2.5 FISH

Fish are an important part of the Cowichan Valley Regional District (CVRD). They are ecologically critical to both the terrestrial and aquatic ecosystems as food for other organisms, as users of the habitat and food resources, and as nutrient inputs into these ecosystems. They are also important to people and communities for food, economic wealth, and their spiritual and cultural value. Salmon species in particular are a cultural icon and a key indicator of ecosystem health for this region.

Introduction

The CVRD covers a wide range of watersheds, each of which has its own specific fish values, and each of which is vital to maintaining the biodiversity of fish, especially salmon, in the area. Watersheds such as the Nitinat, Caycuse, Cheewhat, Carmanah, and Walbran flow west into the Pacific. Others, such as the Koksilah, Chemainus, and Cowichan rivers flow east into the Strait of Georgia. In addition, numerous small streams and lakes, many of which are affected by specific local land and water uses are found in the CVRD.

Various species and stocks of fish use the CVRD in different ways and at different times. Some are year-round residents; others are ocean migrants that can return in a single year or multiple years. Some fish species within the same watershed show genetic and physical variations in response to different habitat conditions. Characteristics of each individual watershed, such as water quality and temperature, the annual flow regime, and spawning habitat availability are just a few of the variables that affect fish populations. These are important considerations as they will affect potential policy actions on the part of the CVRD or other players.

While there is a considerable diversity and abundance of fish throughout the CVRD, declines are occurring for some species in the CVRD. Human impacts on the watersheds have been extensive. The early forest practice of wide-spread clearcutting and the development of roads, bridges and other structures resulted in significant changes to the quality and quantity of water entering the system. The Cheewhat and Cowichan Rivers were impacted by the running of logs resulting in riparian instability and increased sedimentation and degraded water quality throughout the systems. Fish harvesting has been extensive, both in the rivers and the ocean. Ocean conditions have also changed. These impacts have occurred and interacted during the last century, and many impacts continue.

This report focuses on the general characterization of fisheries resources in the CVRD using a watershed approach. Fisheries data were used to focus more specifically on the developed areas in which CVRD can exercise policy levers. Salmon species are considered key indicators of ecosystem health reflecting the cumulative impacts occurring in marine, freshwater and terrestrial environments of the CVRD and larger area.

Policy and Adaptive Management

Habitat protection may occur through implementation of environmental policies and promotion of stewardship activities. Water flow, water levels, water and habitat quality and protection of riparian areas may serve as indicators of watershed and aquatic habitat conditions. An adaptive management framework monitors key indicators, e.g. water levels and flow, and links monitoring results with habitat protection policies and stewardship. These links provide the foundation to test and adjust management strategies to changing conditions and achieve management objectives.

Policies and activities listed in Table 2.5.1 apply broadly to the CVRD and other parts of BC. Discharge and water level information presented in the Water Quality and Quantity section provides an illustration of indicators that can be incorporated into an adaptive management framework specific for the CVRD.

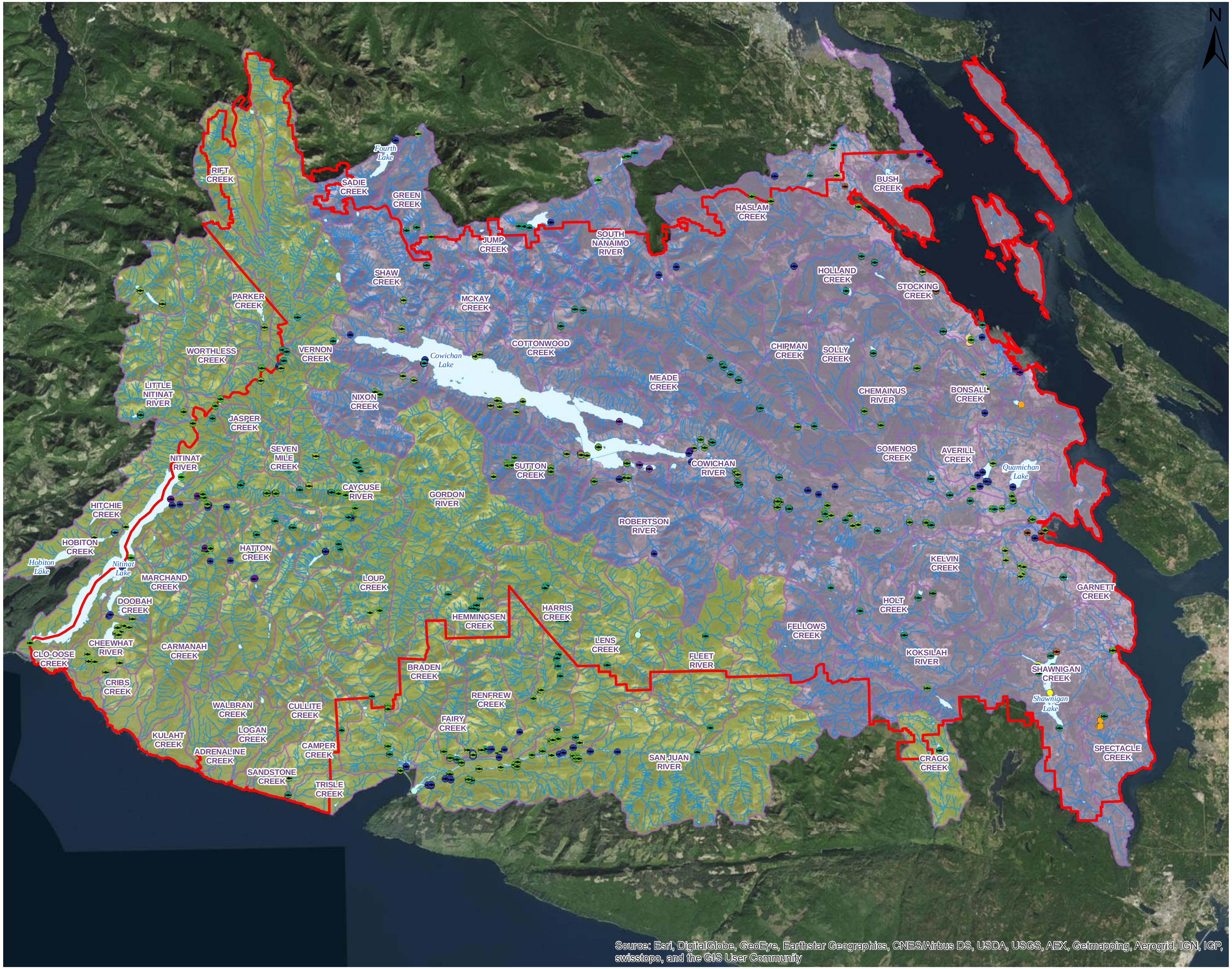
Table 2.5.1: Summary of Relevant Regulatory Legislation and Standards

Legislation or Regulation	Description
Fisheries Act (1968, revised in 2013)	Prohibitions against causing serious harm to fish that are part of or support commercial, recreation or Aboriginal fishery.
Wild Salmon Policy – DFO 2005 Framework (Luedke, 2011)	Policy for the conservation of wild Pacific salmon. Three overall goals: safeguard the genetic diversity of wild pacific salmon; maintain ecosystem and habitat integrity; and manage fisheries for sustainable benefits.
US/Canada Pacific Salmon Treaty	The Pacific Salmon Treaty (PST), signed by Canada and the United States (U.S.) in 1985, provides the framework through which the two countries work together to conserve and manage Pacific salmon.
Riparian Areas Regulation (RAR) Section 12 of the *Fish Protection Act*, 2004	The Riparian Areas Regulation is provincial legislation that requires local governments in applicable areas to protect riparian areas during residential, commercial, and industrial development.

Fish in the CVRD

There are 53 watersheds within the CVRD that support 13 native and 9 introduced fishes (Figure 2.5.1). Supporting approximately 22 species, the Cowichan watershed represents the highest fisheries values of any watershed in the CVRD. The Cowichan watershed supports multiple trophic levels of fish, sport fish and active recreational fisheries. Presence of fish in multiple trophic levels indicates relatively healthy ecosystem function.

Shawnigan and Nitinat watersheds also support multiple trophic levels and feeding groups including top fish-eating species (piscivores), large-bodied benthic invertebrate feeders such as Pupkinseed and Sculpin, and small-bodied forage base species such as Threespine Stickleback. The Shawnigan and Nitinat watershed support 18 and 15 species of fish respectively. In part, the species diversity of the Cowichan, Shawnigan and Nitinat watersheds is enhanced compared to other watersheds because of lake environments. Lakes comprise diverse habitat types that support fish that prefer still water in cold, cool and warm environments and occupy multiple trophic levels and feeding groups.



LEGEND

- Study Area
- East Flowing Watersheds
- West Flowing Watersheds

Known Fish Observations (GeoBC)

- Arctic Grayling
- Bull Trout
- Chinook Salmon
- Chum Salmon
- Cutthroat
- Coastrange Sculpin
- Coho Salmon
- Dolly Varden
- Kokanee
- Lake Chub
- Lake Cisco
- Lake Lamprey
- Lake Trout
- Pink Salmon
- Prickly Sculpin
- Rainbow Trout
- Sockeye Salmon
- Staghorn Sculpin
- Steelhead
- Threespine Stickleback
- Troutperch
- Western Brook Lamprey
- White Sucker

Introduced Species (GeoBC)

- Atlantic salmon
- Brook trout
- Brown trout
- Black bullhead
- Brown bullhead
- Largemouth bass
- Pumpkinseed sunfish
- Smallmouth bass
- Yellow perch

0 2.5 5 10 Kilometers

SCALE: 1:325,000
WHEN PLOTTED CORRECTLY AT 11 x 17
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NOTES

This map is for conceptual purposes only and should not be used for navigational purposes.

STATE OF THE ENVIRONMENT REPORT 2015

SPECIES OCCURENCES IN CVRD WATERSHEDS 1995 TO 2015

November 4, 2015	Rev 0.0	Figure No.
Project No. 202.02005.00000		2.5.1

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Draining to the east of the CVRD, the Cowichan River watershed is one of the largest in the CVRD (Figure 2.5.1). Unlike most other river systems in the district, the Cowichan River flow is moderated by Cowichan Lake, and further by the presence of a water-control structure (weir) at the outlet of this lake. The Cowichan River is designated as a Canadian Heritage River System. One major reason for this designation is the significant abundance and importance of the fishery resource. The Cowichan River is known historically for its substantial runs of Chinook (*Oncorhynchus tshawytscha)*, Coho (*Oncorhynchus kisutch)*, Chum (*Oncorhynchus keta)*, and Steelhead Salmon (*Oncorhynchus mykiss)*. As a result, it is an index river for the US/Canada Pacific Salmon Treaty, and is used as an indicator of abundance, survival, and exploitation of chinook in the broader region of the Georgia Basin.

Chinook salmon maintain special status in BC. In the past, the Cowichan supported some of the largest spawning runs of Chinook in the entire Georgia Basin. Other species native to the Cowichan Basin include Rainbow Trout, resident Cutthroat (*Oncorhynchus clarki)*, and Dolly Varden (*Salvelinus malma*), Char, and—within Cowichan Lake—resident Kokanee (*Oncorhynchus nerka*) salmon (Figure 2.5.1). The Cowichan is known as one of the finest trout rivers on Vancouver Island and possibly in the whole of BC. In addition to these well-known fish species many smaller fish, such as minnows, chub, sculpins, and lamprey make important contributions to the ecosystem. The Vancouver lamprey, resident in Cowichan Lake, is listed as a “threatened” species under the Canadian Species at Risk Act.

The largest westward flowing watershed in the CVRD is the Nitinat River (Figure 2.5.1). The Nitinat River flows to Nitinat Lake, a tidal salt water fjord that empties into the Pacific Ocean (DFO 2014). As a result of stocking efforts, salmonid runs on the Nitinat River are very healthy. The Nitinat River Hatchery was built in 1980 to help sustain salmon populations for local commercial, recreational and Ditidaht First Nations fisheries. Species released form the hatchery into Nitinat River include Chinook, Chum, Coho, and Steelhead (DFO 2014). A summary of the most recent stocking efforts are shown in Table 2.5.2.

Table 2.5.2 Summary of 2015 Stocking Efforts in Nitinat River

Species	Release Total (2015)
Chinook	3,460,515
Chum	17,767,521
Coho	69,862
Steelhead	1,199 (2006)

(Source Fisheries and Oceans Canada. http://pacgis01.dfo mpo.gc.ca/DocumentsForWebAccess/HatcheryReleaseReports/ReleaseReport.aspx?IDValue=114#Chumreleased from Nitinat River)

Other species known to occur in the Nitinat watershed include Cutthroat Trout, Rainbow Trout, Steelhead and Threespine Stickleback. Species distribution in the northern portion of Nitinat watershed is less dense in comparison to the southern tip. This may be a result of natural obstacles to fish passage such as impassable gradients or velocity barriers, or constructed features such as dams or culverts.

Several species of fish have been introduced into the Cowichan and Nitinat watersheds. In the Cowichan watershed, mostly in the early 1900s, Brown Trout (*Salmo trutta*), Kamloops Trout (*Oncorhynchus mykiss)*, Speckled Char, Lake Trout (*Salvelinus namaycush*), Brown Bullhead, and Atlantic Salmon (*Salmo s*alar) (Neave, 1941) were introduced. Only Brown Trout appear to have established to self-sustaining populations. Other more recent observations of invasive fish species, including Smallmouth Bass, represent a concern to the native biodiversity in the region. Introduced species in the Nitinat watershed include Atlantic Salmon.

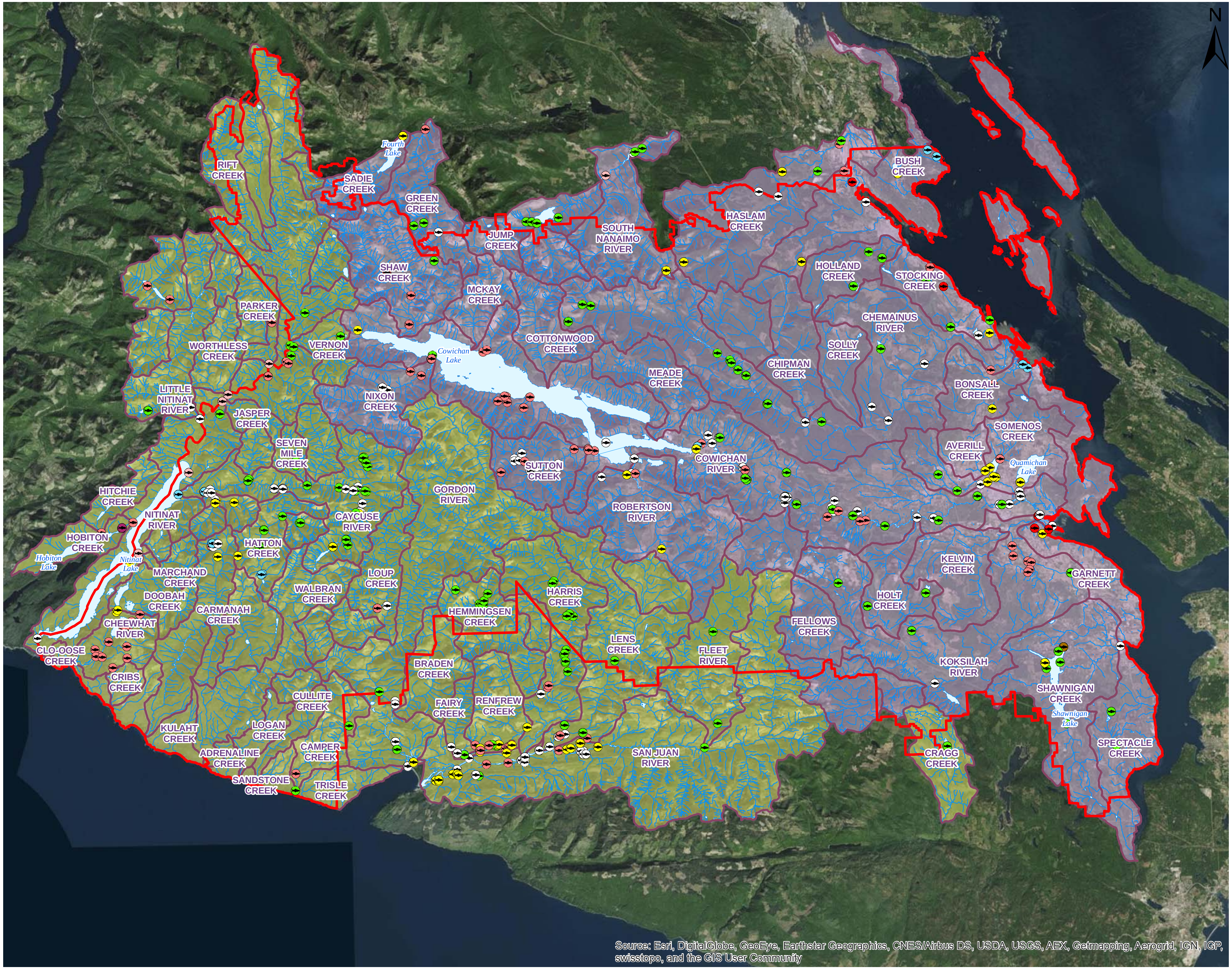
Habitat features for 10 indicator fish species are provided in Table 2.5.3. These habitat features can be inferred where these indicator species occur. Indicator species include a forage species Threespine Stickleback, a benthic generalist feeder (Brown Catfish) and several fish-eating fishes of recreational and traditional value distributed throughout the District.

Table 2.5.3. Typical Habitat Features for Indicator Fish Species.

Common Name	Scientific Name	Habitat Features
Threespine Stickleback	*Gasterosteus aculeatus*	• usually inhabits coastal waters or freshwater bodies well connected (or once well connected) to the coasts • prefers slow-flowing water with areas of emerging vegetation • can be found in ditches, ponds, lakes, backwaters, quiet rivers, sheltered bays, marshes, and harbours
Brown Catfish	*Ameiurus nebulosus*	• thrives in a variety of habitats, including lakes, ponds and drainage with low oxygen and sand to muddy bottom
Cutthroat Trout	Oncorhynchus clarkii	• gravelly lowland coastal streams and lakes, inland alpine lakes and small rivers, and estuaries or the sea near shore
Brook Trout (Speckled Char)	*Salvelinus fontinalis*	• clear, cool well oxygenated streams, rivers, spring ponds and lakes
Rainbow Trout	*Oncorhynchus mykiss*	• small to moderately large, but shallow rivers of the pool-riffle type with moderate flow and gravel bottoms
Steelhead	*Oncorhynchus mykiss*	• migratory form of Rainbow Trout that spawns in freshwater and reaches adult stage in the sea • requires passage from sea to fine gravel spawning habitat in riffle areas above pools
Chinook Salmon	*Oncorhynchus tshawytscha*	• spawn over gravel and require clean, cool, oxygenated, sediment-free fresh water for egg development • Juvenile salmon grow in clean, productive estuarine environments • Adults live in a rich, open ocean habitat
Chum Salmon	*Oncorhynchus keta*	• spawn over gravel in small streams and intertidal zones • migrate to sea where they stay until returning to streams to spawn
Coho Salmon	*Oncorhynchus kisutch*	• spawning occurs in swifter water of shallow, gravelly areas of river tributaries • most migrate to the open ocean after one year of growth in freshwater

Common Name	Scientific Name	Habitat Features
Sockeye Salmon	*Oncorhynchus nerka*	• typically spawn in pea-size gravel in the inlet stream to a lake • seaward migration of smolts occurs at age 2 to 5 and adults return to freshwaters to spawn after 1 to 3 years in the open ocean • some sockeye, commonly called Kokanee, live and reproduce in lakes

The distribution of indicator fish species collected from 1995 to 2015 appears on Figure 2.5.2. Watershed occurrences for the indicator species are shown in Table 2.5.4. Rainbow trout, Steelhead, Cutthroat and Coho are the most widely distributed indicator fish species in the CVRD. Rainbow trout occur in 15 east-flowing watersheds and 12 west-flowing watersheds. Chinook and Sockeye are the least widely distributed indicator species in the CVRD. Sockeye were found only in Nitinat Lake watershed. Brook trout, Brown catfish and Chum were found only in eastern watersheds. The distribution of these species can be considered the basis from which future distributions are compared.



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LEGEND

- Study Area
- East Flowing Watersheds
- West Flowing Watersheds

Known Fish Observations (GeoBC)

- Brook Trout
- Brown Catfish (formerly Brown Bullhead)
- Chinook Salmon
- Coho Salmon
- Chum Salmon
- Cutthroat Trout (Anadromous)
- Rainbow Trout
- Sockeye Salmon
- Steelhead
- Threespine Stickleback

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SCALE: 1:325,000
WHEN PLOTTED CORRECTLY AT 11 x 17
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NOTES

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STATE OF THE ENVIRONMENT REPORT 2015

INDICATOR SPECIES DISTRIBUTION 1995 TO 2015

November 2, 2015	Rev 0.0	Figure No.
Project No.	202.02005.00000	2.5.2

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Table 2.5.4 Indicator Species Distribution 1995 to 2015.

Watershed		Rainbow Trout	Steelhead	Cutthroat	Brook Trout	Brown Catfish	Chum	Chinook	Threespine Stickleback	Coho	Sockeye	No. Species
East Flowing Watersheds	Green	x	x									2
	Shaw	x								x		2
	Jump	x										1
	South Nanaimo	x		x				x				3
	Haslam	x	x	x						x		4
	Holland	x										1
	Bonsall			x					x	x		3
	Garnett	x	x	x			x					4
	Robertson	x	x	x						x		4
	Cowichan	x	x	x	x		x			x		6
	Bush								x	x		2
	Chemainus	x	x	x			x			x		5
	Somenos	x	x	x	x					x		5
	Sutton		x							x		2
	Nixon		x							x		2
	Holt	x										1
	Koksilah	x	x	x			x			x		5
	Shawnigan	x		x								2
	Stocking	x		x		x	x			x		5
	Total	15	10	11	2	1	5	1	2	12	0	59
West Flowing Watersheds	Cheewhat			x						x		2
	Nitinat	x	x					x		x	x	4
	Little Nitinat	x	x	x								3
	Carmanah		x	x					x			3
	Hatton	x	x						x			3
	Caycuse	x	x	x					x			4
	Loup		x							x		2
	Camper	x								x		2
	Gordon	x	x	x								3
	Hemmingsen	x										1
	Harris	x	x	x						x		4
	Lens	x	x	x						x		4
	San Juan	x	x	x						x		4
	Fleet	x										1
	Cragg	x										1
	Total	12	9	8	0	0	0	1	3	7	1	41

Measuring the State of Salmon in the CVRD

Indicators and Measures

Indicators of fish and fish habitat, which in turn indicate ecosystem health, can be based on fast and slow variables. Fast variables change over months to years and examples include changes in fish population size, fish species diversity, and water flow. Slow variables change over years to decades and include examples such as land use change and nutrient loading.

Salmon abundance integrates many of the factors described below and serves as a main indicator of watershed health, both at present and as a trend through time. Ideally, historical data on the salmon runs (i.e., prior to extensive harvesting that began more than 100 years ago), provide the most appropriate benchmark for understanding recent trends. While abundance data over extended periods are not available, data on relatively long-term escapement (number of adults that escaped being caught and returned to the river to spawn) for key species within the CVRD are available. As a general indicator, these data sets are presented for each major species or stock in the Cowichan watershed.

Other more detailed watershed trend indicators might provide additional insight into an understanding of fish abundance trends, and a more precise indication of the factors affecting specific components of the salmon life history. Life history components of interest may include spawning and egg survival to returning adult if data are available. These additional indicators could include habitat area and quality changes over time, water quality, food productivity for species such as aquatic invertebrates, egg-to-fry survival rates, fry density and distribution, and predator pressures (such as presence of predator birds and fish). Some of this information is available in an assessment of the habitat in the Cowichan watershed which was undertaken in conjunction with this report (DFO 2010).

The following three general types of factors help explain fish abundance:

1. The ocean ecosystem (factors such as ocean conditions affecting food sources, near-shore habitat complexity, productivity of the estuary, competition with other species, natural predation, etc.) indicators include ocean temperature and catch quota, estuary health and productivity.
2. The freshwater ecosystem (factors such as spawning and rearing habitat, habitat quality, water quality, adjacent land use, predation pressures, water temperatures, competition and predation from other species, etc.) indicators include % riparian cover, Total Suspended Sediment (TSS), temperature, species compositions, and diversity of benthic communities.
3. Direct human intervention indicators include fishing or hatchery production, and percentage of natural spawners versus hatchery stock.

Determining which of these many factors influence fish population trends at any given time is a complex exercise. Species may exhibit different responses to the same factors. In addition, trends can alter within individual systems—making it difficult to summarize information.

Findings

The following section presents spawning data for Chinook, Coho, Chum and Steelhead.

Chinook

Remedial work at Stoltz Slide from 2006 to 2008 reduced erosion and sediment contribution to the Cowichan River by 90%. Estimates prior to remediation showed that 40% of the Total Suspended Solids (TSS) load 15 km downstream originated from Stoltz Slide. Egg to fry survival upstream from the slide was approximately 86% while downstream survival ranged from 0.7 to 6% prior to remediation, providing clear indication of a significant effect of TSS on fish production. Increases in chinook natural spawners observed after 2009 in part may be the result of reduced erosion and sediment contribution in the Cowichan River.

Annual estimates for chinook natural fall spawners have increased each year since 2009 to over 5,000 spawners in 2013 (Figure 2.5.3).Sediment and erosion control at Stoltz Slide, km 27 of the Cowichan River, may have contributed to the increases. Future measurement of TSS at key river locations and the number of sediment remediation initiatives may indicate positive changes to fish abundance and in turn ecosystem health in the CVRD.

The spring-run population of Chinook Salmon is currently at an extreme low, practically at zero. Little is known about the historic size of this population, though anecdotal information suggests that this run was once of similar size to the fall run (Burns 2002, Burt and Robert 2002). Good information on the factors affecting this population is unavailable.

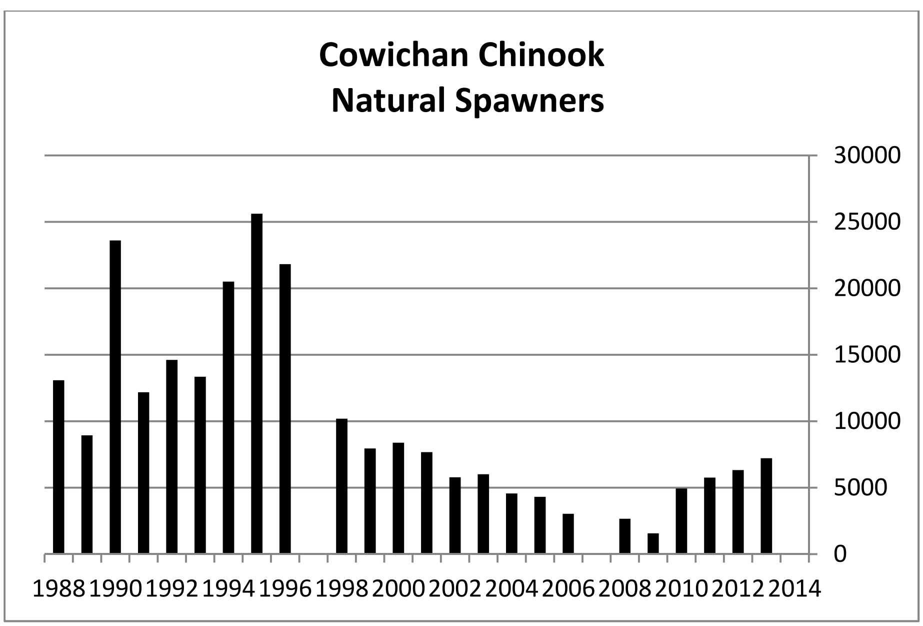

Figure 2.5.3: Annual estimates of chinook salmon “fall” spawners in the Cowichan River, 1953—2013 (Source: Data from 1953 to 1987 are based on DFO Fisheries Officers’ estimates. Data from 1988 to present are based on

DFO fixed point enumeration (counting fence) and carcass mark/recapture estimates where necessary. DFO Salmon Escapement Database (NuSEDs), 2015.)

Coho

Coho populations are currently at low levels throughout the Georgia Basin. The Coho return to the Cowichan in the fall, taking advantage of habitat and migration options as water levels rise significantly from October through December. As with Chinook, the escapement numbers for Coho spawning in the Cowichan system have also dramatically declined recently—with 2007 numbers lower than any seen previously (less than 1,000 individuals compared with in excess of 70,000 in periods up to the 1970s) (Figure 2.5.4). No estimates have been made since 2007. One important difference from Chinook is that the commercial and sport fishery catch rate for Coho is low. Therefore, the continued low abundance of Coho is most likely due to a combination of factors affecting survival in both the ocean ecosystem and the freshwater ecosystem. Coho spend a full year in freshwater prior to entering the ocean, making the freshwater ecosystem especially important. Suitable freshwater rearing habitat and/or near-shore marine habitat has likely become a major limitation for Coho abundance (see Section 2.2 for information on the condition of the Cowichan estuary).

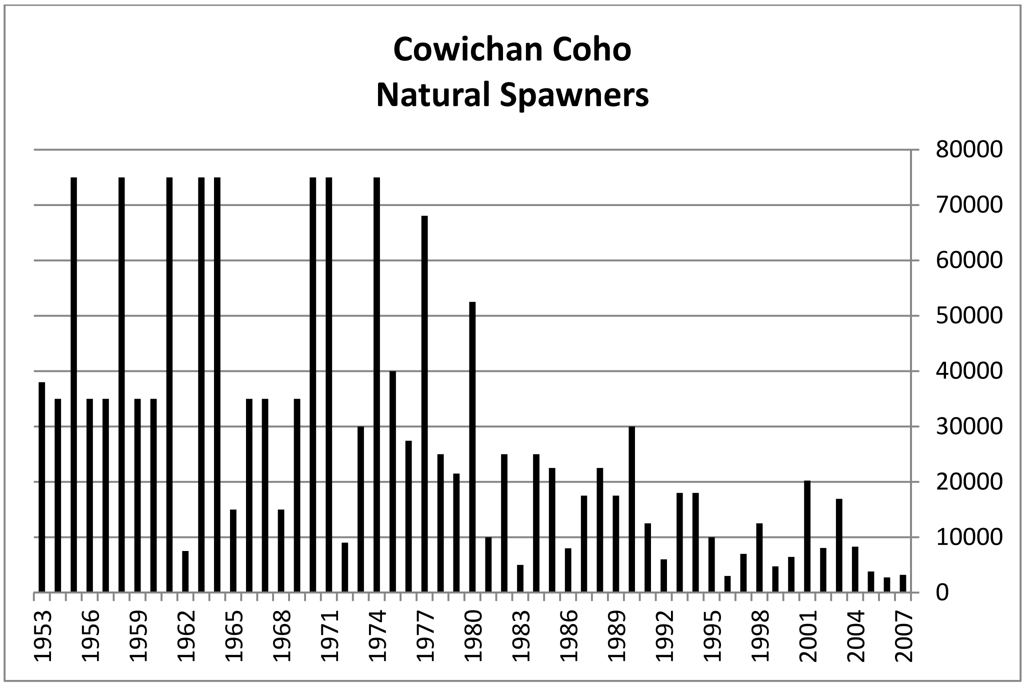

Figure 2.5.4: Annual estimates of Coho salmon spawners in the Cowichan River, 1953—2007. No estimates were made since 2007. (Source: Data from 1953 to 1992 are based on DFO Fishery Offices' estimates. Data from 1993 to 2007 are based on expansion of selected tributary estimates. DFO Salmon Escapement Database (NuSEDs), 2010.)

Chum

Chum salmon stocks are considered part of a single management unit called the Inner South Coast (ISC) Chum stock. The average returns for ISC wild Chum salmon was 1.3 million from 1968-1982, which reduced to 1.1 million for 1983-1996 (DFO 1999, LGL undated).

Although numbers fluctuate widely (Figure 2.5.5), the estimates for Chum spawning returns do not show the obvious negative trends seen for the other species. Chum salmon have the most limited interaction with the watershed of all the salmon species. They spawn in the lower reaches of the river and migrate to the ocean shortly after emergence from the gravel. The factors generally considered to have the greatest influence on Chum abundance are those which affect eggs in the gravel (flooding, stream bed movement, predation, etc.), as well as ocean conditions.

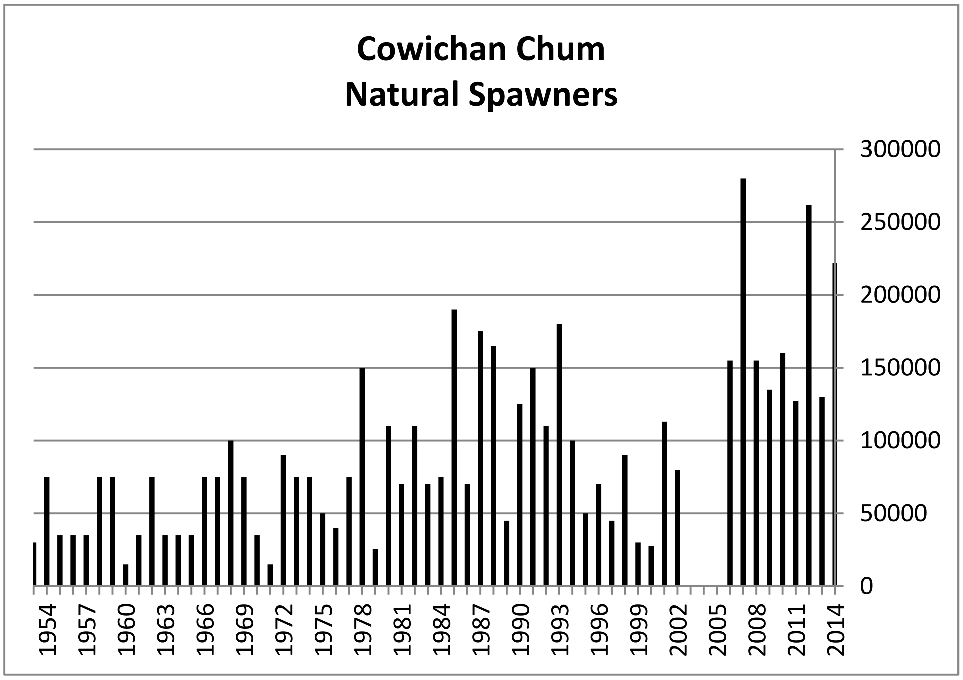

Figure 2.5.5: Annual estimates of Chum salmon spawners in the Cowichan River, 1953—2014. No estimates were made for 2003 through 2005. (Source: Data from 1953 to 2003 are based on DFO Fishery Officer and Fishery Managers' estimates. Data from 2006 to present are based on enumeration of migrants using a Dual Identification Sonar unit (DIDSON). DFO Salmon Escapement Database (NuEDs), 2015.)

On balance the abundance of Chum spawners appears greater from 2006 to 2014 than the period from 1954 to 2002. The method of enumeration changed from previous practice in 2006 and may account in part for the apparent increased abundance since 2002.

Steelhead and Trout

Steelhead on the Cowichan has both winter runs and spring runs. Many Steelhead stocks on Vancouver Island have declined significantly in the last 30 years. The distribution of Steelhead within the Cowichan system has also declined; Steelhead are now absent from many tributaries of Cowichan Lake. Similarly, Steelhead in the Koksilah River are classified as conservation concern (Lill 2002). Detailed data for Steelhead are more difficult to obtain, but Cowichan River abundance is thought to be 500—800 winter-run escapement, which is considered to be 10 to 30% of habitat capacity (Lill 2002). Historic abundance of fish in this system is unknown, thus present population cannot be related to historical abundance.

Resident Rainbow Trout are very limited within the whole Cowichan system today, though they were historically abundant. They are suspected to have been impacted by historic heavy fishing pressure.

Resident Cutthroat Trout appear to be scarce, while sea-run Cutthroat Trout appear more numerous. However, detailed population trends are unavailable.

DFO installed a fish way at Marble Falls on the Koksilah River approximately 12 km upstream from confluence with Cowichan River to improve abundance of Steelhead. The fish way may allow Steelhead greater upstream access to additional winter food supply, and reduce poaching losses by relieving a migration bottleneck. Annual counts of Steelhead using the fish way would indicate use of upstream reaches by migratory fish.

Sockeye

Sockeye is one of the least distributed salmonid in the CVRD. The Cheewhat watershed supports populations of Sockeye (*Orncorhynchus nerka*) in addition to Cutthroat Trout, Coho, and Chum. DFO escapement records from 1944-1991 show a drop in the mean escapements for Sockeye, Coho and Chum (Parsley et al. 2015). Unpublished escapement information form 1994-1996 recorded Sockeye escapements of 2,800, 4,451, and 4,280 respectively (Figure 2.5.6). The salmon escapement program was discontinued by DFO in 1996. In 2001 an adult enumeration estimate study was conducted in Cheewhat Lake. The estimated escapement was 6,904 Sockeye (Parsley et al. 2015).

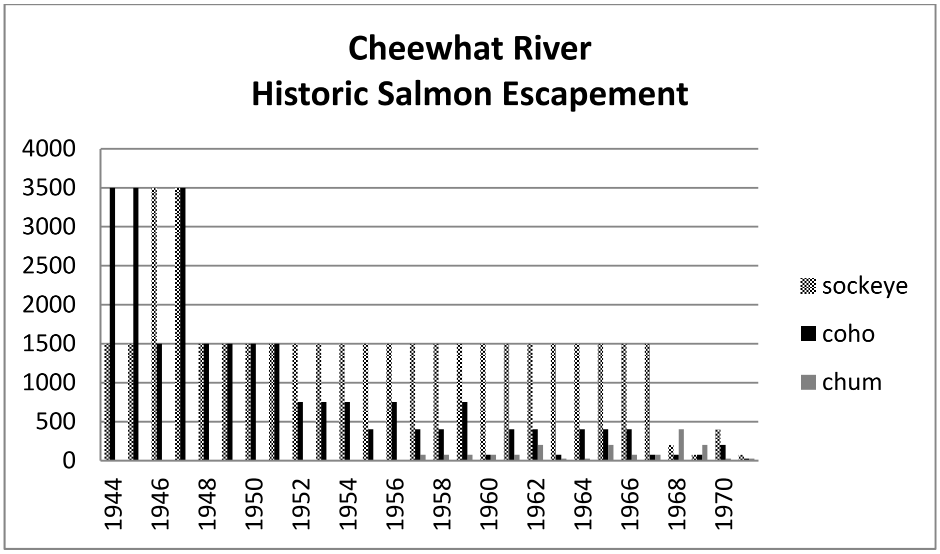

Figure 2.5.6 Historic salmon escapement to the Cheewhat River (DFO, unpub.data)

Factors Affecting Fish Abundance in the CVRD

Fish (particularly salmon) abundance and distribution is affected by a wide range of factors in both the freshwater and marine environments. Some of these factors, such as those related to environmental change or marine harvest regimes, are determined on a broader scale than the Cowichan Region. Others, such as instream water levels and riparian conditions, are directly related to impacts in the local area. The table at the end of this section (Table 2.5.5) summarizes the range of factors affecting Cowichan salmon abundance and distribution, and their relative impacts on these species.

There is general agreement within the local Cowichan Stewardship Roundtable (which deals with local fisheries issues) that the highest risks in the freshwater ecosystem stem from low water flow, high water temperature, and sediment loads from bank erosion. Additionally, the loss of rearing area in the lower river is significant. As the fish migrate to the ocean, the ability to feed and grow in the lower floodplain, in the estuary (where much habitat has been lost as a result of a wide variety of development), and in the nearshore environments of the southern shores of Vancouver Island and the Gulf Islands, is critical to determining overall abundance. Other important factors affecting salmon returns include harvest by commercial and sport ocean fisheries (particularly for Chinook), the production from the Cowichan hatchery, and broader ecosystem considerations such as seal and killer whale predation, land use impacts and changes in ocean currents.

Water Quality and Quantity

In the Cowichan watershed, water flow and quality (e.g., temperature) are thought to be key issues affecting fish populations, at least in some years (*pers. comm.*, Luedke, DFO 2009). The Cowichan is a rain-dominated system, so water levels are maintained by groundwater aquifers adjacent to the river and reduced precipitation levels can significantly alter low-flow levels during critical periods of the year.

Water quality parameters such as suspended sediment and water temperature also cause stress effects in fish. At low concentration suspended sediments cause changes in fish behavior such as feeding and abandoning cover. Higher suspended sediment concentrations alter respiration, smother eggs, and may lead to physiological stress and ultimately death. High air temperatures combined with low water flow results in high water temperature, and causes reduced growth rates, low survival of fry and low resistance to parasites and diseases in cold-water fish species. Increased temperatures are thought to be of particular concern within the Koksilah River system because temperatures are not buffered by a major lake (as is the case with the Cowichan River).

Natural hydrology in the Cowichan is altered by a low-head weir located at the outlet of Cowichan Lake, and intakes for the Crofton Mill and City of Duncan water supplies, both located about 10 km above the mouth of the river. The water held behind the Lake Cowichan Weir is released according to objectives to provide sufficient water supply for industrial needs, fisheries, waste dilution and recreational requirements, yet less than amounts that would scour eggs in the Cowichan River. Use of the weir is typically successful in maintaining water levels however, at times lake levels have been insufficient to maintain adequate water flow, leading to conflicts between ecosystem, fish and human water requirements. When summer (low-flow) water levels in the Cowichan Basin system have been critically low, habitat availability for spawning, migration and rearing is limited, thus reducing overall fish productivity. At critically low levels, fish do not enter the watershed system and cannot bypass physical barriers in the system and therefore cannot migrate to the upper reaches. In some cases, rapid release of water through the weir results in rapid reduction in water level stranding fish in side channels leading to mortality.

Habitat Quality

In general, spawning and rearing habitats have degraded over time compared to their historic condition. No “natural” habitat baseline is available because the most significant effects occurred over the last hundred years or more, with progressive clearcutting of most of the Cowichan watershed and harvesting of second-growth underway leaving variable riparian conditions (Figure

2.5.7). Over this period, altered riparian habitat resulted in reduced input of natural coarse woody debris, and reduced natural complexity of the system. These changes affect water quality and temperature, and reduce quality and quantity of spawning habitat. Development and historic diking on the floodplain has changed the natural dynamics of the floodplain and reduced habitat for rearing fish. Recent diking and flood control measures have substantially increased fisheries habitat by reconnecting and re-watering valuable off channel habitat.

Two major estuaries in the eastern portion of the region, Cowichan-Koksilah estuary and Chemainus estuary have been significantly altered. The 832 acre floodplain in the Cowichan-Koksilah estuary has been reduced by approximately 600 acres as a result of increased settlement in the floodplain, logging, dredging, waste and agriculture runoff (Burt and Robert 2002). The estuary serves as critical rearing habitat for salmonid species. For as many as 5 months, salmonids rely on the space and food within the estuary for growth and development before migrating to marine environments. This degradation of estuary habitat represents a reduction in rearing habitat. With the decrease in logging practices in the 2000s, pressure on the estuary slowly decreased (CERCA, 2015). Approximately 120 acres of the 500 acre Chemainus estuary were leased by forestry, pulp and paper and agriculture industries (Ducks Unlimited, 2010). These industries present adverse environmental impacts including water quality degradation and have altered estuary habitat for fishes.

Two west-draining watersheds, the Carmanah and Cheewhat occur within the Pacific Rim National Park Reserve. Approximately half of the Cheewhat watershed is located within the park boundary. The remaining northeast portion of the Cheewhat watershed has been heavily impacted from logging related activities over the past two decades (*pers. comm.*, Jim Lane, Nuuchahnulth, 2015). Logging significantly impacted spawning and rearing fish habitat. Increased peak flows in headwater streams and the removal of riparian habitat caused channel widening, reduced pool capacity, sediment erosion and loss of channel structure. As a result of riparian logging the increased bank erosion caused increased sediment loading in the channel. Impacts to habitat now have occurred within the park boundary as a result of upslope logging.

Historically the Cheewhat Sockeye population was considered unique due to the presence of both Jacks and Jills. The Sockeye run has collapsed as a result of degraded habitat. Recently, habitat restoration efforts have been implemented to decrease sediment load via collection basins (*pers. comm.*, Mike Wright, M.C. Wright & Asscociates, 2015). The collection of sediment and reduction of sediment input will assist restoration of the streambed to its natural elevation.

Rearing habitat (estuary and freshwater) is the most limited type of fish habitat in the CVRD (Burt and Robert 2002). Based on natural spawning data, the river systems appear capable of supporting the same or increased number of spawning adults over the past few decades. Due to significant deterioration of rearing habitat in the floodplain, river and estuary, the carrying capacity of these areas has likely reduced smolt production and reduced the overall number of natural spawners. Stewardship efforts have improved habitat condition at some locations, but significant limitations remain.

Furthermore, the reduction in estuary habitat can cause increased pressure on wild populations. Density dependent mortality and interspecific competition intensifies when hatchery fish are released into the estuary. Hatchery fry are generally larger than wild fry and will have an advantage when competing for space and food. However, given the larger size of hatchery fry, it is possible that these fish would not stay in the estuary as long as wild fry (Burt and Robert 2002). Fish condition should be monitored to determine potential impacts to growth.

Substrate diversity downstream of development and shoreline alteration can indicate the effects of land-use change on fish production. Quality of spawning gravels in upper Cowichan River is high, while spawning substrate in the lower river is less suitable (large size substrate – cobble and boulder). The upstream substrates are suitable for Chinook. Bjornn and Reiser (1991) report that survival of Chinook embryos begins to decline when percentage of fines (<6.35 mm) exceed 15% of redd material, and when fine particles exceed 30% of red material, embryo survival is significantly impacted. Percent composition of fine particles in redds is a good indicator of embryo survival and fish production if the information is available.

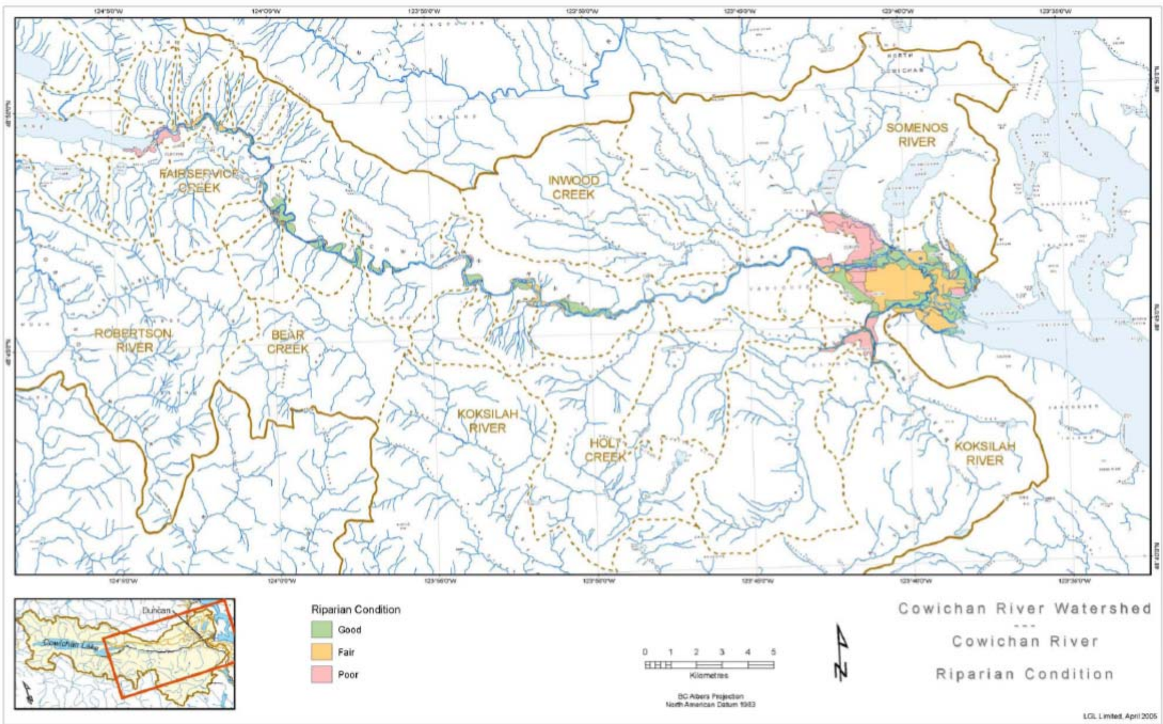

Figure 2.5.7: Riparian condition for the lower Cowichan system Note: This map used with permission of Cowichan Tribes.

Marine Harvesting

Marine harvesting can be a significant factor affecting the abundance of salmon in a watershed. Marine harvesting occurs through commercial fisheries using seine, gillnet, or troll gear, and through recreational fisheries and First Nations fisheries.

For Cowichan Chum, Coho, and Steelhead, the ocean harvest is relatively low and not likely a limiting factor for abundance. For Chum salmon spawning in the Cowichan, the marine harvest is held at a conservative level of less than 20%, mostly from commercial fisheries in Johnstone Strait and more locally in Satellite Channel, but also including a small portion of recreational catch. Cowichan Tribes also harvest fish in the vicinity of the Cowichan River.

For Coho salmon, the marine exploitation is even lower, mostly in the range of 5-10%. However, this level of fishery impact is relatively recent (since 1997). Prior to 1997, Coho catches were significant, up to 80% of the total production of many stocks. For wild Steelhead, harvest is currently at low levels. For Chum, Coho, and Steelhead, river abundance is not determined by harvest, but more likely by natural limiting factors in both the freshwater and marine ecosystems.

Cowichan Chinook are harvested at a much higher rate in ocean fisheries. In recent years, an average of about 60% of the Cowichan Chinook were harvested by marine fisheries, plus another 10-15% by Cowichan Tribes for constitutionally protected food, social, and ceremonial use. The marine harvest of these Chinook included about 15% by Washington State fisheries, about 15% by the commercial troll fishery, and about 30% by recreational fisheries in southern BC.

Ocean harvest of Cowichan Chinook has been a significant factor in the low number of these fish returning to the river. In order to reduce overall harvest, several actions have been taken in recent years. These have included an approximately 50% reduction in allowable catch by the commercial troll fishery, significant closures of the recreational fishery in the Gulf Islands during the fall migration, and the extensive implementation of more selective fisheries in Washington State. Whether these management actions are sufficient to effect a reversal in recent precipitous declines in Cowichan Chinook returns will become clear in upcoming years.

Marine Survival

Marine survival is defined as the proportion of out-migrant juvenile fish that survive ocean residence and return to spawning grounds.

The trends in marine survival of Chinook and Coho entering the Strait of Georgia suggest that changes in marine conditions affect salmon abundance negatively. Substantial evidence indicates salmon mortality in the ocean occurs mainly in the first few months after leaving the river and estuary, as they mature in the nearshore areas of the region’s coastline, Gulf Islands and Georgia Strait. The specific causal factor is not known and is widely debated, but lack of food, lack of habitat, and increased predation are all likely contributing factors. Changes in the Strait of Georgia, such as increased water temperature, may in part be due to climate change; other changes such as water quality may be caused by a range of factors including storm water and upland development. Additional changes include more variable primary plankton production, loss of kelp forests in many parts of the Strait, and major shifts in the ecosystem structure.

Figure 2.5.8 shows a significant decline in marine survival of Chinook from smolts released from the hatchery to age two since the early 1990s. Note that using age two precludes most of the fishery impacts, and so is a good indicator of natural mortality. From 2000 to 2006 survival rate of Cowichan Hatchery Chinook averaged about 0.3% (e.g., three out of 1,000 Chinook survive to age two). This level is comparable to other hatcheries in the lower Strait of Georgia. From 2006 to 2010, marine survival rate increased to over 2%, levels not observed since the early 1990s. Similarly, marine survival for Strait of Georgia Coho has been poor for both hatchery and wild stocks, with the decline starting about 1990 and a slight increase from 2006 to 2014 (Figure 2.5.9).

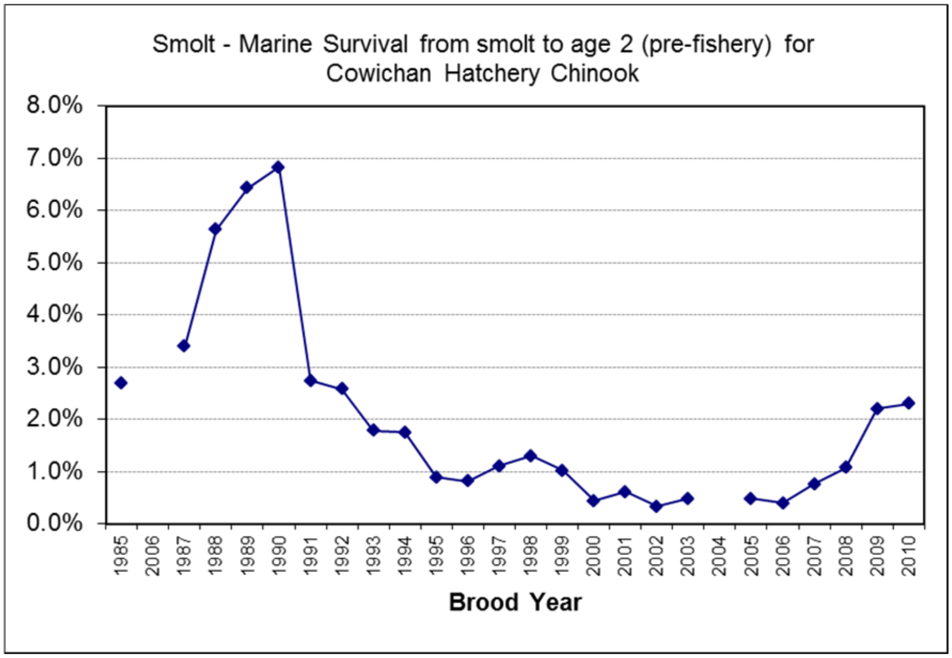

Figure 2.5.8: Cowichan Hatchery Chinook survival rate trend to age 2, based on coded wire tag recoveries (Source: DFO, 2015)

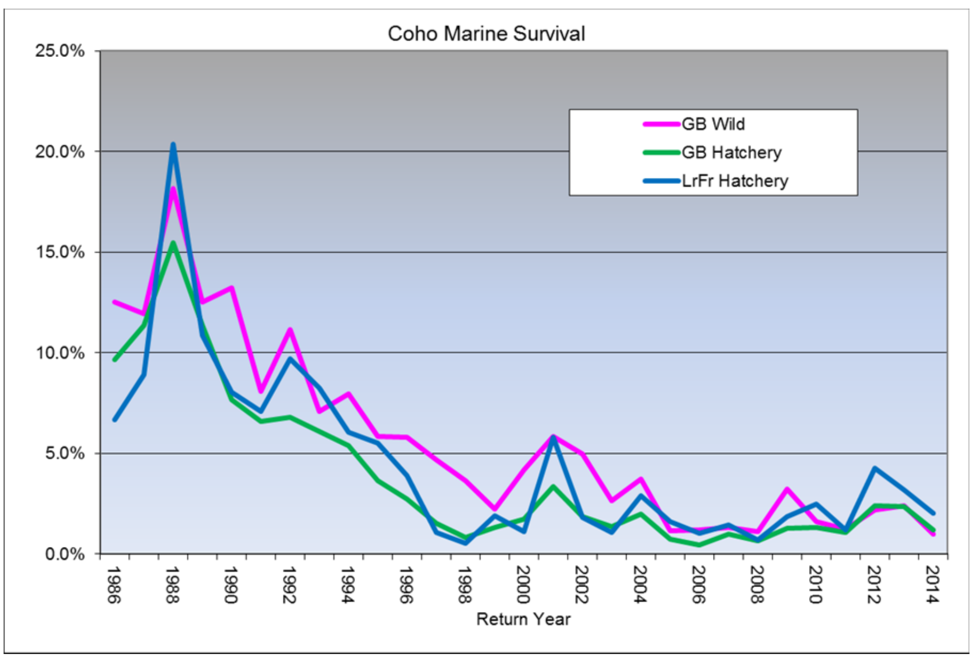

Figure 2.5.9: Marine survival data for Coho in the Strait of Georgia showing declining trend (Source: DFO, 2015)

Data Gaps and Recommendations

Key data gaps relate to the identification and understanding of issues and factors limiting ecosystem productivity and fish abundance, and their relation to human activities in the region. The identification of key indicators related to ecosystem health and the collection of data for these indicators will be important to linking the ecosystem health to species such as salmon. Some potential indicators to be explored were discussed above, and include such things as habitat area and quality, habitat utilization, water quality, productivity (such as benthic invertebrate densities), egg to fry survival rates, fry density and distribution, and predator interactions (e.g., birds and fish).

The following list includes variables for indicators that could provide greater resolution and interpretation of fish abundance and trends in ecosystem condition. Information for some elements in the list may be available, other information must be developed. Indicators are classified as 'fast' and 'slow' variables.

Fast Variables

1. As part of the Steelhead Recovery Plan, DFO constructed a fish way at Marble Falls
   - Record annual counts of Steelhead using the fish way to indicate use and distribution of migratory fish into upstream reaches
2. Identify locations of erosion control or remediation
   - Cumulative increase through time = improved condition, increased fish production
3. Record water flow
   - % time achieve minimum flow at Cowichan Lake outlet
   - % time or frequency of egg-scouring flow
4. Record size and condition factor of migrating fish
   - Increased size and condition indicates improvement for fish
5. Record size of rearing habitat
   - Cowichan Bay and Cowichan-Koksilah estuary
   - Cheewhat watershed
6. Record particle size in redds
   - Low percent fine particles indicates higher embryo survival and fish production

Slow Variables

1. Record TSS at key locations
   - Downward trends in TSS indicates improved conditions for fish
2. Record riparian habitat quality along CVRD watercourses
   - Movement to high percentage high quality habitat indicates improvements for fish and overall ecosystem condition

Ideally suites of indicators will be developed for key locations in each of the watersheds in the Cowichan Valley Regional District. Indicators would include fast variables which change over short periods and may provide rapid indications of changes to fish and ecosystem conditions and slow variables that may indicate the overall effectiveness of policies such as land use, shoreline protection and sediment and erosion control.

Summary

Fish—particularly Chinook and Coho salmon—historically have been foundation species in the CVRD, as these abundant species provided massive inputs of nutrients to both aquatic and terrestrial ecosystems. Their populations have been central for maintaining human populations, and remain a critical component of both the First Nations' cultures and the community's vitality. In addition, fish populations have an important impact on the functioning of the broader ecosystem, providing food and nutrients to ocean, aquatic and terrestrial ecosystems. Because of all these factors, dominant fish species are good indicators of broader ecosystem health since they are affected by a wide range of factors and reflect these factors in data on their survival to reproduction.

Data suggests that in recent years indicator species are more widespread throughout the CVRD. In the last several years, the number of returning spawners for two of the Cowichan River's primary salmon runs—fall Coho and Chinook—have been reduced by approximately 90% from levels documented in the last 80 years, although Chinook abundance has increased each year since 2009. Chum abundance has remained fairly stable. Often the diversity of trends and of factors affecting these fish (see Joint Technical Working Group evaluation in Table 2.5.4) is used as a reason for inaction, since it is always easy to point the blame at some factor that is out of local control. Yet many land-use factors within the terrestrial and freshwater ecosystems of the CVRD are highlighted in this evaluation as having a high impact on these fish populations.

The Joint Technical Working Group (organized by DFO (*pers. comm*., Luedke, DFO 2009) provided an initial evaluation of the significance of the issues or limiting factors affecting salmon life history (Table 2.5.4). Each impact is rated and confidence in the rating is provided.

The long-term implications of declining fish populations will be realized over the coming generations for both ecosystems and humans. These implications will likely cascade through ecosystems and human communities, and result in both obvious and less obvious changes in the future. Some results appear to indicate recent improvements in sediment and erosion control and Chinook abundance.

Figure 2.5.2 shows that indicator fish species such as Rainbow trout, Coho and Cutthroat are relatively widely distributed in CVRD watersheds. Recent habitat restoration efforts in the heavily impacted Cheewhat watershed have occurred. Fish population levels should be tracked to indicate response to habitat restoration.

Continued effort and action is required at various jurisdictional levels to maintain current positive trends, to return these fish stocks to their former abundance, and to reverse the current trends of increasingly poor ecosystem health.

Table 2.5.4: Qualitative assessment of the importance of different factors affecting the Cowichan fishery. Note that as described above, the specifics likely change by species; however, broad patterns are visible from this table

Issue or limiting factor in salmon life history	**Comment**	**Risk**	
		Impact	**Certainty**
Harvest Impacts			
a. Impact by commercial marine fisheries	- Primarily associated with Chinook, where catch rates have remained high. New rules have recently reduced catch by 50%. - Other species affected very little by commercial catch.	Moderate	High
b. Impact in marine recreational fisheries	- Increased incidence of Cowichan Chinook in the west coast Vancouver Island fishery, but lots of variation from year to year, so hard to deliver specific actions. - Recreational priority over commercial access to Chinook.	High	High
c. Catch in First Nations fisheries	- Food fisheries have constitutional priority and are important to Cowichan Tribes. Part of this issue is that this fishery is at the end of the gauntlet of fisheries.	Moderate	Moderate
d. In-river poaching	- Thought to be minor issue in Cowichan.	Low-Moderate	Low
e. Bycatch in non-salmon fisheries	- Bycatch in ground fish trawl fisheries is generally low but in some years is significant.	Low	Moderate
Hatchery Issues			
f. Lack of long term plan for the hatchery.	- Changes in the ecosystem, the need for succession planning at the hatchery, infrastructure issues, changing role of the hatchery all need to be addressed.	High	High
g. Hatchery infrastructure	- Water is a limiting factor in the Cowichan hatchery. There may be other potential issues which have not been clearly established at this time.	Moderate	Moderate
Habitat Issues in Freshwater			
h. Water quality	- Many factors affect water quality, including sewage, septic fields, sediment load due to natural erosion, increasing water temperatures, etc.	High	High

Issue or limiting factor in salmon life history	Comment	Risk	
		Impact	Certainty
i. Water flow	- Many factors affect water flow, including high localised water use and lack of metering and monitoring. Expected to be exacerbated by climate change.	High	High
j. Smothering of eggs by sedimentation	- Typically natural erosion that is exacerbated by human impacts, particularly land use /logging /clearing and exacerbated by invasive species (e.g., knotweed).	High	High
k. Scouring substrate/redds[1] by floods	- Land use (logging and clearing) results in greater flow variation	High	High
l. Lack of rearing habitat in mainstem[2]	- Loss of habitat is caused by loss of riparian cover, reduced large natural woody debris in streams, land use issues (forest-increased runoff and flood control; agriculture-dyking, development-impervious surface, etc.)	High	High
m. Lack of rearing in lower river and estuary	- Land use reduces habitat availability, quality, and complexity (e.g., loss of large woody debris and eel grass habitat). Also impacted by log booming in the estuary and channelization of natural streams.	High	High
n. Fry stranding in side channels	- Caused by lack of water in the creek at the right time—factors include changes to groundwater hydrology, side channel morphology due to development, operation of weir, etc.	Medium	Medium
o. Stress during spawner migration and spawning	- Stress increased by many factors, particularly low water flow caused by weir operation, water extraction, groundwater hydrology changes and climate change. - High water temperature also increases stress for these “cold water” species. Impervious surface runoff, fishway blockages and human disturbance all contribute.	High	High

[1] A salmon redd is a depression created by the upstroke of the female salmon's body and tail, sucking up the river bottom gravel and using the river current to drift it downstream. The female salmon digs a number of redds, depositing a few hundred eggs in each during the one or two days she is spawning.

[2] A mainstem is the main channel of the river in a river basin (as opposed to the streams and smaller rivers that feed into it).

Issue or limiting factor in salmon life history	Comment	Risk	
		Impact	Certainty
p. Lack of spawning gravel	- Natural dynamics of creeks are impacted by "bank stabilization" work, so new gravel does not become available. Fish can't get access to existing gravel due to sedimentation cementing the existing gravel, and the impacts of invasive species such as knotweed.	Medium	Medium
Ecosystem Considerations			
q. Predation on eggs or fry	- Existing fish such as trout or sculpin, birds, and other species	Medium	Medium
r. Seal predation on smolts	- Unknown extent of this issue. Known to be high in some east coast Vancouver Island rivers. Likely have habituated seals in area.	Unknown	Unknown
s. Poor survival of smolts	- Likely a combination of low food and habitat availability. Begins with rearing success in lower river and estuary, need for complexity in foreshore areas, and changing conditions in Georgia Strait. Land use in lower watershed and effects of climate change may be primary issues. In Georgia Strait there is poor understanding of the causal factors for early marine mortality.	High	High
t. Seal predation on mature adults	- Unknown extent of this issue, but seals observed in Bay and lower river up to fishway. Evidence of predation.	Unknown	Unknown
u. Predation by southern resident orcas.	- Chinook known to be preferred food source and Cowichan Chinook historically resided in lower Georgia Strait in August-Sept.	Unknown	Unknown

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