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 of this region and a key indicator of ecosystem health because they reflect the cumulative impacts occurring in marine, freshwater and terrestrial environments of the CVRD and larger area.

Introduction

The CVRD covers a wide range of different watersheds, each of which has its own specific fish values, and each of which is vital to maintaining the biodiversity of fish, and 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, there are numerous small streams and lakes, many of which are affected by specific local land and water uses.

While there is a considerable diversity and abundance of fish present, declines are occurring – particularly for some species in some systems, and likely due to human activities. There are many species and stocks of fish which use the Cowichan Region in different ways and at different times. Some are year-round residents, some are ocean migrants that can return in a single year or multiple years. Some fish have several genetic and physical variations within the same watershed in response to different habitat conditions around the watershed. Different 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.

This report focuses on one of the most important watersheds for salmon: the Cowichan Basin drainage area. It is one of the largest tributaries flowing into the Strait of Georgia and has significant salmon populations. The Cowichan Basin is also relatively data-rich and is culturally significant for this region.

The Cowichan Basin watershed is influenced by many natural factors, including a mountainous terrain and coastal climate. Historically, mild-wet winters and cool-dry summers were the norm. Climate trends now suggest increasing annual stream temperatures. Rain-dominated watersheds such as the Cowichan will be more easily affected by changes in winter flood events (increasing in frequency) and low-flow periods. Unlike

most of other river systems in the district, the Cowichan River flow is buffered (or moderated) by the presence of a large lake (Cowichan Lake), and further by the presence of a water-control structure (weir) at the outlet of this lake.

Human impacts on the watersheds have been extensive: early forest harvesting proceeded through extensive clearcutting, resulting in significant changes to the quality and quantity of water entering the system. The rivers themselves were impacted by the running of logs through the system. Fish harvesting has been extensive, both in the rivers and the ocean. Ocean conditions themselves have changed. All these impacts have occurred and interacted over significant periods of time during the last century, and many are ongoing today.

Fish in the Cowichan Basin Watershed

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 historically known for its substantial runs of chinook, coho, chum, and steelhead salmon. 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 have a special status in BC. The Cowichan has, in the past, supported some of the largest spawning runs of chinook in the entire Georgia Basin.

Other native species include rainbow trout, resident cutthroat, and Dolly Varden char, and – within Cowichan Lake – resident Kokanee salmon. 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 there are many smaller fish, such as minnows, chub, sculpins, and lamprey which are important parts of the ecosystem. The Vancouver lamprey, resident in Cowichan Lake, is listed as a "threatened" species under the Canadian Species at Risk Act.

Several species of fish have been introduced into the Cowichan watershed, mostly in the early 1900s, including brown trout, Kamloops trout, speckled char, lake trout, catfish, and Atlantic salmon.[73] Only brown trout appear to have established themselves to significance in the system. There are other, more recent, observations of invasive fish species which are not documented in this report but are a concern to the native biodiversity in the region.

73 Neave, 1941.

Measuring the State of Salmon in the Cowichan Basin Watershed

Indicator and Measures

For the purpose of this report salmon abundance is 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 was initiated more than 100 years ago), would provide the most appropriate benchmark for understanding recent trends. While this data cannot be readily accessed in this timeframe, data does exist on relatively long-term escapement (number of adults that escaped being caught and returned to the river to spawn) for key species within the Cowichan. These data sets are presented for each major species/stock.

It is important to note that other, more detailed, watershed trend indicators might provide additional insight into fish abundance trends, and a more precise indication of the factors affecting specific components of the salmon life history, from egg in the river to returning adult. These additional indicators might 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, predator pressures (such as presence of predator birds and fish), etc. These indicators would provide more baseline data to help us understand the trends in adult fish abundance. Some of this information will be available in an assessment of the habitat in the Cowichan watershed which was undertaken in conjunction with this report.[74]

However, the number of adults spawning remains an overall indicator which is relatively easy to measure. Like a canary in a mineshaft, salmon are an indicator of the overall health of the watershed, because they integrate so many of the factors mentioned above.

When interpreting trends in numbers of fish, it is important to understand that fish abundance is determined by a combination of the following three general types of factors (a few of these factors are explored in detail towards the end of this section):

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.)
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.)
3. Direct human interventions such as fishing or hatchery production.

74 DFO, 2010.

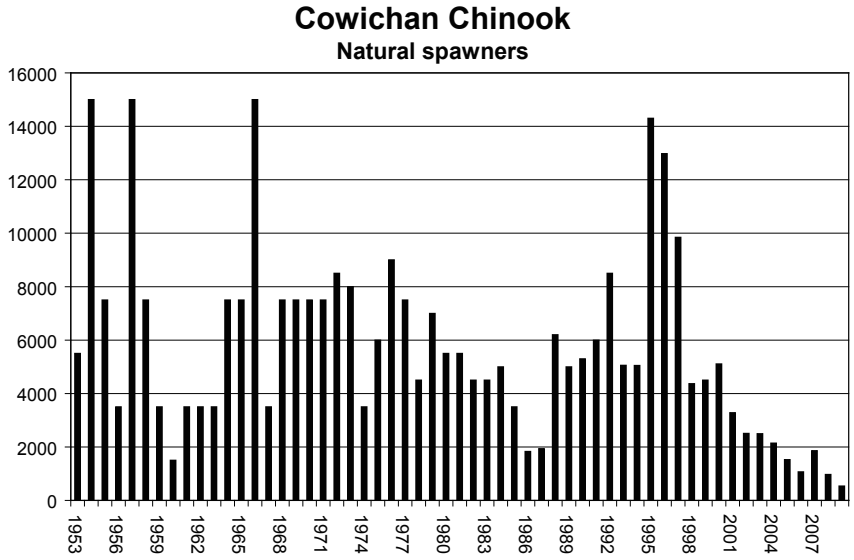
Determining which of these many factors has the most influence on fish population trends is a complex issue. Multiple species can be affected differently by different factors and can in turn affect one another. In addition, trends can alter within individual systems – making it difficult to summarize information. One thing is certain; the freshwater ecosystem is an important determining factor in the abundance of fish in the Cowichan Basin watershed.

Findings

Chinook

Historically, the major chinook run in the Cowichan returns in the fall, and over the last 56 years has had an average "escapement" (i.e., returning spawning adults) of 6,000 fish (Figure 2.25), with high variability across the years. For example, a strong El Niño in 1983 resulted in poor spawning numbers three to four years later, and improved ocean conditions in the late 1980s led to some large return numbers. Since the mid-1990s, however, natural spawning numbers have declined significantly to very low numbers, with the lowest ever recorded in 2009. Other contributors to this declining trend include: ocean conditions combined with continued high fishing pressure (catch rate), both from commercial and sport fisheries, fluctuating hatchery production, and impacts to freshwater areas (fish rear their young in the lower river and estuary prior to heading to the ocean, and survival in these zones has decreased through time). It is important to note that Cowichan chinook abundance has declined more than other chinook populations in the lower Strait of Georgia (such as Nanaimo or Squamish), suggesting that local impacts are significant for the Cowichan fish.

FIGURE 2.25: Annual estimates of chinook salmon "fall" spawners in the Cowichan River, 1953 – 2009



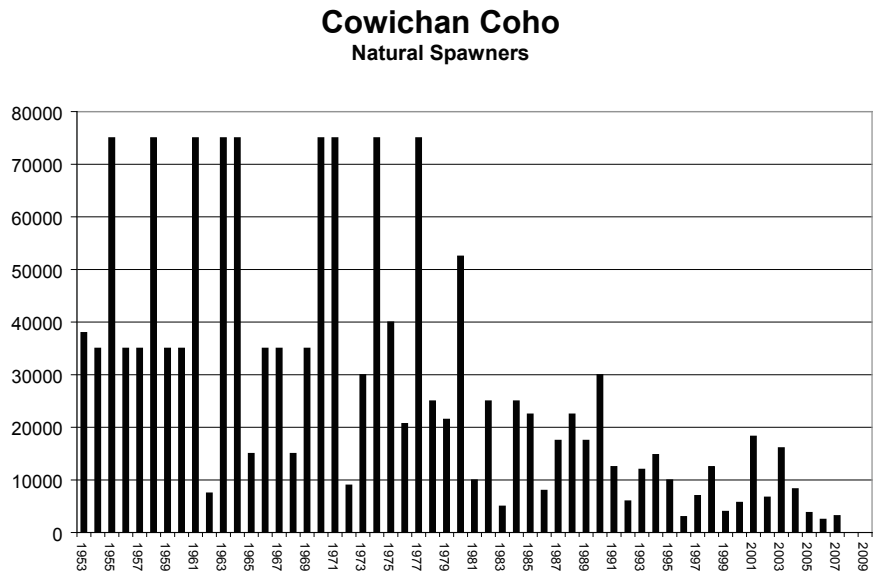
Source: Data from 1953 to 1987 are based on DFO Fisheries Officers' estimates. Data from 1988 to present are based on DFO fixed point enumeration (counting fence) and carcass mark/recapture estimates where necessary. DFO Salmon Escapement Database (NuSEDs), 2010.

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.[75] Good information on the factors affecting this population is unavailable.

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 2.26). 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 2.26: Annual estimates of coho salmon spawners in the Cowichan River, 1953 – 2009. No estimates were made for 2008 and 2009



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.

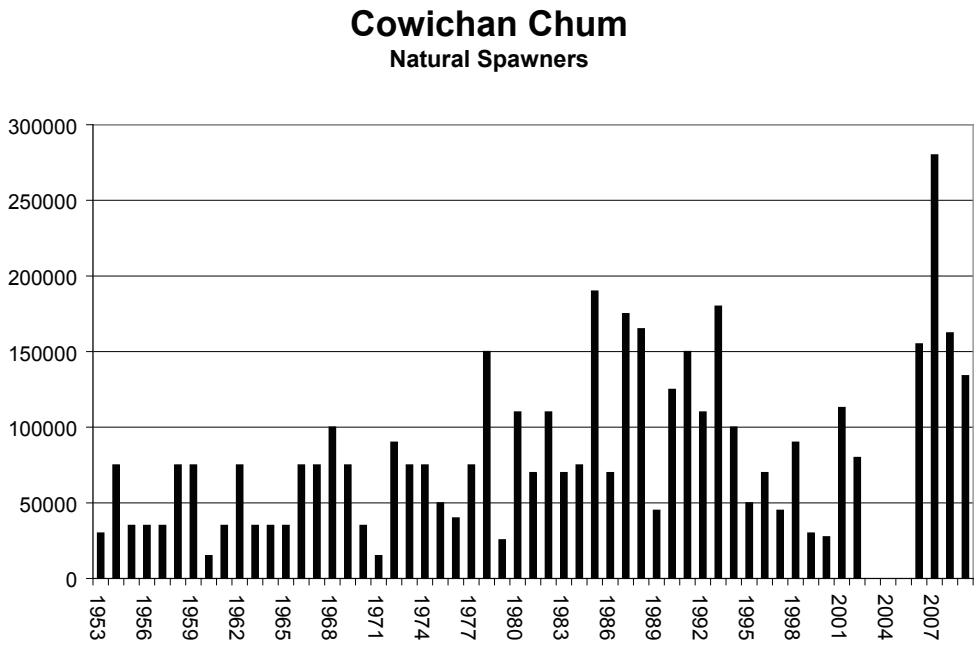
75 Burns, 2002, referenced in Burt and Robert, 2002.

Chum

Chum salmon stocks are considered as part of a single management unit called the Inner South Coast (ISC) chum stock. The average return for ISC wild chum salmon was 1.3 million from 1968-1982, which reduced to 1.1 million for 1983-1996[76].

Although numbers fluctuate widely (Figure 2.27), 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 2.27: Annual estimates of chum salmon spawners in the Cowichan River, 1953 – 2009. 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 (NuSEDs), 2010.

76 DFO, 1999, quoted in LGL, undated.

Steelhead and Trout

Steelhead on the Cowichan have 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, the steelhead in the Koksilah River are classified as of conservation concern.[77] 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 at 10 – 30% of habitat capacity,[78] though it is not known if this represents the historic abundance of fish in this system. A number of stewardship-based restoration projects, such as the remediation of Stoltz Bluff, are hoped to benefit this species.

Resident rainbow trout are very limited within the 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.

Factors Affecting Salmon Abundance in the Cowichan Basin

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 2.11) 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 – see Section 2.2), and in the nearshore environments of the southern shores of Vancouver Island and the Gulf Islands, is critical

77 Lill, 2002.

78 Lill, 2002.

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.

A few of these factors are explored below.

Water Quality and Quantity

In the Cowichan, water flow and quality (e.g., temperature) are thought to be key issues affecting fish populations, at least in some years[79]. 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. 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 weir is theoretically to be used to maintain fish habitat in time of low flow, and is typically successful in maintaining water levels. However, lake levels have at times been insufficient to maintain adequate water flow, leading to conflicts between ecosystem, fish and human water requirements.

There have been recent years when summer (low-flow) water levels in the Cowichan Basin system have been critically low – which results in significant impacts to habitat availability for spawning, migration and rearing, reducing overall fish productivity. At critically low levels, fish are dissuaded from even entering the watershed system and cannot bypass physical barriers in the system. The stranding of fish in side channels at times of low flow can be a significant issue and, although stewardship efforts are made to recover these losses, both coho and chinook salmon incur significant mortality through stranding.

Water quality also interplays with habitat quality. For example, above Skutz Falls the spawning habitat is of high quality, with much lower quality below the falls due to the high proportion of cobbles and boulders, combined with high fine sediment inputs. In addition, higher air temperatures combined with low water flow results in increasing water temperature, which, in turn, can have significant impacts on these primarily cold-water species (e.g., reducing growth rates, survival of fry and resistance to parasites and diseases). Increased temperatures are thought to be of particular concern within the Koksilah River system, as the temperature within this system is not buffered by a major lake (as is the case with the Cowichan River).

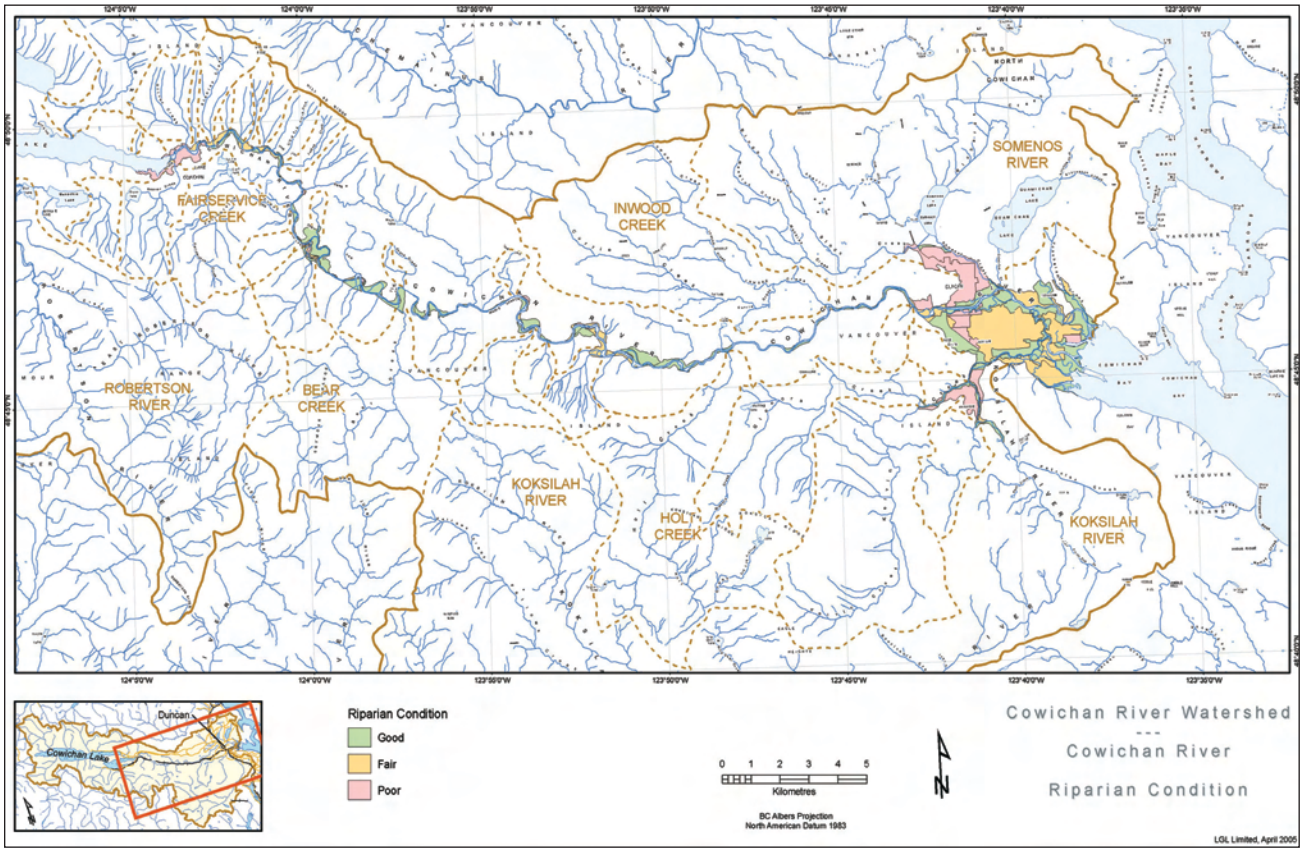
79 W. Luedke, Department of Fisheries and Oceans, personal communication, 2009.

Habitat Quality

In general, spawning and rearing habitats have been 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. Over this period, significant changes have occurred within stream channels and riparian habitat, reducing the natural complexity of the system, altering the input of natural coarse woody debris to the system (which creates spawning habitat under natural conditions), and affecting water quality and temperature. Development and dyking on the floodplain has changed the natural dynamics of the floodplain and affects habitat availability, particularly for rearing fish.

At the lower end of the system (from Cowichan Lake to Cowichan Bay), significant areas of riparian habitat are also considered to be in poor condition (Figure 2.28). The effects of pollution and habitat degradation on fish populations in the Cowichan Estuary (Section 2.2) are largely unquantified, but this area is important as a juvenile rearing habitat. Stewardship efforts have worked to improve the condition of habitat, but significant limitations remain.

FIGURE 2.28: 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 likely 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.

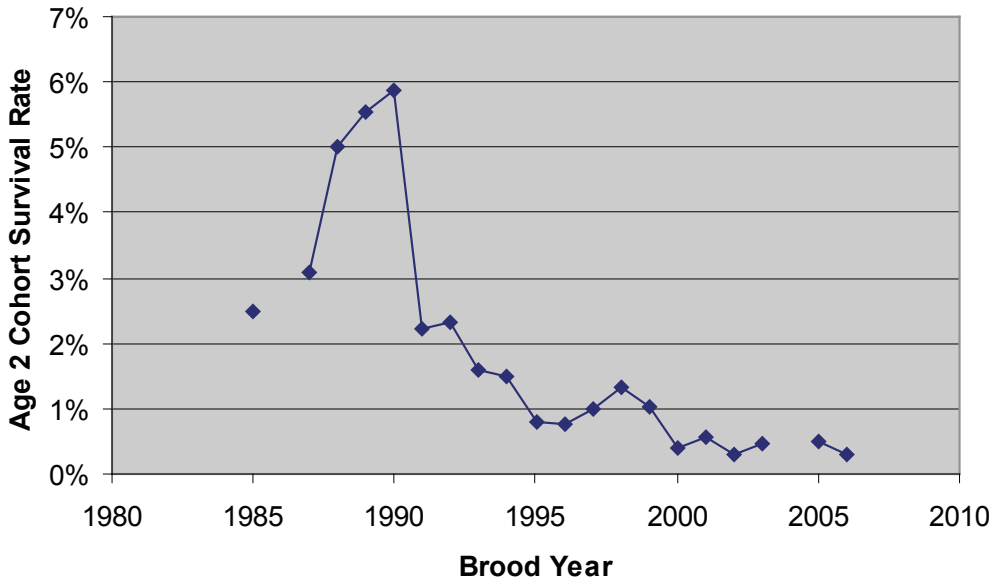
Ocean harvest of Cowichan chinook has been a significant factor in the low number of these fish returning to the river. In order to reduce overall harvest, several actions have been taken in recent years. These have included an approximately 50% reduction in allowable catch by the commercial troll fishery, 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

The trends in marine survival of chinook and coho entering the Strait of Georgia suggest that changes in marine conditions have had a negative consequence on salmon abundance. There is substantial evidence that 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 have a range of causes, 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.

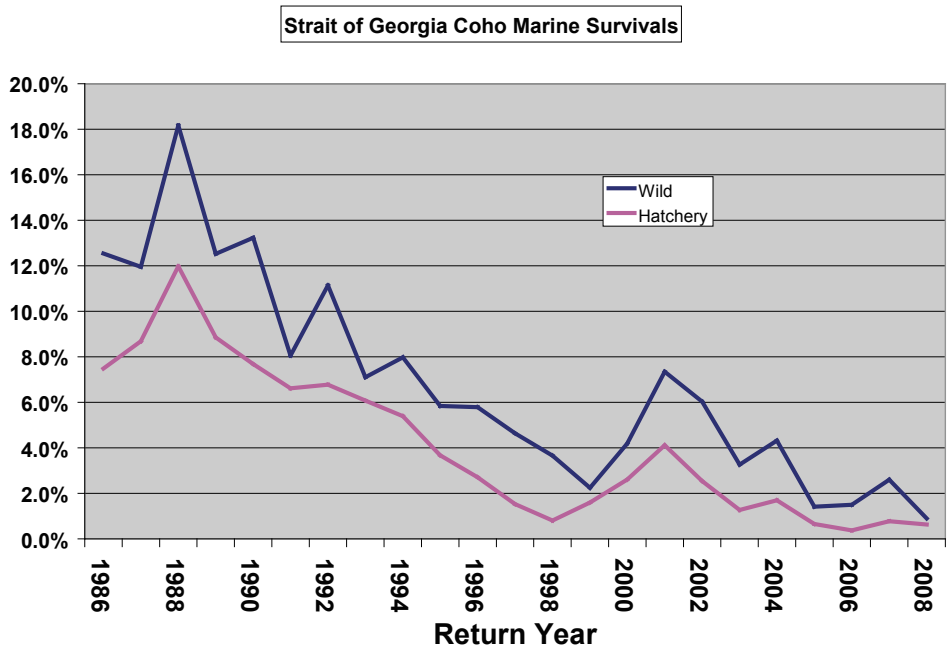
Figure 2.29 below shows a significant decline in marine survival of chinook from smolts released from the hatchery to age two since the early 1990s. Note that using age two precludes most of the fishery impacts, and so is a good indicator of natural impacts. The recent survival rate of Cowichan Hatchery chinook is only 0.3% on average (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. Similarly, marine survival for Strait of Georgia coho has been poor for both hatchery and wild stocks, with the decline starting about 1990 (Figure 2.30).

FIGURE 2.29: Cowichan Hatchery chinook survival rate trend to age 2, based on coded wire tag recoveries



Source: DFO, 2010.

FIGURE 2.30: Marine survival data for Coho in the Strait of Georgia showing declining trend



Source: DFO, 2010.

Summary

Fish – particularly chinook and coho salmon – historically have been foundation species in the Cowichan Region, 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 community 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.

In the last five 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, while others, such as chum are at relatively high levels. Often, the diversity of trends, and of factors affecting these fish (see Joint Technical Working Group evaluation in Table 2.11) 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 long-term implications of the fish population crashes will be realized over the coming generations for both ecosystems and humans. These implications can be expected to cascade through ecosystems and human communities, and result in both obvious and less obvious changes into the future. Significant effort and action is required at all levels and jurisdictions to return these stocks to their former abundance and to reverse the current trends of increasingly poor ecosystem health.

The Joint Technical Working Group (organised by DFO[80]) has provided an initial evaluation of the significance of the issues or limiting factors affecting salmon life history (Table 2.11). The impact level suggests how important various factors are in the decline of the Cowichan fishery. The certainty column defines how certain it is that the impact rating is correct.

80 W. Luedke, DFO, personal communication, 2009.

TABLE 2.11: 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	Risk: 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
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[81] by floods	> Land use (logging and clearing) results in greater flow variation	High	High

81 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.

TABLE 2.11: 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
l. Lack of rearing habitat in mainstem[82]	> 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
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

82 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).

Data Gaps

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 in 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).

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