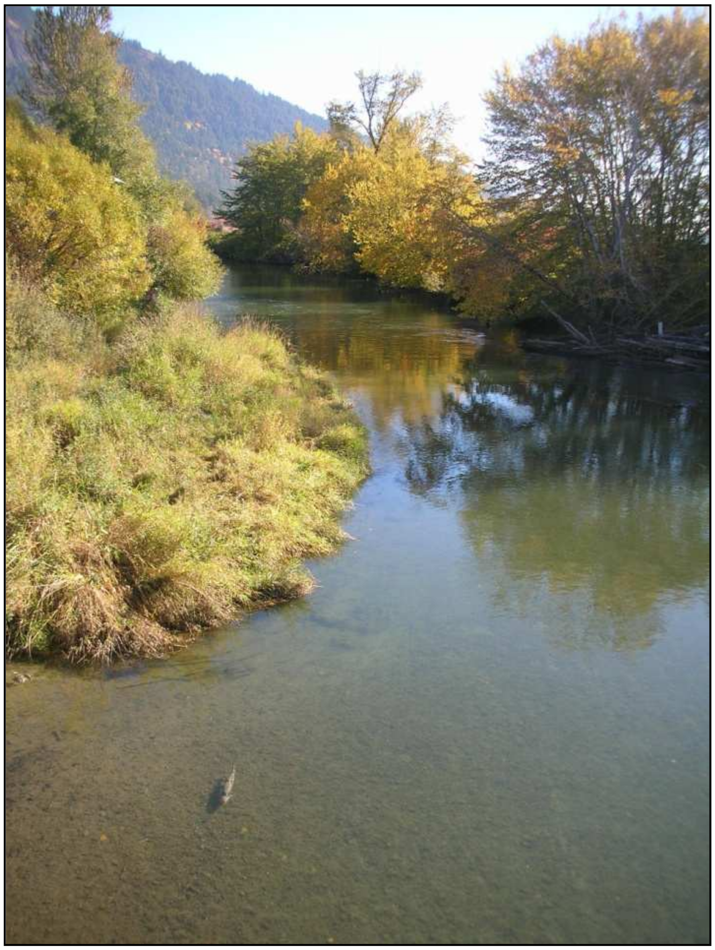
Cowichan River Fall Chinook
Habitat Status Report



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DRAFT REPORT

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1.0 INTRODUCTION

The present population of fall run chinook is a severe conservation concern with wild chinook escapement decreasing to a historical record low in 2009 with less than 500 natural spawning adults (age 3) migrating upriver and approximately 300 adults collected for broodstock (Luedke pers. comm.). In contrast, between 1988 and 2002, fall chinook escapement to the Cowichan averaged between 5,000 – 10,000 spawners.

The natural escapement of fall run chinook stock has illustrated a declining escapement trend since the late 1990's. Despite recent efforts to assist the recovery of Cowichan River chinook, by 2007 the stock had the highest rate of decline of any BC chinook conservation unit (Holtby and Ciruna 2007). As part of the 2010 Salmon Outlook, FOC, the status of Cowichan fall chinook is designated as a "stock of concern" and as well, is classified as "endangered" according to the COSEWIC criteria.

In an effort to address declining the Cowichan river chinook stock, several initiatives are already underway. In 2005, Fisheries and Oceans initiated the implementation of the Wild Salmon Policy. The WSP strategies strive to incorporate habitat and ecosystem considerations into salmon management and to establish local processes for collaborative planning throughout BC. Initial strategies outlined by the Wild Salmon Policy include an assessment and documentation of the habitat status for chinook within both freshwater and marine ecosystems and development of indicators for ongoing monitoring and assessment. On a more targeted level, in 2005 the Cowichan Tribes developed a watershed wide, multi-species Recovery Plan for the Cowichan watershed (LGL 2005).

In 2009, FOC initiated a comprehensive ecosystem based planning process to rebuild the Cowichan chinook stock through development of an Integrated Chinook Recovery Plan. The first priority of this initiative is to provide a collaborative process to develop a holistic, ecosystem based plan for rebuilding and sustaining the severely declining fall chinook run. Over the longer term, the intent of the Integrated Recovery Plan is to sustain all salmon species in the Cowichan River. The process is working towards building on existing planning initiatives to develop local governance and ownership of fish stocks in the Cowichan along with the capacity to implement salmon rebuilding programs (Luedke pers. comm.). The Cowichan Tribes, Cowichan Valley Regional District, Living Rivers Society and the Cowichan Basin Watershed Advisory Council (CBWAC) will be key players for local governance and ownership within the Cowichan watershed.

1.1 Purpose and Scope

The purpose of this report is to provide a comprehensive review of the freshwater habitat status of the Cowichan River as outlined by the Wild Salmon Policy. Key elements of this Habitat Status Report includes the identification of known sensitive habitat types by life stage, potential limiting factors to chinook production and proposed habitat based measures to address these limiting factors and to maintain freshwater productivity. This project also includes the development of a preliminary list of habitat indicators for further discussion and implementation as part of a long term habitat status Monitoring Plan for the Cowichan watershed.

The study area includes chinook-producing habitat within the watershed and therefore focuses on the mainstem Cowichan River to Cowichan Lake and to a lesser degree the lower Koksilah River to the Marble Falls barrier (Fig 1). Small numbers of chinook are produced in some years in the Robertson River and Shaw Creek, upstream of Cowichan Lake. However, utilization of these systems by chinook

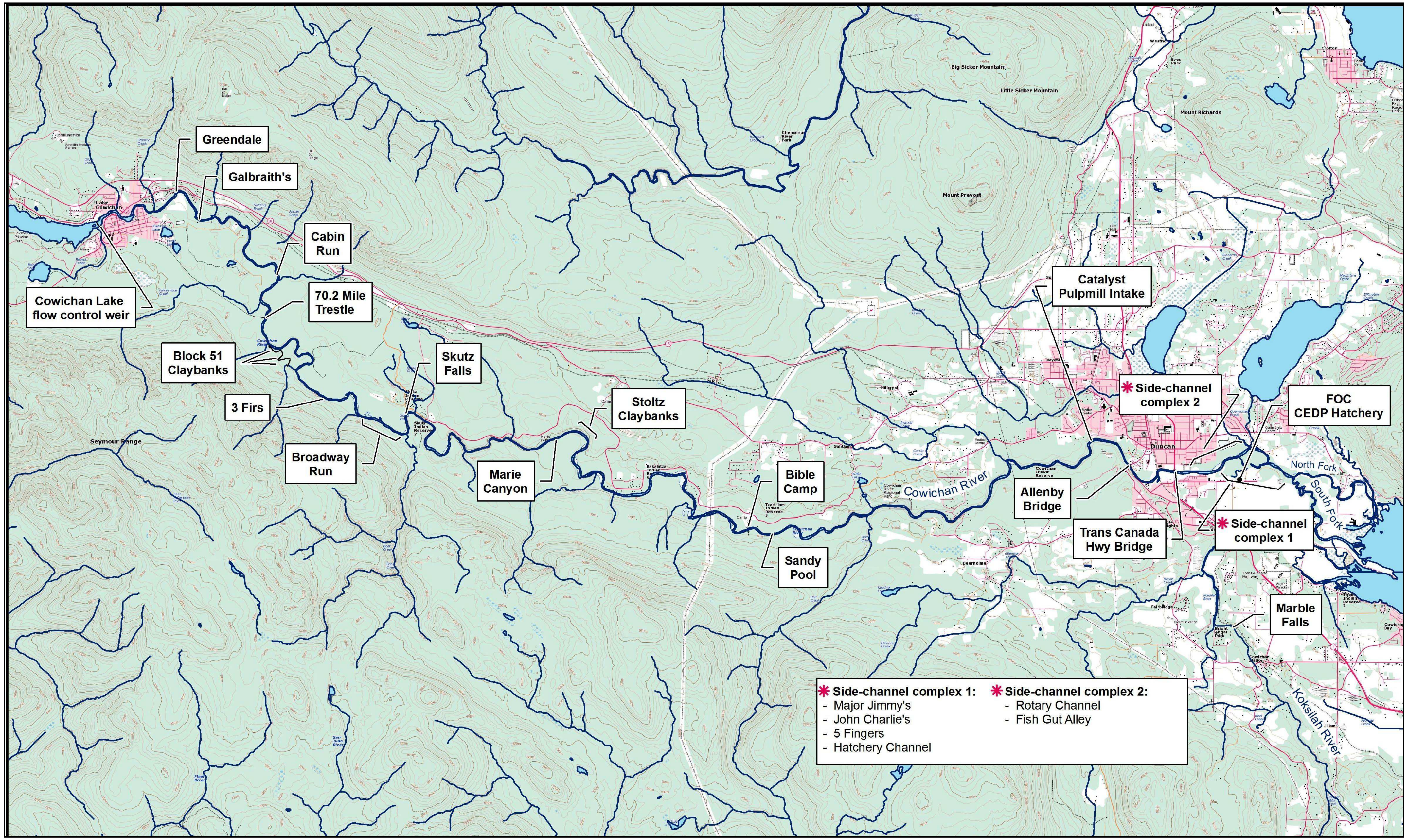


Figure 1. Location Map for the Cowichan chinook study area illustrating key features between the estuary and the outlet of Cowichan Lake as well as the Koksilah River to the anadromous barrier at Marble Falls.

is infrequent and therefore habitat status and limiting factors were not examined or discussed in any detail within this report.

This information is relevant to developing a Recovery Strategy for Cowichan River fall run chinook as outlined for Strategy 2 of Wild Salmon Policy. As well, the contents of this report will provide habitat related components for the ecosystem based Integrated Chinook Recovery Plan or more recently known as the Cowichan Salmon Initiative currently in progress.

A coordinated approach is necessary to develop immediate and effective measures to address the diminishing chinook stock. Other factors that directly affect the total abundance of fall run chinook include hatchery/enhancement efforts, nearshore and offshore marine survival, exploitation in commercial and sport fisheries, predation by southern resident Orcas and the terminal First Nations fishery (Fig 2). These factors are outside the scope of this study but are briefly discussed in the following section.

1.2 Other significant factors that influence natural chinook abundance

Commercial, sport and the Terminal Native harvest, hatchery enhancement and marine survival can have a significant influence on the total return of chinook spawners to the Cowichan watershed (Fig 2). In some cases, the effects of these factors will vary in some years depending on environmental conditions or are based on disciplines (i.e. enhancement, fisheries management) that are outside of the focus of this study. As well, further assessment is needed to determine whether they are limiting to chinook production. However, inclusion of these factors is vital to development of a holistic, Recovery Plan for the Cowichan River fall chinook run.

1.2.1 Commercial, Sport and Native Harvest

Exploitation rates in the commercial and sport fisheries can have a significant effect on the total number of adults returning to the Cowichan River with chinook being harvested at a higher rate relative to other salmon species in the Cowichan watershed. The total exploitation rate for chinook (catch + incidental) has ranged from a low of 34% for the 1995 brood year to a high of 87% for the 1985 brood year (Fig 3, Tompkins et al. 2005). In general, exploitation rates for Lower Georgia Strait chinook stocks were higher (70-80%) until the early 1990’s (W. Luedke pers. comm.). During the late 1990’s, the exploitation rate for Cowichan fall chinook was reduced to 30% as a conservation measure. However actual ocean fishery exploitation rates ranged between 50 - 70% from 1996 to 2000 and is likely due to the loss of sportsfishing opportunities for coho in Georgia Strait as well as an increase in incidental catch in commercial and sport fisheries outside of the Strait of Georgia (Tompkins et. al. 2005). Coincidentally, in 1995, lowest recorded exploitation rate coincided with the highest historical escapement for natural adult spawners in the Cowichan River.

In the most recent years, the current exploitation rates for Cowichan Chinook continues to average around 60% (W. Luedke, pers. comm.). A more conservative approach has been implemented to protect Cowichan chinook by a 50% reduction to the WCVI troll fisheries in 2009, spot closures for sportsfishing during the fall migration period and implementation of mark selective fisheries in Washington State (W. Luedke pers. comm.). The broad and recently variable marine distribution of Cowichan fall chinook run increases the challenge, risk and complexity for fishery management actions. The benefits of recent management actions will be evident in the forthcoming years.

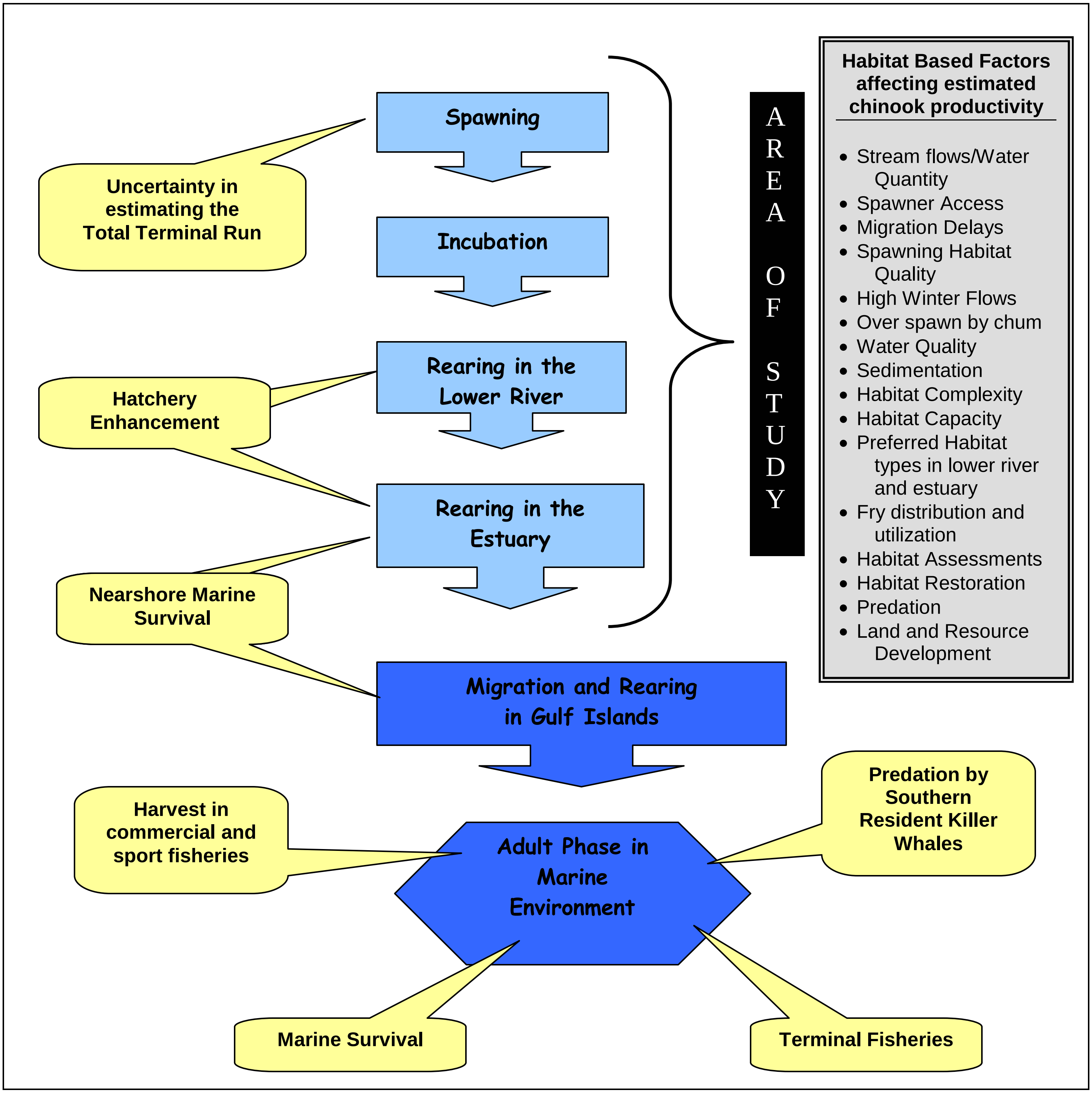


Figure 2. Overview of Factors that affect the total abundance of Cowichan chinook illustrating Habitat based Factors included in this report (light blue) as well as other external factors (yellow) that are relevant but not within the scope of this document.

There has been a traditional terminal Native Fishery for chinook by the Cowichan Tribes for food and ceremonial purposes using a variety of traditional fishing methods throughout the lower reaches of the Cowichan and Koksilah Rivers from June through October (Nagtegaal and Riddell 1998). Since 1990, the Cowichan Tribes Aboriginal Fisheries management Program developed a systematic approach to monitoring the fishery and estimate the Native food fish catch with weekly estimates of catch per unit effort obtained. The terminal native fishery is not fully evaluated by FOC and considered to be nominal, relative to the catch of fall chinook in ocean fisheries (Tompkins et. al. 2005). Since 2005, there has been a voluntary reduction in the harvest of fall run Cowichan River chinook for food, social and ceremonial purposes.

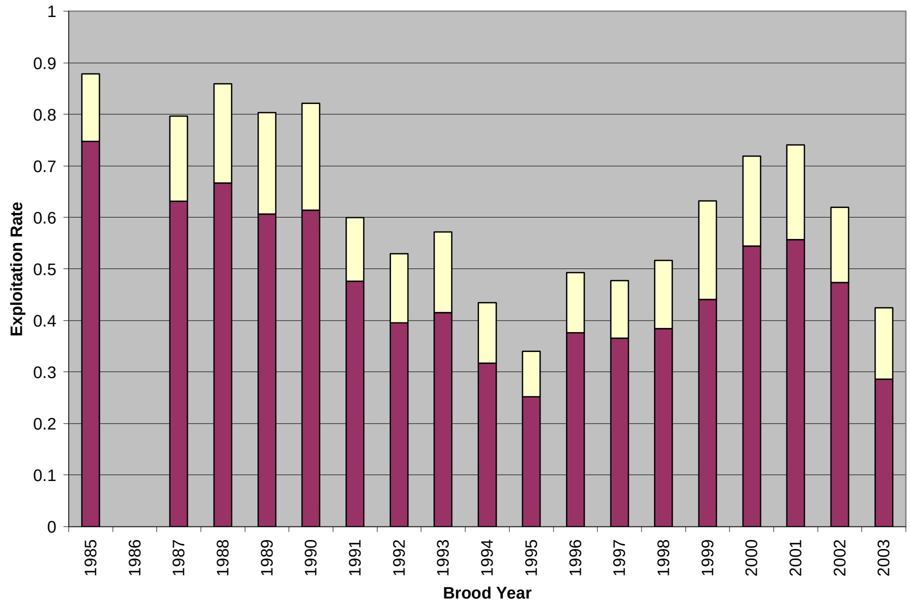


Figure 3. Annual exploitation rate by brood year for the Cowichan River chinook stock by landed (purple) and non-landed mortality (white) (FOC Working Paper 2008).

1.2.2 Hatchery Enhancement

The Community Economic Development Program hatchery was constructed in 1979 approximately 5 km upstream of the estuary. The facility is managed by the Cowichan Tribes with chinook production initiated in 1980. Broodstock is collected in the lower reaches with a limit of 30% of the spawners available for hatchery enhancement (LGL 2005).

From the early 1980's to 1990, the annual production and release of chinook fry from the hatchery was less than 1 million fry (Tompkins et al. 2005). Between 1991 to 2004, hatchery releases have notably increased and have ranged between 1.5 million and 3 million in most years and reached a peak of 3.3 million in for the 2001 brood year (Fig 8, Tompkins et al. 2005). For the 2004 brood year, a power failure resulted in complete loss of chinook eggs with no release in 2005. For brood years 2005- 2008, total chinook fry released were lower and ranged from 460,000 to 1.9 million (W. Luedke pers. comm.).

Survival rates for chinook smolt release to adults averaged 0.3% for the 1998 – 2002 brood years and low survival may be attributed to low marine survival rates and/or marine capacity (Sheng and Bonnell 2010). It is possible that marine capacity is less than it was during the 1970's and 1980's when high productivity/survival was observed. During 1974 and 1975, juvenile chinook populations of 581,000 and 172,000 produced an adult escapement of over 9000 adults with survival to escapement rates of 1.6 and 5.5% respectively (Sheng and Bonnell 2010).

For the 2009 brood, the Cowichan hatchery will maintain a late May release strategy and will pilot fish culture requirements to raise smolts to 20-35 grams and assess the feasibility of a September release

(Sheng and Bonnell 2010). A portion of hatchery raised chinook fry are coded wire tagged or in more recent years, thermally marked with recovery information used to support Pacific Salmon Treaty analysis including an estimate of distribution, exploitation rates, marine survival and hatchery contribution to returning escapement (Sheng and Bonnel 2010, LGL 2005). The survival of hatchery raised chinook, operational and infrastructure issues at the hatchery as well as the role of the hatchery production to overall chinook production are current issues that warrant further studies and discussion.

1.2.3 Ocean Productivity, Marine capacity and Marine Survival

Pacific salmon stocks are influenced by long-term marine climate changes and associated changes in ocean productivity. Marine environmental factors including a change in oceanic conditions within the Strait of Georgia have been correlated with declining Cowichan chinook abundance (Beamish et al. 1995).

Marine capacity is also an important factor in the management of Cowichan hatchery chinook production. In theory at this time, is a belief that there could be a limit to the capacity of salmonids produced in Georgia Strait and that combined hatchery and wild production may currently exceed the marine capacity. Ongoing science based studies are investigating marine capacity and if current marine capacity is being exceeded, hatchery production may need to be adjusted within the Georgia Basin to lower production level, similar to numbers released during the 1970's and 1980's (Sheng and Bonnell 2010).

Marine survival is considered to be the proportion of juveniles that outmigrate to sea and successfully return to their natal stream as spawning adults. The intent of calculated marine survival rates is to reflect ocean rearing conditions for salmonids and therefore with mortality due to interception by targeted and incidental fisheries are not included. Between 1980 and 2000, marine survival rates of Cowichan fall chinook to Age 2 recruitment have ranged from <1% to approximately 6% based on hatchery-released chinook (Fig 4, Riddell et. al. 2000, Tompkins et al. 2005). Marine survival rates from 1988 to 1990 were relatively good, averaging 5.5% but decreased substantially to an average of less than 1% between 1993 and 2006 (W. Luedke pers. comm.). For the Cowichan River, marine survival rates are based on CWT hatchery fry and therefore include mortalities during the downstream migration and more significantly, their residence time in the estuary.

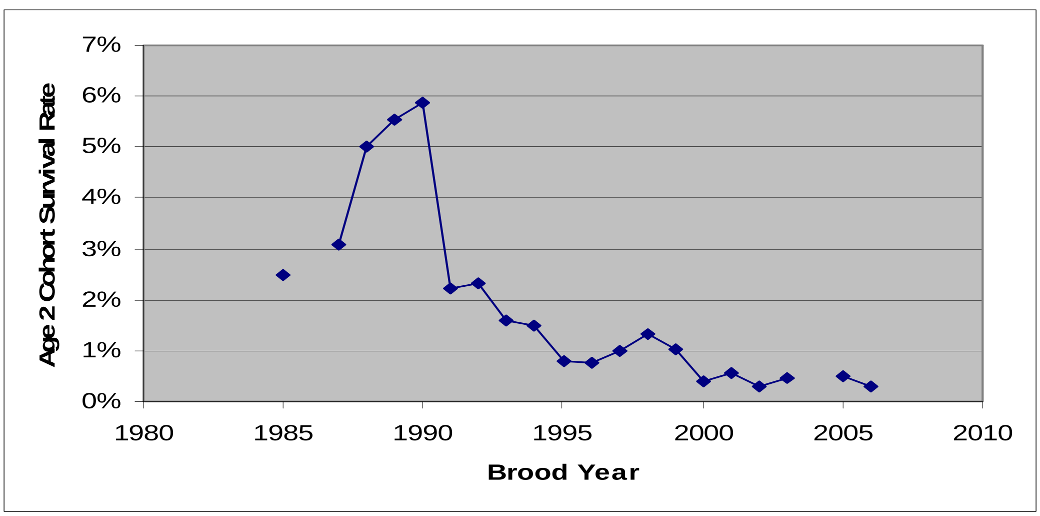


Figure 4. Graph illustrating % Marine survival (release to adult) for Cowichan River Fall chinook run (W. Luedke, pers. comm.)

Low marine survival rates are not believed to be river specific and have affected the production of all lower Georgia strait stocks. Low marine survival is thought to be due to a decline in carrying capacity of the Georgia Strait as a result of an increase in mean water temperature (Beamish et al. 1995). As well, early marine survival may be attributed to an increase in predation by spiny dogfish (*Squalus acanthias*) and river lamprey (*Lampetra ayersi*) (Beamish et al. 1995). Decreased early marine survival can also be due to the availability (quantity and distribution) of marine zooplankton as well as competition with other species for prey. As well, a variation in the size of preferred zooplankton for chinook can also play an important role in the growth and strength of each year class of juveniles.

1.2.4 Predation

The seasonal movement of harbor seals (*Phoca vitulina),* Stellar sea lions (*Eumetopias jubatus)* and California sea lions (*Zalophus californianus*) into the Cowichan Estuary coincides with the arrival of adult salmonids during the fall. Pinnipeds have potential to play a major role on the overall predation of adult chinook, particularly during years with low water levels. Adults become more vulnerable in shallow habitat with predation more significant in the lower river and estuarine areas with limited instream cover.

Within the Cowichan Bay, an estimated 23% (Sept) to 48% (Nov) of the harbor seals diet consisted of chum and chinook salmon with seal numbers ranging from 30 in April to a peak of 100 seals in Dec (Bigg et. al. 1990). Therefore, seal predation on chinook adults could range from 100 to 500 adults (Riddell et. al. 2000). As well, the extent of predation by pinnipeds is dependant on chinook residence time in the lower river and estuary (Nagtegaal and Carter 2000). Therefore, seasonal periods of low water that delay upstream migration of chinook would likely increase the incidence of predation. In 2009, for the first time fisheries personnel from the Cowichan Tribes observed that seals were migrating further upriver and observed them in the mainstem upstream of the enumeration fence site.

Seal predation on outmigrating chinook juveniles in the Cowichan River is not currently a primary concern as chinook fry migrate soon after emergence and therefore are small in size (outmigrating at 42-55 mm for early and late migrants in Lister et al. 1971) and do not appear to represent a primary food source targeted by pinnipeds. In contrast, seal predation on outmigrating smolts and returning spawners is a major concern in the Courtenay River as research has confirmed a significant impact of seal predation on overall chinook productivity. However, the impacts of predation by seals and seal lions in the Cowichan River is currently unknown but believe to be minimal.

The seal population has been increasing in the Strait of Georgia over the past 30 years while the total catch/abundance of salmon has drastically declined. As well, chinook are the principal prey species of fish eating killer whales (*Orcinus orca)* populations in the northeastern Pacific Ocean (Ford et al. 2009). The increase in northern and southern resident killer whales coincides with the declining abundance of chinook (Ford et al. 2009). However, the impacts of killer whale predation on Cowichan River fall chinook are unknown.

1.3 Methodology

Methodology for this report includes a literature search, with subsequent review of existing references, maps, databases and unpublished materials. Interviews/contact to collate the most recent reference documents were conducted during the spring of 2010 with Fisheries and Oceans staff (W. Luedke, M. Sheng, C. Neville S. Baillie), Cowichan Tribes (J.R. Eliot), Cowichan Valley Regional District (K. Miller), Ministry of Environment (P. Law) and the Living Rivers Society (Tom Rutherford).

Hardcopy base maps (1:20,000) and electronic topographic maps for the study area were generated and printed by Project Watershed Society. These were taken to interview with relevant locations and habitat based information transcribed on them for later integration into a GIS product.

Based on the literature review and interviews, potential limiting factors were identified for further discussion. Appropriate measures were also developed for further consideration in order to effectively address each of the potential limiting factors. Each limiting factor is numbered as LF# with recommendations for corresponding Measures labeled with M#.#. For example, LF7 would have Measures listed as M7.1, M7.2 etc.

An important component of a comprehensive recovery plan for Cowichan chinook also includes a Monitoring Program to provide a snapshot of the current habitat status as well as provide a measure of habitat based changes over time. As outlined in the Terms of Reference for this project, a very preliminary list of state and pressure indicators has been compiled based on the literature review and professional judgment. These indicators do not represent a comprehensive list of potential indicators for the Cowichan chinook run and intended to provide as a starting point for further literature review and discussion amongst fisheries practitioners in the Cowichan Valley.

2.0 SUMMARY DESCRIPTION OF THE COWICHAN RIVER WATERSHED

2.1 Background

The Cowichan River is recognized as one of the most important and productive fish bearing rivers on Vancouver Island based on the abundance and variety of salmonid species, significance to the Cowichan Tribes First Nation for food social and ceremonial purposes and importance to local commercial and recreational fisheries (Lill et. al. 1975, Burt and Wightman 1997). In 1995, the province of B.C. designated Cowichan as Provincial Heritage River based on outstanding natural, cultural and recreational values. In 2005, the Federal and Provincial governments in cooperation with First Nations officials designated the Cowichan River as a Canadian Heritage River, with this status awarded to only 2 other rivers in B.C. (Kicking Horse and Fraser River).

Due to the decline in chinook production in the Strait of Georgia combined with the importance of Cowichan stocks to local fisheries, the Cowichan River was selected as the sole indicator stock for exploitation rates and estimated escapement (Matthews and Baillie 2007). The Cowichan River chinook run is used to indicate the status of all lower Georgia Strait chinook stocks within the framework of the Canada/US Pacific Salmon Treaty (Candy et al. 1996). Coded wire tag data has confirmed the contribution of Cowichan River chinook to commercial fisheries outside of the anticipated Georgia Strait fisheries, including commercial catches along the west coast of Vancouver Island as well as Alaska.

Cowichan chinook stock belongs to the Lower Strait of Georgia Fall Chinook group, one of five major groups based on geographic location, spawning run timing, distribution, age at maturity and genetics in some instances (Riddell and Nagtegaal 1999). The Cowichan used to produce one of the largest remaining naturally spawning populations along with the Nanaimo River within the lower Georgia Strait stocks.

The Cowichan River watershed encompasses a total of 826 km^2 with a mainstem length of 47 kilometers extending from Cowichan Lake into Cowichan Bay (Fig 1). The mean annual discharge (MAD) near Duncan is 53 cms with 70% of the mainstem flow supplied by Cowichan Lake and it's tributaries (Burt and Robert 2002). Anadromous distribution extends to Cowichan Lake and tributaries upstream. Extensive floodplain habitat is present off the mainstem Cowichan R and Koksilah R downstream of Trans Canada Highway crossing. The mainstem Cowichan is tidal to approximately the Somenos confluence.

The Koksilah River is the largest tributary that flows into the Cowichan mainstem approximately 1.5 km upstream of the estuary. The Koksilah is 209 km^2 with a mainstem length of 44 km and a mean annual discharge of 9.8 cms (LGL 2005). Anadromous distribution in the Koksilah River is limited by Marble Falls, located 13.4 km upstream of the river mouth. The falls consist of a series of small chutes and cascades that rise 5 m over a 25 m run. In 1980, a slotted fishway was constructed through the falls but has not been successful in improving passage for coho and chinook salmon (FHIIP 1998).

The Cowichan River estuary ranks fourth in size on Vancouver Island encompassing approximately 492 hectares with 277 hectares of intertidal area (Fig 1, Clermont 2009, CETF 1980, Williams and Langer 2002). The estuary is ranked within the top 10 estuaries in B.C. based on conservation values and potential for habitat restoration (Clermont 2009). The Cowichan estuary holds cultural significance to the Cowichan Tribes and was historically used to harvest shellfish, waterfowl and salmon (Law 2008).

The complex ecology of the estuary provides the foundation for a critical food supply and unique, year round habitat for fish, shellfish, mammals and at least 229 bird species (Law 2008). The estuary provides a year round migration and nursery area for many species of fish including 4 salmon and 3 trout species, sole, herring, sand lance, several *Cottidae* species and invertebrates during their early life stages (Law 2008, MOE 1994). The Cowichan river estuary also provide critical overwintering habitat for thousands of waterfowl that nest in Alaska and northern B.C. as well as a regionally important migratory bird staging area within Georgia Strait (Law 2008, MOE 1994). The estuary also supports at least 12 waterfowl species (loons, grebes, ducks, gulls, cormorants) as well as numerous shorebirds, herons and raptors on a year round basis. An estimated 16,000 waterfowl overwinter or utilize the estuary and lower floodplain habitat during migration (Lill et. al. 1975).

2.2 Fisheries Resources

Anadromous fish species within the Cowichan watershed includes major runs of fall chinook salmon (*Onchorhynchus tshawytscha*), coho salmon (*O. kisutch*) and chum salmon (*O. keta*). There is also a strong run of winter run steelhead (*O. mykiss*) with limited presence of sea run cutthroat trout (*O. clarki*) (Burns 2002). A small run of summer run chinook is present and both sockeye (*O. nerka*) and pink salmon (*O. gorbuscha*) are typically rare. However, during the fall of 2007, a small run of pinks were observed in the lower Cowichan River.

Major runs of indigenous resident fish species include rainbow trout (*O. mykiss*), cutthroat trout (*O. clarki*) and Dolly Varden char (*Salvelinus malma*) and landlocked sockeye (kokanee) in Cowichan Lake (Burt and Wightman 1997). Brown trout (*Salmo trutta*) were introduced during the 1930's and have successfully colonized the system (Lill et al. 1975). Introduced species within the study area include the pumpkinseed fish (*Lepomis gibbosus*), three-spine stickleback (*Gasterosteus aculeatus*), prickly sculpin (*Cottus asper*) and various lamprey species (*Lampetra spp.*) (Hanelt 2002).

2.3 Land ownership and projected land use

Urban, rural and industrial development is primarily concentrated in the lower floodplain area of the Cowichan watershed with exception of the communities of Cowichan Lake at the lake outlet and Youbou along the north margin of the lake. There are 9 Indian Reserves within the Cowichan watershed that total 23.9 km^2 that provides residence to approximately 19000 people in 2005 (LGL 2005). The three major urban nodes are located in the City of Duncan (4900 residents) Town of Lake

Cowichan (3000 people) and Youbou/Meade Creek (1200 people) with a total population of approximately 70,000 for all municipalities within the Cowichan Valley Regional District (LGL 2005).

The majority of the Cowichan watershed downstream of the Allenby Road bridge is owned and managed by the Cowichan Tribes or under jurisdiction of the Cowichan Valley Regional District. Smaller areas are under jurisdiction of the City of Duncan and the District of North Cowichan. Much of the upper watershed is privately owned and managed for forestry values. For more detailed information, please refer to the CVRD State of the Environment Report due for release in 2010.

2.4 Resource Development

The primary resource development activities in the Cowichan watershed include forestry development in the middle and upper reaches, agriculture in the lower floodplain reach with urban and rural development in the lower watershed and adjacent Cowichan Lake. There is a shipping port and sawmill in the estuary, with light industrial development primarily located adjacent to the Trans Canada Highway corridor. Potential land use impacts specific to the Cowichan watershed are summarized in Appendix B.

2.4.1 Agriculture

Agricultural development started in the Cowichan Valley around 1862 and continues to be one of the major economic activities within the watershed. There is approximately 17,600 ha designated as ALR within the productive valley bottom areas of the lower Cowichan and Koksilah Rivers where dairy farming is the dominant agricultural activities with smaller areas producing forage crops, fruit and vegetables with more contemporary initiatives included wine, organic fruits/vegetables, pond aquaculture and exotic livestock (LGL 2005).

Impacts of agricultural have included extensive land clearing, dewatering of wetlands as a result of ditching as well as degraded water quality from excessive nutrient inputs to Somenos and Quamichan lakes (LGL 2005). Other impacts as a result of agricultural, residential and rural development has been the construction of flood control dykes in the lower river downstream of the Trans Canada Highway that has altered natural floodplain hydrology as well as limiting fish access to critical off channel habitat.

2.4.2 Forestry

Forestry development in the Cowichan River watershed has been extensive. Forest harvesting started in 1878 at easily accessible sites around Cowichan lakes where the logs were boomed in the lake and run down the river to Cowichan Bay during higher flows. The banks of the river and riparian areas were damaged causing bank erosion and aggradation that altered channel depth as well as the natural channel pattern. Logjams formed at sidechannel intakes and erosion and flooding issues became a problem in the lower river. Extensive harvesting occurred with very few areas of old growth remaining by 1908 (CHRB 1999 in LGL 2000).

Historical impacts to the Cowichan mainstem as a result of forestry development includes chronic channel erosion and channel/riparian disturbance from running logs down the mainstem. The practice of running logs down the river was stopped in 1908 and from 1909 to 1915, logjams were removed from sidechannel intakes and in 1921, DFO undertook the first passage improvement works at Skutz Falls (Nagtegaal, unpublished data). In 1956, DFO constructed a vertical slot fishway at Skutz Falls to facilitate upstream passage of spawners. During the 1950’s, the lower floodplain was diked to reduced flooding and to improve the use of land for agriculture (CETF 1980).

Much of the Cowichan and Koksilah watersheds consist of second growth forest that is privately owned. Four major forestry operators actively harvest timber primarily on private forest lands in the Cowichan watershed and include: TimberWest Forest (Cowichan Lake and upper Koksilah R) Corporation, Island Timberlands (south side of mainstem from Robertson River east to Koksilah R), Hancock Timber Resource Group (Cowichan Lake near Meade C, Gordon and Honeymoon B) and Teal Jones (TFL 46 along south side of Cowichan mainstem) (LGL 2005). B.C Timbers Sales manage forestry development in the upper Cowichan mainstem downstream of Cowichan Lake (B. Rushton pers. comm.) with several small logging operators harvesting timber in the Koksilah watershed.

At this point, from a watershed perspective, the impacts of forestry development and urban development on slope stability, bank erosion, riparian habitat, off channel habitat and stream flows have not been assessed and documented. The assessment of hydrological characteristics in combination with stream habitat assessments can identify if and where forest harvesting activities have had an impact on fish and fish habitat. Known impacts in the Robertson River upstream of Cowichan Lake, include accelerated bedload movement and aggradation in the lower 1-2 kilometers that has caused channel stability issues and seasonal dewatering (T. Rutherford, pers. comm.). FOC is currently in the process of mapping land use and land cover types by watershed on Vancouver Island at a 1:250,000 mapping scale with forest land classified into 5 age classes (B. Mason pers. comm.).

2.4.3 Industrial/Resource development in the Estuary

Development of the estuary began in 1862 upon arrival of settlers that constructed dykes over a large portion of the estuary for agricultural purposes, resulting in the loss of marsh and meadow habitat (Prentice and Boyd 1988). Further degradation occurred during the 1880's from logging and rafting logs down the river and into the estuary (Law 2008). In 1925, an extension of the CNR was constructed through the lower river and into the tidal flats to provide coastal access for logging operations. A causeway was constructed on filled estuarine land and resulted in the loss of marsh, meadow, intertidal and subtidal habitats (See Appendix A for time series aerial images of the Cowichan Bay estuary).

By 1957, 2 sites along the south side of the estuary were filled to use as log dumps and in 1965 the Westcan lumber storage facility was constructed by infilling intertidal and subtidal habitat. By the 1960's, the sawmill and shipping facility were constructed in the estuary on infilled land, with dredging for/and log storage throughout the intertidal habitat. The operation of the sawmill and shipping port as well as resource development activities involved ongoing channel dredging, dyking and infilling within estuary, causing significant habitat loss, including the accumulation of wood waste within the intertidal and subtidal habitat as well as the release of chemicals including dioxins and furans into marine waters (Firth et al. 1993).

By 1975, approximately 600 acres (72%) of the estuary was affected by development (Lill et al. 1975). Currently, the two major commercial industries located in the estuary include the continued operation of a sawmill operated by Western Forest Products and a deep-sea port for shipping lumber operated by Westcan Terminal Ltd (Fig 1). The mill holds two log storage leases that total 24.6 ha and Westcan leases 6 Crown land parcels in the estuary that totals 54.2 ha (Vis-à-vis 2005). Hayes Forest Services holds an additional 4 crown Land foreshore licenses that encompass 12 ha, some that currently have limited use.

Agricultural development in the estuary currently includes the Blackley Farm (cattle) on land leased from WFP (Vis-à-vis 2005). Nature Trust now manages the Cowichan Estuary Farm land and the land is used to graze cattle and grow forage crops but concurrently managed to provide waterfowl habitat (Vis-à-vis 2005).

Lill et al (1975) estimates that 72% or 600 acres out of 832 acres were affected by development. Historical impacts of resource use on ecological values in the estuary include the loss or damage of sensitive estuarine habitat due to dyking of river channels and infilling for agriculture and flood protection dating back to the 1860's. Another major impact has resulted from log handling and log storage in the intertidal habitat. The accumulation of debris creates anoxic conditions and compacted sediments that reduces the abundance and diversity of aquatic plants and benthos, thereby decreasing the overall productivity of the estuary. Disturbance has also resulted in the loss of productive eelgrass beds relative to historical abundance that has altered the natural ecology and productivity of the estuary. At the current time, eelgrass habitat is limited to a small area in the southwest section of the estuary (LGL 2005).

As well, there has been a reduction in water quality within the estuary from sewage treatment facilities, marinas and agricultural runoff, infilling for industrial/commercial purposes and log storage/booming activities since the 1880's (Law 2008). The wetland located on both sides of Khenipsen Road that extends north along Page road has been altered by road development that has bisected the estuarine wetland (Jones 2005). The flapper valve at Khenipsen road has limited both tidal influences and anadromous fish access to the north portion of the wetland (Jones 2005). According to the CVRD atlas, this system supports both anadromous and resident salmonids species. The Village of Cowichan Bay includes several small marinas, float homes and 2 breakwater structures. For more detailed information on the development history of the estuary, see Firth et. al. 1993.

The CNR intertidal wetlands were transferred to the provincial government for the protection of fish and wildlife habitat in trade for the continuation of log storage and operation of a wood processing facility to continue in the estuary (Appendix A, Clermont 2009). In 2005, subtidal habitat (>2 m) within the estuary flats and foreshore areas were mapped as part of the Cowichan Tribe's Recovery Plan (LGL 2005). Foreshore areas and shallow intertidal habitat was not included in the study. Sediment size class, eelgrass beds, bivalves and habitat features (oyster beds, eelgrass, bladed kelp etc) are mapped for the study area (LGL 2005).

2.5 Selected Resource Management Planning

2.5.1 Water Management and Flow Release Strategies

Flow control is one of the single most important factors affecting chinook production in the Cowichan River. Of major concern is the provision of adequate maintenance flows and pulse flows during the late summer and early fall to facilitate migration of spawners, spawning, incubation, rearing and downstream migration of fry. The provision of flows during the low flow period can improve marginal water quality conditions in the lower river. During years of low flows, chinook are subject to increased poaching, predation by seals and increased stress while holding in the lower river and estuary. Stress while holding can also increase spawner mortality as well as increase egg sterility in mature chinook (FOC Working Paper 2008).

In 1965, the natural hydrological characteristics of the Cowichan mainstem were altered by construction of a 1 m high low head weir at the outlet of Cowichan Lake to store spring run off. The dam was constructed to ensure an adequate summer water flow to supply water intakes (approximately 40 km downstream at river km 10) for the Crofton Mill (Catalyst) and the City of Duncan municipal water supply. At present, seasonally stored water is released from approximately mid-April to mid October through the weir at the outlet of Cowichan Lake. Flow releases are managed according to a Rule curve and provide a minimum maintenance flow of 7.08 cms (250 cfs) established to provide adequate rearing habitat conditions for salmonids. By September 15, flows are to be increased to 9.91 cms (350 cfs) to assist the migration of chinook salmon (Burt and Wightman 1997). For more details, see Burt and Roberts (2002).

The weir has not affected the mean annual discharge but has altered seasonal flows by decreasing spring flows and increasing summer low flows, particularly in September (Burt and Robert 2002). Water withdrawal by the pulp mill affects natural river hydrology by decreasing the mean annual flows downstream of km 10. The Catalyst diversion is more substantive at 2.8 cms relative to the City of Duncan at 0.16 cms (McKean 1989 in Burt and Roberts 2002). The pulp mill also provides water to the Municipality of North Cowichan for domestic use in the Town of Crofton (LGL 2005).

In 1988, a Water management Plan for the Cowichan River was implemented to facilitate upstream migration of chinook by increasing water flows for a short pulse period (5-10 days) during low flow conditions in early fall (Nagtegaal and Riddell 1998). The water flow regime was negotiated by FOC, BC MOE and BC Forest Products Ltd (Crofton Mill). In 1988 and 1990, DFO conducted experimental fall flow releases that successfully facilitated the upstream migration of spawners (LGL 2005). The intent of the pulse flows was to move chinook holding in warmer, less protected habitat in the lower river upstream to the middle reaches where cooler and more protected habitat is available. An analysis of the impacts of pulse flow releases in available in Hop Wo et al. 2005.

Since August 2003, an ad hoc multi-interest committee known as the Cowichan River Committee has cooperatively managed water flows. The group was made up of the Cowichan Tribes, Catalyst Paper, FOC and MOE. This group collectively makes in-season flow management decisions during times of the annual drought period. In 2004, they advocated for a more proactive approach to water management to manage and plan for current and future water needs within the Cowichan watershed (Westland 2007).

In 2004, the Cowichan Stewardship Round Table (CSRT) was formed in response to low water levels in the Cowichan River. The RT is a community partnership that includes representative from the Cowichan Tribes, federal and provincial agencies, local government, non-government organization and the public. This group was instrumental in the development of the Cowichan Basin WMP. A subcommittee to the CSRT is the Cowichan river Ad Hoc Water Advisory Group that provides comment and community input to Catalyst paper who manages flow releases from the weir at Cowichan Lake (nhc 2009).

By 2007, the Cowichan Valley Regional District, BC MOE, FOC, Catalyst Paper Corporation, Cowichan Tribes and the Pacific Salmon Commission collectively funded and developed the Cowichan Basin Water Management Plan with significant input and support from public and non-profit organizations. The purpose of the plan included having broad public support, protecting the ecological function of the system, balancing water supply today both present and into the future and to increase understanding of the study area and water issues (Westland 2007).

The ability to sustain adequate maintenance flows is dependant on available water storage in Cowichan Lake and precipitation during the regulation period. Stream flows rarely exceed the minimum standard and in some years, provisional flows are not met due to the lack of storage. According to minimum flows recorded by the WSC between 1981 and 2001, provisional flows were not met for 16 out of 21 years (76% of the time). A study undertaken in 1991 indicates that an increase of 0.57 m in the weir height would provide sufficient water storage to augment summer and fall flows for salmonids (KPA 1991 in LGL 2005).

2.5.2 Flood Management and Flood Maintenance Plan

Flood management and flood maintenance activities within the lower Cowichan watershed have altered natural flood characteristics as well as natural ecological features and function of the floodplain. There is a total of 14 engineered or non structural dikes in the lower floodplain reaches of the Koksilah and Cowichan rivers downstream of the trans Canada highway ranging from 0.5 to 2 km in length (nhc 2009).

Ecological impacts of the flood protection dikes in the lower Cowichan and Koksilah Rivers include:

- ***Channelization and loss of flood capacity:*** Construction of standard engineered dikes (south side and north side dikes) as well as non-standard or orphan dikes (Quamichan, Hatchery dike) have resulted in channelization and a reduction of flood capacity of the Cowichan mainstem. Habitat complexity, connectivity and riparian function have been altered with the loss of floodplain connectivity affecting available stream flows and fish access to off channel habitat. Within the lower Cowichan and Koksilah Rivers, there is both isolated and connected off channel and remnant channel habitat.
- ***Loss or alteration of sensitive estuarine habitat*** : Since 1962, european settlers have constructed dykes for agricultural purposes and flood protection (Williams and Langer 2002). Dyking and development of cultivated fields has altered natural flow patterns over the floodplain and tidal habitat.
- ***Loss of functional riparian habitat:*** The construction of shoreline dykes and/or shoreline erosion protection features for flood control typically alters natural riparian and shoreline habitat features by removing the Native riparian canopy. Loss of natural riparian habitat features reduces shade, food supply, recruitment of LWD to the stream channel as well as nesting, foraging and roosting habitat for shorebirds, songbirds and raptors and important migration and foraging habitat for deer, black bear and other furbearers. Over time, impacts to riparian habitat in the Cowichan watershed have recovered with only a few permanent alterations within the lower floodplain areas.
- ***Loss of channel stability, increased bank erosion:*** Shoreline flood protection dykes structures have channelized stream sections and increased bank erosion downstream (LGL 2005).

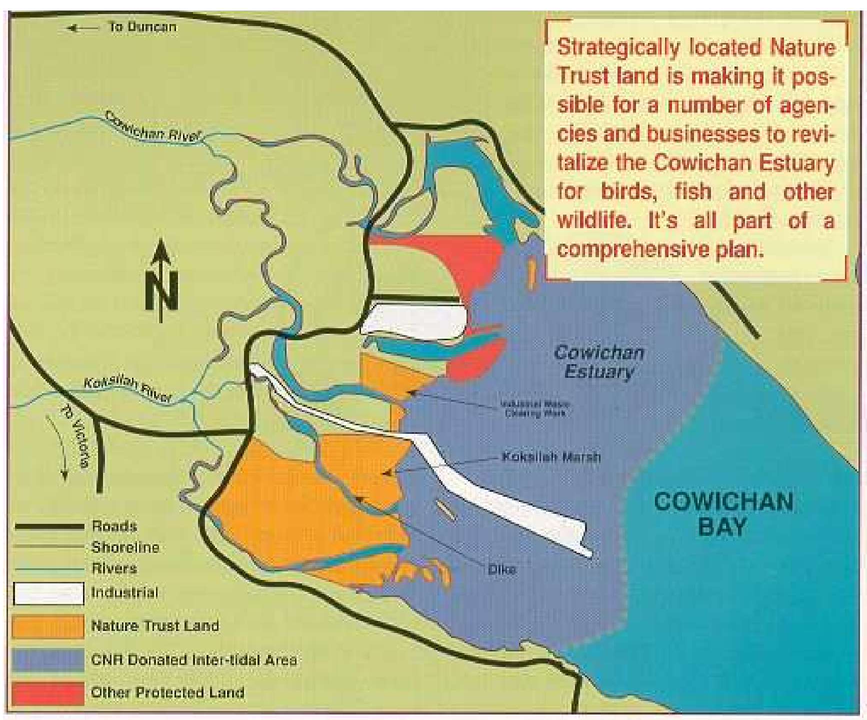
2.5.3 Cowichan Bay Environmental Estuary Management Plan

As a result of the high environmental concerns, as of 1986, the Cowichan River estuary has been managed through an Order in Council under the Environmental Management Act according to the Cowichan Bay Environmental Estuary Management Plan (MELP 1994). There is no other estuary in BC that in is managed according to an Order in Council. The Plan has been designed to balance the complex needs of land and resource use as well as to sustain and protect high value ecological features within the Cowichan/Koksilah estuary. The purpose of the CEEMP is to provide a framework for land and resource management planning that addresses ecological and other interests. Objectives of the Plan include the establishment of guidelines for land and resource management as well as a review process for proposed development within the estuary study area (MELP 1994). Key elements of the Estuary management Plan include the reduction of log storage areas from 49% of the intertidal to 19%, establishment of an environmental review process and restoration of impacted sites (Clermont 2009, Law 2008). Another key element of the Plan is the designation of mapped zones to guide land use; industrial/commercial, agricultural, habitat management, mixed use, conservation/recreation and log storage (Lambertsen 1987). However, the Plan does not provide specific details for allowable activities within each zone and more explicit details regarding acceptable activities would be beneficial (P. Law, pers. comm.). At this time, conservation zones are also open for recreational activity and this warrants further discussion and recommendations in order to effectively establish conservation areas for wildlife, aquatic species and waterfowl habitat.

Since 1987, the ecological interests of the estuary have been managed under the auspices of the Pacific Estuary Conservation Program developed through a partnership of several agencies and organizations including BC Environment, Ducks Unlimited, DFO, Nature Trust, the Land Conservancy, Nature Conservancy of Canada, Habitat Conservation Trust Fund and the Canadian Wildlife Service. Within 5 years, the group secured nine parcel of key habitat within the estuary totaling 308 hectares (Law 2008). Endeavors of these groups also includes developing management strategies, land acquisitions, monitoring, assessments, mapping as well as habitat restoration activities and rehabilitation of Native and/or culturally significant estuarine species and their habitats. In 1993, the CNR transferred all of the tidal mudflats under their ownership to the Province as it was originally designated as private land, rather than Crown Land as the case with most other estuaries (Fig 5, P. Law, pers. comm).

In 2005, an independent study was undertaken to review the effectiveness of the CEEMP over the 20 years since it’s inception and to assess the adequacy of the plan to address contemporary issues (Law 2008). The CEEMP was found to have successfully provided certainty and reduced conflict with industry and established a process to limit further environmental degradation including an initial reduction in log handling and storage (61% reduction) as well as the acquisition of lands for conservation purposes but has had little affect on restoring water quality and degraded habitat features (Vis-à-vis 2005). The Plan was proactive during the late 1980’s/early 1990’s but the process has shifted to being more reactive in recent years (Vis-à-vis 2005). The Plan continues to provide some degree of environmental protection but there is lack of citizen involvement and public knowledge. However, the Plan has provided industry with certainty and to ensure sustainable growth (P. Law, pers. comm.).

Figure 5. Cowichan River estuary illustrating land acquired by Nature Trust, CNR Donated intertidal area, other protected land and area zoned for Industrial purposes.



Improvements to the Plan from an environmental perspective would be to empower stakeholders to development and implement a proactive approach to habitat restoration and improvements (Vis-à-vis

2005). The 2005 review found that the CEEMP is not coordinated or linked to other planning initiatives in the area and provided 3 options for improving further implementation of the Plan (Vis-à-vis 2005). An amendment to the Plan is warranted but would require major consultation. Option 2 proposes a short-term improvement to the existing Plan with development and transition to a new Plan and governance model over the long-term (Law 2008).

3.0 COWICHAN RIVER CHINOOK

3.1 Total Abundance

The present population of fall run chinook is a severe conservation concern with wild chinook escapement decreasing to a historical record low in 2009 with less than 500 natural spawning adults (age 3) migrating upriver and approximately 300 adults collected for broodstock (Luedke pers. comm.). Age 2-jack chinook escapement was also very low at 120 spawners.

Prior to 1980, chinook escapement to the Cowichan River ranged from 5,000 to 10,000 spawners even with several years of large commercial and sport fisheries in Georgia Strait during the 1970's (Fig 6), Tompkins et al. 2005). Escapement decreased to a low of 2100 – 2500 spawners in 1986 and 1987, possibly the result of extremely low water conditions (Tompkins et al. 2005). Total chinook escapement steadily increased and reached the highest recorded escapement of 16,000 in 1995 as a result of reduced exploitation rates and increased hatchery production. Since 1996, escapement has steadily declined and the current escapement goal of 6500 spawners has not been met in over a decade since 1998. In recent years, reduced escapement may be due to a combination of factors that includes high exploitation rates (60%) and decreasing marine survival rates (<1%) .

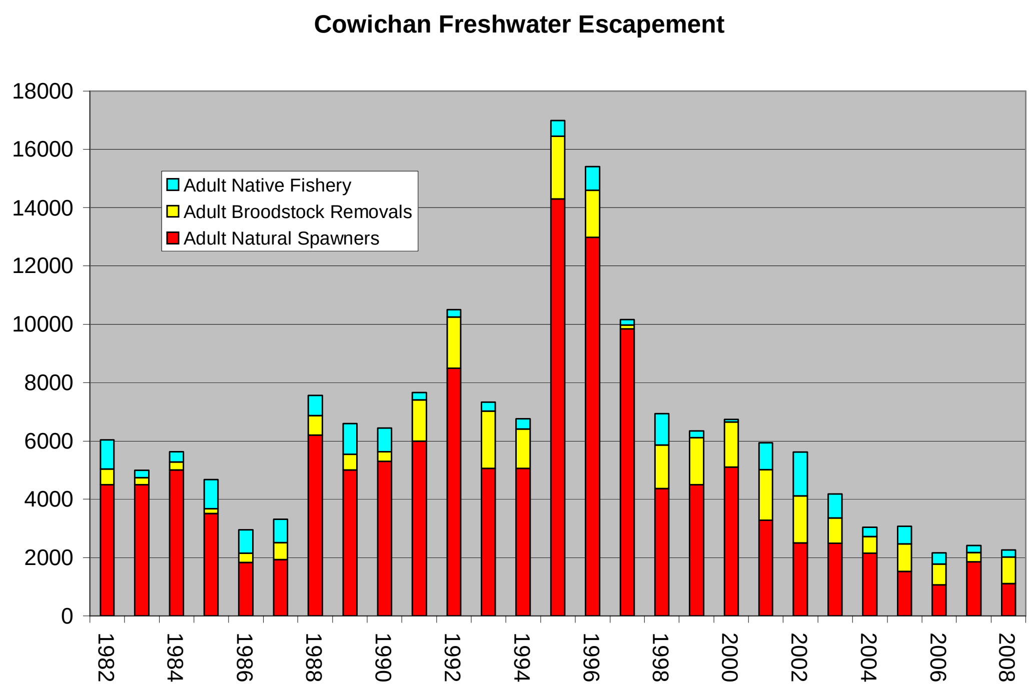


Figure 6. Cowichan Chinook Escapement (1982 – 2008) (Luedke, W., 2010. Pers. comm.).

Efforts to address declining chinook escapement in lower Georgia Strait were initiated in 1985, through a chinook rebuilding plan as part of the U.S. / Canada Pacific Salmon Treaty. Within selected indicator stocks, a target of doubling the 1979 – 82 spawning escapement was established. The Cowichan fall chinook were selected as an indicator stock but despite established catch limits in the mixed stock chinook fisheries, by 1987, spawning escapement had decreased to 15% of the interim escapement goal of 11,625 (Riddell et. al. 2000). Further conservation measures were implemented and included reduced harvest rates on sport, troll and native fisheries and enhancement initiatives (i.e. CEDP hatchery) along with an intensive escapements enumeration program. In 2000, the biologically based escapement goal for the naturally spawning population was set at 7400 (95% CI = 4185, 18915)(Riddell et. al. 2000). In 2005 through stock and recruitment modeling, the biologically based escapement goal for adult fall chinook was assessed and revised to **6500** adults (90% CI = 4159, 14962) (Tompkins et. al. 2005).

Another issue of concern relating to the total return of chinook to the Cowichan river is the proportion of hatchery-produced chinook. Enhancement guidelines for the Cowichan River were established such that enhanced returns were not to exceed 50% of the total adult escapement goal, once the goal was met. As well, *"enhanced production was not to increase beyond the 1987 level until escapement exceeded the 1987 escapement level"* (1987 natural escapement was 2500 adults) (Nagtegaal and Riddell 1998). Most recently, cwt data was found to underestimate the hatchery contribution to total escapement and actual hatchery contribution has been estimated to be up to 70-80% based on dead pitch results (see graph).

Since 1950, Federal fisheries officers have enumerated fall chinook escapement and recorded the data on Salmon Stream Spawning Reports (referred to as BC16's). The reliability of escapement estimates are highly variable. Enumeration methods have included stream walks, index sites, anecdotal information from various sources, regularly scheduled swim surveys, observation of spawning ground index sites, and aerial counts (helicopter) of spawners during peak spawning periods (Riddell *et al*. 2000). In 1988, the Cowichan Adult productivity study was initiated with construction of a counting fence approximately 5 km upstream of the estuary and is operated from late August to late October (Candy et al. 1995, Nagtegaal *et al*. 1994). In some years, a carcass mark-recapture program has been undertaken on the spawning grounds to augment data collected from the counting fence (FOC Working Paper 2008).

Since 1995 brood year, the age specific returns per spawner has been <2 with a slight increase to 1999 (LGL 2005). In comparison, returns per spawner were 4-9 during the late 1980's, between 2-3 from 1990 to 1994, declining to <1 in 1995 (LGL 2005).

3.2 Chinook Distribution

Chinook salmon are distributed throughout the entire length of the Cowichan mainstem with smaller runs of chinook extending upstream of Cowichan Lake into the Robertson River and Shaw Creek as well. A small run of fall chinook is also produced in the Koksilah River with anadromous distribution in mainstem to the barrier falls located at km 13.4.

There are 3 primary sites on the mainstem Cowichan River that have potential to limit upstream chinook spawner migration. These include the shallow aggraded sections in the lower river; Marie Canyon, located 5 km downstream of Skutz Falls and the Skutz Falls fishway located 15 km downstream of the lake. Skutz Falls extends for a distance of 150 m and poses a partial obstruction for upstream migration of chinook spawners. In 1956 a fishway was constructed to facilitate passage through the falls during all water levels (Lill et al. 1975, Lister et. al. 1971). Upstream migration through the fishway in some years remains difficult due to the accumulation of woody debris at the inlet. Marie canyon is 3-meter drop over a 30 m run.

The primary spawning habitat is located over a 31.5 km section in the upper mainstem from the Bible Camp upstream to the outlet of Lake Cowichan (Fig 1, Burt and Roberts 2002). The highest concentration of spawners have been observed in the uppermost 11.6 km of the mainstem between the lake outlet and the Three Firs area providing water levels are suitable for passage through the lower river and Skutz falls (Photo 1). Between 2005 and 2008, the most highly utilized spawning sites were Greendale, Gailbraiths Reach, Cabin Run and the 70.2 Mile bridge (S. Baillie pers. comm.). Spawning distribution in the upper river is typically dependant on stream flows with a lower proportion of spawning in the upper river during years when low flows occur during the upstream migration period (Nagtegaal and Riddell 1998, T. Rutherford and J.R. Eliot, pers. comm.). In some years, chinook are known to spawn sporadically between the Bible Camp and the Allenby Bridge and have also been observed spawning downstream of the Trans Canada Highway bridge when flows are too low and upstream passage is difficult.

Photo 1. Downstream view of Skutz Falls illustrating the vertical slot fishway constructed in 1956 (Sheng and Bonnell 2010).

Over half of the fall chinook typically migrate up the north arm in the lower river and in 2009, the North Fork was dry due to the accumulation of bedload. Upstream migrants were therefore forced to turn round and navigate up the South Fork, creating the potential for increased stress, migration delays in the estuary and exposure to predation by seals as well as the terminal fishery (T. Rutherford and J.R. Eliot pers. comm.). As well in 2006, the Cowichan Tribes captured and transported chinook from the lower river to the upper river due to low flows that limited migration opportunities (J.R. Eliot).

3.3 Life history characteristics

The Cowichan River supports a dominant Fall run of chinook along with a smaller (near extinct) Spring run (Burns 2002). Historically, spring run chinook run would arrive in the river during March and April and were believed to reside in or near Cowichan Lake over the summer (Anon 1941, Burns 2002). At one time, the spring chinook run was apparently fairly abundant and supported good angling opportunities (Anon 1941).

Chinook congregate in Cowichan Bay from late August to early November and migrate into the Cowichan River with the first significant increase in river discharge between mid August to early November (Fig 7, Lill et al. 1975, Bell and Kallman 1976). Migration typically peaks during mid-

October to early November (Lill et. al. 1975). The average run timing based on returns between 1996 and 2008 indicate that initial entry of chinook spawners into the river occurs during the first week of September with 50% of the run observed by Oct 9 and 90% of the run observed by Oct 28 annually (S. Baillie pers. comm.).

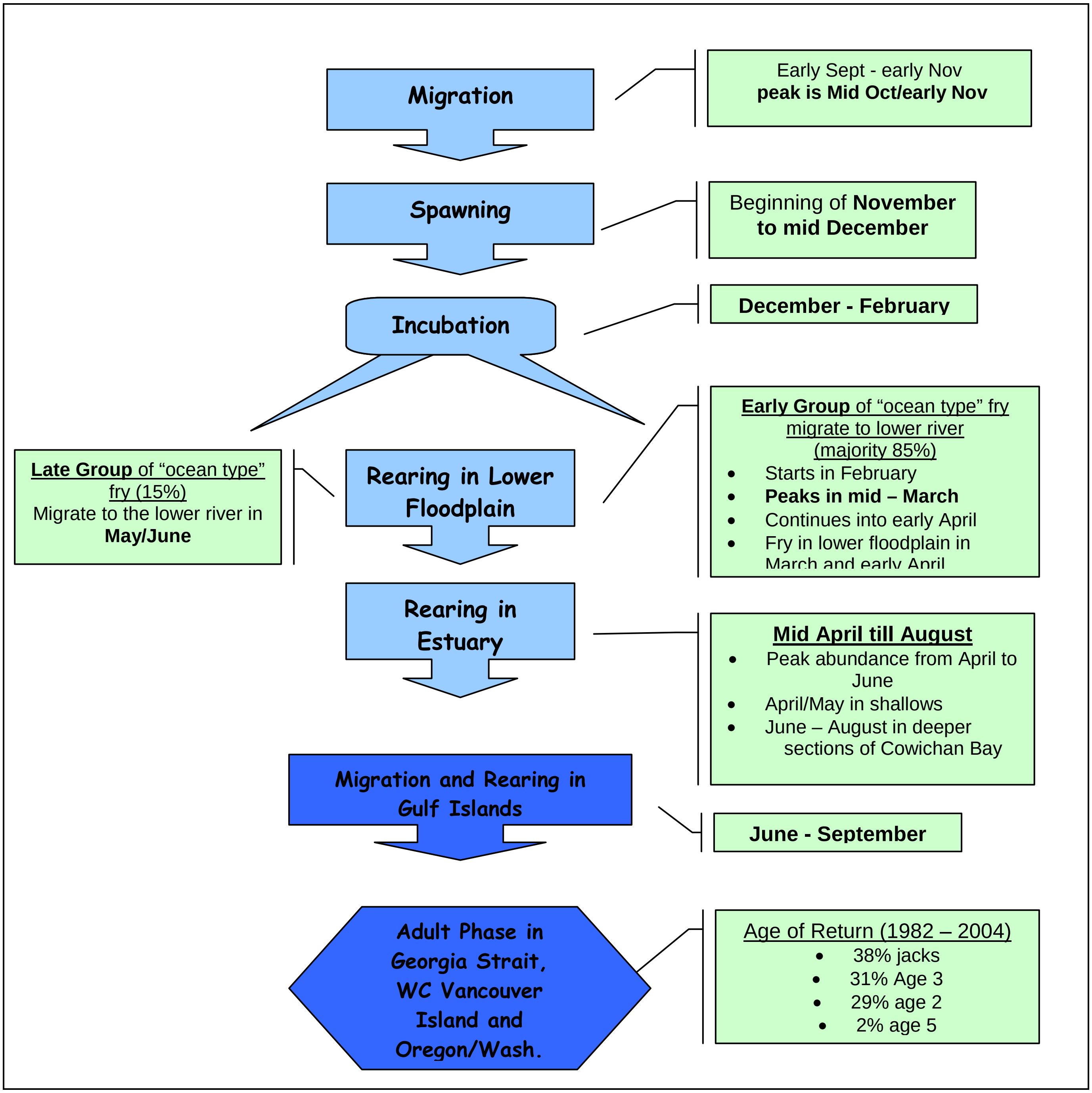


Figure 7. Life History Timing of the Cowichan River Fall Chinook Run (Lill et al. 1975, Argue et al. 1986, T. Rutherford, pers comm.).

The age composition of the terminal fall chinook run consists mainly of 2, 3 or 4 yr olds fish with a smaller proportion of 5-year-old spawners. The age composition for fall run chinook between 1982 – 2004 was 38.5% jacks, 30.6% for age 3 and 28.7% age 4 fish (Draft unpublished FOC document). In some years, up to 73% (1990) of the escapement consisted of jacks (Tompkins et al. 2005). Sex ratios are variable with the proportion of females ranging between 23-55% (LGL 2005).

Chinook spawning takes place throughout the Cowichan mainstem but is concentrated in the upper 18 km of the mainstem upstream of Skutz Falls (FOC 2010 data). Spawning takes place from the beginning of November to mid December with all chinook adults produced from an ocean type juvenile life history where fry are age 0+ at migration (Nagtegaal and Riddell 1998). Chinook spawning in the Koksilah takes place in the mainstem and in Kelvin Creek (Lill et. al. 1975).

The freshwater rearing strategy of Cowichan chinook fry is variable with the majority considered to be “ocean type” that migrate to sea normally within 3 months of emergence. There are two distinct groups of downstream migrants based on migration timing and size. The majority of naturally spawned and reared chinook fry emigrate as “early run” age 0+ fry and outmigrate during March and April, with highest levels of utilization in the estuary from April to June (Nagtegaal et al. 2004, Healey 1991). After which they can rear along the shores of Cowichan bay for up to another 5 months (Sparrow 1968 and Argue et al 1986). A less dominant (15%) portion of outmigrants, typify the river rearing group migrating as the “late” group in May/June (Healey 1991, Candy et. al. 1995). The early group consisted of primarily emergent fry averaging 42 mm in length while the late group were fingerlings averaging over 55 mm (Lister et al. 1971).

In 1991, FOC began a study of juvenile chinook productivity to estimate fry production, determine migration timing and assess in river interactions between hatchery and naturally spawned juvenile populations (Nagtegaal et al. 1997). According to the results of the downstream trapping program in the mainstem undertaken in 1997 and 1998, downstream fry migration would start by February and peak during mid March/early April, with 80% of chinook fry population migrating at night into the lower river immediately after emergence (Nagtegaal and Carter 1998, Nagtegaal et. al. 1997, Candy et al. 1995). In 1966 and 1967, fry migration started in late February with the maximum number of fry captured between late march and early April at 38 to 50 mm (Sparrow 1968). A second peak of downstream migrants was observed in early June with the average weight of late migrants being 9 or 10 x the mean wt of early migrants and with fork lengths ranging between 41 to 85 mm (Sparrow 1968). The capture of wild fry at the downstream trap located 5 km upstream the estuary typically decline by June.

Wild chinook fry reside in the lower floodplain reach during March and early April prior to their migration into the estuary (T. Rutherford, pers. comm.). Distribution and utilization of habitat types by chinook fry in the lower Cowichan River is not well known.

Both natural and hatchery reared chinook juveniles are known to extensively utilize the Cowichan River estuary and typically resident in the estuary from April to August (Candy et al. 1995). They majority of chinook fry typically migrate into the estuary by the middle of April (T. Rutherford, C. Neville pers. comm.), with the greatest abundance observed during May and June and typically take residence in the estuary flats for approximately 2-4 months (Argue et al. 1986). They have a varied diet consisting primarily of herring larvae, decapod larvae (zoea) and polychaete worms (Argue et al. 1986). The majority of chinook fry migrate from the estuary flats to deeper sections of the estuary and along the north and south shorelines of Cowichan Bay by the end of June where they remain for up to 5 months (Argue et al. 1986).

In 2008, FOC initiated a study to investigate early marine survival of Cowichan chinook with funding provided by the Pacific Salmon Commission. Existing annual surveys to determine early marine survival of juvenile salmonids in Georgia Strait were augmented with beach seines during April and May in the Cowichan estuary and continued until catch numbers decrease. By June, fish sampling involves purse seining in deeper sections of the estuary. FOC conducts an ongoing early marine survival sampling for salmonid juveniles that includes trawling in July and September through the Gulf Islands.

Cowichan chinook smolts begin to outmigrate from the Cowichan estuary to the Gulf Islands during May and June. Acoustic tagging has been used to determine migration during the early marine life stage of coho along with a small sample (50-100) of Cowichan chinook tagged in 2008 (C. Neville, pers. comm.). As well, stock origin in the trawl catches is determined by DNA sampling. Preliminary results indicate that Cowichan chinook are remaining in the Gulf Islands to rear until September rather than migrating into the Strait of Georgia (W. Luedke, C. Neville pers. comm.).

Based on the recovery of coded wire tags, the majority of Cowichan River chinook were once known as "resident" chinook that used to remain within the strait of Georgia, Puget Sound and Juan de Fuca Strait for their entire marine growth phase. However, a proportion of Cowichan chinook are now illustrating a more variable and extensive migration pattern that extends throughout southern B.C. as far as Area 13 (Campbell River) in Georgia Strait and Area 26 (Kyuquot) along the west coast of Vancouver Island. Cowichan chinook are also migrating south and captured in fisheries in Washington and Oregon (W. Luedke pers. comm.).

3.4 Salmonid Enhancement

Since 1976, the Cowichan Tribes has managed a FOC Community and Economic Development Program (CEDP) hatchery located 2 km upstream of the estuary along the south side of the mainstem in the lower river (Fig 1). This facility produces coho, chinook and chum salmon for release into the Cowichan R. Hatchery programs typically feed juveniles for three months prior to release as "90-day smolts", that migrate to the ocean between late May and early June (FOC Working Paper 2008).

Hatchery production for Cowichan River chinook was initiated in 1979/1980 with the release of 64,681 chinook juveniles. With expansion of the facility in 1992, production increased to more than 2.5 million chinook annually (Nagtegaal and Riddell 1998, Candy et al. 1995 Cross et al. 1991). Chinook production for brood years 1998 to 2008 ranged between 1.1 to 3.2 million with exception of a smaller release for the 2007 brood year at just less than 500,000 and no release for the 2004 brood year due to a power failure at the hatchery (Fig 8). Since 2007, all chinook fry produced in the hatchery are thermally marked whereas in the past, only a portion of the fry were coded wire tagged.

Fish were released according to 3 primary strategies (early, late and lake pen) as well as smolt release from sea pen sites in Cowichan Bay and Saanich Inlet. An "early" release took place from mid to late April, whereas a "late" release occurred mid May to early June at a number of sites along the river. Fish were initially reared at the hatchery then transferred to net pens in Cowichan Lake at a release time that corresponded to the late release group. Most recently, the CWT application rate has been doubled for improved precision of exploitation rates and research into early marine survival.

Hatchery released chinook juveniles appear to migrate to the estuary within a few day from release. The potential for interaction between naturally reared and hatchery chinook is greatest in the transition zone of the estuary and the interaction between these groups in the Cowichan system are probably minimal in the river and likely in the estuary as well (Candy et. al. 1995).

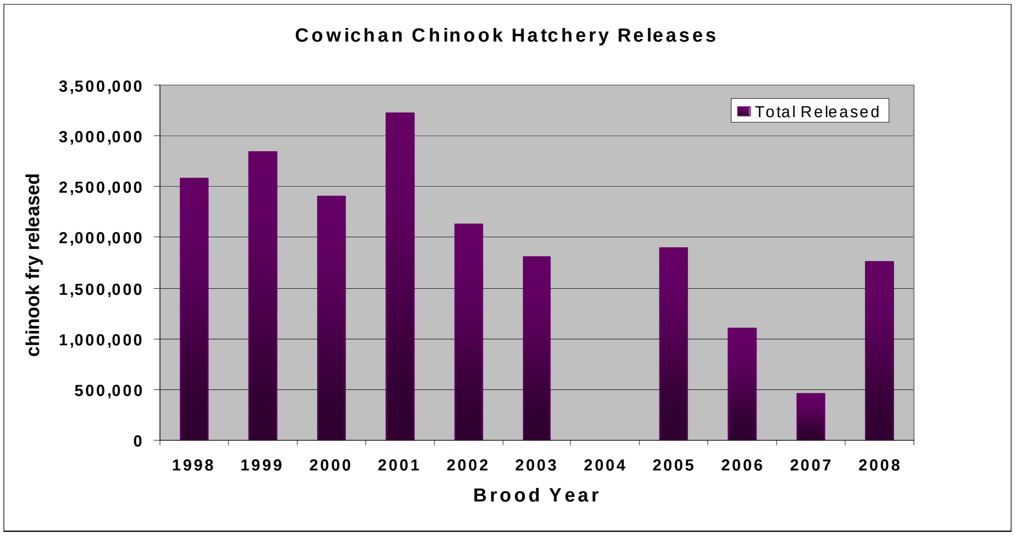


Figure 8. Total release of chinook fry from the Cowichan River hatchery between 1998 – 2008 (W. Luedke pers. comm.)

The enhancement plan was for Cowichan chinook to be managed for natural production with hatchery supplementation where enhanced returns were not to exceed 50% of the total adult escapement goal. Between 1990- 2004, the enhanced proportion has averaged 31% with exception of 2002 when the hatchery proportion of the natural spawning population peaked at approximately 72% (Tompkins et al. 2005). As well, enhanced production was not to increase beyond the 1987 level (~33% hatchery proportion) until escapement exceeded 1987 escapement levels (Tompkins et al. 2005).

Goals for hatchery production is to mimic the growth pattern, size and outmigration timing of natural fish and produce high quality smolts that migrate downstream rapidly to minimize any negative ecological impacts of hatchery stock on wild fish (Sheng and Bonnell 2010). Egg to release survival is good and averaged 91% based on 1996 – 2005 brood years (Sheng and Bonnell 2010).

Other enhancement facilities in the Cowichan watershed include the Provincial Vancouver Island Hatchery (VIH) located on the north side of the lower river, downstream of the Trans Canada Highway. The VIH was constructed in 1981 and raises cutthroat trout, captive rainbow trout and winter steelhead, with the steelhead juveniles released into the Cowichan River system. Prior o 1997, brown trout were also raised and released into the study area. There are also 2 other aquaculture based hatchery operations, one in the lower Cowichan and another in the lower Koksilah.

Salmonid enhancement in the Cowichan watershed also includes an annual off channel fry salvage program aimed at reducing stranding mortality. The Cowichan Lake Enhancement Society coordinates the program at sites upstream of Skutz Falls while the Cowichan Tribes operates the fry salvage program downstream of the falls. Up to 20% of the stranded fry in the upper river are typically chinook, with the majority being coho (Burt and Roberts 2002).

3.5 Habitat Restoration

Salmonid habitat restoration projects have been undertaken since at least 1950 with fish access improvements completed in both the Cowichan and Koksilah Rivers. In 1950, a vertical slot fishway was constructed at Skutz Falls to improve upstream fish passage up the mainstem Cowichan River. In 1990, upstream juvenile access through the flow control weir at the outlet of Cowichan Lake was improved through construction of a fishway and bypass channel. In the Koksilah River, a fishway was constructed at Marble Falls located at km 13.4 in 1980 but has had limited success in facilitating upstream passage for anadromous species. Fish passage was also improved in the lower Koksilah by removal of a large debris jam and sediment wedge at the old CNR crossing.

Over the past 5 years, over 1.5 million dollars has been spent on habitat improvement and restoration works that have included erosion control to reduce suspended sediment contributions at the Stotlz slide area, side channel development (Five Fingers, Bonsall slough) and/or flow/access improvements (John Charlies, 70.2 Mile Trestle Channel), spawning gravels placements at the outlet of Cowichan lake and debris removal from the Skutz falls fishway. In addition to these works, habitat restoration in the Cowichan watershed has included a project in 2005, where a series of 5 LWD complexed rock groynes were constructed as bank stabilization works at Mariner's pool located within the tidal portion of the North Fork. As well, in 2007 a series of 3 rock groynes and 3 LWD complexes were constructed as part of emergency maintenance works at the JUB outfall site for erosion protection.

Prior to 2000, past habitat restoration efforts in the lower Cowichan River have included improvements to access/habitat quality and quantity in off channel sites throughout the mainstem Cowichan River, bank protection works, as well as gravel/debris removal. Over the winter of 1991/92 the Cowichan mainstem redirected itself and created an avulsion that started immediately upstream of the Block 51 area. The avulsion significantly reduced flows to approximately 2 km of the original mainstem channel known as the "Horseshoe Bends" reach (P. Law pers. comm.). In 1993, remedial works were undertaken to minimize the loss of valuable fish habitat and included construction of the Trestle channel to provide flows to the horseshoe bend area.

Off channel development downstream of the Trans Canada Highway is also relatively extensive and includes development of the Rotary channel, Fish Gut Alley, John Charlie's channel and Major Jimmy's channel. However, more opportunity exists to increase access to/utilization of isolated or abandoned off channel habitat. For more details on restoration efforts in the Cowichan watershed, refer to LGL 2005 and nhc 2009. Over the past decade, the Ministry of Transportation and Infrastructure, Living Rivers Georgia Basin/Vancouver Island, Pacific Salmon Foundation and Fisheries and Oceans Canada have provided major funding and/or technical expertise for these projects.

Photo 2. Upstream view of an excavated off channel pond near the CEDP Hatchery that receives flows from the Major Jimmy's and the Hatchery sidechannel complex.

There has also been significant habitat restoration efforts undertaken to restore estuary habitat that includes removal of dikes, enhancement of wetlands on agricultural lands, enhancement of swales for water control and restoration of the Koksilah Marsh. The Pacific Estuary Conservation Program has been instrumental in the following projects (Vis-a-vis 2005):

- Westcan Access Rd: buried 3000' of overhead wire to prevent bird strikes
- Cowichan Estuary Farm: removed livestock and fencing, created swales and constructed stop log structures
- Koksilah Marsh: breached dyke to connect to exiting swale and improved 2 natural breaches in the dike
- Rooke Rodenbush property: hog fuel removal, re-established back channel and built up dike for flood protection of adjacent land
- Doman's/WFP sawmill property: breached the dike in 4 places to re-establish tidal influence
- Cowichan estuary: eelgrass inventory and transplanted 400 plants in 2005

The results of restoration efforts in the estuary include higher waterfowl densities than most other BC estuaries as well a 100% increase in utilization by dabblers, swans and geese in comparison to use between 1992-1997 (Clermont 2009).

4.0 CRITICAL HABITAT FEATURES AND CONDITIONS BY LIFE STAGE

4.1 Migration and Spawning Habitat

Critical habitat features for successful upstream migration and spawning includes:

1. Adequate maintenance flows in the Cowichan mainstem
    a. Determines spawner distribution
    b. Provides passage through shallow reaches of the lower Cowichan mainstem (including the North Arm) and the Skutz Falls area
    c. Minimizes holding and migrations delays in the lower river and estuary
    d. Reduces stress and mortality in the lower river and estuary
    e. Reduces predation through extensive shallow riffle/glide sections in the Cowichan and Koksilah mainstem

2. Good quality spawning substrates
3. Suitable water quality conditions (i.e. suspended sediment load, DO, water temperature)
4. Unrestricted upstream passage through Skutz Falls, shallow sections of the lower river and Marie Canyon
5. Gravel recruitment to upper river spawning habitat

Fall chinook enter the lower Cowichan River typically during lower water conditions with preferred spawning habitat located primarily between Skutz Falls and Cowichan Lake with spawning distribution dependant on stream flows (Riddell et. al. 2000, T. Rutherford and J.R. Eliot, pers. comm.). Studies have indicated that during years with low flows during the upstream migration period, there's a tendency for a greater proportion of chinook to spawn downstream of Skutz Falls in the lower river relative to years with normal or high flows (Burns and Roberts 2002). In some years, chinook are known to spawn downstream of the Trans Canada Highway bridge when flows are too low and it's physically impossible to ascend the river.

Water quality conditions in the lower Cowichan and Koksilah Rivers and estuary during the late summer and fall can have a significant effect on spawning success. Possible sources of contamination include treated municipal sewage, agricultural activities, urban development and effluents from fish hatchery operation and abandoned metal mines (?) (Phippen 2007). Water quality monitoring results from 1988 to 1993 determined a "fair" rating for both the Cowichan and Koksilah Rivers with objectives not met for microbiological contaminants for both rivers and for algal growth in the lower Cowichan River. There was no monitoring carried out between 1994 – 1997. Water quality monitoring was undertaken in 2005, with an improvement in water quality observed relative to the early 1990's and ranked as "good" for both rivers (Phippen 2007). In 2005, the Ministry of Environment water quality objectives were met 87% of the time, with fecal coliform (<10/100 ml) in the Koksilah and dissolved oxygen levels (8 mg/L min June to September and 11.2 mg/L min Oct to May) in both Cowichan and Koksilah Rivers not meeting the objectives on occasion (Phippen 2007). However, dissolved oxygen levels of 8.0 – 11 mg/L in the lower Cowichan and Koksilah River remained adequate throughout the sampling period to support salmonids in the lower Cowichan and Koksilah River. Fecal objectives were not met in the Koksilah River from Aug 24 to September 28 and from Jan 20 to February 24 in the Koksilah River at Highway 1 (Phippen 2007).

Based on spawning habitat surveys undertaken by Duane Hardie (1998 – 2000), the upper section of the Cowichan River between Skutz Falls and Cowichan Lake has exceptionally high quality gravel for chinook spawning (Burt and Roberts 2002). Prime spawning habitat is located at Greendale, as well as numerous other suitable spawning sites between Skutz Falls and Cowichan Lake (Fig 1). Spawning habitat downstream of Skutz Falls in the lower river has a higher proportion of cobbles and boulders as well as an accumulation of fine sediments (Duane Hardie pers. comm. in Burt and Roberts 2002).

The ***quantity*** of available spawning habitat is not likely a limiting factor to Fall chinook production. There is an estimated total spawning habitat of 210,500 m^2 that can support approximately 14,600 spawners within the mainstem Cowichan River (Burt and Roberts 2002). In the upper river alone, above Skutz Falls, there is an estimated 140,000 m^2 of spawning habitat that could support 6000 – 8000 females (Tompkins et al. 2005). This estimate is based on designation of prime and secondary quality spawning habitat, assuming each pair requires 20 m^2 of prime spawning habitat and 42 m^2 for secondary habitat. Therefore, with the most recently established biologically based escapement goal for fall chinook of 6514 spawners (90% CI = 4159, 14962) (Tompkins et. al. 2005), it is unlikely this run is limited by available spawning habitat (Burt and Roberts 2002).

Photo 3. Downstream view of spawning habitat in the lower Cowichan River at the JUB outfall site that supports primarily chum and coho spawners but is also utilized by chinook in years with low water conditions and upstream migration is limited (Nov 09).

However, the ***quality*** of spawning habitat has potential to limit chinook productivity as there is a lack of natural gravel recruitment to mainstem chinook spawning habitat in the Cowichan River (Sheng, pers. comm.). A smaller deposit of gravel is delivered to the Greendale spawning reach and therefore, this site should be considered to be of very high value.

In 1988, a Water management Plan for the Cowichan River was implemented to facilitate upstream migration of chinook by increasing water flows for a short pulse period (5-10 days) during low flow conditions in early fall (Nagtegaal and Riddell 1998). The water flow regime was negotiated by FOC, BC MOE and BC Forest Products Ltd (Crofton Mill). In 1988 and 1990, DFO conducted experiment fall flow releases that successfully facilitated the upstream migration of spawners (LGL 2005). The intent of the pulse flows was to move chinook holding in warmer, less protected habitat in the lower river upstream to the middle reaches where cooler and more protected habitat is available. An analysis of the impacts of pulse flow releases is available in Hop Wo et al. 2005.

4.2 Incubation

Critical habitat features for incubation success include: good quality spawning habitat; good water quality conditions over the fall, winter and spring; stable flows during incubation and juvenile migration and limited disturbance to redds

Incubation survival and overall egg to fry survival is significantly affected by several physical factors including gravel quality, disturbance by chum, scouring of redds during high flows and dewatering of redds (FOC Working Paper 2008). Overall gravel quality in the Cowichan River is dependant upon the degree of suspended sediment loads in the Cowichan River. The primary source of sediment originates from channel avulsion and subsequent erosion of glacial outwash and glaciolacustrine sediments. In the Cowichan River, there are several sites in the upper mainstem at the Stoltz slide, Block 51, 3 Firs and Broadway run areas that contribute fine sediment to mainstem spawning habitat (Fig 1). The Stoltz slide is predominantly fine-grained glacial sediment deposit that extends for 600 m along an outside meander bend and reaches a height of 50-60 m (Fig 1, Photo 4, LGL 2005). Major remedial works at the Stoltz slide in 2006 and 2007 included construction of a 650 m long riprap berm and erosion control along the main terrace that has successfully reduced erosion and the contribution of sedimentation by 90% at that site (LRS 2007).

Photo 4. Aerial upstream view of the Stoltz slide that extends for 600 m along the left bank for the mainstem Cowichan River. Remedial works undertaken in 2006 and 2007 have successfully reduced erosion and sedimentation (Sheng and Bonnell 2010).

Higher incubation survival may be achieved by reducing the accelerated degree of sediment loading from the eroding clay banks located at the Block 51 slides, 3 firs and Broadway way sites (Fig 1). The Living Rivers Society in partnership with FOC have been instrumental in the assessment and remediation of the bank erosion and clay bank failures that contribute a fine sediments to the mainstem Cowichan. Conceptual drawings for remedial works at all 3 sites have been conceptually completed with engineered prescriptions and pre-construction details to be completed in 2010 for proposed construction starting in 2011 (Gaboury 2010, Sheng, pers. comm.). In February 2010, the BC Conservation Society contracted Trow Associates Ltd. to undertake a slope stability study at the Broadway run area. Results indicate that silt deposition originates from bank erosion as well as small slough failures and soil flows from the adjacent slopes. Slope instabilities are due to increased surface runoff and seepage flows within the south slope setback from the river's edge (Sykes and O'Brien 2010). The study also determined that there is potential for large-scale slope failure to occur in a large older slide that is setback approximately 200 m from the rivers edge. Remobilization of the slide would have significant implications on the river by impeding flow and/or generating an increased silt load (Sykes and O'Brien 2010). Recommendations include monitoring of the older slide setback from the mainstem.

Incubation studies were undertaken during 2004/05 and 2005/06 in the Cowichan mainstem to determine survival of chinook during the incubation phase (alevins to button up size). Prior to the Stoltz remediation work, study results indicate that the upstream of the Block 51 area, that survival is good at 80% or higher to the button up stage whereas incubation survival in the lower river is low.

However, at both upper and lower river sites, emergence from the incubators was difficult due to the accumulation of silt that formed into an impenetrable concrete layer. After the majority of the Stoltz remediation work was completed in 2006 and 2007 incubation survival at the upper river remained high and the concrete layer was no longer observed and survival in the lower river was also improved. However, in the lower river, the accumulation of silt continued to be substantial enough to form the hard concrete layer over the redds, thereby limited emergence of alevins (Burt and Ellis 2006). Additional incubation studies are planned for 2010 and will use similar stations (Sheng, pers. comm.).

DFO conducted a juvenile assessment/outmigration study in the Cowichan River during most years between 1991 – 2002 but the program was discontinued after the 2002 season. The purpose of the program was to provide annual estimates of total juvenile chinook production as well as to investigate the interaction between hatchery and naturally reared fish in the lower river and estuary (FOC Working Paper 2008). Estimated egg to fry survival rates of Cowichan chinook ranged from 1.5 to 12.7% between 1990 and 2002 (FOC Working Paper 2008).

4.3 Rearing Habitat

Chinook fry utilize both offchannel and mainstem habitat throughout the mainstem reach on a seasonal basis likely from Feb/March until June/July. Of particular value are nutrient rich, tidal, off channel areas in the lower Cowichan and Koksilah Rivers. Many of these sites are groundwater fed and thereby offer cool water refuge habitat when the Cowichan mainstem temperatures are less suitable for fish production.

There is little specific information regarding the relative use of various reaches and preferred habitat types for CH rearing (Burt and Roberts 2002) but key habitat features for chinook rearing typically includes: stable mainstem and off channel rearing habitat; adequate food supply; suitable water quality conditions; instream habitat complexity that provides suitable cover components and intact natural riparian areas

4.3.1 Off Channel Rearing Habitat

Off channel areas provide critical rearing habitat during the spring and early summer for fall run Cowichan River chinook fry with highest utilization in low gradient floodplain habitat downstream of the Allenby bridge (Lill et. al. 1975). Off channel areas typically provide warmer and nutrient rich foraging habitat with chinook fry seeking out these areas prior to heading seaward. Intermittent flood areas also provide high quality rearing habitat that is highly utilized by chinook fry (Sheng, pers. comm.). The distribution of fry is usually determined by the abundance and availability of food (Sheng, pers. comm.). As well, tidal or brackish habitat is typically more nutrient rich than freshwater habitat. However, the location of the highest value and preferred habitat types within off channel habitat in the lower floodplain reach is currently unknown.

In 2009, the Cowichan Tribes operated a downstream trap in the 5 fingers sidechannel complex (~25,000 m^2) from early March to early June. A total of 820 chinook fry were captured in 2009, representing 1.4% of the total catch of salmonid juveniles (Alphonse 2010). There were two distinct groups based on size and timing with the first peak of smaller fry captured between late March/early April and a larger second peak catch period of larger chinook fry captured during mid May 9-16 (Alphonse 2010).

The availability of off channel habitat in the Cowichan watershed is affected by the total water storage and the operation of the weir. An assessment of the influence of river discharge on sidechannel habitat in the Cowichan River estimated that that when baseflows were reduced from 7 cms to 4.5 cfs, an average of 12-17% of the total wetted area of sidechannel habitat was lost in the upper, middle and lower off channel areas of the Cowichan River (Burns et al. 1988). The natural incidence of fry stranding can also be exacerbated during periods of draw down.

Survival of chinook fry during rearing and migration downstream of Cowichan Lake is also affected by operation of the flow control weir during the spring. A significant decrease in river flows over a short interval of time can increase stranding mortality (i.e. in 2002 a 60 cm drop in water levels were observed over a 48 hr period Burt and Robert 2002).

4.3.2 Riparian Habitat

Riparian areas are distinct and provide critical habitat components for fish and wildlife. Intact riparian habitat provides important features that support biological diversity, structure and function along the Cowichan floodplain. Natural and intact riparian habitat adjacent to streamside areas also provide an important source of food, overhead cover, shade, undercut banks, natural alcoves and undisturbed shoreline habitat that consists of seasonal channel that connect mainstem and off channel habitats.

The provincial Sensitive Ecosystem Inventory (SEI) program recognizes the high value of intact riparian habitat within the lower Cowichan and Koksilah Rivers. A significant portion of the riparian corridor adjacent to the lower mainstem Cowichan River and Koksilah River is currently delineated as sensitive riparian habitat (http://www.env.gov.bc.ca/sei/index.html).

Disturbance within the lower Cowichan riparian corridor downstream of the Trans Canada Highway has resulted primarily from the construction of dikes for flood control as well as agricultural development throughout the estuary and floodplain habitat. Within the Koksilah River, historical disturbance to natural riparian structure and function has occurred as a result of agricultural and rural development along the South arm and historical linear development by the CN railway and the now deactivated Westcan Terminal Road north of the mainstem.

4.3.3 Estuarine Rearing Habitat

The first 90-day period into June/July is the most critical time for chinook fry and the time when most mortalities occur (Luedke pers. comm.). Preliminary results from recent studies undertaken by FOC suggest that Cowichan chinook fry are vulnerable to high mortality rates in June and July during their early marine life history phase. In the Cowichan, this phase is spent in the lower river and estuary/ nearshore marine environment. However, the distribution, utilization and preferred habitat types of chinook fry in the estuary are not well known.

The Cowichan estuary supports at least 31 species of fish including juvenile herring, salmon and steelhead (CETF 1980). An important biological feature of estuaries is their role in nutrient production cycling and distribution. The estuarine environment provides a complex food web that consists of primary producers that include submergent (eelgrass) and emergent (grasses, rushes and sedges) vegetation as well as mud algae (CETF 1980). There plants support primary consumers that include amphipods, insect larvae and zooplankton that in turn support secondary consumers that include fish, birds and mammals.

The majority of wild chinook fry in the lower river begin to migrate into the estuary by the middle of April and reside in the estuary to August (Argue et al. 1986, C. Neville, pers. comm.). Migration of chinook smolts to the estuary likely peaks prior to the end of June with juveniles moving from estuary flats to deeper water toward the end of June/July along the north and south shores of Cowichan Bay (Argue et al. 1986). Chinook smolts are believed to remain in Cowichan Bay in significant numbers until late August (Argue et al. 1979). Hatchery chinook tend to migrate downstream in a large pulse and arrive in the estuary within a week of release (Nagtegaal et. al. 1997, Candy et al. 1995).

Critical habitat features in the estuary include good water quality, adequate vegetation, food, cover from predators and adverse weather conditions as well as suitable water quality conditions. Highest value habitat features for fish production within the estuary include nutrient rich brackish waters, stable vegetated foreshore habitat, vegetated intertidal and shallow subtidal habitat i.e. eelgrass beds as well as shallow, low gradient mud and gravel flats.

In 2003, the Cowichan Community Land Trust Society and MELP hosted a public workshop involving the local and the scientific community to identify future monitoring and restoration priorities for the Cowichan estuary. Water quality (PCP contamination, sewage and ballast dumping) and habitat loss were the two primary issues of concern regarding the future health of the Cowichan estuary in a public forum held in 2004 (CCLT 2004).

In 2008, FOC initiated a study to investigate early marine survival of Cowichan chinook with funded provided by the Pacific Salmon Commission. Existing annual surveys underway to determine early marine survival of juvenile salmonids in Georgia Strait were augmented with beach seines during April and May in the Cowichan estuary and continued until catch numbers decrease. By June, fish sampling involves purse seining in deeper sections of the estuary. FOC has an ongoing program to determine early marine survival of salmonids that includes trawling in July and September through the Gulf Islands.

Studies undertaken in 2008 and 2009 to investigate early marine survival of Cowichan River chinook suggest that there is critical period during June and July when fry are subject to high mortality in the estuary and nearshore marine environment. Survival during this phase may be the determining factor in overall marine survival of the Cowichan fall run chinook stock. The vulnerability of chinook fry during this early marine life history phase may be associated with several contributing factors including the lack of food or suitable habitat and/or increased predation. Ongoing sampling in the Cowichan estuary to determine early marine survival and/or influencing factors for chinook fry will be continued in 2010.

4.4 Marine Coastal

Cowichan chinook smolts begin to outmigrate from the Cowichan estuary to the Gulf Islands during May and June. Acoustic tagging has been used to determine migration during the early marine life stage of coho, along with a small sample (50-100) of Cowichan chinook tagged in 2008 (C. Neville, pers. comm.). As well, stock origin in the trawl catches is determined by DNA sampling. Preliminary results indicate that Cowichan chinook are remaining in the Gulf Islands to rear until September rather than migrating into the Strait of Georgia (W. Luedke, C. Neville pers. comm.). In contrast, the Upper Fraser River chinook fry illustrate a different rearing strategy and arrive later to the Gulf islands during the summer and then outmigrate to Georgia Strait earlier than Cowichan River chinook by the fall. Stock status of the UFR chinook remains good.

During the fall, the majority of Cowichan chinook smolts are thought to migrate throughout Georgia Strait into the northern sections with a smaller portion of the stock mixing with other stocks along the west coast of Vancouver Island, Juan de Fuca Strait and north to Hecate Strait and Fitzhugh Sound (Lill et al. 1975). Recent recoveries of CWT's in the commercial (and sport?) fisheries indicate that a larger proportion of Cowichan hatchery produced chinook are migrating out of Georgia Strait both south to Washington and Oregon as well as along the west coast of Vancouver Island (W. Luedke, pers. comm.).

Juvenile chinook in Georgia Strait ranging between 10-30 cm fork length feed primarily (70-92%) on herring, pelagic amphipods and crab megalopa (Healey 1991). Chinook salmon off southern Vancouver Island are dependant on Pacific herring (*Clupea pallasi*) as their primary (72%) food source (Healey 1991). Other target food items include Pacific sand lance (*Ammodytes hexapterus*), euphausiids and Pacific sardine (*Sardinops sagax*) but food preference is dictated by chinook size, location and time of year (Healey 1991).

5.0 POTENTIAL LIMITING FACTORS TO CHINOOK PRODUCTION AND RECOMMENDED MEASURES

As outlined for standardized habitat status reporting, potentially limiting habitat-based factors to chinook production within the Cowichan watershed are identified in the following sections and summarized in the Habitat Status Summary Table in Appendix C. Also provided are recommendations for habitat-based ***measures*** to address these limiting factors as well as to maintain freshwater productivity.

The intent of this chapter is to identify options for increasing productivity of the fall run Cowichan chinook during their freshwater phase. Increasing freshwater productivity can assist in the recovery of the fall chinook run by incrementally balancing the effects of recent exploitation rates (35-65%) as well as low (<1%) marine survival rates on chinook escapement to the Cowichan watershed.

Perhaps the single most critical factor affecting chinook productivity within the freshwater phases is the availability of adequate water flows during the migration, spawning, incubation, fry outmigration and lower river/estuary rearing phases.

5.1 Adult Migration and Spawning Phase

Potentially limiting factors to Cowichan chinook production during the adult migration and spawning phase includes:

1. Low mainstem flows that limit spawner access to higher quality spawning habitat upstream of Skutz Falls
2. Debris accumulation at Skutz Falls and the fishway that limits upstream migration
3. Lack of instream complexity and good quality holding habitat in the lower river
4. Aggradation of sediments in the lower Cowichan mainstem that exacerbates passage issues
5. Poor water quality conditions during the fall migration period
6. Migration delays at the counting fence
7. Lack of gravel recruitment to mainstem spawning habitat

5.1.1 Low mainstem flows that limit spawner access to higher quality spawning habitat upstream of Skutz Falls (LF1).

Adequate maintenance flows are needed to facilitate upstream passage of chinook spawners and potentially increase freshwater production by providing access to higher quality spawning habitat, thereby increasing incubation survival and from a broader perspective, increasing overall egg to fry ratios for fall run chinook.

The Cowichan River is a regulated system, with the lower river downstream of the Catalyst intake subject to low summer flows that limit and/or delay upstream migration of chinook. Cowichan River flows are managed according to the present rule curve and the Cowichan Lake weir is operated to provide a minimum maintenance flow of 7.08 cms over the duration of the summer low flow period and 9.91 cms after September 15 (Burns et. al. 1988). In 2003, 2006 and 2009 the minimum maintenance flow of 7 cms was not met due to inadequate storage in Cowichan Lake and therefore min flows have not been met for 4 out of the last 7 yrs (T. Rutherford, pers. comm.). An additional 50 million m^3 of water storage would be sufficient to meet existing water demands and to provide maintenance flows for all salmonids and pulse flows to facilitate chinook migration (Westland 2007). Increasing the Cowichan Lake weir by 30 cm could create additional storage.

Prime spawning habitat is located between the falls and Cowichan lake with spawning distribution dependant on stream flows (T. Rutherford and J.R. Eliot, pers. comm.).The majority of chinook will migrate to spawn upstream of Skutz Falls providing water levels are suitable for passage through the falls and lower river. Skutz Falls extends for 150 m down the length of the river with a vertical slot fishway constructed in the mid 1950’s to facilitate passage of spawners over a range of flow levels (Photo ___). In some years, up to 66% of the run will spawn in the lower river when low flows occur during the migration period and it’s physically impossible to ascend to the preferred higher quality spawning habitat upriver (Burt and Robert 2002).

Measure 1.1: Provide adequate water storage in Cowichan Lake to facilitate the release of adequate maintenance flows for all users including fall run chinook during their migration and spawning phase.

Measure 1.2: Develop a Monitoring and education program for Cowichan Lake residents to illustrate seasonal variations in the water surface elevation in the lake and downstream in the river proper. Illustrate where the control point is in an effort to gain support and cooperation with the water storage project.

Measure 1.3: Continue pulse flows and assess for effectiveness to facilitate upstream migration through estuary, lower river and falls reach.

5.1.2 Debris Accumulation at the upstream end of Skutz Falls and the fishway (LF2)

Upstream migration through the fishway in some years is also difficult due to the accumulation of large woody debris at the inlet to Skutz Falls as well as at the entrance to the Skutz Falls fishway (Photo 5).

Measure 2.1: Develop a Maintenance Plan and related protocol for the woody debris accumulation at Skutz Falls with a designated proponent and dedicated budget to ensure upstream passage for migrating chinook spawners.

Photo 5. Downstream view of the entrance to Skutz Falls and the fishway illustrating the large woody debris accumulation that requires annual maintenance to facilitate upstream migration of spawners (Sheng and Bonnell 2010).

5.1.3 Lack of instream habitat complexity and good holding habitat through the lower Cowichan and Koksilah Rivers (LF3).

The effects of delayed access through the lower Cowichan and Koksilah Rivers by chinook spawners is exacerbated by the lack of habitat complexity and good holding habitat for chinook. The lower mainstem habitat offers only marginal quality holding habitat due to aggraded shallow reaches, lack of instream cover and complexity as well as a low frequency of functional LWD and deep holding pools through the lower floodplain reaches of the Koksilah and Cowichan Rivers. The lack of cover and extended shallow sections leave the spawners exposed and vulnerable to predation and interception.

M3.1: Develop a restoration plan for the lower river and improve instream cover and complexity in the mainstem. Restoration options are outlined in nhc 2009 Flood Management Plan.

Photo 6. Downstream view of the lower Koksilah River illustrating extensive shallow habitat lacking sufficient deep pool cover and complexity for migrating spawners (fall 2009)

5.1.4 Bedload Aggradation in the lower mainstem Cowichan (LF4).

Upstream access by chinook spawners through the lower river is affected by the aggradation of coarse sediment in the lower reaches of the Cowichan mainstem downstream of the Trans Canada Highway. During the fall of 2009, the north arm was impassable due to aggradation combined with low water conditions and in most years, the north arm provides access for the majority of chinook migrants. Delayed migration creates additional stress and increased migration related mortality for spawners.

M4.1: Ensure passage of chinook spawners through the lower river by providing adequate summer/fall flows and maintaining access through the aggraded North Fork channel.

M4.2: Discuss and consider an annual flood maintenance program (including operational protocol) that involves gravel removal at designated sites to facilitate passage though the north arm and lower mainstem areas.

5.1.5 Poor water quality conditions in the lower river (LF5).

Low summer flows can create poor water quality conditions that are unsuitable for fish production, including high water temperatures and low dissolved oxygen levels that result in increased stress and metabolic dysfunction in spawners. Poor water quality conditions can result in increased mortality of chinook spawners holding and migrating in the lower river and estuary. See S. 4.1 for details on water quality monitoring in the lower Koksilah and Cowichan mainstem.

M5.1: Reduce migration mortality by providing adequate maintenance flows that can assist in sustaining suitable water quality conditions for holding and migrating chinook spawners.

M5.2: Undertake an annual water quality monitoring in the lower Cowichan and Koksilah River during the chinook migration and spawning period that includes water temperature, dissolved oxygen level and fecal coliform.

5.1.6 Migration delays at the counting fence (LF6).

Upstream chinook migration is also delayed by the Cowichan River counting fence with similar delays observed in other systems with similarly designed enumeration fences. Since the Cowichan chinook run is at record low numbers, it is important to improve freshwater production over each life history phase. Potential delays at the counting fence can increase stress and susceptibility to predation while chinook are forced to hold in warm unprotected mainstem habitat. Therefore, consideration of modifications to the counting fence are warranted to reduce any incidence of migration delays.

M6.1: Evaluate access through the enumeration fence to determine if chinook are being detrimentally delayed (as based on variations in flow rating curve).

M6.2: Consider reducing delays at the counting fence by installation of a lead in fence that facilitates passage and consider incorporating a Didson counting system.

5.1.7 Lack of natural gravel recruitment to mainstem spawning habitat (LF7).

Good chinook spawning habitat is located in deep water during winter flows with an abundance of larger substrates that are flushed clean by flows that are often lake fed. Some of the most productive chinook spawning habitat is located in the mainstem adjacent to a major tributary system that provides a continuous source of gravel that is washed by clean mainstem flows (M. Sheng, pers. comm.).

In the Cowichan River mainstem, there is an absence of major tributary systems that contribute a continuous and significant amount of gravel. The most ideal chinook spawning habitat is located at Greendale, where a small creek delivers gravel to the mainstem but in limited quantity (M. Sheng pers. comm.). Incubation survival could be improved by enhancing spawning habitat quality through gravel placements in the wider sections of the mainstem such as downstream of the lake outlet where the gravel will remain in place during higher flows.

M7.1: Assess suitable spawning gravel placement sites in the mainstem Cowichan River and prioritize/undertake habitat enhancement works at suitable sites.

M7.2: Consider mobilizing the bedload accumulation in the lower river that blocked passage through the North Arm in 2009 to suitable gravel placement sites in the upper river.

5.2 Incubation Phase

Estimated chinook egg to fry survival rates in the Cowichan River between 1990 and 2000 ranged from 1.5% (1993) to 12.1% with an average of ~ 6% (Fig __, Tompkins et al. 2005, 1995) This range in egg to fry survival is typical for a natural system (M. Sheng, pers. comm.). Variations in egg to fry survival in the Cowichan River can be due to several factors including chinook spawner distribution, environmental conditions including sedimentation and/or scouring redds during floods and to a lesser degree from over spawn by chum on chinook redds (Nagtegaal et. al. 1997).

Habitat based limitations to chinook production in the Cowichan watershed include reduced egg to fry survival due to the following factors that are discussed in more detail in the following sections.

- high input of fine sediments
- scouring by high flows
- disturbance by chum spawners
- Dewatering of redds due to low flows

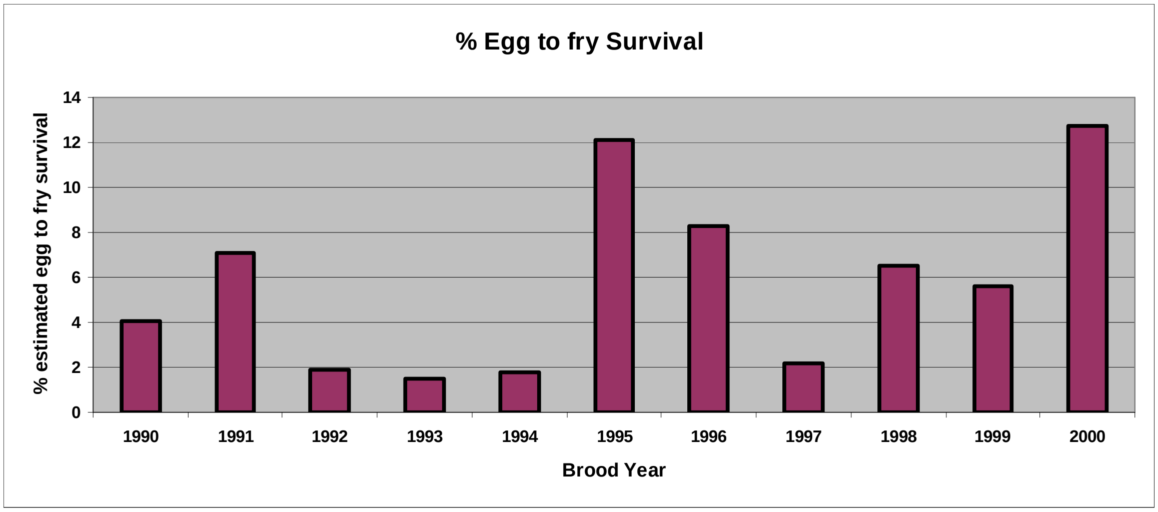


Figure 9. Estimated Egg to fry survival for Cowichan River fall run chinook for brood years 1990 - 2000 (Tompkins et. al. 2005).

5.2.1 Reduced egg to fry survival due to high input of fine sediments (LF8).

There are several sites along the upper Cowichan mainstem where naturally eroding banks are or have potential to contribute a continual and significant amount of fine clay sediments. Sediment is released during high flow events and peaks when flows are rising (Burt and Ellis 2006). The high input of fine sediments can settle into the interstices of spawning gravels and reduce incubation success and overall egg to fry survival. Bjorn and Reiser (1991) suggest that egg survival begins to decrease when the proportion of fines <6.35 mm exceeds 15% within the redd materials and a significant decrease in survival is observed when fines comprise >30%.

There are several erosion sites in the upper Cowichan mainstem that are a concern as they contribute or have potential to contribute a high level of fine sediment. The most significant sediment source at one time was the Stoltz slide area with rehabilitation measures undertaken in 2006 and 2007. At least 6 other erosion sites upstream of the Skutz Falls deliver fine sediments to the mainstem with the most significant sites at the series of eroding bluffs in the Block 51 area, the clay seam immediately downstream of 3 firs and Broadway Run (Fig __) (Gaboury 2010, Burt and Ellis 2006). Of these sites, Broadway run is identified as "*having the greatest potential of having an impact on fish habitat in the Cowichan River and therefore the highest priority for rehabilitation*" (Gaboury 2008). In January 2010, preliminary design options for erosion protection were developed for the Broadway run site with a slope stability review completed in February 2010 (Gaboury 2010, Sykes 2010).

Rehabilitation opportunities have also been developed for 3 erosion sites at Block 51 and includes re-establishing the abandoned river channel along the left bank to improve flood conveyance at more frequent flood events, thereby providing flood relief in the mainstem by reducing water levels and water velocities and resulting erosive forces (Gaboury 2010). Rehabilitation opportunities and conceptual designs have been developed for the 3 firs and Broadway run sites and include realignment of the mainstem channel to reduce erosion along the left bank at the 3 firs area as well as reduce the impact of flood flows downstream along the toe of right bank slope at the Broadway run (Gaboury 2010). Details for rehabilitation options and conceptual designs can be found in Gaboury 2010.

Photo 7. Silt input from eroding clay bluffs in the Block 51 area where a series of 4-5 slide areas are contributing fine sediment to the mainstem Cowichan River (Sheng and Bonnell 2010).

Egg to fry survival in the Cowichan River is also affected by chinook spawner distribution. Incubation success is generally higher for redds located upstream of the Stoltz slide area relative to the lower 20 km of the river where incubation survival is lower due to decreased bank stability, erosion, accelerated bedload movement and elevated rates of natural sedimentation.

Results from an incubation study undertaken by FOC in 2004/05 indicate higher incubation survival rates in the upper river (mean survival of 86.2% for the control site in Greendale) relative to the lower river (Sheng and Bonnel 2010). In comparison, mean survival of the eggs at sites downstream were significantly lower at 0.7% (mud slide), 3.4% (sandy pool) and 6.8% (CEDP hatchery) (Sheng and Bonnell 2010). Incubation study results also identify that a compacted layer of fine sediment accumulates over the redds due to deposition of silt over the winter that forms an impenetrable layer that limits or prevents the emergence of alevins (Sheng, pers. comm.). The accumulation of fines accumulated to a depth of 3-5 cm over the winter and also reduced the intra-gravel oxygen levels and thereby reduce overall incubation survival.

Egg to fry survival estimates provides a critical measure of freshwater production. A target to increase chinook incubation survival to 20% has potential to increase the overall productivity of fall run chinook in the Cowichan River during an era of uncertain marine survival. The determination of egg to fry survival estimates in the Cowichan River is only possible for years when FOC operates the Downstream Trapping Program.

Therefore, an essential component of a Chinook Recovery Plan is to continue the Juvenile outmigration program in order to determine the annual freshwater productivity. As well, the assessment of the late migrant chinook during June has typically not been included as trapping is usually terminated in May and therefore an extension of the trapping period would also be beneficial (Burt and Robert 2002).

M8.1: Continue juvenile outmigration program for fall run chinook as this data provides an absolute measure for egg to fry survival ratios and contributes essential information directly associated with habitat improvement and remediation/restoration works.

M8.2: Continue incubation studies to determine the effects of sedimentation on incubation success of chinook as well as to measure the benefits of remedial measures at eroding clay bank sites.

M8.3: Extend the downstream trapping program until the third week of June to determine the contribution and survival of the late migrant juvenile chinook population

M8.4: Support ongoing assessment and remediation of eroding clay banks/ sedimentation issues in the Block 51 area, Broadway run and the 3 firs areas (Fig 1).

M8.5: Map highly sensitive areas that have a high potential for bank erosion. Manage land and resource development adjacent to and within these areas with a more conservative approach to minimize bank erosion and siltation.

M8.6: Ensure resource development and land use practices strive to sustain or improve bank stability along the mainstem corridor, includig an emphasis on riparian protection.

M8.7: Evaluate the impacts of forestry development and urban development on natural hydrological characteristics (peak flows, low summer flows, riparian, slope stability) and bank erosion. Restore/rehabilitate where needed.

5.2.2 Reduced egg to fry survival due to scouring by high flows (LF9).

Environmental factors that affect Cowichan fall chinook egg to fry survival also includes scouring overwinter flows that can mobilize bedload materials to a depth of up to 20 cm. The effects of scouring flows are increased where the river width is confined (Sheng, pers. comm.). The depth (>50 cm) of chinook redds makes them less vulnerable to scouring flows relative to other species as well as dewatering during periods of low winter flows. Despite attenuation of flood flows from Cowichan Lake, peak flows in the Cowichan mainstem coincide with the period when chinook eggs are most vulnerable to loss from physical shocking (Armstrong 1973).

Riverbed scour is known to occur when flood conditions exceed 400% of the mean annual discharge (MAD = 53 cms). In the Cowichan River between 1958 – 1998, there were 26 years (68%) when the scour threshold of $\leq$212 cms was recorded (Burt and Robert 2002). The severe floods in the winter of 1994 that may have contributed to lower survival rates of the 1993 brood compared to the 1992 brood (Candy et al. 1995) and above average flows in November and December of 1998 resulted in scouring of spawning beds and therefore loss of chinook fry (Nagtegaal and Carter 2000).

The effects of winter floods on chinook redds in the Cowichan River have not been sampled in a meaningful way as the majority of chinook redds are inaccessible during the winter months.

M9.1: Investigate the impacts of river scour on chinook redds in the Cowichan system to determine if scouring of redds is a limiting factor to production

5.2.3 Reduced egg to fry survival due disturbance by chum spawners (LF10).

The distribution of chinook spawning (upper river versus lower river) has potential to affect egg to fry survival. Superimposition of redds by chum can reduce chinook egg to fry survival in years when chinook spawn in the lower and middle reaches, with chum spawning overtop of the chinook redds.

For both 1992 and 1993 chinook broods, a portion of the spawning occurred in the mid-lower river downstream what is considered traditional spawning habitat (Nagtegaal et al. 1994 c and 1995). Lower survival recorded for these broods may be due to reduced spawner success because of poorer spawning gravel quality or possibly superimposition of chum spawning in lower and middle river sections. Low chum escapement during years when most chinook spawning takes place in the middle river seems to enhance the egg to fry survival rate (Nagtegaal and Carter 2000).

M10.1: Strive to sustain adequate maintenance flows to facilitate passage to higher quality spawning habitat in the upper mainstem river.

M10.2: Document the years when chinook spawn in the middle and lower reaches of the river due to lower flows and chum are likely to over spawn in these areas.

5.2.4 Dewatering of redds due to low flows (LF11)

It is unknown whether dewatering of redds is a significant issue affecting egg to fry survival in the Cowichan River. Dewatering of spawning habitat was observed in March and April 2005 and dewatering of redds observed in December 2005 (FOC Working Paper 2008).

M11.1: Assess the incidence of dewatering of chinook redds and spawning areas on a preliminary level by documenting and correlating water levels with field observations during the incubation study. If warranted, undertake a more comprehensive study to determine if dewatering is a limiting factor to chinook production.

5.3 Rearing in the Lower Floodplain Reach

5.3.1 Lack of knowledge regarding preferred habitat types, utilization and capacity of the lower floodplain reach by chinook fry (LF12).

The majority (85%) of chinook fry migrate soon after emergence to rear in the lower floodplain reach of the mainstem Cowichan and Koksilah Rivers. There is an abundance of low gradient off channel sloughs, side channels and ponds throughout the lower Cowichan and Koksilah floodplain area. However, specific information regarding preferred habitat types as well as the utilization of freshwater and brackish areas of the mainstem and off channel habitat by chinook fry is unknown.

The habitat capacity of off channel and mainstem rearing areas is also unknown at this time as there are numerous channels and ponds, with many of them unmapped. The rearing capacity of the lower river is also affected by water flows and water depth. However, habitat capacity for chinook fry is less affected by low flows relative to coho and trout fry as they utilize off channel areas seasonally during the late spring and early summer. A study undertaken during the summer of 2003 in the middle and lower reaches of the Cowichan observed an average loss of 67% of wetted areas when flows dropped from 7 cms to 4.2 cms, with primarily (>75%) coho fry stranded in off channel areas (Burns 2003).

M12.1: Determine chinook fry distribution and habitat utilization in the lower floodplain area by conducting presence/ absence fish sampling. Use visual observation and minnow trapping to identify preferred habitat types and relative distribution of chinook fry (early March to June).

M12.2: Estimate the available rearing habitat area and rearing capacity of the lower river and off channel habitat. Correlate with both actual stage/flow measurements and defined seasonal rule curve.

M12.3: Identify and map the highest value nursery sites within the lower floodplain reach and protect and/or restore them.

M12.4: Determine how stream flows and river levels affect rearing capacity in the lower Cowichan and Koksilah mainstem and off channel habitat d/s of the Trans Canada highway.

M12.5: Restore fish access and where feasible, restore the natural inundation of flood flows through the floodplain and off channel habitat.

5.3.2 Loss of instream complexity in the lower mainstem and off channel areas (LF13).

The natural productive capacity of the mainstem and off channel habitat in the lower floodplain reach downstream of the Trans Canada Highway has been altered by urban development, flood management and maintenance practices as well as agricultural/rural development activities. Loss of instream complexity as well as the loss of natural channel bank features that typically provide a source for LWD recruitment has resulted from extensive dyking for flood protection and channelization of the mainstem Cowichan River.

M13.1: Assess chinook habitat in the lower 5 km of the mainstem Cowichan and Koksilah rivers between March and June, determine fish utilization and identify limiting habitat based factors to chinook production

M13.2: Develop a restoration plan for the lower mainstem and floodplain habitat that coordinates with the Integrated Management principles and habitat restoration projects as outlined in the Lower Cowichan/Koksilah Flood Management Plan (nhc 2009).

M13.3: Restore natural frequency of instream complexity including functional LWD, boulders, overhead cover and deep pool habitat.

5.3.3 Limited access or no access to existing and historical off channel habitat (Trailer park channel, Priests slough/marsh etc) (LF14).

Urban, rural, agricultural, linear, industrial development in combination with flood management activities have altered natural stream flow patterns over the Cowichan and Koksilah floodplain area. As a result, historical off channel areas have been isolated from flow and fish access.

As well, variable stream flow patterns over the floodplain can affect inflow to sidechannel habitat.

M14.1: Restore access and habitat quality to off channel habitat that has been altered by urban and resource development activities

M14.2: Consider the construction of setback dikes at Somenos Creek and Priests Marsh to support increased access and utilization of off channel habitat by salmonids as recommended in the Cowichan River Flood Management Study (nhc 2009).

M14.3: Consider following maintenance projects to sustain flows:

- **Rebuild Newbury weir downstream of the intake to the Major Jimmy's sidechannel to ensure recruitment of water in the channel during summer low flows (Alphonse 2010)**

- **Connect the 2 arms (hatchery channel and 5 fingers) of the channel complex downstream of the footbridge to increase flows to alcove areas downstream (Alphonse 2010)**

5.4 Rearing in the Estuary

5.4.1 Habitat Degradation in the Cowichan Estuary (LF15).

Historical resource development activities have impacted near shore and intertidal habitat quality and quantity within the estuary with the peak of industrial activity and associated impacts observed during the 1970's (Appendix A). A time series of aerial photographs of the estuary are provided and illustrate the habitat status of the estuary in 1930, 1947, 1977, 1985 and 2002 (Appendix A). By 1977, infilling activities had resulted in the permanent loss of approximately 7% of the estuary including 17 acres of intertidal mudflat habitat, 34 acres of vegetated stream channels and 32 acres of agricultural land (CETF 1980).

Over the past 40 years, the estuarine habitat has been slowly but gradually recovering through establishment of the EMP as well as efforts by the Pacific Estuary Conservation Program to acquire land for conservation purposes. Habitat restoration efforts are ongoing and include transplanting eel grass (2005), re-establishing back channel, creating swales, breaching dykes to restore natural flow patterns over estuarine habitat as well as removing livestock and fencing.

The trend in declining chinook escapement since the late 1990's may not be directly linked to the historical effects of habitat degradation in the estuary as nearshore and intertidal habitat quality in the Cowichan estuary is slowly improving over time. However, chinook fry reside in the estuary between mid April to August, with survival of fry and smolts affected by food availability as well as habitat quantity and quality. Therefore, any incremental improvements to chinook productivity within the freshwater and estuarine life history stages can assist in the overall recovery of fall chinook stocks. Habitat restoration and/or habitat improvement efforts within the estuary have the potential to increase the survival of chinook fry in the estuary.

Current issues that could be considered in a restoration plan for the estuary includes the alteration of benthic ecosystem due to the accumulation of wood wastes that have created anoxic conditions. Water quality is another issue of concern, due to inputs of domestic sewage as well as sewage output by recreational vessels (Clermont 2009). Other priority issues within the estuary includes the colonization of invasive species, dumping of ballast materials and mooring recreational vessels within habitat conservation/restoration areas.

Baseline studies include the distribution of vegetation types (emergent and submergent communities) during the mid/late 1970's (CETF 1980). As well, a study in 2005 mapped physical and biological features of Cowichan Bay according to sediment size class, location of eelgrass beds, bivalves and generalized habitat features i.e. oyster beds, river channel, bladed kelp beds etc. (Archipelago Marine Research 2005).

M15.1: Support ongoing identification, prioritization, restoration and monitoring of eelgrass habitat and other submergent vegetation types in the Cowichan estuary to pre-development conditions. Determine limiting factors to eelgrass colonization, assess extent of wood waste and any other factors that could potentially be limiting rehabilitation of eelgrass habitat.

M15.2: Implement a monitoring program to determine and document the benefits and estimated production from restoration efforts, land acquisition, as well as foreshore or estuarine habitat improvement projects.. Consider the initiation of an intertidal transect survey to monitor key changes in habitat types over time and integrate with the updated EMP.

M15.3: Develop a Restoration Plan for the estuary that identifies long-term goals, priority projects, anticipated benefits (i.e. production benefits if possible) and a Monitoring Plan.

M15.4: From an environmental perspective, undertake short-term improvements to the CEEMP that includes empowering stakeholders to develop and implement a proactive approach to habitat restoration and improvements. Over the long term through major consultation, develop a new plan and revised governance model.

M15.5: Control the colonization of Invasive species (Japanese knot week, yellow flag iris, bullfrogs, Canada geese, white clematis) by increasing public education, identify areas of infestation and determine/undertake the most appropriate control methods.

M15.6: Determine zones in estuary that are most suitable for recreational use/anchoring.

5.4.2 Lack of knowledge regarding the rearing capacity of the Cowichan Estuary (LF16).

The estuary provides critical rearing habitat for Cowichan River chinook. As of 2002, there were no studies to assess the rearing capacity of the Cowichan – Koksilah estuary (Burt and Roberts 2002). As well, the distribution and utilization of the lower river and estuary by chinook fry is relatively unknown. Presence/absence fish sampling to determine juvenile distribution and habitat types would be beneficial to identify the timing and habitat types that chinook fry are using for nursery habitat. Despite habitat impacts to the estuary, during the mid 1970's an estimated juvenile population of 500,000 chinook fry (1974) or less (172,000 in 1975) were producing a returning escapement of over 9000 spawners (Sheng and Bonnell 2010).

However, recent studies indicate that early marine survival during June and July in the estuary is a critical period for chinook fry as they appear to be subject to high mortality rates during this life history phase.

M16.1: Determine chinook fry distribution and habitat utilization in the estuary during the rearing period. Determine chinook density and condition factors by habitat types and for hatchery vs. wild juveniles.

M16.2: Determine if there are density dependent effects that affect survival of chinook fry in the estuary.

M16.3: Support ongoing research investigating the early marine survival of wild and hatchery raised chinook fry and by early/late migrants.

M16.4: Assess and quantify the current level of habitat degradation in the estuary as well as recovery of these sites through implementation of a long-term monitoring program that includes assessment of fish, plant communities and habitat types.

M16.5: Review potential restoration projects within the Cowichan estuary and priorize restoration efforts based on rationale, restoration targets and anticipated benefits.
M16.6: Support further restoration of eelgrass habitat, fish access to isolated sloughs and side channels.

M16.7: Consider the assessment, feasibility and restoration of shellfish and crab populations to historical levels.

M16.8: Provide additional resources and personnel to increase the effectiveness of the Cowichan Estuary Management Plan. Continue to protect estuarine and foreshore habitat from further degradation.

M16.9: Undertake an annual water quality monitoring during the chinook migration and spawning period that includes water temperature, dissolved oxygen level and fecal coliform. Coordinate with water quality monitoring in the lower Cowichan and Koksilah Rivers.

M16.10: Determine the level of ballast dumping and use of PCP's in the estuary and identify potential impacts to water quality as well as fish, vegetation and invertebrate communities. Determine options for mitigative measures if warranted.

6.0 PRELIMINARY HABITAT INDICATORS FOR COWICHAN RIVER CHINOOK

As part of Canada's Policy for Conservation of Wild Pacific Salmon, two types of indicators were developed to assess the status of salmon habitat and are referred to as "Pressure Indicators" and "State Indicators" (Stalberg et al. 2009). "**Pressure**" indicators describe external man made conditions that can be applied over broad geographic areas or within CU's. More costly "**State**" indicators would be used for smaller geographic areas and describe habitat conditions on a more site or reach specific basis. A short list of indicators developed by a FOC Habitat Working Group is illustrated in Appendix C.

For the Cowichan watershed, a preliminary list of primarily ***habitat status*** indicators is provided in Table 1. These indicators are relevant to the freshwater and estuarine life history phases of chinook and have been derived from the literature review for the habitat status report as well as Stalberg et al. 2009). These indicators should be considered as a starting point for further review, discussion and implementation as part of a long term habitat status Monitoring Plan for the Cowichan watershed. More research regarding appropriate habitat indicators would be beneficial to develop a more comprehensive list of indicators for discussion purposes. Once pressure and state indicators are selected, a threshold point or indicator should be identified.

Habitat based indicators can only provide an indirect indicator of freshwater productivity with the absolute measure being the enumeration of chinook escapement and the abundance of out migrating juveniles. Therefore, a comprehensive monitoring plan would require inclusion of habitat status indicators in combination with selected stock management and stock enhancement related indicators as well.

Table 1. List of Preliminary Pressure and State Indicators related to chinook production in the Cowichan River watershed.

Life Stage	Pressure Indicators	State Indicators
Spawner	% water withdrawal during Aug – Oct (m^3/month as % of MAD)	Surface water elevations in Cowichan lake and river proper Water surface elevation relative to adjacent chinook redds at pilot sites
		Water temperature, DO in lower river during summer and early fall. (Thresholds: Spawning and Incubation: 10^oC, Rearing: 15^oC, Adult migration: 16^oC)
		Frequency of LWD and number of deep holding pools/km
		Frequency of chum spawning over chinook redds
Egg/ Alevin	% or linear length of bank erosion	Total abundance of naturally spawned fry (Target of 20% egg to fry survival)
	Linear measure (m or km) of exposed eroding silt banks along the mainstem Cowichan R.	Total suspended sediment load at stations throughout the mainstem Cowichan River (Max: TSS < 25 ppm)
	% egg to fry survival	Number of naturally spawned outmigrating chinook fry
Fry/ Juvenile	Abundance of chinook fry in lower river and estuary	Relative density (CPUE) for chinook fry by habitat type
	% and km of stream length channelization d/s of the Trans Canada hwy bridge.	LWD frequency, cover types and %, frequency of holding pools, etc
	% riparian zone alteration	Total (km and %) and accessible off channel habitat d/s of the TC hwy bridge
	Area and/or % of altered or disturbed foreshore (Carex, Typha, riparian) inshore/intertidal (eelgrass, mudflats) and subtidal habitat (log booms).	Intertidal transect survey to identify existing % species and substrate composition to determine current status/alteration and monitor recovery.
Smolt/ Marine coastal	% surface area disturbed offshore i.e. subtidal area, log booms	Area (ha) and % of estuary according to type: sedge habitat, eelgrass and mudflats
All Life Stages	% and ha by land use type	
	% and area of impervious surface area	

7.0 SUMMARY AND RECOMMENDATIONS

Argue et al. 1979 anticipated that a "combination of adequate escapement and unfavorable environmental conditions or inadequate escapement and unfavorable environmental conditions could prove disastrous for adult production in the Cowichan River". It appears that the Fall Cowichan chinook stock has reached such a critical and "disastrous" level with current condition that consisting of very low escapement, low egg to fry survival, uncertain capacity and utilization of the lower river and estuary. When combined with unfavorable marine conditions of <1% marine survival and an average exploitation rate of 60% the result has been a low natural chinook productivity rate of less than 2 adults produced per spawner to 2004.

The recovery of the fall chinook run will require a collaborative approach across various disciplines including Stock Enhancement, Fisheries Management, Fisheries Research, Stock Assessment and Habitat Management within DFO. Declining chinook escapement to the Cowichan River can be partially addressed by incrementally increasing natural productivity over various life stages.

The freshwater and estuarine production of Cowichan River fall chinook stock is affected by several potentially limiting factors as identified by life history stage in Table 2. A total of 16 limiting factors to chinook production have been identified for further discussion. Strategies to increase freshwater survival are outlined by habitat based "**measures**" that improve or sustain fish access, provide adequate migration flows and increase/restore water quality and habitat quality. A total of 47 measures have been recommended to address these limiting factors. A more detailed description of limiting factors and measures is provided in Section 5 of this report with a summary provided in the Habitat Status Table (Appendix B).

A priority level was not assigned to these limiting factors or measures as they should be considered to be a starting point for further review and discussion. As well, they represent critical factors to chinook production primarily in the freshwater life history stages. Highlighting these habitat based limiting factors identifies the need for further discussion and prioritization of management actions through a multi-stakeholder committee or the existing Joint Working Technical Group. Limiting factors relevant to marine survival, stock enhancement and fisheries management are not discussed in this report, though provide an important component when developing a comprehensive priority list of the limiting factors affecting chinook production.

A very preliminary list of habitat-based **indicators** by life history stage has also been proposed for further review and discussion. Indicators are presented by life stage and include primarily watershed-based indicators. Although stock assessment activities are outside the scope of this study the study results indicate that stock assessment indicators including the adult enumeration and fry outmigration program provides an important and direct measure of habitat status. Further research into suitable habitat based indicators is needed to develop a comprehensive list for further discussion amongst local practitioners.

Table 2. Summary of habitat based limiting factors to chinook production in the Cowichan River with Recommended Remedial Measures.

Life History Stage	Limiting Factor	Recommended Measures
Migration/Spawner	LF1: Low mainstem flows that limit spawner access to higher quality spawning habitat upstream of Skutz Falls	*Measure 1.1: Provide adequate water storage in Cowichan Lake to facilitate the release of adequate maintenance flows for all users including fall run chinook during their migration and spawning phase.* *Measure 1.2: Develop a Monitoring and education program for Cowichan Lake residents to illustrate seasonal variations in the water surface elevation in the lake and downstream in the river proper. Illustrate where the control point is in an effort to gain support and cooperation with the water storage project.* *Measure 1.3: Continue pulse flows and assess for effectiveness to facilitate upstream migration through estuary, lower river and falls reach.*
Migration/Spawner	LF2: Debris accumulation at Skutz Falls and the fishway that limits upstream migration	*Measure 2.1: Develop a Maintenance Plan for the woody debris accumulation at Skutz Falls with a designated proponent and dedicated budget to ensure upstream passage for migrating chinook spawners.*
Migration/Spawner	LF3: Lack of instream complexity and good quality holding habitat in the lower river	*M3.1: Develop a restoration plan for the lower river and improve instream cover and complexity in the mainstem. Restoration options are outlined in nhc 2009 Flood Management Plan.*
Migration/Spawner	LF4: Aggradation of sediments in the lower Cowichan mainstem that exacerbates passage issues	*M4.1: Ensure passage of chinook spawners through the lower river by providing adequate summer/fall flows and maintaining access through the aggraded North Fork channel.* *M4.2: Discuss and consider an annual flood maintenance program that involves gravel removal at designated sites to facilitate passage though the north arm and lower mainstem areas.*
Migration/Spawner	LF5: Poor water quality conditions during the fall migration period	*M5.1: Reduce migration mortality by providing adequate maintenance flows that can assist in sustaining suitable water quality conditions for holding and migrating chinook spawners.* *M5.2: Undertake an annual water quality monitoring in the lower Cowichan and Koksilah River during the chinook migration and spawning period that includes water temperature, dissolved oxygen level and fecal coliform.*
Migration/Spawner	LF6: Migration delays at the counting fence	*M6.1: Evaluate access through the enumeration fence to determine if chinook are being detrimentally delayed* *M6.2: Consider reducing delays at the counting fence by installation of a lead in fence that facilitates passage and consider incorporating a Didson counting system.*
Migration/Spawner	LF7: Lack of gravel recruitment to mainstem spawning habitat	*M7.1: Assess suitable spawning gravel placement sites in the mainstem Cowichan River and prioritize/undertake habitat enhancement works at suitable sites.* *M7.2: Consider mobilizing the bedload accumulation in the lower river that blocked passage through the North Arm in 2009 to suitable gravel placement sites in the upper river.*

Life History Stage	Limiting Factor	Recommended Measures
Egg/Alevin	LF8: Reduced egg to fry survival due to high input of fine sediments	*M8.1: Continue juvenile outmigration program for fall run chinook as this data provides an absolute measure for egg to fry survival ratios and contributes essential information directly associated habitat improvement and remediation/restoration works.* *M8.2: Continue incubation studies to determine the effects of sedimentation on incubation success of chinook as well as to measure the benefits of remedial measures at eroding clay bank sites.* *M8.2: Extend the downstream trapping program until the third week of June to determine the contribution and survival of the late migrant chinook population* *M8.4: Support ongoing assessment and remediation of eroding clay banks/ sedimentation issues in the Block 51 area, Broadway run and the 3 firs areas* *M8.5: Map highly sensitive areas that have a high potential for bank erosion. Manage land and resource development adjacent to and within these areas with a more conservative approach to minimize bank erosion and siltation.* *M8.6: Ensure resource development and land use practices strive to sustain or improve bank stability along the mainstem corridor.* *M8.7: Evaluate the impacts of forestry development and urban development on natural hydrological characteristics (peak flows, low summer flows, riparian, slope stability) and bank erosion. Restore/rehabilitate where needed.*
Egg/Alevin	LF9: Reduced egg to fry survival due to scouring by high flows	*M9.1: Investigate the impacts of river scour on chinook redds in the Cowichan system to determine if scouring of redds is a limiting factor to production*
Egg/Alevin	LF10: Reduced egg to fry survival due disturbance by chum spawners	*M10.1: Strive to sustain adequate maintenance flows to facilitate passage to higher quality spawning habitat in the upper mainstem river.* *M10.2: Document the years when chinook spawn in the middle and lower reaches of the river due to lower flows and chum are likely to over spawn in these areas.*
Egg/Alevin	LF11: Dewatering of redds due to low flows	*M11.1: Assess the incidence of dewatering of chinook redds and spawning areas on a preliminary level by documenting water levels and field observations during the incubation study. If warranted, undertake a more comprehensive study to determine if dewatering is a limiting factor to chinook production.*
Fry in the lower River	LF 12: Lack of knowledge regarding preferred habitat types, utilization and capacity of the lower floodplain reach by chinook fry	*M12.1: Determine chinook fry distribution and habitat utilization in the lower floodplain area by conducting presence/ absence fish sampling. Use visual observation and minnow trapping to identify preferred habitat types and relative distribution of chinook fry (early March to June).* *M12.2: Estimate the available rearing habitat area and rearing capacity of the lower river and off channel habitat*

Life History Stage	Limiting Factor	Recommended Measures
Fry in the lower River (con't)	LF 12: Lack of knowledge regarding preferred habitat types, utilization and capacity of the lower floodplain reach by chinook fry (con't)	*M12.3: Identify highest value nursery sites within the lower floodplain reach and protect and/or restore them.* *M12.4: Determine how stream flows and river levels affect rearing capacity in the lower Cowichan and Koksilah mainstem and off channel habitat d/s of the Trans Canada highway.* *M12.5: Restore fish access and where feasible, restore the natural inundation of flood flows through the floodplain and off channel habitat.*
Fry in the lower River	LF13: Loss of instream complexity in the lower mainstem and off channel floodplain reach	*M13.1: Assess chinook habitat in the lower 5 km of the mainstem Cowichan and Koksilah rivers between March and June, determine fish utilization and identify limiting habitat based factors to chinook production* *M13.2: Develop a restoration plan for the lower mainstem and floodplain habitat that coordinates with the Integrated Management principles and habitat restoration projects as outlined in the Lower Cowichan/Koksilah Flood Management Plan (nhc 2009).* *M13.3: Restore natural frequency of instream complexity including functional LWD, boulders, overhead cover and deep pool habitat.*
Fry in the lower River	LF14: Limited access or no access to historical off channel habitat (Trailer park channel, Priests slough/marsh	*M14.1: Restore access and habitat quality to off channel habitat that has been altered by urban and resource development activities* *M14.2: Consider the construction of setback dikes at Somenos Creek and Priests Marsh to support increased access and utilization of off channel habitat by salmonids as recommended in the Cowichan River Flood Management Study (nhc 2009).* *M14.3: Consider following maintenance projects to sustain flows:* • *Rebuild Newbury weir downstream of the intake to the Major Jimmy's sidechannel to ensure recruitment of water in the channel during summer low flows (Alphonse 2010).* • *Connect the 2 arms (hatchery channel and 5 fingers) of the channel complex downstream of the footbridge to increase flows to alcove areas downstream (Alphonse 2010).*
Fry in the Estuary	LF15: Habitat Degradation in the Cowichan Estuary	*M15.1: Support ongoing identification, prioritization and restoration of eelgrass habitat in the Cowichan estuary to pre-development conditions. Determine limiting factors to eelgrass colonization, assess extent of wood waste and any other factors that could be limiting the rehabilitation of eelgrass habitat.* *M15.2: Implement a monitoring program to determine and document the benefits and estimated production from the restoration efforts, land acquisition, as well as foreshore or estuarine habitat improvement projects. Consider intertidal transect survey to monitor key changes in habitat types over time.*

Life History Stage	Limiting Factor	Recommended Measures
Fry in the Estuary (con't)	LF15: Habitat Degradation in the Cowichan Estuary (con't)	*M15.3: Develop a Restoration Plan for the estuary that identifies long-term goals, priority projects, anticipated benefits (i.e. production benefits) and a Monitoring Plan.* *M15.4: Implement short-term improvements to the CEEMP that includes empowering stakeholders to develop and implement a proactive approach to habitat restoration and improvements. Over the long term through major consultation, develop a new plan and governance model.* *M15.5: Control the colonization of Invasive species (Japanese knot weed, yellow flag iris, bullfrogs, Canada geese, white clematis) by increasing public education, identify areas of infestation and determine/undertake the most appropriate control methods.* *M15.6: Determine zones in estuary that are most suitable for recreational use/anchoring.*
Fry in the Estuary	LF16: Lack of knowledge regarding the rearing capacity of the Cowichan River Estuary	*M16.1: Determine chinook fry distribution and habitat utilization in the estuary during the rearing period. Determine chinook density and condition factors by habitat types and for hatchery vs. wild juveniles.* *M16.2: Determine if there are density dependent effects that affect survival of chinook fry in the estuary.* *M16.3: Support ongoing research investigating the early marine survival of wild and hatchery raised chinook fry.* *M16.4: Assess and quantify the current level of habitat degradation in the estuary as well as recovery of these sites through implementation of a long term monitoring program that includes assessment of fish, plant communities and habitat types.* *M16.5: Review potential restoration projects within the Cowichan estuary and priorize restoration efforts based on rationale, restoration targets and anticipated benefits.* *M16.6: Support further restoration of eelgrass habitat and fish access to isolated sloughs and side channels.* *M16.7: Consider the assessment and restoration of shellfish and crab populations to historical levels.* *M16.8: Provide additional resources and personnel to increase the effectiveness of the Cowichan Estuary Management Plan. Continue to protect estuarine and foreshore habitat from further degradation.* *M16.9: Undertake an annual water quality monitoring during the chinook migration and spawning period that includes water temperature, dissolved oxygen level and fecal coliform.*

Life History Stage	Limiting Factor	Recommended Measures
Fry in the Estuary	LF16: Lack of knowledge regarding the rearing capacity of the Cowichan River Estuary (con't)	*M16.10: Determine the level of ballast dumping and use of PCP's in the estuary and identify potential impacts to water quality as well as fish, vegetation and invertebrate communities. Determine options for mitigative measures if warranted.*

In addition to the assessment and monitoring recommendations included in the "Recommended Measures", the following data gaps and recommendations for future studies are recommended based on the results of the habitat status and limiting factors analysis

Table 3. Data Gaps and Recommendations for Future Studies.

Data Gap	Recommendations for Future Studies
1. Impacts of forestry development and urban development on slope stability, bank erosion, sedimentation and stream flows in the upper and middle reaches of the Cowichan and Koksilah Rivers.	Assess the impacts of forestry on a watershed or sub-basin basis to determine impacts of forestry development on chinook/salmonid habitat.
2. Unknown survival of late release chinook fry/smolts	The hatchery can operate to achieve an egg to fry survival of 90%. There is potential to increase early marine survival if smolts if the hatchery fry are held to smolt stage and released later when they are larger. This strategy would also minimize any interaction or competition for food and cover in the lower river and estuary with wild spawned chinook fry (Sheng, pers. comm.).
3. Impacts of seals and seal lions on chinook fry and spawners in Cowichan estuary and lower river	Assessment and management of predation by seals and seal lions on chinook.

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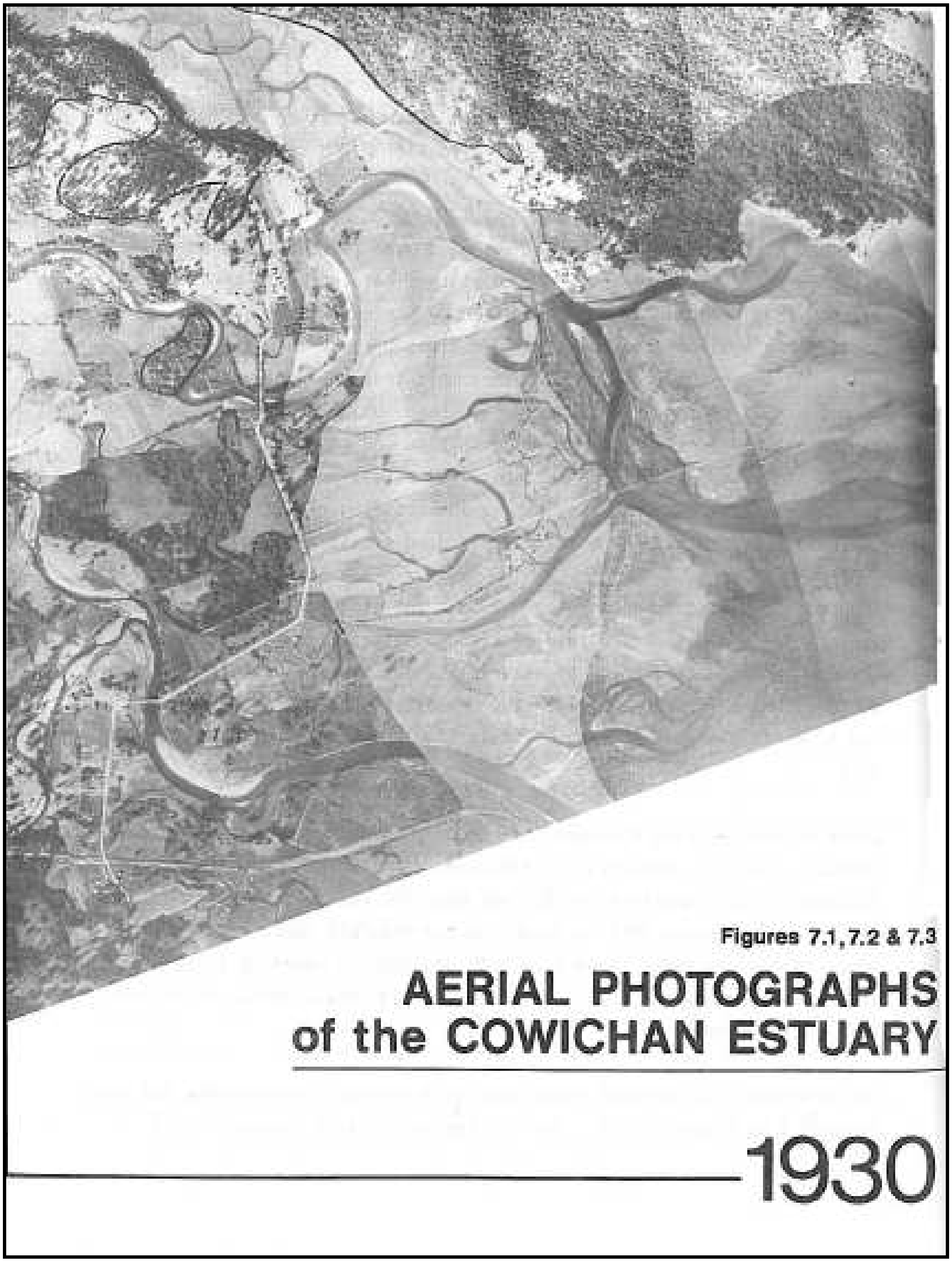
Appendix A. Historical series of aerial photos of the Cowichan Bay estuary illustrating the level of development in 1930, 1947, 1976, 1985 and 2002.



Aerial image of the Cowichan River estuary illustrating the undeveloped status of the estuary in 1930 (CETF 1980).

Aerial view of the Cowichan River estuary illustrating the construction of the CN causeway and the first log dump areas in southern sections of the estuary (CETF 1980).

1976 air photo during the peak of development in the Cowichan River estuary with primary industries including the Westcan terminal and the Doman's sawmill. Log storage areas were abundant and covered an estimated 49% of the total intertidal habitat area. (Photo courtesy of Peter Law, MOE).

Aerial image of the Cowichan estuary during 1985 with some reduction in log storage areas (photo courtesy of P. Law).

Aerial image of the Cowichan River estuary in 2002 after implementation of the Cowichan Environmental Estuary Management Plan in 1986 and reduction of log storage from 49% to 19% of the intertidal area (Photo Courtenay of P. Law).

Appendix B. *DRAFT* Land Use Impacts Table for the Cowichan Habitat Status Report *(To be Completed -- Work in Progress)*

Resource Development Type	Associated Activity	Potential Habitat Impacts	Potential Impacts to salmonids
FORESTRY	Road construction	Altered surface flow patterns Landslides Isolation off channel habitat	• Fish Access, Water Quality • Reduced availability and quality of off channel habitat
	Forest Harvesting	Bank instability and erosion Increased sediment transport Altered hydrological regime (higher peak flows, lower summer flow) Aggradation, channel widening, loss of lateral and vertical complexity Loss of streamside vegetation on smaller headwater streams Debris jams	• Reduced water quality and egg to fry survival, spawning habitat quality, incubation success, Water Quality • Debris jams • Loss of instream complexity, functional LWD frequency loss of natural pool riffle ration, loss of deep holding pools, presence of extensive shallow riffle sections, lack of boulder cover, subsurface flows • Loss of shade, overhead cover and food to downstream fish bearing water • Reduced Water Quality: higher water temperatures and lower dissolved oxygen levels • Lack of LWD recruitment
	Culverts	Loss of natural stream characteristics	• Limited chinook distribution and access
AGRICULTURE	Dairy Farms, crop production, grazing	Land clearing Ditching and dewatering Infilling and land reclamation	• Loss of wetland habitat and natural riparian structure, function and diversity Increased nutrient input and reduced overall water quality
URBAN/LIGHT INDUSTRIAL	Domestic Sewage	Discharge of treated and untreated sewage	• Reduction in Water Quality
	Duncan, Lake Cowichan, Youbou, rural residents, rural	Increase in impervious surface area Contaminated runoff (discharge from hatcheries, non point sources)	• Altered water cycle • Reduced water quality
	Flood Protection	Engineered flood control dikes, extensive riprap bank protection feat	• Channelization, loss of shoreline diversity, structure and function • Loss of natural riparian function, diversity and structure.
INDUSTRIAL IN ESTUARY	Western Forest Products sawmill	Infilling/land reclamation Dredging Log dumps and log booms	• Loss of marsh, meadow, intertidal and subtidal habitat • Accumulation of woody debris that lead to compacted sediments, anoxic conditions • Altered ecology and reduced productivity of the estuary. • Loss or reduced abundance of emergent and submergent vegetation, bivalves and crustaceans/
	Westcan Terminal causeway shipping port	Dredging Infilling and land reclamation	• Loss of intertidal and subtidal habitat, • Disturbance of benthic substrates and associated fauna

Appendix C. Cowichan River Fall Chinook Habitat Status Report – Summary of Habitat Features, Limiting Factors and Potential Measures.

Life Stage	Known High Value Habitat	Potential Limiting Factors	Possible Performance Indicator	Indicator Threshold (benchmarks)	Measures to address LF	Measures to maintain productivity	Habitat Protection and Restoration Measures undertaken
1.Spawner	High value spawning habitat Skutz Falls to Cowichan Lake outlet, abundance of spawners in 11.6 km between 3 firs and the lake. In 2005 – 2008 highly utilized sites:Greendale, Gailbraiths, Cabin run, 70.2 Mile bridge	Low mainstem flows that limit spawner access to higher quality spawning habitat upstream of Skutz Falls.	Water extraction during Aug – Oct (m3/month as % of MAD)		Provide adequate water storage in Cowichan Lake by increasing the outlet weir height to facilitate the release of adequate maintenance flows during the fall for chinook migration and spawning. Continue pulse flows and assess for effectiveness to facilitate upstream migration	Ensure adequate flows for adult upstream migration through the lower river and through the enumeration fence. Evaluate access through the enumeration fence and implement improvements as required. Develop a Monitoring and education program for Cowichan Lake residents to illustrate seasonal variations in the water surface elevation in the lake and downstream in the river proper. Illustrate where the control point is in an effort to gain support and cooperation with the water storage project.	1950 vertical slot fishway constructed as Skutz Falls, 1980 fishway constructed at Marble Falls (Koksilah), 1990 fishway and bypass channel through weir at lake outlet.
Spawner	Critical migration corridor through falls reach	Debris accumulation at the inlet to Skutz Falls and the fishway that limits upstream migration			Develop a Maintenance Plan for the Skutz Falls fishway with a dedicated budget and responsibility to provide clear passage for migrating spawners.		Sporadic debris removal program, could benefit from allocated budget
Spawner	Critical Migration corridor through lower floodplain reach (5 km) of Cowichan R and Koksilah R	Shallow water in combination with lack of instream complexity and good quality holding habitat in the lower Koksilah and Cowichan mainstem	frequency of functional LWD, # of deep holding pools/km		Assess mainstem habitat and develop a restoration strategy to improve instream cover and complexity. Refer to restoration options outlined in nhc 2009 Flood Management Plan.		
Spawner	Critical migration corridor, spawning habitat for chum and coho	Aggradation of sediment in the lower Cowichan mainstem that exacerbates passage of chinook spawners.	Sediment sampling stations in the lower river		Maintain access through the North fork and lower mainstem migration corridor. Discuss and consider an annual flood maintenance program that involves gravel removal at designated sites to facilitate passage though the north fork and lower mainstem areas.	Develop a restoration plan for the lower river that facilitates chinook access during low water conditions and strives to improve instream cover and complexity. Restoration options are outlined in nhc 2009 Flood Management Plan.	
Spawner	High value Migration, spawning and rearing habitat in the lower 5-6 km of the mainstem Cowichan and Koksilah R	Poor water quality/high water temperature in lower river and estuary during chinook migration results in increased stress, spawner mortality.	Water quality monitoring Water temperature during summer/early fall	Spawning and incubation: 10C Rearing: 15C Adult migration: 16C (Richter and Kolmes 2005)	Reduce water temperatures and manage flows to sustain adequate water quality conditions through lower river during the fall migration period. Undertake an annual water quality monitoring in the lower Cowichan and Koksilah River during the chinook migration and spawning period that includes water temperature, dissolved oxygen level and fecal coliform.		
Spawner		Migration delays at the adult counting fence			Evaluate access through the enumeration fence to determine if chinook spawners are being detrimentally delayed Consider reducing delays at the counting fence by installation of a better lead in fence combined with a Didson counting system.		
Spawner		Lack of gravel recruitment to upper river spawning habitat			Determine feasibility and suitable sites for spawning gravel placement works to increase spawning habitat quality upstream of Skutz Falls		2004, '08 small scale chinook spawning gravel placements at Cowichan L outlet for chinook, heavily used by coho in 2009. CLSES and LRS proj.

Life Stage	Known High Value Habitat	Potential Limiting Factors	Possible Performance Indicator	Indicator Threshold (benchmarks)	Measures to address LF	Measures to maintain productivity	Habitat Protection and Restoration Measures undertaken
2.Egg/Alevin	High value spawning habitat from Skutz Falls upstream to the outlet of Cowichan Lake.	Reduced egg to fry survival due to high input of fine sediments to the mainstem	Total No of naturally spawned outmigrating fry % or linear length of bank erosion Linear measure of exposed eroding silt banks Total suspended sediments	20% Target egg to fry survival <25% ppm (DFO 2000)	Continue juvenile outmigration program for fall run chinook as this data provides an absolute measure for egg to fry survival ratios and contributes essential information directly associated habitat improvement and remediation/restoration works. Continue incubation studies to determine egg to alevin survival and effects of sedimentation on incubation success. Continue with ongoing remediation works at the eroding clay banks/ sedimentation issues in the Block 51 area, Broadway run and the 3 firs areas. Identify and map highly sensitive areas that have a high potential for bank erosion. Manage land and resource development adjacent to and within these areas with a more conservative approach to minimize bank erosion and siltation. See D. Burt and M. Gaboury for GPS points/locations of known high sensitivity sites.	Extend the downstream trapping program to at least the third week of June to include assessment of the late migrant fry. Continue ongoing assessment and remediation plan for the upper mainstem clay bank erosion sites. Ensure resource development and land use practices strive to sustain or improve bank stability along the mainstem corridor. Evaluate the impacts of forestry development on natural hydrological characteristics (peak flows, low summer flows, riparian, slope stability) and restore/rehabilitate where needed.	2006/2007 Stoltz slide remediation works, 650 m long riprap berm has reduced sediment contribution by 90%. Assessment and proposed works at the Block 51, 3 firs and Broadway run sites.
2.Egg/Alevin (con't)		Reduced egg to fry survival due to scouring by high flows, bank erosion along clay bluffs	Egg to fry survival Total abundance of chinook fry	Target of 20% egg to fry survival	Investigate the impacts of river scour on chinook redds in the Cowichan system to determine if scouring of redds is a limiting factor to production	Continue juvenile outmigration program for fall run chinook	
2.Egg/Alevin		Reduced egg to fry survival due to disturbance by chum spawners	Frequency of chum spawning over chinook redds Water surface elevaton and chinook redd depth and elev		Strive to sustain adequate maintenance flows to facilitate passage to higher quality spawning habitat in the upper mainstem river. Document the years when chinook spawn in the middle and lower reaches of the river due to lower flows and chum are likely to over spawn in these areas.		
2.Egg/Alevin		Dewatering of redds due to low flows	Flow/water surface elevation relative to adjacent chinook redds, pilot sites.		Assess the incidence of dewatering of chinook redds and spawning areas on a preliminary level by documenting water levels and field observations during the incubation study. If warranted, undertake a more comprehensive study to determine if dewatering is a limiting factor		
3.Fry/Juvenile							
Lower River	High value off channel habitat d/s of the Trans Canada bridge provides critical rearing habitat for chinook fry primarily from Feb – April/ May, with lower utilization from June – Aug.	Unknown utilization and preferred habitat types by chinook in the lower floodplain reach. Unknown capacity of the lower floodplain reach	Presence/absence or CPUE of chinook fry by habitat type		Determine chinook fry distribution and habitat utilization in the lower floodplain area. Conducting presence/ absence fish sampling, use VO and MT to identify preferred habitat types and relative distribution of chinook fry (early March to June). Identify highest value nursery sites within the lower floodplain reach and protect and/or restore them. Estimate the available rearing habitat area and rearing capacity of the lower river and off channel habitat	Re-establish natural ecosystem function by restoring fish access as well as the natural innundation during high flows throughout the floodplain and off channel habitat through implementation of habitat restoration projects as outlined in Section ___. Determine how stream flows and river level affect rearing capacity in the lower cowichan and Koksilah mainstem and off channel habitat d/s of the Trans Canada highway.	Lower river: 5 sidechannel habitat improvement sites and increased access to: John Charlies, Major Jimmies, Five Fingers complex, Rotary Channel, Fish gut Alley Upper river: 702. Mile Trestle sidechannel restoration (access and habitat improvements)

Life Stage	Known High Value Habitat	Potential Limiting Factors	Possible Performance Indicator	Indicator Threshold (benchmarks)	Measures to address LF	Measures to maintain productivity	Habitat Protection and Restoration Measures undertaken
Lower River	Stable mainstem habitat for chinook fry outmigration and rearing	Loss of instream complexity in the lower mainstem and off channel habitat i.e. lack of holding pools, instream cover, diversity and instream complexity, particularly during low flow periods	% and type of instream features (overhead veg functn'l LWD, boulders, deep quiet water, aquatic vegetation)	See Johnston and Slaney 1996, Tripp and Bird 2004	Assess chinook habitat in the lower 5 km of the mainstem Cowichan and Koksilah rivers between March and June, determine fish utilization/relative density (CPUE) by habitat type and identify limiting habitat based factors to chinook production Restore natural frequency of instream complexity including functional LWD, boulders, overhead cover and deep pool habitat.	Provide adequate mainstem flows during the late summer and fall for chinook migration and spawning. Develop a priorized restoration plan based on results of the chinook habitat and distribution study. Integrate the restoration projects as outlined in the lower Cowichan/Koksilah flood management study (nhc 2009)	2007 3 rock groynes and 3 LWD complexes constructed for bank stabilization works and the JUB outfall.
Lower River	High value stable off channel rearing habitat	Limited access or no access to existing and/or historical off channel habitat (Trailer park channel, Priests slough/marsh etc)	Km or % of channelization and riparian alteration in the Cowichan mainstem downstream of the Trans Canada highway. Total off channel habitat available		Restore access and habitat quality to off channel habitat that has been altered by urban and resource development activities Construct setback dikes at Somenos Creek and Priests Marsh to support increased access and utilization of off channel habitat by salmonids as recommended in the Cowichan River Flood Management Study (2009) M14.3: Consider following maintenance projects to sustain flows: Rebuild Newbury weir downstream of the intake to the Major Jimmy's sidechannel to ensure recruitment of water in the channel during summer low flows (Alphonse 2010). Connect the 2 arms (hatchery channel and 5 fingers) of the channel complex downstream of the footbridge to increase flows to alcove areas downstream (Alphonse 2010).		Annual fry salvage efforts by the Cowichan lake Enh Society and Cowichan Tribes
Estuary	Nutrient rich estuarine habitat, submergent and emergent plant communities provide good foraging habitat. High value chinook rearing habitat from mid – April through Aug for chinook fry Valuable eelgrass habitat is isolated to southern sections of the estuary	Degradation of estuarine habitat, alteration of submergent vegetation communities, alteration of benthic substrates and species composition	Transect study to determine proportion or % of riparian, sedge, eelgrass and mudflats % and area of riparian intactness Area (and %) of altered or disturbed of foreshore (carrex, typha, riparian), inshore/intertidal (eelgrass, mudflats) or subtidal/offshore (log booms)	N/A	Develop a Restoration Plan for the Estuary that identifies long term goals, priority project, anticipated benefits and a Monitoring Plan. Support further restoration of eel grass habitat as well as fish access to isolated sloughs and sidechannels. Support ongoing identification, prioritization and restoration of eelgrass habitat and other submergent vegetation types in the Cowichan estuary to pre-development conditions. Assess and consider the restoration of shellfish and crab populations to historical levels. Undertake an annual water quality monitoring during the chinook migration and spawning period that includes water temperature, dissolved oxygen level and fecal coliform.	Protect estuarine and foreshore habitat from further degradation through the CCEMP. Control the colonization of Invasive species by increasing public education, identify area of infestation and determine /undertake the most appropriate control methods. Implement a monitoring program to determine and document the current level of degradation as well as the benefits and estimated production from restoration efforts, land acquisition as well as foreshore or estuarine habitat improvement projects. Consider the initiation of an intertidal transect survey to monitor key changes in habitat types over time.	Land acquisition, Eelgrass inventory and small scale pilot, 400 eelgrass transplants Koksilah Marsh, Doman's sawmill property, Removal of dikes to restore intertidal habitat, marsh restoration, enhancement of swales Rodenbush property: hogfuel removal, re-established back channel

Life Stage	Known High Value Habitat	Potential Limiting Factors	Possible Performance Indicator	Indicator Threshold (benchmarks)	Measures to address LF	Measures to maintain productivity	Habitat Protection and Restoration Measures undertaken
Estuary (cont)		Unknown rearing capacity of the estuary			Determine if there are density dependent effects that affect survival of chinook fry in the estuary. Support ongoing research investigating the early marine survival of wild and hatchery raised chinook fry Determine the level of ballast dumping and use of PCP's in the estuary and identify potential impacts to water quality as well as fish, vegetation and invertebrates communities. Determine options for mitigative measures if warranted.	Determine chinook fry distribution and habitat utilization in the estuary during the rearing period. Once preferred habitat types are known, determine chinook density and condition factor for each habitat type and for hatchery versus wild juveniles. Provide additional resources and personnel to increase the effectiveness of the CEEMP. Investigate Option 2 in the 2005 Review/Assessment of the EMP that recommends short term improvements to the existing EMP with transition to New Plan and governance model over the longer term	2005 series of 5 rock groynes complexed with LWD for bank stabilization at Mariners Pool Cowichan Est Farm: removed livestock and fencing
4.Smolt/Marine Coastal and Offshore		Low marine survival at less than ~1% in Georgia Strait Unknown mechanisms controlling marine survival and density dependant effects of large hatchery releases of chinook fry.			Continue with monitoring the marine survival of Cowichan River chinook.		

Appendix D. Short List of Pressure and State indicators developed by the Habitat Working Group (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 % watershed area impervious surface	Channel stability measures (pool: riffle, channel width: depth ratios etc Stream discharge measures (base and peak flows)
% watershed area converted to various land uses (forestry, agriculture, urban)	Water temperature
Wetland loss	Sediment, substrate
Water withdrawal as % MAD	LWD, instream cover
Permitted outfall discharges	Water chemistry (nutrients, DO, pH, conductivity, contaminants)
% lake foreshore alteration	
% estuary foreshore alteration	
Estuaries	
% estuary foreshore altered (carex, tyha, riparian zone)	Accessible off channel habitat area
% surface area disturbed inshore (eel grass zone)	Estuarine habitat area
% surface area disturbed offshore (eg log booms)	River or stream discharge
	Aquatic invertebrates
	Marine riparian vegetation
	Spatial distribution of wetlands, mudflat

(Short list of indicators for lake habitat also avail)