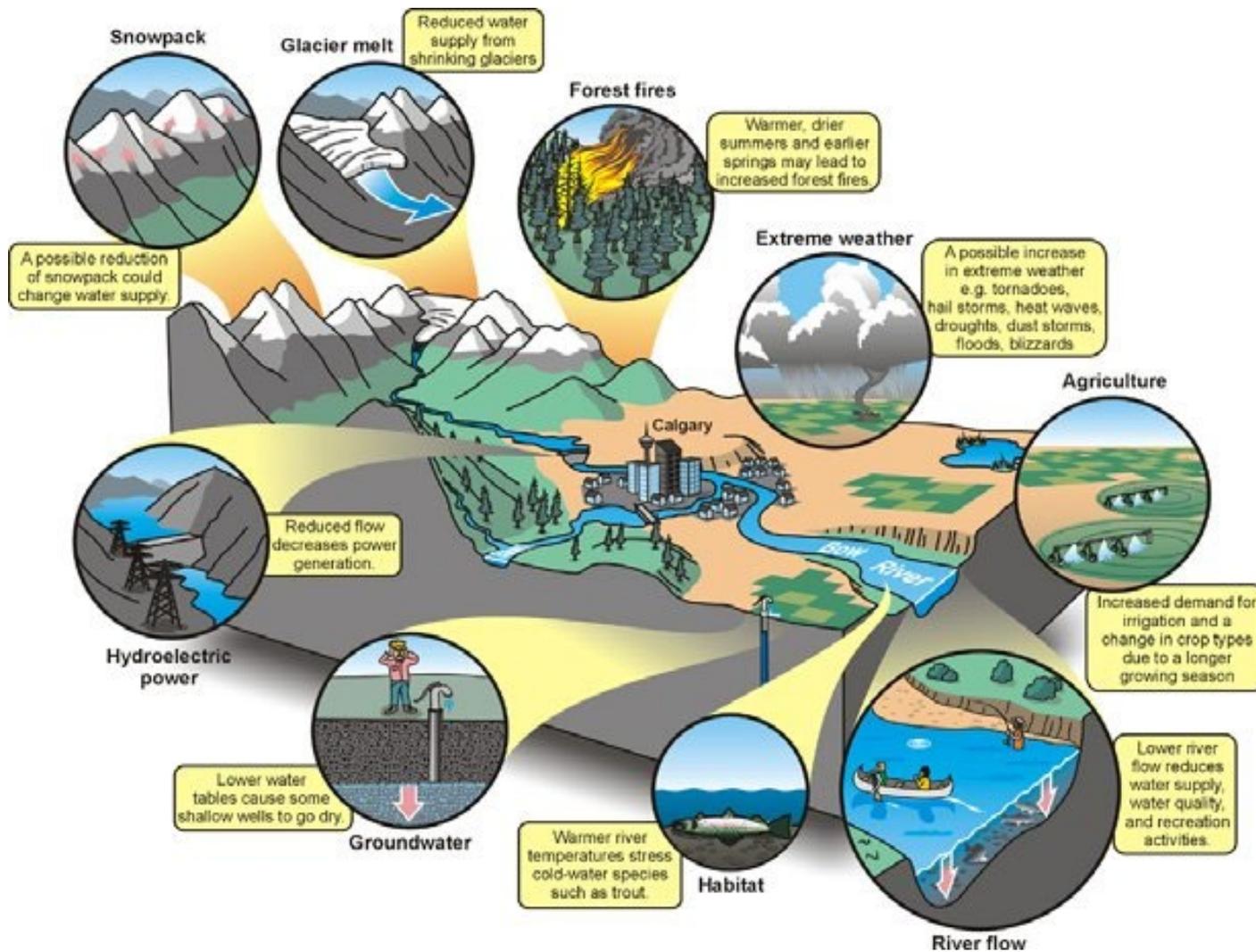


The biggest cause of flow changes is climate change (Figure 22). More frequent droughts and warmer air temperatures cause low flows, reduced groundwater tables, and earlier freshets. As climate change eliminates glaciers, reduces winter snowpacks, and results in winter precipitation falling as rain rather than snow over a larger area of BC, glacier-fed streams will become snowmelt-fed streams, and snowmelt-fed streams will start to resemble rain-fed streams<sup>24</sup>. Climate change also plays a role in increased frequency of forest fire and in the pine beetle infestation, which along with logging, increase runoff and reduce groundwater infiltration in watersheds resulting in flow changes to streams. Climate change is also responsible for more frequent extreme weather events, impacting flows in streams (Bonsal *et al.* 2019).

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<sup>24</sup> Glacier-fed streams (e.g., Kwoiek Creek) are cold and see their highest, most turbid flows in summer when glacier meltwater is the primary input. Snowmelt-fed streams are the most common in the Fraser River basin and show their highest flows in the late spring/ early summer during freshet, when mountain snowmelt is the primary input. By late summer, when the snow in the mountains is gone, these streams rely primarily on groundwater for flow. Similarly, in winter when the majority of precipitation falls and accumulates as snow, both glacier-fed and snowmelt-fed streams see low flows dominated by groundwater. By contrast, rain-fed streams (common at lower elevations in the Lower Mainland) have their highest flows in fall and winter during the rainy season.

Figure 22. Climate change impacts to freshwater flows (from Moe *et al.* 2010).



As noted, increased impermeability in a watershed also creates abrupt flow changes. Other causes of flow changes are dams and controlled releases of water, although this is more of an issue in the Columbia than in the Fraser River. Human overuse of groundwater and drawdown of aquifers can also impact stream flows.

Shifts in precipitation from snowfall to rain, more frequent and intense storm events, reduced low flows, larger extreme flood events, and earlier spring freshets are all anticipated in Kanaka Bar tributaries in the future, and many are already occurring (Kanaka Bar Band 2018). Activities/causes in Kanaka Bar territory contributing to flow changes include those related to forest cover (i.e., logging, forest fires, pine beetle), climate change and, to a small degree, impermeable surfaces. The severity of flow change impacts to Kwoiek Creek resulting from operation of the Kwoiek Creek Hydroelectric Project was assessed during that project's environmental assessment along with recommended mitigation and offsetting; to date operational monitoring has not shown negative impacts to fish populations in Kwoiek Creek. This project did not change flows from Kwoiek Creek into the Fraser River (Focus 2008; Associated Environmental 2019; Chambers and Faulkner 2021).

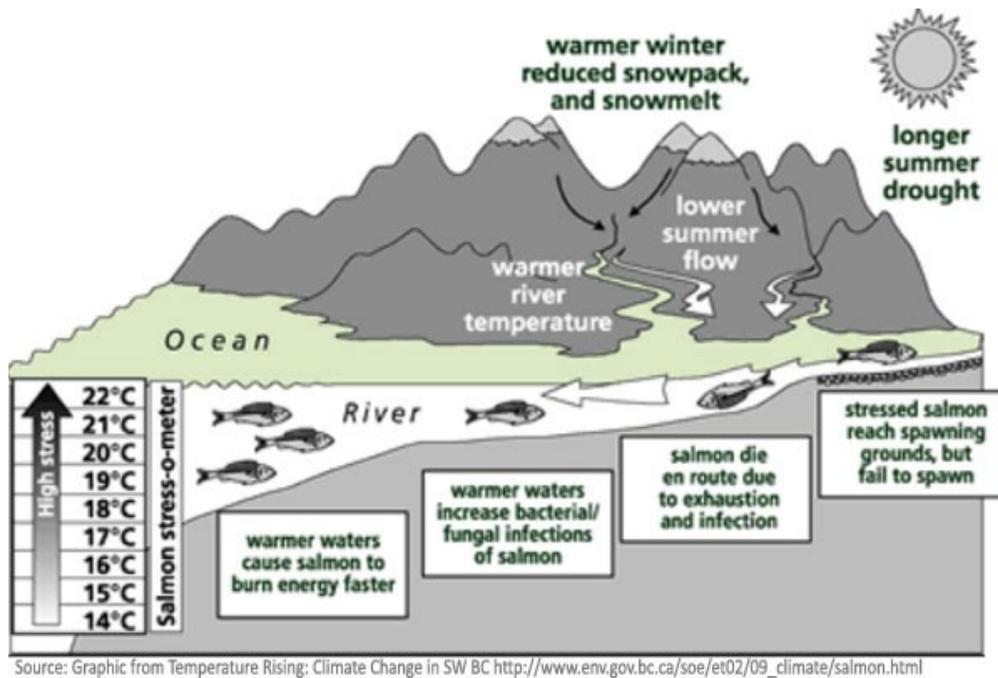
#### 3.3.1.4. Temperature Changes

Water temperatures below the optimal range of salmon and steelhead slow growth rates and productivity, however, it is high water temperatures that are have the most pronounced negative impact on Fraser River salmon and steelhead (COSEWIC 2016, 2017, 2018; ECCC 2019a). Higher than normal Fraser River temperatures occurred from 2015 to 2018; summer water temperatures are increasingly exceeding upper thermal tolerances<sup>25</sup> for salmon in assessed systems (DFO 2020b). Higher water temperatures increase fish metabolism, resulting in increased demand for food (affecting rearing fry), and in burning through fat stores more quickly (affecting overwintering fry and returning spawners). Water temperatures above the optimal range stress fish, leaving them more susceptible to disease and parasites, contaminants, and other stressors. The recent years of high summer river temperatures have been associated with high levels of migration mortality in some populations (COSEWIC 2017). Concentrations of dissolved oxygen are inversely related to water temperature, as cold water can hold more dissolved oxygen than warm water. In extreme cases high temperatures (and associated low dissolved oxygen concentrations) can result in fish kills. Salmonids in particular are sensitive to temperature changes (Richter and Kolmes 2005) and dissolved oxygen concentrations (MOE 1997). Increased water temperatures can also create a more favourable environment for exotic predators and competitors, and for diseases and parasites (Figure 23).

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<sup>25</sup> Temperatures above 18-20°C negatively impact up-migrating adults (MacDonald *et al.* 2021). Optimal temperatures for individual species and life stages can be found at [temperature-or.pdf \(gov.bc.ca\)](https://www2.gov.bc.ca/gov2/temperature-or.pdf).

Figure 23. How water temperatures affect fish.



Climate change is the primary driver of increased water temperatures, but on a local scale, removal of shade (i.e., through riparian clearing) and changes in flow (i.e., slowed flows, shallower water levels, and/or loss of groundwater inputs) can also create increased temperatures. Increased water temperature has been identified as a key contributor to salmon declines at all life stages, in both marine and freshwater environments (MacDonald *et al.* 2021). Activities in Kanaka Bar territory that may contribute to this stressor are carbon emissions and riparian clearing.

#### 3.3.1.5. Contaminants

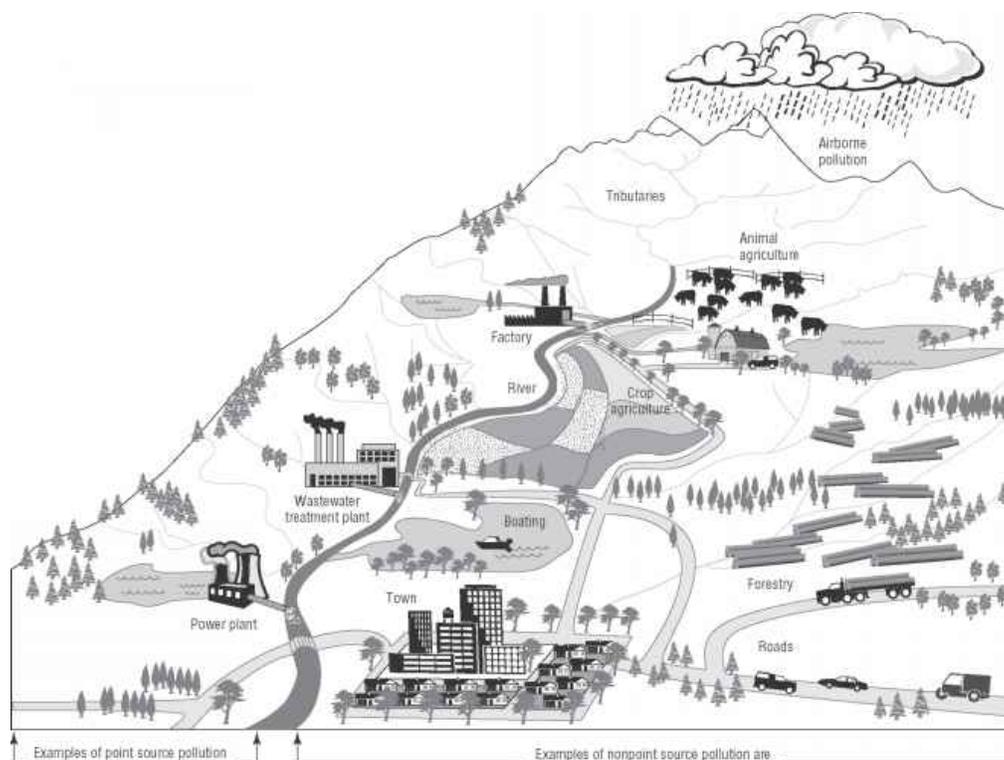
Freshwater contaminants in the Fraser River watershed include sediment (see Section 3.3.1.2), nutrients, metals, phenols, hydrocarbons, fluids from equipment (e.g., antifreeze), concrete, cleaning products and a number of other substances not regularly monitored such as hormone mimicking substances, chlorinated compounds, pharmaceuticals and nanoparticles (Cohen 2012b). These contaminants can cause acute effects to fish such as mortality or injury, and/or chronic effects to fish health, with the severity of effect depending on the contaminant, the magnitude of release, and the duration of exposure.

The Cohen Report specifically evaluated the potential effects of water quality in the Fraser River Basin on Sockeye Salmon, the results of which can be extrapolated to other salmonid species that spend a similar amount of time in freshwater. The evaluation was constrained by data gaps, but the results suggested that while not the primary factor, exposure to freshwater contaminants likely had contributed to the decline of Sockeye Salmon over the previous 20 years (MacDonald *et al.* 2011). However, it can be difficult to determine a clear cause and effect for any one contaminant source

(Ross *et al.* 2013). More recent overviews of Fraser River water quality upstream of Hope were not available.

Contaminants can enter the water through accidental spills<sup>26</sup> (e.g., railway derailments, the Mount Polley mine tailings dam breach), permitted effluent releases<sup>27</sup> (e.g., pulp and paper mills, mines, municipal wastewater), groundwater leaching from contaminated sites (e.g., underground heating oil tanks, old gas stations), and through non-point source inputs (e.g., runoff from paved roads and agricultural fields). Contaminant inputs at Kanaka Bar are likely primarily non-point source in nature, with hydrocarbons, metals and tire particulates from highway runoff a key concern (Chow *et al.* 2019; Tian *et al.* 2021). Kanaka Bar Band has identified creosote railway ties (a source of hydrocarbon contamination) and a 1997 train derailment that resulted in inputs of hydrocarbons, fluoride and sulphur into the Fraser River as potential point sources of contamination in their territory (AGRA 1997; Michell 2020, pers. comm.), and have expressed concern about the lasting downstream effects of the 2014 Mount Polley mine tailings dam breach, which left behind a potential source of remobilized metals contamination in the form of spilled tailings (Byrne *et al.* 2016).

**Figure 24. Examples of point and non-point sources of contaminants (from GAO 2000).**



<sup>26</sup> Information about recent and historical spill incidents in BC is publicly available at [Spill incidents - Province of British Columbia \(gov.bc.ca\)](https://www2.gov.bc.ca/gov/content/safety/spill_incidents).

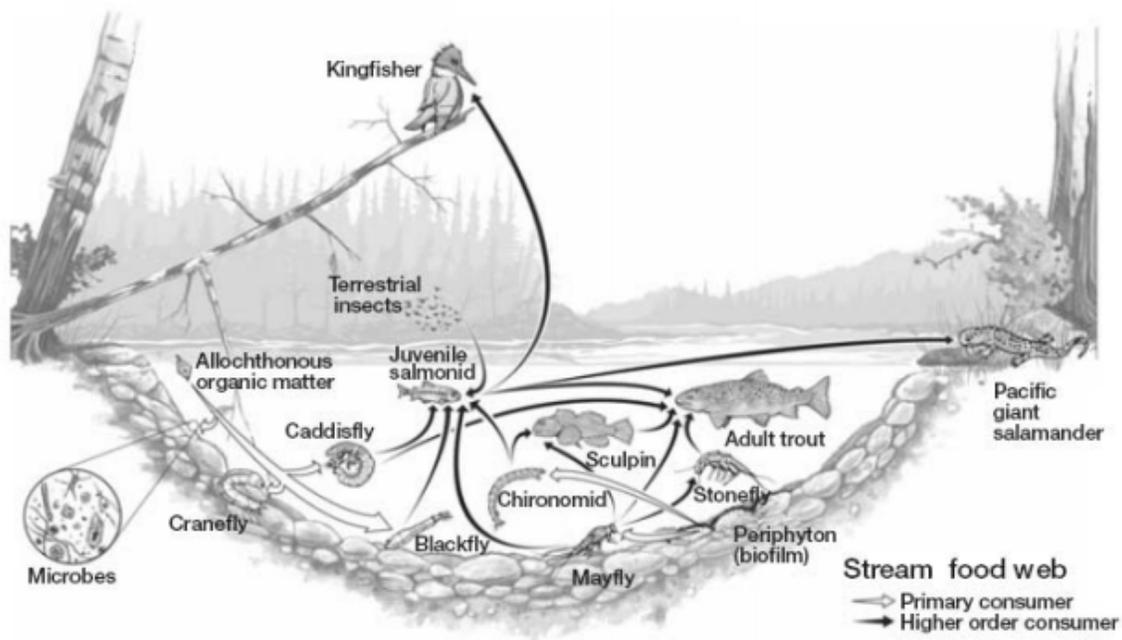
<sup>27</sup> Information about discharge permits in BC is publicly available at [Search Waste Authorization Status & Documents - Province of British Columbia \(gov.bc.ca\)](https://www2.gov.bc.ca/gov/content/safety/search_waste_authorization_status_documents).

### 3.3.1.6. Food Supply

Primary productivity (i.e., aquatic photosynthesis) is supported by nutrient inputs from the surrounding watershed (Figure 25). Primary production supports secondary productivity (e.g., macroinvertebrates) that in turn provides food for higher trophic levels such as fish. Removal or alteration (e.g., change in species composition) of the food supply, including plants and organic debris that fall into a watercourse, can cause changes to the aquatic community (DFO 2018b). Upland and riparian vegetation can uptake nutrients and other compounds in runoff, and thus influence nutrient concentrations in watercourses. Nutrients are essential for maintaining productivity and community structure, but high concentrations of nitrogen and phosphorus can cause an increase in algae to levels that harm water quality, food resources and habitat for fish and other aquatic life.

Light is one of the primary factors limiting the growth and reproduction of primary producers. Loss of aquatic and riparian vegetation, could increase light penetration, leading to increased productivity. Changes to substrate composition can result in changes to aquatic vegetation communities (including periphyton), as many species are adapted to a specific substrate size class (Wetzel 2001). The new community may be more or less productive than the one it replaced.

**Figure 25.** A simple food web, typical of BC salmon streams (from Macneale *et al.* 2010).



Changes in food supply can result from physical habitat changes, sedimentation, flow changes, temperature changes, and from the inputs of certain contaminants (i.e., excess nutrients). Reduced food supply impacts rearing fry, both directly through starvation and indirectly when the stress of

insufficient food leaves them susceptible to other stressors. Changes in food supply can also create a more favourable environment for exotic predators and competitors, and for parasites.

Causes of habitat changes, sedimentation, flow changes, temperature changes and contaminant inputs are discussed in the previous five sub-sections. Specifically, with regards to contaminant inputs, municipal wastewater, agricultural runoff, and access to streams by livestock are common causes of nutrient inputs. A site visit to Kanaka Bar territory in summer 2021 is intended to identify potential causes related to this stressor.

#### 3.3.1.7. Predation and Competition

Freshwater predators to salmon and steelhead fry and smolts include adult salmonids (e.g., Bull Trout, Rainbow Trout, kokanee), Northern Pikeminnow, sculpins, birds such as herons and mergansers, and mammals such as mink. Introduced species such as Largemouth Bass may also predate on and compete with juvenile salmon and steelhead. Introduced species can also alter food webs to the detriment of native species (COSEWIC 2016). The current low numbers of many populations of Fraser River salmon and steelhead may increase the impacts of predation, as the mitigating effects of predator swamping<sup>28</sup> during outmigration are reduced (Baumann 2015).

Competition with hatchery fish is also possible, particularly where habitat and food supply are limited. Hatchery fish aren't exposed to predators, so tend to be more reckless and aggressive when it comes to going after food, which could be an advantage where food is limited (ECCC 2019a).

Human harvest of Fraser River salmon and steelhead in freshwater consists of Indigenous and recreational fisheries. In recent years allowable harvests for both of these fisheries have been severely curtailed (DFO 2020b). However, given the drastic drop in productivity in some CUs, even modest fishing can create a negative impact (COSEWIC 2016). Catch and release recreational fisheries can result in stress, and in some cases, fish mortality if fish are improperly handled (Dempson *et al.* 1998; COSEWIC 2016; Twardek *et al.* 2018).

It is unknown whether introduced species or hatchery fish are negatively impacting wild salmon and steelhead in Kanaka Bar territory. The Kanaka Bar Band has rights to an Indigenous fishery but have not exercised these rights in recent years out of conservation concerns, although recreational fishing by others in their territory has continued.

#### 3.3.1.8. Disease and Parasites

Freshwater disease and parasites have not received as much attention as marine pathogens (Section 3.3.2.6) but are certainly a potential cause of mortality for fish at all life stages. Generally younger, smaller fish (i.e., fry and smolts) are more susceptible than adults. High water temperature and pollution can stress fish and reduce immune function; high water temperatures can also increase

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<sup>28</sup> Predator swamping refers to a prey evolutionary strategy utilized by salmon where prey occur at high population densities during vulnerable periods (e.g., out-migration). Predators can only consume a finite amount of prey during this time period, allowing some individuals to survive and reproduce (Furey *et al.* 2016).

parasite replication rate (Cohen 2012b). Disease and parasites are more of a concern where fish are confined to small spaces (e.g., small streams, spawning channels, hatcheries). There has not yet been evidence of pathogen transfer from hatchery to wild fish, but it is possible as hatchery conditions could promote disease as compared to wild (ECCC 2019a).

Potential causes of increased disease and parasite loads at Kanaka Bar are currently limited to those related to temperature changes and contaminants.

### 3.3.2. Marine Stressors

There is growing consensus that low marine survival, related to marine food availability, is the dominant reason for recent declines in Fraser River salmon and steelhead productivity (MacDonald *et al.* 2021). Early marine survival does appear to be more important than later life-history stages (ECCC 2019a), with marine conditions near the point of ocean entry correlated with overall survivorship (Riddell *et al.* 2013).

Marine stressors affect smolts and adult Fraser River salmon and steelhead while they are in estuary, nearshore, and offshore habitats. With the exception of climate change, none of the causes of these stressors occur in Kanaka Bar territory, however they are presented for a thorough understanding of the causes of Fraser River salmon and steelhead declines.

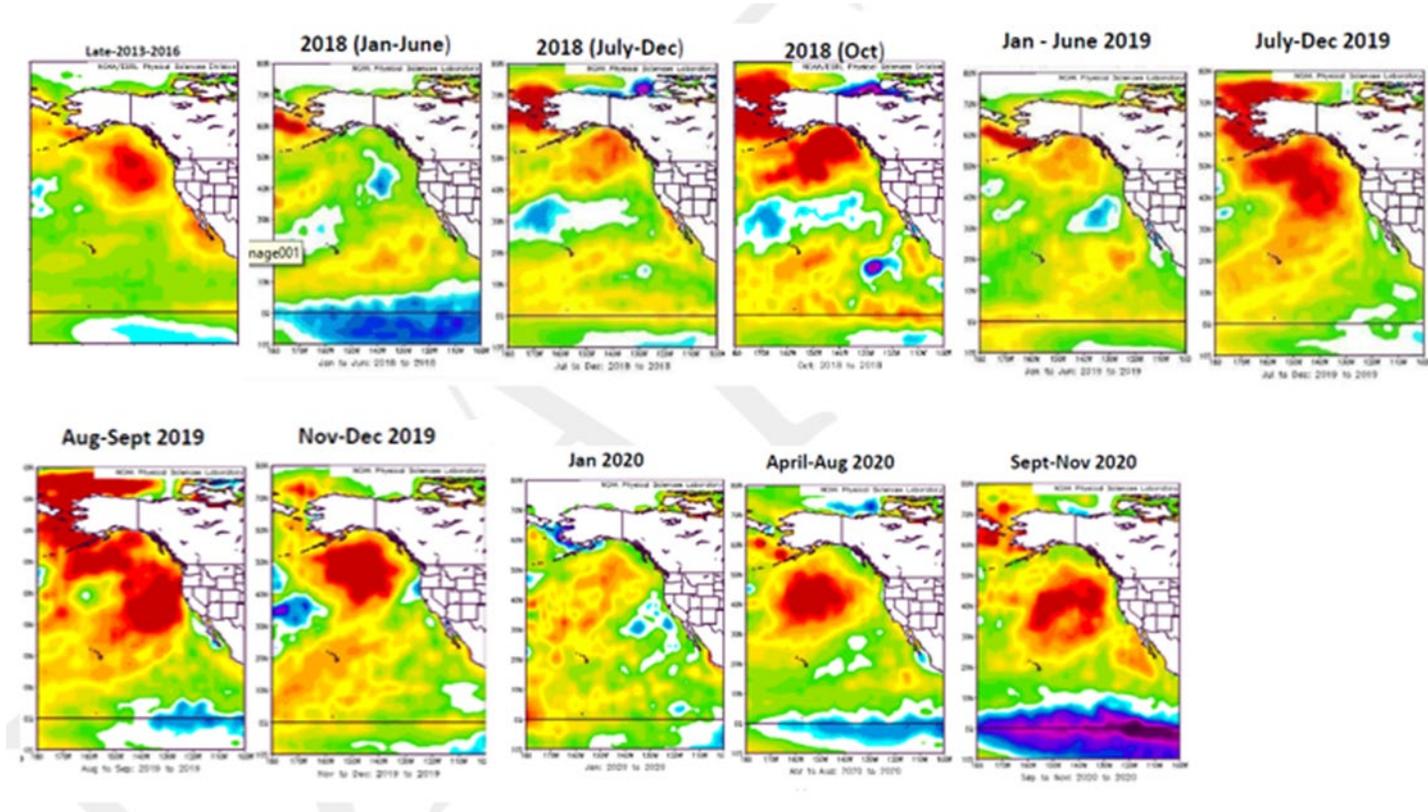
#### 3.3.2.1. Water Temperature

Like freshwater, ocean water is warming as the result of climate change. Warmer water affects the food web (see Section 3.3.2.2) and is changing ocean current patterns. For example, there has been a spring/summer marine water heatwave in the northeastern Pacific for the last few years known as “the Blob” (Figure 26) that counter-acted the effects of La Niña<sup>29</sup> in 2020. Warmer waters are also changing species composition, as southern fish species expand their range northwards (MacDonald *et al.* 2021).

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<sup>29</sup> La Niña is a coupled ocean-atmosphere phenomenon that forms the cooler phase of a broader climate pattern. During a La Niña, eastern equatorial parts of the central Pacific Ocean are 3 to 5 C cooler than normal, resulting in cooler temperatures and more rainfall in the northeastern Pacific and in the Fraser River watershed, i.e., better conditions for Pacific salmon and steelhead (MacDonald *et al.* 2021; NOAA 2021).

Figure 26. Spring/ summer heatwave in the northeastern Pacific, 2013-2020. Yellow and red show temperatures above normal, blue and purple show temperatures below normal. Note cool water related to La Niña in the bottom of the last image (from MacDonald *et al.* 2021).



In estuaries, warmer water has many of the same effects as in freshwater, influencing dissolved oxygen levels and, in shallower areas where optimal temperatures for smolts may be exceeded, directly stressing fish and making them more susceptible to other stressors.

#### 3.3.2.2. Food Supply

Northern zooplankton typical of cooler water are relatively large, with high fat reserves. Fraser River salmon and steelhead that are supported by<sup>30</sup> these more nutritious zooplankton are more likely to survive and are larger at maturity, with higher fat reserves to sustain them for their upstream migration to spawning habitat. Smaller, less nutritious zooplankton with smaller fat reserves are more common when water is warmer, and have dominated northeast Pacific food webs in recent years (MacDonald *et al.* 2021).

Earlier warming, and an earlier Fraser River freshet, also impact the timing of zooplankton peak biomass in the Strait of Georgia, which is now almost two months earlier than in the 1970s (Johannessen and McCarter 2010). Late migrating smolts may now miss the peak zooplankton biomass.

#### 3.3.2.3. Contaminants

Marine and estuarine contaminants and their impacts on fish are even less well understood than those in freshwater. Contaminants in marine and estuarine environments are from freshwater inputs and from spills and discharges from ships at sea. Plastic pollution is also a concern in marine environments (NOAA 2020).

#### 3.3.2.4. Habitat destruction and degradation

Estuarine habitat destruction and degradation affects availability and quality of critical rearing habitat for smolts of all Fraser River salmon species (Chalifour *et al.* 2019). The Fraser River estuary has been heavily altered by human activities including log booms, armoured shorelines, and dikes, with less than 30% of its habitat intact (Natural Resources Canada 2004; Kehoe *et al.* 2020).

#### 3.3.2.5. Predation and Competition

Predation, by seals and sea lions in particular, is a potential contributing factor towards Fraser River salmon population declines (Riddell *et al.* 2013). Seal and sea lion populations along the British Columbia coast were artificially depressed for much of the last century by commercial harvesting and predator control programs, but numbers began to rebound after regulatory protection in the 1970s (Olesiuk 2010). Seals, sea lions and killer whales are currently the largest consumers of Chinook Salmon by biomass (Trites and Rosen 2018, 2019), and a number of commercial and Indigenous fishers suspect that seal predation is now negatively impacting numbers of Chinook Salmon (Rasmussen 2018; Smart 2019; Hamelin 2019). Some marine mammal and fisheries biologists are not

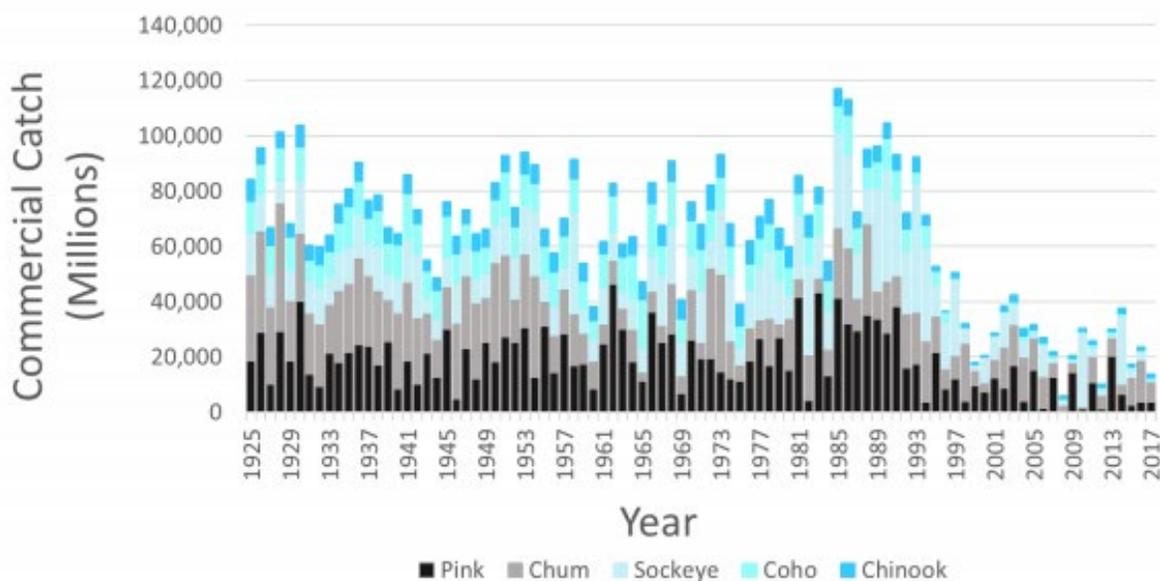
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<sup>30</sup> Either as primary consumers (i.e., directly feeding on zooplankton) or secondary consumers (i.e., feeding on fish that eat zooplankton), depending on life stage.

so certain, as linkages between seal and sea lion abundance and salmon declines are not well understood and data on seal and sea lion diet is incomplete (Trites and Rosen 2019). It does seem clear that on a small scale, these marine mammals may have an impact on individual runs (Trites and Rosen 2019). Research has shown that individual seals can become specialists for salmon smolts at river mouths and in estuaries where they are easily captured (Wright *et al.* 2007; Graham *et al.* 2011; Allegue 2017), particularly where regular hatchery releases provide a more reliable food source than less predictable natural sources (Yurk and Trites 2000). The current low numbers of many populations of Fraser River salmon and steelhead may exacerbate the impacts of predation, as the mitigating effects of predator swamping during outmigration are reduced (Baumann 2015).

Humans are also predators of Fraser River salmon and steelhead, and past overfishing has been identified as a potential cause of population declines (Riddell *et al.* 2013; COSEWIC 2016, 2017). Harvest and exploitation rates of salmon in BC have declined sharply since the 1990s (Figure 27), but given corresponding declines in productivity, it is possible that many stocks remain over-exploited even at these reduced harvest rates (COSEWIC 2016; ECCC 2019a). By-catch, with a fishery targeting healthy CUs or hatchery stock, can also negatively impact co-migrating weaker CUs (COSEWIC 2016, 2017).

**Figure 27.** Canadian commercial catch numbers (note this includes all BC salmon populations, not just Fraser River) for all five species of Pacific salmon (from Grant *et al.* 2019).



There has been some debate on the negative impact hatchery fish may have on wild salmon survival, (Riddell *et al.* 2013). Hatchery fish are often larger than wild fish and may outcompete or prey on

native fish. Straying and hybridization are also concerns, as are disease and parasites and carrying capacity of the environment into which fish are released (Poirier and Olson 2017). A number of these issues are due to poor historic practices and can be mitigated with better technology (e.g., sterilizing hatchery releases) and methods (e.g., timing and location of release, staggering releases).

Sockeye Salmon and Pink Salmon may also compete with each other, negatively impacting Sockeye Salmon when Pink Salmon are relatively more abundant (COSEWIC 2017).

### 3.3.2.6. Disease and Parasites

Parasites and disease are naturally present in Fraser salmon and steelhead populations, but have a more severe impact on fish already stressed by reduced food supply, warmer water and contaminants (COSEWIC 2016, 2017; ECCC 2019a), and, in turn, stress from parasites and disease can make fish more vulnerable to additional stressors. Harmful algal blooms can also cause mortality in Fraser River salmon and steelhead, and have been increasing in frequency and intensity worldwide (Cohen 2012b). Parasites and disease are more easily transmitted where host populations are more concentrated (e.g., in hatcheries or in fish farms), and there has been considerable concern about the potential for parasites (particularly sea lice) and disease to be transferred from fish farms to wild salmon smolts as they migrate past (Morton *et al.* 2005; Krkošek *et al.* 2011; Godwin *et al.* 2021).

### 3.3.3. Summary

The five species of Pacific salmon and steelhead migrating through Kanaka Bar are made up of numerous unique populations, each with their own life history strategy and run timing. With few exceptions, these populations have seen steep declines in abundance over the past few decades, and many populations are in serious risk of extinction. The causes of these declines are numerous and interconnected, but can be summarized as follows:

- *Climate change, which has induced or worsened water temperature changes, food web changes (particularly in the marine environment), flow changes, frequency of forest fires, pine beetle infestation of forests, and an expansion of range for southern species of fish, wildlife, and vegetation.* The risk<sup>31</sup> associated with this cause is high for most populations of Fraser River salmon and steelhead. While Kanaka Bar's contributions to climate change are relatively small, actions can be taken to address these effects.

<sup>31</sup> Risk to Fraser River salmon and steelhead survival was calculated as per the risk matrix below.

		Risk Exposure		
		High	Medium	Low
Probability	High	Medium	High	High
	Medium	Low	Medium	High
	Low	Low	Low	Medium
		Low	Medium	High
		Impact		

- *Habitat loss and fragmentation related to human impacts, including forestry, mining, urban development, hydroelectric facilities, agriculture, roads, and other land uses.* The risk associated with this cause varies by population (see Appendix B and Figure 18), ranging from medium to high for most populations of Fraser River salmon and steelhead. Logging and habitat impacts associated with development activities are occurring in Kanaka Bar territory. While again these are small in magnitude compared to impacts throughout the watershed, Kanaka Bar can take actions to address these impacts in their territory.
- *Predation by humans (i.e., fishing pressure) and others (e.g., pinnipeds, such as seals), which has a disproportionate effect on small salmon populations.* The effect of overfishing during the 1980s and 1990s, for example, negatively impacted many populations of Fraser River salmon and steelhead. The current risk associated with this cause ranges from low to high, depending on the population. Kanaka Bar has a small impact on current fishing take but does have the power to take action on this cause.
- *Disease, parasites, and competition related to aquaculture and hatcheries.* The risk to Fraser River salmon and steelhead associated with this cause likely ranges from low to medium, but there is some uncertainty in that determination. There are currently no aquaculture or hatchery operations within Kanaka Bar territory.
- *Natural disasters such as the recent Big Bar landslide that cause obstruction of fish migration.* The risk associated with this cause is high for populations of salmon and steelhead that spawn upstream of Big Bar, particularly early-season spawners. While located nearby, the Big Bar slide is not located on Kanaka Bar territory, although Kanaka Bar could join the ongoing efforts to restore passage through the slide area.
- *Contaminants from both point and non-point sources throughout the Fraser River watershed.* The risk to salmon and steelhead from this cause has been previously concluded to be low, but there are significant data gaps and uncertainty in that determination. There are likely non-point sources of water pollution on Kanaka Bar territory (e.g., road runoff), that, while small in relative magnitude to the watershed as a whole, could be addressed.

With the likely exception of climate change, none of these causes on their own are enough to produce the current declines in Fraser River salmon and steelhead, although previous overfishing played a large role in decreasing some populations to a point where they lack the resilience to withstand other pressures. While there is a general consensus that low marine survival is driving population declines (MacDonald *et al.* 2021), there is also evidence that freshwater conditions may be important. Northern Sockeye Salmon and Coho Salmon populations are doing better than their southern counterparts, and for the most part Fraser River salmon populations that spend little time in freshwater (e.g., river-type Sockeye Salmon, ocean-type Chinook Salmon, Pink Salmon) have not shown the same declines as other populations, or at least not as recently (Grant *et al.* 2019; Davis and Xu 2021). So, there likely is

a benefit to addressing freshwater impacts where possible, especially to populations that spend more time in that environment.

#### 4. RECOMMENDATIONS

The contents of this report are based upon a literature review, and upon communication with Chief Patrick Michell of the Kanaka Bar Band. As such, it provides a first, big picture view of the causes of Fraser River salmon and steelhead declines and potential actions to address those causes. A critical next step to identify site-specific environmental trends, causal factors, and appropriate actions that the Kanaka Bar Band can take will be a site visit with broader community engagement. The primary intent of the site visit will be to hear Traditional Knowledge focused on a) changes in the Fraser River and its inhabitants over time (including whether some species can serve as ‘indicator species’), and b) the implications of environmental changes to the cultural use of these species. The site visit is also intended to provide a first-hand sense of place, and to view potential contaminant sources with a view to informing future water quality monitoring studies.

Additional specific recommendations for mitigation and monitoring are provided in the sub-sections below.

##### 4.1. Mitigation

The stressors negatively affecting salmon and steelhead in the Fraser River are multiple, interactive, and many are non-point-source in nature. This means that there is no one easy fix, and individual mitigation measures are unlikely to result in measurable results. This is not cause for despair, however. Just as stressors are cumulative, so too is mitigation. The Kanaka Bar Band has the opportunity to both lead by example and to exert political pressure on others. The mitigation and monitoring efforts described below are a drop in the bucket when compared to the enormity of the problems faced by Fraser River salmon and steelhead, but many drops fill a bucket. At an individual and community level these drops include:

- Continue to reduce the community’s greenhouse gas emissions through use of renewable energy, retrofitting buildings to improve energy efficiency, and encouraging sustainable transportation choices (Kanaka Bar Band 2018, 2020).
- Implement the recommendations in the Kanaka Bar Indian Band Climate Change Vulnerability Assessment (Kanaka Bar Band 2018).
- Improve stormwater runoff management. Capture and treat rainfall and road runoff through natural infrastructure (e.g., swales, phytoremediation) and design (e.g., permeable hard surfaces), particularly for new developments.
- Ensure local wastewater is being treated to a high standard prior to discharge and encourage upstream and downstream communities to do the same.

- Investigate potential point sources of pollution (e.g., historical railcar derailment, creosote associated with railway line) and remediate if necessary.
- Enforce high standards for future construction and land clearing within Kanaka Bar territory with regards to erosion and sediment control, changes in stormwater runoff patterns, and protection of riparian vegetation.
- Enforce sustainable forestry practices<sup>32</sup> within Kanaka Bar territory, including protection of riparian areas, maintenance of slope stability and restoration of degraded habitat.
- Continue to refrain from fishing until stocks are restored and join with other First Nations<sup>33</sup> in pressuring DFO for even more stringent fish harvest limits for all users.
- Investigate salmon and steelhead enhancement opportunities in Kanaka Bar territory.
- Investigate the potential for aquaculture to meet short to medium-term food needs.

Cold water storage for later release during summer low flows is a mitigation measure that has been proposed in watersheds such as the Cowichan (DFO 2017) and Coldwater (Summit 2002; DFO 2020d), with the intent to both augment low flows and reduce high summer temperatures. However, these are considerably smaller streams than the Fraser River; the relative volumes of water in the Fraser River compared to potential storage in the headwaters of Kwoiek Creek or other Kanaka Bar tributaries means that such cold water releases would likely not significantly change Fraser River water temperatures or water levels, at least not over any significant distance. These small changes might nevertheless be incrementally helpful and, were this a simple and inexpensive mitigation measure, it may warrant investigation. However, this measure is technologically complex, would require permitting, and may affect other species resident to the headwaters where the storage may occur. It is unlikely that the benefit would outweigh these costs unless this were a coordinated effort among many sub-watersheds in the Fraser River basin.

Perhaps the greatest impact Kanaka Bar can have on the causes of salmon decline is through modelling good environmental stewardship for other First Nations and small communities and through political pressure with regards to:

- Carbon emission reductions,

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<sup>32</sup> The Canadian Standards Association (CSA), Sustainable Forestry Initiative (SFI) and Forest Stewardship Council (FSC) each provide criteria and guidance for forest management practices (FSC 2005a,b, 2018; SFI 2015; CSA 2016) that exceed the requirements of provincial regulation (i.e., the *BC Forest and Range Practices Act* and the *Private Managed Forest Act*).

<sup>33</sup> E.g., T'silhqot'in Nation along with T'lesqox (Toosey), Yunesit'in (Stone), T'petinqox (Anaham), T'sideldel (Alexis Creek), ?Esdilagh (Alexandria) and Xenit Gwet'in (Nemiah) also forfeited their right to harvest fish in 2020 and have asked DFO to implement stronger restrictions on exploitation (Dyok 2020), a recommendation echoed in formal First Nations' feedback to DFO regarding 2021 fisheries management planning (DFO 2021).

- Municipal wastewater treatment in upstream communities, and
- Rehabilitation of historical logging impacts (e.g., culverts, roads, reforestation of tributary stream watersheds).

#### 4.2. Monitoring

Monitoring of environmental variables in the Fraser River at Kanaka Bar can both provide information on conditions in Kanaka Bar territory and contribute to the greater body of knowledge for the Fraser River as a whole. The results of monitoring programs can describe the effectiveness of local mitigation measures, providing encouragement to other small communities considering similar stewardship actions. Similarly, monitoring program results can highlight potential upstream impacts, lending weight to requests by Kanaka Bar that upstream communities take action.

Monitoring programs at Kanaka Bar that may provide valuable information include:

- Implement a water quality monitoring program intended to measure conditions in the Fraser River and Kanaka Bar tributaries, including monitoring locations in the Fraser River both above and below Kanaka Bar territory. This monitoring program should include further investigation of existing water quality data (e.g., Mount Polley effects monitoring, processing of raw ECCC data), in order to scope monitoring program parameters and synthesize existing and site-specific data.
- Monitor numbers of migrating salmon and steelhead (adults and/or smolts) to better understand survivorship and timing of stocks.
- Implement a water quality monitoring program intended to measure the impacts of point and non-point source pollution in Kanaka Bar territory and track the effectiveness of any mitigation of those pollution sources.
- Implement an aquatic invasive species monitoring program, educating community members in fish identification, and setting up a protocol for preserving samples and reporting any new species encountered.

Monitoring will be more effective if it is coordinated with other groups, particularly if data collection and analysis methods are designed to integrate with ongoing monitoring (e.g., the provincial Environmental Monitoring System (EMS) and existing Water Survey of Canada (WSC) monitoring). The University of British Columbia's (UBC) Centre for Indigenous Fisheries was launched in 2021 with the intent of "building a community of Indigenous scholars and allies that engage in community-based research" that aims to "support the management and protection of culturally significant fish and fisheries in ways that uphold and respect Indigenous rights, values, practices, and knowledge systems" (UBC 2021). This UBC program may be a good starting place for coordination of monitoring efforts.

## 5. CLOSING

The majority of salmon and steelhead populations that pass through Kanaka Bar territory are suffering serious declines, the result of numerous and interrelated causes, chief among them climate change. This is not a new story: First Nations in British Columbia have been raising the alarm about the consequences of environmental degradation for decades (George 1967) and continue to do so (Kanaka Bar Band 2019), as have scientists (Cohen 2012c; COSEWIC 2016, 2017, 2018; ECCC 2019a; Grant *et al.* 2019). Mitigation possible on Kanaka Bar territory is small in comparison to the scope of these causes, but that does not mean such actions are futile. Small actions by the many, and big actions by elected officials, will be necessary in order to tackle such problems. Kanaka Bar Band can lead by example when it comes to carbon emissions, non-point source pollution, and sustainable land and resource use, and can monitor conditions in their territory to encourage others to take both the small and large actions required.

## REFERENCES

- AGRA. 1997. Environmental Assessment CN Train Derailment Mile 106.12 Ashcroft Subdivision Kanaka Bar IR 2 11.75 km south of Lytton, BC. Consultant's report prepared for Canadian National, Kanaka Bar Indian Band, Siska Indian Band by AGRA Earth & Environmental Ltd. (AGRA).
- Allegue, H. 2017. Variability of harbour seal (*Phoca vitulina*) foraging behaviour during out-migrations of salmon smolts.
- Associated Environmental (Associated Environmental Consultants Inc.). 2019. 2018 (Year 5) Summary Report Kwoiek Creek Hydroelectric Project Long-term Monitoring Plan. Consultant's Report Prepared for Kwoiek Creek Resources Limited Partnership by Associated Environmental Consultants Inc. (Associated Environmental). March 2019.
- Baker, R. 2020. "Quite dire": Fraser River sockeye salmon run expected to be worst ever recorded. CBC. Available online at: <https://www.cbc.ca/news/canada/british-columbia/2020-fraser-river-sockeye-record-1.5682765>.
- Baumann, H. 2015. In the Anthropocene, 'Predator Swamping' is a Doomed Evolutionary Strategy. Stony Brook, NY Available online at: <https://befel.marinesciences.uconn.edu/wp-content/uploads/sites/938/2015/05/In-the-Anthropocene.pdf>.
- Bison, R. 2012. Population Attributes for Fraser River Late-Run Summer Steelhead. Kamloops, BC Available online at: [https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/fish-fish-habitat/fishery-resources/interior-fraser-steelhead/bison\\_2012.pdf](https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/fish-fish-habitat/fishery-resources/interior-fraser-steelhead/bison_2012.pdf).
- Bison, R. 2020. Re: Status Update for Interior Fraser Steelhead. Letter Report from Robert Bison, Fisheries Stock Assessment Biologist, Ministry of Forests, Lands, Natural Resource Operations & Rural Development. July 23, 2020. Available online at: [https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/fish-fish-habitat/fishery-resources/interior-fraser-steelhead/ifs\\_status\\_update\\_july\\_2020.pdf](https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/fish-fish-habitat/fishery-resources/interior-fraser-steelhead/ifs_status_update_july_2020.pdf).
- Bonsal, B.R., D.L. Peters, F. Seglenieks, A. Rivera and A. Berg. 2019. Changes in freshwater availability across Canada; Chapter 6 in Canada's Changing Climate Report.
- Byrne, P., K.A. Hudson-Edwards, M.G. Macklin, P. Brewer, G. Bird and R. Williams. 2016. The long-term environmental impacts of the Moutn Polley mine tailings spill, British Columbia, Canada.
- CDC (Conservation Data Centre). 2021. BC Species and Ecosystems Explorer. B.C. Ministry of Environment, Victoria B.C. Available online at: <https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/conservation-data-centre/explore-cdc-data/species-and-ecosystems-explorer>. Accessed on February 25, 2021.
- Chalifour, L., D.C. Scott, M. MacDuffee, J.C. Iacarella, T.G. Martin and J.K. Baum. 2019. Habitat use by juvenile salmon, other migratory fish, and resident fish species underscores the importance of estuarine habitat mosaics. Marine Ecology Progress Series.
- Chambers, K. and S. Faulkner. 2021. Kwoiek Creek Salmon Enhancement Opportunities, Overview Assessment. Draft V1. Consultant's report prepared for Kanaka Bar Band by Ecofish Research Ltd., March 10, 2021.
- Chow, M.I., J.I. Lundin, C.J. Mitchell, J.W. Davis, G. Young, N.L. Scholz and J.K. McIntyre. 2019. An urban stormwater runoff mortality syndrome in juvenile coho salmon. Aquatic Toxicology.

- Cohen, B.I. 2012a. The Uncertain Future of Fraser River Sockeye Volume 1 - The Sockeye Fishery. In: Commission of Inquiry into the Decline of Sockeye Salmon in the Fraser River (Canada), Vol. 1.
- Cohen, B.I. 2012b. The Uncertain Future of Fraser River Sockeye. Volume 2: Causes of the Decline. In: Commission of Inquiry into the Decline of Sockeye Salmon in the Fraser River (Canada), Vol. 2.
- Cohen, B.I. 2012c. The Uncertain Future of Fraser River Sockeye. Volume 3: Recommendations - Summary - Process. In: Commission of Inquiry into the Decline of Sockeye Salmon in the Fraser River (Canada), Vol. 3.
- Cooke, S.J., S.G. Hinch, A.P. Farrell, M.F. Lapointe, S.R.M. Jones, J.S. Macdonald, D.A. Patterson, M.C. Healey and G. Van Der Kraak. 2004. Abnormal Migration Timing and High en route Mortality of Sockeye Salmon in the Fraser River, British Columbia. Fisheries.
- COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2016. COSEWIC assessment and Status Report on the coho salmon *Oncorhynchus kisutch* Interior Fraser population, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa Available online at: <http://www.registrelep-sararegistry.gc.ca/default.asp?lang=en&n=24F7211B-1>.
- COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2017. COSEWIC assessment and update 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.
- COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2018. Technical Summaries and Supporting Information for Emergency Assessments. Steelhead Trout, *Oncorhynchus mykiss*, (Thompson River and Chilcotin River populations). Committee on the Status of Endangered Wildlife in Canada. Ottawa. 26 pp.
- COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2019a. About COSEWIC and the Species at Risk Act. Available at: [https://cosewic.ca/index.php/en-ca/about-us/cosewic-sara#:~:text=About COSEWIC and the Species,species at risk of extinction.&text=Wildlife species that have been,protection and recovery under SARA](https://cosewic.ca/index.php/en-ca/about-us/cosewic-sara#:~:text=About%20COSEWIC%20and%20the%20Species,species%20at%20risk%20of%20extinction.&text=Wildlife%20species%20that%20have%20been,protection%20and%20recovery%20under%20SARA.). Available online at: [https://cosewic.ca/index.php/en-ca/about-us/cosewic-sara#:~:text=About COSEWIC and the Species,species at risk of extinction.&text=Wildlife species that have been,protection and recovery under SARA](https://cosewic.ca/index.php/en-ca/about-us/cosewic-sara#:~:text=About%20COSEWIC%20and%20the%20Species,species%20at%20risk%20of%20extinction.&text=Wildlife%20species%20that%20have%20been,protection%20and%20recovery%20under%20SARA).
- COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2019b. COSEWIC definitions and abbreviations. Available online at: [https://cosewic.ca/index.php/en-ca/about-us/definitions-abbreviations#:~:text=2012%3B accepted by COSEWIC in,to its extirpation or extinction](https://cosewic.ca/index.php/en-ca/about-us/definitions-abbreviations#:~:text=2012%3B%20accepted%20by%20COSEWIC%20in,to%20its%20extirpation%20or%20extinction.).
- COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2020. COSEWIC Wildlife Species Assessments (detailed version), November 2020. Available online at: <https://cosewic.ca/index.php/en-ca/assessment-process/detailed-version-november-2020>.
- CSA (Canadian Standards Association). 2016. CAN/CSA-X809-16. Sustainable forest management. SKU:2424363, Fourth Edition. Canadian Standards Associations (CSA) Group Available online at: <https://www.csagroup.org/store/product/2424363/>.

- Davis, B. and Y. Xu. 2021. 2021 Sockeye and Pink Forecasts. Presented by DFO to Fraser Panel. Feb. 9, 2021.
- Dempson, J.B., D.G. Reddin and M.F. O'Connell. 1998. To what extent does catch and release contribute to mortality in Atlantic salmon.
- Déry, S.J., M.A. Hernández-Henríquez, P.N. Owens, M.W. Parkes and E.L. Petticrew. 2012. A century of hydrological variability and trends in the Fraser River Basin. *Environmental Research Letters* 7.
- DFO (Fisheries and Oceans Canada). 2000. Effects of sediment on fish and their habitat. DFO Pacific Region Habitat Status Report 2000/01. DFO Pacific Region Habitat Status Report 2000/01 Available online at: <https://www.dfo-mpo.gc.ca/Library/255660.pdf>.
- DFO (Fisheries and Oceans Canada). 2005. Canada's policy for conservation of wild Pacific salmon. Available online at: <http://www.pac.dfo-mpo.gc.ca/fm-gp/species-especes/salmon-saumon/wsp-pss/index-eng.htm>.
- DFO (Fisheries and Oceans Canada). 2013. Review and Update of Southern BC Chinook Conservation Unit Assignments. Available online at: <https://waves-vagues.dfo-mpo.gc.ca/Library/350518.pdf>.
- DFO (Fisheries and Oceans Canada). 2017. Cowichan Watershed Health and Chinook Initiative DRAFT for review, March 27th 2017. Available online at: <http://www.pacfish.ca/cowichan/index.html>.
- DFO (Fisheries and Oceans Canada). 2018a. Recovery Potential Assessment for Chilcotin River and Thompson River Steelhead Trout (*Oncorhynchus mykiss*) designatable units. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep.
- DFO (Fisheries and Oceans Canada). 2018b. Pathways of Effects. Available online at: <https://www.dfo-mpo.gc.ca/pnw-ppe/pathways-sequences/index-eng.html>. Accessed on February 26, 2021.
- DFO (Fisheries and Oceans Canada). 2020a. 2020 Fraser River Chinook salmon management measures. Available online at: <https://www.canada.ca/en/fisheries-oceans/news/2020/06/2020-fraser-river-chinook-salmon-management-measures.html>. Accessed on January 13, 2021.
- DFO (Fisheries and Oceans Canada). 2020b. Pacific Region Final Integrated Fisheries Management Plan. June, 1, 2020 - May 31, 2021. Salmon Southern BC. Available online at: [http://publications.gc.ca/collections/collection\\_2020/mpo-dfo/Fs144-31-2020-eng.pdf](http://publications.gc.ca/collections/collection_2020/mpo-dfo/Fs144-31-2020-eng.pdf).
- DFO (Fisheries and Oceans Canada). 2020c. Fraser River environmental watch. Available online at: <https://www.pac.dfo-mpo.gc.ca/science/habitat/frw-rfo/index-eng.html>. Accessed on March 19, 2021.
- DFO (Fisheries and Oceans Canada). 2020d. Fraser Watershed Priority Area. Available online at: <https://www.dfo-mpo.gc.ca/species-especes/sara-lep/cnfasar-fnceap/priority-priorite/profiles/fraser-eng.html>. Accessed on March 16, 2021.
- DFO (Fisheries and Oceans Canada). 2021. Southern BC Chinook: 2020 Season and 2021 Planning. February 2021.

- Dyok, R. 2020. Tsilhqot'in Nation demands meeting with feds on declining Fraser River chinook stocks. Salmon Arm Observer. Available online at: <https://www.saobserver.net/news/tsilhqotin-nation-demands-meeting-with-feds-on-declining-fraser-river-chinook-stocks/>.
- ECCC (Environment and Climate Change Canada). 2014. Freshwater Quality Monitoring and Surveillance - Online Data. Site Details: Fraser River at Hope (BC08MF0001). Available online at: <http://aquatic.pyr.ec.gc.ca/webdataonlinenational/en/SiteDetails/BC08MF0001/Projects/PYLTM/Regions/0>. Accessed on March 3, 2021.
- ECCC (Environment and Climate Change Canada). 2019a. COSEWIC assessment and status report on the chinook salmon, *Oncorhynchus tshawytscha*, designatable units in southern British Columbia (part one - designatable units with no or low levels of artificial releases in the last 12 years), in Canada. Environment and Climate Change Canada (ECCC) Available online at: [http://publications.gc.ca/collections/collection\\_2019/eccc/CW69-14-469-2019-eng.pdf](http://publications.gc.ca/collections/collection_2019/eccc/CW69-14-469-2019-eng.pdf).
- ECCC (Environment and Climate Change Canada). 2019b. Fraser River Long-term Water Quality Monitoring Data. Available online at: <https://open.canada.ca/data/en/dataset/1e0e8033-3113-4297-a813-13ec6f239039>. Accessed on March 3, 2021.
- Focus. 2008. Kwoiek Creek Hydroelectric Project Amended Application for an Environmental Assessment Certificate: Volume I. Consultant's Report Prepared for Kwoiek Creek Resources Limited Partnership by Focus Environmental Inc. (Focus). August 2008.
- FSC (Forest Stewardship Council). 2005a. Forest Stewardship Council Regional Certification Standards for British Columbia: Small Operations Standards. Forest Stewardship Council Canada. October 2005. Available online at: <https://ca.fsc.org/en-ca/standards/small-community-forests>.
- FSC (Forest Stewardship Council). 2005b. Forest Stewardship Council Regional Certification Standards for British Columbia: Main Standards. Forest Stewardship Council Canada. October 2005. Available online at: <https://ca.fsc.org/en-ca/standards/forest-management-standards>.
- FSC (Forest Stewardship Council). 2018. The FSC National Forest Stewardship Standard of Canada. FSC-STD-CAN-01-2018 V 1-0 EN. Available online at: <https://ca.fsc.org/en-ca/standards/new-national-forest-management-standard>.
- Furey, N.B., S.G. Hinch, A.L. Bass, C.T. Middleton, V. Minke-Martin and A.G. Lotto. 2016. Predator swamping reduces predation risk during nocturnal migration of juvenile salmon in a high-mortality landscape. *Journal of Animal Ecology*.
- GAO (United States General Accounting Office). 2000. Water Quality: Key EPA and State Decisions Limited by Inconsistent and Incomplete Data. Report to the Chairman, Subcommittee on Water Resources and Environment, Committee on Transportation and Infrastructure, House of Representatives by United States Gene. Available online at: <https://www.gao.gov/assets/rced-00-54.pdf>.
- George, D. 1967. Lament for Confederation.
- Godwin, S.C., M. Krkošek, J.D. Reynolds and A.W. Bateman. 2021. Bias in self-reported parasite data from the salmon farming industry. *Ecological Applications*.

- Golder (Golder Associates Ltd.). 2007. Kwoiek Creek Hydroelectric Project: Baseline Water Quality Report. Consultant's Report Prepared for Kwoiek Creek Limited Partnership by Golder Associates Ltd. (Golder). May 23, 2007.
- Gomez, L. and J. Scroggie. 2021. Salmon update for Kanaka Bar, January 21 2021. Fraser Chinook, Coho and Sockeye and Pink.
- Government of British Columbia. 2019. Big Bar Landslide Incident - Province of British Columbia. Available online at: <https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/fish/fish-passage/big-bar-landslide-incident>. Accessed on January 8, 2020.
- Government of Canada. 2021. Species at risk public registry. Available online at: <https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry.html>. Accessed on February 22, 2021.
- Graham, I.M., R.N. Harris, I. Matejusová and S.J. Middlemas. 2011. Do “rogue” seals exist? Implications for seal conservation in the UK. Animal Conservation.
- Grant, S.C.H., B.L. MacDonald and M.L. Winston. 2019. State of Canadian Pacific Salmon: Responses to Changing Climate and Habitats. Can. Tech. Rep. Fish. Aquat. Sci. 3332. ix + 50 p. Available online at: <https://waves-vagues.dfo-mpo.gc.ca/Library/40807071.pdf>.
- Grant, S.C.H., M. Townsend, B. White and M. Lapointe. 2014. Fraser River Pink Salmon (*Oncorhynchus gorbuscha*) Data Review: Inputs for Biological Status and Escapement Goals. Final Project Report to Southern Boundary Restoration and Enhancement Fund. Prepared for Pacific Salmon Commission. May 2014. Available online at: <https://www.google.ca/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjLwrSyh8zvAhUUJTQIHQa4D7AQFjAAegQIAxAD&url=https%3A%2F%2Fwww.psc.org%2Fdownload%2F509%2Finformation%2F8561%2Fs13-i06-fraser-pink-salmon-&usq=AOvVaw3fBMXwq1zKxr65aXZU1P>.
- Green Valley Power. 2013. Siwash Creek Hydro Project Development Plan. Submitted by Green Valley Power Ltd. (Green Valley Power). January 10, 2013.
- Griffith, R.P. 1997. Kwoiek Creek Drainage Assessment of Fish Habitat and Production 1995. Consultant's Report for BC Conservation Foundation and BC Environment by P. Griffin & Associates. February, 1997. Available online at: <http://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=34698>.
- Hamelin, L. 2019. B.C. group proposing First Nation led commercial seal harvest as tensions mount. APTN. Available online at: <https://www.aptnnews.ca/national-news/b-c-group-proposing-first-nation-led-commercial-seal-harvest-as-tensions-mount/>.
- Johannessen, S.C. and B. McCarter. 2010. Ecosystem status and trends report for the Strait of Georgia ecozone. Canada.Dept.of Fisheries and Oceans; Canadian Science Advisory Secretariat.
- Kanaka Bar Band. 2018. Kanaka Bar Indian Band Climate Change Vulnerability Assessment. Available online at: <https://www.kanakabarband.ca/files/climate-change-vulnerability-assessment.pdf>.
- Kanaka Bar Band. 2019. Letter from Chief Patrick Michell, Kanaka Bar Band to Naina Sloan, Natural Resources Canada Re: Trans-Mountain Expansion Project (“TMX”) - NO. May 29, 2019.
- Kanaka Bar Band. 2020. Kanaka Bar Band. Available online at: <https://www.kanakabarband.ca/>. Accessed on October 23, 2020.

- Kehoe, L.J., J. Lund, L. Chalifour, et al. 2020. Conservation in heavily urbanized biodiverse regions requires urgent management action and attention to governance. *Conservation Science and Practice*.
- Kjelland, M.E., C.M. Woodley, T.M. Swannack and D.L. Smith. 2015. A review of the potential effects of suspended sediment on fishes: potential dredging-related physiological, behavioral, and transgenerational implications. *Environment Systems and Decisions*.
- Krebs, C.J. 2009. *The Experimental Analysis of Distribution and Abundance*, 6th edition. Pearson Benjamin Cummings.
- Krkošek, M., B.M. Connors, H. Ford, S. Peacock, P. Mages, J.S. Ford, M. Alexandra, J.P. Volpe, R. Hilborn, L.M. Dill and M.A. Lewis. 2011. Fish farms, parasites, and predators: Implications for salmon population dynamics. *Ecological Applications* 21:897–914.
- Lakel, W.A., W.M. Aust and C.A. Doiioff. 2006. Effects of forestry streamside management zone characteristics on soil erosion and water quality. In: *Hydrology and Management of Forested Wetlands - Proceeding of the International Conference*.
- MacDonald, B., D. Lewis, N. Wilson and S. Grant. 2021. DFO State of the Salmon Program. *Environmental Conditions: Informing Salmon Returns in 2021*.
- MacDonald, D., J. Sinclair, H. Prencipe and M. Meneghetti. 2011. Potential effects of contaminants on Fraser River sockeye salmon. MacDonald Environmental Sciences Ltd. Cohen Commission Tech. Rept. 2: 164p & appendices. Vancouver, BC Available online at: [www.cohencommission.ca](http://www.cohencommission.ca).
- Macneale, K.H., P.M. Kiffney and N.L. Scholz. 2010. Pesticides, aquatic food webs, and the conservation of Pacific salmon. *Frontiers in Ecology and the Environment*.
- Malick, M.J. and S.P. Cox. 2016. Regional-scale declines in productivity of pink and chum salmon stocks in western North America. *PLoS ONE*.
- McPhail, J.D. 2007. *The Freshwater Fishes of British Columbia*. University of Alberta Press. Edmonton, AB.
- MELP (Ministry of Environment, Lands and Parks) and DFO (Department of Fisheries and Oceans). 1998. Review of Fraser River Steelhead Trout (*Oncorhynchus mykiss*). Prepared by Ministry of Environment, Lands and Parks (MELP) and Department of Fisheries and Oceans (DFO). October 1998. Available online at: [https://a100.gov.bc.ca/pub/acat/documents/r281/Anonymous1998\\_1062018598770\\_bd5e32610c5c44b4927ed0fbcf804c77.pdf](https://a100.gov.bc.ca/pub/acat/documents/r281/Anonymous1998_1062018598770_bd5e32610c5c44b4927ed0fbcf804c77.pdf).
- MFLNRO (BC Ministry of Forests, Lands and Natural Resource Operations). 2016. Provincial Framework for Steelhead Management in British Columbia. Prepared by Ministry of Forests, Lands and Natural Resource Operations, Fish and Wildlife Branch, April 2016. Victoria, BC Available online at: <http://www.env.gov.bc.ca/fw/fish/docs/Provincial-Framework-for-Steelhead-Management-in-BC-April-2016.pdf>.

- MOE (BC Ministry of Environment). 1997. Ambient water quality criteria for dissolved oxygen: overview report. Prepared pursuant to Section 2(e) of the Environmental Management Act, 1981. Signed by Don Fast, Assistant Deputy Minister, Environment and Lands HQ Division. Victoria, BC Available online at: <https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/water-quality-guidelines/approved-wqgs/dissolvedoxygen-or.pdf>. Accessed on February 2, 2020.
- MOE (BC Ministry of Environment). 2005. Steelhead stream classification. Policy released by the BC Ministry of the Environment, December 13, 2005.
- Moe, J., O. Kaste and B. Faafeng. 2010. How can climate change be incorporated in river basin management plans under the WFD? Report from the EurAqua conference 2008. Norwegian Institute for Water Research Available online at: [https://www.researchgate.net/publication/230838751\\_How\\_can\\_climate\\_change\\_be\\_incorporated\\_in\\_river\\_basin\\_management\\_plans\\_under\\_the\\_WFD\\_Report\\_from\\_the\\_EurAqua\\_conference\\_2008](https://www.researchgate.net/publication/230838751_How_can_climate_change_be_incorporated_in_river_basin_management_plans_under_the_WFD_Report_from_the_EurAqua_conference_2008).
- Morrison, J., M.C. Quick and M.G.G. Foreman. 2002. Climate change in the Fraser River watershed: flow and temperature projections. *Journal of Hydrology* 263:230–244.
- Morton, A., R.D. Routledge and R. Williams. 2005. Temporal Patterns of Sea Louse Infestation on Wild Pacific Salmon in Relation to the Fallowing of Atlantic Salmon Farms. *North American Journal of Fisheries Management* 25:811–821.
- Natural Resources Canada. 2004. Fraser River Delta, British Columbia: Issues of an Urban Estuary.
- New Zealand Ministry for the Environment. 2020. Issue 3: Changing water flows affect our freshwater. Available online at: <https://www.mfe.govt.nz/publications/fresh-water/our-freshwater-2020/issue-3-changing-water-flows-affect-our-freshwater>. Accessed on March 29, 2021.
- NHC (Northwest Hydraulic Consultants). 2002. Review of lower Fraser River sediment budget. Consultant's Report prepared for Dredge Management Advisory Committee Fraser River Estuary Management Program.
- NOAA (US National Oceanic and Atmospheric Administration). 2020. Ocean pollution. Available online at: <https://www.noaa.gov/education/resource-collections/ocean-coasts/ocean-pollution>. Accessed on March 16, 2021.
- NOAA (US National Oceanic and Atmospheric Administration). 2021. What are El Nino and La Nina. Available online at: <https://oceanservice.noaa.gov/facts/ninonina.html>. Accessed on March 9, 2021.
- Oke, K.B., C.J. Cunningham, P.A.H. Westley, M.L. Baskett, S.M. Carlson, J. Clark, A.P. Hendry, V.A. Karatayev, N.W. Kendall, J. Kibele, H.K. Kindsvater, K.M. Kobayashi, B. Lewis, S. Munch, J.D. Reynolds, G.K. Vick and E.P. Palkovacs. 2020. Recent declines in salmon body size impact ecosystems and fisheries. *Nature Communications*.
- Olesiuk, P.F. 2010. An assessment of population trends and abundance of harbour seals (*Phoca vitulina*) in British Columbia. Available online at: <https://waves-vagues.dfo-mpo.gc.ca/Library/340454.pdf>.

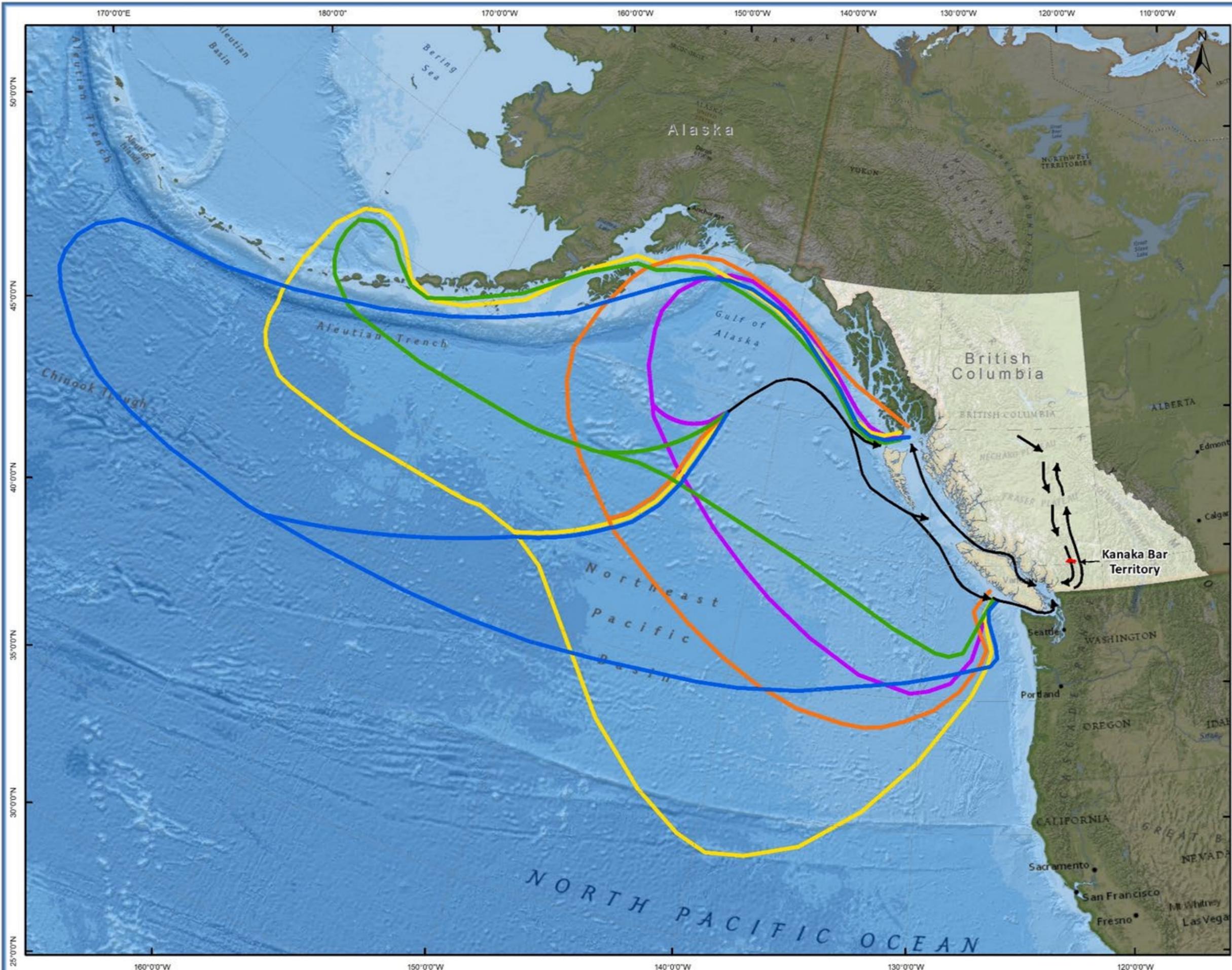
- Poirier, J. and D. Olson. 2017. Literature review of survival, age at return, straying, life history diversity and ecological effects of subyearling and yearling hatchery release strategies for fall Chinook salmon. U.S. Fish and Wildlife Service, Columbia River Fish and Wildlife Conserv.
- Province of British Columbia. 2020. Habitat Wizard. Available online at: <http://maps.gov.bc.ca/ess/hm/habwiz/>. Accessed on December 1, 2020.
- Province of British Columbia. 2021. Surface Water Monitoring Sites, part of the Environmental Monitoring System. Available online at: <https://www.arcgis.com/apps/webappviewer/index.html?id=0ecd608e27ec45cd923bdceefba00a7>. Accessed on March 3, 2021.
- PSF (Pacific Salmon Foundation). 2020a. Methods for Assessing Status and Trends in Pacific Salmon Conservation Units and their Freshwater Habitats. The Pacific Salmon Foundation, Vancouver BC, Canada. Version 1.0. Available online at: [https://salmonwatersheds.ca/libraryfiles/lib\\_459.pdf](https://salmonwatersheds.ca/libraryfiles/lib_459.pdf).
- PSF (Pacific Salmon Foundation). 2020b. Pacific Salmon Explorer. Available online at: <https://www.salmonexplorer.ca/#!> Accessed on November 14, 2020.
- Rasmussen, G. 2018. "Get the balance back": Amid seal and sea lion boom, group calls for hunt on B.C. coast. CBC. Available online at: <https://www.cbc.ca/news/canada/british-columbia/seal-hunt-b-c-1.4921610>.
- Riche, O., S.C. Johannessen and R.W. Macdonald. 2014. Why timing matters in a coastal sea: Trends, variability and tipping points in the Strait of Georgia, Canada. *Journal of Marine Systems*.
- Richter, A. and S.A. Kolmes. 2005. Maximum temperature limits for chinook, coho, and chum salmon, and steelhead trout in the Pacific Northwest. *Reviews in Fisheries Science*.
- Riddell, B., M. Bradford, R. Carmichael, D. Hankin, R. Peterman and A. Wertheimer. 2013. Assessment of Status and Factors for Decline of Southern BC Chinook Salmon: Independent Panel's Report. Prepared with the assistance of D.R. Marmorek and A.W. Hall, ESSA Technologies Ltd., Vancouver, B.C. for Fisheries and Oceans Canada (Vancouver, BC) and Merrit, BC Available online at: <https://www.psc.org/publications/workshop-reports/southern-bc-chinook-expert-panel-workshop/>.
- Ross, P.S., C.J. Kennedy, L.K. Shelley, K.B. Tierney, D.A. Patterson, W.L. Fairchild and R.W. Macdonald. 2013. The trouble with salmon: Relating pollutant exposure to toxic effect in species with transformational life histories and lengthy migrations. *Canadian Journal of Fisheries and Aquatic Sciences*.
- Scroggie, J. 2021. 2020 Post-season Review Fraser Sockeye Salmon. DFO Presentation.
- SFEG (Skagit Fisheries Enhancement Group). 2021. Salmon of the Skagit. Available online at: <http://www.skagitfisheries.org/skagit-fisheries-enhancement-group/edgewater/salmon/>. Accessed on March 4, 2021.
- SFI (Sustainable Forestry Initiative). 2015. SFI 2015-2019 (Extended through December 2021) Standards and Rules. Available online at: <https://www.forests.org/forestmanagementstandard/>.
- Smart, A. 2019. Proposed B.C. seal hunt will come with consequences for ecosystem, scientists warn. *Globe and Mail*. Available online at: <https://www.theglobeandmail.com/canada/article-scientists-warn-of-damage-to-ecosystem-after-bc-group-proposes-seal/>.

- Summit. 2002. Coldwater River Storage Feasibility Study. Consultant's report prepared for Pacific Salmon Foundation by Summit Environmental Consultants Ltd. December 2002. Available online at: [https://www.google.ca/url?sa=t&rc=tj&q=&esrc=s&source=web&cd=&ved=2ahUKEwjt\\_83Dm8TvAhXzOX0KHZwvD8oQFjAAegQIAhAD&url=https%3A%2F%2Fwww.nwcr.ca%2Fapp%2Fdownload%2F14201930733%2FColdwater\\_River\\_water\\_storage.pdf%3Ft%3D1570500721&usq=AOvVaw0FGvJvaVb1KX1dZ1iw](https://www.google.ca/url?sa=t&rc=tj&q=&esrc=s&source=web&cd=&ved=2ahUKEwjt_83Dm8TvAhXzOX0KHZwvD8oQFjAAegQIAhAD&url=https%3A%2F%2Fwww.nwcr.ca%2Fapp%2Fdownload%2F14201930733%2FColdwater_River_water_storage.pdf%3Ft%3D1570500721&usq=AOvVaw0FGvJvaVb1KX1dZ1iw).
- Swain, L.G. 2007. Water Quality Assessment of Fraser River at Hope (1979-2004). Prepared for BC Ministry of Environment and Environment Canada. January 2007.
- Taylor, G. 2020. An overview of 2020 salmon returns. Available online at: [https://watershedwatch.ca/greg-taylor-an-overview-of-2020-salmon-returns/#:~:text=Only two cycles \(eight years,number will be even lower. Accessed on January 13, 2021](https://watershedwatch.ca/greg-taylor-an-overview-of-2020-salmon-returns/#:~:text=Only two cycles (eight years,number will be even lower. Accessed on January 13, 2021).
- Tian, Z., H. Zhao, K.T. Peter, et al. 2021. A ubiquitous tire rubber-derived chemical induces acute mortality in coho salmon. *Science*.
- Trites, A.W. and D.A.S. Rosen. 2018. Availability of Prey for Southern Resident Killer Whales. Technical Workshop Proceedings. November 15–17, 2017. Vancouver, BC.
- Trites, A.W. and D.A.S. Rosen. 2019. Synthesis of Scientific Knowledge and Uncertainty about Population Dynamics and Diet Preferences of Harbour Seals, Steller Sea Lions and California Sea Lions, and their Impacts on Salmon in the Salish Sea. Technical Workshop Proceedings. May 29-30, 2019. Vancouver, BC Available online at: <http://mmru.ubc.ca/wp-content/pdfs/Trites and Rosen 2019 Pinniped Workshop Proceedings.pdf>.
- Triton. 2012. Siwash Creek Small Hydro Fisheries Assessment. Consultant's Report prepared for Green Valley Power Ltd by Triton Environmental Ltd. (Triton). August 8, 2002; updated 2012.
- TSB (Transportation Safety Board). 1997. Railway Investigation Report R97V0063: Derailment, Canadian National Train No. Q-102-51-26 Mile 106.15, Ashcroft Subdivision Conrad, British Columbia, 26 March 1997. Available online at: <http://bst-tsb.gc.ca/eng/rapports-reports/rail/1997/r97v0063/r97v0063.html>.
- Twardek, W.M., T.O. Gagne, L.K. Elmer, S.J. Cooke, M.C. Beere and A.J. Danylchuk. 2018. Consequences of catch-and-release angling on the physiology, behaviour and survival of wild steelhead *Oncorhynchus mykiss* in the Bulkley River, British Columbia. *Fisheries Research*.
- UBC (University of British Columbia). 2021. Centre for Indigenous Fisheries. Available at: <https://oceans.ubc.ca/centre-for-indigenous-fisheries/#:~:text=At the Centre for Indigenous,focused unit launched in 2021. Available online at: https://oceans.ubc.ca/centre-for-indigenous-fisheries/#:~:text=At the Centre for Indigenous,focused unit launched in 2021>.
- VIU (Vancouver Island University). 2009. Salmonid Biology Course Module. Vancouver Island University. January 2009. Nanaimo, BC Available online at: [www.viu.ca/nrep/](http://www.viu.ca/nrep/).
- Wetzel, R.G. 2001. *Limnology: Lake and River Ecosystems*, Third Edit. Academic Press. San Diego.
- Wright, B.E., S.D. Riemer, R.F. Brown, A.M. Ougzin and K.A. Bucklin. 2007. Assessment of harbor seal predation on adult salmonids in a Pacific Northwest estuary. *Ecological Applications*.
- WSC (Water Survey of Canada). 2017. Water Survey of Canada – Fraser River. Government of Canada. [updated 2017 July 13; cited 2017 September 25]. Available from: <http://wateroffice.ec.gc.ca>.

WSC (Water Survey of Canada). 2021. Annual Maximum and Minimum Daily Discharge Graph for FRASER RIVER AT HOPE (08MF005) [BC]. Available online at: [https://wateroffice.ec.gc.ca/report/historical\\_e.html?stn=08MF005&dataType=Annual+Extremes&parameterType=Flow&year=2019&mode=Graph](https://wateroffice.ec.gc.ca/report/historical_e.html?stn=08MF005&dataType=Annual+Extremes&parameterType=Flow&year=2019&mode=Graph). Accessed on March 1, 2021.

Yurk, H. and A.W. Trites. 2000. Experimental Attempts to Reduce Predation by Harbor Seals on Out-Migrating Juvenile Salmonids. Transactions of the American Fisheries Society.

## PROJECT MAPS



KANAKA BAR BAND  
**State of the Fraser River  
 at Kanaka Bar -  
 Project Overview**

- Legend**
- █ Kanaka Bar Territory
  - Migration Routes\***
  - █ Chinook Salmon
  - █ Coho Salmon
  - █ Pink Salmon
  - █ Steelhead
  - █ Sockeye Salmon
  - █ All Species

\* Data Sources:  
 Light et al. 1989; Cohen 2012; DFO 2019

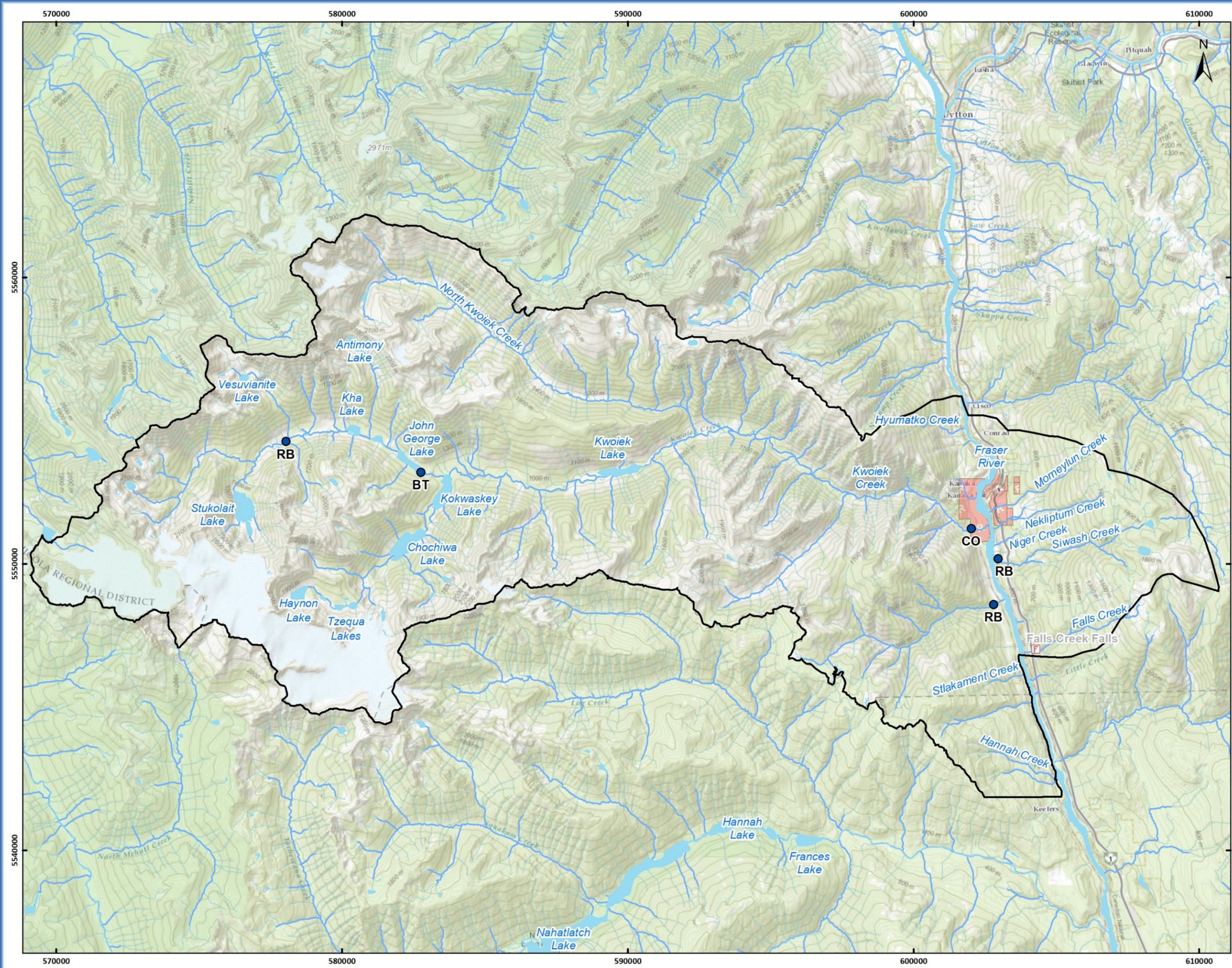
**MAP SHOULD NOT BE USED FOR LEGAL  
 OR NAVIGATIONAL PURPOSES**

0 80 160 320 480 640 800 km  
 Scale: 1:15,000,000

NO.	DATE	REVISION	BY
1	2021 03 22	1457 Project Overview 4122 20210219	CSA
2			
3			
4			
5			

Date Saved: 2021-03-22  
 Coordinate System: NAD 1983 BC Environment Albers

**ECOFISH** RESEARCH Map 1



**KANAKA BAR BAND**  
**Kanaka Bar Territory**

- Legend**
- Most Upstream Known Fish Observations (FISS)
  - Kanaka Bar Reserve
  - ▭ Kanaka Bar Territory
- Species Code:**  
 BT = Bull Trout  
 RB = Rainbow Trout  
 CO = Coho Salmon



**MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES**



NO.	DATE	REVISION	BY
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2			
3			
4			
5			

Date Saved: 2021-05-14  
 Coordinate System: NAD 1983 UTM Zone 10N

## APPENDICES

**Appendix A. Annotated Table of Major Sources**

**LIST OF TABLES**

Table 1. Annotated Table of Major Sources.....1

**Table 1. Annotated Table of Major Sources<sup>1</sup>.**

Author	Year	Report Title	Information Summary
<i>Online databases/ mapping applications</i>			
Pacific Salmon Foundation	2020	Pacific Salmon Explorer ( <a href="https://www.salmonexplorer.ca">https://www.salmonexplorer.ca</a> )	This tool provides access to the best available data for salmon conservation units (CUs) in BC. Applying a standardized assessment approach, the Pacific Salmon Foundation (PSF) evaluates the current status of salmon CUs and pressures on their habitats.
Province of British Columbia	2020	Habitat Wizard ( <a href="http://maps.gov.bc.ca/ess/hm/habwiz/">http://maps.gov.bc.ca/ess/hm/habwiz/</a> )	HabitatWizard is a map-based tool that allows users to spatially access detailed fish, wildlife and ecosystem information online. HabitatWizard displays several spatial layers that can be selected to show all required information.
Conservation Data Centre	2021	BC Species and Ecosystems Explorer ( <a href="https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/conservation-data-centre/explore-cdc-data/species-and-ecosystems-explorer">https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/conservation-data-centre/explore-cdc-data/species-and-ecosystems-explorer</a> )	BC Species and Ecosystem Explorer provides information for over 22,000 plants, animals and ecological communities in BC.
Government of Canada	2021	Species at risk public registry ( <a href="https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry.html">https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry.html</a> )	In this registry you will find documents relating to the administration of the <i>Species at Risk Act</i> (SARA). The online portal allows you to search by species; for each species you will find listed a summary of the species description, at risk status, threats and recovery initiatives, as well as links to relevant documents (e.g., COSEWIC reports, recovery strategies).

<sup>1</sup> This table lists major data sources only for the State of the Fraser River at Kanaka Bar report; the References section of the report contains a full list of sources reviewed and cited.

Author	Year	Report Title	Information Summary
<i>Population declines: causes and recommendations</i>			
Cohen, B.I.	2012	The Uncertain Future of Fraser River Sockeye Volumes 1 - 3 In: Commission of Inquiry into the Decline of Sockeye Salmon in the Fraser River (Canada).	Reporting on the results of the Commission of Inquiry into the Decline of Sockeye Salmon in the Fraser River. This report ("the Cohen Report") covers a description of the life cycle of Fraser River Sockeye Salmon, an overview of regulation and management of Fraser River Sockeye Salmon, a description of possible causes of decline in Fraser River Sockeye Salmon populations, and recommendations for actions needed reverse those declines.
Riddell, B., M. Bradford, R. Carmichael, D. Hankin, R. Peterman and A. Wertheimer	2013	Assessment of Status and Factors for Decline of Southern BC Chinook Salmon: Independent Panel's Report	Fisheries and Oceans Canada (DFO) and the Fraser River Aboriginal Fisheries Secretariat (FRAFS) organized a scientific workshop and an independent science panel to evaluate the relative importance of factors that may have affected the abundance and productivity of southern BC Chinook salmon. A science panel was commissioned to provide an independent review of the evidence presented and to provide recommendations for future research priorities.
Grant, S.C.H., B.L. MacDonald and M.L. Winston	2019	State of Canadian Pacific Salmon: Responses to Changing Climate and Habitats	A description of environmental and anthropogenic causes of Pacific salmon population declines, with a focus on climate change.
<i>Species at-risk status and recovery strategies</i>			
COSEWIC (Committee on the Status of Endangered Wildlife in Canada)	2016	COSEWIC assessment and Status Report on the coho salmon <i>Oncorhynchus kisutch</i> Interior Fraser population, in Canada.	COSEWIC status reports are comprehensive technical documents that compile and analyze the best available information on a wildlife species' status in Canada. They contains information on the basic biology of a wildlife species, as well as information on a wildlife species' distribution in Canada, population sizes and trends, habitat availability and trends, and threats to the wildlife species. COSEWIC status reports inform the COSEWIC assessment process, where at risk status is assigned to individual species.
COSEWIC (Committee on the Status of Endangered Wildlife in Canada)	2017	COSEWIC assessment and update status report on the Sockeye Salmon <i>Oncorhynchus nerka</i> , 24 Designatable Units in the Fraser River Drainage Basin, in Canada	

Author	Year	Report Title	Information Summary
ECCC (Environment and Climate Change Canada)	2019	COSEWIC assessment and status report on the chinook salmon, <i>Oncorhynchus tshawytscha</i> , designatable units in southern British Columbia (part one - designatable units with no or low levels of artificial releases in the last 12 years), in Canada.	COSEWIC status reports are comprehensive technical documents that compile and analyze the best available information on a wildlife species' status in Canada. They contain information on the basic biology of a wildlife species, as well as information on a wildlife species' distribution in Canada, population sizes and trends, habitat availability and trends, and threats to the wildlife species. COSEWIC status reports inform the COSEWIC assessment process, where a risk status is assigned to individual species.
COSEWIC (Committee on the Status of Endangered Wildlife in Canada)	2018	Technical Summaries and Supporting Information for Emergency Assessments Steelhead Trout, <i>Oncorhynchus mykiss</i> , (Thompson River and Chilcotin River populations)	Documentation of the emergency assessment conducted for Thompson/ Chilcotin Steelhead Trout; this report is an abbreviated version of a status report, containing a description of designatable units, available abundance information, threats, and the assessment results.
DFO (Fisheries and Oceans Canada)	2018	Recovery Potential Assessment for Chilcotin River and Thompson River Steelhead Trout ( <i>Oncorhynchus mykiss</i> ) designatable units.	A description of the biology, life history, habitat requirements, residence, threats and limiting factors, and suggested mitigation for those threats for Thompson/ Chilcotin Steelhead Trout, along with an assessment of allowable harm and discussion of uncertainty in the data.
MFLNRO (BC Ministry of Forests, Lands and Natural Resource Operations)	2016	Provincial Framework for Steelhead Management in British Columbia	A description of the goals and objectives for steelhead management in BC; includes information on stock status and stock assessment methods.
<i>DFO and provincial fisheries management</i>			
Bison, R.	2020	Re: Status Update for Interior Fraser Steelhead. Letter Report from Robert Bison, Fisheries Stock Assessment Biologist, Ministry of Forests, Lands, Natural Resource Operations & Rural Development.	Preliminary spawning estimates for the 2019/2020 run of Interior Fraser steelhead.

Author	Year	Report Title	Information Summary
Davis, B. and Y. Xu	2021	Sockeye and Pink Forecasts. Presented by DFO to Fraser Panel, February 9, 2021.	Preseason forecasts for 2021 Fraser River Sockeye Salmon and Pink Salmon.
MacDonald, B., D. Lewis, N. Wilson and S. Grant	2021	DFO State of the Salmon Program, Environmental Conditions: Informing Salmon Returns in 2021	A summary of environmental conditions and causes for forecast low 2021 returns for all Pacific salmon species
DFO (Fisheries and Oceans Canada)	2021	Southern BC Chinook: 2020 Season and 2021 Planning, February 2021	A description of 2020 Fraser River Chinook Salmon returns and forecasts for 2021 returns
Gomez, L. and J. Scroggie	2021	Salmon update for Kanaka Bar, January 21 2021. Fraser Chinook, Coho and Sockeye and Pink.	A description of 2020 Fraser River Chinook Salmon, Coho Salmon, Sockeye Salmon and Pink Salmon returns and estimates for 2021 returns, with a focus on populations passing through Kanaka Bar.
Scroggie, J.	2021	2020 Post-season Review Fraser Sockeye Salmon	A description of 2020 Fraser River Sockeye Salmon returns
DFO (Fisheries and Oceans Canada)	2020	Pacific Region Final Integrated Fisheries Management Plan, June, 1, 2020 - May 31, 2021. Salmon Southern BC	This plan describes the management of First Nations, recreational and commercial fisheries for Pacific salmon in southern BC and the factors that influence decision-making. This report includes stock assessment methods and fishing plans for each salmon species, as well as a biological synopsis and abundance metrics for the various species.
Grant, S.C.H., M. Townsend, B. White and M. Lapointe	2014	Fraser River Pink Salmon ( <i>Oncorhynchus gorbuscha</i> ) Data Review: Inputs for Biological Status and Escapement Goals. Final Project Report to Southern Boundary Restoration and Enhancement Fund	Abundance and biological data for Fraser River Pink Salmon, prepared for the Pacific Salmon Commission.

Author	Year	Report Title	Information Summary
<i>Water quality and hydrology</i>			
ECCC (Environment and Climate Change Canada)	2019	Freshwater Quality Monitoring and Surveillance - Online Data. Site Details: Fraser River at Hope (BC08MF0001) ( <a href="http://aquatic.pyr.ec.gc.ca/webdataonline/national/en/SiteDetails/BC08MF0001/Projects/PYLTM/Regions/0">http://aquatic.pyr.ec.gc.ca/webdataonline/national/en/SiteDetails/BC08MF0001/Projects/PYLTM/Regions/0</a> ); Fraser River Long-term Water Quality Monitoring Data ( <a href="https://open.canada.ca/data/en/dataset/1e0e8033-3113-4297-a813-13ec6f239039">https://open.canada.ca/data/en/dataset/1e0e8033-3113-4297-a813-13ec6f239039</a> )	A map interface of long-term freshwater monitoring locations throughout Canada. Clicking on a station provides the name and description of the monitoring station as well as direct links to the Environment and Climate Change Canada dataset.
Province of British Columbia	2021	Surface Water Monitoring Sites, part of the Environmental Monitoring System ( <a href="https://www.arcgis.com/apps/webappviewer/index.html?id=0ecd608e27ec45cd923bdceefba00a7">https://www.arcgis.com/apps/webappviewer/index.html?id=0ecd608e27ec45cd923bdceefba00a7</a> )	The Surface Water Monitoring Sites web application allows users to browse a map interface to find freshwater monitoring locations throughout BC. Clicking on a station provides the name and description of the monitoring station as well as direct links to EMS Web Reporting for that station where the data can be downloaded as a csv file.
Déry, S.J., M.A. Hernández-Henríquez, P.N. Owens, M.W. Parkes and E.L. Petticrew	2012	A century of hydrological variability and trends in the Fraser River Basin.	This study examines the 1911–2010 variability and trends in annual streamflow at 139 sites across the Fraser River Basin (FRB) of British Columbia (BC), Canada.
Swain, L.G.	2007	Water Quality Assessment of Fraser River at Hope (1979-2004)	This report assesses eighteen years of water quality data from the Ministry of Environment (1987 – 2004) and twenty years of Environment Canada data (1985 – 2004). The provincial station number in EMS is E206581 and the federal site number in ENVIRODAT is BC08MF0001. The station is located at the highway 1 bridge in Hope. Flow data 1985-2004 data from Water Survey of Canada station BC08MF005 at Hope is also presented.

Author	Year	Report Title	Information Summary
<i>Local information</i>			
Kanaka Bar Band	2018	Kanaka Bar Indian Band Climate Change Vulnerability Assessment	A summary of recent and potential climate changes and associated influences on the Territory, in order to help Kanaka Bar understand its vulnerabilities, prepare for a community transition, and develop adaptation strategies for the environment and economies of tomorrow.
Chambers, K. and S. Faulkner	2021	Kwoiek Creek Salmon Enhancement Opportunities, Overview Assessment.	An assessment of fish and fish habitat values, and potential enhancement opportunities for Pacific salmon, on Kwoiek Creek.
Triton Environmental Ltd.	2012	Siwash Creek Small Hydro Fisheries Assessment	An assessment of fish and fish habitat values on Siwash Creek in support of an environmental assessment for a proposed run-of-river project

**Appendix B. Detailed Species Accounts**

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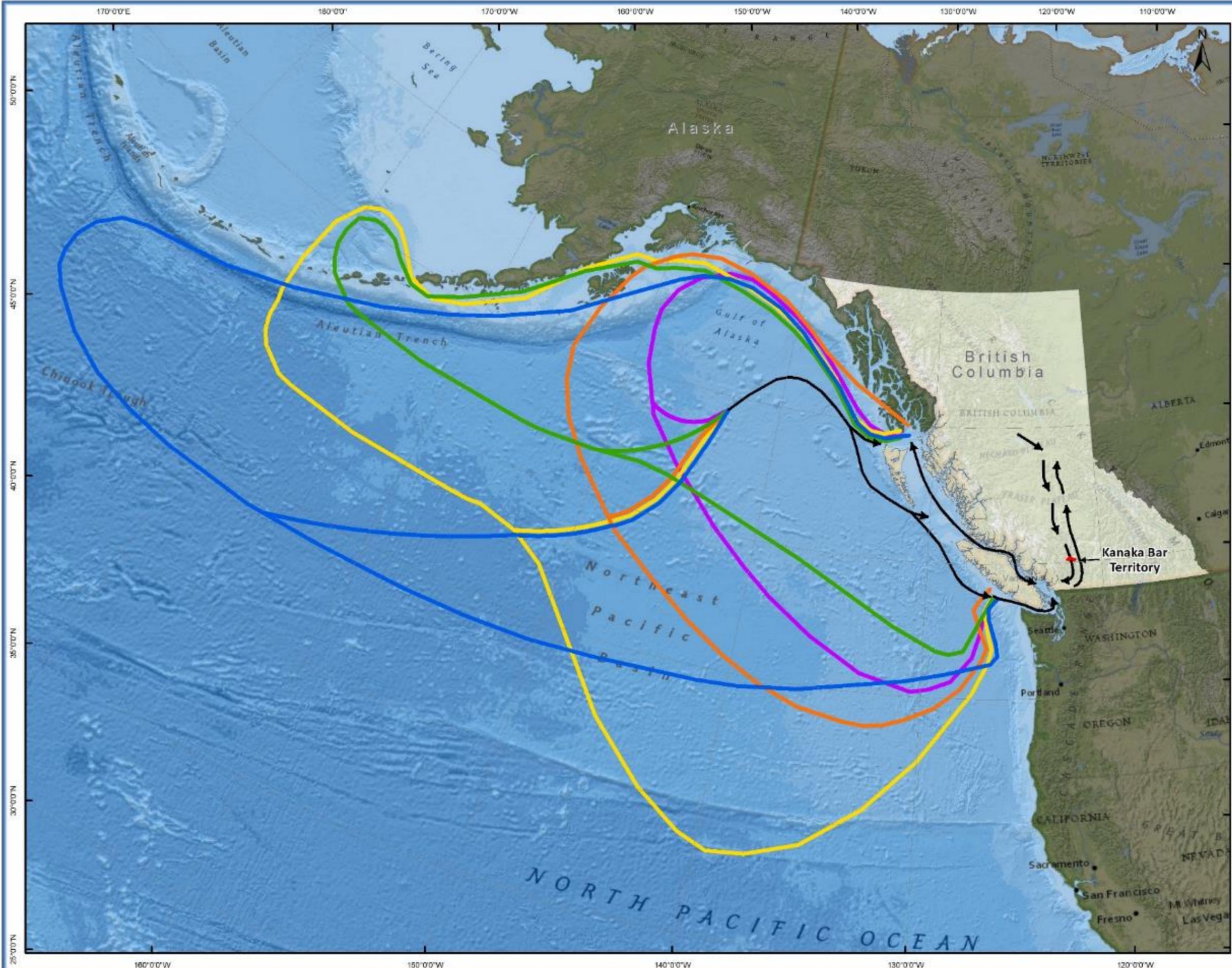
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KANAKA BAR BAND  
**State of the Fraser River  
 at Kanaka Bar -  
 Project Overview**

- Legend**
- █ Kanaka Bar Territory
  - Migration Routes\***
  - █ Chinook Salmon
  - █ Coho Salmon
  - █ Pink Salmon
  - █ Steelhead
  - █ Sockeye Salmon
  - █ All Species

\* Data Sources:  
 Light et al. 1989; Cohen 2012; DFO 2019

**MAP SHOULD NOT BE USED FOR LEGAL  
 OR NAVIGATIONAL PURPOSES**

0 80 160 320 480 640 800 km  
 Scale: 1:15,000,000

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**ECOFISH** RESEARCH Map 1

## 1. CHINOOK SALMON

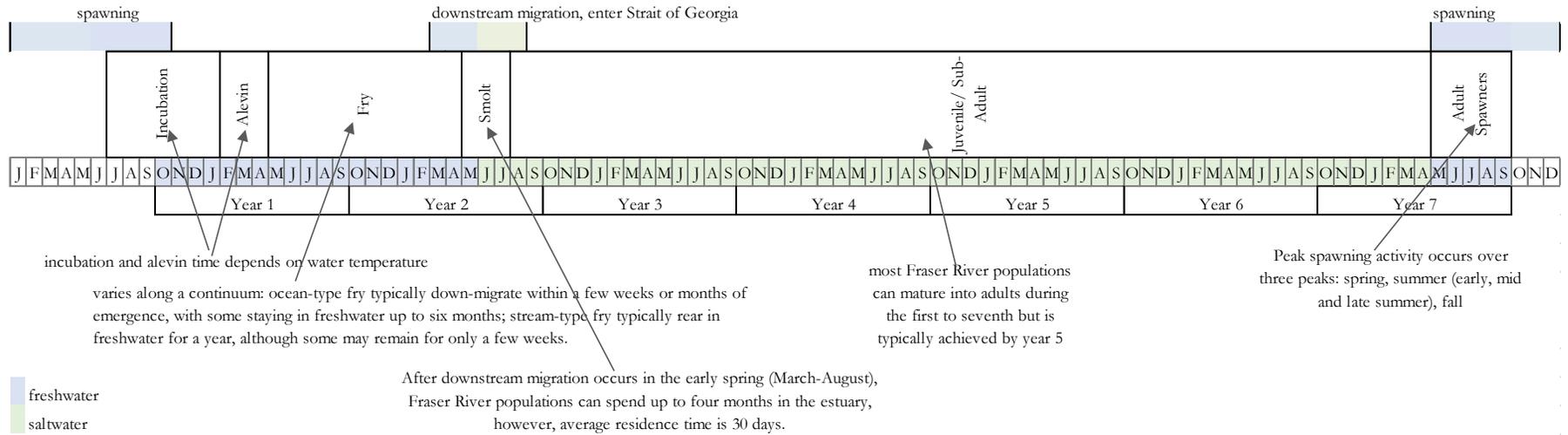
Chinook Salmon (*Oncorhynchus tshawytscha*; Figure 1) are the largest Pacific salmon, and show a diverse array of life history patterns and habitat tolerances. Chinook Salmon are known by many names: King, blackmouth, quinnat, chube, spring salmon, and tyee (for those larger than 14 kg).

**Figure 1. Chinook Salmon at different life stages (Pollard *et al.* 1997; Steele 2011; DFO 2020; BC Fishing Journal 2021)**



Chinook Salmon populations vary widely in age at seaward migration; length of freshwater, estuarine and oceanic residence; ocean distribution and ocean migratory patterns; and age and season of spawning migration (ECCC 2019). Chinook Salmon are divided into two major forms: stream-type and ocean-type, although in reality Chinook Salmon populations exist on more of a continuum than in two separate bins. Generally, however, stream-type Chinook Salmon spend one or more years in freshwater before migrating to sea, perform extensive offshore oceanic migrations, and return to their natal stream in the spring or summer several months prior to spawning. Ocean-type Chinook Salmon migrate to sea during their first year of life (normally within two to five months of emergence), spend most of their ocean life in coastal waters, and return to their natal stream in the fall only a few days or weeks before spawning (ECCC 2019).

**Figure 2. Fraser River Chinook Salmon typical life cycle (McPhail 2007; VIU 2009; DFO 2013, 2019; ECCC 2019; Gomez and Scroggie 2021).**



Chinook Salmon have a wide variety of life history strategies at all life stages: freshwater residence, estuarine and ocean residence, ocean distribution, and age/timing of spawning

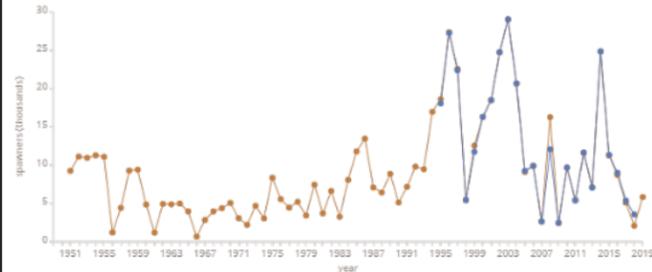
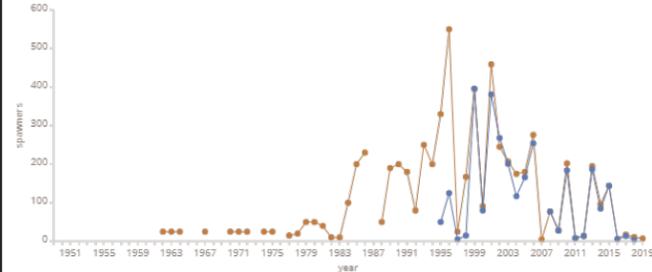
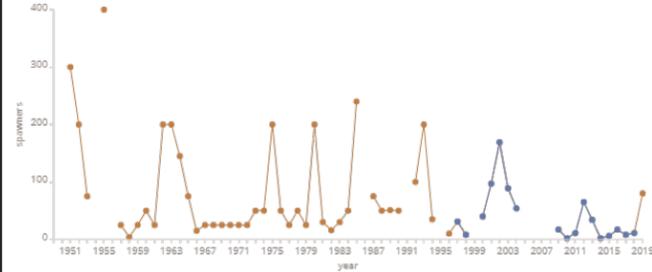
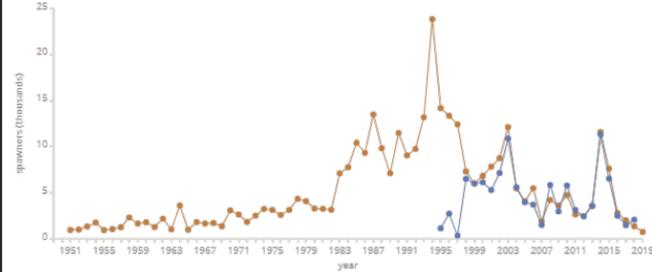
Chinook Salmon will spawn in a broad range of substrates and water depths and velocities, as long as subgravel flow conditions are adequate (i.e., stable flows high enough to provide oxygen but not so high as to cause gravel movement or streambed scour) (ECCC 2019). However, generally they are found in the main channel of rivers in medium to large gravel with faster flow than that preferred by other salmon species (VIU 2009), reflective of Chinook Salmon's larger body size (Roberge *et al.* 2002). Temperatures between 0-15°C are best for egg survival (ECCC 2019).

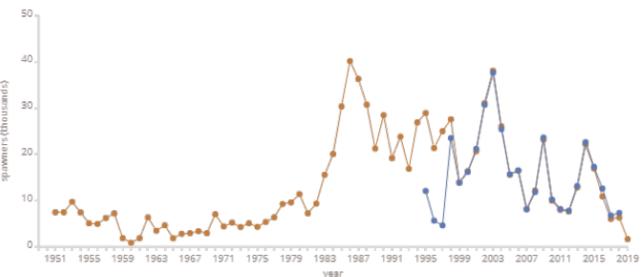
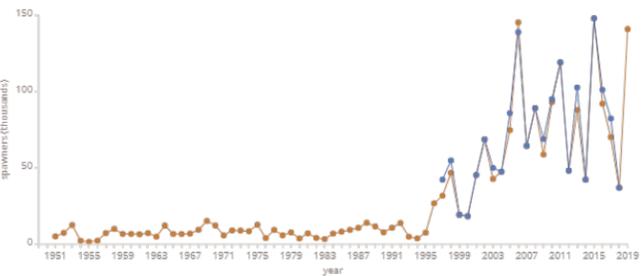
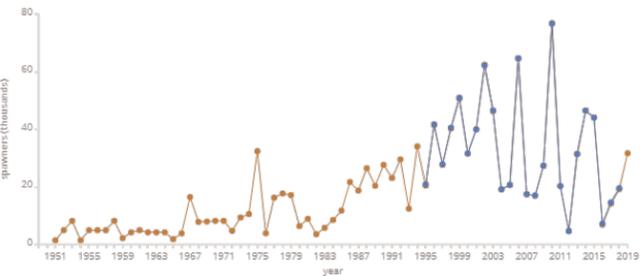
Chinook Salmon from four Fraser River SMUs travel through Kanaka Bar territory, including 11 DUs and 13 CU<sup>1</sup>s. Spawning locations of these population units are shown in Table 1. Suitable spawning and rearing habitat for Chinook Salmon is not present in Kanaka Bar territory. Most of these population units are suffering low enough abundance to be considered at risk. Table 1 provides abundance descriptors and identified threats by population unit.

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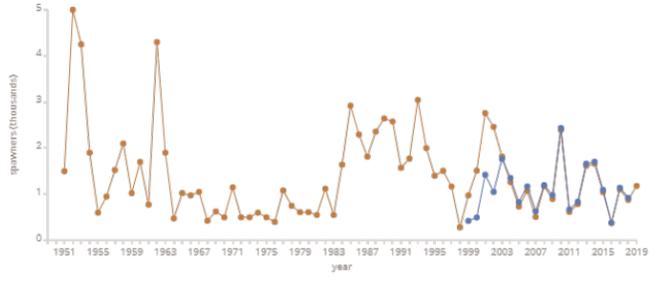
<sup>1</sup> Includes Fraser Canyon – Nahatlatch CU, which is downstream of Kanaka Bar but close enough that straying is possible.

**Table 1. Fraser River Chinook Salmon populations potentially present at Kanaka Bar – distribution and abundance (ECCC 2019; PSF 2020).**

SMU	DU	CU	CU Location	Major Watersheds (CU)	Ocean Distribution	Escapement	Status			Causes of Decline (DU)
							COSEWIC	WSP	PSF	
Fraser Chinook Salmon - Spring 4 <sub>2</sub>	Lower Thompson Stream Spring	Lower Thompson River (Spring 4-2)		Bonaparte River, Deadman River, Louis Creek, Nicola River, Coldwater River, Spius Creek	Offshore		Endangered	red	data deficient	Marine survival has been low since 2000. There has been a steep decline in the number of mature individuals from 2013 to 2018. This population faces a number of continuing and severe threats in its freshwater and marine habitat, including post Pine Beetle deforestation, short and long-term effects from wildfires (the large Elephant Hill fire occurred here in 2018), habitat destabilization, and climate-change induced disruption to water quality. Agriculture water withdrawal is substantial and ongoing.
	South Thompson, Stream, Summer 1.2	South Thompson River - Bessette Creek (Spring 4-2)		Bessette Creek, Duteau Creek, Harris/(Nicklen) Creek, Creighton Creek	Offshore?		Endangered	red	data deficient	agriculture, cattle ranching, dams in headwaters, climate change (groundwater)
Fraser Chinook Salmon - Spring 5 <sub>2</sub>	Middle Fraser River Stream Spring (MFR+GStr)	Fraser Canyon - Nahatlatch		Nahatlatch River, Anderson River	Offshore		Endangered	data deficient	data deficient	DU-specific threats not yet assessed, can assume climate change and marine survival also affect this DU. Freshwater spawning and rearing habitat is only moderately affected by human activity.
	Middle Fraser River Stream Spring (MFR+GStr)	Middle Fraser River (Spring 5-2)		Baker Creek, Bridge River (incl. Yalakom), Cariboo-Upper, Chilako River, Chilcotin River, Churn Creek, Cottonwood River (incl. Ahbau, Lightning, Swift River), Driftwood River, Endako River, Horsefly River, Minton Creek, Nadina River, Narcosli Creek, Naver (Hixon) Creek, Stein River, Taseko Lake, West Road River (incl. Baezaeko, Clisbako, Coglistiko, Euchiniko, Nazko, Snaking)	Offshore		Threatened	red	data deficient	Connectivity due to hydroelectric dams, currently cut off from historic range; highest threats are ecosystem modifications (irrigation diking and ditching; conversion of agricultural land to residential, some mining water quality impacts)

SMU	DU	CU	CU Location	Major Watersheds (CU)	Ocean Distribution	Escapement	Status			Causes of Decline (DU)
							COSEWIC	WSP	PSF	
Fraser Chinook Salmon - Spring 5 <sub>2</sub>	North Thompson Stream Spring	North Thompson River (Spring 5-2)		Albreda River, Blue River, Finn Creek, Lyon Creek, Mad River, Mud River, North Thompson River – Upper, Thunder River	Offshore		Endangered	red	not assessed	climate change (groundwater)
	Upper Fraser River Stream Spring	Upper Fraser River (Spring 5-2)		Bowron River (inc. Haggen Creek, Indianpoint Creek, Sus Creek), Dome Creek, East & West Twin Creeks, Fraser River – Above Tete Jaune Cache, Goat River, Holliday Creek, Holmes River, Horsey Creek, Kenneth Creek, Herrick-McGregor (incl. Bad River (James Creek), Captain, Fontoniko, Ice, Otter, Seebach, Spakwaniko) McKale River, Morkill River (incl. Forget-me-not Creek), Nevin Creek, Ptarmigan Creek, Robson River, Salmon River, Slim Creek, Small Creek, Snowshoe Creek, Swift Creek, Willow River (incl. Wansa Creek)	Offshore		Endangered	red	data deficient	climate change - impacts groundwater through timing and volume of snowmelt, historic placer mining - sedimentation
Fraser Chinook Salmon - Summer 4 <sub>1</sub>	South Thompson Ocean Summer	South Thompson River (Summer 4-1)		Adams River, Little River, Thompson River – Lower, South Thompson	Far North Migrating		Not at Risk	not assessed	not assessed	mining (no current contamination, but risk of tailings dam)
		Shuswap River (Summer 4-1)		Shuswap River – Lower, Shuswap River – Upper, Wap Creek	Far North Migrating		Not at Risk	green	data deficient	mining (no current contamination, but risk of tailings dam)

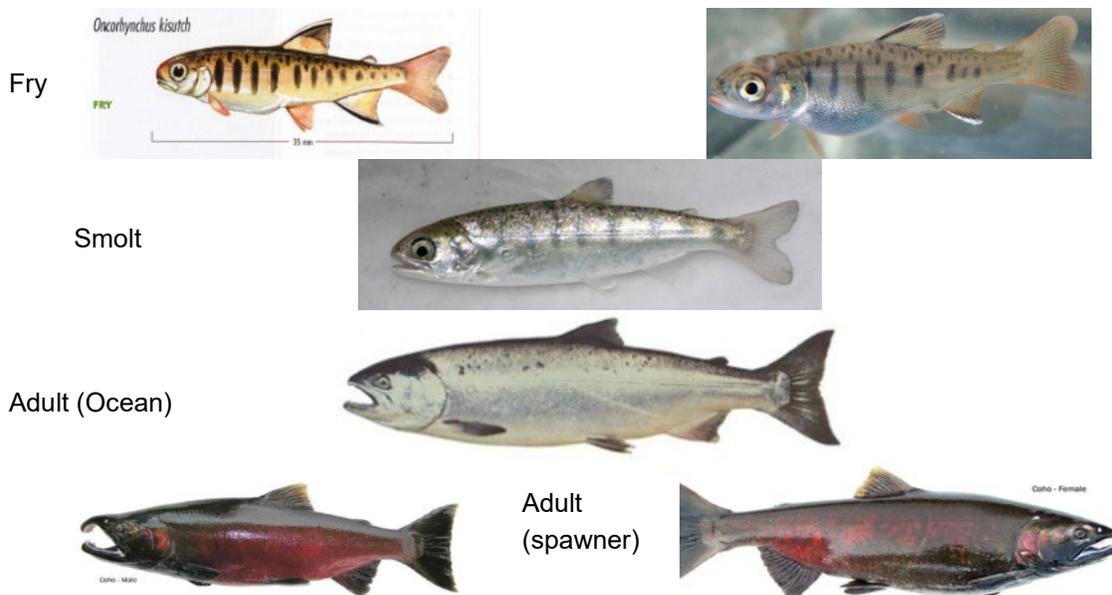
SMU	DU	CU	CU Location	Major Watersheds (CU)	Ocean Distribution	Escapement	Status			Causes of Decline (DU)
							COSEWIC	WSP	PSF	
Fraser Chinook Salmon - Summer 4 <sub>1</sub>	South Thompson Ocean Summer	South Thompson - Adams River Upper		Battle Creek, Spectrum Creek, Seymour Arm, Shushwap Lake, Ferry Creek	Far north migrating?		Not at Risk	not assessed	data deficient	mining (no current contamination, but risk of tailings dam)
Fraser River Chinook Salmon - Summer 5 <sub>2</sub>	Middle Fraser River Stream Fall	Middle Fraser River - Portage (Fall 5-2)		Portage Creek	Offshore?		Endangered	red	data deficient	Seton Dam degrading downstream spawning habitat, abandoned mine impacting water quality
Fraser River Chinook Salmon - Summer 5 <sub>2</sub>	Middle Fraser River Stream Summer	Middle Fraser River (Summer 5-2)		Baptiste Creek, Cariboo River, Chilko River, Elkin Creek, Kazchek Creek, Kuzkwa River, Leo Creek, Mitchell River, Nancut Creek, Natazutlo Creek, Nechako River, Necoslie River, Ormond Creek, Pinchi Creek, Pitka Creek, Quesnel River, Seton & Cayoosh Creeks, Seton River, Stellako River, Stuart River, Taseko River	Offshore		Threatened	amber	data deficient	Mount Polley, Kenney dam (temperature and flow impacts to Nechako River), mining water quality impacts
Fraser River Chinook Salmon - Summer 5 <sub>2</sub>	North Thompson Stream Summer	North Thompson River (Summer 5-2)		North Thompson River, Lemieux Creek, Mann Creek, Barriere River, Raft River, Clearwater River, Mahood River	Offshore		Endangered	red	data deficient	This summer run of chinook spawning in the North Thompson River has steeply declined in abundance. Declines in marine and freshwater habitat quality, and harvest, are threats facing this population.

SMU	DU	CU	CU Location	Major Watersheds (CU)	Ocean Distribution	Escapement	Status			Causes of Decline (DU)
							COSEWIC	WSP	PSF	
	South Thompson Stream Summer 1.3	South Thompson River (Summer 5-2)		Eagle River, Salmon River, Scotch Creek, Seymour River	Offshore		Endangered	amber/red	data deficient	Threats include decreased water levels (water withdrawal and changes in volume as a result on low marine survival, harvest, and timing of snow melt), agricultural runoff, pollution from transportation accidents, and highly-modified freshwater habitats. Such threats are accentuated due to a relatively long freshwater residence.

## 2. COHO SALMON

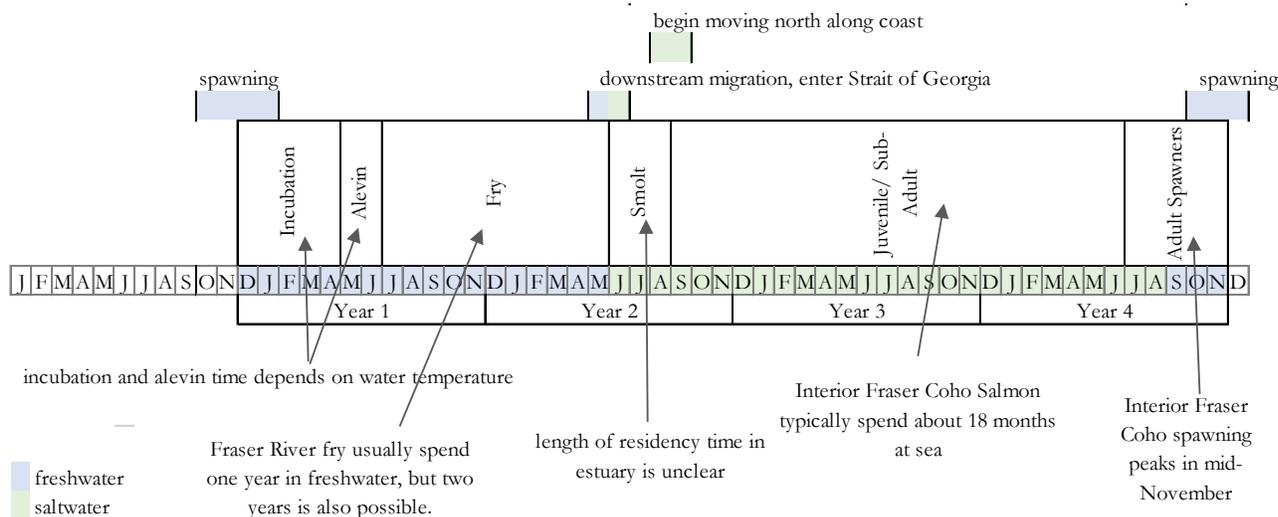
Coho Salmon (*Oncorhynchus kisutch*; Figure 3) have a reputation for being fast and active in comparison to other salmon species. Adults are typically 45 – 70 cm in length, weighing 2 - 5 kg, although some can be as large as 9 kg. Interior Fraser Coho Salmon are typically smaller than other British Columbia populations (COSEWIC 2016; DFO 2019).

**Figure 3. Coho Salmon at different life stages (Pollard *et al.* 1997; Steele 2011; DFO 2020; BC Fishing Journal 2021).**



Interior Fraser Coho Salmon spawn in the fall and early winter (Figure 4), with fry emerging the following spring and typically remaining in freshwater for a year before migrating to the ocean as smolts in their second spring. Estuarine residence time is not well understood. Unlike other salmon species, Coho Salmon tend to remain in coastal waters as adults rather than migrating long distances offshore. Most Interior Fraser Coho Salmon spend 18 months at sea before returning to their natal stream to spawn (COSEWIC 2016; DFO 2019).

**Figure 4. Fraser River Coho Salmon typical life cycle (McPhail 2007; VIU 2009; COSEWIC 2016; Gomez and Scroggie 2021).**



Spawning habitat is often located at the head of riffles in small streams, and in side channels of larger rivers, where water is shallow (< 30 cm), rocks and gravel are less than 15 cm diameter, and there is good circulation of well-oxygenated water. Winter stream flow and temperature are instrumental in egg survival, favouring lake-headed systems and areas of groundwater input. Fry prefer small streams, sloughs, ponds, side channels and small tributaries, with low gradients and velocities. Juvenile Coho Salmon are very territorial, which can make rearing habitat a limiting factor for productivity of small streams (COSEWIC 2016; DFO 2019).

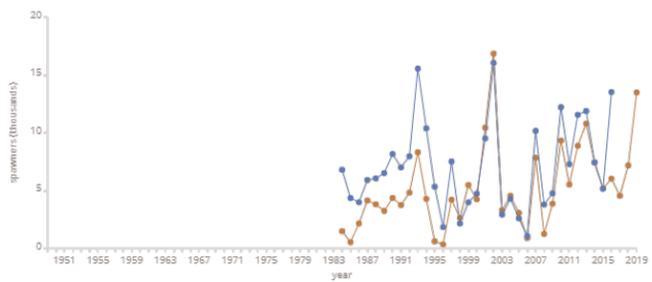
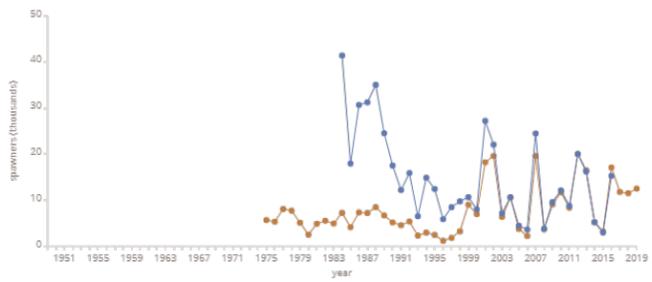
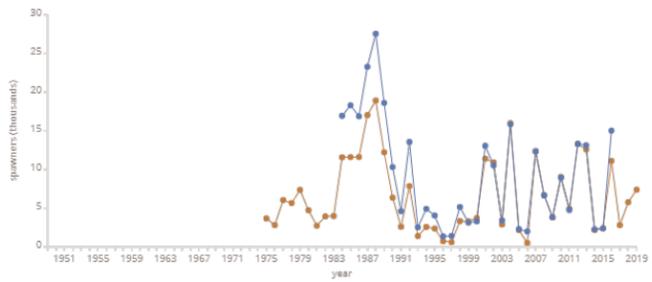
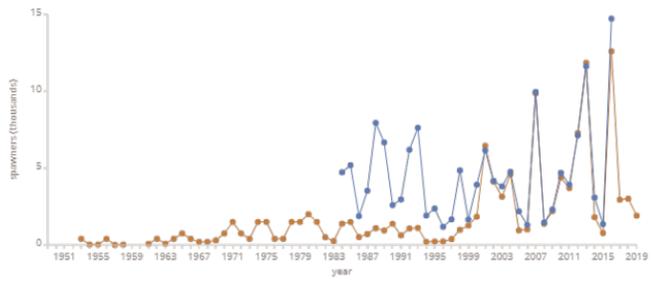
Coho Salmon fry have been observed in the lower reach of Kwoiek Creek (Griffith 1997), as have returning adults assumed to be Coho Salmon based on the timing of the observation and the size and colouration of the fish (Chambers and Faulkner 2021; Figure 5). Other tributary streams in Kanaka Bar territory may also provide some Coho Salmon spawning habitat in their downstream-most reaches.

**Figure 5.** Fish (likely Coho Salmon) attempting to pass through the flume on Kwoiek Creek on September 30, 2020.



Coho Salmon from one SMU (Interior Fraser) travel through Kanaka Bar territory. This SMU contains one DU (also named Interior Fraser) and five CUs that travel through Kanaka Bar (Table 2). The Coho Salmon documented in Kwoiek Creek likely belong to the Fraser Canyon CU, which counts the Nahatlatch River and the Thompson River as confirmed spawning locations (PSF 2020). The Fraser Canyon CU has a WSP status of amber (Table 2).

**Table 2. Fraser River Coho Salmon populations potentially present at Kanaka Bar – distribution and abundance (COSEWIC 2016; PSF 2020).**

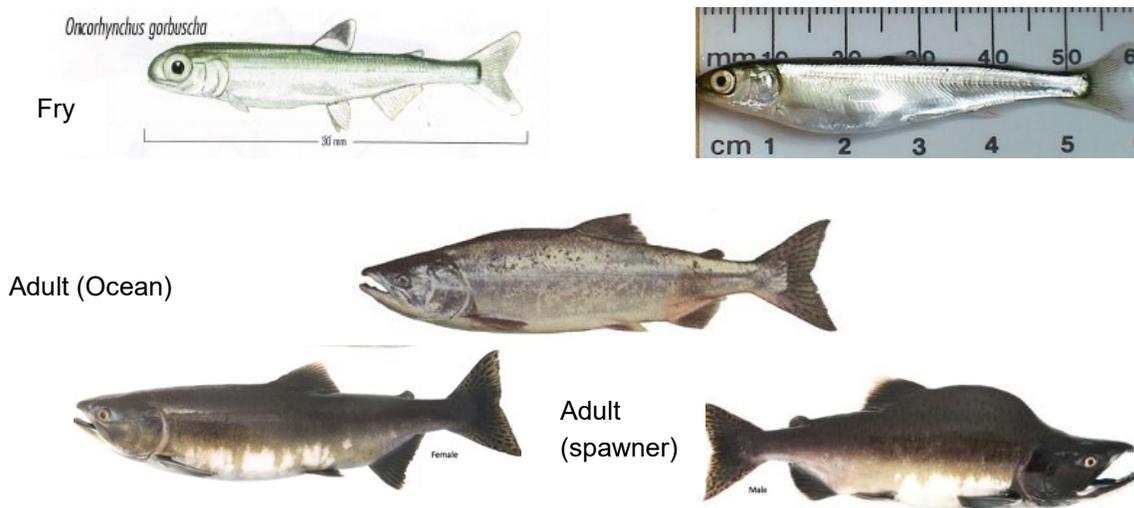
SMU	DU	CU	CU Location	Major Watersheds (CU)	Ocean Distribution	Escapement	Status			Causes of Decline (DU)
							COSEWIC	WSP	PSF	
Interior Fraser	Interior Fraser	Lower Thompson		Lower Thompson, Nicola River	Coastal		Threatened	green/amber	data deficient	Overfishing, changing marine conditions, and habitat perturbations all contributed to declines in abundance. Ongoing unfavourable marine conditions, disturbance of the freshwater habitat and introduction of invasive non-native species pose a continuing threat.
Interior Fraser	Interior Fraser	North Thompson		Lower North Thompson, Middle North Thompson, Upper North Thompson	Coastal		Threatened	green/amber	data deficient	Overfishing, changing marine conditions, and habitat perturbations all contributed to declines in abundance. Ongoing unfavourable marine conditions, disturbance of the freshwater habitat and introduction of invasive non-native species pose a continuing threat.
Interior Fraser	Interior Fraser	South Thompson		South Thompson, Adams River, Middle and Lower Shuswap, Shuswap Lake	Coastal		Threatened	amber	data deficient	Overfishing, changing marine conditions, and habitat perturbations all contributed to declines in abundance. Ongoing unfavourable marine conditions, disturbance of the freshwater habitat and introduction of invasive non-native species pose a continuing threat.
Interior Fraser	Interior Fraser	Interior Fraser		Middle Fraser, Upper Fraser	Coastal		Threatened	amber	data deficient	Overfishing, changing marine conditions, and habitat perturbations all contributed to declines in abundance. Ongoing unfavourable marine conditions, disturbance of the freshwater habitat and introduction of invasive non-native species pose a continuing threat.

SMU	DU	CU	CU Location	Major Watersheds (CU)	Ocean Distribution	Escapement	Status			Causes of Decline (DU)
							COSEWIC	WSP	PSF	
Interior Fraser	Interior Fraser	Fraser Canyon		Fraser Canyon	Coastal		Threatened	amber	data deficient	Overfishing, changing marine conditions, and habitat perturbations all contributed to declines in abundance. Ongoing unfavourable marine conditions, disturbance of the freshwater habitat and introduction of invasive non-native species pose a continuing threat.

### 3. PINK SALMON

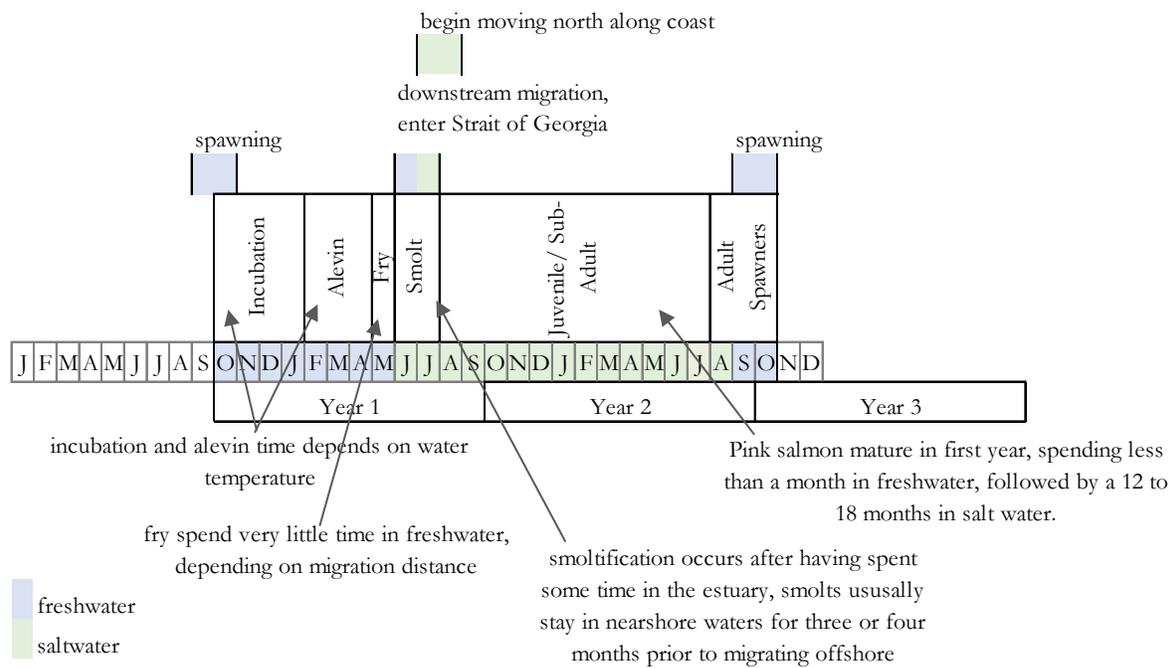
Pink salmon (*Oncorhynchus gorbuscha*; Figure 6) are the most abundant of the Pacific salmon species, and are also the smallest, with adults typically 45 – 60 cm in length and weighing 1.4 – 5 kg (DFO 2019; PSF 2021).

**Figure 6. Pink Salmon at different life stages (Pollard *et al.* 1997; Steele 2011; DFO 2020; BC Fishing Journal 2021).**



Pink Salmon's fixed, two-year lifespan is the shortest of any Pacific salmon, with even and odd year returns genetically distinct from one another. Fraser River Pink Salmon only spawn in odd years. Pink Salmon spend the least time in freshwater of any Pacific salmon species, heading for the ocean immediately after emergence (DFO 2019; PSF 2021).

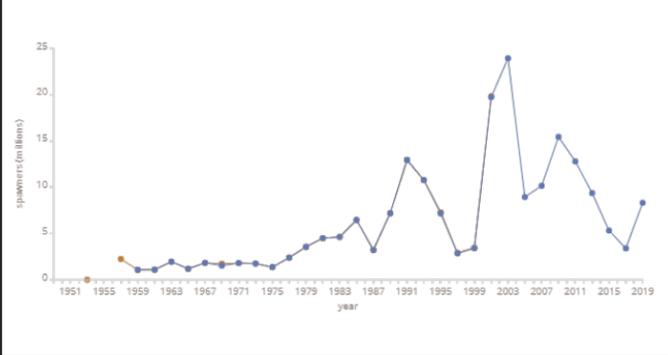
**Figure 7. Fraser River Pink Salmon typical life cycle (Roberge et al. 2002; McPhail 2007; VIU 2009; Grant et al. 2014; DFO 2019; Davis and Xu 2021).**



Pink Salmon prefer to spawn in the lower reaches of streams and rivers and tend to avoid obstacles. Spawning usually occurs in or near riffles with low to moderate flows and clean gravel, in depths from 0.3 to 1 m. Fry begin downstream migration towards the estuary immediately after emergence (McPhail 2007; VIU 2009). Suitable spawning habitat for Pink Salmon is not present in Kanaka Bar territory.

One SMU of Pink Salmon, forming a single CU (Fraser River (odd)), travels through Kanaka Bar territory (Table 3). COSEWIC has not listed this species, and so no DUs have been established. This CU has not been assessed by DFO through the WSP, however the Pacific Salmon Foundation has rated it as having a poor (roughly equivalent to the WSP “red”) biological status using a methodology similar to that of the WSP (PSF 2020b; Table 3 **Error! Reference source not found.**).

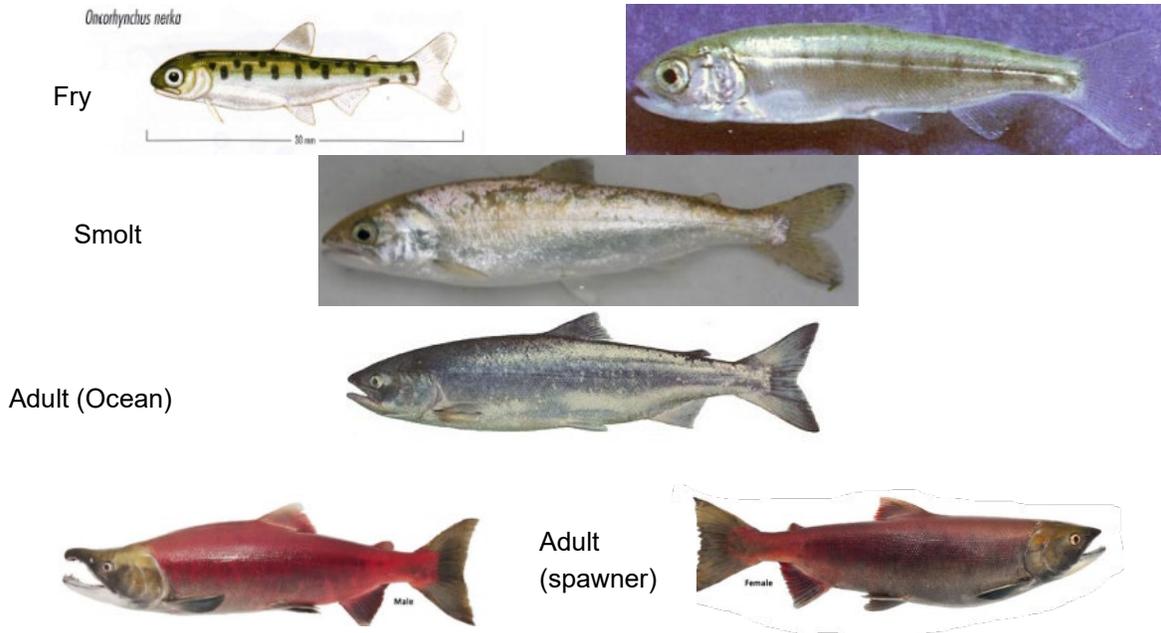
**Table 3. Fraser River Pink Salmon populations potentially present at Kanaka Bar – distribution and abundance (PSF 2020).**

SMU	DU	CU	CU Location	Major Watersheds (CU)	Ocean Distribution	Escapement	Status			Causes of Decline (DU)
							COSEWIC	WSP	PSF	
Fraser Pink Salmon (odd)	Not Applicable	Fraser River, Thompson River		Fraser River and tributaries	Offshore		Not Listed	not assessed	red	Poor marine survival

#### 4. SOCKEYE SALMON

Sockeye Salmon (*Oncorhynchus nerka*; Figure 8) are a species of major importance to the Kanaka Bar Band, and to many other First Nations cultures. They are an iconic species in British Columbia, with distinctive bright red colouring during spawning. Adults are typically 50 – 60 cm in length, weighing 2.2 -3.1 kg, although some can be over 6 kg (COSEWIC 2017; DFO 2019; PSF 2021).

**Figure 8. Sockeye Salmon at different life stages (Pollard *et al.* 1997; Steele 2011; DFO 2020; BC Fishing Journal 2021).**

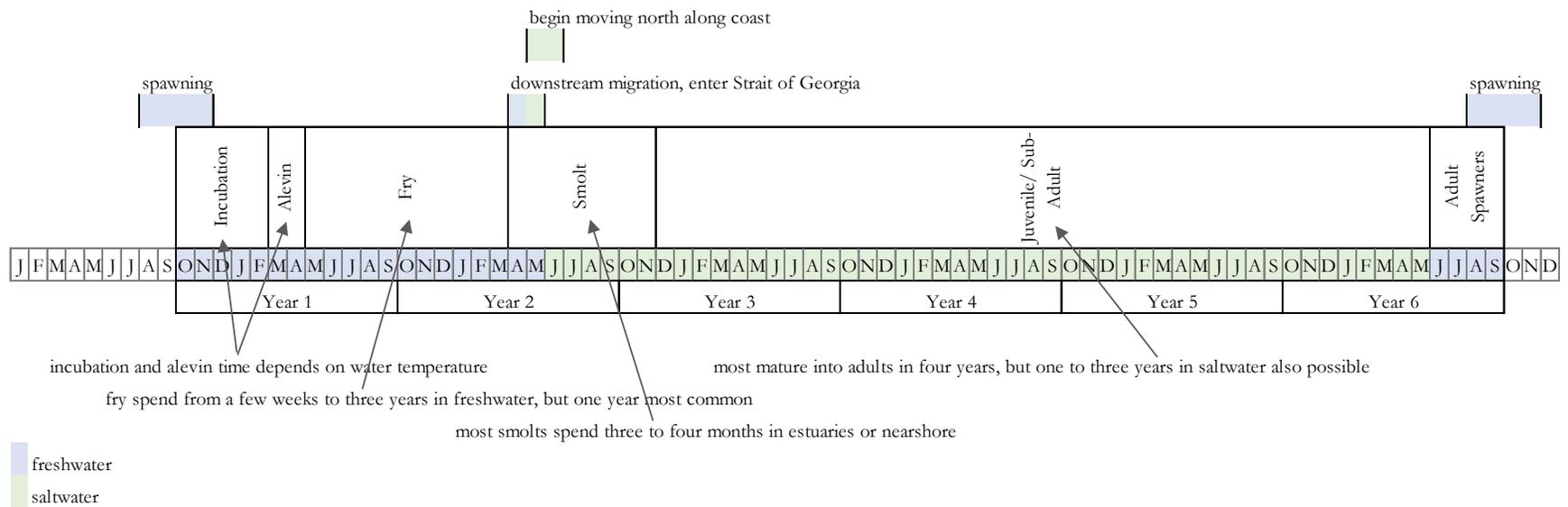


Sockeye salmon display a wide variety of life history patterns (including an entirely freshwater form called kokanee), but typically they will spend between four to six months incubating, one year<sup>2</sup> rearing in freshwater, followed by a four-year<sup>3</sup> period in saltwater before returning to spawn (Figure 9).

<sup>2</sup>One year is most common; a few days to three years possible.

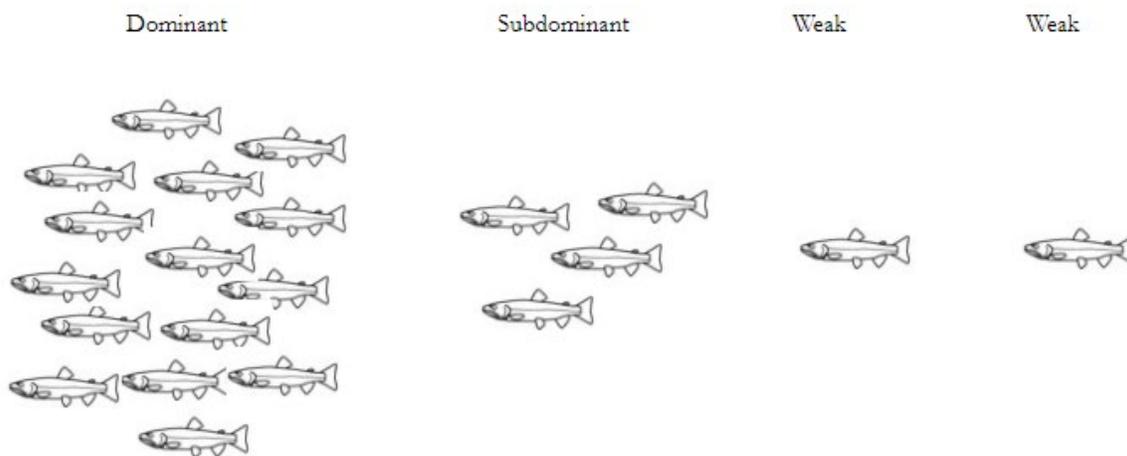
<sup>3</sup> Four years is most common; one to four years possible.

**Figure 9 Fraser River Sockeye Salmon typical life cycle (McPhail 2007; VIU 2009; Cohen 2012; COSEWIC 2017).**



Many Sockeye Salmon populations have a four-year cycle of abundance (Figure 10), with a dominant line<sup>4</sup> (i.e., high abundance), a subdominant line (10-25% of the size of the dominant line), and two weak lines (each with <1% of the dominant line). As a result, returns from year to year can be dramatically different (Ricker 1997; DFO 2019).

**Figure 10. Four-year Sockeye Salmon abundance cycle.**



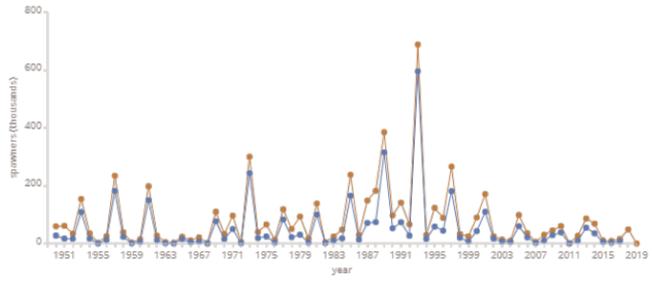
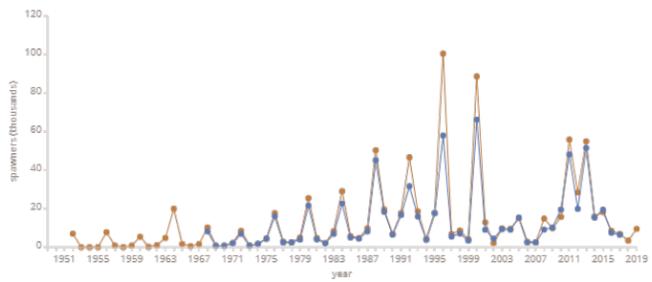
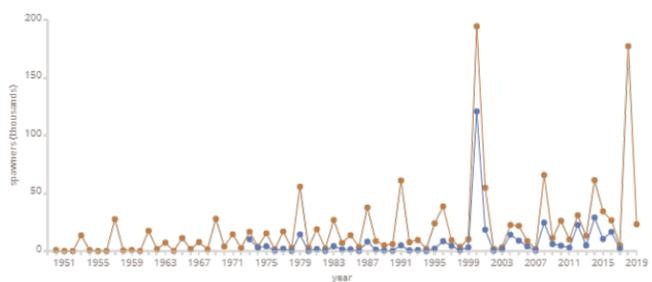
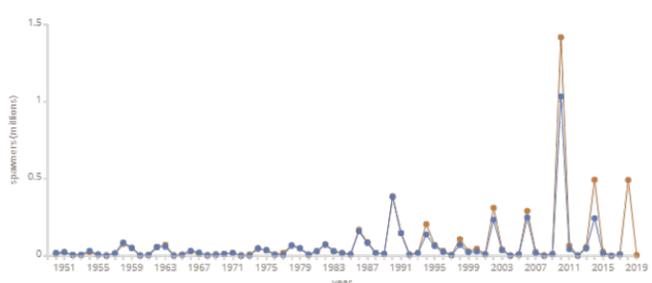
Sockeye Salmon spawn in rivers or along gravelly lake shoals and typically rear in lakes, although there are exceptions. River-type Sockeye Salmon prefer low-gradient slough and backwater or off-channel areas for rearing. They tend to spawn along gravelly lake shoals or in lake inlet or outlet streams, in areas of groundwater upwelling. Spawning areas typically have low to moderate flows, clean gravel, and range in depth from 0.3 to 9.2 m (McPhail 2007; COSEWIC 2017a). Sockeye Salmon are not known to spawn in Kanaka Bar territory tributary streams, and suitable habitat is not present.

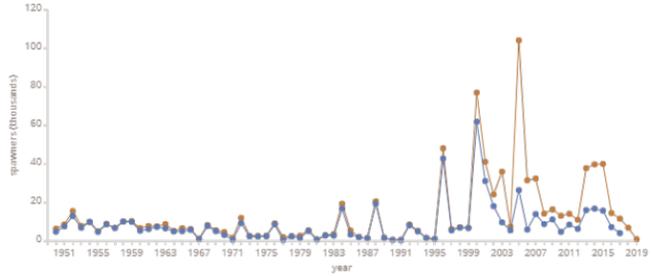
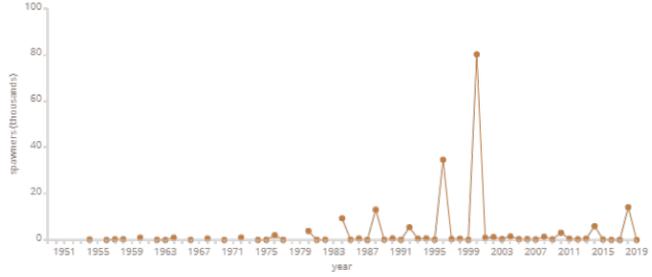
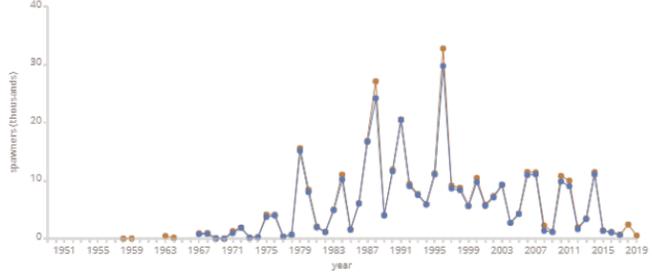
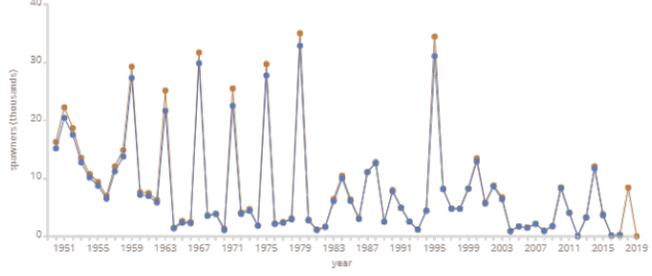
Sockeye Salmon from four Fraser River SMUs (Early Stuart, Early Summer, Summer, and Late) travel through Kanaka Bar territory, encompassing 14 DUs and 15 CUs potentially present at Kanaka Bar. Spawning locations of these population units are shown in Table 4.

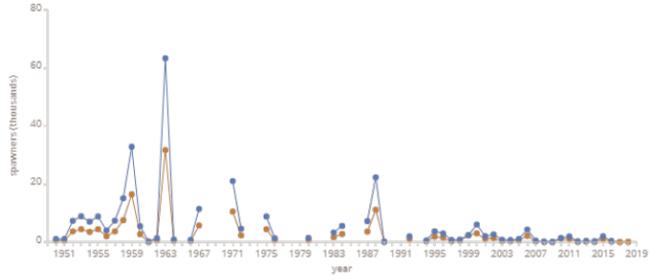
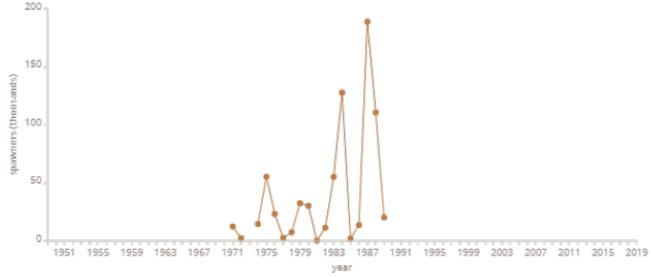
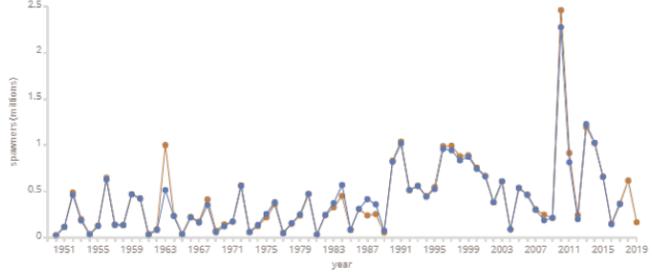
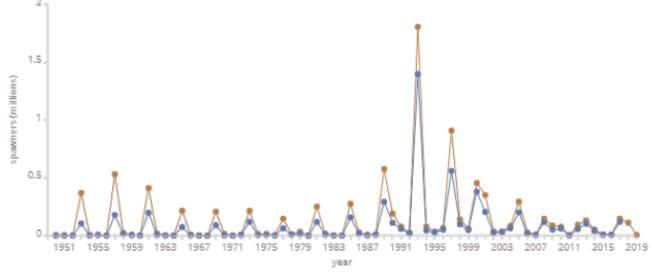
Almost half of Fraser River Sockeye Salmon CUs have been assessed as red by WSP (with most of the corresponding DUs listed as Endangered by COSEWIC). River-type Sockeye Salmon, which spend less time in freshwater than lake-type life history forms, seem to be doing better, with many of these CUs ranked as green by WSP (Grant *et al.* 2019). Table 4 provides abundance descriptors and identified threats by population unit.

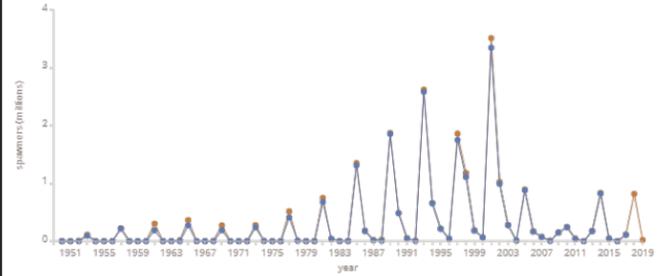
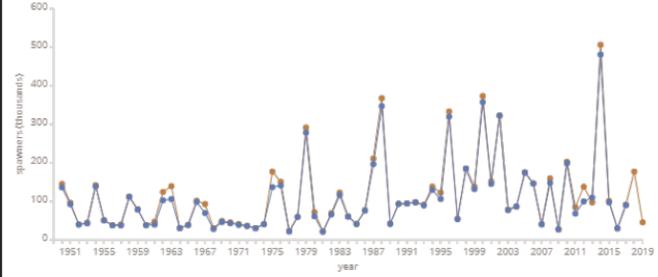
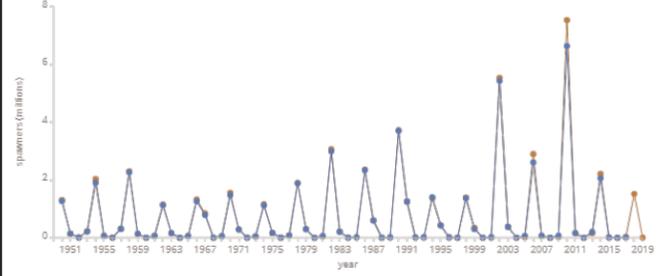
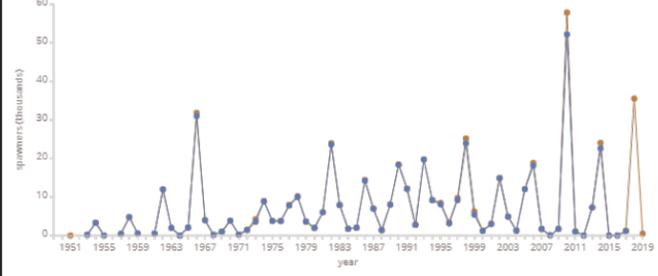
<sup>4</sup> Line or cycle line: A sequence of runs separated by an interval that is the principal age of maturity of the population in question. Lines are identified by the year in which each occurred at the start of this century, i.e., 1901–1904, and also (where dominance exists) by their position in the cycle (Ricker 1997).

**Table 4. Fraser River Sockeye Salmon populations potentially present at Kanaka Bar – distribution and abundance (COSEWIC 2017; PSF 2020).**

SMU	DU	CU	CU Location	Major Watersheds (CU)	Ocean Distribution	Escapement	Status			Causes of Decline (DU)
							COSEWIC	WSP	PSF	
Fraser Sockeye Salmon - Early Stuart (cyclic)	Takla-Trembleur-EStu	Takla - Trembleur - Early Stuart (cyclic)		Takla Lake, Middle River, Driftwood River, Sakeniche River, Rossette (Van Decar) Creek, Paula Creek, Sydney (Felix) Creek	Offshore		Endangered	red	data deficient	Productivity is currently very low. Threats include fisheries, depressed marine survival, freshwater temperature extremes, changes in the timing of freshet, industrial effluent, marine mammal predation, competition with abundant Pink Salmon at sea and pathogens. This DU has been severely affected by the Big Bar landslide.
Fraser Sockeye Salmon - Early Summer	Anderson-Seton-ES	Anderson - Seton - Early Summer		Gates Channel, Gates Creek	Offshore		Not at Risk	green/amber	red	Numbers have been increasing since the mid-1950s. Extreme cyclic dominance (dominant cycle line averages 600 times larger than the smallest). Threats: pollution from industrial effluents in freshwater, the Fraser River estuary and Strait of Georgia; the possibility of spills from train derailments beside nursery lakes; landslides; freshwater temperature extremes (leading to severe losses during adult migrations to spawning grounds); agricultural effluent, marine mammal predation, competition with abundant Pink Salmon at sea and pathogens.
Fraser Sockeye Salmon - Early Summer	Nadina-Francois-ES	Nadina - Francois - Early Summer		Glacier Creek, Nadina River, Nadina Channel, Tagetochlain Creek	Offshore		Not at Risk	green/amber	amber	The number of mature individuals has steadily increased since 1950. Freshwater spawning and rearing habitat is relatively unimpacted by human activities, but climate change-related stressors apply. As an early spawner, this DU has been heavily impacted by loss of access to spawning habitat due to the Big Bar landslide.
Fraser Sockeye Salmon - Early Summer	Shuswap-ES	Shuswap - Early Summer (cyclic)		Adams River, Eagle River, Seymour River, Scotch Creek	Offshore		Not at Risk	amber	data deficient	The number of mature individuals in the population has increased since records were first taken in the mid-1950s. DU-specific threats have not been assessed, but climate change, urban land use, agricultural land use, water restriction and placer mines may be impacting this DU. As an early spawner, this DU has been heavily impacted by loss of access to spawning habitat due to the Big Bar landslide.

SMU	DU	CU	CU Location	Major Watersheds (CU)	Ocean Distribution	Escapement	Status			Causes of Decline (DU)
							COSEWIC	WSP	PSF	
Fraser Sockeye Salmon - Early Summer	Kamloops-ES	Kamloops - Early Summer		Clearwater River, North Thompson River, Barriere River	Offshore		Special Concern	amber	amber	Numbers greater than 1960-1995, but decline over last three generations. Threats: Seton Dam (changes to Seton Lake limnology, attraction of adult fish to the river, passage of fish through the dam, smolt mortality through the powerhouse); industrial effluents in freshwater, the Fraser River estuary and Strait of Georgia; possible spills from train derailments beside Kamloops Lake; freshwater temperature extremes impacting adult migrations; roads and railroads; marine mammal predation; competition with abundant Pink Salmon at sea and pathogens. As an early spawner, heavily impacted by the Big Bar landslide.
Fraser Sockeye Salmon - Early Summer	Kamloops-ES	Adams & Mornich Lakes - Early Summer		Clearwater River, North Thompson River, Barriere River	Offshore		not assessed	not assessed	data deficient	Numbers greater than 1960-1995, but decline over last three generations. Threats: Seton Dam (changes to Seton Lake limnology, attraction of adult fish to the river, passage of fish through the dam, smolt mortality through the powerhouse); industrial effluents in freshwater, the Fraser River estuary and Strait of Georgia; possible spills from train derailments beside Kamloops Lake; freshwater temperature extremes impacting adult migrations; roads and railroads; marine mammal predation; competition with abundant Pink Salmon at sea and pathogens. As an early spawner, heavily impacted by the Big Bar landslide.
Fraser Sockeye Salmon - Early Summer	North Barriere-ES	North Barriere - Early Summer (de novo)		Upper Barriere River, Harper Creek	Offshore		Threatened	amber	amber	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. DU-specific threats have not been assessed, but logging, Mountain Pine Beetle disturbance, road density and placer mines all may impact this DU.
Fraser Sockeye Salmon - Early Summer	Bowron-ES	Bowron - Early Summer		Antler Creek, Bowron River, Pomeroy Creek, Huckey Creek, Sus Creek	Offshore		Endangered	red	red	This DU faces a number of threats in both freshwater and marine areas which are causing habitat quality to decline; threats specific to this DU have not yet been assessed although Mountain Pine Beetle disturbance may play a role. 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.

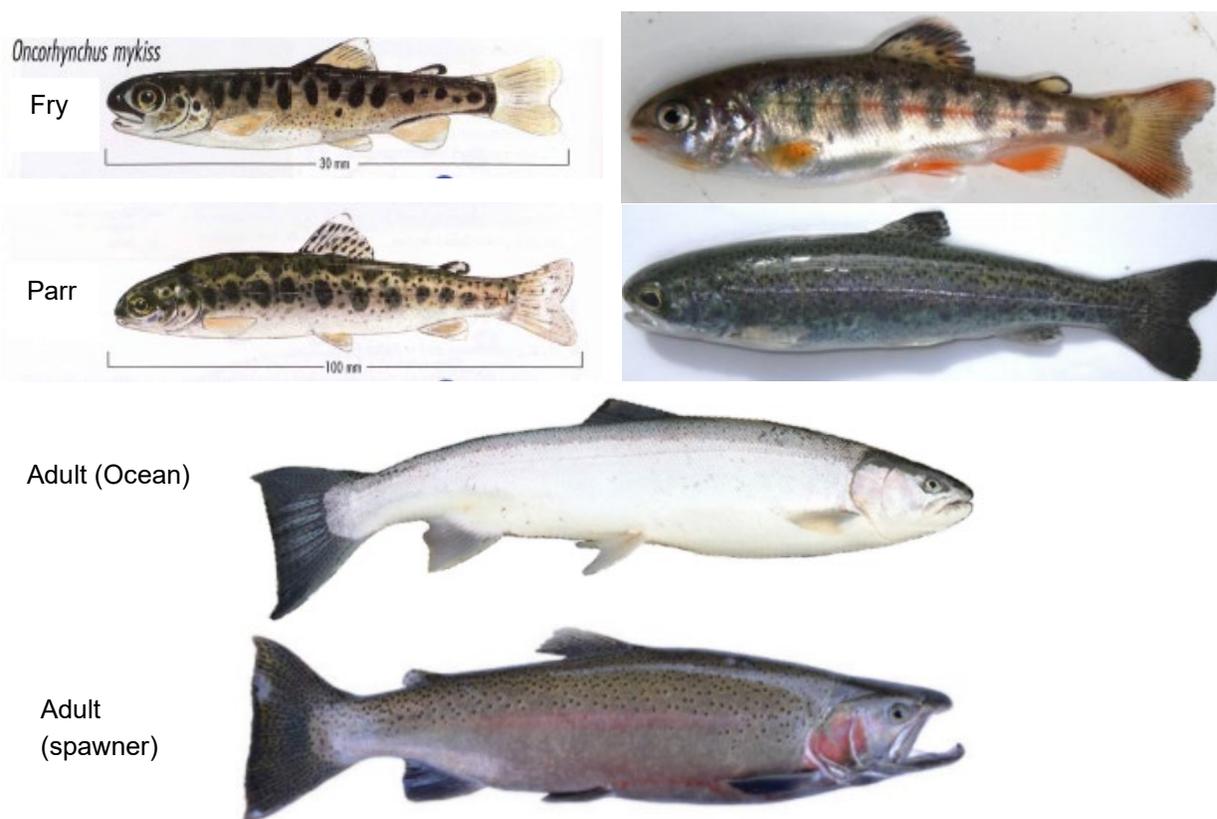
SMU	DU	CU	CU Location	Major Watersheds (CU)	Ocean Distribution	Escapement	Status			Causes of Decline (DU)
							COSEWIC	WSP	PSF	
Fraser Sockeye Salmon - Early Summer	Taseko-ES	Taseko - Early Summer		Taseko Lake	Offshore		Endangered	red	red	The number of mature individuals was relatively high in the late 1990s; since then the numbers have declined considerably and are close to a historical minimum. DU-specific threats have not been assessed, although as with other populations climate change is a factor. Freshwater spawning and rearing habitat has seen relatively few impacts from human activities.
Fraser Sockeye Salmon - Early Summer	Chilko-ES	Chilko - Early Summer		Chilko River, Chilko Channel, Chilko Lake North, Chilko Lake South (Includes Chilko-S as data aggregated)	Offshore		Not at Risk	green	data deficient	The number of mature individuals in the population has been increasing since records were first taken in the mid-1950s. Freshwater survival has been good recently, although marine survival has declined since the early 1990s. DU-specific threats have not been assessed, but those general to Sockeye Salmon (e.g., climate change, habitat loss) apply. As an early spawner, this DU has been heavily impacted by loss of access to spawning habitat due to the Big Bar landslide.
Fraser Sockeye Salmon - Summer	Chilko-S	Chilko - Summer		Chilko River, Chilko Channel, Chilko Lake North, Chilko Lake South (Includes Chilko-ES as data aggregated)	Offshore		Not at Risk	green	green	The number of mature individuals in the population has been increasing since records were first taken in the mid-1950s. Freshwater survival has been good recently, although marine survival has declined since the early 1990s. DU-specific threats have not been assessed, but those general to Sockeye Salmon (e.g., climate change, habitat loss) apply. This DU has been impacted by loss of access to spawning habitat due to the Big Bar landslide.
Fraser Sockeye Salmon - Summer	Takla-Trembleur-Stuart-S	Takla - Trembleur - Stuart - Summer (cyclic)		Middle River, Sakeniche River, Stuart River, Tachie River	Offshore		Endangered	amber/red	data deficient	DU-specific threats have not been assessed, but those general to Sockeye Salmon (e.g., climate change, habitat loss) apply. Freshwater habitat for this DU is subject to high intensity Mountain Pine Beetle disturbance, and a lesser intensity of logging, placer mines and road density occurrences.

SMU	DU	CU	CU Location	Major Watersheds (CU)	Ocean Distribution	Escapement	Status			Causes of Decline (DU)
							COSEWIC	WSP	PSF	
Fraser Sockeye Salmon - Summer	Quesnel-S	Quesnel - Summer (cyclic)		Horsefly River, Quesnel Lake, McKinley Lake	Offshore		Endangered	amber/red	data deficient	Threats to this DU include fisheries, depressed marine survival, freshwater temperature extremes, marine mammal predation, competition with abundant Pink Salmon at sea and pathogens. Modifications to the freshwater ecology of Quesnel Lake related to fisheries management actions directed at changing cyclic dominance may also pose a threat, as may lingering effects of contaminants from the 2014 Mount Polley tailings pond failure.
Fraser Sockeye Salmon - Summer	Francois-Fraser-S	Francois - Fraser - Summer		Stellako River, Uncha Creek, Ormonde Creek	Offshore		Special Concern	amber/green	amber	DU-specific threats have not been assessed, but those general to Sockeye Salmon (e.g., climate change) apply. Freshwater spawning and rearing habitat is relatively unimpacted. Previous high exploitation rates may have influenced current abundance. This DU has been impacted by loss of access to spawning habitat due to the Big Bar landslide.
Fraser Sockeye Salmon - Late	Shuswap Complex-L	Shuswap - Late (cyclic)		Adams Lake, Shushwap Lake, Little Shushwap Lake, Mara Lake, Mabel Lake	Offshore		Not at Risk	green/amber	data deficient	Urban development, water allocation, placer mines, fisheries, depressed marine survival, exposure to industrial effluents in freshwater, the Fraser Estuary and Strait of Georgia, possibility of contaminant spills from train derailments into Shushwap Lake, agricultural effluent, marine mammal predation, competition with abundant Pink Salmon at sea, and pathogens.
Fraser Sockeye Salmon - Late	Seton-L	Seton - Late (de novo)		Portage Creek	Offshore		Endangered	red	red	Water allocation, fisheries (particularly as this DU can be harvested in a mixed stock fishery with the large Shuswap Complex L DU, hence experiencing high exploitation), exposure to industrial effluent in freshwater, the Fraser River estuary and Georgia Strait, possible spills from train derailments, marine mammal predation, competition with abundant Pink Salmon at sea and pathogens. Freshwater spawning and rearing habitat relatively unimpacted by human activities. As a late-spawning population this DU has been less impacted by the Big Bar slide than some others, but landslides in and around Portage Creek are a threat.

## 5. STEELHEAD

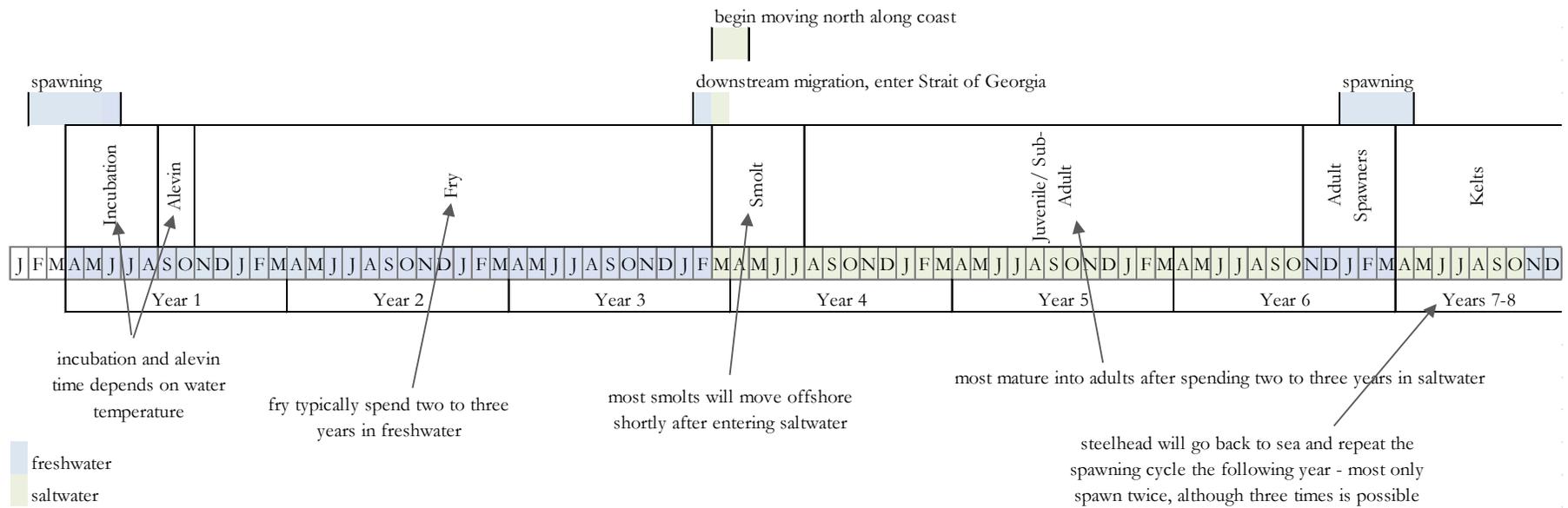
Steelhead (*Oncorhynchus mykiss*; Figure 11) are the anadromous form of Rainbow Trout. Juvenile steelhead and resident Rainbow Trout cannot be differentiated, and for reasons as of yet not understood sometimes steelhead remain resident and vice versa (i.e., resident Rainbow Trout smolt and migrate to the ocean, becoming steelhead) (Kendall *et al.* 2015). Unlike Pacific salmon, steelhead can be repeat spawners, and are long-lived (up to eight years). The largest adults can be over a metre in length and weigh 30 kg, although most weigh 3.6 – 9 kg (PSF 2021).

**Figure 11. Steelhead at different life stages (Pollard *et al.* 1997; Steele 2011; DFO 2020; BC Fishing Journal 2021).**



Steelhead can spend anywhere from one to five winters in freshwater before smolting and migrating to sea. Once there, steelhead typically spend two or three summers in the ocean before returning to freshwater to spawn (Figure 12). Steelhead have two forms: summer-run and winter-run, differentiated on the basis of the timing of their return from the ocean. Steelhead populations potentially present in Kanaka Bar territory all belong to the summer-run form, entering the Fraser River in late summer through autumn. Summer-run steelhead have two migration phases: first, from the ocean to freshwater overwintering habitat, and second, from overwintering areas to spawning sites (DFO 2018; PSF 2021).

Figure 12. Fraser River steelhead typical life cycle (Light *et al.* 1989; McPhail 2007; VIU 2009; Bison 2012; MFLNRO 2016).



Steelhead spawn in moderate to high gradient sections of streams at the head of riffles or the tail end of pools, in areas that have clean gravel and groundwater upwelling, at depths from 0.1 to 1.4 m. Larger steelhead spawn in habitat similar to Chinook Salmon, i.e., mainstem habitat in large shallow rivers with medium to large gravel substrate. Juveniles typically rear in freshwater for two to three years, and display various habitat preferences (e.g., tributary stream, side channel, mainstem, lake) depending on size (Roberge *et al.* 2002; McPhail 2007; VIU 2009). Juvenile Rainbow Trout have been documented in Kanaka Bar territory tributary streams. While spawning habitat in Kanaka Bar territory tributary streams is more suitable to resident Rainbow Trout than the larger steelhead form, as juveniles of the two life forms are impossible to distinguish steelhead presence cannot be ruled out.

One provincial run, Interior Fraser, travels through Kanaka Bar territory, comprised of 11 stocks in total, all of which are potentially present at Kanaka Bar. There are no documented stocks of steelhead specific to tributary streams in Kanaka Bar territory; the two nearest stocks are Nahatlatch and Stein (Bison 2012; PSF 2020). Spawning locations of these stocks are shown in Table 5.

The Province considers Interior Fraser steelhead populations to be in a state of Extreme Conservation Concern (i.e., stocks at less than 10% of habitat capacity) (MOE 2005; Bison 2020). COSEWIC has assessed two DUs (Thompson and Chilcotin) that pass through Kanaka Bar territory as Endangered; these two DUs encompass six of the stocks within the Interior Fraser run (Bison 2012; COSEWIC 2018; DFO 2018a). Other stocks of steelhead belonging to the Interior Fraser run have not been assessed by COSEWIC. Table 5 provides abundance descriptors and identified threats by population unit, where available.

**Table 5. Fraser River steelhead populations potentially present at Kanaka Bar – distribution (Bison 2012; MFLNRO 2016; COSEWIC 2018; DFO 2018; PSF 2020).**

Ecotype	DU	Major Drainage	Stock	Ocean Distribution	Escapement	Status		Causes of Decline (DU)
						COSEWIC	Province of BC	
Interior Late Summer-run	n/a	Fraser Canyon	Nahatlatch	Unknown	Not available	Not assessed	Extreme Conservation Concern	Not assessed
			Stein		Not available			
			Seton		Not available, but stock known to be very small			
			Bridge		Not available			
	Thompson River	Thompson	Thompson	Offshore - Bering Sea		Endangered	Extreme Conservation Concern	Declining habitat quality and reduced survival rates while at sea, due to factors such as increased ocean temperatures, bycatch in fisheries for other species, competition from hatchery fish and abundant Pink Salmon, and possible predation from pinnipeds. Freshwater habitat quality is also declining, but the severity of this threat is not well understood. Water scarcity and freshwater temperatures are an issue in this DU.
			Nicola					
			Bonaparte					
			Deadman					
	Chilcotin River	Chilcotin	Chilcotin	Offshore - Bering Sea		Endangered	Extreme Conservation Concern	Declining habitat quality and reduced survival rates while at sea, due to factors such as increased ocean temperatures, bycatch in fisheries for other species, competition from hatchery fish and abundant Pink Salmon, and possible predation from pinnipeds. Freshwater habitat quality is also declining, but the severity of this threat is not well understood.
			Chilko					
			Taseko					
			Little Chilcotin					
	n/a	Quesnel	Cariboo	Unknown	Not available, but stock possibly marginally existent	Not assessed	Extreme Conservation Concern	Not assessed

## REFERENCES

- BC Fishing Journal. 2021. Pacific Salmon / Steelhead Identification and Lifecycle. Available online at: <https://www.bcfishingjournal.com/project/pacific-salmon-species-identification/>.
- Bison, R. 2012. Population Attributes for Fraser River Late-Run Summer Steelhead. Kamloops, BC Available online at: [https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/fish-fish-habitat/fishery-resources/interior-fraser-steelhead/bison\\_2012.pdf](https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/fish-fish-habitat/fishery-resources/interior-fraser-steelhead/bison_2012.pdf).
- Bison, R. 2020. Re: Status Update for Interior Fraser Steelhead. Letter Report from Robert Bison, Fisheries Stock Assessment Biologist, Ministry of Forests, Lands, Natural Resource Operations & Rural Development. July 23, 2020. Available online at: [https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/fish-fish-habitat/fishery-resources/interior-fraser-steelhead/ifs\\_status\\_update\\_july\\_2020.pdf](https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/fish-fish-habitat/fishery-resources/interior-fraser-steelhead/ifs_status_update_july_2020.pdf).
- Chambers, K. and S. Faulkner. 2021. Kwoiek Creek Salmon Enhancement Opportunities, Overview Assessment. Draft V1. Consultant's report prepared for Kanaka Bar Band by Ecofish Research Ltd., March 10, 2021.
- Cohen, B.I. 2012. The Uncertain Future of Fraser River Sockeye Volume 1 - The Sockeye Fishery. In: Commission of Inquiry into the Decline of Sockeye Salmon in the Fraser River (Canada), Vol. 1.
- COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2016. COSEWIC assessment and Status Report on the coho salmon *Oncorhynchus kisutch* Interior Fraser population, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa Available online at: <http://www.registrelep-sararegistry.gc.ca/default.asp?lang=en&n=24F7211B-1>.
- COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2017. COSEWIC assessment and update 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.
- COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2018. Technical Summaries and Supporting Information for Emergency Assessments. Steelhead Trout, *Oncorhynchus mykiss*, (Thompson River and Chilcotin River populations). Committee on the Status of Endangered Wildlife in Canada. Ottawa. 26 pp.
- DFO (Fisheries and Oceans Canada). 2013. Review and Update of Southern BC Chinook Conservation Unit Assignments. Available online at: <https://waves-vagues.dfo-mpo.gc.ca/Library/350518.pdf>.
- DFO (Fisheries and Oceans Canada). 2018. Recovery Potential Assessment for Chilcotin River and Thompson River Steelhead Trout (*Oncorhynchus mykiss*) designatable units. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep.
- DFO (Fisheries and Oceans Canada). 2019. Information about Pacific salmon. Available online at: <https://www.pac.dfo-mpo.gc.ca/fm-gp/salmon-saumon/facts-infos-eng.html>. Accessed on March 17, 2021.
- DFO (Fisheries and Oceans Canada). 2020. Identify Your Catch. Available online at: <https://www.pac.dfo-mpo.gc.ca/fm-gp/rec/identify-identifier-eng.html>.

- ECCC (Environment and Climate Change Canada). 2019. COSEWIC assessment and status report on the chinook salmon, *Oncorhynchus tshawytscha*, designatable units in southern British Columbia (part one - designatable units with no or low levels of artificial releases in the last 12 years), in Canada. Environment and Climate Change Canada (ECCC) Available online at: [http://publications.gc.ca/collections/collection\\_2019/eccc/CW69-14-469-2019-eng.pdf](http://publications.gc.ca/collections/collection_2019/eccc/CW69-14-469-2019-eng.pdf).
- Gomez, L. and J. Scroggie. 2021. Salmon update for Kanaka Bar, January 21 2021. Fraser Chinook, Coho and Sockeye and Pink.
- Grant, S.C.H., B.L. MacDonald and M.L. Winston. 2019. State of Canadian Pacific Salmon: Responses to Changing Climate and Habitats. Can. Tech. Rep. Fish. Aquat. Sci. 3332. ix + 50 p. Available online at: <https://waves-vagues.dfo-mpo.gc.ca/Library/40807071.pdf>.
- Griffith, R.P. 1997. Kwoiek Creek Drainage Assessment of Fish Habitat and Production 1995. Consultant's Report for BC Conservation Foundation and BC Environment by P. Griffin & Associates. February, 1997. Available online at: <http://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=34698>.
- Kendall, N.W., J.R. McMillan, M.R. Sloat, T.W. Buehrens, T.P. Quinn, G.R. Pess, K. V. Kuzishchin, M.M. McClure and R.W. Zabel. 2015. Anadromy and residency in steelhead and rainbow trout (*Oncorhynchus mykiss*): A review of the Processes and Patterns. Canadian Journal of Fisheries and Aquatic Sciences.
- Light, J.T., C.K. Harris and R.L. Burgner. 1989. Ocean distribution and migration of steelhead (*Oncorhynchus mykiss*, formerly *Salmo gairdneri*). (Document submitted to the International North Pacific Fisheries Commission.) 50 pp. FRI-UW-8912. Fisheries Research Institute, University of Washington, Seattle. Available online at: <https://digital.lib.washington.edu/researchworks/bitstream/handle/1773/4115/8913.pdf>.
- McPhail, J.D. 2007. The Freshwater Fishes of British Columbia. University of Alberta Press. Edmonton, AB.
- MFLNRO (BC Ministry of Forests, Lands and Natural Resource Operations). 2016. Provincial Framework for Steelhead Management in British Columbia. Prepared by Ministry of Forests, Lands and Natural Resource Operations, Fish and Wildlife Branch, April 2016. Victoria, BC Available online at: <http://www.env.gov.bc.ca/fw/fish/docs/Provincial-Framework-for-Steelhead-Management-in-BC-April-2016.pdf>.
- MOE (BC Ministry of the Environment). 2005. Steelhead stream classification. Policy released by the BC Ministry of the Environment, December 13, 2005. 7.
- Pollard, W.R., G.F. Hartman and C. Groot. 1997. Field Identification of Coastal Juvenile Salmonids. Harbour Publishing. Madeira Park, BC.
- PSF (Pacific Salmon Foundation). 2020. Pacific Salmon Explorer. Available online at: <https://www.salmonexplorer.ca/#!> Accessed on November 14, 2020.
- PSF (Pacific Salmon Foundation). 2021. Species and Lifecycle. Available online at: <https://www.psf.ca/learn/species-lifecycle>. Accessed on May 17, 2021.
- Ricker, W.E. 1997. Cycles of abundance among Fraser River sockeye salmon (*Oncorhynchus nerka*). Can. J. Fish. Aquat. Sci. 54: 950-968.

- Roberge, M., J. Hume, C. Minns and T. Slaney. 2002. Life history characteristics of freshwater fishes occurring in British Columbia and the Yukon, with major emphasis on stream habitat characteristics. Can. Manuscr. Rep. Fish. Aquat. Sci. 2611: xiv + 248 p. Available online at: [http://publications.gc.ca/collections/collection\\_2007/dfo-mpo/Fs97-4-2611E.pdf](http://publications.gc.ca/collections/collection_2007/dfo-mpo/Fs97-4-2611E.pdf). Accessed on February 8, 2013.
- Steele, E. 2011. Juvenile Salmon Identification. Available online at: [https://www.google.ca/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiPzb\\_s5cTvAhWdRTABHcUAAksQFjAOegQIFxAD&url=http%3A%2F%2Fstatic1.1.sqspcdn.com%2Fstatic%2F%2F1175413%2F27156531%2F1468878187247%2FJuvenile%2BSalmon.pdf%3Ftoken%3D7eZVP](https://www.google.ca/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiPzb_s5cTvAhWdRTABHcUAAksQFjAOegQIFxAD&url=http%3A%2F%2Fstatic1.1.sqspcdn.com%2Fstatic%2F%2F1175413%2F27156531%2F1468878187247%2FJuvenile%2BSalmon.pdf%3Ftoken%3D7eZVP).
- VIU (Vancouver Island University). 2009. Salmonid Biology Course Module. Vancouver Island University. January 2009. Nanaimo, BC Available online at: [www.viu.ca/nrep/](http://www.viu.ca/nrep/).