PACIFIC SALMON COMMISSION
HABITAT AND RESTORATION TECHNICAL COMMITTEE

ASSESSMENT OF SALMON HABITAT STATUS AND TRENDS AND RESTORATION PROJECT EFFECTIVENESS

REPORT HRTC (12)-1

October 2012

MEMBERSHIP OF THE HABITAT AND RESTORATION TECHNICAL COMMITTEE

Canadian Members
Ms Melody Farrell, Co-Chair, CDFO
Mr Matt Foy, CDFO
Mr Howie Wright, FNC
Dr Allen Gottesfeld, SFC
Dr Peter Tschaplinski, BCMOE

United States Members
Mr Thom Hooper, Co-Chair, NOAA
Dr K Koski, NOAA
Mr Jeff Nichols, ADF&G
Mr Kim Jones, ODFW
Mr Kit Rawson, Tulalip Tribes
Mr Phil Rogers, CRITFC

LIST OF ACRONYMS WITH DEFINITIONS

ADF&G	Alaska Department of Fish and Game
BC	British Columbia
BC MOE	British Columbia Ministry of Environment
CDFO	Canadian Department of Fisheries and Oceans
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CNR	Canadian National Railway
CPR	Canadian Pacific Railway
CRITFC	Columbia River Intertribal Fish Commission
CU	Conservation Unit
ECA	Equivalent Clear Cut Area
EF	Endowment Fund
EMB	Ecosystem Management Branch of CDFO
FNC	First Nations Caucus
FREP	Forest and Range Evaluation Program
FRPA	Forest and Range Practices Act
FPC	Forest Practices Code
GIS	Geographical Information System
HRTC	Habitat and Restoration Technical Committee
HWG	Habitat Working Group
IFC	Interior Fraser Coho
LFR	Lower Fraser River
MPB	Mountain Pine Beetle
NEF	Northern Endowment Fund
NNL	No Net Loss
NOAA	National Oceanic and Atmospheric Agency
NPF	Not Properly Functioning
NPS	Northern Puget Sound
NPCC	Northwest Power and Conservation Council
NRC	National Research Council
NWVI	North West Vancouver Island
ODFW	Oregon Department of Fish and Wildlife
OWEB	Oregon Watershed Enhancement Board
PFC	Properly Functioning Condition
PS	Puget Sound
PSC	Pacific Salmon Commission
PST	Pacific Salmon Treaty
SEF	Southern Endowment Fund
SFC	Skeena Fisheries Commission
SWVI	South West Vancouver Island
TRC	Thompson River Coho
WCVI	West Coast Vancouver Island

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

EXECUTIVE SUMMARY

This technical report which is the product of concepts developed by the HRTC since June 2010 became a commitment in the 2011-2012 HRTC work plan. That work plan began to deliver on the commitments under the Treaty by focussing on the following 2 major objectives:

1. fostering effective sharing of information on habitat restoration initiatives, activities and practices, and promoting the establishment of a network of individuals to facilitate the exchange of information and knowledge, and
2. providing strategic advice to the Commission and to the Northern and Southern Fund Committees on habitat matters (upon request).

This report addresses the first objective by introducing a habitat restoration practitioner's directory (Appendix C); a new GIS map-based inventory of restoration projects funded by the Endowment Funds (Chapter 4); and strategic advice and guidance for designing effective restoration projects and assessing their benefits (Chapter 3).

Chapter 2 partially addresses the second objective by adding a habitat dimension to the SEF Strategic Plan by presenting two habitat status and trend case studies for stocks of concern to the Southern Endowment Fund (SEF). The HRTC recommends future efforts begin to address similar habitat condition and status reports for other stocks, particularly those of interest to the Northern Fund Committee.

The HRTC spent time reviewing the process by which the EF Committees solicit proposals for habitat restoration projects. As a result this report recommends several process improvements and provides suggestions/guidance to restoration project proponents for preparation of effective habitat restoration proposals to the EFs (Appendix D).

It is the failing of most restoration projects that little or no effort is put into effectiveness monitoring, nor in most cases, is it requested by the funding entity. These are lost opportunities that could inform us when taking the next restoration step(s). This type of information is particularly useful when it is clear that habitat protection and improvements are necessary to help maintain and improve populations of many stocks of interest to the PSC, and when it is clear that hatchery practices and harvest management alone cannot restore runs while habitat continues to endure diminishing suitability for spawning, rearing, or migration. In a large proportion of our watersheds, strategic habitat restoration is a necessary companion to improved harvest and hatchery management. The outlay of funds (from all sources) over the years for restoration has been significant, as necessitated by the degree of degradation. With these increased financial commitments have come greater expectations of restored ecosystems, yet remarkably little is known about the productivity benefits these projects may represent. This report proposes a different approach and one that the PSC may wish to champion.

Chapter 3 goes into the details of this approach. It presents an argument and methodologies for an approach that takes a broader view on salmon habitat restoration; and focuses on the reasons for loss of habitat function rather than focussing on the symptoms. Most scientific reviews of restoration protocols agree that the focus should be at the watershed scale and on restoring the natural ecological processes that create and maintain habitat rather than simply manipulating in-stream habitats. Yet many projects continue to be funded where it cannot be demonstrated how they fit in a larger context of restoring long-term habitat function within the watershed. In order to shift the focus successfully, we need a science based approach to restoration that incorporates habitat assessments, limiting factors analyses, adaptive management, understanding and using habitat indicators, and institutionalizing effectiveness monitoring.

1. INTRODUCTION

In June of 1999, negotiators for the United States and Canada recommended to the governments of the Unites States and Canada a proposed comprehensive agreement that would resolve longstanding differences between the two Parties concerning implementation of the Pacific Salmon Treaty. The negotiators' recommendations were accepted and formalized by both countries. Referred to as the "1999 Agreement," this agreement consisted of a number of separate but related elements. It included formal revisions to the fishing regimes ("chapters") in Annex IV of the Treaty, which were effectuated by the Parties pursuant to Article XIII of the Treaty.

In addition, the 1999 Agreement included several side agreements spelled out in various attachments. One such attachment – Attachment E – concerns Habitat and Restoration. In it, the Parties agreed:

1) To use their best efforts, consistent with applicable law, to:
   a) protect and restore habitat so as to promote safe passage of adult and juvenile salmon and achieve high levels of natural production,
   b) maintain and, as needed, improve safe passage of salmon to and from their natal streams, and
   c) maintain adequate water quality and quantity.

2) To promote these objectives by requesting the Commission to report annually to the Parties on:
   a) naturally spawning stocks subject to the Treaty for which agreed harvest controls alone cannot restore optimum production,
   b) non-fishing factors affecting the safe passage of salmon as well as the survival of juvenile salmon which limit production of salmon identified in sub-paragraph 2(a) above,
   c) options for addressing non-fishing constraints and restoring optimum production, and
   d) progress of the Parties' efforts to achieve the objectives of this agreement for the stocks identified in sub paragraph 2(a) above.

The 1999 Agreement also established two endowment funds, the Northern Fund and the Southern Fund, to be capitalized by the United States for the purpose of providing funding for (among other things) habitat conservation and restoration projects. These funds are managed by the Northern Fund Committee and the Southern Fund Committee respectively. The establishment of the funds spelled out in Attachment C and the commitments in the Habitat Agreement provided in Attachment E to the 1999 Agreement are related in that both acknowledge the importance of non-fishing factors in limiting stock productivity and of the necessity of habitat restoration work to achieve the Treaty's objective of optimum production.

In the years immediately following the 1999 Agreement, the Commission considered a variety of approaches concerning how best to implement Attachment E. In February of 2006, the Commission approved the establishment of a Habitat and Restoration Technical Committee (HRTC), but did not act at that time to appoint members to the committee. In February of 2007, the Commission established a Habitat Scoping Committee to further refine the charter of the HRTC. The Scoping Committee held a workshop in September of 2009 at which time the purpose and approach of an HRTC was further discussed and refined, then presented to the Commission in October of 2009. In January and February of 2010, the Commission accepted the recommendations of the Scoping Committee regarding the initial activities of the HRTC, which were designed to be both practical (affordable) and to add value to the Commission's and Parties' implementation of the Treaty. Members were appointed to the HRTC and its inaugural meeting was held in June of 2010. Additional organizational and developmental meetings occurred in 2011 concurrent with the Commission meetings. In October of 2011, the Commission approved the HRTC's work plan for 2011-12, which included development of this report, with the expectation that its content and value would help inform next steps with respect to future work of the HRTC.

The HRTC work plan for 2011-12 focused the committee on 2 major objectives, which are:

1. fostering effective sharing of information on habitat restoration initiatives, activities and practices, and promoting the establishment of a network of individuals to facilitate the exchange of information and knowledge, and
2. providing strategic advice to the Commission and to the Northern and Southern Fund Committees on habitat matters, upon request.

This inaugural report of the HRTC addresses the first objective by introducing a habitat restoration practitioners directory, a new map based inventory of EF funded restoration projects, and providing advice and guidance for assessing habitat status and trends as well as restoration project design and evaluation.

The second objective is addressed by the presentation of two habitat status and trend case studies for stocks of concern to the Southern Endowment Fund (SEF), which adds a habitat dimension to the SEF Strategic Plan. This report also includes guidance to proponents for preparation of effective habitat restoration proposals to the EFs.

Chapter 2 focuses on assessing limiting factors in freshwater habitats and examining the potential contributions of freshwater habitats to recent productivity declines in two of the stocks of greatest current conservation concern to the SEF. These two stocks, which are identified as examples of stocks of highest concern in the 2008 SEF Strategic Plan, are the Western Vancouver Island (WCVI) Chinook and the Thompson coho. The other two examples of stocks of highest conservation concern are Northern Puget Sound (NPS) Spring Chinook and NPS Fall Chinook. They will be the subject of a Northwest Fisheries Science Center analysis, which is due in mid-2013.

Chapter 3 is a synoptic review of salmon habitat restoration assessment and monitoring information from the Pacific Northwest. It builds on methodologies and frameworks that have already been developed to guide the design of salmon habitat restoration projects and the monitoring and assessment of their effectiveness. The appendices for this chapter include a directory of salmon habitat restoration practitioners in the Pacific Northwest and a checklist of issues for proponents to consider when preparing restoration proposals for EF funding.

Chapter 4 introduces a new GIS based map product that provides ready access to information on habitat projects funded by the Endowment Funds. Recommendations on improvements to enhance the utility of this tool are also provided.

Information and data gaps are identified in each chapter and are addressed with recommendations intended to:

1. improve the data available for both habitat status/trends assessments and limiting factors analyses for stocks of concern,
2. enhance the quality of habitat and restoration project submissions to the EFs,
3. assist EFs in evaluating habitat restoration proposals,
4. improve monitoring and evaluation of restoration project effectiveness, and
5. make geographic and summary information on EF-funded habitat restoration projects, readily accessible to the fund committees, project proponents and the public.

2. Habitat Status and Trends Case Studies

Freshwater habitat quality and quantity are among the key non-fishing factors affecting safe passage and survival of juvenile salmon that could limit production. Information on habitat status and limiting factors is required to identify options for addressing habitat-based production constraints and restoring stocks to optimum production. Such analyses depend on habitat pressure data, state indicator information and habitat quantity measurements, however in many cases this information is either not available or has not been collated to inform conclusions about limiting factors or the identification of options to address them.

To assist the Commission and the Endowment Fund Committees in determining appropriate management actions for stocks of concern, the HRTC initiated two habitat status and trend assessments in 2011-12 for stocks of highest conservation concern to the Southern Endowment Fund. This analyses was based on available information and the results of these case studies are provided below.

2.1 Thompson River Coho

2.1.1 Background and General Stock Status Information

Thompson River coho (*Oncorhynchus kisutch*) are part of a larger Interior Fraser River coho (IFC) complex. IFC are considered a nationally significant population. They occupy approximately 25% of the natural freshwater range of coho salmon within Canada.

Within the Interior Fraser River there appear to be at least five separate subpopulations of coho (North Thompson, South Thompson, Lower Thompson/Nicola, Fraser canyon, and upper Fraser), which are considered separate conservation/management units. Thompson coho consist of three distinct Conservation Units (CUs); North Thompson, South Thompson and Lower Thompson/Nicola.

Models of freshwater production using reconstructed smolt abundance indicates that IFC populations are likely less productive than coastal populations. Most coho salmon returning to the Thompson River are the product of natural spawning, with hatchery coho generally contributing around 15% to total escapement. Available data suggest that little genetic exchange occurs among the three Thompson CUs, but that considerable genetic exchange occurs among various tributaries within them.

The Canadian Department of Fisheries and Oceans (CDFO) time series of reliable spawner estimates for Interior Fraser coho salmon began in 1975. Spawner numbers in the North and South Thompson watersheds peaked in the mid-1980’s, then declined rapidly until about 1996, and have been stable but low ever since. There were four years (1991, 1995, 1997, and 1998) during which some populations likely could not have replaced themselves even in the absence of fishing. Spawner numbers in 1999 and 2000 did exceed parental escapements. The outlook for Interior Fraser coho in general and Thompson River coho specifically is considered highly uncertain and dependent on fishing, habitat perturbations, and climate-related changes in survival in both freshwater and marine environments.

Ocean survival of coho salmon appears to have improved slightly since the low observed in the mid-1990's (< 3%) but remains low (4-6%) relative to the 1980's (> 12%). Fishery exploitation rates (proportion of adults caught in fisheries) averaged 68% until 1996. In response to conservation concerns, exploitations were reduced to approximately 40% in 1997. This dropped to an average of 6.5% over the next three years and continues at this low level today. In 2002, Interior Fraser River coho were designated by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as "endangered" based on the rate of escapement decline over three generations (COSEWIC 2002).

More recent data indicates that total abundance and spawning escapements for all Interior Fraser coho CUs remain depressed. While escapements to the North Thompson in 2007 approached those noted in 2001 and 2002, there has been no discernible trend in either index for any of the South, North or Lower Thompson populations from 2007 to 2011.

Variations in ocean survival and fishery mortality are thought to be the largest drivers of the changes in abundance observed for Thompson River coho since the 1980's. Changes in freshwater habitat were likely more important in earlier population declines and in the recent and severe declines that have been observed in those watersheds with the highest levels of agricultural and urban land pressures.

2.1.2 General Habitat Overview

There are three major sub basins (Figure 2.1) and nine biogeoclimatic zones within the Thompson basin. The major sub basins are: the North Thompson, the South Thompson-Shuswap and the Lower Thompson (Thompson-Nicola). The biogeoclimatic zones are: Alpine Tundra (AT); Engelmann Spruce- Subalpine Fir (ESSD); Montane spruce (MS); Sub-Boreal spruce (SBS), Sub-Boreal Pine-Spruce (SBPS); Interior Cedar-Hemlock (ICH); Interior Douglas Fir (IDF); Ponderosa Pine (PP) and Bunchgrass (BG).

The Thompson Basin includes over 56,000 km^2 of the interior of British Columbia and includes numerous large lakes and hundreds of tributaries, which differ significantly in climate, geomorphology, physiography and hydrology. Coho salmon occupy a wide range of the habitats this diverse geography has created.

There are over 2,200 km of accessible stream habitat within the known range of Thompson coho. The areas of greatest management concern tend to be located in the southern valleys, which receive less seasonal precipitation, experience warmer summers, and are most conducive for agriculture and human settlement.

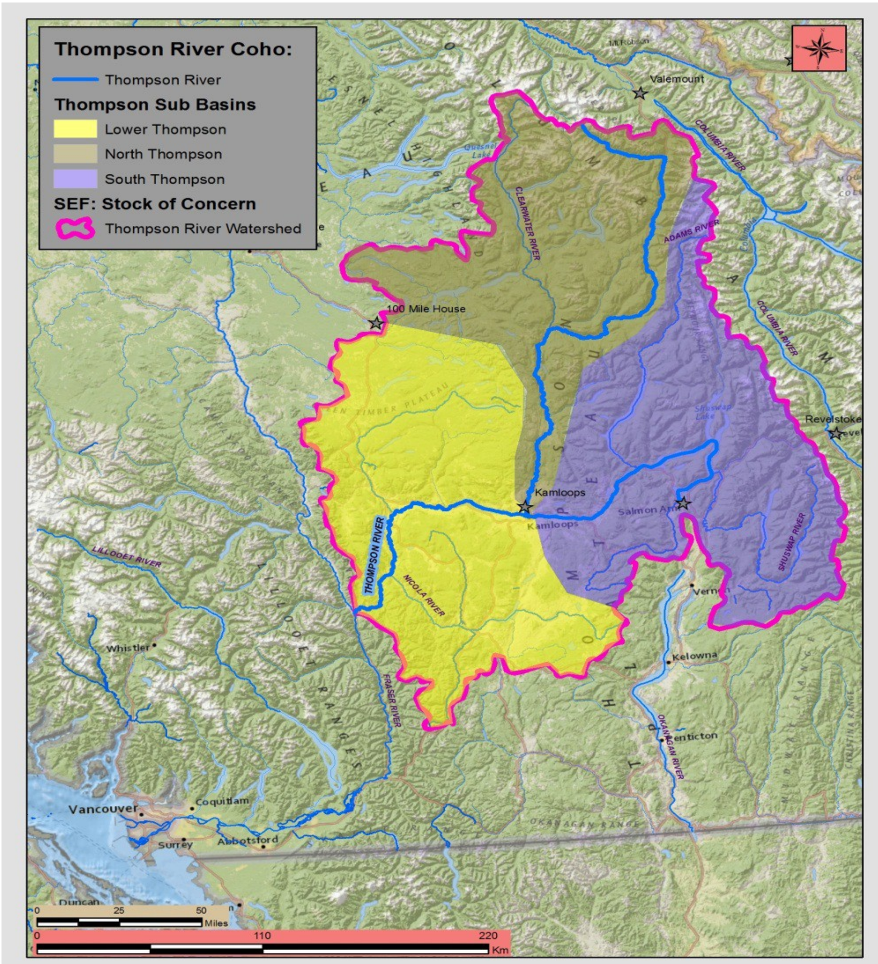


Figure 2.1. Thompson River watershed and major sub-basins

2.1.2.1 *The North Thompson*

The North Thompson drainage overlaps with six physiographic land units within the Interior Plateau of the Canadian Cordillera (Holland, 1976). These units include the Thompson Plateau, Shuswap Highlands, Monashee Mountains, Quesnel Highlands and Cariboo Mountains. Detailed physiographic information and hydrologic descriptions of each physiographic unit are available in the Strategic Review of Fisheries Resources for the North Thompson Habitat Management Area (CDFO 1994). Annual precipitation and snowfall in the basin increase from south to north, ranging from a low (400 mm and 80 cm respectively) near Kamloops to a high (approximately 800 mm and 400 cm) in the Upper North Thompson/Albreda drainages. The biophysical conditions in the North Thompson range from warm, dry plateaus to cold, wet mountain ranges and have created a wide range of aquatic habitats.

2.1.2.2 *The South Thompson*

The South Thompson drainage overlaps four physiographic land units within the Interior Plateau of the Canadian Cordillera (Holland, 1976). These are the Thompson Plateau, Shuswap Highlands, Monashee Mountains and Okanagan Highlands. Detailed physiographic information and hydrologic descriptions of each unit are available in the Strategic Review of Fisheries Resources for the South Thompson- Shuswap Habitat Management Area (CDFO 1997). The South Thompson hydrograph is largely driven by snowmelt with annual precipitation and snowfall increasing from the south-west to the north-east areas of the basin. Biophysical conditions in the South Thompson range from low-relief, dry plateau terrain to steep, wet mountain ranges. This diversity has created a wide variety of habitat types, ranging from small, steep headwater channels to moderately sized channels flowing through rolling hills with numerous small lakes, to wide river valleys and floodplains and large lakes.

2.1.2.3 *The Lower Thompson*

The Lower Thompson basin overlaps three physiographic land units within the Interior Plateau of the Canadian Cordillera (Holland 1976). These are: the Thompson Plateau, the Fraser Plateau and the Cascade Mountains. Detailed physiographic information and hydrologic descriptions of each physiographic unit are available in the Strategic Review of Fisheries Resources for the Thompson- Nicola Habitat Management Area (CDFO 1998). The hydrograph is largely driven by snowmelt. Precipitation and snow pack are typically low on the Thompson Plateau and high in the coastal Cascade Mountains unit. Systems within the Lower Thompson range from low-gradient, highly productive channels in flat or rolling terrain (Thompson Plateau), to small, stable channels with numerous lakes and wetlands in undulating terrain created by glacial deposits (Fraser Plateau), to high-gradient, confined channels in steep terrain characterized by large freshets and high bedload movement (Cascade Mountains).

2.1.3 Life History and Habitat Use

Coho are opportunistic, occupy diverse habitats, and are widely distributed in the Thompson system. Most Thompson River coho spend their first year in freshwater then live and grow in the coastal marine environment for approximately one and a half years, before returning to their natal watershed to spawn and die at three years of age. However there appear to be a number of different life histories displayed by Thompson coho. While most juveniles outmigrate as 1 year old smolts, two-year-old smolts have also been reported from the North Thompson. Since juveniles spend at least one full year in freshwater before migrating to the sea and are generally associated with small, complex systems and off-channel habitats, they are particularly vulnerable to disturbances in (or adjacent to) small tributaries or floodplains of larger systems.

Spawning habitat for coho salmon is typically clumped within watersheds, usually at the heads of riffles in small streams, and in side channels of larger rivers. Females generally construct nests in shallow water (30 cm) where substrate material is less than 15 cm in diameter and in infiltrated by well-oxygenated water. Low or high flows, freezing temperatures, siltation, predation, and disease can reduce egg survival, but under average conditions, 15-30% of the fertilized eggs will emerge from the gravel.

Fry typically disperse from spawning sites to nearby lakes, ponds and off-channel habitats in the spring to rear. In streams, they are found in both pools and riffles, but generally prefer pools, where they feed on invertebrates drifting downstream in the current. As they grow juveniles typically move into areas of faster moving water. The highest stream flows in the interior occur in late spring/early summer when the snow pack melts. During this period, juvenile coho often move into off-channel refuge habitat. Even as velocities in mainstems decrease, a significant proportion of the juveniles may remain in off-channel habitats to rear for the rest of the year, migrating out as smolts the following year. Some make migratory forays into mainstems through the summer and fall, and move back into small tributaries and off-channel habitats in the late fall to overwinter. Others have been reported to overwinter in larger mainstems and lakes, particularly where tributary overwintering habitat is limited (e.g., smaller tributaries in the South Thompson CU).

Juvenile coho tend to cluster in areas of suitable habitat, most frequently in streams with gradients less than three percent. Recent research into interior coho behaviour suggests that they are opportunistic, but not territorial as juveniles. Unlike coastal coho, Thompson coho tend to aggregate as juveniles under all feeding regimes.

Structurally complex habitats with large woody debris and heterogeneous substrate (ideally groundwater fed) with a mix of pools and areas of lower velocity are necessary to ensure high summer rearing and overwinter survival of young coho. They do utilize littoral zones of accessible lakes for rearing, but less frequently than stream habitats. Productivity (food abundance) and rearing habitat quality play major roles in regulating coho densities and growth rates in streams.

Juvenile Thompson coho salmon migrate down the Fraser River and rear for an unknown length of time in the highly developed and physically constrained estuary of the Fraser River at Vancouver. They generally spend the majority of their oceanic residence near the coast in southern BC. Recent studies suggest that juvenile Thompson coho reside in the Strait of Georgia for about six months, until their first fall at sea, and then migrate to the west coast of Vancouver Island where they mature.

Prior to 1991, large numbers of Thompson coho remained within the Strait of Georgia for most of their marine life and supported important fisheries within the Strait in their second marine year. From 1994 to the present, these stocks, in common with most Strait of Georgia coho, appear to have shifted their second year oceanic distribution almost completely to the waters in and around the west coast of Vancouver Island. This shift in marine distribution coincided with the period of reduced marine survival that continues today.

2.1.4 Habitat Status

Coho are widely dispersed throughout the accessible rivers, streams and lakes in the Thompson drainage. Habitats located within forested or rural watersheds, particularly in the North Thompson, are generally considered to be in fair condition whereas the lower reaches of streams in the valleys of the South and Lower Thompson CUs, which are subject to extensive floodplain and riparian area alterations and to water use conflicts, are in relatively poor condition.

A 2006 GIS assessment of seven landscape-scale habitat pressure indicators [1] in the 264

[1] Indicators included road density, riparian disturbance and total land cover alteration due to forestry, urban settlement, agriculture, and other land uses (recreational, transportation corridors). Flow was.

watersheds that comprise the Lower Thompson coho CU identified a wide range in habitat condition across sub-drainages. In addition to identifying specific habitat pressures in each watershed of the Lower Thompson coho CU the analysis also identified the sub-drainages at greatest cumulative risk (Figure 2.2).

Two of the 264 watersheds were considered to be at extremely high risk or severely degraded based on all seven habitat pressure indicators being high. Sixteen watersheds were considered to be at very high risk as six of the 7 habitat pressure indicators were high. Only 18 watersheds were considered to be at low risk, with only 1 pressure indicator rated high. No watersheds were considered to not be at risk. The remaining 228 sub-drainages ranged from moderate to high risk. Habitat pressures in the Thompson Basin are examined in more detail in section 2.1.6, below.

The analysis presented here is based on available (and dated) information for a limited number of habitat pressure indicators. Much more work is needed to generate or compile data for other habitat state and pressure indicators (e.g., water temperature, discharge, barriers to migration, effluent discharges, water withdrawals) in all of the Thompson CUs to properly assess habitat status for Thompson coho.

2.1.5 Habitat Pressures

Many valley bottoms in the Thompson drainage were first logged of old growth forest at the turn of the 20th century, and were subsequently developed and used for agriculture (mainly livestock, dairy, and animal feed crops) and urban/rural settlement. Logging of second growth timber is now occurring in the headwaters of some tributaries. Increasing land and water use pressures and widespread development in both the Lower and South Thompson, over the last several decades, are thought to be the leading reasons coho spawner abundance declined at a greater rate in these areas than the North Thompson.

In the South and Lower Thompson basins, much of the riparian vegetation has been altered or removed and off-channel habitats, wetlands, lake foreshores and floodplains have been in-filled, drained, or isolated by dykes, ditches, linear developments and human settlements. Livestock have destabilized stream banks in many sub-drainages and ground and surface water withdrawals are leading to insufficient stream flows for fish, exacerbating the impacts of the naturally occurring summer low-flow period. Low stream flows and riparian vegetation removal also contribute to elevated summer water temperatures and impaired water quality.

In the following sections, land use pattern and pressure information extracted from a series of Fisheries Resource Strategic Review documents for the Thompson sub-basins produced by CDFO as part of the Fraser River Action Plan (CDFO 1994, 1997, 1998) is summarized.

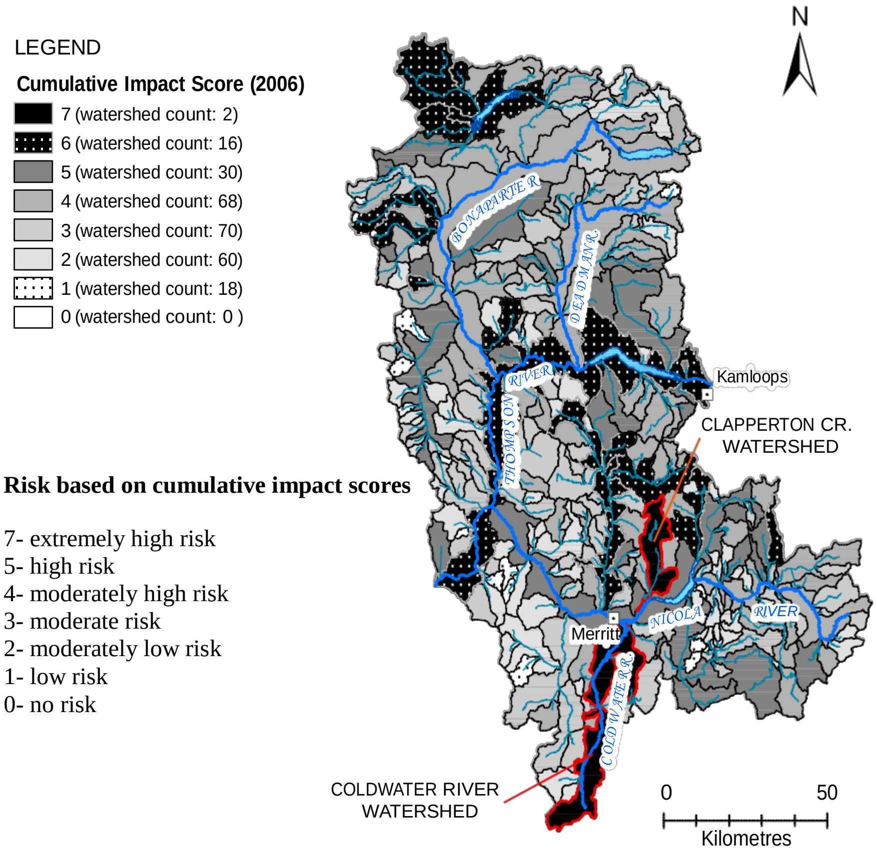


Figure 2.2. Lower Thompson coho CU habitat pressure analyses.

2.1.5.1 *Forestry*

Logging has been a major resource activity in all Thompson CUs over the past century. The major concerns associated with logging and road building are: passage obstructions associated with road and culvert crossings, changes in hydrology, sediment transport, hill slope stability, riparian condition and channel stability. The results of this are often increased flashiness of flows, water temperatures, nutrient and dissolved ion concentrations, channel and bank erosion, turbidity and reduced sources of large woody debris, leaf detritus and terrestrial insect production.

2.1.5.1.1 North Thompson

Many valuable coho spawning areas are located within sections of stream channel adjacent to unstable hill slopes and valley walls (e.g., Finn Creek, Raft River). By the mid 1990's most of the salmon producing systems in the North Thompson CU had over 20% of their watershed logged, which is considered to be approaching a threshold where significant hydrology changes may begin to occur due to altered snow accumulation and melt patterns.

2.1.5.1.2 Lower Thompson

Extensive logging (> 30% of the basin) has occurred in the headwaters of most systems, including the Nicola River, Spius Creek, Coldwater River, Bonaparte River and Deadman River.

2.1.5.1.3 South Thompson

More than 20 % of the area of most watersheds has been logged, with the greatest harvest pressures (> 40% area) occurring in the Scotch, Bolean, Ross, Onyx, Noisy and McNomee Creek and the Salmon River basins. Although the Upper Adams, Seymour and Harris drainages have less than 20% equivalent clear cut area (ECA), increased sediment supply and channel instability have occurred there due to high road density and logging in steep, unstable terrain.

2.1.5.1.4 Summary of Forestry Impacts

The effects of historic harvesting and road building in many sub-basins of the Thompson are still apparent, and while some systems are recovering, higher elevation harvesting continues in many watersheds. Salvage harvest of Mountain Pine Beetle (MPB) infested wood is occurring on a large scale in portions of the Thompson drainage. Provincial Forest and Range Evaluation Program (FREP) monitoring has shown that forests killed by Mountain Pine Beetle are also more susceptible to fire. MPB infestations and fire have been cited as a principal impact for 40% of all habitat-impacted streams in the southern interior of BC (Tschaplinski 2010).

FREP assessments were conducted in a random sample of 537 streams in the southern interior in, or adjacent to, harvest blocks logged under the Forest Practices Code (FPC; Tschaplinski 2010). Ten percent of these streams were deemed not *properly functioning* (NPF).The majority of NPF streams were non-fish bearing headwater tributaries, however the potential for downstream transport of impacts into fish bearing reaches was recognized. These moderately to highly impacted sites together with some in *proper functioning condition* (PFC) which sustained moderate level alterations, are a focus for improving current forest management practices.

Impacts associated with MPB in combination with fine sediment from roads and low levels of riparian tree retention were cited as main causal factors for 65% and 44%, respectively, of all impacted stream reaches harvested since 1996, under the Forest Practices Code and Forest and Range Practices Act (Tschaplinski 2010).

2.1.5.2 *Agriculture*

The three main concerns associated with agriculture are water withdrawals, water quality and riparian habitat loss.

2.1.5.2.1 North Thompson

The main agricultural activities in the North Thompson are cattle grazing and feed crop production, which are concentrated in the Thompson Plateau, along the North Thompson Valley up to Clearwater and on the Fraser Plateau near 100 Mile House. While the proportion of land area in agricultural production in the North Thompson is low, it is concentrated along stream corridors and damage to streams and their banks is considerable in some areas.

2.1.5.2.2 Lower Thompson

Agriculture is intensive in the Lower Thompson and is concentrated along the lower, more productive reaches of most systems. Valley bottoms are used for crop production and winter rangeland while upland areas are used as summer range. The systems most severely impacted (water quality and riparian degradation) by agriculture are the Deadman River, Bonaparte River, Cache Creek, Hat Creek, Nicola River, Spahomin Creek, Clapperton Creek, Guichon Creek, Spius Creek and the Coldwater River.

2.1.5.2.3 South Thompson

Agriculture is also intensive in the South Thompson Basin, and is concentrated along the South Thompson River and in the arable lands to the south of Shuswap Lake. Cattle grazing and feed crop production are concentrated in Chase, Salmon, Creighton, Duteau, and Bessett creeks and the Shuswap River drainages. Dairy farms are concentrated in the latter four systems. Beef cattle grazing occurs on several very large private ranches and much of the Crown land in the South Thompson drainage.

2.1.5.3 *Water Management*

The main concerns associated with water withdrawals or diversions are reductions in the quality and quantity of available spawning, incubation, rearing and overwintering habitats, reduced migratory access, increased water temperatures and poor water quality. Lack of adequate screening on water intakes and fish stranding are also concerns associated with water withdrawals, particularly in agricultural irrigation.

The South and Lower Thompson basins are semi-arid. Consequently, these systems are particularly vulnerable to changes in stream flows. Water withdrawals, diversions and impoundments by agricultural, domestic, commercial, and industrial water users in these drainages have increased significantly in the last 30 years. Over 50 % of licensed stream lengths in the Thompson Basin now have allocation restrictions (Table 2.1). Allocation restrictions are an indicator of both intensity of water use and limitations in water supply.

Increased restrictions on surface water withdrawals have increased the pressure on groundwater aquifers. As coho tend to prefer groundwater-fed, off-channel habitat for both summer rearing and overwintering, the drawdown of aquifers that are hydraulically connected to surface water bodies supporting coho, have significant implications. The intense competition for water in the summer is exacerbating a natural flow sensitivity, decreasing stream flows and increasing water temperatures during critical coho rearing periods in the South and Lower Thompson CUs.

Table 2.1. Water Allocation Restrictions in the Thompson Basin from 1950 to 2000.

Water Allocation Restrictions in the Thompson Basin (BC MWLAP 2002)						
1950’s		1970’s		2000		
Stream length licensed	Stream length restricted	Stream length licensed	Stream length restricted	Stream length licensed	Stream length restricted	% restricted
937.5 km	142.5 km	1078 km	346.9 km	1143.7 km	602.7 km	52.7%

2.1.5.3.1 North Thompson

Most North Thompson water licenses are for domestic use or irrigation, which typically have lower demands than power, storage or industrial licenses. Current water demands, however, already exceed minimum in stream flow requirements for fish in many systems, including Louis, Lemieux, Christian, Mann, Mahood and Reg Christie Creeks.

2.1.5.3.2 Lower Thompson

Water demands are highest in the Nicola River, Coldwater River, Deadman River, Bonaparte River, Spahomin Creek and Spius Creek basins. Impacts of water use in combination with low flow conditions are also reported in Shakan Creek, Skuhun Creek, Guichon Creek and Clapperton Creek (tributaries of the Nicola River); Midday Creek, Voght Creek and Brook Creek (tributaries of the Coldwater River); and Cache Creek and Hat Creek (tributaries of the Bonaparte River).

Although there are storage licenses in the Nicola, Deadman and Bonaparte rivers from which water is to be released to provide minimum flows for fish, adequate flows are seldom available. The Nicola, Bonaparte and Deadman Rivers and Spius Creek are fully allocated (i.e., further licenses are to be denied unless compensated by storage). Despite modifications to the storage dams on the Bonaparte and Nicola Rivers in the 1990s and adoption of rule curves and release schedules for fish conservation purposes, discharges have still not been adequate to provide sufficient downstream flows for fish. The Coldwater River and Spahomin Creek have few irrigation licenses with associated storage, but have very high water demand, extremely low flows, and no restrictions on further licensing.

2.1.5.3.3 South Thompson

Water demand is the most significant habitat pressure in the South Thompson. The number of water licenses held in the South Thompson in the early 1990s represented over 20% of the total for the entire Fraser Basin, and the demand has increased since that time. Conflicts between consumptive water uses and in stream flow requirements for fish are most severe in Chase Creek, Hiuhill Creek, Canoe Creek, Fortune Creek Trinity Creek, Bessette Creek, Creighton Creek, Duteau Creek, Harris Creek and the Salmon River. Late summer and winter flow problems in Duteau Creek are also exacerbated by water diversions into the Okanagan basin from this system.

The BC Hydro facility which was originally constructed in 1929 that includes the Peers dam at the outlet of Sugar Lake, Wilsey dam downstream of Sugar Lake and a generating facility at Wilsey that services the City of Vernon have also modified the natural flow regime of the Shuswap River.

2.1.5.4 *Linear developments*

Numerous linear developments including railway corridors, highways, resource roads, pipelines and transmission corridors traverse the Thompson sub-drainages and have encroached onto floodplains, eliminated riparian habitats, reduced channel complexity, channelized streams and rivers, increased bank erosion and isolated many kilometers of off-channel habitats on the main stem Thompson and many of its tributaries. In addition, the close proximity of highways and railways along the rivers increases the risk of chemical spills

2.1.5.4.1 North Thompson

The corridor parallel to the North Thompson River includes the Yellowhead Highway, a twin tracked Canadian National Railway (CNR), BC Hydro transmission corridors and numerous pipelines. Other major transportation / utility corridors that parallel or transect Highway 97 (Cariboo Highway) include Highway 24 (90 Mile to Little Fort), BC Rail, various oil and gas pipelines and BC Hydro transmission corridors.

2.1.5.4.2 Lower Thompson

The major transportation and utility corridors in the Lower Thompson include the Canadian Pacific Railroad (CPR), CNR , BC Rail, the Trans-Canada Highway, the Coquihalla Highway, numerous BC Hydro transmission corridors and oil and gas pipelines including those of Westcoast Energy, Kinder Morgan, Trans-Mountain pipelines and BC Gas distribution lines. Secondary highways and resource roads are also extensive.

2.1.5.4.3 South Thompson

Major transportation corridors in the South Thompson include the east-west Trans-Canada Highway and the CPR, which parallels the South Thompson River, Shuswap Lake at Salmon Arm, and the Eagle River. Highway 97 (a and b) and Highway 6, also parallel or the Salmon and Shuswap Rivers at several locations. A major forestry road bisects the Adams River watershed and parallels Adams Lake for most of its length. Other resource roads are also common throughout the CU.

2.1.5.5 *Urban and Recreational Development*

Of all proposed land uses, urban development has the greatest permanent effect on fish and fish habitat. Land clearing, regrading, road paving and construction of other impervious areas (parking lots and rooftops), water impoundments for drinking water reservoirs, installation of sewer/water lines, gas and electrical distribution systems, sewage or septic field outfalls and the development and maintenance of other urban infrastructure significantly alters the hydrology of streams, impacts riparian corridors, degrades water quality and increases erosion and sedimentation of water bodies. Similarly, development of recreational properties on rivers and lakes affects water quality and the quality and quantity of foreshore habitat. The associated transportation corridors and channel crossings associated with urban and recreational development also alter in stream and riparian habitats, and increase the potential for toxic spills from road, rail and pipelines.

The major transportation corridors along Highway 1 (Trans Canada) and Highway 97 (Okanagan to Cariboo) support a number of small to moderate sized urban centers which have grown significantly in the last 30 years. The Thompson Basin is also an extremely popular recreational destination for boaters, fishers, hikers and skiers. Recreational development pressure and demand for access to back country areas continues to increase. Urban development pressures have been greatest in Kamloops, Merritt, Salmon Arm and Sicamous, while recreational pressures have continued to increase on Shuswap, Mara, Mabel, Adams, Sugar, Nicola and Clearwater lakes.

2.1.5.5.1 North Thompson

The population in the North Thompson has fluctuated, decreasing through the mid-1980s, when the area experienced a pronounced and sustained economic recession, and remaining fairly constant from the 1990s to today. Settlement is concentrated in two areas. The first closely parallels the North Thompson River, Yellowhead Highway and CN Railway corridor and includes the suburban areas of Kamloops and the communities of Barriere, Little Fort, Clearwater, Vavenby, Avola and Blue River. The second is around the community of 100 Mile House and east in the House, Bridge, 108 Mile and Canim Lake areas.

Recreational facilities in the North Thompson sub-basin include more than 30 fishing lodges, two major ski areas, and numerous Provincial Parks, including Wells Gray Park, which occupies almost 5,000 km^2 within the Clearwater River watershed. Approximately 60 forest recreation sites, several large golf courses in Clearwater, and the 108 Mile Ranch are also situated in the CU.

2.1.5.5.2 Lower Thompson

Urban growth has been steady in the Lower Thompson over the last 30 years, particularly in Merritt, Cache Creek and the outlying incorporated areas of Kamloops. Other smaller communities including Ashcroft, Clinton, Lytton, Logan Lake, Savona and Spence’s Bridge have experienced much lower growth.

Recreational facilities in the Lower Thompson include 29 fishing lodges, 18 of which are in the Bonaparte system. There are also 10 resorts, numerous small provincial parks, forest recreation sites and golf courses located in the Lower Thompson basin.

2.1.5.5.3 South Thompson

Urban development in the South Thompson has been significant in the last 15 years, extending along the South Thompson River, the Lower Shuswap River, the Salmon River, Bessette Creek and Chase Creek. Major urban settlements are located in the Cities of Kamloops, Salmon Arm, Sicamous, Chase and Enderby with smaller centers including Falkland, Celesta, Sorrento and Lumby.

The Shuswap lake system is the focus of recreational activities in the South Thompson with over 25 resorts and more than 15 marinas on the lake. Development pressures on the foreshore of Shuswap Lake have increased substantially in the last 20 years. Other recreational developments in the South Thompson include fishing lodges, principally in the Salmon River area, various resorts, marinas on Mara and Mabel lakes, Silver Star and Sun Peaks ski resorts, golf courses in Kamloops, Chase, Salmon Arm, Sicamous and Lumby, and numerous provincial parks and forest recreation camp sites.

2.1.5.6 *Mining*

Mining pressure has varied in the Thompson drainage over the past century. Prior to 1945 placer mines operated in the Barriere River, Louis Creek and the North Thompson River, and there are still active placer claims and reserves on Cache Creek, Hat Creek, Shakan Creek, Tranquille River, Monashee and Cherry creeks. The Thompson was the focus of substantial metal mining exploration activity in the early 1990s which subsided in the late 1990s, and increased again in the early 2000s. There are over 25 closed mines in the Nicola and Coldwater drainages and more than 36 in the South Thompson-Shuswap drainage.

There are currently only two major metal mines operating in the Thompson system both of which are located in the Lower Thompson CU near Merritt. A lead-zinc mine has been proposed on Ruddock Creek in the headwaters of the Adams River, while another on the Bonaparte system is in the preliminary exploration phase. Mineral interests in the North Thompson have largely been concentrated in the Barriere River, Raft River, Lemiuex Creek, Clearwater River, Louis Creek, Bonaparte and Adams River drainages.

Despite the relatively low mining pressure at present, there is renewed interest in mineral claims and exploration in many parts of the Thompson drainage and a May 2012 announcement by the President of the Canadian Mining Association indicated that the BC interior is an emerging national mining hub.

Estuary Pressures

Coho from the Thompson drainage must migrate through the Lower Fraser Valley and estuary en route to the Strait of Georgia. The Fraser estuary reaches upstream to the extent of saltwater influence (Mission), and is the obligatory migratory corridor for all juvenile coho produced in the Fraser River. It is highly urbanized and developed. Over two million people live along the lower Fraser River. The cumulative impacts are significant and the majority of streams in the Lower Fraser have been classified as threatened or endangered due to large-scale watershed alterations. These include channelization, disconnection of the floodplain from foreshore habitats by dykes, increased urban impervious area, riparian zone degradation, and pollution (CDFO 1997b,1998b).

2.1.5.7 *Marine habitat pressures*

Thompson coho leave the Fraser estuary and share the marine environment of the Strait of Georgia with many other salmon stocks and species. Although marine habitats are less directly affected by development than the Fraser estuary, coho generally remain close to the coast and therefore face a host of nearshore marine habitat pressures in the Strait of Georgia. These include discharges from pulp mills and sewage treatment plants, harbour and terminal operations, tanker, barge and ferry traffic, marine construction and maintenance activities, intertidal, foreshore and backshore dyking, and shoreline modifications including riparian removal. While the individual and cumulative effects these pressures have on coho populations are difficult to quantify, the quantities of effluents and waste water discharges continue to increase with population growth on both the east and west coasts of the Strait of Georgia. Air borne and non-point-source contaminants also remain a concern.

Climate related changes have also had a major influence on marine habitat productivity. A shift to a lower productivity regime in 1989/90 coincided with substantial reductions in the marine survival and changes in marine distribution of Thompson River coho salmon (CDFO 2002). The mechanisms for this change in productivity and ocean distribution remain unknown.

2.1.6 Habitat Trends

Historic forest harvesting practices continue to impact many small coho systems in the Thompson Basin and over the last decade the effects of the Mountain Pine Beetle infestation have been significant. While disturbance to Thompson coho habitat from Mountain Pine Beetle deforestation and salvage harvesting has not been quantified, impacts are expected to include changes in hydrographs, mass wasting frequency, fine sediment mobilization, transport and deposition in streams, and increased stream temperatures, all of which will negatively affect both the quality and quantity of coho habitat. Future trends in forest harvesting in the Thompson basin are uncertain, however second growth harvesting is currently occurring in the headwaters of many systems.

Agriculture intensification, urbanization, lakeshore developments, and linear corridor development, have significantly impacted many of the southern valleys of the Thompson drainages and this trend is expected to continue.

Conflicts between consumptive water uses and in-stream flow requirements for fish are increasing, particularly in the South and Lower Thompson. Emerging industrial sectors such as mining and mineral processing are also expected to increase water demand in the Basin.

The cumulative impacts to coho habitat in the South and Lower Thompson CUs have already been significant and given the increasing habitat threats associated with population growth and development pressure, both the quantity and quality of coho habitat in these CUs is trending downward.

The North Thompson CU is subject to many fewer habitat threats than the Lower or South Thompson CUs. There are, however, numerous fish passage obstructions in the North Thompson CU associated with linear corridors and failing forestry and resource road culverts. These have eliminated access to many kilometers of suitable coho habitat. In addition Little Hells Gate creates a natural hydraulic barrier to fish migration and under certain flows, eliminates access to the Upper North Thompson. Overall, however, habitat status in the North Thompson is considered good and the trend is stable.

2.1.7 Mitigating factors

2.1.7.1 *Legislation and Policy*

Fortunately, several legislative and management improvements over the last few decades are mitigating the severity and magnitude of habitat pressures and threats in the Thompson. These include significant improvements in forest harvesting practices including requirements for riparian reserves as a result of both the 1996 *Forest Practices Code* and the subsequent (2004) *Forest and Range Practices Act*.

In addition the fish habitat management provisions in the *Fisheries Act* were enacted in 1978 and were followed in 1986 by the CDFO *National Habitat Policy*, which called for "No Net Loss" (NNL) in habitat productive capacity. This resulted in CDFO habitat staff becoming engaged in land and water use planning in BC for projects with the potential to negatively affect fish habitat and has been credited with significantly slowing habitat loss. Water quality impacts from sewage treatment facilities; pulp mills, metal mines and fish farms are difficult to quantify; however, the updates to *Fisheries Act* pulp and paper, sewage, metal mining and finfish farm effluent regulations in the last 20 years have improved effluent quality in each of these sectors

The province of BC enacted the *Riparian Area Regulation* in 2004. This regulation, which applies to settlement lands in the Lower and South Thompson CUs, requires that local governments address riparian area protection as part of their development approval process, and refer projects that cannot avoid harmful alteration, disruption or destruction of fish habitat to CDFO for review and /or authorization. The province is currently updating its century-old *Water Act*, to include provisions for in-stream flows to maintain stream and aquatic health, which is expected to benefit coho in the semi-arid interior of BC.

Numerous multi- stakeholder, collaborative land and water use planning and management processes are now in place and are improving habitat protection. The Shuswap Lake Integrated Planning Process is one example that brings together the regional districts, municipalities, stakeholders in the Shuswap basin with CDFO and BC MOE to address land and water use planning and fish habitat protection on Shuswap Lake. Another is the Farmland Riparian Integrated Stewardship Program, championed by the BC Ranchers Association, which focuses on protecting riparian habitat on range lands.

The Fraser River Estuary Management Program (a joint initiative of federal, provincial, municipal and port authorities) has improved habitat protection standards and regulatory requirements for projects occurring in the estuary and remains a model today for integrated resource management and planning. Municipal development application review committees that bring representatives from CDFO, BC, and municipalities together to adjudicate land development proposals have also improved aquatic and riparian habitat protection standards and practices in the Lower Fraser in the last 20 years.

On balance, while trends in environmental management and restoration in the Thompson basin are positive and have significantly ameliorated impacts to coho habitat, they are being outpaced by the cumulative development pressures on the finite habitat base particularly in the Lower and South Thompson, the Fraser River Estuary, and inshore waters of the Strait of Georgia.

2.1.7.2 *Protected Areas*

While there are a number of provincial parks in the Thompson drainage, their primary purpose is recreation and they provide limited protection for fish habitat. There are also a number of small ecological reserves and wildlife/waterfowl management areas in the lower Fraser and Fraser Estuary, but they are not expressly managed for protection of salmon habitat.

2.1.7.3 *Watershed Restoration Efforts*

Significant coho salmon habitat restoration has occurred throughout the Thompson basin since the late 1970s. Several of the programs that historically funded restoration works such as the Watershed Restoration Program and the Fraser River Action Plan no longer exist. Since 2004 the Pacific Salmon Commission Southern Endowment Fund has been a major funder of restoration projects in the Thompson. These have included works on off-channel coho habitat and water management planning in the Nicola River, riparian planting and livestock exclusion fencing in the Coldwater River, coho spawning habitat improvements in the South Thompson River, fish screening improvements in the Lower Shuswap River, water budget assessments and coho groundwater channel construction in the Salmon River, erosion management in coho habitats of the Bonaparte River, alternate water use strategies in Creighton Creek, irrigation ditch decommissioning in Guichon Creek, and various coho passage improvements throughout the Thompson drainage.

Reestablishing fish passage at problematic forestry road-stream crossings is a current focus of a federal/provincial fish passage working group which is supported by the BC Land Based Investment Strategy. Despite this focused effort on forestry associated passage problems, it is clear the number of additional barriers created by other resource roads, highways, railways and agricultural intakes significantly outstrips the capacity of existing restoration programs to redress. Additional partnerships are constantly being sought to identify, assess, prioritize and remediate these obstructions, which could restore access to many kilometers of productive coho habitat.

2.1.8 Conclusions/Recommendations

Freshwater habitat conditions particularly in the South and Lower Thompson CUs are believed to be contributing to depressed abundance of Thompson River coho. This is supported by studies which have indicated that the rate and magnitude of coho population declines are higher in the more impacted watersheds of the Thompson (CDFO 2002). The greatest habitat limitations to coho production in the Thompson are associated with water withdrawals, obstructions to passage, riparian vegetation removal, loss of in stream complexity and loss of off-channel habitat. Freshwater habitat condition, particularly in the South and Lower Thompson CUs is poor and is likely contributing to depressed abundance of Thompson coho whereas coho habitat condition in the North Thompson CU is considered fair to good.

Although freshwater habitat condition in the South and Lower Thompson is likely contributing to declines in stock abundance recovery of these stocks to historical levels is believed to be highly dependent on marine survival (CDFO 2002). The widespread decline of Thompson River coho that occurred in the 1990s was concurrent with declines in coho ocean survival and changes in their ocean distribution which further supports the hypotheses that marine survival is a major determinant of population trends.

Productive freshwater habitats help sustain coho salmon populations during periods of adverse marine conditions by maximizing the number of smolts produced per spawner. Consequently, populations from healthy and productive watersheds would be expected to experience the smallest declines during poor ocean conditions, and would likely recover at a faster rate if and when ocean conditions improve.

In order to better understand potential freshwater habitat constraints to Thompson coho production, studies on juvenile coho survival, growth and fitness in the Thompson system are necessary. Enumeration of smolt outputs from various sub-drainages would provide insight into freshwater productivity of these systems, while focused collection of data on habitat indicators would permit more rigorous analyses of habitat factors limiting production. All of this information in turn would better inform restoration actions and support the assessment of trends in habitat status over time.

Recovery of Thompson coho would be assisted by targeted restoration of freshwater habitats where there is an opportunity to cost effectively improve freshwater productivity even in watersheds that are severely degraded by land and water use activities. The extent and magnitude of watershed damage in some of the sub-drainages may, however, limit feasible and practical restoration solutions and exceed available resources.

2.2 West Coast Vancouver Island Chinook

2.2.1 Background and General Stock Status Information

The West Coast of Vancouver Island (WCVI) contains 4 chinook conservation units (CUs) or unique spawning populations: Nootka/ Kyuquot; South West Vancouver Island (SWVI); North West Vancouver Island (NWVI) and Port San Juan.

The Somass/Stamp River system, which is located in the Southwest Vancouver Island CU is the chinook exploitation rate indicator system for WCVI. Chinook from this system are predominately of Robertson Creek hatchery origin. Since the development of Robertson Creek Hatchery in 1971, this system has become one of Canada’s major producers of chinook salmon, with large contributions to ocean troll and sport fisheries, as well as substantial terminal sport, native, and commercial fisheries.

The Chinook escapement indicator systems that are consistently enumerated on WCVI include: the Artlish, Burman, Kaouk,Tahsis, and Tahsish Rivers in the Nootka/ Kyuquot CU; and the Marble River in the Northwest Vancouver Island CU. As resources have permitted, escapement enumeration has also occurred in the Bedwell/Uris; Megin; Moyeha; Nahmint and Sarita Rivers in the SWVI CU; Colonial/Cayegle creeks in the NWVI CU; Leiner River in Nootka/Kyuquot CU and the San Juan River in the Port San Juan CU.

Spawning population sizes range from less than 100 to more than 100,000 chinook in rivers with major hatcheries Of the roughly 60 rivers supporting WCVI chinook that exceed 100 spawners, twenty have some form of enhancement to supplement natural spawning, including major hatcheries on the Stamp, Conuma, and Nitinat rivers.

The overall status of wild chinook on the West Coast of Vancouver Island is of concern. Stocks are rapidly declining, and have been since the 1990’s.This downward trend in abundance is not limited to WCVI but is a broad pattern affecting several southern chinook stocks (particularly upper and mid Fraser and North Thompson early spring, spring and summer stocks, as well as the early spring, summer lower Fraser stocks). However as WCVI chinook are less productive than interior stocks the level of concern is elevated. Of particular concern on WVCI, are chinook spawning populations originating from rivers in Clayoquot and Kyuquot Sound. These populations remain depressed (ie: < 500 fish) despite significant reductions in exploitation rates in both ocean and terminal fisheries.

Over the last several years, stocks in the North West Vancouver Island CU have shown moderate improvements, however this trend has not been observed in South West Vancouver Island.

2.2.2 Habitat overview

WCVI is dominated by the coastal western hemlock biogeoclimatic zone with a much smaller, high elevation area that falls within the subalpine mountain hemlock biogeoclimatic zone. Prior to the early 1900s, the majority of the West Coast Vancouver Island was covered by large tracts of intact temperate rainforest.

WCVI is comprised of hundreds of watersheds and estuaries, numerous inlets, islands, submarine canyons, and banks, and is bounded to the west by a relatively narrow band of low relief continental shelf.

The climate is cool and wet, with mean annual temperature ranging from 7° to 12° C. Mean annual precipitation ranges from 2,000 to 4,500 mm, with relatively little snowfall. Freshwater runoff in watersheds and rivers is dominated by precipitation rather than snowmelt. Consequently, hydrographs exhibit peak flows from November to January and minimum flows from August to October. Exceptions are high elevation watersheds with consistent annual snow packs which have 2 peaks in the hydrograph - a first associated with winter rains and the second coinciding with snowmelt in May.

There are 124 estuaries on the WCVI, all of which have been ranked by the Pacific Estuary Conservation Program for importance (Figure 2.3). The indices used to determine "importance" were; estuarine size, habitat rarity index, species rarity index, waterfowl index and herring spawn index. Of the 124, 10 are considered Class 2, forty seven are Class 3, sixty five are Class 4 and 2 are Class 5 (EC CWS, 2007). While none of the estuaries in the NW Coast of Vancouver Island are ranked as Class 1, the concentration of estuaries in the top three classes makes this one of the top ranked areas in BC for estuarine importance. Collectively the estuaries of WCVI represent 3,067 ha of intertidal flat, 387 ha of river/lake habitat, 427 ha of marsh and 88 ha of island habitats.

The marine habitats of WCVI are very diverse and influenced by seasonal interactions between bathymetry, wind, freshwater runoff, and tidal currents that control both the circulation of water and its properties. Conditions encountered by Chinook salmon in most sounds and inlets are dictated either directly or indirectly by powerful but remote climate systems controlled in fall and winter by the Aleutian Low and in spring and summer by the North Pacific High that influences seasonal and annual to multi-decadal variations in current fields, thermal regimes, salinity gradients, and prey density. Marine ecosystems and biological communities, in contrast to those in freshwater, are less stable as they are highly responsive to the sudden shifts in atmospheric forcing which creates rapid changes in upper ocean conditions and re-organization of biological communities.

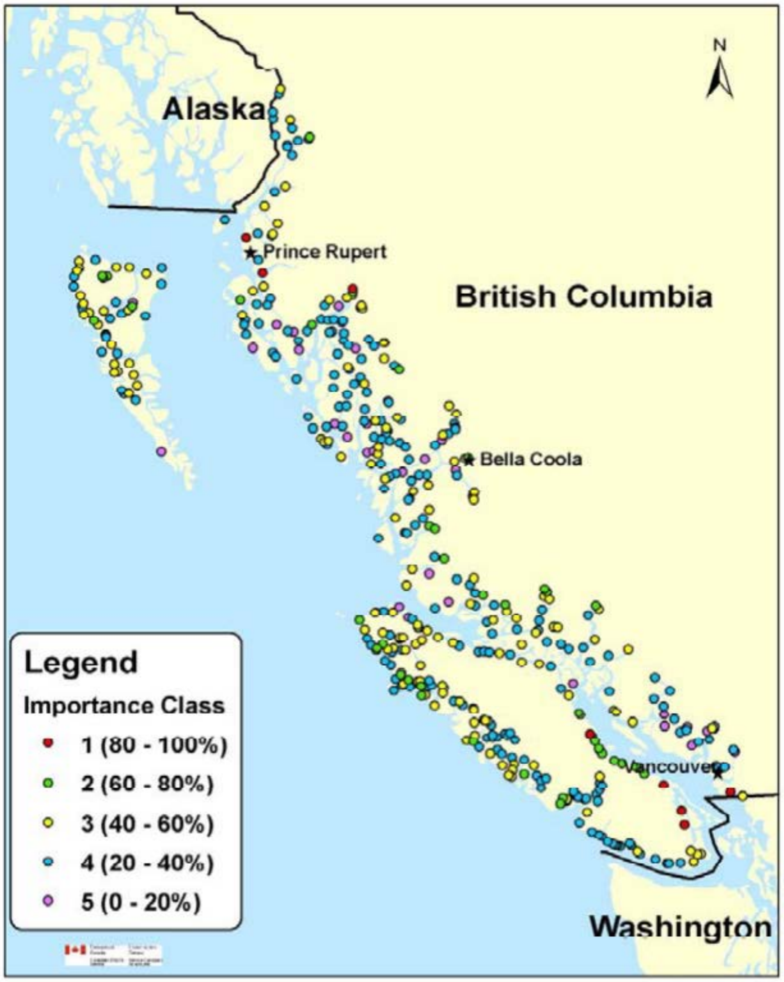


Figure 2.3 Illustration of estuary concentrations by "importance" class.

2.2.3 Life History Type and Habitat Use

All WCVI chinook have an ocean-type life history with juveniles migrating to sea within a few weeks to months of fry emergence. As a result, WCVI chinook are exposed to freshwater perturbations for a short period of their life history and are therefore less vulnerable to cumulative freshwater habitat pressures than are stream-type chinook. The freshwater life history stages of greatest concern for WCVI chinook are migrating adults, spawners, eggs/alevin, and emergent fry. Unfortunately there is no data available on survival or fitness of the early life history stages of chinook from WCVI which could inform freshwater productivity.

2.2.3.1 *Spawners/Eggs/Alevins*

As with all anadromous species, unimpeded access to spawning grounds is essential. Activities that create migration barriers, destabilize slopes, exacerbate landslide potential, or alter flows will significantly limit spawner migration and spawning success.

Chinook have the largest eggs of all pacific salmon and the smallest surface to volume ratio which makes their eggs particularly sensitive to reduced oxygen levels. Egg survival is very dependent on gravel permeability. Where there is good sub-gravel flow chinook will spawn in water of almost any depth or flow velocity and over a wide range of substrates. Egg to alevin survival varies widely between systems and is directly influenced by stream flow, water temperature, dissolved oxygen, gravel composition, spawn timing and spawner density. Activities that remove riparian vegetation, and increase erosion (hence sedimentation) will reduce sub-gravel flows and oxygen exchange and increase stream temperature which reduces reproductive success. While survival during this life history stage is quite variable, under good conditions it is relatively high and can average about 30%. Data on WCVI chinook egg to fry survival is not available.

2.2.3.2 *Outmigrating Fry*

During their limited residence in freshwater, ocean-type chinook fry rely heavily on both aquatic and terrestrial larval and adult insects for food.

Downstream migration is active with fry tending to use back eddies and river margins, where velocity is reduced and insect production is high. They move into deeper faster waters to feed and avoid competitors as they grow in size. Migration timing is generally associated with elevated river flows. Successful outmigration requires moderate stream flows, moderate temperatures and productive insect populations.

Estuaries are known to be important transition, rearing and refugia zones for ocean-type chinook. Juveniles tend to occupy deeper estuarine waters where they feed intensively for several weeks to months. The enhanced growth that occurs in estuaries results in larger size at ocean entry, which has been correlated with higher marine survivals. Sufficient food sources, good water quality and cover to reduce predation and competition in estuaries are essential for ocean-type chinook.

Broad landscape modifications such as forest harvesting, which alter stream hydrology, slope and channel integrity, stream temperature, water quality and riparian habitat quality will negatively impact all of these life history stages.

2.2.3.3 *Sub-adults/A**dults***

The length of time that ocean-type chinook use sheltered near-shore environments depends food availability, competition, predation and environmental conditions, but unlike stream-type chinook, ocean-type chinook generally remain in coastal waters on the continental shelf for most of their lives. . Therefore factors that reduce the productivity of estuarine and near-shore waters will have a significant impact on overall survival and production of WCVI chinook.
The marine habitats of the WCVI used by sub-adult chinook can generally be categorized as follows:

1. Transitional, estuarine staging and near shore marine rearing areas used extensively by both the juvenile and sub-adult stages (e.g., Alberni Inlet, Clayoquot , Kyquot, Nootka/Esperanza and Quatsino Sounds);
2. Upwelling areas of productive underwater shoals and banks that are especially important rearing areas for aggregations of sub-adult Chinook salmon (e.g., banks proximal to the Broken Islands or La Perouse Bank);
3. Surface eddies of the continental-shelf that entrain and concentrate juvenile Chinook and plankton; and
4. Advection zones along the continental shelf where surface waters move rapidly seaward as filaments or plumes (e.g., coastal waters near Brooks Peninsula) with replacement from depth by upwelling, nutrient-rich waters.

Historic surveys of the distribution and abundance of juvenile salmon suggest differential use of these areas across seasons. In early spring and summer juveniles of all salmon species are found aggregated in the inside waters of inlets and sounds. However, by mid-July, chinook will vacate and by October juveniles will be found further offshore concentrated in pelagic surface waters over the continental shelf (i.e. concentrate at less than 50m depth in areas where the ocean is 100m to 1,000m deep).

Ocean type chinook in general do not disperse more than 1000 km offshore and persistently use these continental-shelf waters for rearing and migration. They are virtually absent offshore in this area of the coast.

Activities, works, or undertakings which decrease the quality or quantity of estuarine or near-shore marine habitats or directly impact areas of high biological production and juvenile aggregation (such as banks and shoals) will negatively impact sub-adult and adult WCVI chinook.

2.2.4 Habitat pressures

Analyses of habitat limiting factors have not been conducted for the watersheds or estuaries on WCVI, nor is there data available on juvenile chinook survival or fitness for WCVI. As a result it is not possible to quantitatively assess freshwater or estuarine productivity or habitat constraints to production.

Synoptic GIS habitat pressure analyses for each of the four chinook CUs on the WCVI is available however, as are detailed salmon habitat status reports for several chinook exploitation or escapement indicator systems on WCVI including: the Sarita, Bedwell and Stamp/Somass watersheds in the SWVI CU and the San Juan/Gordon Rivers in the Port San Juan CU. A review of known habitat pressures and threats on WCVI (Appendix A) provides some insight into the potential role of freshwater habitat perturbation in the decline of WCVI chinook.

2.2.4.1 *Pressure Indicator Analyses for WCVI CUs*

The synoptic GIS analyses in Appendices A through D includes a series of risk maps for habitat pressure indicators for which data was available across all watersheds in each WCVI CU.

Indicator values were compared against empirical benchmarks or thresholds for concern (where they exist) and where they did not, they were determined based on distribution of indicator values across all watersheds in the CU. Where distributional analyses was conducted relative risk categories (red, yellow, green) were then established based on percentiles with any value under the 50th percentile being considered low risk, values between the 50-75th percentile being moderate risk and the 75th percentile and above being considered high risk. Distributional analyses was required in the case of mountain pine beetle kill, total land cover alteration, forest disturbance, urban development, agriculture/rural development and riparian disturbance indicators. Several other pressure indicators (specifically mines, permitted waste discharges, and water allocation) were ranked using thresholds of 0 for no/low risk, >0 for moderate risk and outliers beyond the normal distribution of values across all watersheds being considered high risk.

An aggregated pressure profile was then produced for each of the watersheds in every CU. The aggregated risk score was based on 5 independent indicators using a rule based algorithm. The five indicators selected for aggregation included: 1) total land cover alteration; 2) road density; 3) stream crossing density;4) water allocation; and 5) permitted waste discharges. The rules based algorithm for aggregation stipulated the following: if 2 or more of the 5 indicators in the watershed were red then the cumulative risk rating for the watershed was red; otherwise if 4 or more of the indicators were green then the risk rating was green; otherwise the risk rating was yellow.

A CU overview slider figure was also produced to allow rapid comparison of the relative risk to the CU posed by the various pressure indicators. The values are based on an area-weighted average of all watershed scores in the CU, and were then normalized for each indicator so that the low to moderate risk threshold (t_1) occurs at 0.33 and the moderate to high risk (t_2) threshold is at 0.66 on a scale of 0 to 1

The CU habitat report cards for each of the WCVI CUs as well as a description of the methodology applied to indicator analyses are presented in Appendices A through E.

2.2.4.1.1 Nootka/Kyuquot CU

Numerous watersheds in this CU are considered to be at high risk based on a high cumulative risk score for the 5 indicators selected for analyses. These watersheds include the Malksope, Tahsish Kaouk Zeballos, Oktawanch, Tlupana, Houston, Mooyah, Tsowwin, Sucwoa and Perry Rivers as well as Pandora, Gold Valley, McCurdy, Cougar, Kendrick, Brodick, Owossitsa, Spud, Eliza, Clannick, and Chamiss Creeks. The predominant habitat pressures in these watersheds were all associated with logging (ie: stream crossing density, road density, total land cover alteration and riparian disturbance). As noted in the maps, these high risk watersheds are widely distributed throughout the CU illustrating the broad extent of forest harvesting and road development in the CU.

CU overview

Based on normalized area-weighted averages of all watershed scores within the CU, the indicators of greatest concern are all forestry related with stream crossing density representing a moderately high risk across the CU while the other forestry associated indicators of road density , forest disturbance and riparian disturbance all represented moderate risks. Water allocation, permitted waste water discharges and mine development represented moderate to low-moderate risks while urban development and agriculture/urban development present low risks at the CU scale.

2.2.4.1.2 Northwest Vancouver Island CU

Several watersheds in this CU are considered to be at high risk based on a cumulative score of the 5 indicators selected for analyses. These watersheds include: the San Josef, Keith, Benson and Marble Rivers as well as Klootchlimmis, Mahatta, Pinch, Craft, Howlal, Lippy, and Buck Creeks. The predominant pressures in these watersheds were all associated with logging. As noted in the maps these high risk watersheds are widely distributed throughout the CU illustrating the extent of forest harvesting and road development in the CU.

<u>CU overview</u>

Based on normalized area-weighted averages of all watershed scores for all indicators within the CU, stream crossing density represents the highest risk to the overall CU. Other forestry associated indicators such as road density, forest disturbance and total land cover alteration represent high-moderate risks. Water allocation and permitted waste water discharges are moderately low risks while the pressures associated with mining development, urban development and agriculture/rural development represent low risks to the overall CU

2.2.4.1.3 Southwest Vancouver Island Conservation Unit

Several watersheds in this CU are considered to be at high risk based on a cumulative score of the 5 indicators selected for analyses. These watersheds include Cypre, Atleo, Sand, Sarita, Klanawa, Sooke, Caycuse and Nitnat Rivers as well as Charters, De Mamiel, Seven Mile, Mactush, Cous, Coeur D'Alene, Lost Shoe and Cass Creeks. The predominant pressures in these watersheds were associated with forestry activities. While these pressures are distributed throughout the CU, the watersheds with greatest pressures tended to be concentrated near Barkley Sound and in the southernmost portion of the CU (i.e.: Sooke River, De Mamiel Creek and Charters Creek).

<u>CU overview</u>

Based on normalized area weighted averages of all watershed scores for all indicators within the CU the indicators of highest concern in this CU are all forestry associated (i.e.: road density, forest disturbance, stream crossing density, total land cover alteration and riparian disturbance. Water allocation pressures, permitted waste discharges and mining development represent moderately low risk to the CU while all other indicators present low risk at the CU scale.

2.2.4.1.4 Port San Juan Conservation Unit

Like other CUs on the WCVI the San Juan and Gordon Rivers and Harris Creek watersheds which comprise this CU have all been heavily logged and the indicators of greatest concern such as road development, stream crossing density and total land cover alteration reflect this predominant land use pressure.

<u>CU overview</u>

Unlike the other CUs each forestry associated indicator in this CU represents high to very high risk to the CU at large. All other pressure indicators represent moderately low to low risk to the overall CU.

2.2.4.2 *Activities, works and undertakings*

All development proposals on Vancouver Island submitted to CCDFO staff for regulatory review between 2003 and March 2012 were reviewed and provided additional information on the relative freshwater habitat pressures on WCVI.

Of over 5,025 projects with the potential to negatively affect fish habitat on Vancouver Island, only 850 (< 20%) were located on the WCVI, indicating low cumulative development pressure compared to that on the east coast of Vancouver Island. This does not include forest harvesting activities, which are no longer reviewed by (or referred to) CDFO, but rather are managed by the province through the *Forest and Range Practices Act* for Crown land harvesting projects and the *Private Managed Forest Lands Act* (for private land harvesting).

The human population on the WCVI is very low and concentrated in several small settlement areas (Port Alberni, Tofino, Ucluelet , Port Alice, Gold River, Tahsis, Sooke). Most referrals in these areas focused on local infrastructure works (subdivisions, sewer/water lines/pumping stations, water extraction or diversion applications, marinas/wharves/docks/jetties, fuel and barge facilities, shoreline protection works, park development, reservoirs, roads and trails).

The majority of the remaining projects were for construction or maintenance works associated with forest harvesting activities (log dumps/sorts, roads, bridges and culvert replacements / upgrades, debris removal and log salvage). Foreshore water tenures for in-water log sorts and handling are associated with every forest harvesting license and are therefore widely dispersed across the lakes, estuaries and bays of the WCVI.

A very limited number of applications have been received for energy projects (wind or wave farms) and mineral exploration/extraction (sand or gravel extraction) and numerous applications were received for habitat restoration works (in-stream complexing, bank stabilization, sediment removal, riparian planting).

Finfish aquaculture, another commercial enterprise on the WCVI is concentrated in the near shore marine areas of Quatsino, Nootka, Barkley and Clayoquot Sounds, and Kyuquot Inlet and Esperanza Inlets (Figure 2.4). The potential impacts of these operations (specifically sea lice interactions) on wild juvenile chinook during their out migration phase has been raised as a concern based on findings of sea lice interactions with juvenile Pink and Chum salmon in the Strait of Georgia and Broughton Archipelago. Recent research, however, indicates that juvenile chinook are far less susceptible to infestation by sea lice than Pink or Chum salmon are. Chinook juveniles tend to be larger and scale formation is more advanced by the time they enter the near shore marine environments, which significantly reduces the potential for sea lice attachment.

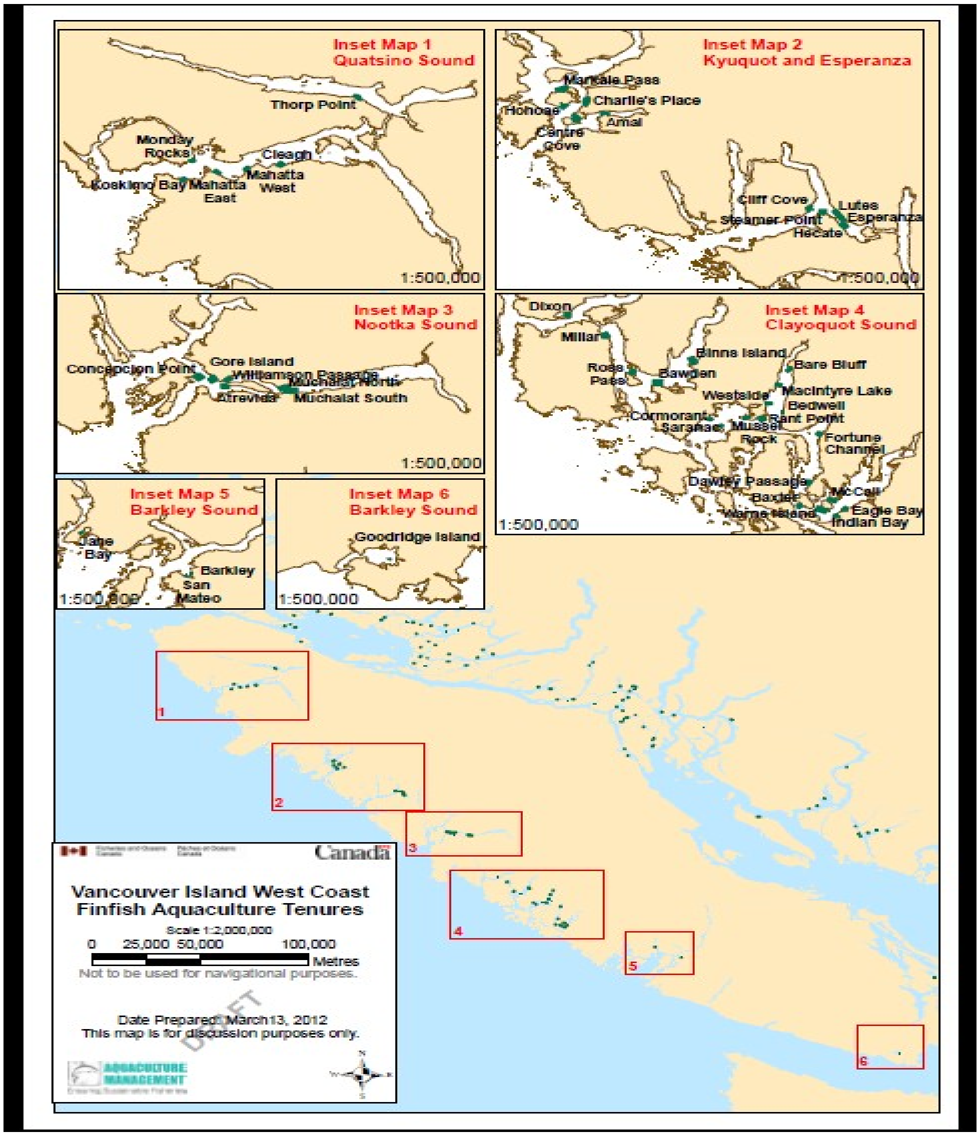


Figure 2.4. Finfish aquaculture tenures on the West Coast of Vancouver Island.

2.2.5 Habitat Trends

The predominant habitat pressures on the WCVI are all related to logging and associated road construction and maintenance. These activities often lead to destabilized slopes, banks, and stream channels, loss of riparian habitat, isolated off-channel habitats, increased soil erosion and sedimentation, altered timing, magnitude and velocity of flows and increased stream temperatures.

The focus for harvesting in coastal BC watersheds since 1996 has been on higher elevation hill slopes and has been adjacent to non-fish bearing stream reaches. The potential for downstream transport of impacts to lower more productive fish bearing habitats, however, is significant, particularly in regions of steep terrain and high precipitation such as WCVI.

The provincial FREP assessed the post-harvest condition of a random sample 367 streams in the coastal region of BC in, or adjacent to, harvest blocks logged under the FPC. Compared to other areas in the Province, the highest percentage of streams considered *not properly functioning* (19%) were found in this sample- and the majority were in non-fish bearing tributaries or reaches. Until harvesting ceases (or hydrologic green-up occurs) and forestry roads are deactivated these impacts can continue to be expressed.

While some logging on the WCVI continues today, intensity has decreased significantly in the past decade with the economic downturn in the forest sector. There have also been significant improvements to forest harvesting practices and increased legal requirements for riparian protection over the last 20 years as a result of the Forest Practices Code (FPC) and the *Forest and Range Protection Act* (FRPA), however there is still scope for improvements to current practices.

There are a number of large private forest land holdings on the WCVI, and while these are not subject to the same regulatory regime as commercial forest harvesting, they are still actively managed by the province under the *Private Managed Forest Lands Act*.

Collectively, the reduced intensity and enhanced regulatory regime for forest harvesting have decreased pressures on fish habitat, increased planning requirements for aquatic habitat protection and improved riparian habitat protection in recent years. These improvments occurred in the same period as the most recent and severe declines in chinook escapements suggesting thatwhile historic logging activities have affected freshwater habitat condition, factors other than recent forest harvesting are likely responsible for the recent declines.

The future of forestry on WCVI is uncertain, but in the absence of a return to the pre-1990 harvesting rate on the WCVI, the status of freshwater fish habitat is considered relatively stable and a trend of improvement due to forest recovery and past restoration efforts is expected.

2.2.6 Mitigating Factors

2.2.6.1 *Protected areas*

The WCVI includes several significant protected areas, including one of Canada's largest National Marine Parks (Pacific Rim) a 500 km^2 park extending along 125 kilometers of coast from Tofino in the north to Port Renfrew in the south. A 3,500 km^2 UNESCO Biosphere Reserve (Clayoquot Sound) has also been endowed to serve as an international testing site for biodiversity conservation.

2.2.6.2 *Watershed Restoration Efforts*

The Forest Renewal BC Watershed Restoration Program, which operated from 1994-2002, invested close to $10M in watershed restoration works on the WCVI to benefit salmonids.

The PSC Southern Endowment Fund has also supported a variety of salmon habitat restoration projects on WCVI including side channel and floodplain habitat restoration in the Kauwinch system, side channel construction in Harris Creek, channel complexing in Charters Creek, feasibility studies for groundwater fed side channel development in the Nahmint system, Somass estuary saltmarsh restoration; water use planning in the Somass/Sproat system, barrier removal in Kennedy flats, and engineering designs for side channel creation in the Sarita River.

2.2.7 Freshwater habitat status

Compared to many other southern chinook conservation units, particularly those on the East Coast of Vancouver Island, the Lower Fraser River, the Thompson, and the Lower Okanogan, the cumulative freshwater habitat disturbance from various land and water use stressors for the WCVI is low. Forestry associated disturbance, however, is moderate to high across WCVI. Research at Carnation Creek (SWVI) and elsewhere has also shown that forestry related impacts can persist and even increase for decades after harvesting (Tschaplinski et al. 2004). Such impacts are still apparent in many valley bottom streams affected by forestry practices implemented prior to 1996.

Many watersheds are however beginning to recover, and recovery has been accelerated by active restoration efforts (Cleary and Underhill 2002, Underhill 2001, 2002) . Overall, much of the West Coast of Vancouver Island still retains its natural character and, with a few notable exceptions, freshwater Chinook spawning and migratory habitat condition is generally considered fair to good.

Freshwater habitat modeling in a number of watersheds on WCVI (Parken et al. 2006) also indicates that Chinook abundance and productivity is low relative to habitat availability.

2.2.8 Conclusions and Recommendations

In the absence of juvenile Chinook productivity data from WCVI the relationship between freshwater habitat status and Chinook production cannot be quantified. While forestry and associated activities are exerting the greatest pressures on freshwater habitats of the WCVI, impairment of freshwater habitat productive capacity is unlikely the primary causal agent for the current Chinook stock declines for several reasons:

1. The majority of large scale habitat perturbations on the WCVI are due to forest harvesting which peaked several decades ago and have decreased significantly over the most recent period of chinook declines. Forest harvesting practices have also improved considerably since the mid to late 1990's and with significant investments in restoration over the last 20 years many watersheds are now beginning to recover

2. The decline in chinook abundance are mirrored by declines in other marine pelagic species such as herring, and these collapses coincided with significant shifts in oceanic productivity and continue despite severe harvesting restrictions.

3. Despite similar forestry associated impacts and threats across all the CUs on the WCVI, stock status is highly variable with stocks on NWVI showing moderate improvements over the last several years while stocks from protected watersheds (notably those in Clayoquot Sound) in SWVI remain depressed.

The watershed scale habitat status reports that have been completed for WCVI consistently identified the need for habitat restoration that focuses on reversing logging impacts and recommended the following activities: upslope stabilization and erosion control, forestry road deactivation, mainstem channel complexing (creation or enhancement of pool and boulder/riffle habitats), riparian re-planting, and access improvement to off-channel habitats.. Targeted estuarine restoration that focuses on log dump and sort wood debris removal, eelgrass re-establishment, and accumulated sediment removal would likely improve estuarine habitat productive capacity and assist recovery of WCVI chinook.

Monitoring the effectiveness of watershed and fish habitat restoration efforts implemented since the mid 1990's would be also be highly desirable. Additional data on habitat pressure indicators in all drainages on the WCVI would be required to confirm habitat limiting factors, assess changes in habitat status over time and support further analyses of freshwater habitat contributions to WCVI chinook production and declines. Collection of data on juvenile chinook survival, growth and fitness is necessary to better understand freshwater habitat productivity and carrying capacity and elucidate potential freshwater and estuarine habitat constraints to WCVI chinook productivity.

There is no question that productive freshwater and estuarine habitats help sustain populations during periods of adverse marine conditions, by maximizing the number of smolts produced per spawner. Therefore populations from healthy and productive watersheds and estuaries that produce higher numbers of smolts per spawner would be expected to experience smaller declines during poor ocean conditions, and recover at a faster rate if and when ocean conditions improve.

In conclusion, although freshwater and estuarine habitat condition are not suspected to be the main causative agent for the recent decline in WCVI chinook production, the quality and quantity of these habitats has been impacted.. Therefore, restoration efforts focused on improving the habitats of early life history stages of these stocks would be expected to contribute to their recovery. Partnerships already exist with various local First Nations, private land owners, forest companies and others on the WCVI and the interest and capacity amongst these parties to participate in future restoration activities remains high.

3 EFFECTIVE DESIGN, ASSESSMENT, AND MONITORING OF RESTORATION PROJECTS

3.1 Introduction

The protection and restoration of aquatic habitats are key to reversing the widespread decline of wild salmon runs in the Pacific Northwest. Despite extensive efforts and activities to improve aquatic and marine conditions for salmon and to conservatively manage fisheries, populations continue to decline coastwide (NRC 1996). Recognition that non-fishing factors may reduce the productivity of fish populations has led to increased expenditures on stream and watershed restoration (Kondolf and Micheli 1995). There have been thousands of projects and hundreds of millions of dollars spent on Pacific salmon habitat restoration, as documented by the Ad Hoc Habitat Scoping Committee (PSC 2008) and by Roni (2005). With these increased financial commitments have come greater expectations of restored ecosystems. Here we discuss 1) the rationale for actively restoring streams, rivers, and watersheds; 2) the scale and context in which restoration should be considered and designed; 3) habitat and population assessments to direct restoration practices; 4) a quantitative approach to evaluating limiting factors for populations; 5) short and long-term monitoring of restoration to evaluate habitat and fish responses; and 6) provide recommendations to improve the proposal process.

Aquatic systems worldwide are being altered and destroyed at a greater rate than at any time in human history (NRC 1992). Although pollution from point sources has been reduced in recent years, an expanding human population has resulted in increased non-point source pollution from agriculture, mining, forestry, and urban development. All of these activities alter water quality, produce sediment and increase the speed with which water is delivered to stream channels, as described in the special issue of *Fisheries* (AFS 1997) on Watershed Restoration. Unfortunately, our understanding of the effects of chemical, biological, and mechanical processes in North America’s streams is often inadequate and not well applied. This has resulted in public policies that have often aggravated watershed problems instead of contributing to their restoration. These inadequate and misapplied policies are a major cause of continued deterioration of many of our watersheds. Thus, revamping and better integrating federal, state, provincial, and local programs to implement stronger, more science-based policies are needed (Brouha and Chappell 1997).

A primary reason that some restoration projects have not succeeded is that they have been implemented on a small-scale, site-specific basis, with little apparent appreciation for an overall theory guiding restoration ecology (Hobbs and Norton 1996). They have focused on the symptoms of habitat degradation (e.g., in-stream structural habitat) rather than on the causes of the ecological degradation (e.g., loss of riparian vegetation). The National Research Council (1992) attributed most failed restoration efforts to a failure to integrate geographic scales, ecological principles, and adaptive management into planning and programs. Most scientific reviews of restoration protocols agree that restoration should occur at the watershed scale and should focus on restoring the natural ecological processes that create and maintain habitat rather than simply manipulating in-stream habitats (Johnston and Moore, 1995, Roper et al. 1997, Roni et al. 2002, Roni 2005, Palmer 2009, ISAB 2011a and 2011b). However, focusing on smaller scale (both spatial and temporal) projects in concert with long-term plans is a practical approach.

Another factor in the failure or inconclusive results of restoration projects has been a lack of monitoring and evaluation. Only by monitoring the effectiveness of restoration techniques and applying adaptive management can they be evaluated and improved upon. Reviews of restoration techniques indicate that knowledge of the effectiveness of most is incomplete and that comprehensive research and monitoring is needed (Koning et al. 1998, Mellina and Hinch 1995, Reeves et al. 1991, Kondolf 1995, Kauffman et al. 1997, Roni et al. 2002, Roni 2005; Reeve et al. 2006, PSC 2008). Because of the large inter-annual variation juvenile and adult salmonids abundance, more than10 years of monitoring may be required to detect a population response to restoration (Bisson et al. 1992, Reeves et al. 1997). Consequently, scientific evaluations of the biological effectiveness of restoration techniques are costly and usually hampered by a lack of credible data and the high natural variations in salmon production. As Roni (2005) stated, "Given the debate within the scientific community about the effectiveness of various techniques and the financial investment in restoration, it is incomprehensible that monitoring is not an essential component of designing any restoration project".

No single restoration project is likely to address all of these issues. Rather, fund managers and policy makers should direct habitat restoration proponents to learn from past problems and shortcomings and develop more effective projects in the future. Three actions would greatly improve the value and probability of success of future projects, and are the principal elements of a strategic project design:

1. planning the project in the context of ecological functions and watershed processes,
2. using the lessons learned and resources available from other watershed management programs, and
3. designing the project and associated monitoring in a statistically robust manner.

Individual projects are unlikely to be funded sufficiently to address all design, implementation, and monitoring needs, nor is this necessary. Rather, better coordination and sharing of information among similar efforts within the purview of fund managers and policy makers would significantly increase the value of individual projects. There are several on-line resources to assist in each of the three steps above:

Oregon's Watershed Enhancement Board (http://www.oregon.gov/OWEB/pages/index.aspx) provides a wealth of information on effective methods and monitoring tools and designs.
The Pacific Northwest Aquatic Monitoring Partnership (http://pnamp.org/) provides links to monitoring activities and data in, especially, the Columbia Basin and is developing resources to assist with the design and implementation of statistically-sound monitoring projects (https://www.monitoringresources.org/).
The Puget Sound Partnership provides similar on-line resources (http://www.psp.wa.gov/).
A long-term data set and scientific reports for a coastal rain forest watershed is available for Carnation Creek (http://www.for.gov.bc.ca/hre/ffip/CarnationCrk.htm).
The BC Watershed Restoration program also produced many technical circulars which are relevant to this subject. http://www.env.gov.bc.ca/cariboo/env_stewardship/wrp/wrp_manuals.html

Habitat plays a critical role in the maintenance of healthy salmon stocks and in the restoration of depressed salmon stocks. Without adequate habitat, depressed naturally spawning stocks cannot be restored to optimum production using harvest controls. Improved hatchery practices will not increase natural productivity unless there is high quality habitat to support natural production. In a large fraction of our watersheds, strategic habitat restoration is a necessary companion to improved harvest and hatchery management of the stocks that support the fisheries managed by the PSC.

The Habitat and Restoration Technical Committee (HRTC) wants to ensure that information on the most effective methods is readily available to habitat restoration practitioners to assess stock and habitat health, to implement restoration projects and monitor their outcomes. This Chapter is divided into three sections to help provide managers and practitioners with the knowledge and understanding of the requirements for strategic habitat restoration: Science-Based Restoration (3.2); Habitat Assessment (3.3); and Restoration Project Monitoring (3.4).

3.2 Science-Based Habitat Restoration

To understand the concept of habitat restoration, it is important to understand the terms “habitat”, “ecosystem” and “restoration”. Habitat is the place where an organism lives, and species define their habitat by their spatial and temporal distributions (NMFS 2010). The ecosystem, in the present context, is the aquatic environment with its biota, its physical, chemical, and biological processes, and the landforms, watershed processes and land uses that create, influence and sustain aquatic habitat attributes and populations. There are several definitions of restoration in the literature, but the following definition articulates the concept clearly: “The process of reestablishing a self-sustaining habitat that in time can come to closely resemble a natural condition in terms of structure and function” (Turner and Streever 2002).

Following an intensive watershed assessment, the first and most critical step in the ecological restoration of salmon habitat is passive restoration (Fig 3.1)); the curtailment of impacts from anthropogenic activities in the watershed (e.g., roads, culverts, riparian alteration) that are degrading aquatic habitats or preventing ecological recovery (Kauffman et al. 1997). The next step in the hierarchical sequence is to protect all existing high-quality habitats in the watershed and to reconnect any high-quality fish habitats such as in-stream or off-channel habitats made inaccessible by culverts, channel modifications, diking or other artificial obstructions (Johnson and Moore 1995; Roni et al. 2002). It is far easier to maintain or reconnect good habitat than to try to recreate or restore degraded habitat (; Roni et al. 2002; Simenstad and Bottom 2002). Efforts should then focus on restoring hydrologic, geologic (sediment delivery and routing), and riparian processes through road decommissioning and maintenance, exclusion of livestock, and restoration of riparian areas. The final step or consideration is to use techniques to manipulate in-stream habitat. The success of these techniques tends to be short-lived unless watershed processes are restored first (Roni et al. 2002; Beechie et al. 2003). The targets in in-stream manipulations, such as the number of pools or pieces of woody debris should reflect the range of conditions that existed naturally in the watershed prior to anthropogenic disturbances (Slaney and Martin 1997, Slaney and Zaldokas 1997, Roni et al. 2002). Generic targets should be avoided, as individual salmon stocks are adapted to a range of local environmental conditions for a given watershed.

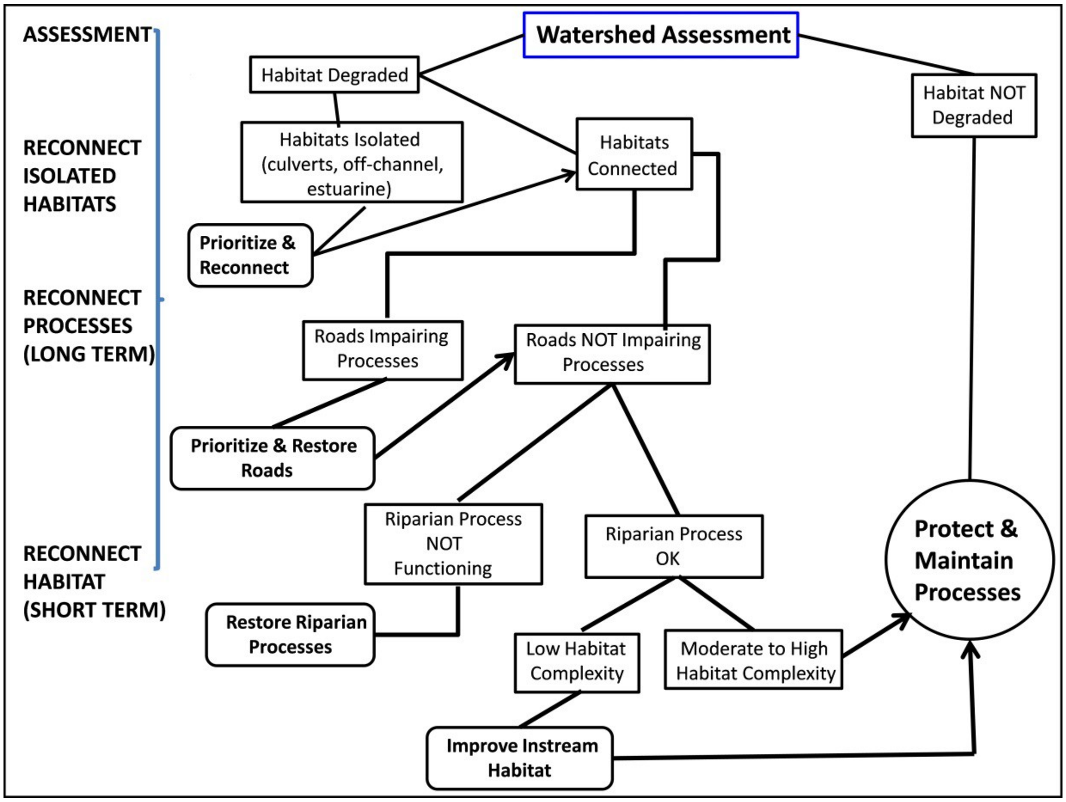


Figure 3.1. Strategy for prioritizing watershed restoration activities (Roni 2005).

There are numerous examples from past 20 years of significant investments in restoration failing to halt declines in aquatic habitat quality and ecosystem function (Bernhardt et al. 2005, Palmer and Allan 2006). To avoid this outcome, decision makers should ask three questions (Beechie et al. 2009):

1. How much restoration do we need?
2. How do we best achieve cost-effective restoration?
3. How do we know when we have restored enough?

The broader management context for these questions includes ongoing development in watersheds for societal and economic gain, the continued application of traditional restoration techniques in piecemeal fashion, and skepticism that river restoration can succeed in the face of climate change and continued population growth. To meet these challenges we must use our ecological knowledge to ensure that we are maximizing the effectiveness of our restoration efforts. This involves identifying the factors limiting production, prioritizing projects in reaches and streams that are actually restorable and self-maintaining, and shifting our efforts toward process-based restoration (Norton et al. 2009, Palmer et al. 2009, Beechie et al. 2009). We must understand how habitat is formed and changes, how habitat changes alter biota, and how human actions alter both the aquatic habitat and the landscape processes that create the habitat (Beechie et al. 2009). The PSC can contribute to this shift by ensuring that restoration projects it funds are planned and implemented in the context of landscape and watershed processes and employ the latest scientific monitoring protocols and tools.

3.3 *Habitat Assessment*

3.3.1 Overview

Habitat assessments should form the scientific basis for decisions on habitat protection and restoration. An assessment is an essential step in understanding the current status of populations and habitat conditions to establish a baseline for development of a restoration plan, if necessary. The information is also important in evaluating a species or population for listing or delisting under the U.S. *Endangered Species Act* (ESA), the Canadian *Species at Risk Act* and for the evaluation of stock status under Canada's Wild Salmon Policy (WSP).

A habitat assessment involves consolidating, analyzing, and reporting the best available information on habitat characteristics important to the population dynamics of salmon and other biological resources. The end goal is to describe the function of habitats in relation to fish productivity and ecosystems to inform management decisions regarding protection and/or restoration. In a habitat assessment, spatial and temporal relationships of environmental data with species life stages are used to describe the types, distribution, and amounts of habitats that support fishery stocks (NMFS 2010). They require an analysis of population or demographic parameters and the physical or biological conditions that affect the species.

An assessment of population viability is the initial step in understanding the need for protection or restoration. Viability of salmon populations can be described in terms of abundance, persistence, productivity, spatial structure (distribution), and diversity, all of which are affected or influenced by the quality and accessibility of habitat (McElhany et al. 2000, Chilcote et al. 2005, ODFW 2007). The primary indicators for these parameters are: adults on the spawning ground (abundance); likelihood that the population will persist in the future (persistence); adult progeny per parent (productivity); geographic distribution of salmon throughout their life stages (spatial structure); and genetic, phenotypic, and behavioral traits (diversity); and the amount of high quality habitat available to each life stage (habitat). Population viability criteria for spatial structure and diversity are more qualitative than those for abundance or productivity. Consequently these attributes are commonly compared to historic conditions. Practical and effective evaluation programs tracking the status of all components of salmon viability are needed.

Should the viability assessment indicate that recovery actions are required, development of a recovery plan is the next step. Scientists and resource managers have recognized that careful consideration of watershed and ecosystem context is necessary to successfully restore or prevent the demise of species (Roni et al. 2002, Roni 2005, FEMAT 1993, Lichatowich et al. 1995, Beechie et al. 1996). Habitat recovery planning, therefore, requires the assessment of disruptions to ecosystem functions and biological integrity, which have reduced the productive capacity of the river system. The goal of such assessments is to identify alterations in key processes that affect aquatic habitats and to specify the management actions required to restore processes that sustain habitats and support biological integrity (Beechie et al. 2003). In this approach, restoring specific salmon populations is subordinate to the goal of restoring ecosystem integrity.

The ecosystem approach to salmon recovery planning includes two main elements: (1) analysis of landscape and habitat factors to help set recovery goals, and (2) analysis of disrupted ecosystem processes to identify watershed and aquatic habitat restoration actions Each element relies on a conceptual framework linking landscape controls, watershed processes, land uses that can alter aquatic habitats, and in turn, populations and communities. Aquatic habitat conditions can be viewed as the link between landscapes and fish populations (Beechie et al. 2003).

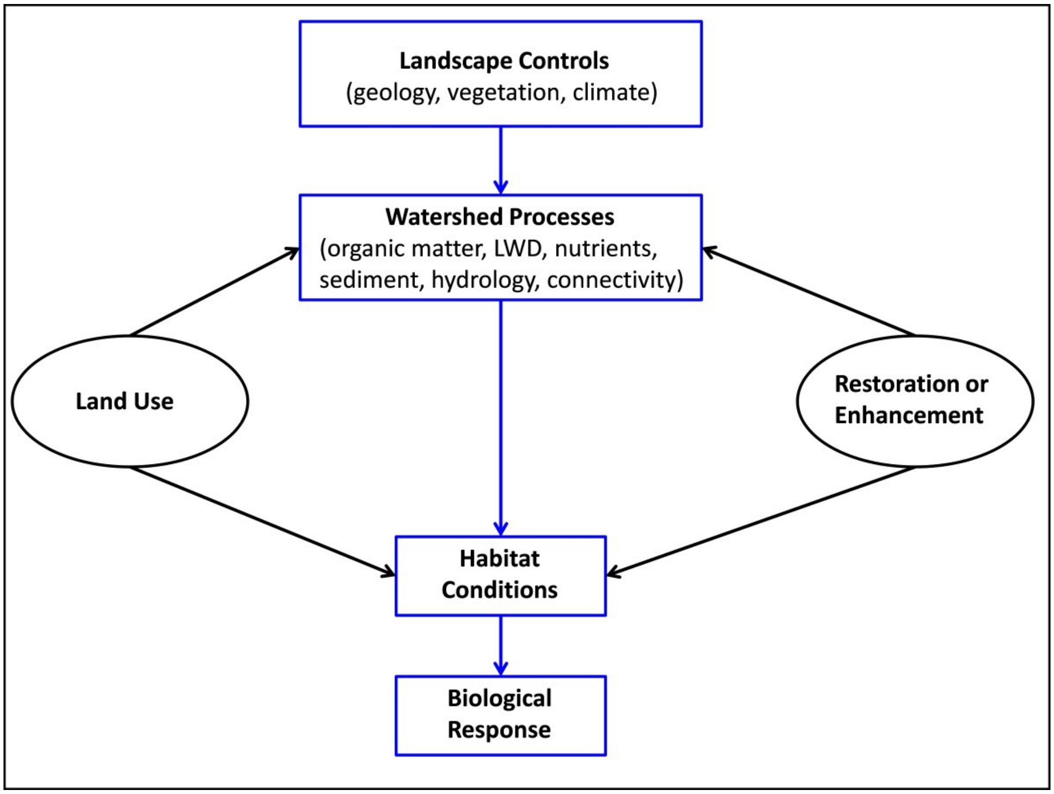


Figure 3.2. Simplified model demonstrating linkages between landscape controls and watershed processes, and how land use and restoration or enhancement can influence habitat and biota (Roni, 2005).

As Beechie et al. (2003) state, making these relationships explicit allows us to organize analyses of ecosystem processes and functions in a way that brings greater clarity of purpose to each analysis, and a better understanding of how the results of each analysis will be used in restoration and recovery planning. First, landscape and land use factors can be correlated with indicators of population performance (e.g., correlation analyses) to indicate where populations have been impacted by various land uses. Second, population-level analyses that assess biological responses (e.g., using a biological indicator) can help identify where ecosystem functions have been impaired within watersheds. Third, assessments of habitat loss and salmon population declines can be conducted by relating current and historical habitat abundance and condition to salmon utilization and survival. Finally, assessing disrupted ecosystem functions and processes can identify causes of habitat change that diminish biological integrity and drive declines in salmon populations. Identifying restoration priorities involves three steps: (1) identifying the types and natural rates of habitat-forming processes, (2) determining where processes are altered and the factors responsible, and (3) deciding how to restore the disrupted processes (Roni et al. 2002).

In addition to freshwater habitats, estuarine and near shore marine habitats are essential to salmon juveniles and adults (Reimers 1973, Healey 1982, Tschaplinski 1987, Simenstad and Cordell 2000, Bottom et al. 2005, Koski 2009). Estuaries form the lowermost link in the chain of aquatic environments stretching from the upper most reaches of a watershed to the ocean. They are the transitional habitat between freshwater and marine habitats and often provide critical habitats for both marine and freshwater fishes (Northcote and Healey 2004). In many cases these habitats have undergone large-scale alterations and degradation similar in scale to those in freshwater (Simenstad et al. 1982, Simenstad and Thom 1992, Simenstad and Cordell 2000, Rice et al. 2005).

3.3.2 Limiting Factor Analysis

An approach to integrating viability measures and watershed scale assessment is to identify specific processes, environmental conditions, or habitats that reduce, or limit, the productivity of a salmonids species or life stage. Simply stated, limiting factors are conditions that limit the productive capacity of habitat for a target species. This definition of limiting factors is fundamental to the established relationships between habitat components and salmonid survival and production. The concept of habitat restoration is based on the premise that alleviating a limiting factor(s) will increase fish production. Consequently, a critical step in the restoration process is assessing those factors that might limit salmonid production (Bisson 1990).

Before restoration is planned, an assessment should be done to ensure that the environment in the watershed/ecosystem or at the proposed site is favorable to survival. For example: dissolved oxygen, water temperature, subsurface light, and dissolved nutrients, which constitute the principal energetic and substances of concern must be within the zone of tolerance for target species (Ryder and Kerr 1989). If these survival determinants are an issue, then those factors of concern must be corrected before planning or restoration can continue.

Nickelson et al. (1992) provided an example of limiting factors. Their study showed a preference by juvenile coho salmon for overwintering in beaver ponds in Oregon coastal streams. Their research concluded that the lack of beaver ponds in some streams probably limited the availability of winter habitat and created a “habitat bottleneck.” Although the limiting factor concept is useful, it can oversimplify complex ecological processes. For example, Everest and Sedell (1984) calculated as many as 73 factors could potentially limit fish production in a hypothetical stream with three or more salmonid species, each with different age classes and habitat requirements. Restoration directed toward benefiting a particular species may also create an ecological trap for another (Jeffres and Moyle 2012). Thus, the limiting factor concept is a useful tool but must be used with adequate knowledge of salmon life history strategies and habitat conditions within a particular system.

3.3.3 Adaptive Management

Adaptive management involves taking an experimental approach to a complex task, making assumptions clear, continuously evaluating them in light of new information and making changes to the original plan as necessary (NOAA 2007). British Columbia’s Watershed Restoration Program (1994 - 2001) adopted adaptive management concepts intended to combine an integrated, watershed-scale approach and experimental design with the best available science for both ecological assessments and rehabilitation treatments. Post-treatment monitoring to evaluate the effectiveness of both traditional and innovative rehabilitation techniques was also a key program component intended to improve restoration strategies and practices (Keeley and Walters 1994; Koning et al. 1998).

An adaptive management approach is useful for both assessment and project monitoring and involves:

1. A clear statement of the metrics and indicators by which progress toward achieving goals will be tracked.
2. A monitoring and evaluation plan for tracking such metrics and indicators.
3. A decision framework through which new information from monitoring and evaluation is used to adjust strategies or actions aimed at achieving a reliable assessment of the population or restoration action.

3.3.4 Assessment Methods

There are many sources of information on assessment methods available on the internet and in publications. One of the more useful internet sites is the Pacific Northwest Aquatic Monitoring Partnership website: http://www.pnamp.org. This interagency partnership also operates another website: http://www.monitoringmethods.org that provides detailed descriptions of monitoring programs, protocols, and methods to assess and monitor projects. Assessment methodologies used in British Columbia for watershed and site level features include: A Watershed Assessment Procedure Guidebook (BC Ministry of Forests, 1999), a Channel Assessment Procedure Guidebook (BC Ministry of Forests, 1996), a Gully Assessment Procedure Guidebook (BC Ministry of Forests, 2001). Additional sources of information are identified in Appendix B.

In 2009 the American Fisheries Society (AFS) published a reference book for assessing and monitoring freshwater fish populations in North America (Bonar et al. 2009). The book provides methods for use in ponds, reservoirs, natural lakes, and streams and rivers containing cold and warm-water fishes. Range-wide and eco-regional averages for indices of abundance, population structure, and condition for individual species are supplied to facilitate comparisons of standard data among populations. It provides information on converting nonstandard to standard data, statistical and database procedures for analyzing and storing standard data, and methods to prevent transfer of invasive species while sampling.

Other useful references include a handbook of techniques for monitoring parameters associated with logging activities (MacDonald et al. 1991), and a book by Roni (2005) on monitoring stream and watershed restoration. Roni describes methods for assessing physical, chemical, and biological attributes important for evaluating the need for habitat restoration.

The U.S. Environmental Protection Agency (EPA) website is also a good source of information on methods and protocols: http://www.epa.gov/bioiweb1/index.html. They have also produced a manual of guidelines and procedures for using fish to evaluate the biological integrity of surface waters (Klemm et al.1993). The manual was developed to provide bio-monitoring programs with fisheries methods for measuring the status and trends of environmental pollution on freshwater, estuarine, and marine habitats in field and laboratory studies. Fish studies are conducted to incorporate biological criteria into surface water quality monitoring in order to evaluate the health of the aquatic environment.

An Estuarine Habitat Assessment Protocol for examining the attributes of estuarine habitats was developed by Simenstad et al. (1991). The goal of the protocol is to assess the attributes of habitats identified as being functionally important to fish and wildlife. The protocol was developed for estuarine wetlands and certain adjacent habitats of the Puget Sound Trough, but could be modified for other areas (see Brophy 2007 for a manual for Oregon estuaries). The protocol can be used to monitor the comparative performance of the site after restoration or mitigation. The protocol is organized to answer questions on habitat type, attributes, and fish and wildlife species assemblages. The protocol manual also provides guidance on study design and recommends appropriate sampling methods.

3.3.5 Habitat Indicators

Habitat indicators are used as a proxy to measure the status of a population or its habitat. An indicator is a numeric value derived from measurements of a pressure, state or ambient condition over a specified geographic area, whose trends over time represent underlying trends in the environmental conditions (see www.epa.gov/bioweb/html/about). Ideal indicators are: (1) relevant to the environmental, institutional or biotic endpoint (2) applicable to the landscape, population, and temporal scale; (3) responsive to human activities; and (4) reliably and efficiently measurable (ISP, 2000). Relevance to an endpoint means that the indicator measures an attribute that occurs at the right temporal and special scale. Specific indicators for salmonid recovery should be selected and measured at the appropriate geographic scale (e.g., reach, stream, river, basin) to answer the question being asked. Choice of the appropriate measurement and scale allows data to be integrated from diverse sources and different levels and to retain their predictive power over a wide range of conditions. Using smaller scales generally limits statistical flexibility in analyzing the data. Indicators that are responsiveness to human activities (e.g., management actions) are more useful than those that are highly correlated with the factor of interest but do not cause the change. Indicators that have a fast response time are particularly useful, if they also satisfy the above criteria, because management policy can adapted quickly reducing the costs of mistakes. Reliability means the indicators can be measured accurately and precisely.

Canada's Wild Salmon Policy (WSP) requires an assessment of habitats in salmon conservation units (CUs) within the Pacific Region. Habitats that support or limit salmon production within CUs are to be identified and indicators selected to assess these habitats. A suite of habitat indicators and their related metrics and benchmarks were developed by a Habitat Working Group (HWG), consisting of expert practitioners from management and science (Stalberg et al. 2009). Table 3.1 summarizes the nineteen habitat indicators that were proposed. Seven relate to human activity stressors: land cover alteration, road development, water extraction, riparian disturbance, marine vessel traffic, estuary disturbance, and permitted discharges. Eight relate to habitat conditions: suspended sediments, water quality, water temperature, stream discharge, lake productive capacity, cold-water refuge zone, estuary chemistry and contaminants, and estuary dissolved oxygen. Four relate to habitat quantity: accessible stream length, key spawning areas, lake shore spawning area, and estuary habitat area.

The HWG considered the indicators reasonable in number, technically feasible, conducive to citizen involvement, and appropriate for monitoring the status and trends of both constrained and highly productive habitat. Impacts of management actions can be linked to habitats by monitoring the indicators. The inclusion of pressure indicators ensures insight into human impacts that limit salmon production, facilitating a precautionary approach to managing habitat across CUs. State indicators provide detailed information on the condition of fish habitat at more localized scales and can be linked to key factors enhancing or limiting wild salmon production. They are likely to be useful in identifying and prioritizing areas for protection, and restoration. Quantity indicators allow assessments of changes over time in availability of key habitats. Benchmarks were established for some indicators based on known thresholds of impairment. Where benchmarks did not exist for an indicator they were established using proportionate or distributional analyses that reflects the relative risk of adverse effects across watersheds in a CU or between CUs.

Table 3.1. Short list of potential assessment indicators for stream, lake, and estuarine habitats (Stalberg et al. 2009).

Pressure Indicators	**State Indicators**
Streams	
% stream length channelization/floodplain connectivity	Accessible stream length/barriers
% stream length riparian zone alteration	Accessible off-channel habitat area
Road density	Channel stability measures (pool:riffle, channel width:depth ratios, etc)
% watershed area impervious surface	Stream discharge measures (base & peak flows)
% watershed area converted to various land uses (forestry, agric, urban)	Water temperature
Wetland loss	Sediment, substrate
Water withdrawal as % MAD (surface, groundwater)	LWD, instream cover
Permitted outfall discharges	Water chemistry (nutrients, D.O., pH, conductivity, contaminants)
% lake foreshore alteration	
% estuary foreshore alteration	
Lakes	
% watershed land cover alterations	Accessible shore length, barriers
% lake foreshore altered	Accessible off-channel habitat area
% watershed area impervious surface	Water chemistry (nutrients, D.O., pH, conductivity, contaminants)
% riparian zone altered	Presence of river deltas
Road density	Sediment substrate
Recreational pressure	Temperature
Invasives	Wetland loss
Estuaries	
% estuary foreshore altered (carex, typha, riparian zone)	Accessible off-channel habitat area
% surface area disturbed inshore (eel grass zone)	Estuarine habitat area
% surface area disturbed offshore (e.g., log booms – subtidal)	River or stream discharge
Amount of vessel traffic	Aquatic invertebrates
Invasives	Marine riparian vegetation
	Spatial distribution of wetlands, mudflats
	Fish
	Flux of detrital organic matter (C,N,P) between marsh and other habitats

Indicators were also developed for the British Columbia Forest and Range Evaluation Program (FREP) to assess the effectiveness of riparian management practices by measuring the post-harvest functioning condition or "health" of stream-reaches adjacent to harvest blocks (Tschaplinski 2010; Tschaplinski and Brownie 2010). Fifteen primary indicator questions are used in the FREP assessment protocol to represent the biological and physical processes and characteristics of streams and their adjacent riparian areas (Tripp et al. 2009). The questions are answered with a simple yes (pass) or no (fail), with the number of 'no' responses out of 15 questions placing the site in one of four categories ranging from properly functioning condition (PFC) to not properly functioning (NPF). A 'no' answer represents indicator failure as a result of either natural or human-caused disturbances. Nine of the indicator questions relate to stream channel, bank, and biological conditions and six questions relate to riparian area conditions. Before the primary set of indicator questions are answered, 38-60 additional sub-indicators of physical and biological attributes and processes are evaluated by making 114-120 observations, measurements or estimates. The numbers of sub- indicators varies with channel morphology and fish use (Tschaplinski 2010). This assessment has become the most commonly employed site-level protocol in BC, having been used at over 2,000 forestry-managed stream reaches to date. It has also been applied strategically in some watersheds to evaluate watershed-level impacts of human-related developments.

Woolsey et al. (2007) presented guidelines for assessing river restoration success based on a total of 49 indicators and 13 specific objectives developed for low to mid-order rivers in Switzerland. A strategy was developed to ensure that selected indicators matched restoration objectives and measures. Success was evaluated by comparing indicator values before and after implementation of restoration measures. Values were first standardized on a dimensionless scale ranging from 0 to 1, then averaged across different indicators for a given project objective and finally assigned to one of five success categories. A case study on the Thur River, Switzerland, that used 7 indicators to meet 5 objectives was presented. The project was successful in meeting 3 objectives but failed in 2 others. Results from this assessment identified potential deficits and gaps in the restoration project. Assessing the outcome of restoration projects is vital for adaptive management, evaluating project efficiency, optimizing future programs and gaining public support. Lack of appropriate guidelines often results in no assessment.

3.4 Monitoring Restoration Projects

Monitoring in ecology generally refers to sampling a physical, chemical, or biological parameter in an effort to detect a change. "Monitoring provides accountability and learning and is necessary to determine whether projects were implemented, whether they were effective, and whether the scientific relationships upon which the expected benefits were based were appropriate" (ISP 2000). The Bonneville Environmental Foundation concluded that the lack of a long-term watershed-scale approach, emphasis on short-term and site-specific restoration actions, and the prevalence of unsystematic and piecemeal monitoring were the primary issues limiting the effectiveness of community-based watershed and fisheries recovery efforts in the Pacific Northwest (Reeve et al. 2006). Several authors have reviewed and defined different types of monitoring needed to document changes or actions (MacDonald et al. 1991, Clewell et al. 2005, Koning et al. 1998, Thayer et al. 2003, 2005, Roni 2005, NOAA 2007).

Roni (2005) compiled information for developing monitoring and evaluation programs for restoration activities at scales ranging from individual sites to multiple projects throughout a watershed. The major types of restoration projects, including road improvements, riparian silviculture, fencing and grazing, floodplains, estuarine, in-stream, nutrient enrichment, reconnection of isolated habitats, and acquisitions and conservation easements are covered. The focus is on is on temperate North American streams and estuaries, with emphasis on restoration activities for cool-water biota and salmonid fishes. Methods are described for monitoring physical (e.g., sediment, habitat, woody debris), chemical (nutrients), and biological (e.g., primary productivity, macroinvertebrates, fishes) responses to techniques that restore watershed processes, habitat complexity, and stream productivity. A key point made by Roni (2005) is that practitioners must be cognizant that "no one monitoring approach fits all project types or scenarios."

3.4.1 Types of Monitoring

There are several types of monitoring relevant to salmon habitat, assessment, and project evaluation. NOAA (2007) distinguished between five types of monitoring types divided into two functional groups: those involved in baseline description, and those involved in elucidating cause-and-effect relationships.

3.4.1.1 *Baseline Descriptive Monitoring*

3.4.1.1.1 Status Monitoring

Status monitoring is used to characterize existing and to establish a baseline for future comparisons. The intent of status monitoring is to provide an assessment of current stock and habitat health and to capture temporal and spatial variability in the parameters of interest.

3.4.1.1.2 Trend Monitoring

Trend monitoring involves taking measurements at regular time or space intervals to assess the long-term or large-scale trend in parameters. The measurements are usually not taken specifically to evaluate management practices; but serve to describe changes in parameters over time or space.

3.4.1.1.3 Implementation Monitoring

Implementation monitoring is used to assess whether activities were carried out as planned, and generally consists of an administrative review or site visit. This type of monitoring does not link restoration actions to physical, chemical, or biological responses, as none of these parameters are measured. For example, if a restoration action is initiated to fence 20 miles of stream with the hope of reducing stream temperature and fine sediment input from run-off and bank erosion, the implementation monitoring would consist of confirming the presence and length of the fence.

3.4.1.1.4 Compliance Monitoring

Compliance monitoring determines whether specified criteria are being met as a result of an action. Criteria may be numeric or descriptive, but result from the direct impact of the action. In the fencing example, compliance monitoring indicator would be an assessment of the project's basic intent; preventing livestock from entering the riparian corridor, an appropriate metric would be the presence or absence of livestock in the fenced-off area.

3.4.1.2 *Cause-and-Effect Monitoring.*

3.4.1.2.1 Effectiveness Monitoring

Effectiveness monitoring evaluates whether the management actions achieved the stated goal(s) of the project. Success may be measured against reference areas, baseline conditions, or desired future conditions (i.e., targets). Effectiveness monitoring can be implemented at the scale of single sites, multiple sites using similar techniques, or for an entire strategy consisting of a multiple techniques. Effectiveness monitoring takes an experimental approach, and requires coupling the monitoring with the restoration action to detect an effect (e.g., with a Before, After Control Impact design). Properly implemented, effectiveness monitoring can attribute cause to effect with a known confidence level.

3.4.1.2.2 Validation Monitoring

Validation monitoring is used to verify the assumptions behind effectiveness monitoring and models. The focus is the assumed linkage between compliance and effectiveness monitoring indicators, and the assumed linkages between effectiveness monitoring indicators and management objectives. Using the livestock fencing as an example, validation monitoring indicators would assess the assumption that livestock exclusion results in riparian vegetation recovery and that riparian vegetation recovery results in reductions in water temperature reduction and sediment delivery to the stream (the ultimate objective of the management action).

Because of the large amounts of time, effort and money already spent to improve the status of salmon in the Pacific Northwest, the University of Washington's Olympic Natural Resources Center convened the Validation Monitoring Panel to define what should be measured to evaluate which actions are effective in improving the status of salmon stocks. The panel concluded that if the goal is to increase the number of salmon, then the variable of interest must be the number of fish. Therefore, counting fish through the process of validation monitoring is the only way that a link between cause and effect can be confirmed quantitatively (Botkin et al. 2000).

3.4.2 Effectiveness Monitoring Planning and Design

To develop plans for quantitative effectiveness monitoring, parameters for selected attributes and effectiveness criteria must be quantified. The restoration objectives must be expressed in terms of desired change (i.e., target values). Steps required for writing an effectiveness monitoring plan developed by NOAA scientists and others are summarized below (Thayer et al. 2003, Harris, 2005, Roni 2005, NMFS 2010):

1. A clearly stated goal for the habitat restoration effort based on the current assessment of the condition or health of the salmon stock(s) and their habitats.
2. Specific objectives of what will be done to achieve the goal.
3. Parameters (structural and functional) or indicators (in metric units) that will be measured for each objective.
4. Techniques and methods to be used.
5. Baseline from pre-construction monitoring of parameters.
6. Targets (proposed numerical value desired for each parameter for evaluating success).
7. Timing (frequency of sampling, start and end dates).
8. Statistical design, analysis and sample size.
9. Entity doing monitoring.
10. Data management plan (storage and retrieval).
11. Project location (Lat. and Long. or UTM coordinates).
12. Entity responsible for final Report.
13. Percent of budget allocated to monitoring.

Two reference documents were developed by NOAA that relate to monitoring coastal habitats and restoration projects: "Science-Based Restoration Monitoring of Coastal Habitats, Volume One: A Framework for Monitoring Plans Under the Estuaries and Clean Waters Act of 2000 (Public Law 160-457) by Thayer et al. (2003), and Volume Two: Tools for Monitoring Coastal Habitats by Thayer et al. (2005). Their objective is to provide restoration practitioners with the information and tools required to develop sound and consistent restoration monitoring plans, to more confidently conduct scientific monitoring restoration efforts, to detect early warnings that their restoration is not on track or to gauge how well the site is functioning, to coordinate projects and efforts, and to evaluate the ecological health of specific coastal habitats before and after project completion.

3.4.3 Data Management

An often overlooked part of a monitoring and evaluation program is data management, quality control and assurance. Scientific cooperation and data sharing methodologies developed by the PSC Panel: Working Group on Data Standards offers guidelines for data management that could be incorporated into studies. Roni (2005) also provides a good discussion of data management, data analysis and reporting procedures.

Assessments and monitoring of restoration projects demand a variety of data and, if work extends over large areas and long time periods, very large data sets may be produced. Proper management of large databases is essential to the overall effort (NOAA 2007, 2010, Botkin et al. 2000). Some key issues that need to be considered and planned for are summarized in the sections below.

3.4.3.1 Data Verification

Verifying data and checking for errors is time consuming and tedious, but is one of the most critical steps in data management. There must be sufficient resources budgeted to ensure data quality and to verify that data entered into electronic databases accurately reflect field measurements.

3.4.3.2 Archiving

Data must be archived in a way that protects their security (i.e., proper backup and redundancy) and stores them in a format that can be imported into database management and statistical analysis programs. All participants in the projects should be aware of the location and have access to the archived data. The archived data must be stored using methods that keep up with the technological advances to avoiding future data loss when current storage media become obsolete.

3.4.3.3 Accessibility

Data from all assessment and monitoring must be available in electronic format to all participants. Because salmon are a publically owned natural resource, data will probably need to be made available to the general public at some time and this must be taken into consideration. Accurate metadata must be developed and made available to the scientific community and general public.

A well-designed and documented data management plan can help to ensure that data is available, to meet data analysis needs. Data management should be based on a needs assessment that identifies:

- roles
- responsibilities
- methods and procedures
- data quality and data assurance
- data management technology
- data access
- data sharing
- investment (time, expense, staff)

3.4.4 Reporting

If we are to learn from restoration activities, we must adhere to the basic principles of the scientific method. This requires defining clear hypotheses, developing appropriate study designs, identifying relevant indicators, and collecting, analyzing, and interpreting data. Unfortunately, scant information on responses to aquatic restoration actions exists in the literature. Regardless of whether a project is deemed a success or a failure, it is important to report the findings and make them available to the scientific community and general public to learn about the efficacy of techniques (Roni 2005).

3.5 Social and Human Dimensions of Habitat Restoration.

The preceding discussion explored restoring the functional characteristics of riverine and estuarine habitats. From a social and human perspective, the emphasis is on identifying and describing how people value, utilize, and benefit from the restoration of freshwater and coastal habitats. Restoration of freshwater and coastal environments is fundamentally a human endeavor, and failure to address human dimensions issues at the beginning of a project may result in its rejection by the community it was intended to benefit (Thayer et al. 2005). Inquiry into human dimensions of salmon habitat restoration should begin with four fundamental questions:

1. Who cares about the restoration (i.e., who are the stakeholders)?
2. Why is the restoration important to them?
3. How will the restoration change people's lives (i.e., what are the social benefits or impacts)?
4. Who would assume long term stewardship and ownership over the project?

3.6 Conclusions/Recommendations

A diversity and abundance of habitat restoration activities and practitioners exist in the Pacific Northwest. With the broad recognition that historical efforts to conserve aquatic habitats have not kept pace with their decline, an unprecedented number of anglers, conservation groups, scientists, tribes/First Nations, state, provincial and federal agencies, members of the public and industry have or will need to combine resources and expertise to turn the tide on the loss of aquatic habitats required for the long term persistence of salmon. Coordination of these diverse groups is essential if the goals of the PSC and others are to be realized.

To this end, the HRTC has compiled lists of references (Appendix B) and current key practitioners (Appendix C). Also provided in this document is a checklist for preparation of PSC proposals for habitat restoration (Appendix D).

Regarding planning of restoration activities, the HRTC strongly recommends strategic rather than merely opportunistic actions. The adoption and implementation of these recommendations might be facilitated by some standardization and detail in the process by which restoration proposals to the Pacific Salmon Commission are written, evaluated and selected. HRTC recommends the following:

1**. Watershed /Habitat Assessment**

a) Assessment of fish population health (e.g., stocks of concern) and habitat condition in watershed and/or estuary;
b) Describe watershed stressors (natural or man-made) and causes of declines in habitat (use limiting factor analysis if possible);
c) Identify functions provided by habitat;
d) Evaluate opportunities to restore watershed processes and habitats

2. **Establishing Restoration Priority**

a) Determine severity of need (scarceness of habitat/threat to habitat or species);
b) Ecological benefits provided by habitat or species;
c) Chances of successful restoration of habitat or species;
d) Public support for restoration of habitat or species;

e) Social and economic benefits provided by habitat or species

3. **Developing a Restoration Activity Plan**
a) Consider multiple stakeholder viewpoints;
b) Establish an open public process;
c) Make strong link to conservation and protection efforts;
d) Document restoration project goals;
e) Revise plan as needed after pre-restoration baseline development

4. **Designing the Actual Restoration Project**
a) Minimize anthropogenic activities in watershed causing habitat degradation;
b) Protect all existing high-quality habitats identified in the assessment;
c) Identify the processes in the system leading to the decline of habitat and fish;
d) Determine and clearly state the realistic restoration goals/objectives for the habitat and fish populations;
e) Develop methods to reverse the habitat degradation and decline in fish abundance;
f) Develop easily observable measures of success for each stated objective including the parameters that will be measured, the technique and method of measurement, and the baseline values for each parameter;
g) Determine target values for each parameter (proposed numerical value desired for the parameter);
h) Develop techniques for the implementation of specific restoration actions; and
i) Establish an effectiveness monitoring program (see 5 below) by monitoring key system parameters identified in (f) and practicing adaptive management; and
j) Documenting and communicating techniques for inclusion in other restoration projects.

5. **Developing the Restoration Monitoring Plan**
a) Clearly state the goals of the restoration project;
b) Clearly state the objectives of the restoration (i.e., the activities that will be done to achieve goal);
c) For each objective list the following:

1. Parameters that will be Measured (in what metrics)
2. Technique and Methods of Measurement
3. Baseline (preconstruction or earliest post-construction numerical value for each parameter)
4. Reference (ideal numerical value for the parameter from nearby site or literature)
5. Target (proposed numerical value desired for each parameter to be reached at end of monitoring – this is best set of indicators for determining success)
6. Timing of sampling (frequency of sampling, start and end dates)
7. Experimental Design (see Roni 2005 for guidance on types)
8. Sample Size
9. Method(s) of data analysis
10. Plans for data management
11. Reporting (media and frequency)

12. Plans for scientific and community outreach
13. Type of socio-economic monitoring to be conducted

4.0. A GIS BASED SPATIAL INVENTORY OF HABITAT RESTORATION PROJECTS FUNDED BY THE PSC ENDOWMENT FUNDS FROM 2004-2009

4.1 Overview

One of the primary functions of the HRTC is to provide useful advice to the PSC and Endowment Fund Committees on the relationship between salmon stock status and habitat rehabilitation, restoration and conservation efforts. To this end, the HRTC is developing several resources which may aid future EF funding decisions and better gauge the effectiveness of past activities.

One of these tools is a user friendly, interactive map-based inventory of EF funded habitat projects. It currently consists of a spatially referenced inventory of 134 habitat projects that were funded from 2004 through 2009. Projects related to 'improved information' or 'enhancement' activities have not been included in this inventory. A GIS allowed the HRTC to capture and overlay all habitat project locations with geographic and hydrologic features, which were then overlain with geopolitical boundaries and polygons that represent the geographic range of the four stocks of greatest concern to the SEF. Similar polygons were not delineated for the Northern Endowment Fund (NEF) area as the NEF does not have a strategic plan that identifies stocks of highest conservation concern.

The interactive mapping package is a bundled PDF product that allows users to locate projects and project descriptions by "clicking" on embedded hyperlinks. An application links project locations on the map to an abbreviated project description with information on project activities, timeframes and costs. Hyperlinks also allow users to peruse project reports, including monitoring reports, where they have been prepared. Information can be used/viewed in either direction (i.e. click on a project description and be taken to the project location on a map or vice versa). Figures 4.1,4.2 and 4.3 further illuminate the utility of the tool and the ways in which it can be configured. Individual project locations are identified by a point on a map and labeled with an associated Project Number (or GIS Project Number). Project description summaries include the Project Number to ensure proper cross-referencing between project locations and project descriptions. Additional hyperlinks to Final Reports are also provided using http portals and links found on the PSC website under Restoration and Enhancement Fund Backgrounders and Reports (http://fund.psc.org/pubs_fund.htm).

Ready access to information on the nature and types of previously funded projects and their locations provides the HRTC, the PSC and the Endowment Funds (as well as future reviewers of funding applications) with a geographic and temporal context for new projects and stock priorities.

The spatial representation of project locations or activities occurring across a river stream reach, watershed, or regional area may be imprecisely depicted in the maps.. These inconsistencies were unavoidable due to either insufficient spatial information being provided in the project descriptions or available in Project Reports or the inability to precisely delineate non-point features (i.e., areas or stream segments better represented by a polyline or polygon).

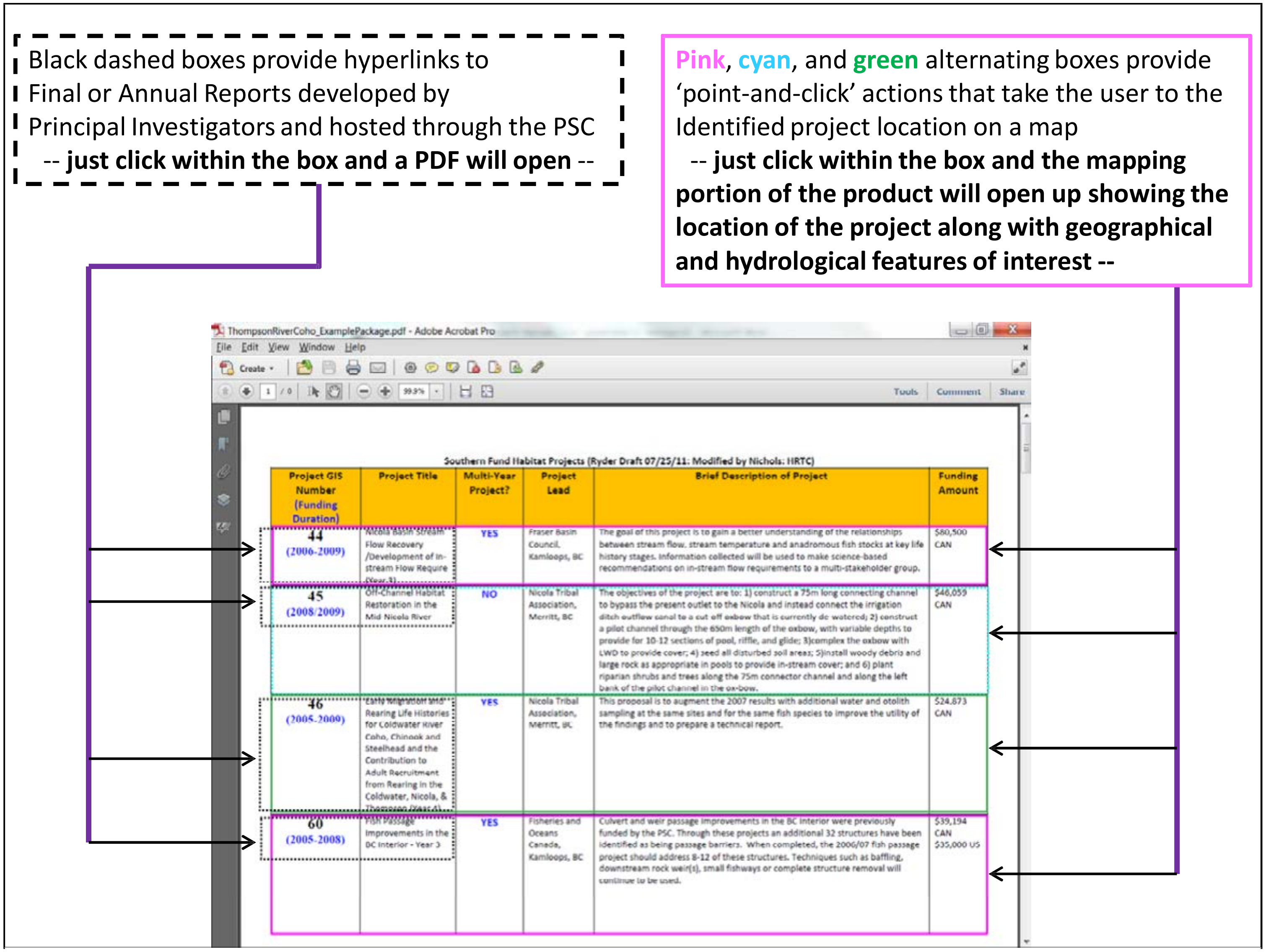


Figure 4.1. Illustration of how embedded hyperlinks work with project descriptions and provide access to Project Reports and Project Locations associated with PSC funded habitat projects.

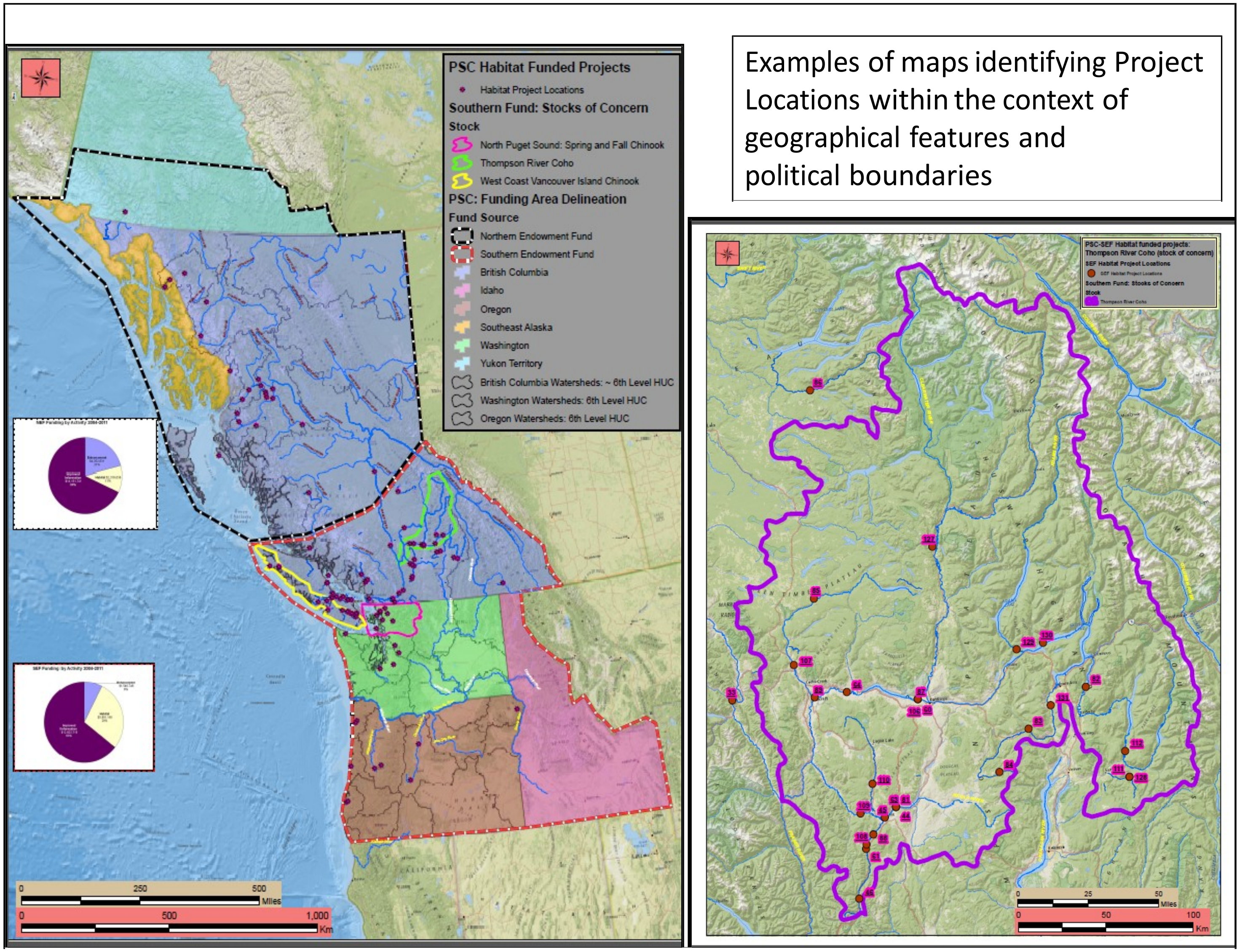


Figure 4.2. Example maps provided in mapping package that show project locations, political boundaries, hydrological delineation, and geographical features.

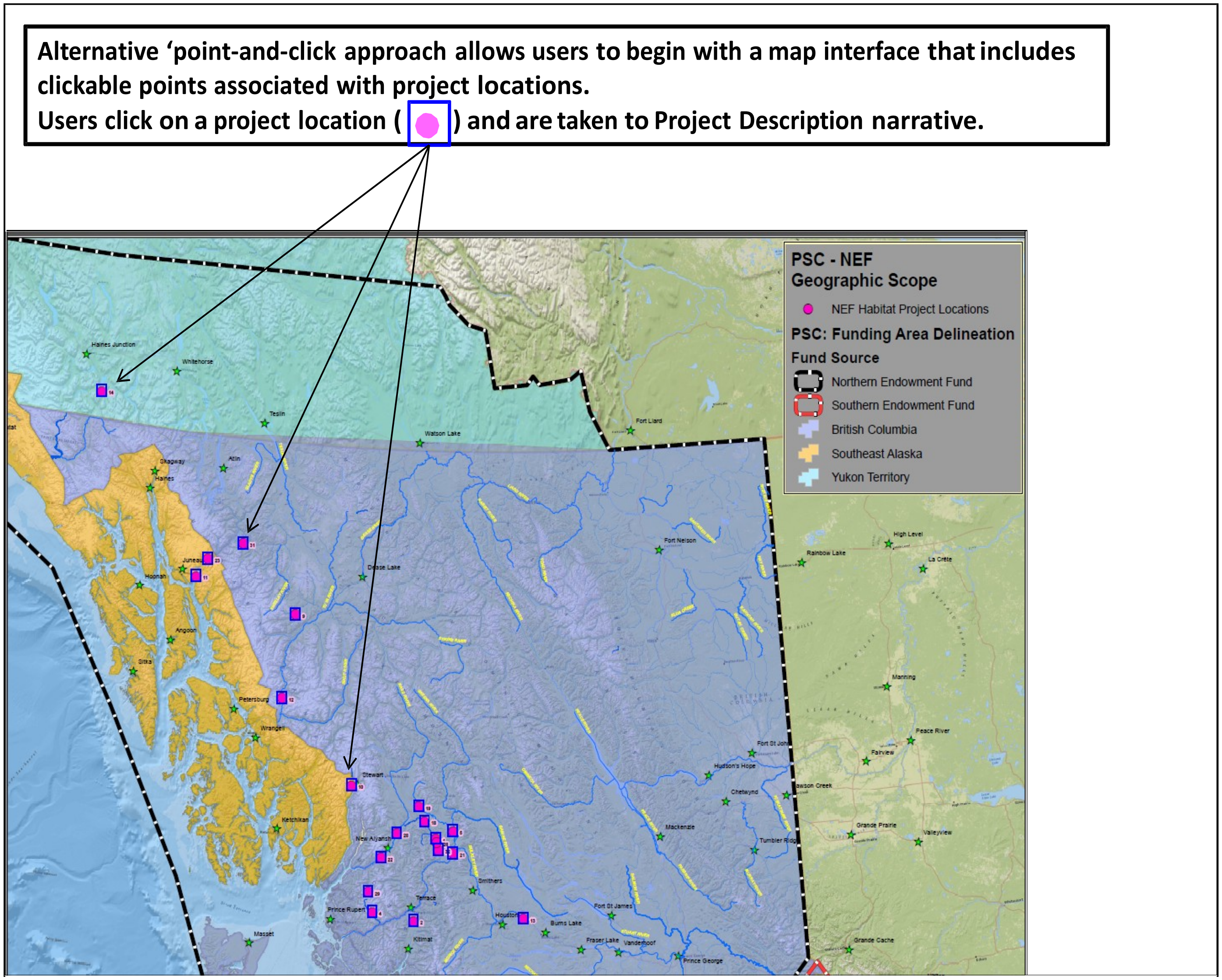


Figure 4.3. An example of an alternative approach that provides clickable links for Project Locations that take users to Project Descriptions and associated Reports.

4.2 Conclusions

This simple Adobe PDF application allows users to view the location of NEF and SEF funded projects on a map. Hyperlinks provided allow users to read abbreviated project descriptions and any completed annual or final reports prepared by project participants. The tool facilitates the evaluation of past expenditures and efforts of the EFs and the PSC and provides a picture of cumulative efforts in given areas. This will be useful in supporting future watershed-based planning for conservation and recovery of stocks of conservation concern to the PSC. While project areas and locations may not be precisely delineated on the map due to lack of information and the use of points rather than polygons to represent projects, the following recommendations provide suggestions for how these issues could be addressed and the product improved upon.

4.3 Recommendations

1. Following endorsement by the Endowment Fund Committees, this map product should be hosted on the PSC website making it widely available to the PSC, the EFs and those preparing proposals for funding

2. The functionality, access, and ease of use of this product could be significantly improved using more sophisticated on-line mapping platforms such as include ArcGIS Viewer for Flex (http://help.arcgis.com/en/webapps/flexviewer/help/index.html), services provided through Google Maps, or other on-line mapping services developed by independent contractors, provided resources were made available.

3. In the future this product could also be improved by ensuring that EFs require project proponents indicate:

   a. the spatial location and extent of their activities (which may consist of GIS shapefiles/geodatabases in point, polyline, polygon format),

   b. project duration (i.e., whether or not a project is multi-year or single-year) and use consistent naming conventions for multi-year projects, and

   c. whether or not a effectiveness monitoring report is available.

4. Adoption of HRTC recommendations for improving the RFP submissions (Appendix D) would also further enhance the utility of future versions of this mapping product.

REFERENCES CITED

AFS (American Fisheries Society). 1997. Fisheries, Special Issue on Watershed Restoration. 2(5):62 pp.

BC MWLAP. 2002. Environmental trends in British Columbia. BC Ministry of Water Land and Air Protection. Victoria. BC. 63 pp.

Beechie, T., E. Beamer, B. Collins, and L. Benda. 1996. Restoration of habitat-forming processes in Pacific Northwest watersheds: A locally adaptable approach to salmonid habitat restoration. In D.L Peterson and C.V. Klimas (eds.), The role of restoration in ecosystem management, p. 48-67. Society for Ecological Restoration, Madison, WI.

Beechie, T.J., G. Pess, P. Kennard, R.E. Bilby, and S. Bolton. 2003. Role of watershed assessments in recovery planning for salmon. In D. R. Montogomery, S. Bolton, D.B. Booth,and L. Wall (eds.), Restoration of Puget Sound rivers, p. 194-225. University of Washington Press, Seattle.

Beechie,T.J., P. Roni, E.A. Steel, E. Quimby. (Eds.) 2003. Ecosystem recovery planning for listed salmon: An integrated assessment approach for salmon habitat. U.S. Dept. of Commerce,NOAA Tech Memo., NMFS_NWFSC-58, 183 pp.

Beechie, Timothy J., George R. Pess, Michael M. Pollock, Mary H. Ruckelshaus, and Phil Roni. 2009. Restoring rivers in the twenty-first century: science challenges in a management context In Richard J. Beamish and Brian J. Rothschild (Eds.) The Future of Fisheries Science in North America, Springer Fish and Wildlife Series, Volume 31: 697-717.

Bernhardt, E.S.,M.A. Palmer, J.D. Allan, G. Alexander, K. Barnas, S. Brooks, J. Carr, S. Clayton, C. Dahm, J.Follstad-Shah, D. Galat, S. Gloss, p. Goodwin, D. Hart, B. Hassett, R. Jenkinson, S. Katz, G.M. Kondolf, P.S. Lake, R. Lave, J.L. Meyer, T.K. O'Donnell, L. Pagano, P. Srivastava, B. Powell, E. Sudduth. 2005. Synthesizing U.S. river restoration efforts. Science 308:636-637.

Bisson, P.A. 1990. Importance of identification of limiting factors in an evaluation program. In R. House, J. Anderson, P. Boehne, and J. Suther (Eds.), Stream rehabilitation manual emphasizing project design, construction, and evaluation. Sec. 2. Oregon Chapter, Am. Fish. Soc. 22pp.

Bisson, P.A., T.P. Quinn, G.H. Reeves, and S.V. Gregory.1992. Best management practices, cumulative effects, and long-term trends in fish abundance in Pacific Northwest river systems. Pages 189-232 in R. J. Naiman, editor, Watershed Management. Springer-Verlag, New York.

Bonar, Scott A., Wayne A. Hubert, and David W. Willis (Eds.). 2009. Standard Methods for Sampling North American Freshwater Fishes. Am. Fish. Soc.,Stock Number 55059C.

Botkin, D. B., D.L. Peterson, and J.M. Calhoun (Eds.). 2000. The scientific basis for validation monitoring of salmon for conservation and restoration plans. Olympic Natural Resources Center Technical Report. University of Washington, Olymic Natural Resources Center , Forks, WA. 82pp.

Bottom, D.L., K.K. Jones, T.J. Cornwell, A. Gray, C.A. Simenstad. 2005. Patterns of chinook salmon migration and residency in the salmon River estuary (Oregon). Estuarine, Coastal and Shelf Science 64:79-93.

British Columbia Ministry of Forests. 1996. Channel assessment procedure guidebook. B.C. Min. Environ. Lands and Parks and B.C. Min. For., Victoria, B.C.

British Columbia Ministry of Forests. 1999. Coastal watershed assessment procedure guidebook (CWAP); Interior watershed assessment procedure guidebook (IWAP). 2nd ed., Ver. 2.1. For. Prac. Br., Victoria, B.C.

British Columbia Ministry of Forests. 2001. Best management practices handbook: hillslope restoration in British Columbia. B.C. Min. For., Res. Ten. & Eng. Br., Victoria, B.C. http://www.for.gov.bc.ca/hfd/pubs/docs/Mr/Mr096.htm

British Columbia Ministry of Forests. 2001. Gully assessment procedure guidebook. 4th ed., Ver. 4.1. For. Prac. Br., Victoria, B.C.

Brouha and Chappell. 1997. Director's Line – A Watershed Call to Arms. AFS, Fisheries, Vol. 22(5): 4-6.

CDFO. 1994. Strategic Review of Fisheries Resources for the North Thompson Habitat Management Area. Fraser River Action Plan. 127pp.

CDFO. 1997a. Strategic Review of Fisheries Resources for the South Thompson- Shuswap Habitat Management Area. Fraser River Action Plan, 132 pp.

CDFO. 1997b. Wild, threatened, endangered and lost streams of the Lower Fraser Valley- Summary Report- Vol. 3, Fraser River Action Plan. 54 pp.

CDFO. 1998a. Strategic Review of Fisheries Resources for the Thompson-Nicola Habitat Management Area. Fraser River Action Plan, 128 pp.

CDFO. 1998b. Lower Fraser Valley streams strategic review - Lower Fraser Valley stream Review, Vol 1, Fraser River Action Plan. 450 pp.

CDFO. 2002. Interior Fraser River Coho Salmon. CCDFO Science Stock Status Report D6-08 (2002)

CDFO. 2006. Review of 2005 WCVI chinook salmon returns and forecast abundance for Stamp River / Robertson Creek Hatchery indicator Stock in 2006. CDFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2006/036.

CDFO. 2012. 2012 Salmon Stock Outlook.

Chilcote, M.W., T.E. Nicholson, and K.M.S. Moore. 2005. Part 1: Viability criteria and status assessment of Oregon coast coho. Oregon Department of Fish and Wildlife, Salem, OR.

Cleary, Jaclyn and Donna Underhill (eds.) 2002. Annual Compendium of Aquatic Rehabilitation Projects for the Watershed Restoration Program 2000 – 2001. Province of British Columbia. Watershed Restoration Project Report No. 19: 228p.

Clewell A., J. Rieger, and J. Munro. 2005. Guidelines for Developing and Managing Ecological Restoration Projects, 2nd Edition. Society for Ecological Restoration International. Washington, D.C.

COSEWIC 2002. 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. viii + 34 pp.

Donat, M. 1995. Bioengineering techniques for streambank restoration, a review of central European practices. B.C. Min. Environ., Lands and Parks, and B.C. Min. For., Vancouver, B.C. Watershed Restoration Program Rep. 2.

Environment Canada, 2007,An Integrated Biophysical Assessment of Estuarine Habitats in British Columbia to Assist Regional Conservation Planning, Environment Canada, Canadian Wildlife Service, Technical Report Series Number 476.

Everest, F.H. and J.R. Sedell.1984. Evaluating effectiveness of stream enhancement projects, p.246-256. In T.J. Hasler (Ed.), Proceedings of the Pacific Northwest stream habitat management workshop, held at Humboldt State University, Arcata, California, Oct 10-12 1984. Western Division Am. Fish. Soc.

FEMAT (Forest Ecosystem Management Assessment Team).1993. Forest ecosystem management: an ecological, economic, and social assessment. U.S. Forest Service and collaborating agencies, Washington, DC.

Ham, D. 1997. Aerial photography and videography standards for fish habitat channel assessment. B.C. Min. Environ., Lands and Parks, Fisheries Br. and Resources Inventory Committee, Aquatic Ecosystems Task Force, Victoria, B.C.

Harris, Richard R. 2005. Monitoring the implementation and effectiveness of fisheries habitat restoration projects. Final Report, Prepared for California Dept. of Fish and Game Salmon and Steelhead Trout Restoration Account Agreement No. P0210566, Center for Forestry, University of California, Berkeley, 24 pp.

Healey, M.1982. Resilient salmon, resilient fisheries for British Columbia, Canada. Ecology and Society 14(1):2.(online) URL:http//www.ecology and society.org/vol14/iss1/art2/.

Hobbs, R.J., and D.A. Norton. 1996. Towards a conceptual framework for restoration ecology. Restor. Ecol. 4(2):93-110.

Hogan, D.L. 2001. Stream channel assessment in the interior of British Columbia. In: Watershed assessment in the southern interior of British Columbia: workshop proc., 9-10 Mar. 2000, Penticton, B.C. D.A.A. Toews and S. Chatwin (editors). B.C. Min. For., Res. Br., Victoria, B.C. Work. Pap. 57, pp. 112-133.

Hogan, D.L., S.A. Bird, and D.J. Wilford. 1997. Channel conditions and prescriptions assessment (interim methods). B.C. Min. Environ., Lands and Parks, and B.C. Min. For., Victoria, B.C. Watershed Restoration Tech. Circ. 7. 42 p.

Holland, S.S, 1976, LanCDFOrms of British Columbia: A physiographic outline. B.C.Department of Mines and Petroleum Resources, Bulletin #48. 138 pp.

Interior Fraser Coho Recovery Team. 2006. Conservation Strategy for coho salmon (Oncorhynchus kisutch), interior Fraser River populations. Fisheries and Oceans Canada. Scientific Advice for input to the Allowable Harm Assessment for Interior Fraser coho Salmon. CDFO CSAS Research document 2005/093

ISAB (Independent Scientific Advisory Board). 2011a. Columbia River Basin food webs: developing a broader scientific foundation for fish and wildlife restoration. Independent Scientific Advisory Board. ISAB 2011-1. Northwest Power and Conservation Council. Portland OR. 350+ pp. http://www.nwcouncil.org/library/isab/2011-1/isab2011-1.pdf

ISAB (Independent Scientific Advisory Board). 2011b. Using a comprehensive landscape approach for more effective conservation and restoration. Independent Scientific Advisory Board. ISAB 2011-4. Northwest Power and Conservation Council. Portland OR. 179 pp. http://www.nwcouncil.org/library/report.asp?d=640.

ISP (Independent Science Panel). 2000. Recommendations for monitoring salmonid recovery in Washington State. Report No. 20002, Independent Science Panel, Olympia, WA., 48p.

Jeffres, C., and P. Moyle. 2012. When good fish make bad decisions: coho salmon in an ecological trap. North American Journal of Fisheries Management 32:87-92.

JNRC (Joint Natural Resources Cabinet). 2001. Guidance on watershed assessment for salmon. Governor's Salmon Recovery Office, Olympia, WA. Online at http://www.governor.wa.gov/gsro/watershed/watershed.htm.

Johnston, N.T. and G.D. Moore. 1995. Guidelines for planning watershed restoration projects. B.C. Min. Environ., Lands and Parks, and B.C. Min. For., Vancouver, B.C. Watershed Restoration Tech. Circ. 1. 50 p.

Joint Chinook Technical Committee. 2012. Annual Report of Catch and Escapement for 2011: Pacific Salmon Commission Report TC Chinook (12)-3.

Kauffman, J.Boone, Robert L.Beschta, Nick Orting, and Danna Lytjen. 1997. An ecological perspective of riparian and stream restoration in the western United States. AFS Fisheries, 1997 22(5):12-24.

Keeley, E.R. and C.J. Walters. 1994. The British Columbia watershed restoration program: summary of the experimental design, monitoring and restoration techniques workshop. B.C. Min. Environ., Lands and Parks, and B.C. Min. For., Vancouver, B.C. Watershed Restoration Project Report 1. 34 p.

Kershner, J.L.1997. Monitoring and adaptive management. Pages 116-131 in J.E. Williams, C.A. Wood, and M.P. Dombeck, (Eds.). Watershed Restoration: Principles and Practices. Am. Fish. Soc.,Bethesda, MD.

Klemm, Donald, J., Quenton J. Stober, and James M. Lazorchak. 1993. Fish field and laboratory methods for evaluating the biological integrity of surface waters. EPA/600/R-92/111.

Kondolf, G.M. 1995. Five elements for effective evaluation of stream restoration. Restoration Ecology 3:133-136.

Kondolf, G.M., and E.R. Micheli. 1995. Evaluating stream restoration projects. Environ. Manage. 19:1-15.

Koning, C.W. and P.A. Slaney. 1996. Techniques to assess and restore fish habitat in streams impacted by logging activity. In: Watercourses: getting on stream with current thinking. Proc. 22-25 Oct. 1996, Vancouver, B.C. R. Hicks (editor). Canadian Water Resources Association, Cambridge, Ont. 187 p.

Koning, C.W., M.N. Gaboury, M.D. Feduk, and P.A. Slaney. 1998. Techniques to evaluate the effectiveness of fish habitat restoration works in streams impacted by logging activities. In: Footprints of humanity: reflections on fifty years of water resource developments. Proc. 50th Annu. Conf. Canadian Water Resources Association, 3-6 June 1997, Lethbridge, Alta. CWRA, Cambridge, Ont., pp. 191-203.

Koski, K V. 2009. The fate of coho salmon nomads: The story of an estuarine-rearing strategy promoting resilience. Ecology and Society 14(1): 4. (Online)URL: http://www.ecology and society.org/vol14/iss1/art4/.

Lichatowich, J., L. Mobrand, L. Lestelle, and T. Vogel. 1995. An approach to the diagnosis and treatment of depleted Pacific salmon stocks in Pacific Northwest watersheds. Fisheries 20(1):10-18.

MacDonald, L.H., A.W. Smart, and R.C. Wissmar.1991. Monitoring guidelines to evaluate effects of forestry activities on streams in the Pacific Northwest and Alaska. U.S. Environmental Protection Agency, Region 10, NPS Section, Seattle.

McElhany, P., M.H. Rucleshaus, M.J. Ford, E.P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionary significant units. U.S. Department of Commerce, NOAA Technical Memorandum NMFSNWFSC – 42. 156 pp.

Mellina, E. and S.G. Hinch. 1995. Overview of large-scale ecological experimental designs and recommendations for the British Columbia Watershed Restoration Program. Victoria, B.C. Watershed Restoration Project Rep. 1. 18 pp.B.C. Min. Environ., Lands and Parks, and B.C. Min. For., Watershed Restoration Program,

NFHP(National Fish Habitat Plan). 2006. National Fish Habitat Action Plan. April 24, 2006, 27 pp., www.fishhabitat.org.

Nickelson, T.E., J.D. Rodgers, S.L. Johnson, and M.F.Solazzi. 1992. Seasonal changes in habitat use by juvenile coho salmon (Oncorhynchus kisutch) in Oregon coastal streams. Can. J. Fish. Aquat. Sci. 49:783-789.

NMFS 2010. Marine fisheries habitat assessment plan. Report of the National Marine Fisheries Service Habitat Assessment Improvement Plan Team. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-F/SPO-108, 115 p.

NOAA. 2007. Adaptive management for ESA-Listed salmon and steelhead recovery: Decision framework and monitoring guidance. National Marine Fisheries Service,

Northcote, T.G. and M.C. Healey. 2004. Fundamental aspects of estuarine ecology relevant to fish-forestry interactions. In T.G. Northcote and G.F. Hartman (Eds.), Fishes and Forestry: Worldwide Watershed Interactions and Management. Blackwell Publishing, Great Britain. pp. 92-105.

Norton, Douglas, J., James D. Wickham, Timothy G. Wade, Kelly Kunert, John V. Thomas, and Paul Zeph. 2009. A method for comparative analysis of recovery potential in impaired waters restoration planning. Environmental Management (2009) 44: 356-368.

NRC (National Research Council). 1992. Restoration of Aquatic Ecosystems: Science, Technology, and Public Policy. National Academy Press, Washington, D.C.

NRC (National Research Council).1996. Upstream: Salmon and Society in the Pacific Northwest. National Academy Press, Washington, D.C.

ODFW (Oregon Department of Fish and Wildlife). 2007. Desired status: measurable criteria for the Oregon coast coho conservation plan for the state of Oregon. Appendix 2, Oregon Coast CohoConservation Plan for the state of Oregon. Oregon Department of Fish and Wildlife, Salem.

OWEB (Oregon Watershed Enhancement Board).1999. Oregon watershed assessment manual (Available from Oregon Watershed Enhancement Board, 775 Summer St. NE, Suite 360, Salem, OR 97301).

Palmer, M. A. 2009. Reforming watershed restoration: science in need of application and applications in need of science. Estuaries and Coasts 32:1-17.

Palmer, M.A. and J.D. Allan. 2006. Restoring rivers. Issues in Science and Technology winter, 40-48.

Parken, C.K., R.E. McNicol, and J.R. Irvine. 2006. Habitat-based methods to estimate escapement goals for data limited chinook salmon stocks in British Columbia, 2004. CDFO Canadian Science Advisory Secretariat Research Document 2006/083. 74 pp.

PSC (Pacific Salmon Commission). 2008. An overview of salmon habitat and restoration related activities in Canada and the United States 1999-2006. Pacific Salmon Commission Technical Report No. 24, prepared by the Ad Hoc Habitat Scoping Committee, January 2008, 21pp.

Reeve, Todd, Jim Lichatowich, William Towey, and Angus Duncan. 2006. Building science and accountability into community-based restoration: can a new funding approach facilitate effective and accountable restoration? Fisheries 31(1): 17-24.

Reeves, G.H., J.D. Hall, T.D. Roelofs, T.L. Hickman, and C.O. Baker.1991. Rehabilitating and modifying stream habitats. Pages 519-557 in W.R. Meehan, editor. Influences of Forest and Rangeland Management on Salmonid Fishes and their Habitats. American Fisheries Society, Special Publication 19, Bethesda, Maryland.

Reeves, G.H., D.B. Hohler, B.E. Hansen, F.H. Everest, J.R. Sedell, T.L. Hickman, and D. Shively.1997. Fish habitat restoration in the Pacific Northwest: Fish Creek of Oregon. Pages335-359 in J.E. Williams, C.A. Wood, and M.P. Dombeck, editors. Watershed restoration: principles and practices. American Fisheries Society, Bethesda, Maryland.

Reimers, P.E. 1973. The length of residence of juvenile fall chinook salmon in Sixes River, Oregon. Dissertation. Oregon State University, Corvallis, Oregon, USA.

Rice, Casimir A., W. Gregory Hood, Lucinda M. Tear, Charles A. Simenstad, Gregory D. Williams, Lyndal L. Johnson, Blake E. Feist, and Philip Roni. 2005. Monitoring rehabilitation in temperate north American estuaries. Pages 167-207 in P. Roni, editor.

Monitoring stream and watershed restoration. American Fisheries Society, Bethesda, Maryland.

Roni, P., editor. 2005. Monitoring stream and watershed restoration. American Fisheries Society, Bethesda, Maryland.

Roni, P., T.J. Beechie, R.E. Bilby, F.E. Leonetti, M.M. Pollock, and G.P. Pess. 2002. A review of stream restoration techniques and a hierarchical strategy for prioritizing restoration in Pacific Northwest watersheds. North American Journal of Fisheries Management 22:1-20.

Roper, Brett B., Jeffrey J. Dose, and Jack E.Williams. 1997. Stream restoration: is fisheries biology enough? Fisheries, 1997 22(5):6-11.

Ryder, R.A. and S.R. Kerr. 1989. Environmental priorities: placing habitat in a hierarchic perspective, 2-12. In C.D. Levings, L.B. Holtby and M.A. Henderson (Eds.). Proceedings of the National Workshop on Effects of Habitat Alteration on Salmonid Stocks. Can. Spec. Publ. Fish. Aquat. Sci. 105.

Simenstad, C.A., and D.L. Bottom. 2002. Guiding ecological principles for restoration of salmon habitat in the Columbia River Estuary. Online at http://www.fish.washington.edu/research/wet/publications/ecol_principles.doc.

Simenstad, C.A. and Jeffery R. Cordell. 2000. Ecological assessment criteria for restoring anadromous salmonid habitat in Pacific Northwest estuaries. Ecological Engineering 15 (2000) 283-302.

Simenstad, C.A., K.L. Fresh, E.O. Salo.1982. The role of Puget Sound and Washington coastal estuaries in the life history of Pacific salmon: an unappreciated function. In Kennedy, V.S. (Ed), Estuarine Comparisons. Academic Press, New York, NY, pp. 3343-364.

Simenstad, C.A., C.D. Tanner, R.M. Thom, and L. Conquest.1991. Estuarine habitat assessment protocol. UW-FRI-8918/-8919, Fish Res. Inst., University of Washington, Seattle, WA, 191 pp.

Simenstad, C.A. and R.M. Thom. 1992. Restoring wetland habitats in urbanized Pacific Northwest estuaries. In Thayer, G.W. (Ed.), Restoring the Nation’s Marine Environment. Maryland Sea Grant, College Park, MD, pp. 423-472.

Slaney, P.A. and A.D. Martin. 1997. Watershed restoration program of British Columbia: accelerating natural recovery processes. Water Qual. Res. J. Can. 32:325-346.

Slaney, P.A. and D.O. Zoldakas (editors). 1997. Fish habitat rehabilitation procedures. B.C. Min. Environ., Lands and Parks, Watershed Restoration Program, Vancouver, B.C. Watershed Restoration Tech. Circ. 9. 313 p.

Stalberg, H.C., R.B. Lauzier, E.A. MacIssac, M. Porter and C. Murray. 2009. Canada’s policy for conservation of wild Pacific salmon: streams, lake, and estuarine habitat indicators. Fisheries and Oceans Canada, Oceans, Habitat and Enhancement Branch, Kamloops, BC, Canadian Manuscript Report of Fisheries and Aquatic Sciences 2859.

SWC (Skagit Watershed Council).1998. Habitat protection and restoration strategy. Skagit Watershed Council, Mount Vernon, WA.

Thayer, Gordon W., Teresa A. McTigue, Russell J. Bellmer, Felicity M. Burrows, David H. Merkey, Amy D. Nickens, Stephen J. Lozano, Perry F. Gayaldo, Pamela J. Polmateer, and P. Thomas Pinit. 2003. Science-based restoration monitoring of coastal habitats, Volume One: A Framework for Monitoring Plans Under the Estuaries and Clean Waters Act of 2000 (Public Law 160-457). NOAA Coastal Ocean Program Decision Series No. 23, Volume 1. NOAA National Centers for Coastal Ocean Science, Silver Spring, MD. 35 pp. plus appendices.

Thayer, Gordon W., Teresa A. McTigue, Ronald J. Salz, David H. Merkey, Felicity M. Burrows, and Perry F. Guyaldo, (Eds.). 2005. Science-based restoration monitoring of coastal habitats, Volume Two: Tools for Monitoring Coastal Habitats.NOAA Coastal Ocean Program Decision Series No. 23. NOAA National Centers for Coastal Ocean Science, Silver Spring, MD. 628 pp. plus appendices.

Tripp, D. B., P. J. Tschaplinski, S. A. Bird and D. L. Hogan. 2009. Protocol for evaluating the condition of streams and riparian management areas (Routine riparian management effectiveness evaluation). FRPA Resource Evaluation Program, B.C. Min. For. and B.C. Min. Water, Land and Air Protection. Victoria, B.C.

Tschaplinski, P.J. 1987. Comparative ecology of stream-dwelling and estuarine juvenile coho salmon (Oncorhynchus kisutch) in Carnation Creek, Vancouver Island, British Columbia. Dissertation. University of Victoria, Victoria, British Columbia, Canada.

Tschaplinski, P.J. 2010. State of stream channels, fish habitats and their adjacent riparian areas: Resource stewardship monitoring to evaluate the effectiveness of riparian management, 2005-2008. FREP Report #27. Min For Mines, Lands. For Prac. Invest.Br., Victoria, BC. Forest and Range Evaluation Program. xv+76 pp.

Tschaplinski, P.J. and Kerri Brownie. 2010. Forest and range evaluation program riparian protocol – why these indicators? FREP (Forest and Range Evaluation Program), British Columbia, Extension Note No. 9, May 2010, 6 p.

Tschaplinski, P.J, D.L. Hogan and G.F Hartman, 2004. Fish-forestry interaction research in coastal British Columbia: The Carnation Creek and Queen Charlotte Island studies In Fisheries and Forestry; Worldwide Watershed Interactions and Management, Chapter 18. GF Hartman and T.G Northcote (editors). Blackwell Press, London. U.K. pp. 189-412.

Turner, R.E. and B. Streever. 2002. Approaches to coastal wetland restoration: Northern Gulf of Mexico. SPB Academic Publishing, The Hague, The Netherlands.

Underhill, D. (editor). 2000. Annual compendium of aquatic rehabilitation projects for the Watershed Restoration Program, 1999-2000. B.C. Min. Environ., Lands and Parks, and B.C. Min. For., Watershed Restoration Program, Vancouver, B.C. Watershed Restoration Project Rep. 18. 141 p.

Underhill, D. (editor). 2001. Annual compendium of aquatic rehabilitation projects for the Watershed Restoration Program, 1999-2000. B.C. Min. Environ., Lands and Parks, and B.C. Min. For., Watershed Restoration Program, Vancouver, B.C. Watershed Restoration Project Rep. 18. 200 p.

Underhill, D. (editor). 2002. Streamline Watershed Restoration Technical Bulletin. Vol.6, No. 4, Spring 2002. Ministry of Forests, Ministry of Water, Land and Air Protection, Ministry of Sustainable Resource Management, Watershed Restoration Program. 2204 Main Mall, Vancouver, B.C. 42 p.

WDNR (Washington Dept. Natural Resources).1995. Standard methodology for conducting watershed analysis. Washington Dept. Natural Resources, Olympia.

Woolsey, Sharon, Florence Capelli, Tom Conser, Edward Hoehn, Markus, Hostmann, Berit Junker, Achim Paetzold, Christian Roulier, Steffen Schweizer, Scott D. Tiegs, Klement Tochner, Christine Weber, and Armin Peter. 2007. A strategy to assess river restoration success. Freshwater Biology (2007) 52, 752-769.

APPENDICES

Appendix A: Habitat Status Dashboard Summaries for WCVI Chinook CUs

Southern Chinook CU Dashboard Summaries

Page 1

1. CU overview 'slider' figure. Area weighted average of all watershed scores, for all watersheds that overlap the CU boundary. Scores are calculated, and weighted, using entire watershed areas even when only a portion of the watershed is within the CU. The area weighted average score is normalized for each indicator so that the low to moderate risk threshold ( ) occurs at 0.33 and the moderate to high risk threshold ( ) is at 0.66 on a scale of 0 to 1[1].

2. Cumulative watershed risk score. Map of cumulative risk for each watershed that overlaps the CU. Based on the risk rating of 5 selected indicators (land cover alteration, road density, stream crossing density, waste water discharges, and water allocation). Roll-up rule set: if >= 2 indicators are red (high risk), then watershed = red (high risk), else if >= 4 indicators are green (low risk) then watershed = green (low risk), else watershed = yellow (moderate risk).

3. Habitat quantity

3a. CU spawning length (km) – total linear length of all Chinook spawning zones[2] within the CU boundary.

3b. CU accessible stream length (km) – total linear length of streams accessible to fish passage[3] within the CU boundary.

3c. Estuary area (ha), (% under threat) – total surface area of the estuary[4] downstream of the CU. Total percentage of estuary area under intertidal tenure threat[5] or not under conservation status[6].

3d. (Map) Chinook escapement and spawning zones – average number of spawners (from 1991 to 2010) across streams within the CU, and location of spawning zones[2].

4. Vulnerability

4a. Life history type – the type/race of Chinook (stream-type: higher risk, ocean-type: lower risk, or a mixture: moderate risk) found in the CU.

4b. Large lake influence – is the CU buffered by large lake influence? A large lake is generally defined as > 10 km^2, though some smaller lakes have been included where deemed influential as a result of expert based analysis.

4c. (Map) Flow sensitivity – regional flow sensitivities of streams[7] across all watersheds that overlap the CU.

Page 2

5. Road development. Road density[8] (km/km^2) within each watershed. Risk thresholds are based on categorical indicators[9].

6. Stream crossing density. Number of crossings per km of fish habitat[3]. Risk thresholds are based on categorical indicators[9].

7. Forest disturbance. Forest disturbance[10] (recently logged, selectively logged, and recently burned) as a percentage of watershed area. Using the distribution of values across all watersheds, any value under the 50th percentile is low risk, 50th-75th percentile is moderate risk, and 75th percentile and above is high risk.

8. Mountain pine beetle. Percent of pine stand killed[11] within a watershed. Using the distribution of values across all watersheds, any value under the 50th percentile is low risk, 50th-75th percentile is moderate risk, and 75th percentile and above is high risk.

---

1 Where the average score , the normalized score ; where ,].
2 BC historical fish distribution zones (1:50k) from FISS, restricted to Chinook spawning
3 BC MOE Fish Passage (fish habitat) Data (1:20k)
4 BC Pacific Estuary Conservation Program (PECP) estuaries data
5 Tenure threat footprint by estuary, from PECP
6 Conservation status areas determined by the following datasets: Wildlife Management Areas, Conservancy Areas, Parks, Ecological Reserves and Protected Areas, and Canadian Wildlife Service Protected Areas
7 Flow sensitivities by ecoregion, from Ptolemy, R. A. (2012) pers. com.
8 Digital Road Atlas
9 Categorical risk thresholds from Ministry of Forests watershed assessments procedure guidebook
10 Baseline Thematic Mapping Present Land Use Version 1
11 Percent of pine stand killed generated from 2011 Vegetation Resource Inventory (VRI) data

Page 3

9. Total land cover alteration. Land alteration[12] (agriculture, residential/agriculture mix, recently burned, recently logged, selectively logged, mining, recreation, and urban) as a percentage of watershed area. Using the distribution of values across all watersheds, any value under the 50th percentile is low risk, 50th-75th percentile is moderate risk, and 75th percentile and above is high risk.

10. Mining development. Percent of land cover disturbed by mining[12]. Watersheds with no mining are low risk; any amount of mining (i.e. > 0 %) is moderate risk. Using the distribution of values across all watersheds, outliers (see Additional notes section for definition) are considered high risk.

11. Urban development. Urban land cover[12] as a percentage of watershed area. Using the distribution of values across all watersheds, any value under the 50th percentile is low risk, 50th-75th percentile is moderate risk, and 75th percentile and above is high risk.

12. Agricultural/Rural development. Agricultural land cover[12] as a percentage of watershed area. Using the distribution of values across all watersheds, any value under the 50th percentile is low risk, 50th-75th percentile is moderate risk, and 75th percentile and above is high risk.

Page 4

13. Riparian disturbance. Percent of riparian zone (30 m buffer around streams and water bodies) altered by the same land cover types as used for total land cover alteration. Using the distribution of values across all watersheds, any value under the 50th percentile is low risk, 50th-75th percentile is moderate risk, and 75th percentile and above is high risk.

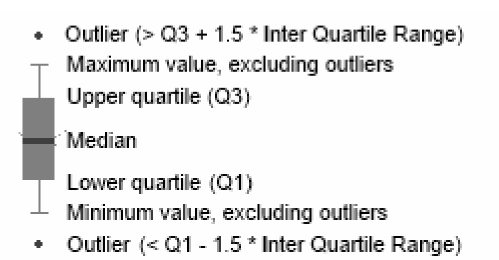
14. Water allocation. Total water allocation for points of diversion[14] within each watershed divided by watershed area (m^3/ha). Watersheds with no water extraction are low risk; any amount of extraction (i.e. > 0 m^3/ha) is moderate risk. Using the distribution of values across all watersheds, outliers (see Additional notes section for definition) are considered high risk.

15. Permitted waste water discharges. Number of waste water discharge sites[13] per watershed. Watersheds with no water discharge sites are low risk; any number of sites (i.e. > 0 sites) is moderate risk. Using the distribution of values across all southern Chinook watersheds, outliers (see Additional notes section for definition) are considered high risk.

16. Air temperature. ClimateBC maximum average monthly air temperature (°C) in CU watersheds during spawning, rearing and migration (Fraser Basin CUs, Albion station) periods for historical, current and predicted future conditions. Risk thresholds have not been defined for air temperature impacts.

Additional notes

Key to interpreting box plots (pressure indicators, pages 2 to 4):

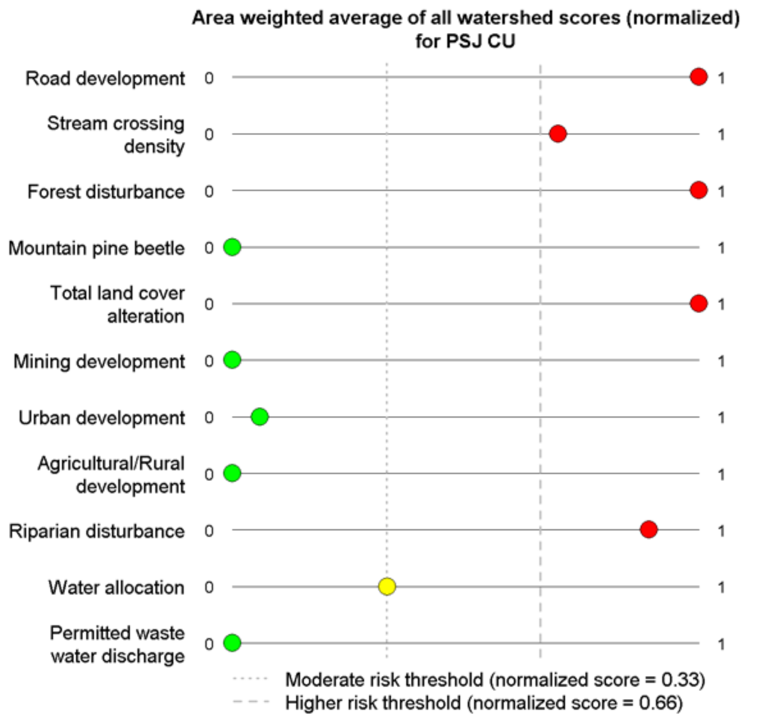


[12] Baseline Thematic Mapping Present Land Use Version 1
[13] Waste water discharge and permits database, from MOE
[14] BC Points Of Diversion

Southern Chinook Conservation Units
CU: Port San Juan

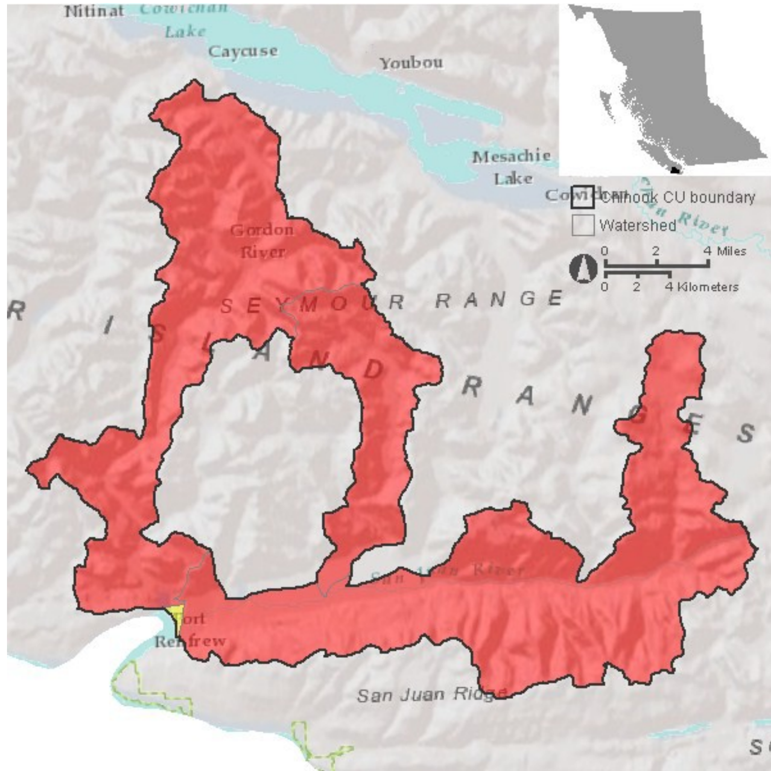
Fisheries and Oceans Canada | Pêches et Océans Canada

CU Overview



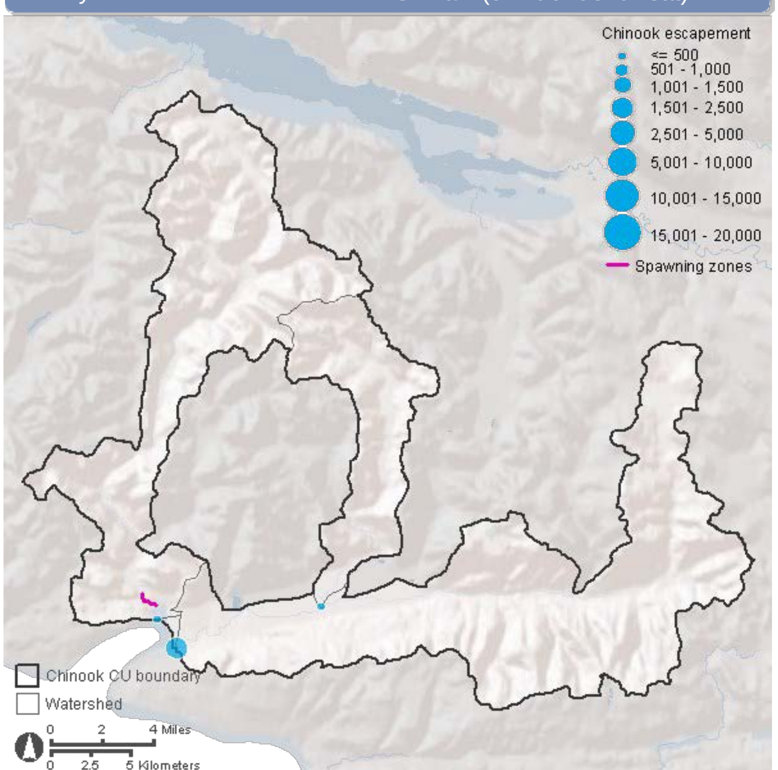
Cumulative Watershed Risk Score (roll up of 5 selected indicators)

Low risk | Moderate risk | High risk



Habitat Quantity

CU spawning length	1.3 km	(**0.05%** of total for all CUs)
CU accessible stream length	690 km	
Estuary area	137 ha	(**0.1%** under threat)

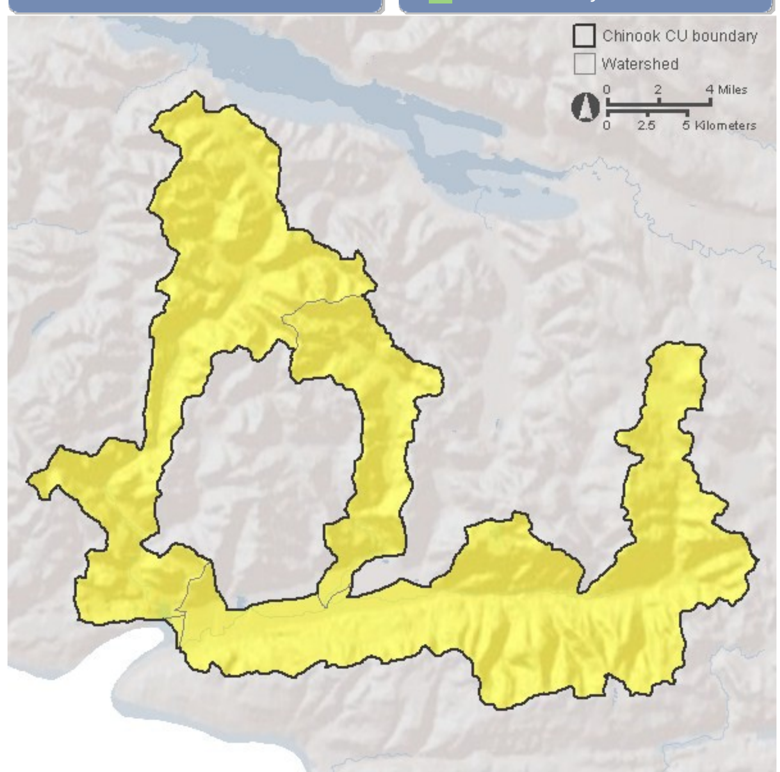


Vulnerability

Life history type: Ocean

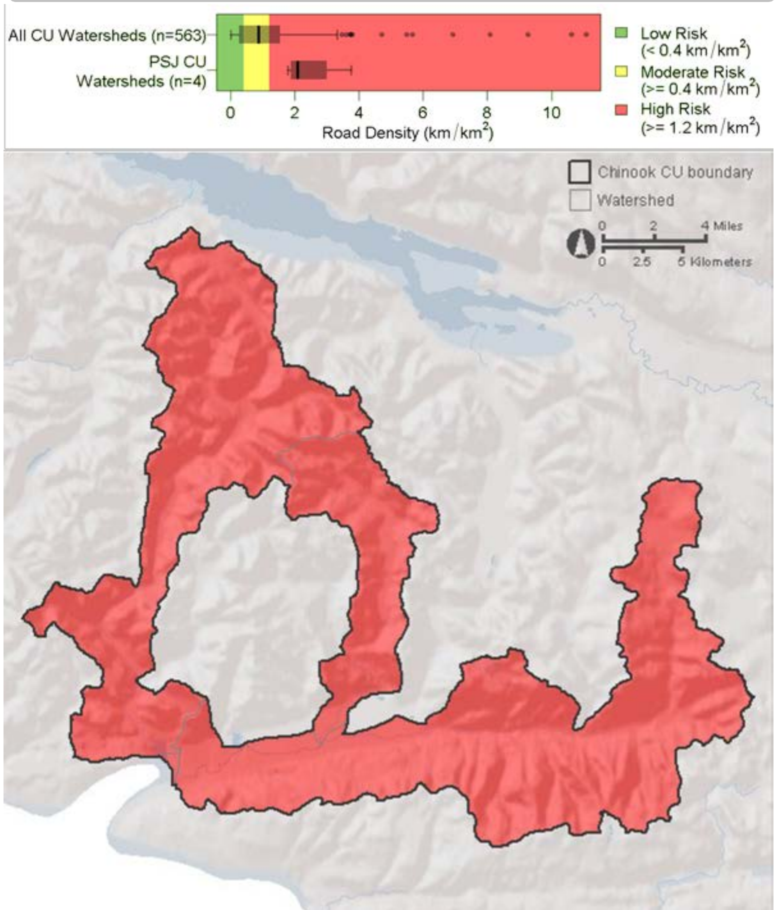
Large lake influence? No

Flow sensitivity
- Summer & winter
- Summer
- Winter
- No sensitivity

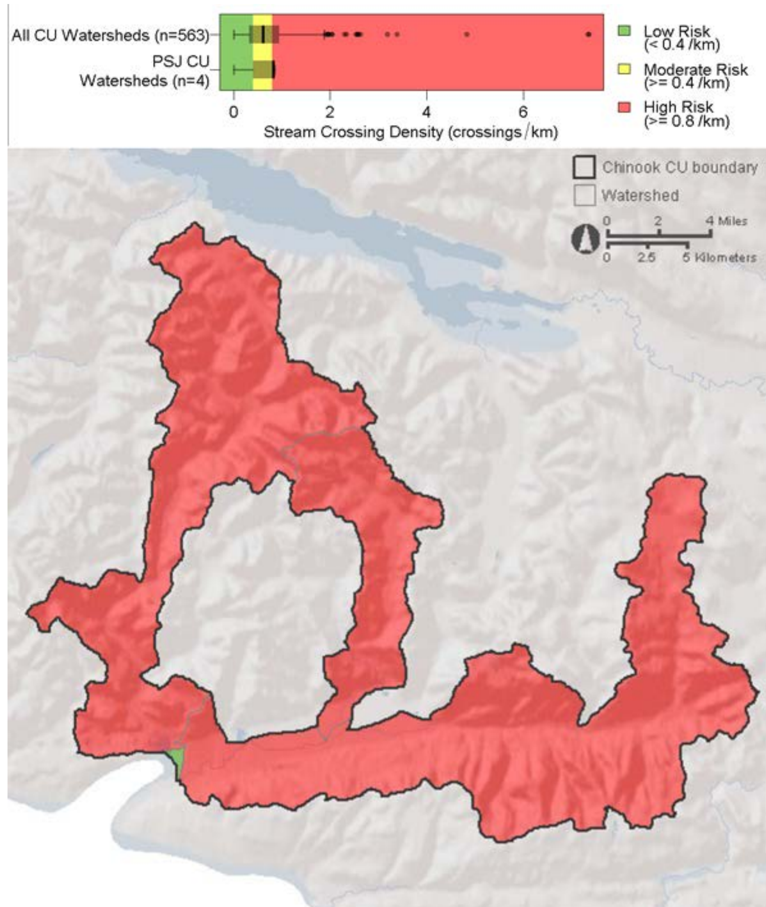


Fisheries and Oceans Canada · Pêches et Océans Canada

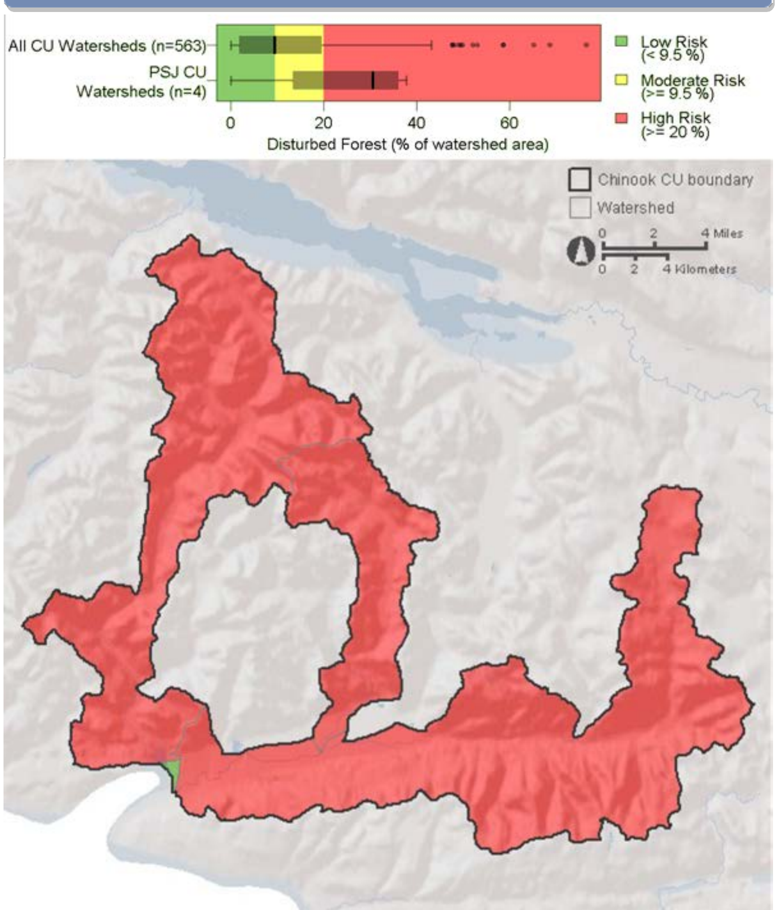
Pressure · Road Development



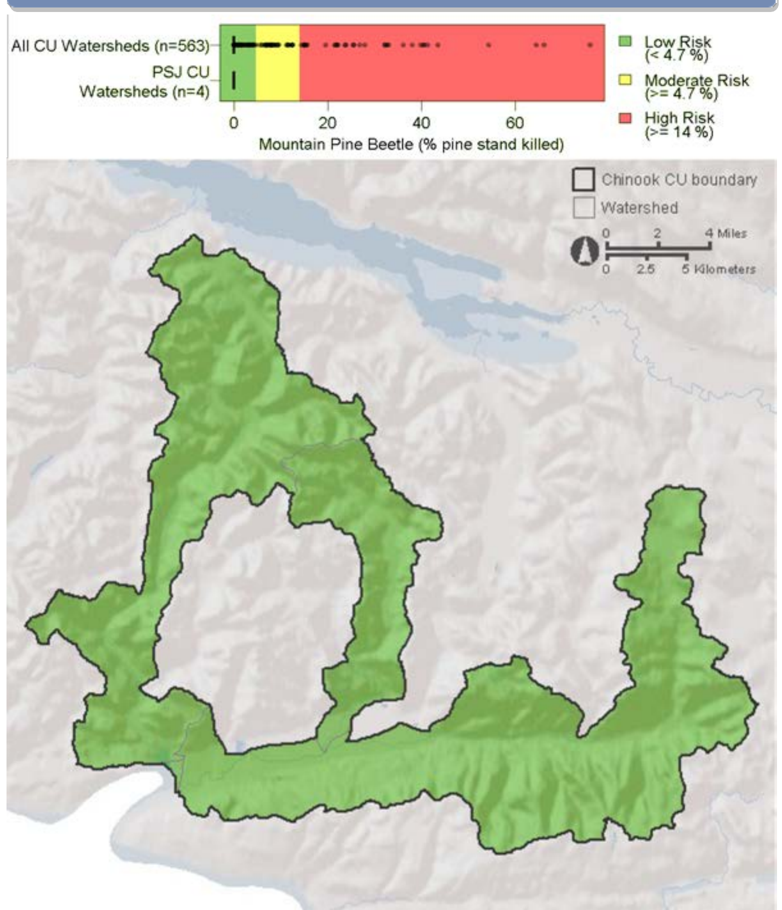
Pressure · Stream Crossing Density



Pressure · Forest Disturbance

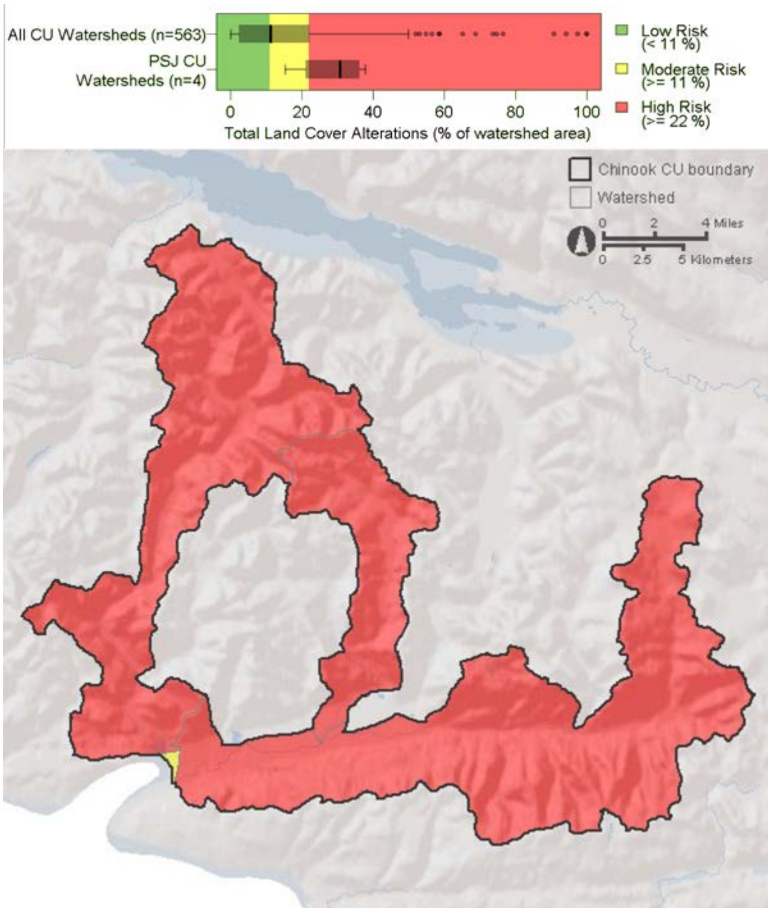


Pressure · Mountain Pine Beetle

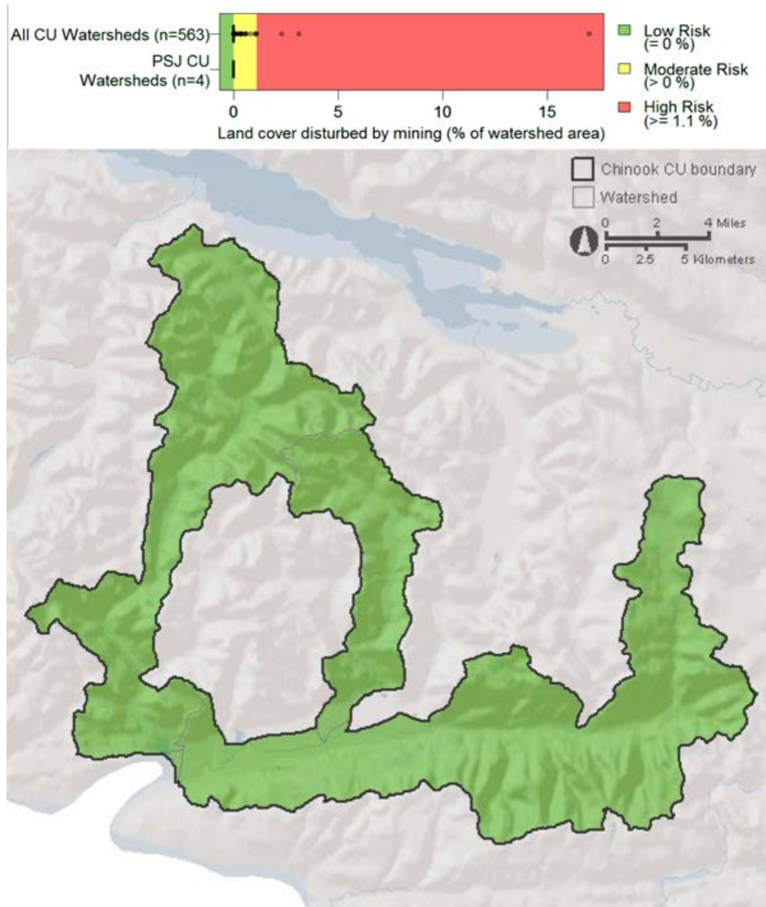


Fisheries and Oceans Canada | Pêches et Océans Canada

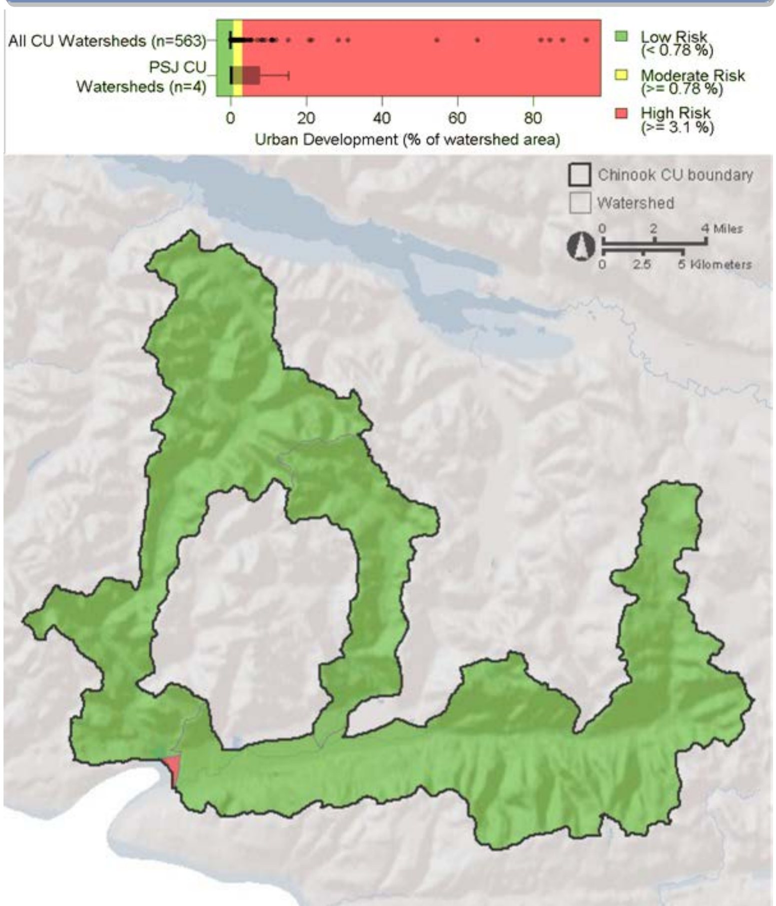
Pressure — Total Land Cover Alteration



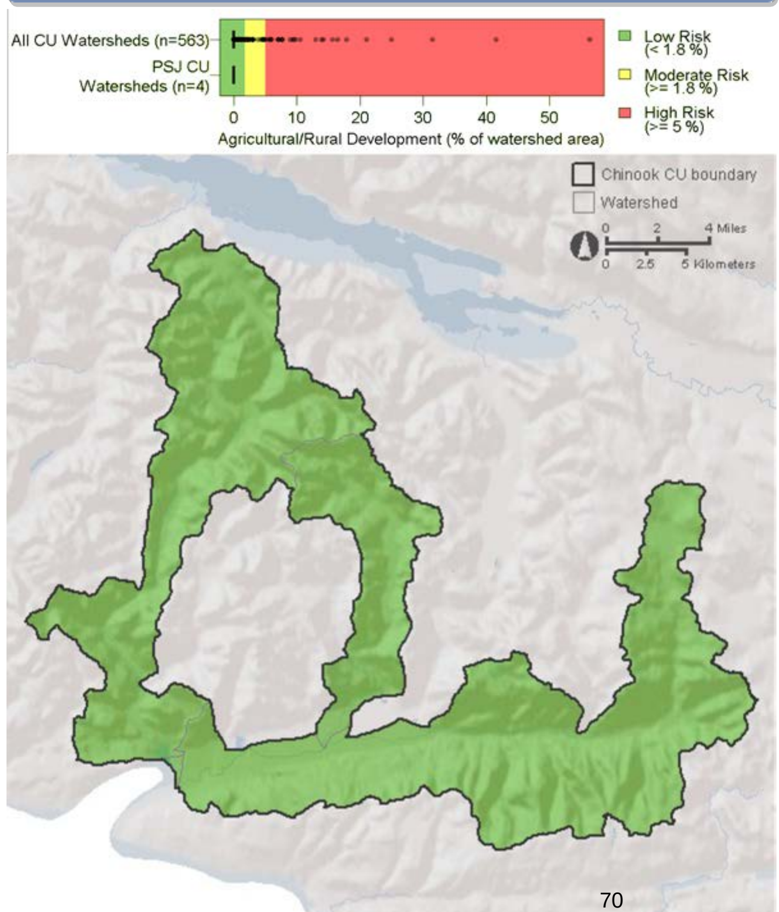
Pressure — Mining Development



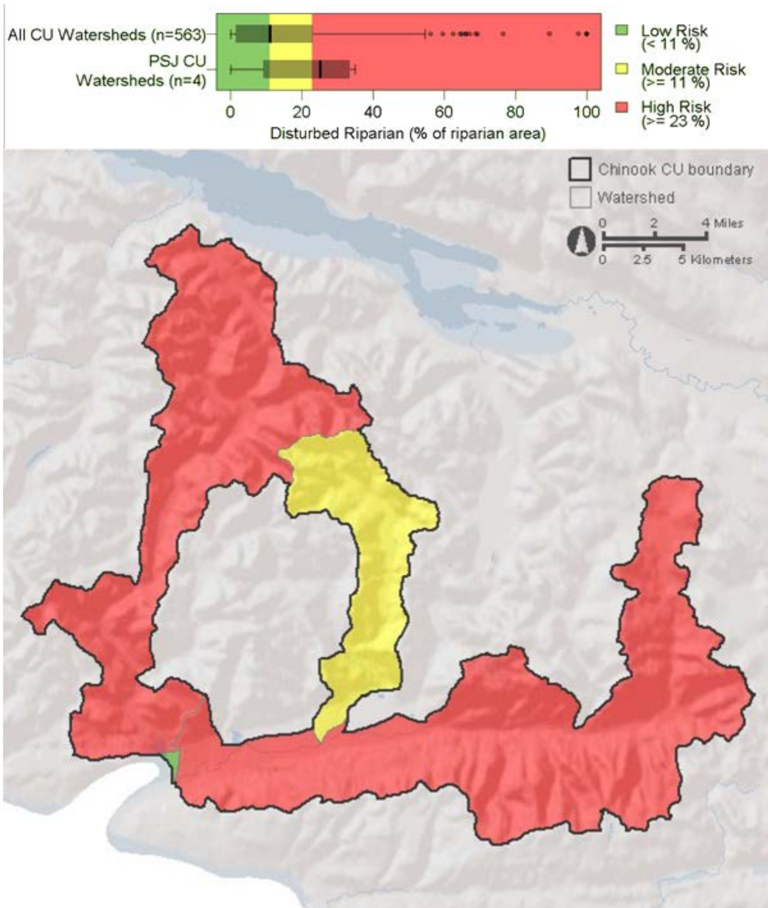
Pressure — Urban Development



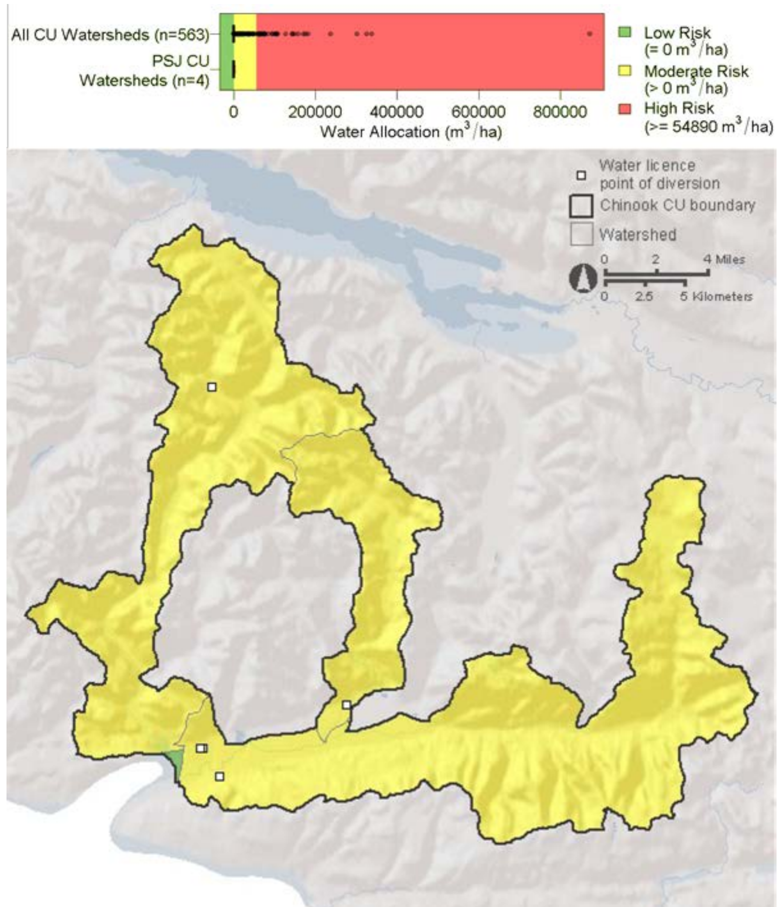
Pressure — Agricultural / Rural Development



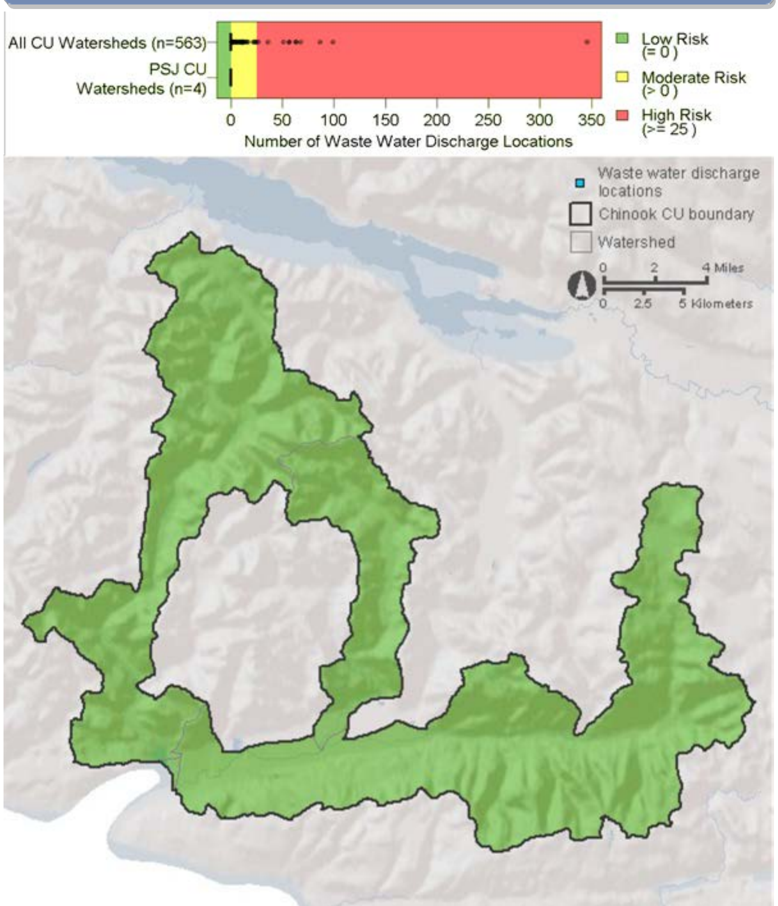
Pressure — Riparian Disturbance



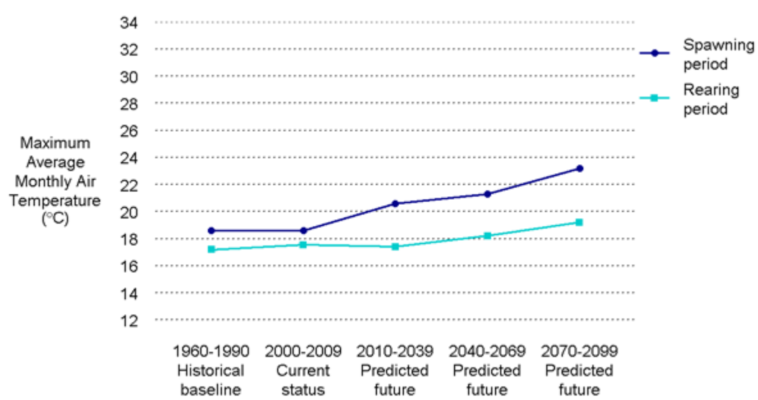
Pressure — Water Allocation



Pressure — Permitted Waste Water Discharges



Climate — Air Temperature (ClimateBC)



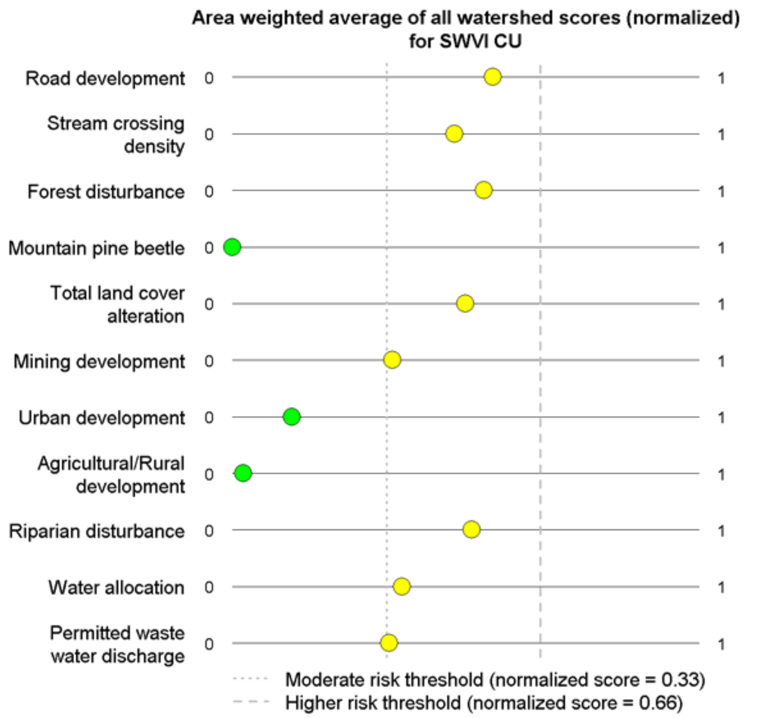
% change in air temperature over historical baseline

	Current	2010-2039	2040-2069	2070-2099
Spawning period	0%	11%	15%	25%
Rearing period	2%	1%	6%	12%

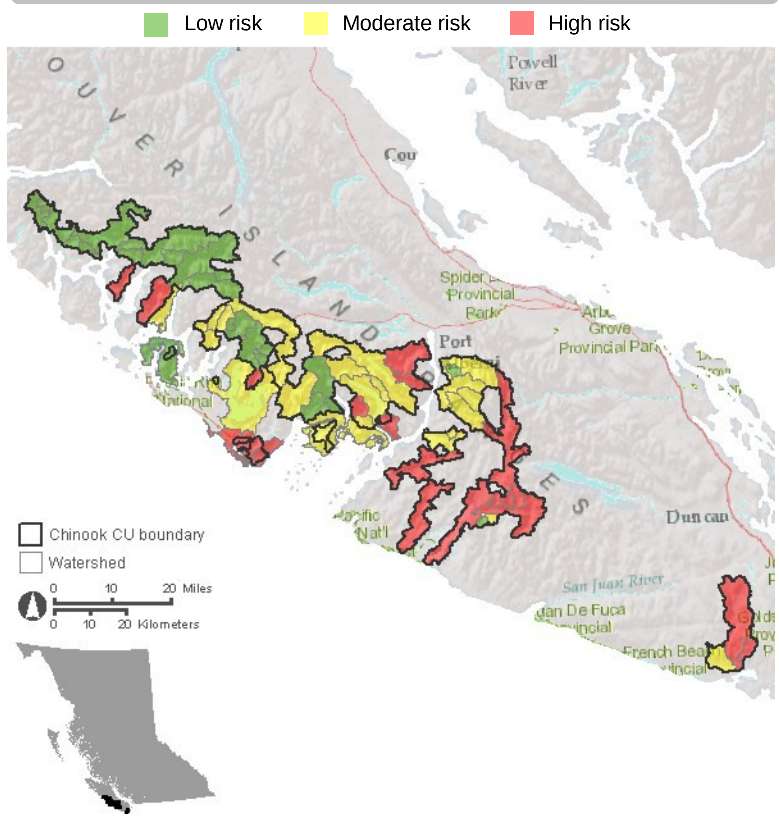
Southern Chinook Conservation Units
CU: Southwest Vancouver Island

Fisheries and Oceans Canada | Pêches et Océans Canada

CU Overview

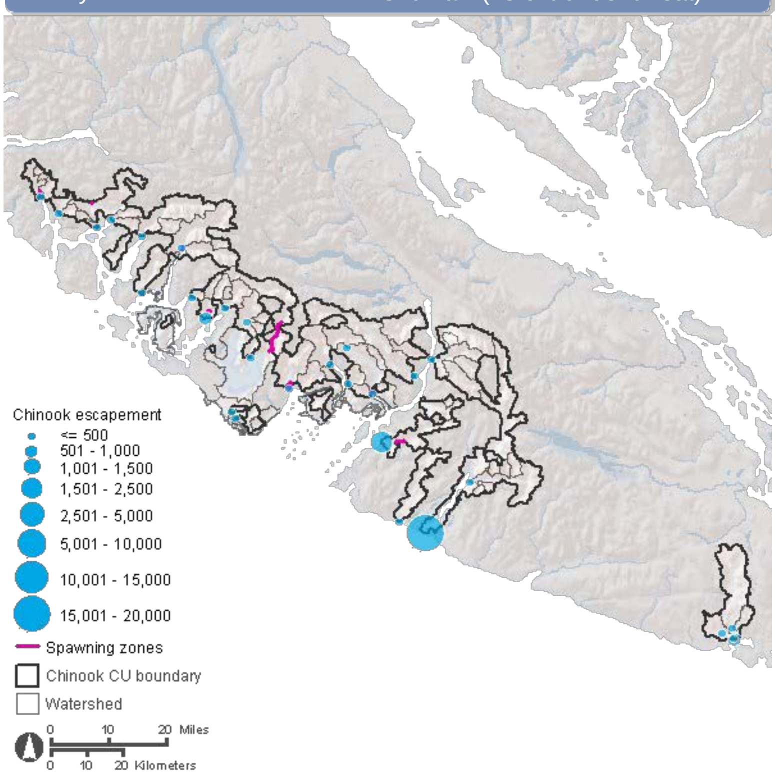


Cumulative Watershed Risk Score (roll up of 5 selected indicators)



Habitat Quantity

CU spawning length	**22 km**	(**0.8%** of total for all CUs)
CU accessible stream length	**2,569 km**	
Estuary area	**810 ha**	(**23.6%** under threat)

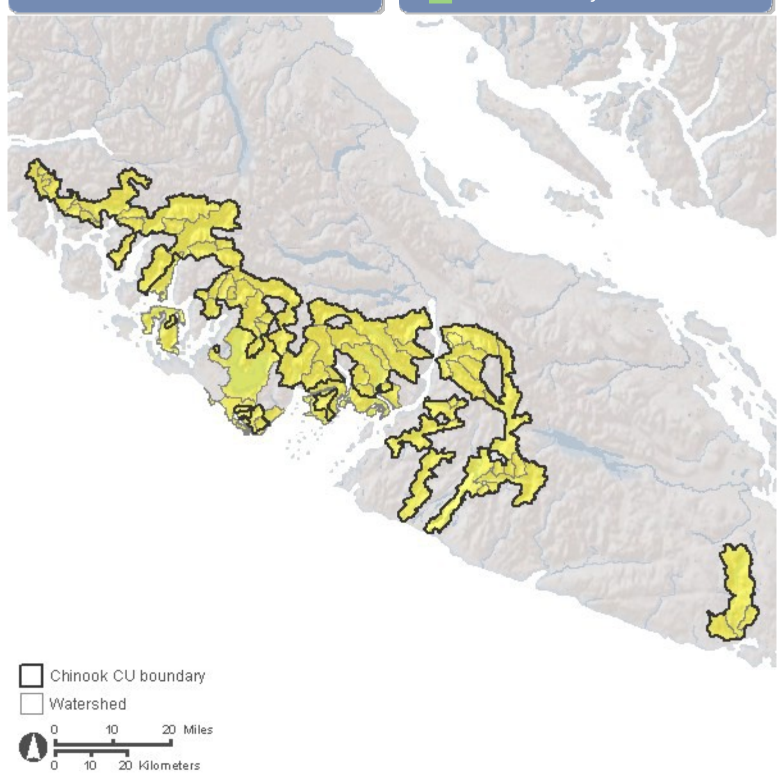


Vulnerability

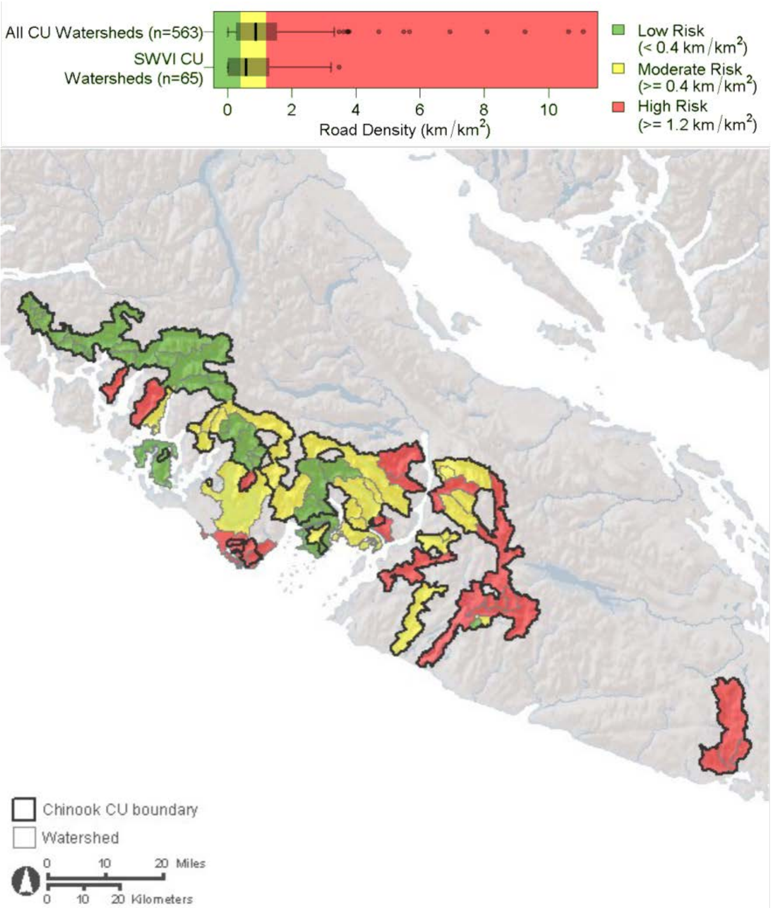
Life history type: **Ocean**

Large lake influence? **No**

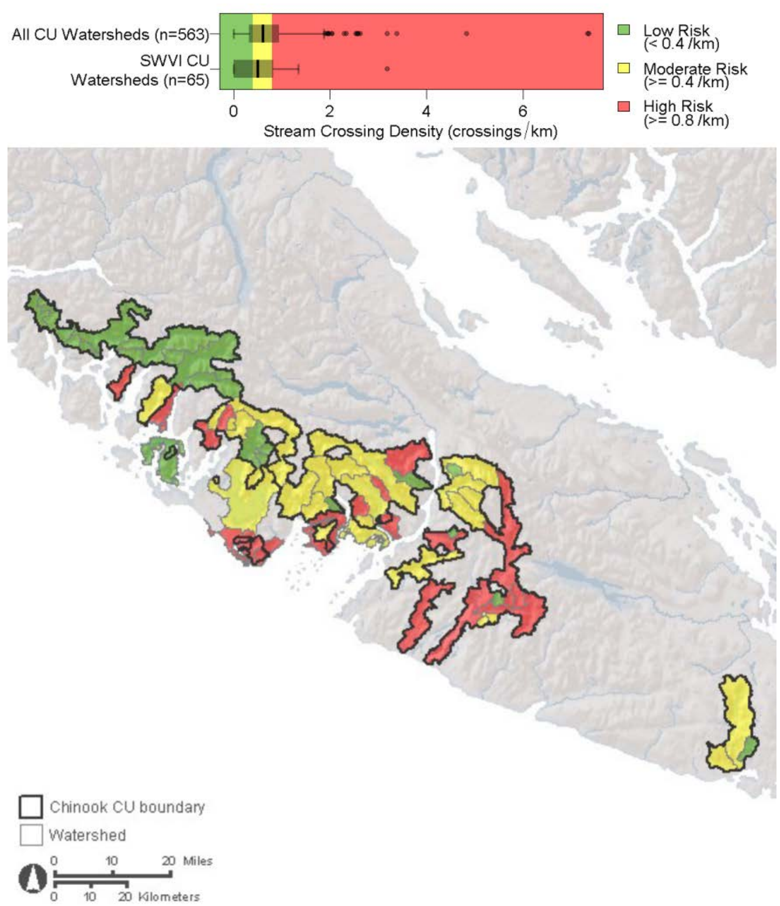
Flow sensitivity
- Summer & winter
- Summer
- Winter
- No sensitivity



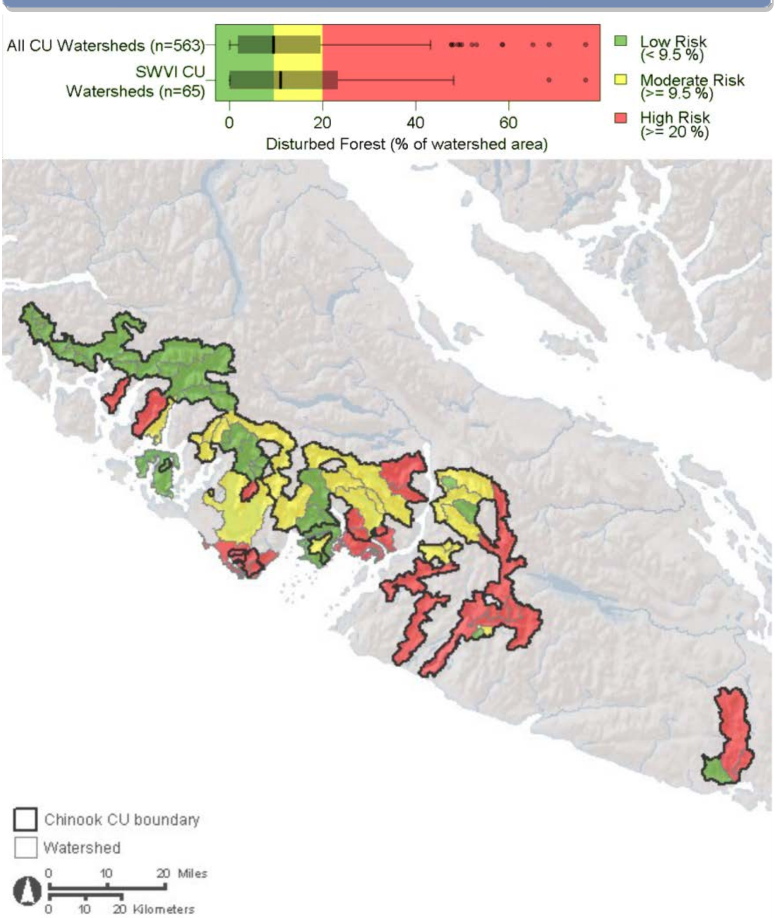
Pressure: Road Development



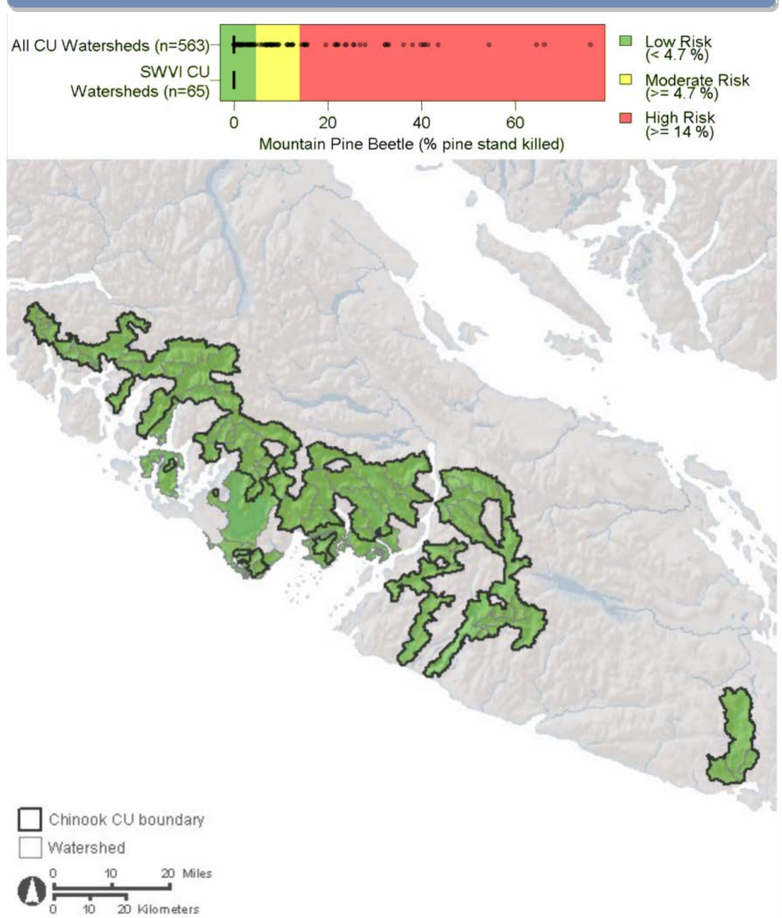
Pressure: Stream Crossing Density



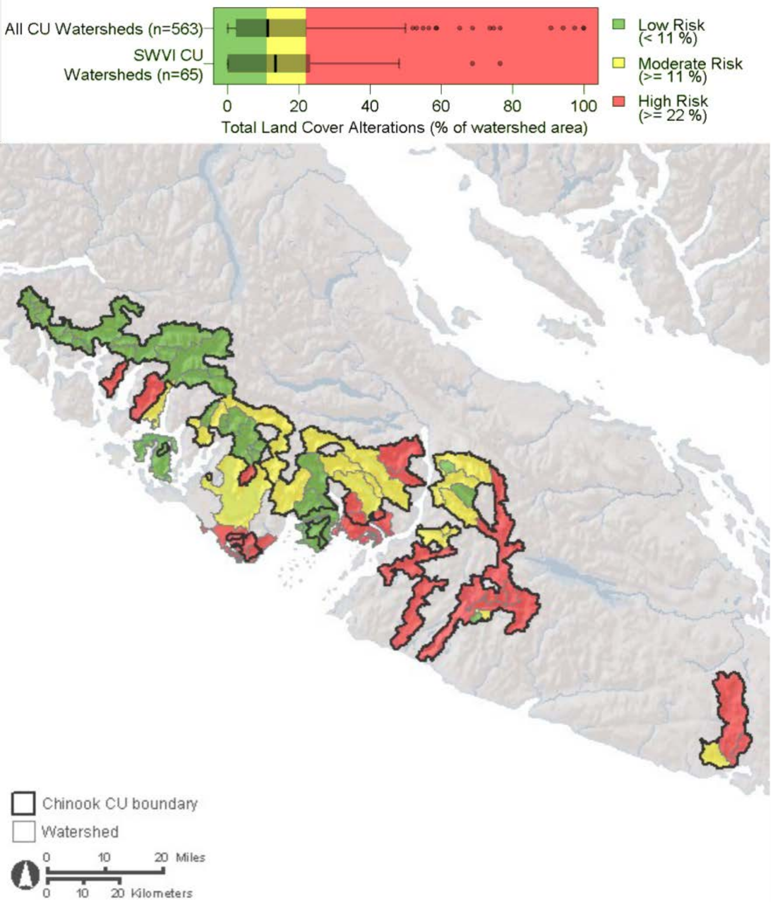
Pressure: Forest Disturbance



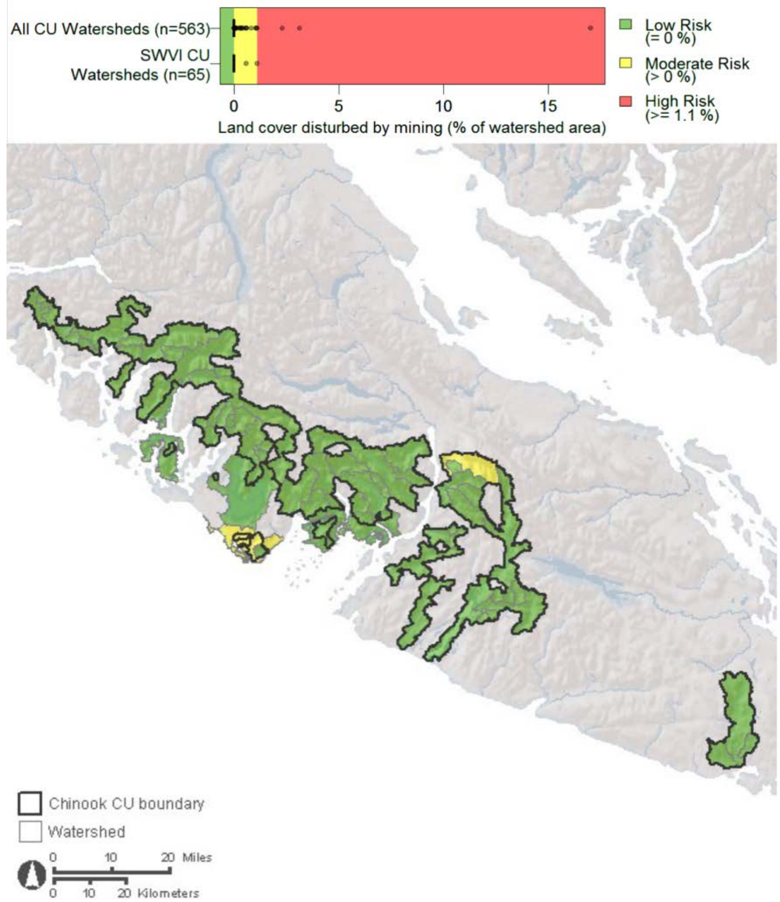
Pressure: Mountain Pine Beetle



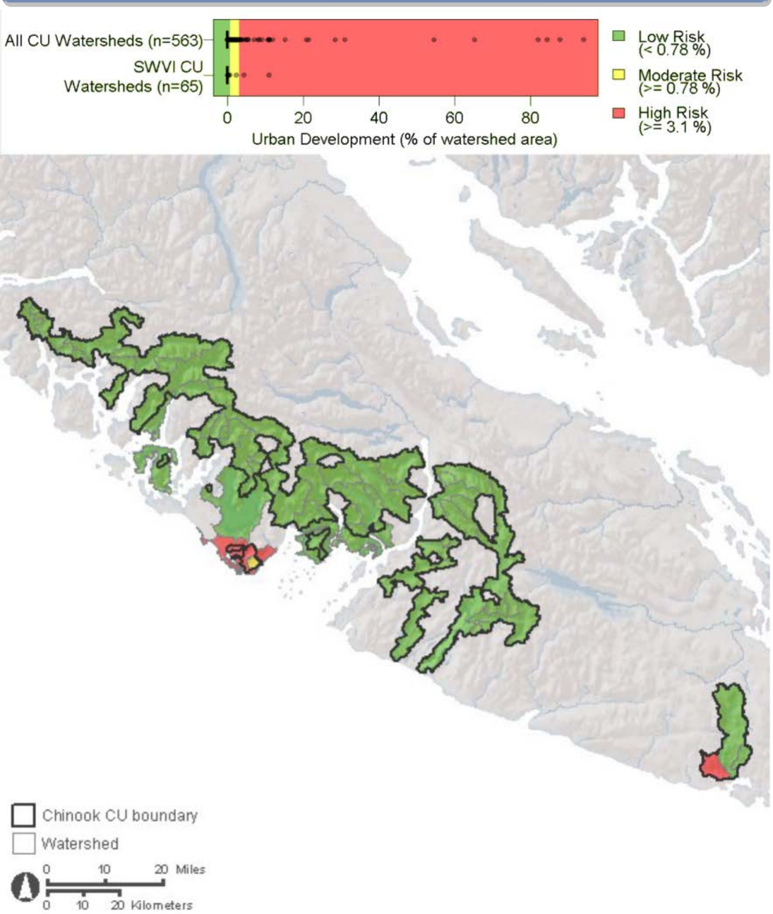
Pressure — Total Land Cover Alteration



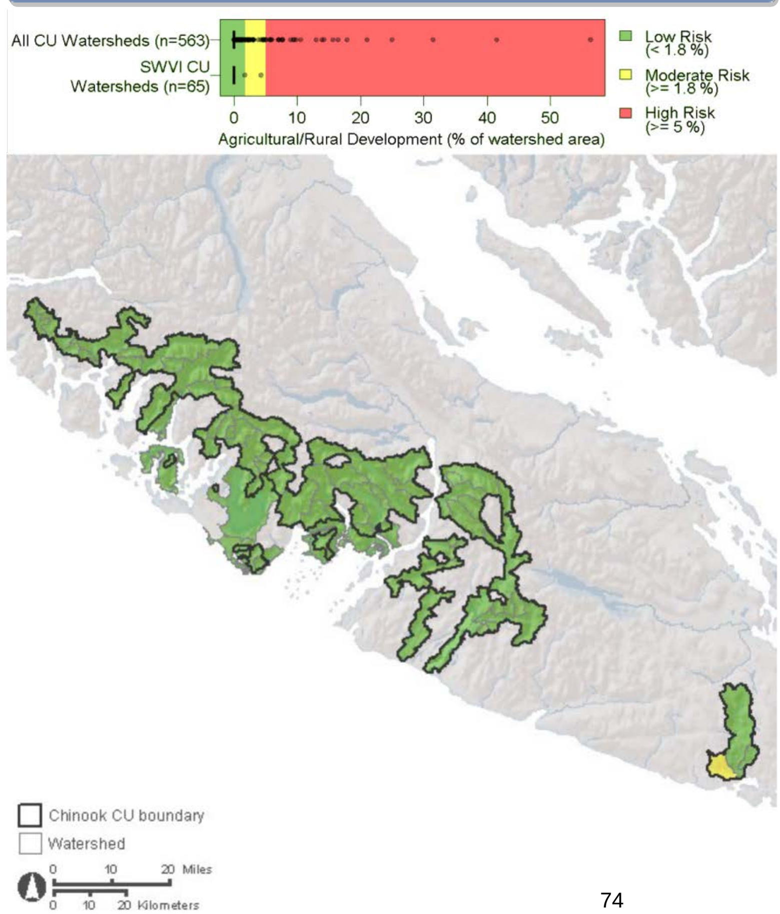
Pressure — Mining Development



Pressure — Urban Development

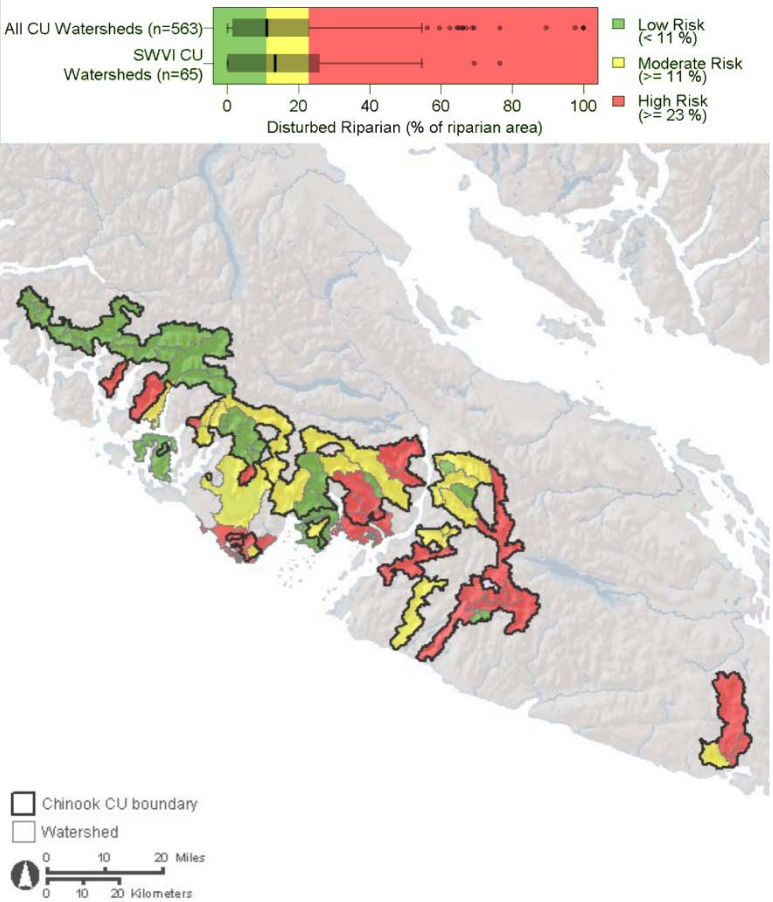


Pressure — Agricultural / Rural Development

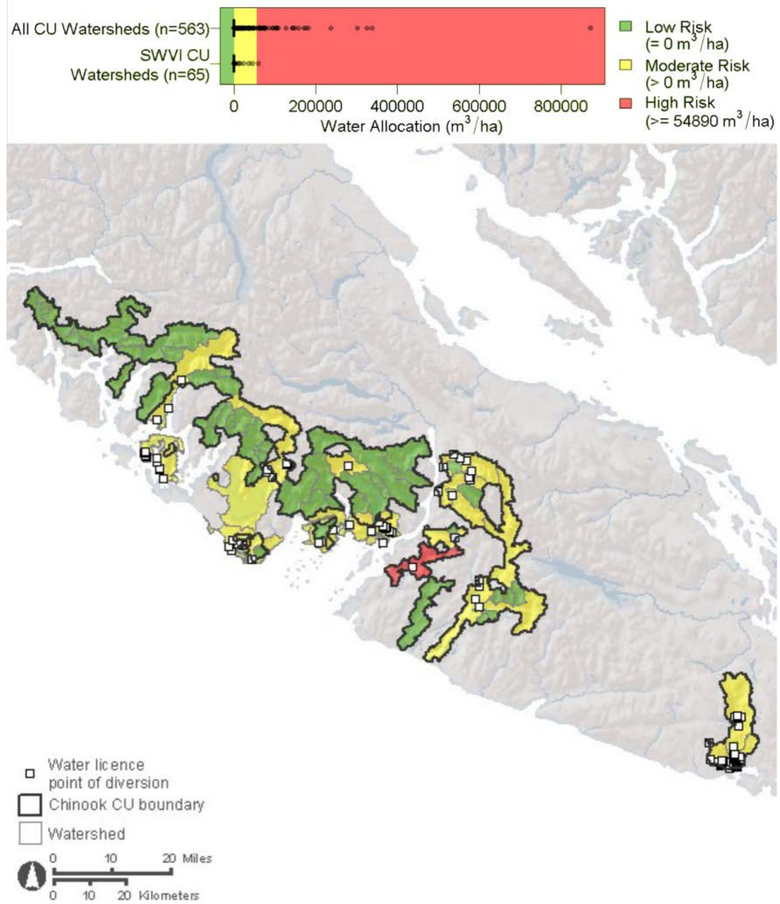


Fisheries and Oceans Canada / Pêches et Océans Canada

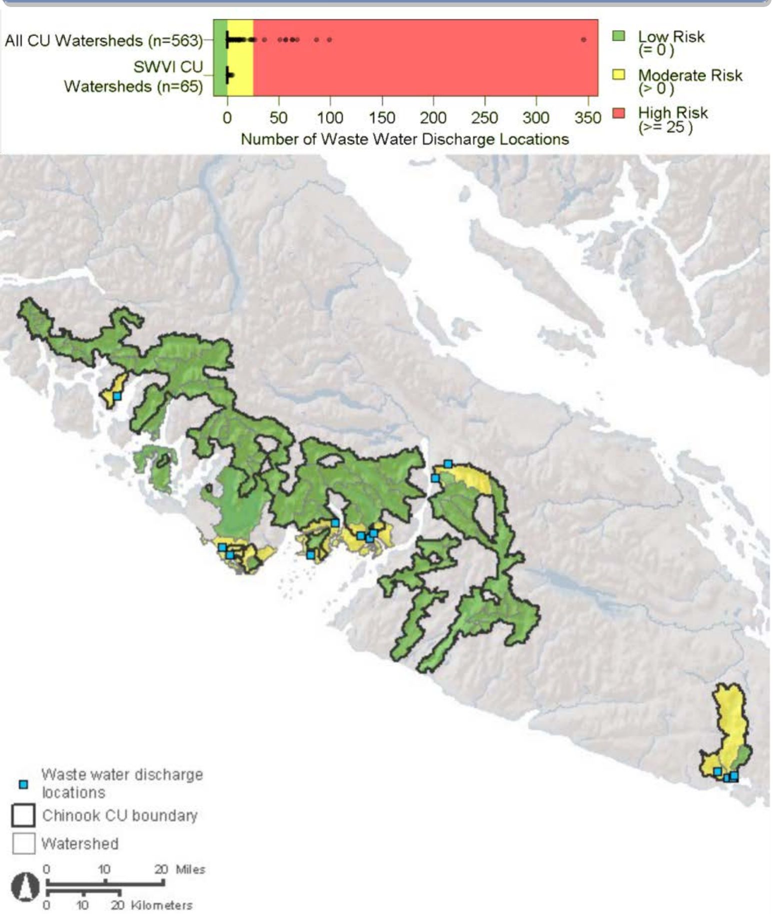
Pressure — Riparian Disturbance



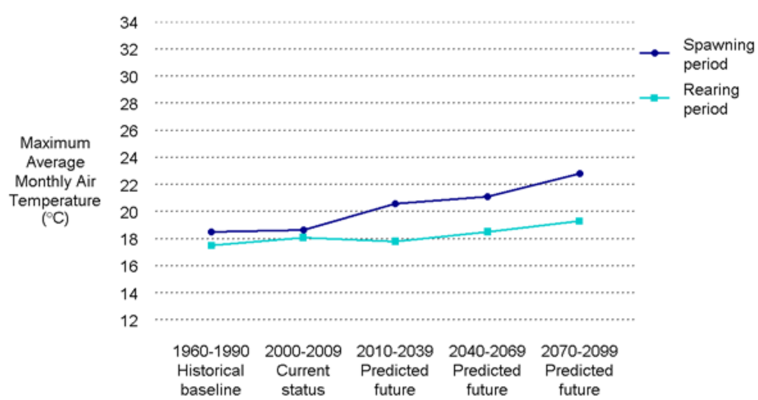
Pressure — Water Allocation



Pressure — Permitted Waste Water Discharges



Climate — Air Temperature (ClimateBC)



% change in air temperature over historical baseline

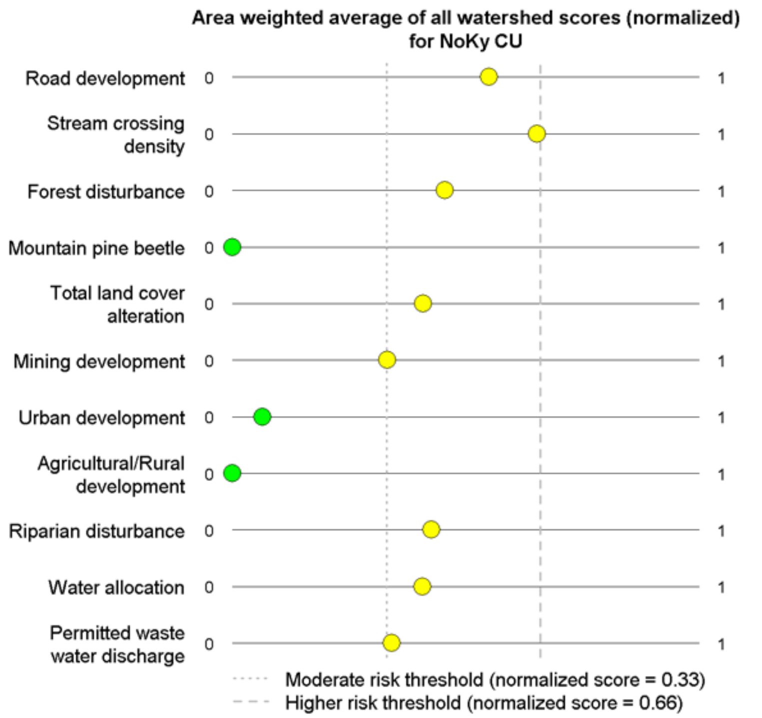
	Current	2010-2039	2040-2069	2070-2099
Spawning period	1%	11%	14%	23%
Rearing period	3%	2%	6%	10%

Southern Chinook Conservation Units

CU: Nootka & Kyuquot

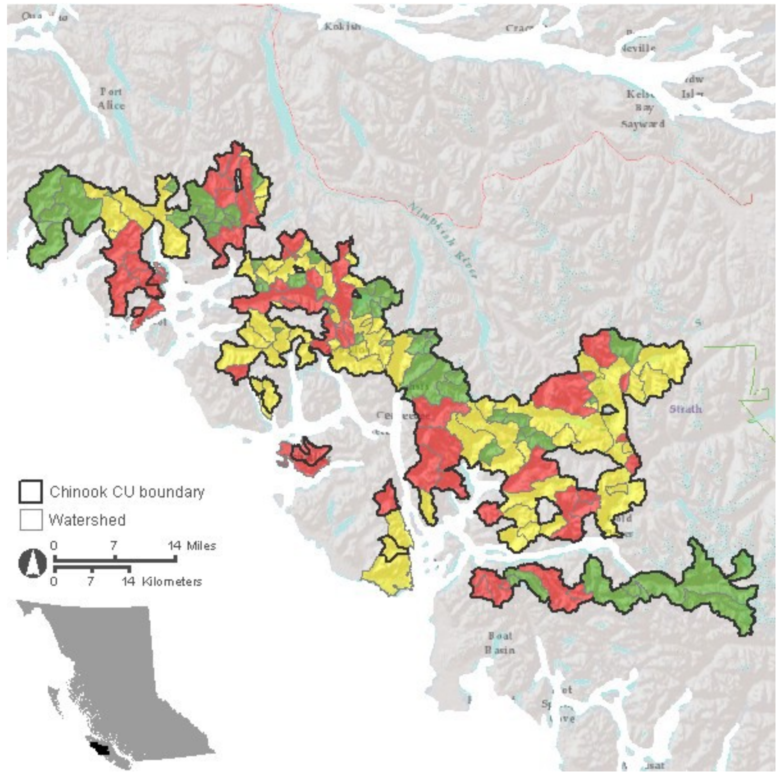
Fisheries and Oceans Canada | Pêches et Océans Canada

CU Overview



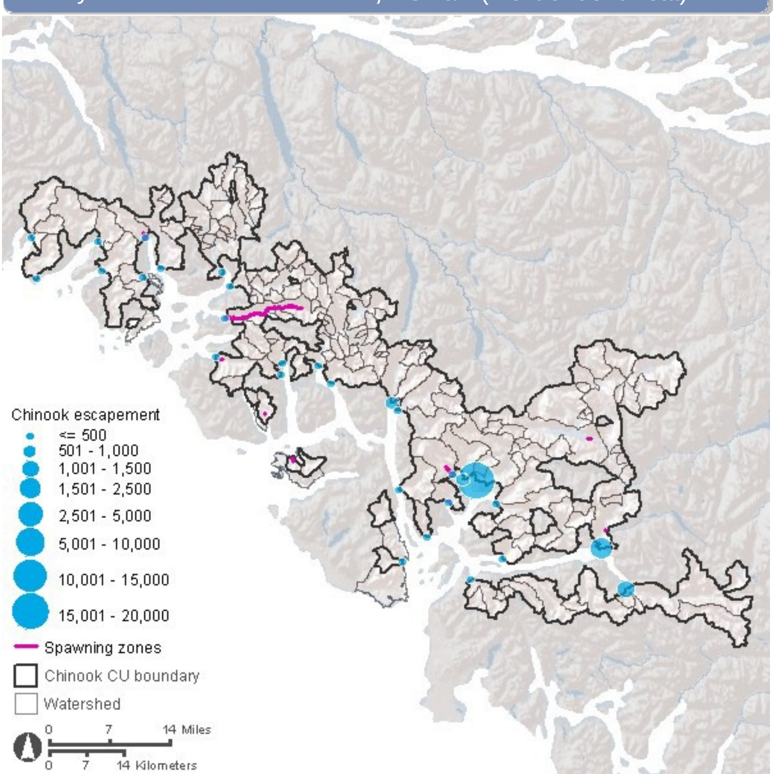
Cumulative Watershed Risk Score (roll up of 5 selected indicators)

Low risk | Moderate risk | High risk



Habitat Quantity

CU spawning length	**25 km**	(**0.9%** of total for all CUs)
CU accessible stream length	**2,369 km**	
Estuary area	**1,115 ha**	(**4.6%** under threat)

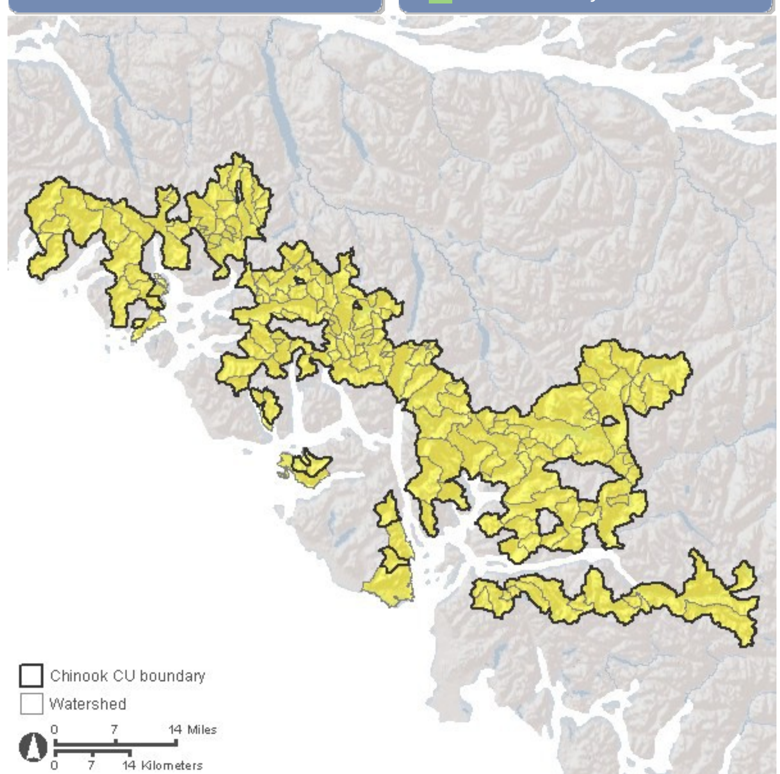


Vulnerability

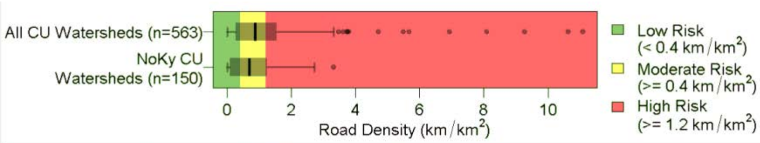
Life history type: **Ocean**

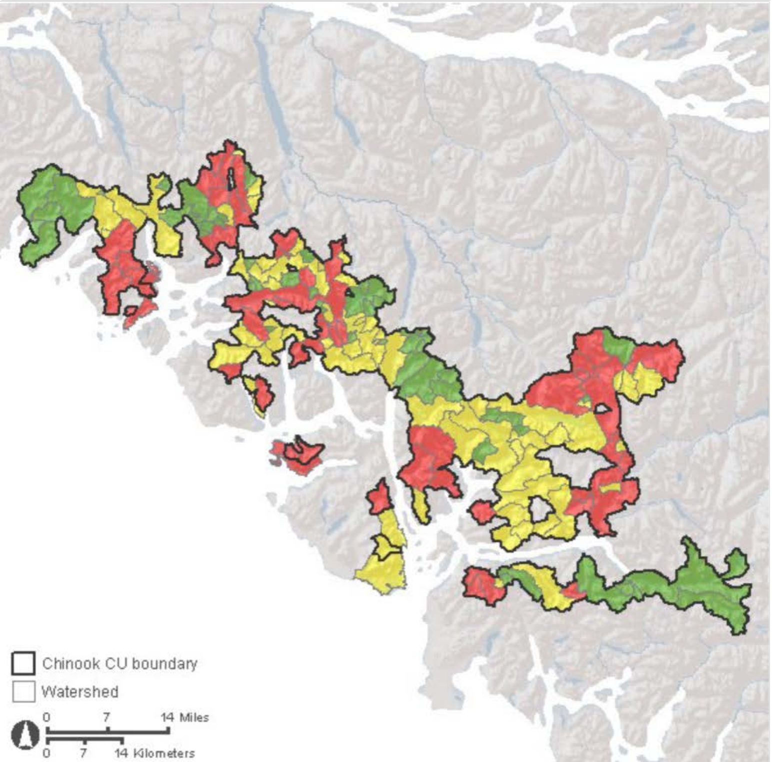
Large lake influence? **Yes**

Flow sensitivity
- Summer & winter
- Summer
- Winter
- No sensitivity

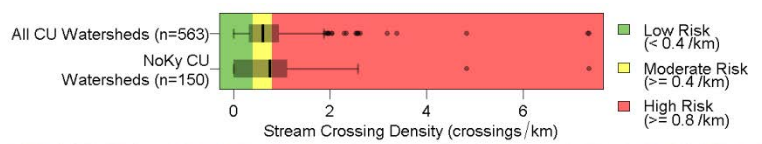


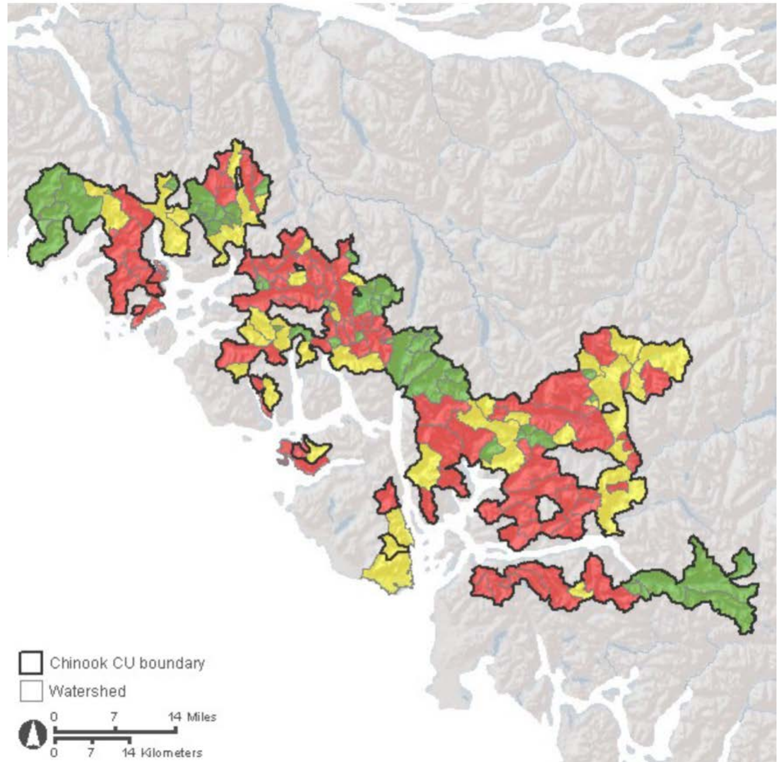
Pressure — Road Development



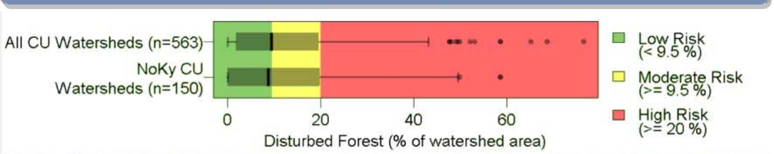


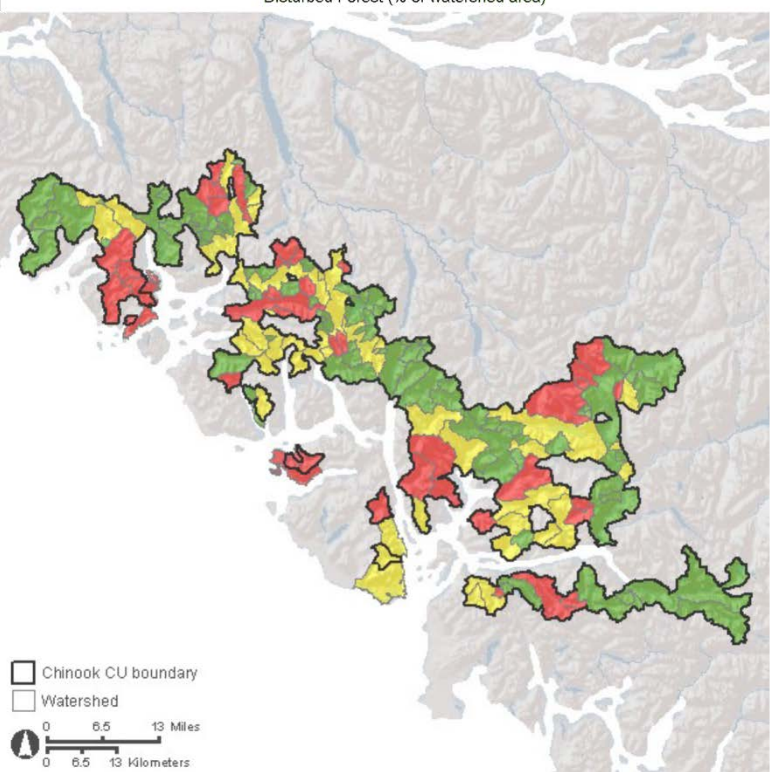
Pressure — Stream Crossing Density



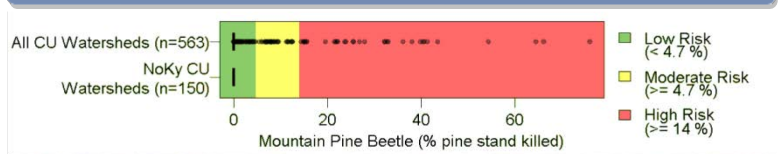


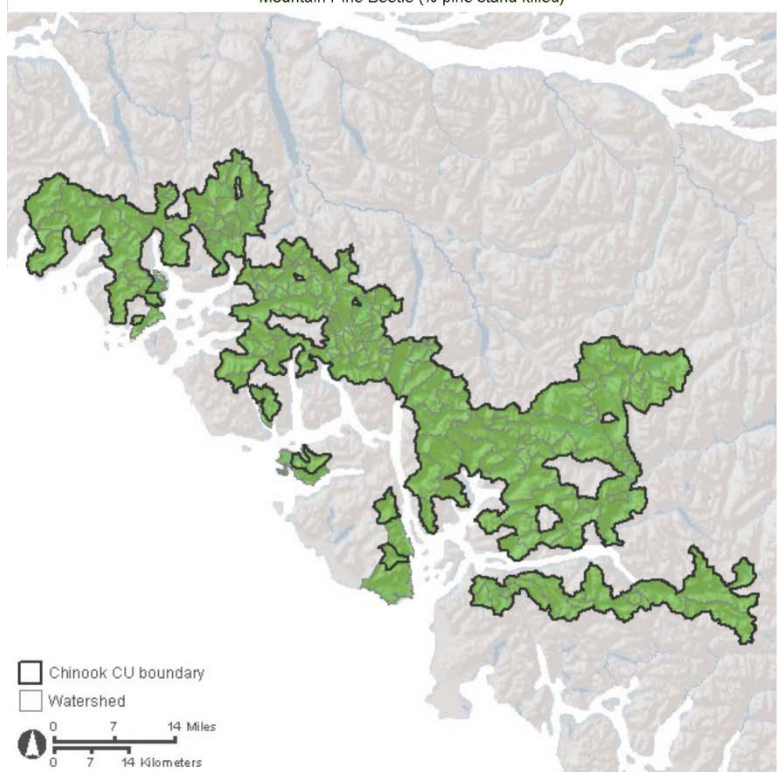
Pressure — Forest Disturbance



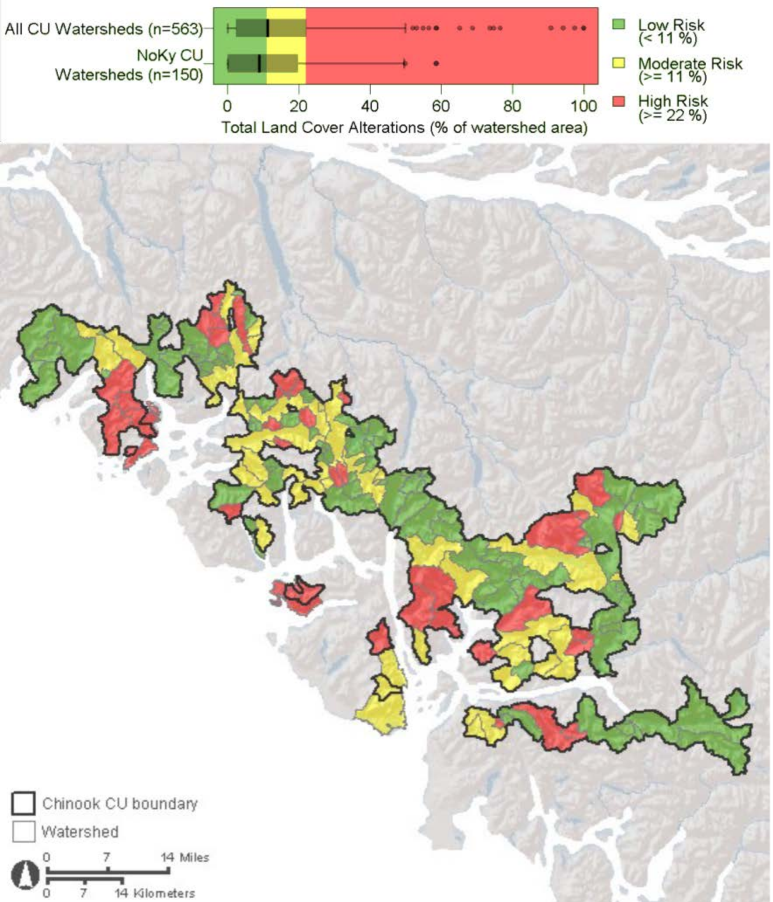


Pressure — Mountain Pine Beetle

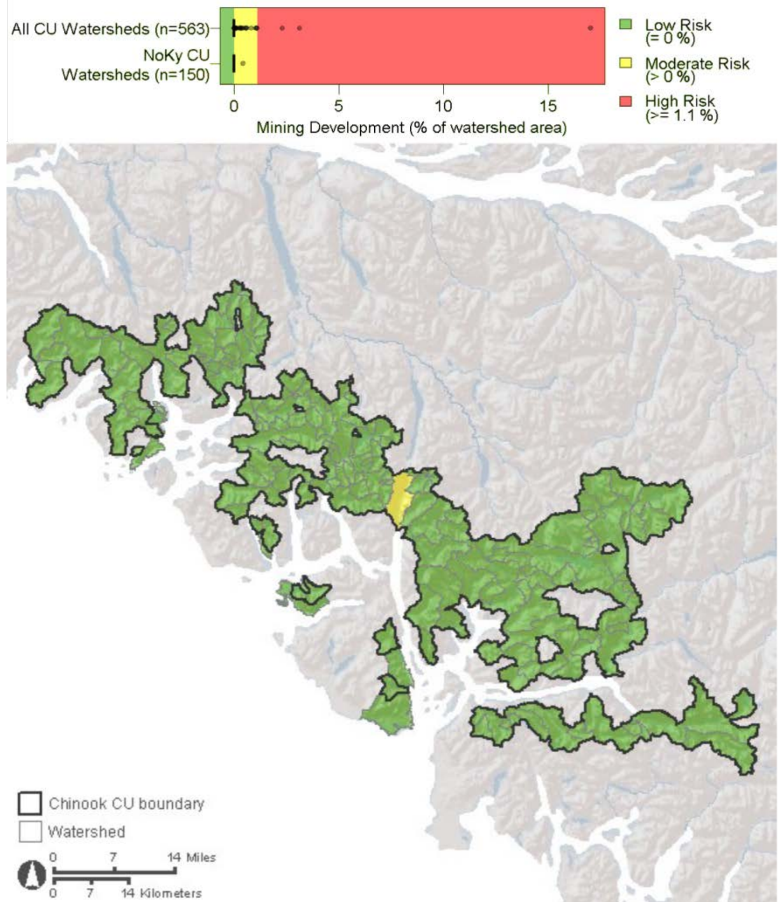




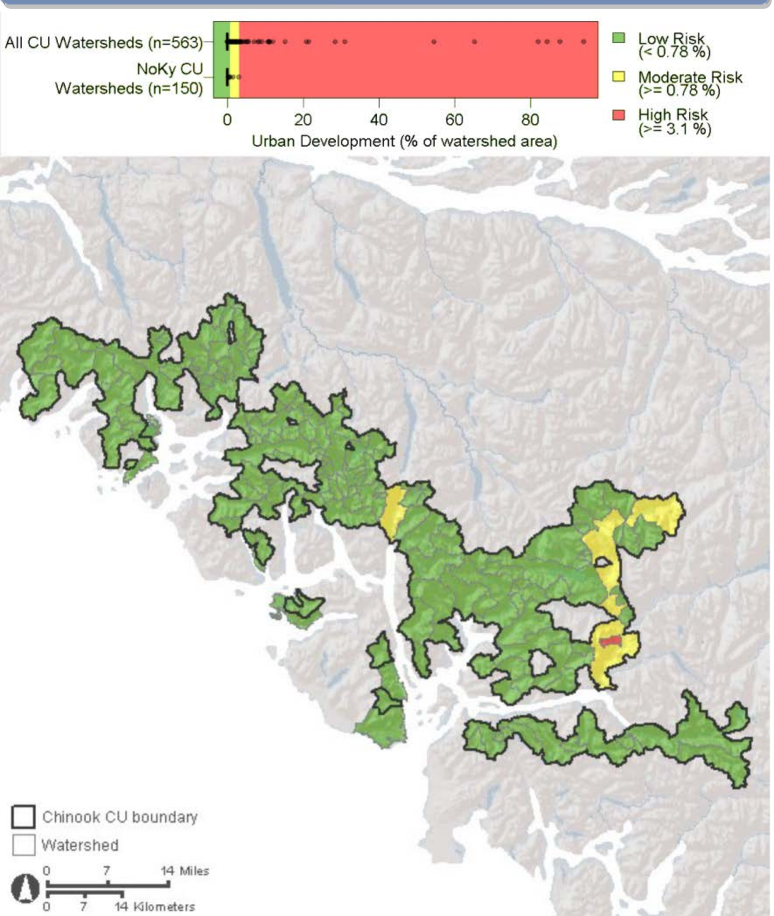
Pressure — Total Land Cover Alteration



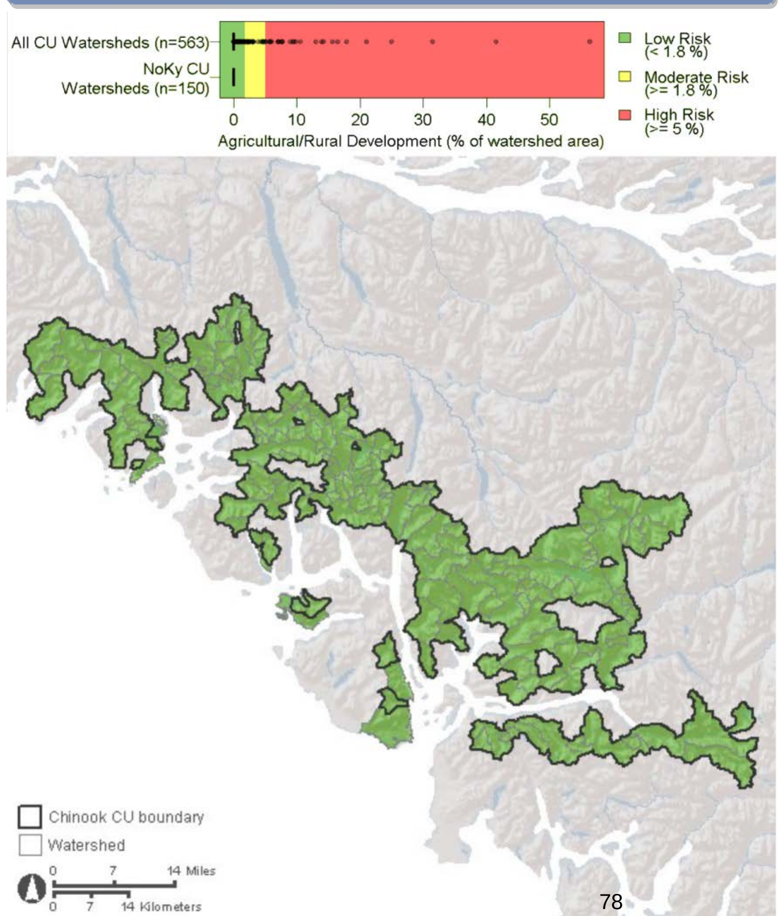
Pressure — Mining Development



Pressure — Urban Development

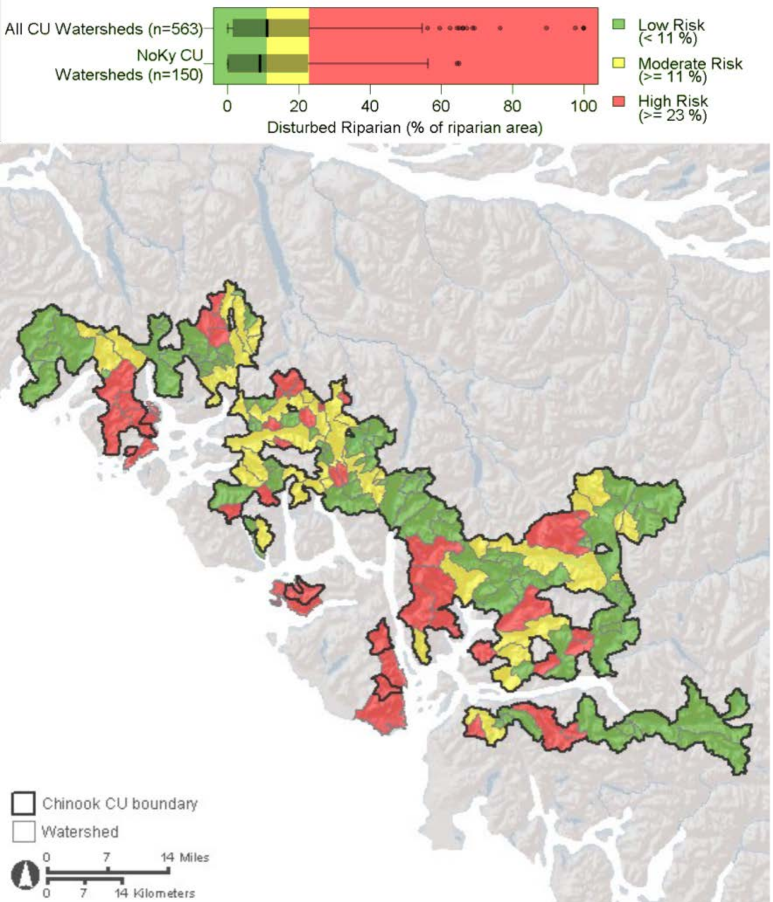


Pressure — Agricultural / Rural Development

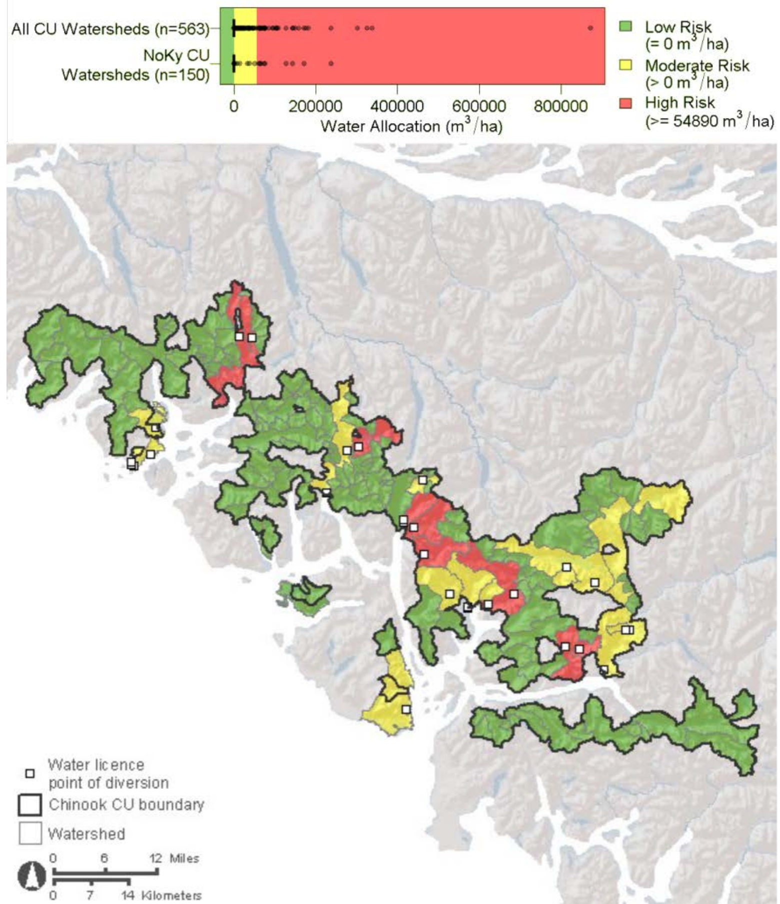


Fisheries and Oceans Canada / Pêches et Océans Canada

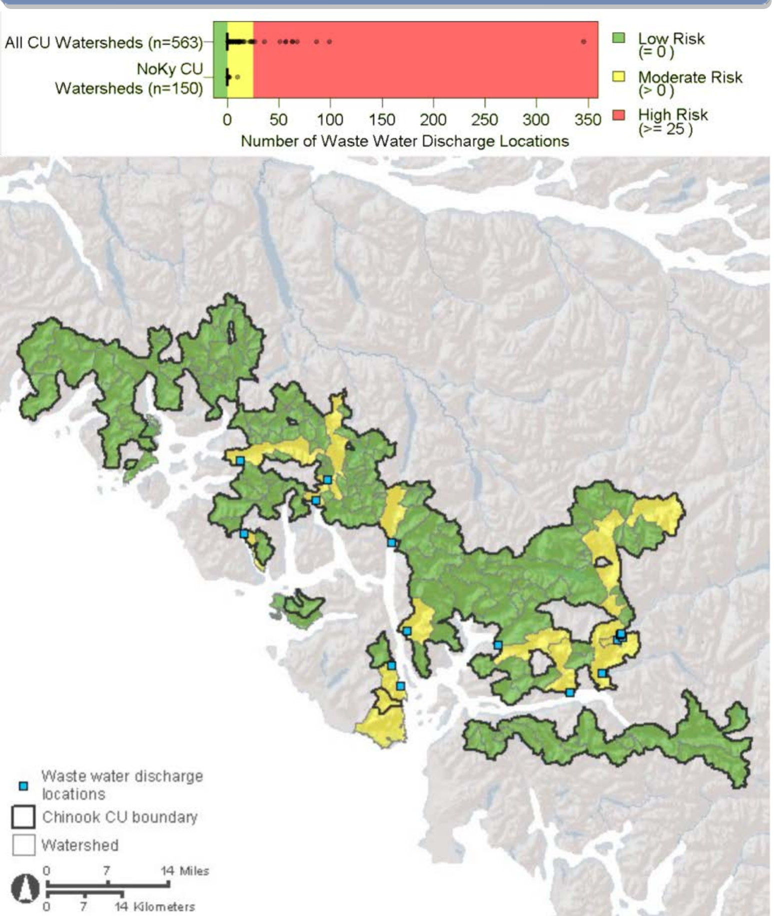
Pressure — Riparian Disturbance



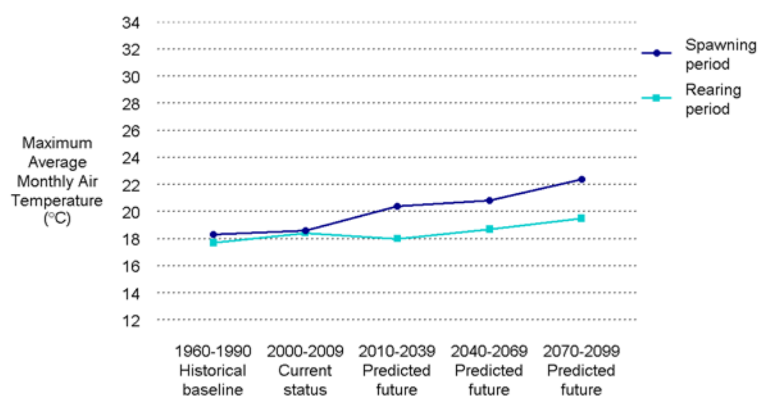
Pressure — Water Allocation



Pressure — Permitted Waste Water Discharges



Climate — Air Temperature (ClimateBC)



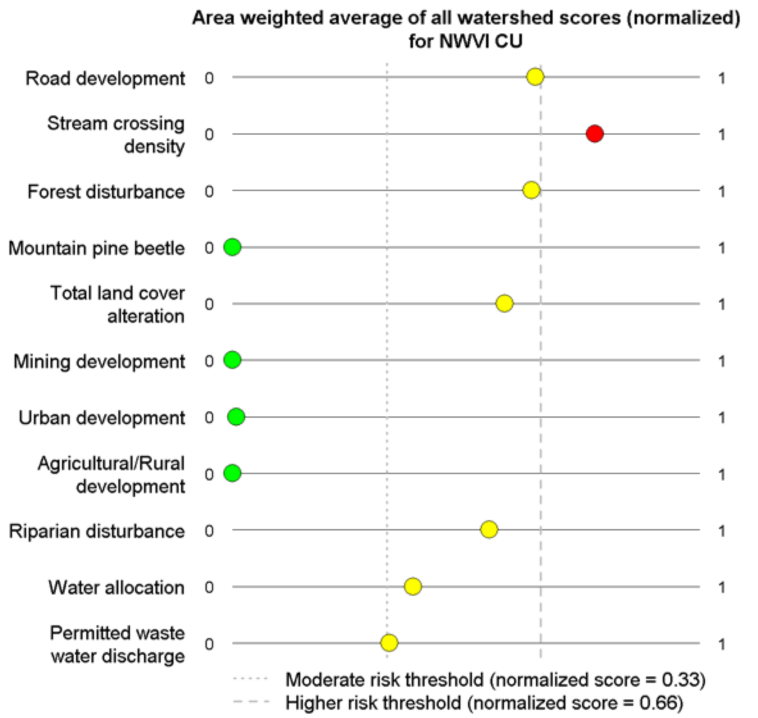
% change in air temperature over historical baseline

	Current	2010-2039	2040-2069	2070-2099
Spawning period	2%	11%	14%	22%
Rearing period	4%	2%	6%	10%

Southern Chinook Conservation Units
CU: Northwest Vancouver Island

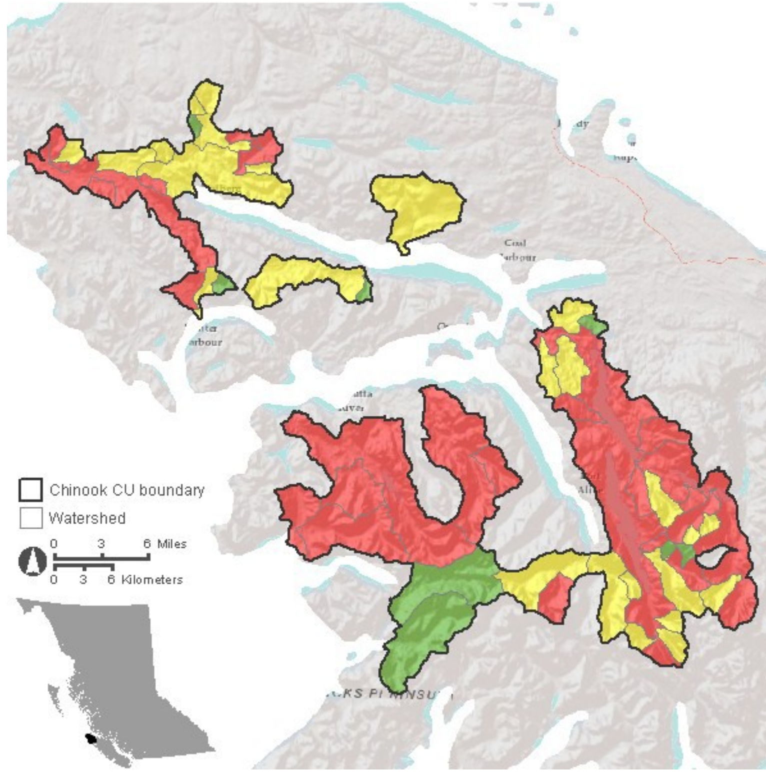
Fisheries and Oceans Canada / Pêches et Océans Canada

CU Overview



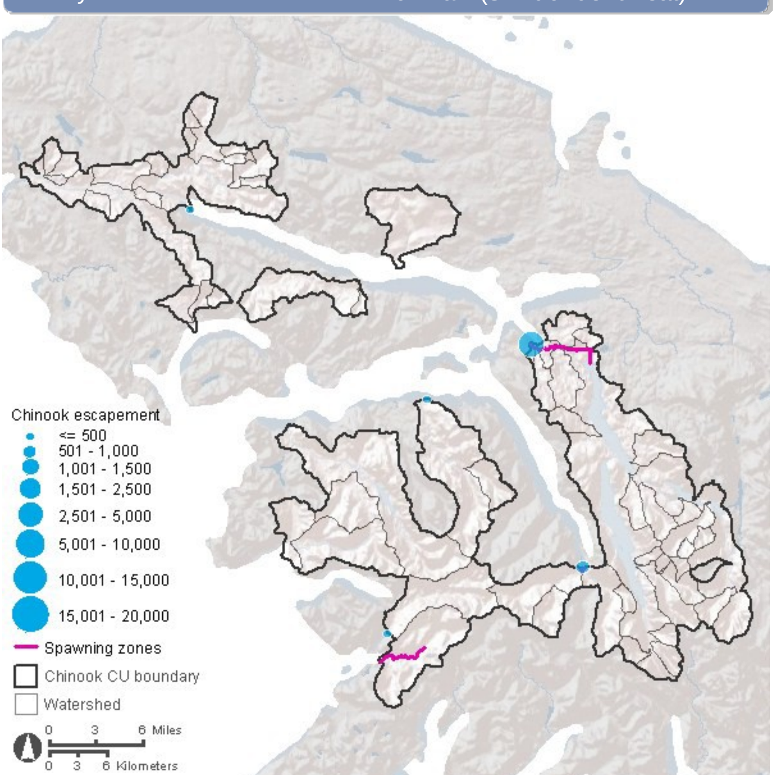
Cumulative Watershed Risk Score (roll up of 5 selected indicators)

Low risk | Moderate risk | High risk



Habitat Quantity

CU spawning length	**16 km**	(**0.6%** of total for all CUs)
CU accessible stream length	**1,619 km**	
Estuary area	**702 ha**	(**8.1%** under threat)

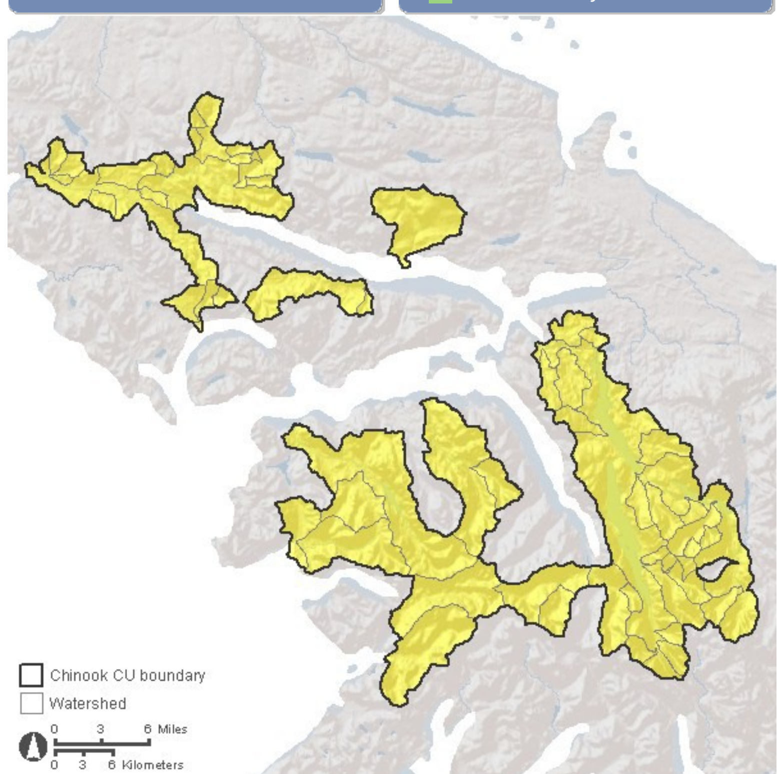


Vulnerability

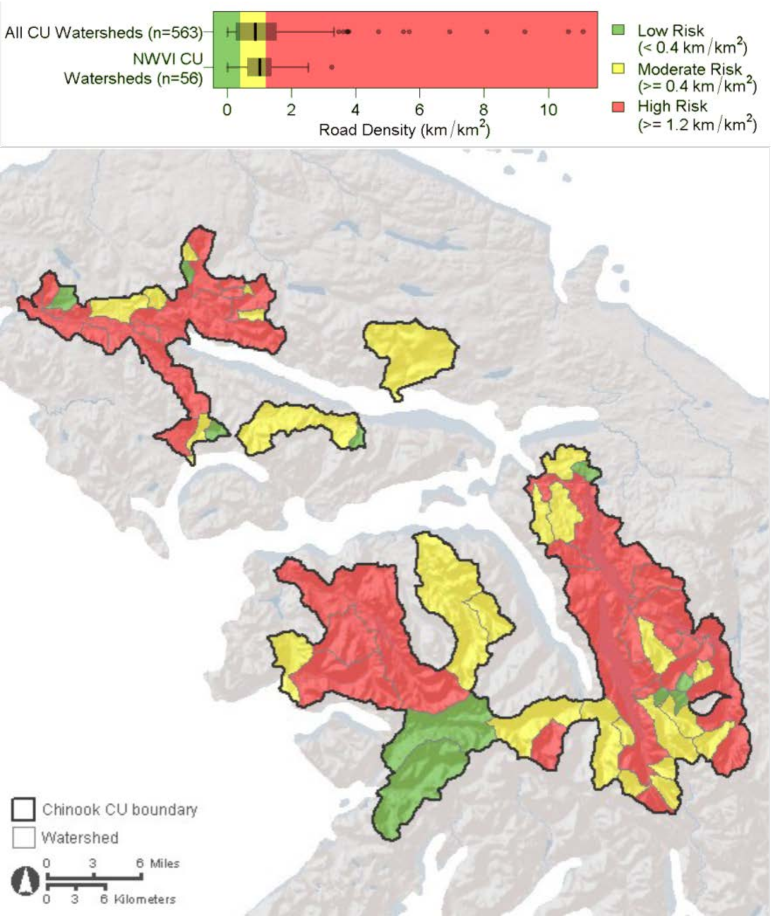
Life history type	**Ocean**
Large lake influence?	**Yes**

Flow sensitivity

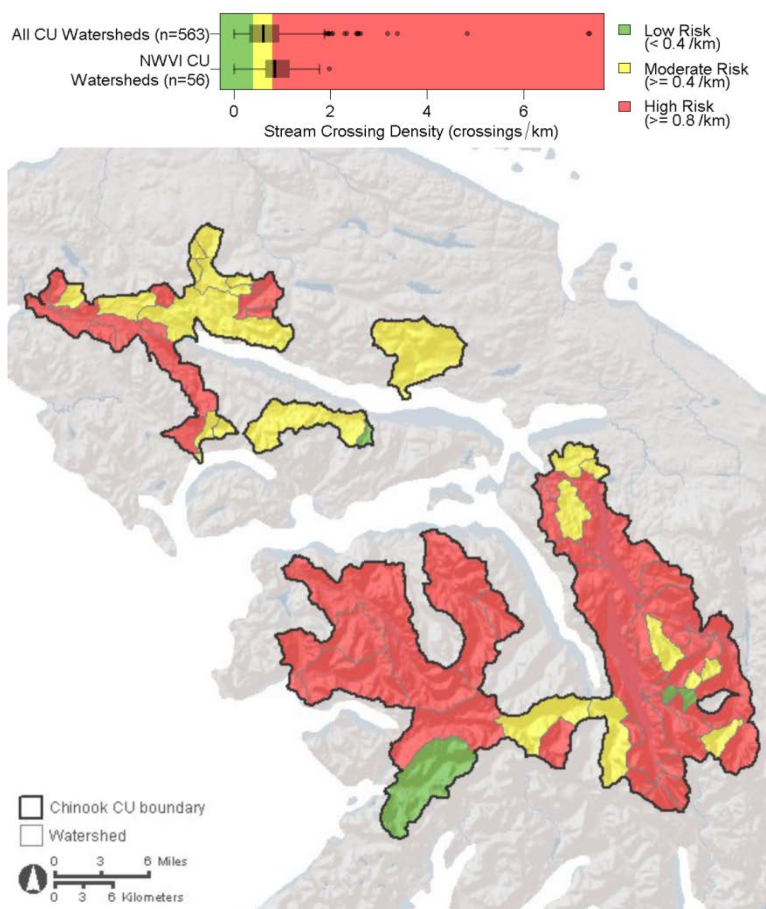
- Summer & winter
- Summer
- Winter
- No sensitivity



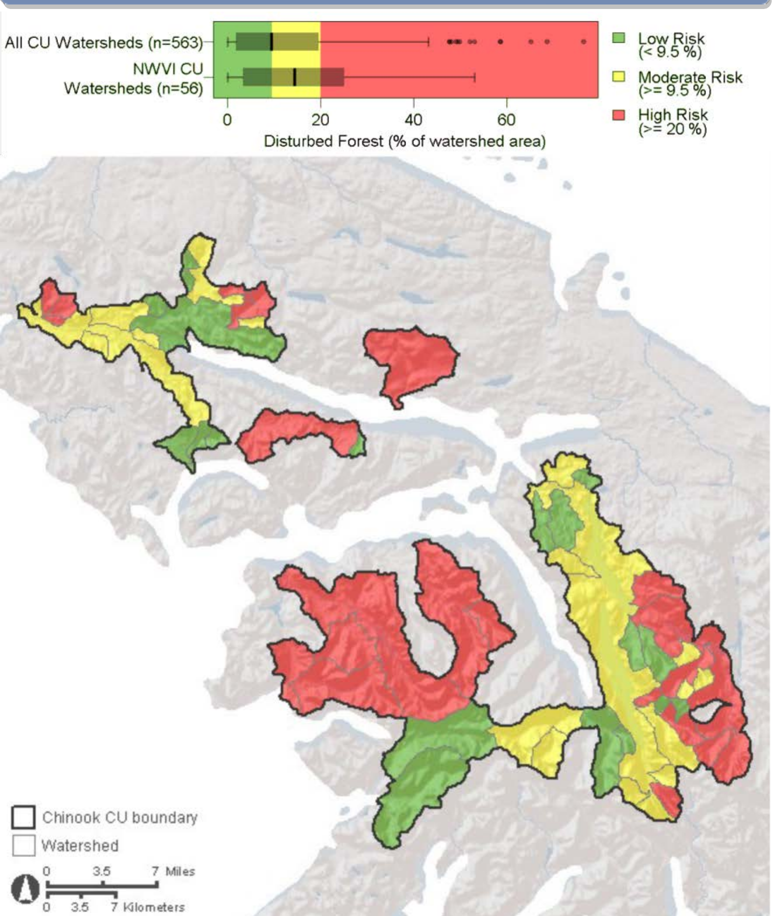
Pressure Road Development



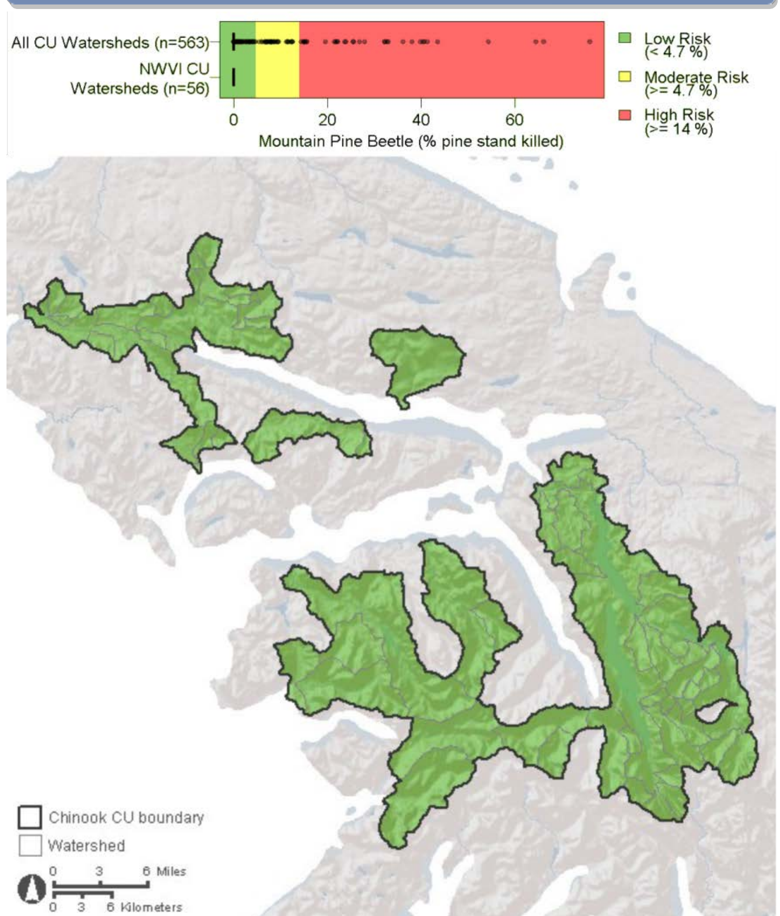
Pressure Stream Crossing Density



Pressure Forest Disturbance

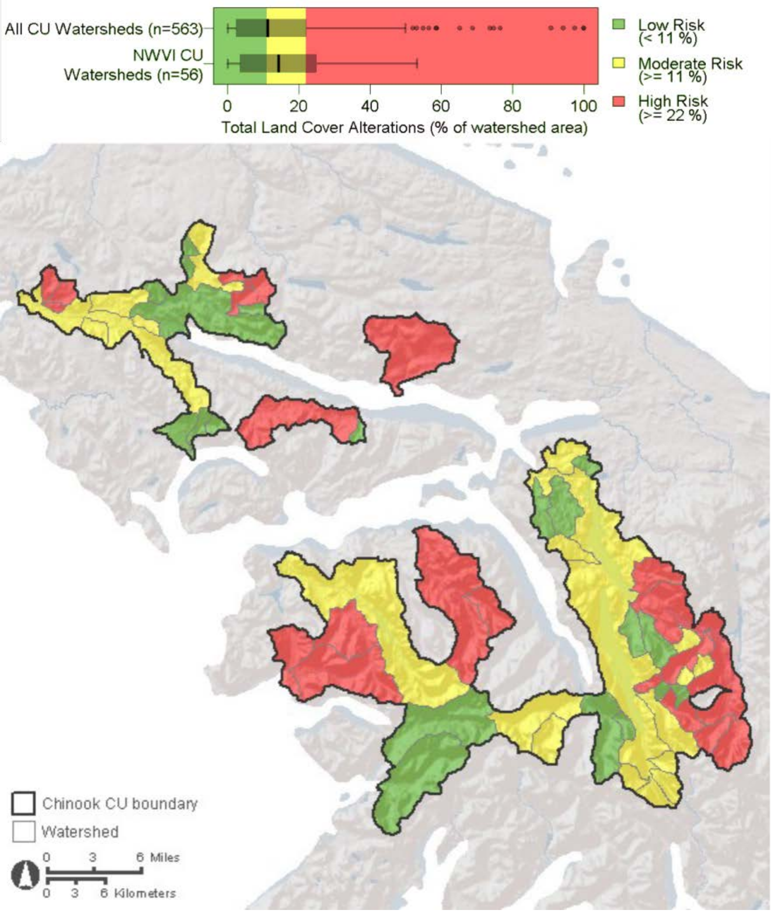


Pressure Mountain Pine Beetle

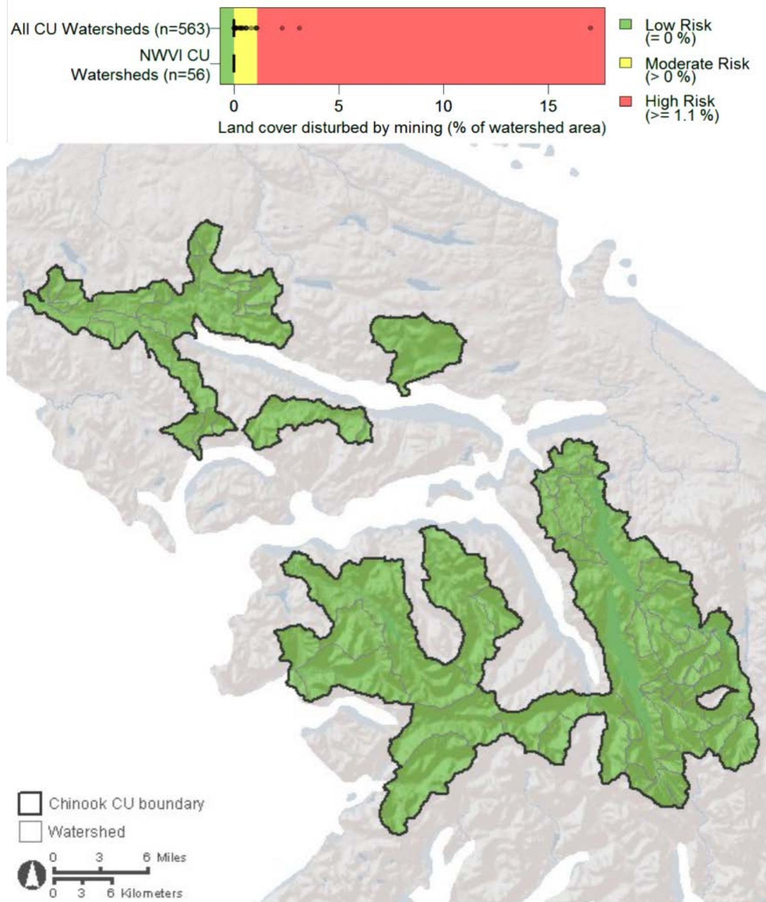


Fisheries and Oceans Canada | Pêches et Océans Canada

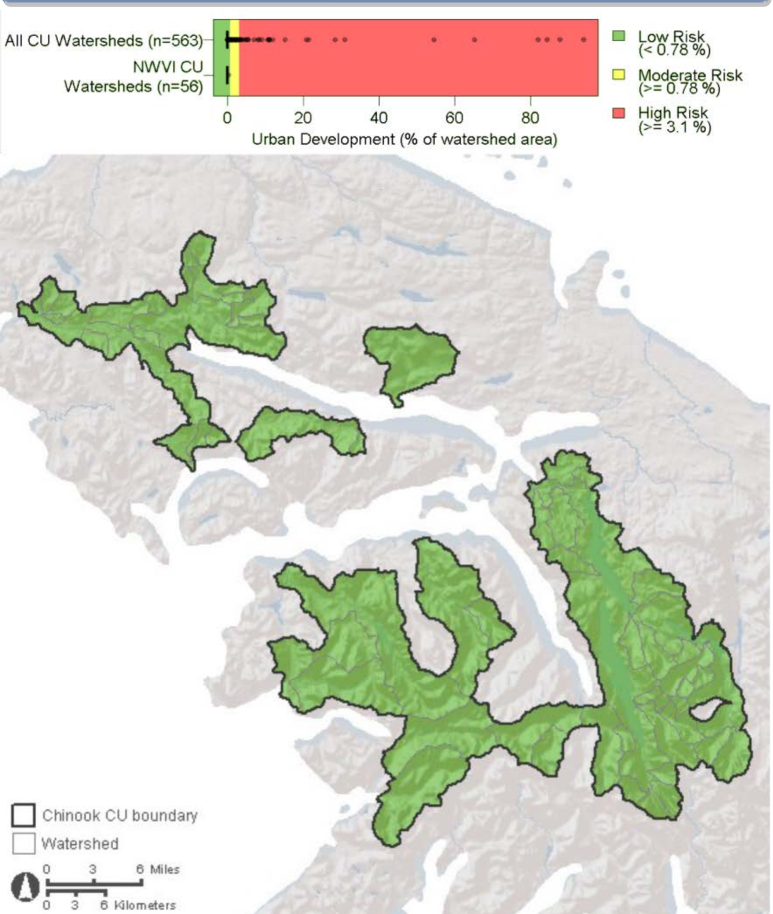
Pressure — Total Land Cover Alteration



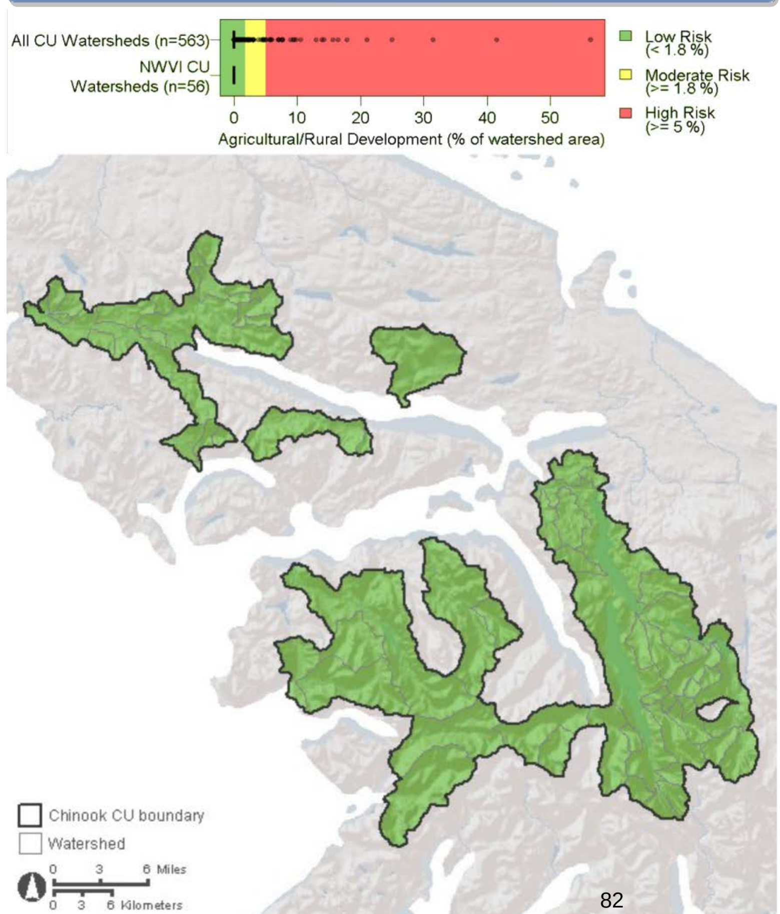
Pressure — Mining Development



Pressure — Urban Development

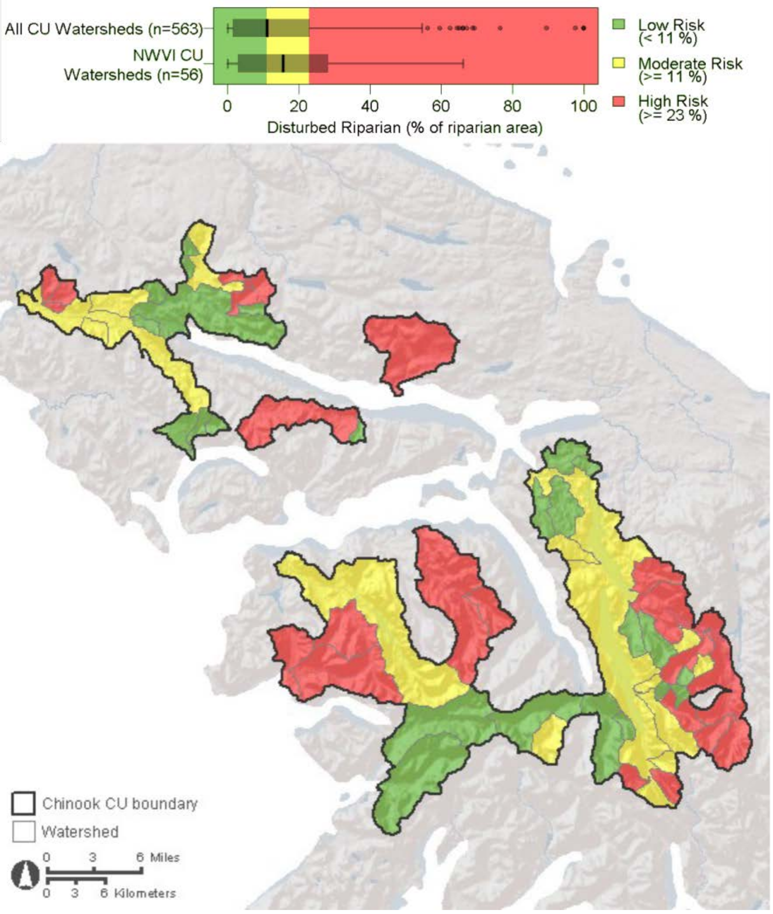


Pressure — Agricultural / Rural Development

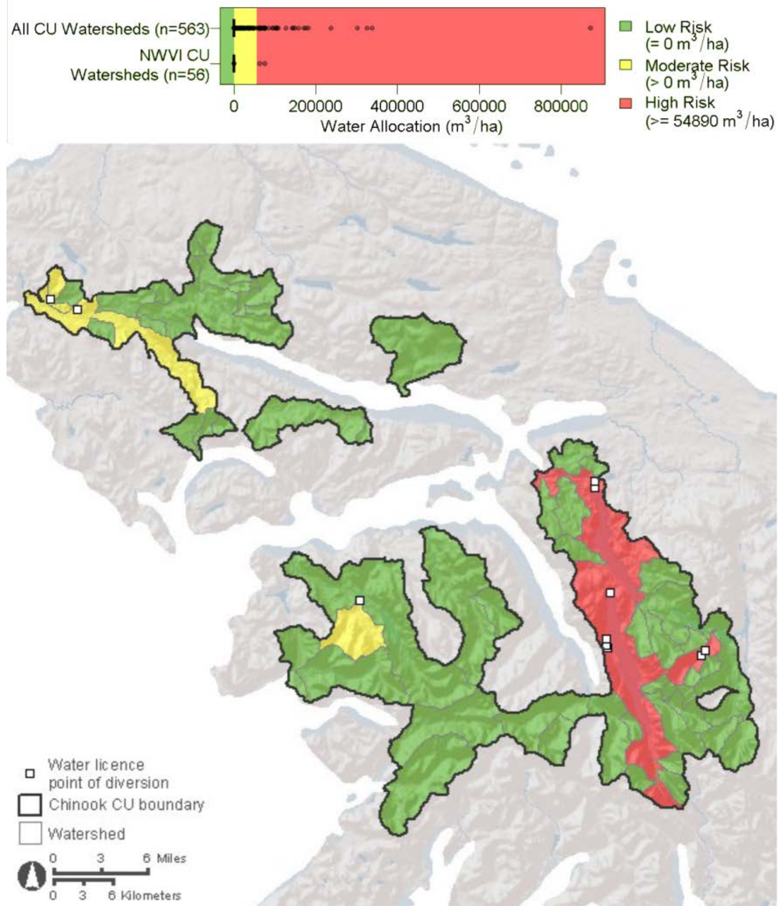


Fisheries and Oceans Canada Pêches et Océans Canada

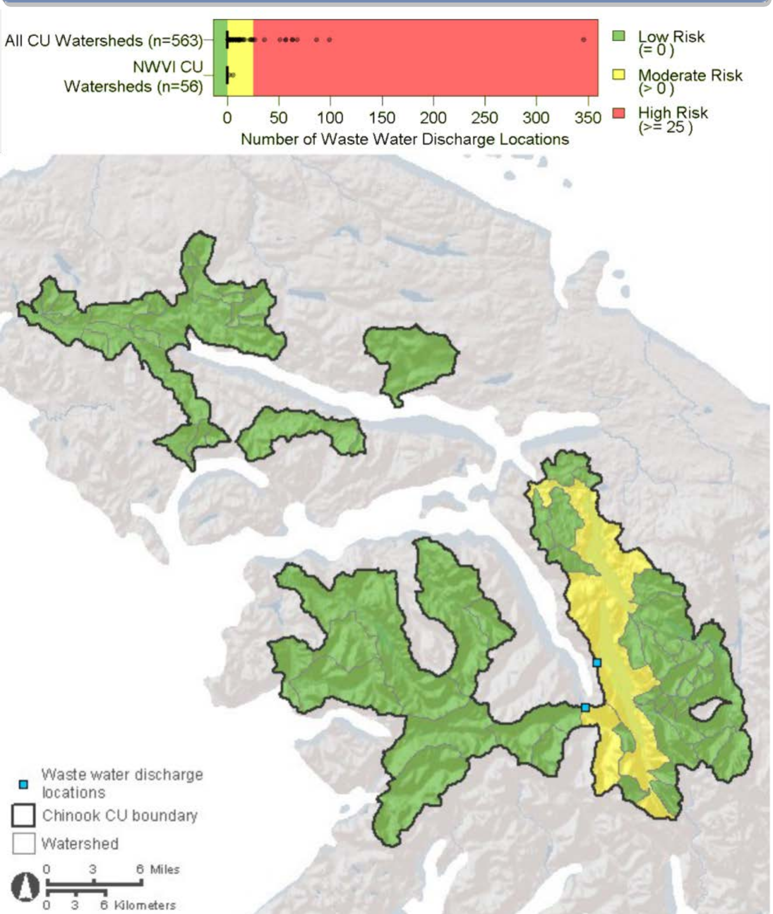
Pressure — Riparian Disturbance



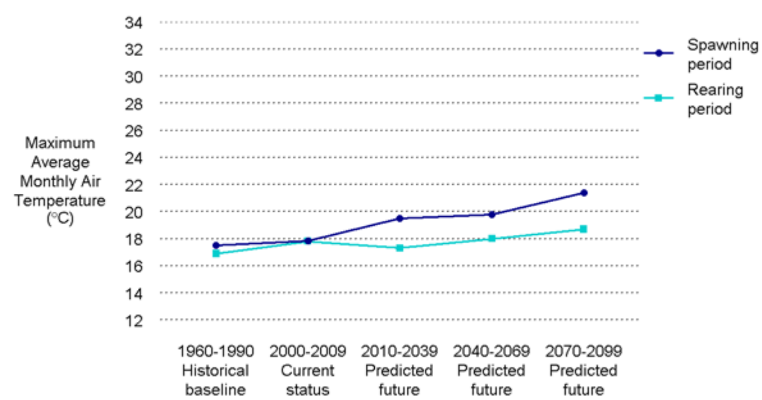
Pressure — Water Allocation



Pressure — Permitted Waste Water Discharges



Climate — Air Temperature (ClimateBC)



% change in air temperature over historical baseline

	Current	2010-2039	2040-2069	2070-2099
Spawning period	2%	11%	13%	22%
Rearing period	5%	2%	7%	11%

Appendix B: Selected Web Resources for Monitoring Practitioners

Introduction

The following web sites contain information useful for planning and implementing habitat and fish monitoring projects. The examples listed span the range of information and activities involved in well-managed monitoring efforts, but they are by no means a complete list of resources available through the Internet. Many of these sites contain links to other information useful for a comprehensive monitoring program.

The sites have been grouped into three categories (methods, data, and reports) depending on the primary type of information found on them. This classification is approximate, however, as many sites contain all three types of information. Within each category, sites are listed alphabetically. It is hoped this organization will foster sharing of information and ideas across agencies and areas. The description of each web site has often been taken directly from it, sometimes edited for completeness and consistency. Any errors in these descriptions are entirely the fault of the author of this Appendix.

Various local stakeholder groups also maintain web sites containing information about habitat restoration activities and status and trends in local watersheds. Their web sites can often be found by searching for *[watershed name]+[species]+restoration.*

Methods and Tools

BC Hydro Fish and Wildlife Compensation Program

http://www.bchydro.com/bcrp/index.html
http://www.bchydro.com/bcrp/about/docs/strategic_plan.pdf
Established in 1999, the goal of the program is to restore fish and wildlife resources that have been adversely affected by the original footprint development of hydroelectric facilities in the Bridge Coastal Generation Area. These footprint impacts include historical effects on fish and wildlife that have occurred as a result of reservoir creation, watercourse diversions and the construction of dam structures. This is accomplished through a competitive grant-awarding process with approximately $1.7 million available annually for eligible projects. Resources available are similar in scale to PSC restoration funds and appropriate monitoring has been a recent topic of interest within that program.

Canada Wild Salmon Policy

http://www.pac.CDFO-mpo.gc.ca/fm-gp/species-especes/salmon-saumon/wsp-pss/docs/barkley-2009-10-15-eng.pdf
The Barkley Pilot introduces the steps required to implement the Canada Wild Salmon Policy within a large watershed (Barkley Sound). The Canada Wild salmon Policy (WSP) maps out six implementation strategies: identification of distinct Conservation Units (CU), assessment of habitat status, inclusion of ecosystem values and monitoring, integrated strategic planning, annual program delivery, and performance review.

Fish-Forestry Interaction Research

http://www.for.gov.bc.ca/hre/ffip/index.htm
An integrated program designed to better understand watershed processes that influence aquatic ecosystems. Watershed scale studies have been done for Bowron River, the Prince George area, Queen Charlotte Islands, Slim-Tumach River, Stuart-Takla Rivers, and Carnation Creek.

ISEMP – Integrated Status and Effectiveness Monitoring Program

http://www.nwfsc.noaa.gov/research/divisions/cbd/mathbio/isemp/index.cfm
The ISEMP develops new and innovative sampling designs, data collection techniques, analysis tools, and data management procedures to inform monitoring programs for ESA listed salmon. These activities are focused in Pilot Basins located throughout the Pacific Northwest.

ISTM – Integrated Status and Trends Monitoring

http://www.pnamp.org/ISTM
The ISTM effort will provide entities tasked with monitoring fish populations and aquatic habitat in the Pacific Northwest with a roadmap for integration of scientifically sound monitoring programs intended to meet the needs of decision-makers and managers. A prototype effort is being conducted in the lower Columbia Basin.

Monitoring and Assessment of Fish Habitat Compensation and Stewardship Projects: Study Design, Methodology and Example Case Studies

http://www.CDFO-mpo.gc.ca/Library/317613.pdf
A three-level strategy for monitoring and evaluating fish habitat compensation and stewardship projects is presented. Basic routine monitoring is applied to stewardship projects and to minor compensation projects (e.g. small riparian planting projects). More rigorous and quantitative site effectiveness monitoring, emphasizing paired before-after control-impact (BACIP) experimental designs, is applied to larger and/or more complex compensation and stewardship projects. The most important principles outlined in this guidebook (establishing measurable objectives, reference and control sites, replication, and pre-impact information) are stressed as key elements upon which to focus any monitoring program. Program effectiveness evaluation, which applies adaptive management methods to studies involving multiple projects, is recommended using standard methods. Four case studies are used to illustrate application of the routine and site effectiveness monitoring methods presented.

Monitoring Resources Web Site

https://www.monitoringresources.org/
This site is being developed by PNAMP. It provides specific descriptions of monitoring programs, protocols, and methods to increase the transparency of what is being done, how, by which agencies, and where. A Monitoring Advisor (http://www.monitoringadvisor.org/) provides a seven-step process to design statistically-sound monitoring projects.

Oregon HABRate Habitat Rating Tool

http://oregonstate.edu/dept/ODFW/freshwater/inventory/habratereg.htm
This is a limiting factors model that assesses the potential quality of stream habitat using stream survey data for each juvenile life stage of salmon and steelhead. The model was developed for a specific application to the middle Deschutes River basin in Oregon, but was intended for general application to Pacific Northwest basins. To paramatize the model, available literature on salmonid habitat requirements was summarized. Habitat criteria are developed for discrete life history stages (i.e. spawning, egg survival, emergence, summer rearing, and winter rearing) and are used to rate the quality of stream reaches as poor, fair, or good, based on attributes relating to stream substrate, habitat unit type, cover, gradient, temperature, and flow. Reach level summaries of stream habitat data are entered into an MS Excel workbook, and are interpreted by a series of algorithms to provide a limiting factor assessment of potential egg-to-fry and fry-to-parr survival for each reach. Model output lists habitat quality by species and life stage for each reach of stream. The model is a decision making tool that is intended to provide a qualitative assessment of the habitat potential of stream reaches within a basin context.

PNAMP – Pacific Northwest Aquatic Monitoring Partnership

http://www.pnamp.org/
PNAMP is a forum for the community of aquatic monitoring practitioners in the Pacific Northwest. PNAMP consists of federal, tribal, and state partners; other interested participants; and a coordinating staff. PNAMP partners conduct aquatic monitoring within the watersheds, estuaries, and coastal zones of the Pacific Northwest. Much emphasis is on species - their abundance, distribution, and habitat - particularly anadromous fishes. PNAMP is a forum to facilitate collaboration around aquatic monitoring topics of interest, promote best practices for monitoring, and encourage coordination and integration of monitoring activities appropriate. The forum's activities are conducted by participant working groups and teams as endorsed by the partner-based steering committee.

Puget Sound PRISM/SHIRAZ Model

http://www.prism.washington.edu/story/Lab+6%3A+SHIRAZ
SHIRAZ (Salmon Habitat Integrated Resource Analysis), is a salmon life-cycle model that incorporates anthropogenic effects into fish-habitat relationships. SHIRAZ was developed under the supervision of UW Fisheries Professor Ray Hilborn. The model allows for future projections of salmon population sizes as affected by habitat variables that are discussed below.

It is important to note that SHIRAZ is closely connected to DHSVM, the distributed hydrology soil-vegetation model (See flowchart below). NOAA (National Oceanic & Atmospheric Administration) is currently using both of these models to predict the effects of anthropogenic factors on the salmon life cycle for Endangered Species Act (ESA) recovery planning.

DHSVM uses land cover, soil, topography, and precipitation to predict stream flow and stream temperature. These two outputs from DHSVM are then used as inputs to drive the SHIRAZ model. SHIRAZ uses information on stream flow & temperature, sediments, and other habitat quality indicators to project future salmon populations by size of stock, life stage, and location.

Status and Trends Monitoring for Watershed Health and Salmon Recovery - Washington State

https://fortress.wa.gov/ecy/publications/publications/0603203.pdf
In response to recommendations from the Governor's Forum on Monitoring, the Washington Salmon Recovery Funding Board funded the development of this quality assurance monitoring plan (*Status and Trends Monitoring Plan*). This plan describes a monitoring program that will provide a consistent, objective picture of the health of stream and river corridor habitat and will detect trends. It will also help policy makers in each region prioritize the environmental features and limiting factors that are in most need of being addressed for protection of watershed health and salmon recovery.

Databases

NHI – Northwest Habitat Institute

http://www.nwhi.org/
The Northwest Habitat Institute (NHI) is a non-profit scientific and educational organization whose mission is to promote and facilitate the conservation of Pacific Northwest native species and habitats through the development and dissemination of data-rich and verifiable information, maps, and tools and the restoration and enhancement of native habitats. The Northwest Habitat Institute focuses on terrestrial condition and data that describes habitat conditions for a wide range of wildlife species.

StreamNet – (Data Queries, Library)

http://www.streamnet.org/
StreamNet is an inter-agency program to share mostly fish data in the Columbia Basin in comparable standard and non-standard formats. It also includes a full-service library focused on fish and habitat information, but specializing in the capture and sharing of technical grey literature information from the Columbia Basin.

Reports

BPA – Bonneville Power Administration

The Bonneville Power Administration is the largest funder of fish and wildlife restoration projects in the Pacific Northwest. BPA maintains two web sites to help it administer and coordinate fish and wildlife restoration projects that it funds. Nearly all of these projects are located in the Columbia River Basin. These sites contain detailed information on project funding and design.

PISCES

*www.efw.**bpa**.gov/contractors/using_**pisces**/get_**pisces**/download/**Pisces**Download.aspx*
PISCES is a project-oriented web site for projects funded by the Bonneville Power Administration under the Northwest Power Act. It contains detailed information on individual projects such as statements of work, project reports and contact information for each project.

TAURUS

http://www.cbfish.org/
Another BPA web site, TAURUS can be used to view project information across years and for groups of related projects.

Canada/ BC Fish Sustainability Plans

http://www.chilliwackwatershedstrategy.ca/ (example)
Watershed based Fish Sustainability Programs tend to focus on informing, educating and engaging the interests that will directly influence habitat status now and in the future. There is a strong social aspect to these programs. The focus of "Fish Sustainability Plans" are to foster good networking opportunities for local decision makers and those wanting to more fully understand and play a role in affecting habitat status and trends in particular watersheds.

Carnation Creek

http://www.for.gov.bc.ca/hre/ffip/CarnationCrk.htm
This is a forty year intensive case study of fish-forestry interactions within a single watershed. Initially, the three principal objectives were 1) to provide an understanding of the physical and biological processes operating within a coastal watershed, 2) to reveal how the forest harvesting practices employed in the 1970s and early 1980s changed these processes, and 3) to apply the results of the study to make reasonable and useful decisions concerning land-use management, and fish and aquatic habitat protection. This project provides long term monitoring of how habitat and salmon population status changes over time in response to short and long term anthropomorphic (logging) disturbances.

Cheakamus River Water Use Monitoring Plan

http://www.bchydro.com/etc/medialib/internet/documents/planning_regulatory/wup/lower_mainland/2011q4/cms_annual_report.Par.0001.File.CMS-Annual-Report-2011-12-16.pdf
The water use planning process for BC Hydro's Cheakamus project was initiated in 1996 and completed in April 2002. Consensus was not achieved at the Consultative Committee table. Some of the conditions proposed in the WUP for the operation of the project reflect the recommendations of the Cheakamus Project WUP Consultative Committee. Additional conditions were included by the Comptroller based on public input following the water use planning process.

OBMEP – Okanogan Basin Monitoring and Evaluation Program

http://www.colvilletribes.com/obmep.php
The Okanogan Basin Monitoring & Evaluation Program (OBMEP) was created in 2004 to improve the resource management infrastructure for the upper Columbia region, the Colville Tribes, our resource management partners and the general public. This was done by implementing and conducting a basin-wide monitoring and evaluation program using a

rigorously-developed and scientifically-based design.

The purpose is to monitor over 20 years the status and trends of components such as physical habitat condition, water quality and quantity, and juvenile and adult fish production in the Okanagan sub basin (CCTFWD 2005). OBMEP is designed to provide long term monitoring of physical and biological indicators to help guide future restoration through an adaptive management process.

This site covers the entire Okanogan River Basin on both sides of the border with Canada. There are numerous reports of their activities and links to partner web sites. Data for the Okanogan River salmon populations are available in the reports. Data are also contained in an Access relational database, although this database is not accessible online.

Oregon Aquatic Inventories Program

http://oregonstate.edu/dept/ODFW/freshwater/inventory/orplan/overview.htm
Monitoring programs under the Oregon Plan for Salmon and Watersheds are designed to assess the status and trends in fish populations and aquatic habitat in Oregon's coastal and lower Columbia River basins. Coordinated site visitations with aquatic habitat surveys, juvenile rearing surveys and adult salmon spawning surveys provide a comprehensive view of freshwater habitat, fish distribution, and abundance of coho salmon and steelhead at juvenile and adult life stages. The sampling framework and panel structure is designed to summarize habitat and population information at the monitoring area scale and at the population scale.

Oregon Salmon and Steelhead Recovery Tracker

http://odfwrecoverytracker.org/
The State of Oregon maintains conservation and recovery plans for populations of salmon and steelhead listed as threatened or endangered under the Endangered Species Act (ESA). These conservation and recovery plans set goals for measurable viability criteria. Analyses of these criteria are reported here. Additional data are also available for download.

Oregon Watershed Enhancement Board

http://www.oregon.gov/OWEB/pages/index.aspx
The Oregon Watershed Enhancement Board (OWEB) is a state agency that provides grants to help Oregonians take care of local streams, rivers, wetlands and natural areas. Community members and landowners use scientific criteria to decide jointly what needs to be done to conserve and improve rivers and natural habitat in the places where they live. OWEB grants are funded from the Oregon Lottery, federal dollars, and salmon license plate revenue. The agency is led by a 17 member citizen board drawn from the public at large, tribes, and federal and state natural resource agency boards and commissions.

Pacific Salmon Foundation Strategic Salmon Recovery Program

http://www.psf.ca/
Promotes watershed- based salmon recovery plans that strive to improve understanding of the current state of salmon and their habitat, biological limits to recovery, local and regional fisheries, and the potential and requirements for recovery. Watershed-scale plans are available for Squamish River, Salmon River (Shuswap Lake), Sakinaw Lake, Rivers and Smith Inlets, Englishman River, and Coldwater River. These plans provide some of the best examples of watershed based analyses and discussions of habitat constraints to salmon production.

PCSRF – Pacific Coast Salmon Recovery Fund

http://webapps.nwfsc.noaa.gov/portal/page?_pageid=34,1&_dad=portal&_schema=PORTAL
Operated by NOAA, the PCSRF web site contains information on fish and habitat restoration projects in Washington, Oregon, Idaho, and California that are funded by the Pacific Coast Salmon Recovery Fund.

Puget Sound Partnership

http://www.psp.wa.gov/
The Puget Sound Partnership is a community effort of citizens, governments, tribes, scientists and businesses working together to restore and protect Puget Sound. Despite its size, *Puget Sound is ecologically delicate;* and while its symptoms of trouble are not easily visible, they are undeniable and getting worse. The charge given to the Puget Sound Partnership by Governor Gregoire and the Legislature is to create a real Action Agenda that turns things around and leads to a healthy Puget Sound. The Action Agenda will prioritize cleanup and improvement projects, coordinate federal, state, local, tribal and private resources, and make sure that participants are working cooperatively. Decisions are based on science, focus on actions that have the biggest impact, and hold people and organizations accountable for results.

USFS – United States Forest Service

The Forest Service operates two habitat monitoring programs on land managed by the Forest Service, Bureau of Land Management and the National Park Service in the Pacific Northwest. The AREMP program (http://www.reo.gov/monitoring/) monitors land west of the crest of the Cascade Mountains in Washington, Oregon and Northern California. The PIBO program (http://www.fs.fed.us/biology/fishecology/emp/) monitors land east of the crest of the Cascade Mountains in Washington, Oregon, Idaho, and Western Montana. Its purpose is to determine whether land management activities are effective in maintaining and restoring the structure and function of riparian and aquatic systems.

Washington State Salmon Recovery Office

http://www.rco.wa.gov/salmon_recovery/index.shtml
The Governor's Salmon Recovery Office was established by the Legislature, through the Salmon Recovery Planning Act, and charged with coordinating a statewide salmon recovery strategy.

Monitoring data must be reliable, pertinent, and scientifically valid. And because monitoring is often difficult and costly, monitoring agencies work together at all levels, sharing data, avoiding duplication, and maximizing everyone's financial investments.
Monitoring is considered so important to success that the federal government requires it of all salmon recovery plans submitted under the Endangered Species Act.

Washington State agencies are following The Washington Comprehensive Monitoring Strategy and Action Plan for Watershed Health and Salmon Recovery. This strategy provides the foundation for coordinating, prioritizing, and standardizing the myriad of monitoring programs and needs across the state.

Appendix C: Salmon Habitat Restoration Practitioners Directory: 'First Level' Contacts

Overview

To better inform habitat restoration practices across the Pacific Salmon Commissions' area of interest (British Columbia, Yukon Territory, and the states of Alaska, Washington, Oregon, and Idaho), the Habitat and Restoration Technical Committee (HRTC) is developing several resources to aid future PSC funding considerations and assist people on the ground trying to foster successful salmon habitat restoration projects.

The purpose of this appendix is to improve information exchange amongst habitat restoration practitioners. Information on salmon habitat restoration issues, projects, and practitioners is abundantly available through the internet. This wealth of information, however, may require significant knowledge and familiarity with habitat restoration topics or specific salmon stocks to address questions at hand. Direct correspondence with informed professionals can often replace or complement internet searches, thereby focusing attention on the specific issues related to habitat restoration under consideration.

The directory identifies key '1st Level' contacts for significant geographical and jurisdictional boundaries within the PSC area of interest who could field inquires related to salmon habitat and restoration of aquatic habitats. Each of the 1st Level Contacts is a resource professional with access to a network of individuals that have additional or project-/area-specific knowledge. These representatives volunteered to serve in a primary contact capacity, and as such may direct questions or interested parties to other colleagues with more specific geographic or biological expertise. This practitioner's directory will be updated annually by the HRTC. It is recommended that it be made available through the PSC website.

British Columbia

The Ecosystem Management Branch (EMB) of the CDFO, has designated staff located throughout BC and the Yukon, who lead many of the efforts to manage, conserve and restore salmon habitats in collaboration with a wide range of partners from government, industry and communities. For individuals or groups interested in salmon habitat restoration, EMB staffs can provide a good "first contact" for local, detailed information on salmon populations, habitat conditions, restoration opportunities, projects or programs already undertaken or under way. Depending on the nature of inquiries, EMB staff may be able to provide additional contacts for queries requiring specialized expertise.

EMB staffs operate out of five Area offices located throughout BC and the Yukon and the CDFO Pacific Region headquarters office located in Vancouver. Within each of these EMB offices there are staff associated with the Salmonid Enhancement Program that are assigned to restoration and community liaison that may be able to provide advice or direct enquiries to others with knowledge or information relating to salmon habitat restoration in their area. In addition, staff in the Habitat Management Program are responsible for managing the regulatory reviews of development projects that may damage fish habitat, some of which may require habitat created, restored, or enhanced to offsets impacts. Habitat Management staff will have information on those compensation projects that have been constructed and evaluated in their geographic area of responsibility.

The Province of BC is the land and water resource management agency for BC while the Yukon Territorial Government is the equivalent in the Yukon. Both these levels of government manage the resources that create fish habitat and have staff in a number of agencies with regional offices located throughout the Province and Territory that may be able to provide information on relevant land and water resources questions or may be directly involved in fish habitat restoration activities.

First Nation groups occupy the entire land base of British Columbia and the Yukon and have significant cultural and economic interests in salmon and their habitat. First Nation organizations can provide important information on salmon resources in their traditional territories and often are involved with or are interested in collaborating on salmon habitat restoration programs. Each of the First Nations Contacts has access to a network of individuals that often may have additional or project-/area-specific knowledge.

For the five areas of the region described above there are a number of distinctive sub areas within those divisions; contacts have been provided for those sub areas.

Alaska

The state of Alaska has a diverse land base managed by numerous federal, state, native corporate, and local entities. These groups and a suite of partners representing a wide range of interests, all lead or contribute to efforts to sustain or restore salmon populations and their habitats. For individuals or groups interested in salmon habitat restoration within Alaska, state and federal staff can provide a good "1st Level Contact" for general or local, detailed information on salmon populations, habitat conditions, restoration opportunities, or existing projects or programs. Depending on the nature of inquiries, these staff may be able to provide additional contacts or relevant information for queries requiring specialized expertise.

Alaska representatives of the HRTC partitioned the state into four primary geographic regions, and then identified key state and federal agencies, within each region and a designated representative from each, to serve in the capacity of 1st Level Contact for questions regarding salmon habitat restoration within Alaska.

Each of the 1st Level Contacts within Alaska has access to a network of individuals that have additional or project-/area-specific knowledge. These representatives volunteered to serve in a primary contact capacity, and as such may direct questions or interested parties to others with more specific geographic, biological, or restoration expertise.

Washington

Within the State of Washington lands are managed by the federal, state, and numerous tribal and local governments. These governments and a suite of partners representing a wide range of interests lead or contribute to efforts to sustain or restore salmon populations and their habitats. Management of most anadromous salmonid fishery resources in Washington is under the joint authority of tribal and state managers, with the federal government having a key role for units listed under the Endangered Species Act. The directors of the salmon recovery regional organizations, under the Governor's Salmon Recovery Office are listed as 1st level contacts because they coordinate much of the structure that organizes the diverse salmon recovery groups in the state, including local watershed recovery groups. We have also listed key contacts from tribal organizations and the federal government.

Oregon

Stream and estuary restoration in Oregon is coordinated and funded through the Oregon Watershed Enhancement Board (OWEB); a state agency that provides grants to help Oregonians take care of local streams, rivers, wetlands and natural areas. OWEB grants are funded from the Oregon Lottery, federal dollars, and salmon license plate revenue. OWEB offers a variety of grant types and programs. In the Columbia River system, the Fish and Wildlife Program of the Northwest Power and Conservation Council (NPCC) funds restoration in main stem Columbia River, tributaries, and estuary.

The Fish & Wildlife Program of the NPCC is a long-term ecological restoration program and its partners, NOAA Fisheries and the Columbia River Inter-Tribal Fish Commission support long term ecological restoration programs in the Columbia River basin. Funding for the program comes from Bonneville Power Administration for restoration of anadromous salmon and steelhead, resident fishes, wildlife and their habitats.

NOAA Fisheries and Oregon Department of Fisheries and Wildlife have published recovery and conservation plans that cover resident and anadromous fish in the Columbia basin, coast, and interior Oregon.

Columbia River Basin

There are 16 tribal groups in the Columbia River Basin with fish and wildlife management responsibilities. The ceded areas of these tribes, where they have management responsibilities, encompass more than 25% of the Basin, an area larger than the State of Georgia. The ceded area has diverse lands managed by numerous federal, state, tribal and local governments. These groups and a suite of partners representing a wide range of interests lead or contribute to efforts to sustain or restore salmon populations and their habitats. For individuals or groups interested in salmon habitat restoration programs and projects of the tribes, staff can provide a good "1st Level Contact" for general or local, detailed information on salmon populations, habitat conditions, restoration opportunities, or existing projects or programs. These staff may be able to provide additional contacts or relevant information for queries requiring specialized expertise.

Practitioner's Directory

State / Province	Region / Subarea	Organization or Entity	Contact(s)	Email / Phone
Canada	Lower Fraser	CDFO (RRU) CDFO (HM East) CDFO (HM West) FN	Dave Nanson Craig Sciankowy Brian Naito Mike Staley	Dave.Nanson@CDFO-mpo.gc.ca Craig.Sciankowy@CDFO-mpo.gc.ca Brian.Naito@CDFO-mpo.gc.ca mstaley@mstaley.com
	South Coast	CDFO (RRU) CDFO (HM) FN (W. Vanc. Island) FN (Atlegay)	Margaret Wright Nick Leone Roger Dunlop Kelsey Campbell	Margaret.Wright@CDFO-mpo.gc.ca Nick.Leone@CDFO-mpo.gc.ca Roger.Dunlop@nuuchahnulth.org
	B.C. I. N.	CDFO (RRU) CDFO (HM) FN FN	Judy Hillaby Byron Nutton GordSterritt Pete Nicklin	Judy.Hillaby@CDFO-mpo.gc.ca Byron.Nutton@CDFO-mpo.gc.ca G.Sterritt@nstq.org indiseaent@shaw.ca
	B.C.I. S.	CDFO (RRU) CDFO (HM) FN	Sean Bennett Mike Crowe Howie Wright	Sean.Bennett@CDFO-mpo.gc.ca Michael.Crowe@CDFO-mpo.gc.ca hwright@syilx.org
	North Coast	CDFO (RRU) CDFO (HM) FN (HaidaGwaii) FN (Skeena ,BC Central Coast) FNNassFN BC Trans Boundary	Lana Miller Joy Hillier Russ Jones DavideLatremouille Allen Gottesfeld Harry Nyce Cheri Frocklage	Lana.Miller@CDFO-mpo.gc.ca Joy.Hillier@CDFO-mpo.gc.ca russ.jones2@gmail.com dlatremouille@skeenafisheries.ca gottesfeld@skeenafisheries.ca eagle1@nisgaa.net tahltan_fisheries@xplornet.com
	Yukon	CDFO (RRU) CDFO (HM) FN	Sean Collins Linaya Workman	Sean.Collins@CDFO-mpo.gc.ca workman@northwestel.net
	Pacific Region	CDFO (RHQ) CDFO (HM RHQ-HCM) CDFO (HM RHQ- WSP) FN	Karl Wilson Dave Carter Melody Farrell Howie Wright	Karl.Wilson@CDFO-mpo.gc.ca Dave.Carter@CDFO-mpo.gc.ca Melody.Farrell@CDFO-mpo.gc.ca hwright@syilx.org

State / Province	Region / Subarea	Organization or Entity	Contact(s)	Email / Phone
British Columbia	Provincial HQ (Victoria) and Vancouver (UBC Office)	Ministry of Environment (MOE) MOE MOE Ministry of Forests, Lands & Natural Resource Operations (FLNRO) FLNRO	Greg Wilson Peter Tschaplinski Jordan Rosenfeld Ian Miller Tom Johnston	Greg.Wilson@gov.bc.ca (250) 387-9586 Peter.Tschaplinski@gov.bc.ca (250) 387-8082 Jordan.Rosenfeld@gov.bc.ca (604) 222-6762 Ian.C.Miller@gov.bc.ca (250) 387-8398 Tom.Johnston@gov.bc.ca (604) 222-6754
	West Coast Region	FLNRO	Mike McCulloch	Mike.McCulloch@gov.bc.ca (250) 751-7224
	South Coast Region	FLNRO	Kenji Miyazaki	Kenji.Miyazaki@gov.bc.ca (604) 586-5652
	Omineca Region	FLNRO	Ted Zimmerman Cory Williamson Ray Pillipow	Ted.Zimmerman@gov.bc.ca (250) 614-9904 Cory.Williamson@gov.bc.ca (250) 614-9924 Ray.Pillipow@gov.bc.ca
	Skeena Region	FLNRO FLNRO	Dana Atagi Mark Beere	Dana.Atagi@gov.bc.ca (250) 847-7290 Mark.Bere@gov.bc.ca (250) 847-7297
	Northeast Region	FLNRO	Brendan Andersen	Brendan.Andersen@gov.bc.ca (250) 751-3152
	Cariboo Region	FLNRO	Mike Ramsay	Mike.Ramsay@gov.bc.ca (250) 389-4546
	Thompson/Okanagan Region	FLNRO FLNRO FLNRO	Andrew Klassen Steve Maricle Tara White	Andrew.Klassen@gov.bc.ca (250) 371-6237 Steve.Maricle@gov.bc.ca (250) 371-6253 Tara.White@gov.bc.ca (250) 490-2287

State / Province	Region / Subarea	Organization or Entity	Contact(s)	Email / Phone
Alaska	Southeast (non-federal lands) --	ADFG NOAA/NMFS USFWS USFS - Tongass	Jeff Nichols K Koski Neil Stichert Don Martin	Jeff.Nichols@alaska.gov; (907) 465-8576 k.koski@noaa.gov; (907) 586-7471 Neil_Stichert@fws.gov; (907) 780-1180 dmartin02@fs.fed.us; (907) 586-8712
	Prince William Sound	ADFG ADFG NOAA/NMFS USFWS	Dean Hughes Amber Bethe Erika Ammann Cecil Rich	Dean.Hughes@alaska.gov; (907) 267-2207 Amber.Bethe@alaska.gov; (907) 267-2403 Erika.Ammann@noaa.gov (907) 271-5118 Cecil_Rich@fws.gov; (907) 786-3510
	South Central	ADFG ADFG NOAA/NMFS USFWS	Dean Hughes Amber Bethe Erika Ammann Cecil Rich	Dean.Hughes@alaska.gov; (907) 267-2207 Amber.Bethe@alaska.gov; (907) 267-2403 Erika.Ammann@noaa.gov (907) 271-5118 Cecil_Rich@fws.gov; (907) 786-3510
	Interior	ADFG ADFG USFWS NOAA/NMFS	Dean Hughes Amber Bethe Mitch Osborne Erika Ammann	Dean.Hughes@alaska.gov; (907) 267-2207 Amber.Bethe@alaska.gov; (907) 267-2403 Mitch_Osborne@fws.gov; (907) 456-0209 Erika.Ammann@noaa.gov (907) 271-5118

State / Province	Region / Subarea	Organization or Entity	Contact(s)	Email / Phone
Oregon	Statewide	Oregon Watershed Enhancement Board (OWEB)	General contact	www.oregon.gov/oweb 503-986-0178
	Coast and Lower Columbia basins	ODFW	Joseph Sheahan Kim Jones Lora Tennant	Joseph.E.Sheahan@state.or.us (503)-947-6091 Kim.jones@oregonstate.edu (541)-757-5129 Lora.tennant@oregonstate.edu
	Oregon North Coast (Siuslaw to Necanicum)	OWEB	Tom Shafer	tshafer@peak.org (541)-528-7451
	Oregon South Coast; Umpqua basin	OWEB	Mark Grenbemer	grenbemer.mark@deq.state.or.us (541)-776-6062
	Willamette Basin	OWEB	Wendy Hudson	wendy.hudson@state.or.us (503)-986-0061
	Lower Columbia (Estuary – Hood River)	Cowlitz Tribe Warm Springs Tribes	 Chris Burn	
	Central Oregon – Deschutes, Great Basin	OWEB Warm Springs Tribes	Rick Craiger Jennifer Graham	SL00015@bendbroadband.com (541)-923-7353 jgraham@wstribes.org (541) 553-2416
	Northeast Oregon	OWEB Umatilla Tribes	Karen Leiendecker Gene Shippentower	karenoweb@eoni.com(541)-786-0061 geneshippentower@ctuir.com (541) 429-7287
	Mid-Columbia – John Day	OWEB Warm Springs Tribes	Sue Greer Brad Houslet	Sue.greer@state.or.us (541) 384-2410 Brad.houslet@wstribes.org (541) 553-2039

State / Province	**Region / Subarea**	**Organization or Entity**	**Contact(s)**	**Email / Phone**
Idaho	Clearwater / Salmon	IDFG Nez Perce Tribe	 Ira Jones	 iraj@nezperce.org (208) 843-3014
Washington	Puget Sound	Puget Sound Partnership WDFW NWIFC	Jeanette Dorner	(360) 464-2006 jeanette.dorner@psp.wa.gov
	Hood Canal	Hood Canal Coordinating Council	Richard Brocksmith	(360) 531-2166 rbrocksmith@hccc.wa.gov
	Washington Coast	Washington Coast Sustainable Salmon Partnership WDFW Makah Quillayute Quinault Hoh	J. Miles Batchelder	(360) 289-2499 milesb@wcssp.org
	Upper Columbia	Upper Columbia Salmon Recovery Board WDFW Yakama Nation Colville Tribes	Julie Morgan Keely Murdoch John Arteburn	(509) 662-4710 keely@mid-columbia-coho.net (509) 548-2206 John.arterburn@colvilletribes.com (509) 422-7424
	Mid Columbia	Yakima Basin Fish and Wildlife Recovery Board WDFW Yakama Nation	Alex Conley Bill Bosch – Yakima R. Bill Sharp – Klickitat R.	(509) 453-4104 bbosch@yakama.com (509) 865-6293 sharp@yakama.com (509) 865-6293

Appendix D: List of considerations for developing EF proposals

Background for Development of Restoration Proposals to Southern and Northern Fund guidelines:

- ☐ Development of improved information for resource management, including better stock assessment, data acquisition, and improved scientific understanding of limiting factors affecting salmon production in the freshwater and marine environments;
- ☐ Rehabilitation and restoration of marine and freshwater habitat, and improvement of habitat to enhance productivity and protection of Pacific Salmon

Projects should foster and enhance mutual and sustainable fishery benefits to either or both Parties' fisheries and, over the long term, the fund should provide equitable benefits to the Parties to the Pacific Salmon Treaty. The potential benefit of each proposed habitat restoration project will be evaluated using the following definitions: 1) the potential contribution to the fisheries or the expected level of production increase resulting from the project; 2) the amount of habitat restored or made accessible; 3) the potential to reduce impact or improve productivity of constraining stocks; or 4) the potential to address social or cultural values. The potential benefit will be ranked as low, medium, or high in relation to the level of conservation concern and fishery relevance.

Restoration projects that address habitat and other non-fishing factors which limit the production of priority stocks will receive higher ranking. Priority stocks in this context are stocks of conservation concern or fishery relevance as identified by the Pacific Salmon Commission or member panels. The fund committees will consider projects vital to the production of salmon that protect and restore salmon habitat, maintain adequate water quality and quantity, or acquire relevant scientific information to guide decision-making and evaluation. Examples of such projects include:

a) Improve habitat project planning, priority setting and feasibility studies, including habitat inventory and mapping.

b) Assist water use planning, water flow conservation, augmentation and water quality improvements.

c) Implement modifications of in-stream habitat to improve productivity e.g. large woody debris structures, spawning gravel placement, boulder clusters and bank stabilization.

d) Construct side channels and other off-channel habitat, including spawning and rearing channels or ponds, oxbow reconnection, dike breaching, etc.

e) Restore salmon habitat in estuaries by re-establishing eelgrass beds, restoring or reclaiming salt water marsh benches, etc.

f) Restore fish passage through such things as culvert removal / replacement, remediation of barriers to migration.

g) Restoring and protecting riparian and upland habitat, through activities such as livestock exclusion fencing, riparian re-vegetation and re-planting, upland sediment source remediation, conservation easements, etc.

h) Monitor habitat restoration projects to evaluate results.

Recommendations for Habitat Restoration Proposals

The following outline describes non-budgetary elements that should be addressed in a proposal for habitat restoration. The items build a spatial, ecological, and geomorphic context for justifying the proposed restoration, and the elements essential for evaluating the proposal.

1. Abstract
    a. Project location (Stream, basin, river kilometer)
    b. Watershed issue or problem
    c. Proposed solution including area or unit to be restored
    d. Identify any proposed effectiveness monitoring, or baseline data collection that will occur that will allow an opportunity to assess pre- and post-implementation results??
    e. How will funds be used
2. Project partners
3. Contextual Overview
    a. Provide the location and significance of the project including why that location was chosen and a brief explanation of the history of the issues leading to the project.
    b. Display the location of the restoration project. Include a map of the project site in its regional setting, the river basin, and site-specific. Include latitude, longitude.
        i. Spatial coordinates including start and end
        ii. Shapefile (ArcMap) with linear extent or polygon for non-fluvial waterbodies
    c. Provide a digital photograph(s) of the site; note the point and orientation of the photograph, time of year, and tide/water level stage.
    d. Provide an aerial image from a satellite or plane. Annotate the image to convey information about the project. Prepare map(s) with landform types delineated.
    e. Describe the major stressors and physical controlling factors.
    f. Assess using existing data whether juvenile or adult salmonids are present in the area and within the site. Describe the species composition and population sizes in the immediate or nearby watershed; use any available historical and current fish species and abundance data. Provide context for the potential of the site for fish availability.
4. Problems to be Addressed
    a. Summarize the site-specific problem(s) the proposed restoration(s) is intended to address. What are the causes of the problem
        i. The specific problem(s) you are addressing
        ii. the *root* cause(s) of the problem(s).
5. Project objectives

    a. Provide specific objectives based on the location, size and significance of the project and provide information on how the objectives could be evaluated. The measurements should be able to be reported to document successful implementation
    b. State the project's objectives in terms of functions for salmon. For example, how will access, capacity, sustainability, etc. be increased or enhanced?
6. Project Description
    a. Provide a description of the project that describes the restoration activities to occur and the equipment planned for use. The degree of detail should match the project complexity and technical difficulty to allow for full evaluation of technical viability. For projects involving multiple sites, be sure to identify and describe them separately, as appropriate.
7. Project design
    a. Describe the design criteria used or proposed and how those criteria take into consideration natural events and conditions
    b. Describe the level of acceptance and maturity of the restoration technique; e.g., tried and true or experimental for the geomorphic setting
    c. Describe the design team and implementation team's expertise/experience with the project type
    d. Explain the extent to which natural processes would be restored and how well the restoration action(s) are anticipated to be maintained through natural processes.
8. Project schedule
9. Projected benefits (to salmon)
    a. Describe which species, stocks, or populations are likely to benefit, based on the best available data.
    b. Describe how the action(s) will affect physical controlling factors.
    c. Describe the expected condition of habitat after restoration.
    d. Describe the expected changes in ecosystem processes and functions, e.g., Juvenile salmon feeding, rearing, refuge, water quality improvement, off site food web support.
    e. Describe habitat complexity, channels, large woody debris
    f. Describe water quality.
    g. Describe potential impacts from invasive plant and animal species. Describe the condition of adjacent lands.
10. Project relationship to regional priorities
    a. Does the project address PSC stocks of interest
    b. If the project specifically implements a plan or larger conservation effort, identify the effort and the specific role of this project.
11. Project Relationship to Watershed Processes and Functions
    a. The restoration and protection of natural watershed process is the foundation of achieving watershed health. Since natural watershed processes have been eliminated, altered or reduced in many areas, habitat restoration activities are the primary method for reintroducing the necessary functions to watersheds that have been altered due to past management practices and/or disturbance events. Restoration activities are intended to address the watershed functions necessary to support natural processes that are indicative of healthy watersheds. This includes,

but is not limited to improving water quality, water quantity, habitat complexity, flood plain interaction, vegetation structure, and species diversity.

   b. Explain how the project complements other efforts under way or completed in the watershed. Identify other restoration, technical assistance, monitoring, assessment or outreach projects, conservation actions and ecological protection efforts in the watershed and explain how this project relates to those actions.

12. Project maintenance
   a. Describe requirements for ongoing or periodic maintenance.
   b. Identify key attributes to monitor.