NANAIMO CHINOOK: BACKGROUNDER FOR RISK ASSESSMENT



GOALS:

DFO has developed a risk assessment methodology to aid in the identification and prioritization of factors that limit salmonid production, both now and in the future under various climate change scenarios. This methodology has been adapted from an "Ecological Risk Assessment for the Effects of Fishing" (ERAEF) framework that was initially developed to inform an ecosystem-based approach to fisheries management in Australia (Hobday et al., 2011).

The modified risk assessment methodology allows us to assess the biological risk posed by man-made and natural stressors acting on Pacific salmon throughout their life cycle in freshwater, estuarine and marine environments, utilizing a life history model approach to assess consequence of these stressors on the productivity and capacity of the population and its habitat.

The primary goal of this workshop is to solicit input on the limiting factors that may affect Nanaimo Summer Chinook survival and to determine their relative impacts on production as well as identifying where critical knowledge gaps occur. Ranking of the factors posing the highest risk to current productivity of Nanaimo Summer Chinook will allow for effective prioritization of management responses.

The second goal of this workshop is to discuss the current and possible future recovery measures/strategies to stimulate the possible recovery of Nanaimo Summer Chinook through remediation, restoration and/or conservation.

BACKGROUND:

In November 2018 COSEWIC assigned the level of ENDANGERED to the East Vancouver Island Stream Spring Designated Unit (DU). This DU is comprised solely by the spring run of Chinook salmon in the Nanaimo River. This designation triggered a response from DFO to produce a Recovery Potential Assessment (RPA), part of which is a risk assessment of the limiting factors that affect this DU. During the course of assembling information DFO could find no evidence that the chinook population that spawns above Second Lake (the 'spring' run) is distinct from the population that spawns below First Lake (the 'summer' run). The run timing, genetics and variability in juvenile life history are not significantly different. As a result, the spring run DU as defined does not exist, and the population should be included in the East Vancouver Island Ocean Summer DU. This DU also includes the summer Chinook in the Puntledge River, and could include summer Chinook in the

Cowichan River however the latter population is currently data deficient. The RPA on the spring run will likely be cancelled. However, with so much work initiated and completed, DFO has decided to continue with the Risk Assessment of Limiting Factors process, and focus on the Summer run of Chinook Salmon in the Nanaimo River. This work will contribute to a future RPA for the EVI Ocean Summer DU, which COSEWIC has indicated will likely be designated as ENDANGERED as well.

NANAIMO WATERSHED & ITS SALMON

The Nanaimo River watershed is located on the east coast of Vancouver Island near the city of Nanaimo, within the traditional territory of the Snuneymuxw First Nation. The 78 km-long Nanaimo River and its tributaries drains an area of about 830 km^2. The river headwaters originate near Mount Hooper, ~ 48 km southwest of Nanaimo.

The Nanaimo River estuary is the largest on Vancouver Island, and the 5th-largest in BC.

In addition to the Nanaimo River, the Chase River and Beck (Hong Kong) Creek discharge into the west side of the Nanaimo River estuary, and Holden Creek discharges into the east side of the estuary.

The Nanaimo River supports all 5 species of Pacific salmon including Coho, Chinook, Chum and Pink and Sockeye salmon with only small, runs of Sockeye and Pink salmon currently produced. The Nanaimo River also produces runs of steelhead trout, rainbow trout, sea run and resident cutthroat trout and Dolly Varden char. The Nanaimo River chinook belong to the Lower Strait of Georgia Management Unit (LGS). The LGS stock are resident to the Strait of Georgia , having limited northward migration along the Pacific coast, with a small portion of the stock emigrating farther northward. When mature, they typically migrate to spawn during late summer/fall as 3 and 4 year-olds. The Nanaimo and Cowichan River chinook stocks are 2 large natural spawning populations in the LGS, both with hatchery augmentation. In the past, this LGS stock has been over fished, and the residency of the stock makes it highly vulnerable to future exploitation.

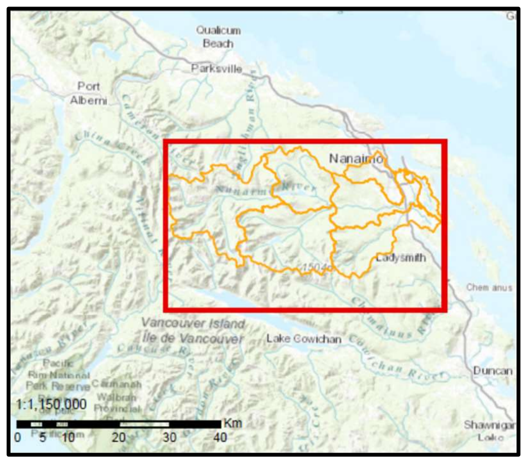


Figure 1. Location of the Nanaimo Watershed

STATUS OF NANAIMO CHINOOK

Distribution: The larger Nanaimo Fall Chinook stock enters the Nanaimo River during August and a portion of the run spawns in the lower river downstream of the Borehole/lower canyon area down to the Cedar Road bridge, while some ascend the falls to spawn in the upper river downstream of First Lake. Summer Chinook are not found in the Nanaimo River until April when they start to appear below White Rapids Falls. Subsequently, by the beginning of June they begin to move upstream into areas downstream from First Lake and upstream of Second Lake. These Chinook are present in the two spawning areas consistently until the end of the spawning period in late October, leading to the conclusion that after upriver migration to these locations they hold there until spawning is complete, and may not hold in the lakes.

Both the fall and summer populations are mainly ocean-type chinook that do not overwinter in freshwater (although a portion of the summer run population has been found to exhibit stream-type life history where fry spend the winter in freshwater).

Spawning Locations: Summer Run Chinook spawn in the following areas:

- Between Second and Fourth Lakes, but may also spawn in tributaries to the Nanaimo River such as Green Creek (these are the upper spawning run, which was referred to as the spring run in the past)
- Within a two kilometre stretch of the Nanaimo River from Wolf Creek up to First Lake; this is also the best quality chinook spawning habitat in the river
- In the vicinity of the South Nanaimo River confluence
- Just below First Lake, there are two important spawning sites for summer run chinook :
  - First Lake Outlet –at the top of a riffle located at the confluence of the lake outlet with the North Nanaimo River
  - Transverse riffle 950 m below First Lake Outlet

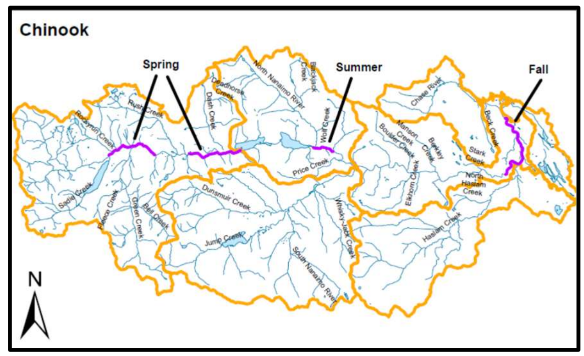


Figure 2. This diagram shows the location of spawning for Nanaimo Chinook. Note that the spring and summer runs are now believed to be one single summer run with different spawning locations.

Escapement: Spawner enumeration information is warehoused in the DFO NuSEDs database, which has maintained records of adult salmon abundance since 1953. In the Nanaimo River, only one spawner estimate was initially recorded which may have included all populations but specific details are not present. When the Nanaimo River Hatchery (NRH) initiated operations in 1978, they conducted periodic swim surveys on the Fall run and both the upper and lower spawning Summer runs: however records in NuSEDs were only created for the lower spawning Summer and Fall populations. Watson (2015) estimated the population abundance for the upper spawning Nanaimo summer run using spots count data or data from one or two swim surveys per year. This level of data provides only a low resolution estimate (Figure 3). The abundance trajectory for the upper spawning Nanaimo Summer population indicates an annual decline of 6.3% (1979 – 2008). The lower spawning Summer and Fall populations, both of which are enhanced by the NRH, show annual increases of 3.4% and 4.6%, respectively (1979 – 2018).

Over the last decade, yearly upper spawning Summer Run chinook escapement has been fewer than 10 spawners. The hatchery-enhanced lower spawning summer and fall runs have had mean escapements of 776 (range of 349–1,125) and 3,743 (range of 2,169–5,023), respectively.

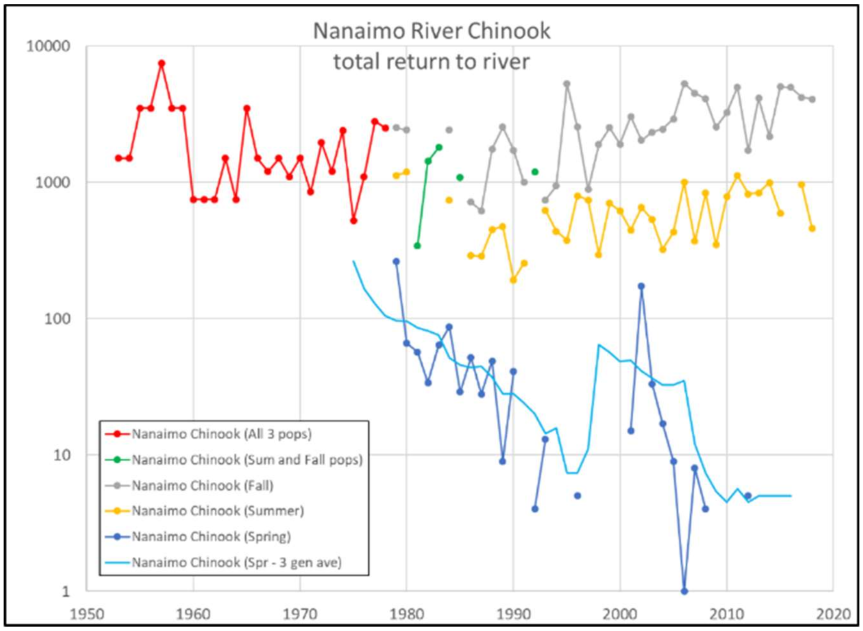


Figure 3. Abundance estimates of Nanaimo River Chinook, DFO NuSEDs database access August 20. Note that the "spring run" is now understood to be an upper spawning Summer Run.

Hatchery Releases: There is a small enhancement project, the Nanaimo River Hatchery (NRH) operated by the Nanaimo River Stewardship Society (NRSS), on the lower River that supports both the lower spawning summer run and fall run Chinook salmon stocks, annually producing approximately 450,000 fall run and 200,000 summer run fry annually (B. Banks, Hatchery Manager, pers. Comm. 2018). The upper spawning Summer Run has had very little direct enhancement. There are two three years that brood stock was collected from the spawning area above Second Lake, and one of those years (1986) was a supplement to an existing captive brood project.

Estuary rearing: Estuaries are important rearing areas for juvenile Chinook. The Nanaimo River estuary is considered critical habitat and provides an environmental transition zone where fish acclimate between freshwater and saltwater and between waters of different temperatures. Estuaries also provide structural cover and refuge from predators, and substantial foraging opportunities, and are highly productive relative to adjacent ocean or freshwater areas. Estuarine rearing habitats are of particular importance to summer and fall chinook run juveniles, which typically arrive in the estuary as subyearling fry and smolt before dispersing seaward in June and July. Healey found that Chinook fry (age 0+) entered the estuarine area in April and May, immediately after emergence and reared and grew there for an average of 25 days. He found high densities of 40-50,000 fry in 1975 and 20-25,000 fry in 1976 and 1977. The largest sampling catches were on the east side of the estuary, along the east channel of the Nanaimo River, and Holden Creek. Healey did not catch Chinook yearlings (age 1+) in the estuary sampling but did encounter them in the nearby marine waters in May, prior to age 0+ moving out of the estuarine waters. This suggests that the older juveniles did not reside in the estuary but moved through and into adjacent habitats.

Ocean distribution: Specific information on ocean distribution of this population is not available. Generically, ocean-type Chinook move away from estuarine habitats into open ocean within the Strait of Georgia between May and August and have been found here through to November. After September of their first summer in marine waters, most will leave the Strait and migrate to the West Coast of Vancouver Island. Stream-type Chinook enter marine waters immediately after downstream migration but will remain in the Strait of Georgia until the fall, similar to the ocean-type Chinook. Offshore distribution of Chinook can be divided into three types: locally distributed, far north migrating, and offshore. Chinook from the ECVI Summer CU, which includes the Nanaimo lower spawning Summer population, are known to be a Far-north migrate. It can be assumed the Nanaimo upper spawning Summer Chinook follows this pattern.

Marine Survival: For Chinook salmon, marine survival is expressed as the survival from the smolt stage (ocean entry) to Age 2, when the Chinook salmon have grown large enough to be available to the fishery. Data for the Nanaimo Summer run Chinook is not available so Puntledge Summer Chinook is used as a proxy. Figure 4 shows the most recent estimated marine survival of Puntledge Summer Chinook, using Brood year as the X axis variable.

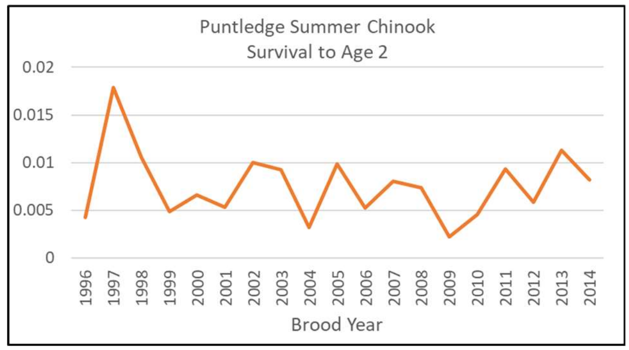


Figure 4. Survival to Age 2, Puntledge Summer Chinook. Data from the Chinook Technical Committee of the Pacific Salmon Commission.

Exploitation: The Puntledge Summer run Chinook is the designated Exploitation Rate and Marine Survival indicator for the Nanaimo upper spawning Summer run Chinook population. As can be seen from Figure 5, the summer timed population generally has a lower exploitation rate than the fall population.

Exploitation rates decreased between the 1990s and 2000s as sport regulations restricted opportunities, especially for coho, and effort moved to the west coast of Vancouver Island. In addition, troll fishery openings ceased in the Strait of Georgia during this period and exploitation from this fishery fell from an average of 10% down to zero.

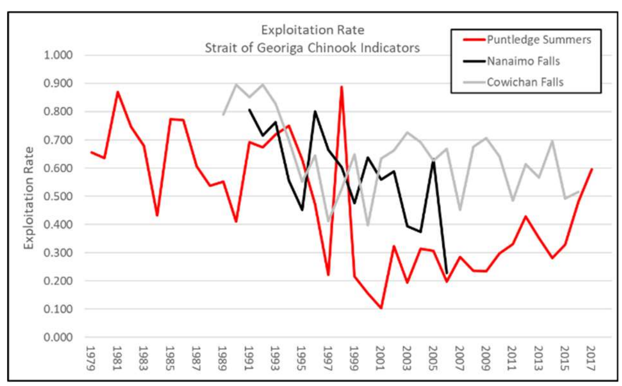


Figure 5. Exploitation rate of Strait of Georgia Chinook indicators

Habitat: A recent habitat assessment for the Nanaimo watershed was completed by M. C. Wright & Asso. They noted that the watershed has been extensively altered by human activities. Key historical impacts include: coal mining between the mid 1800s and 1950s; sand and gravel mining from the Nanaimo River Valley in the mid 1900s; logging since the late 1800s (and extensive since the 1950s after the pulp mill at Harmac was begun); and significant damming and water extraction activities since the 1930. First Lake was historically used for log booming, and historical clear-cut logging and burning eliminated riparian forest, increased erosion and sedimentation in the river and its tributaries, altered stream flow and channel morphology, and increased stream temperatures, all of which adversely impacted fish habitat and decreased fish production.

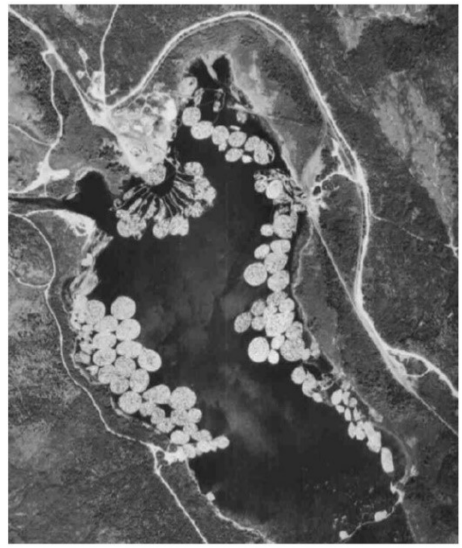


Figure 6. Aerial view of First Lake in 1975 when the lake was used as a log dump and storage area for forestry operations (photo taken from Komori Wong Environmental 2002).

In addition, the estuary has been directly impacted by anthropogenic activities. Raw sewage was discharged directly onto the estuary mudflats until the late 1950s. By the 1970s, it was observed that increased sedimentation due to logging had altered the substrate of the estuarine mudflats and raised the elevation of the mudflats in various areas, making it less suitable or even unsuitable for eelgrass growth. Additionally, the estuary has been used as a log booming ground for sawmills and the Harmac pulp mill since the 1950s. In the mid-1970s, over one third of the estuary was leased for log storage and booming, while in 1980, approximately 73% of the total estuary area was subject to direct physical impact from log storage and towing activities. The estuary also was regularly dredged to maintain depth for log storage.

Currently, 85% of the watershed is private forest land owned by Mosaic Forest Management Corp. (previously Islands Timberlands and Timberwest). The lower part of the watershed consists primarily of rural developments, agriculture land, low density residential developments, and some light industrial development. The Nanaimo River flow is fully allocated from July to September, which means that no future water withdrawal licenses will be issued except for domestic use, unless additional storage is provided. Prior to 2016, this restriction did not apply to groundwater withdrawals, which were generally unregulated in BC. Harmac Pacific, a division of Nanaimo Forest Products Ltd., continues to draw water from both the Nanaimo River and the Cassidy Aquifer to supply water to its Northern Bleached Softwood Kraft pulp mill. The City of Nanaimo continues to supply drinking water to city residents, the Snuneymuxw First Nation, and the South West Extension Improvement District from its Jump Creek and South Fork Dam reservoirs. Water withdrawals adjacent to the lower Nanaimo River have increased with time as the South Nanaimo and Cedar area have been developed and given that much of this area obtains water from wells. The Port of Nanaimo and the forest products industry remain the principal users of the Nanaimo waterfront and Nanaimo River estuary. The log storage lease area footprint in the estuary has not greatly changed since the late 1980s.

The recent habitat status report for the Nanaimo watershed noted the following key concerns:

Total land cover alterations

The watershed has experienced extensive land cover alteration in the middle and upper watershed due to forest harvesting and road building—Only 0.55%, 2.8%, and 1.4% of what would have historically been vegetated land or wetlands in the Lower Nanaimo River, Middle Nanaimo River, and Haslam Creek sub-basins, respectively, is unaltered forest. And in the lower watershed, 7.4% of the Lower Nanaimo River has

been converted to agricultural and urban land development. The remaining forested land in the watershed is covered by very young forest. 29%, 41%, 53%, 44%, and 41% of forest in the Lower, Middle, South, Upper Nanaimo River and Haslam Creek sub-basins is less than 40 years old, These alterations likely have high impact on the following: Water Quality, Stream Discharge, Key Spawning Areas, Habitat Composition, Large Woody Debris, and Estuarine Habitat Area,

Watershed road development and stream crossing density

The road density in the watershed far exceeds benchmarks for protection of salmon habitats. The South and Upper Nanaimo River sub-basins and the Chase River watershed have approximately 380 m to 3.1 km more gravel road per square kilometer than eight of the nine actively logged Clayoquot and Nootka Sound watersheds that MCW has assessed using this Wild Salmon Policy framework and that also exceeded the high-risk benchmark. These alterations likely have high impact on the following: Water Quality, Key Spawning Areas, Habitat Composition, Channel Stability and Estuarine Habitat Area.

Riparian disturbance

Almost no mature conifer riparian forest remains in reaches 1–6 of the Lower Nanaimo River. Up to 58.1% of the riparian forest in each reach of the Nanaimo River is regenerating or deciduous or was recently clearcut. Such a change in riparian vegetation following harvesting leads to increased transpiration by streamside vegetation, increased stream temperatures, reduced summer stream flow, bank erosion, and introduction of sediments from logging, among other effects. These alterations likely have high impact on the following: Water Quality, Stream Discharge, Habitat Composition, Channel Stability, Large Woody Debris and Estuarine Habitat Area.

Water Extraction

The total licenced water extraction in the Nanaimo River watershed is over 193 million m3/y, representing ~10% of mean annual discharge. Consequently, water extraction in the watershed is fully allocated unless more storage is created. Aquifers are under high stress, though groundwater withdrawal for domestic use remains unregulated. The annual watershed yield in the Nanaimo River and South Nanaimo River subbasins will likely decline by approximately 13% in the next 50 years. Total watershed low flow period (June–September) yield is expected to decline by up to 60% in the next 50 years. These concerns likely have high impact on the following: Stream Discharge, Key Spawning Areas and Habitat Composition.

Estuary habitat disturbance

The estuary has been significantly altered by historical and ongoing anthropogenic activities. Portions of the estuarine marsh and meadow habitats were diked to create fields for hay production and grazing by domestic animals. Log booming over the intertidal mudflats resulted in widespread loss of eelgrass from the middle portion of the mudflats. The introduction of coal washings from mining operations in the area and increased sedimentation in the estuary due to clearcut logging in the watershed were additional causes of eelgrass loss. These alterations likely have high impact on the following: Estuarine Habitat Area, Estuary Chemistry and Contaminants and Estuary Dissolved Oxygen.

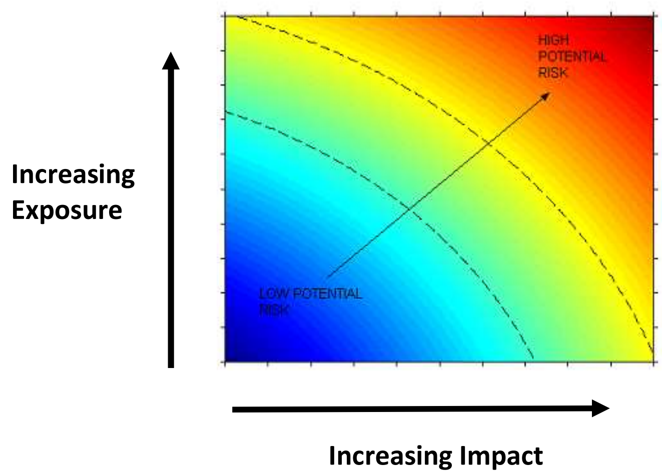
Permitted waste management discharges

Six private companies, the Nanaimo Airport, and the regional District of Nanaimo have waste discharge authorizations for facilities located within the Nanaimo River, Chase, or Holden watersheds. Because of these facilities, the surface water, aquifers, and estuary of the Nanaimo River watershed are exposed to more sources of contamination than less populated Vancouver Island watershed. However, there is presently no direct effluent discharge to rivers or to the Nanaimo River estuary. These alterations likely have high impact on the following: Water Quality, Key Spawning Areas, Estuary Chemistry and Contaminants and Estuary Dissolved Oxygen.

RISK ASSESSMENT PROCESS:

At this workshop we will conduct a first pass (Level 1) risk assessment using expert opinion to determine the risk posed by human and natural factors limiting the productive capacity of the Nanaimo watershed to produce Summer Chinook Run salmon. These 'limiting factors' will be assessed for two time frames, first based on "current conditions", and second based on "future conditions - 50 years in the future". Carrying out the analysis over these two time periods allows us to examine how the impacts of various stressors are predicted to, or could change under ongoing climate change. At some future date, the highest ranked risks may be re-assessed based on more quantitative methods and relationships (Level 2).

The framework for this risk-assessment is based on accepted methods from the Government of Canada Treasury Board and Hobday (2011). These have been adapted to salmon in watersheds by evaluating the biological risk to each life history stage. Biological risk is determined from two variables: Exposure and Impact. The term "exposure" is synonymous with the term "likelihood" which is used in some risk assessment methodologies, while the term "impact" is synonymous with the term "consequence".



Thus, the biological risk of a limiting factor will be related to the amount of exposure that the population has to this factor (in both time and space) and the impact it has on the population. The impact is related to the percent change in the return of Chinook to the river, but changes in key biological characteristics such as age at maturity, sex composition, fecundity, and run timing of the Chinook populations are also considered. The following graph shows how biological risk increases as both impact and exposure increase.

Stages of Risk Assessment

The first phase of the risk assessment is the scoping phase. The scoping phase involves the collection of specific information for the population under consideration. Following the scoping phase is the risk assessment scoring phase.

Scoping involves three steps:

1. Characterizing the population of interest & developing a life history table
2. Describing the biological characteristics & requirements of each life history stage in its habitat
3. Identification of limiting factors and key issues impacting each life history stage

The key steps for the scoring process are:

4. Risk assessment scoring of biological risk by each workshop participant
5. Consensus is reached amongst the group
6. Scoring the level of uncertainty; data and knowledge gaps are identified

Characterization:

The first step is to gather relevant population data for the population under consideration. We examine the data that are available for each life history stage for the species such as fecundity data, relative abundances, percentage mortality data etc. This enables us to build a simple life history table such as depicted in Table 1.

We are particularly interested in the values of recruits per spawner (R/S) and the numbers of spawners. These values provide information on the productivity parameter (α) and the capacity parameter (β) of the Ricker curve- and are two important statistics that describe the relationship of the salmon with the habitat and ecosystem. Given that the risk assessment process should enable us to prioritise key limiting factors, knowledge of these statistics will enable us to examine the possible benefits of various mitigative strategies that are designed to improve either the productivity or the habitat capacity for the population under consideration.

Table 1. Generic Life History Table.

Habitat	Life History Phase	Estimated mortality rate	Estimated relative abundance
Lake	**Spawner**		
	Eggs		
Lake	**Fry**		
Lake/estuary	**Smolt**		

Number of Spawners = S

This estimates the β statistic (capacity parameter of Ricker curve)

Ocean	Ocean year 1		
	Mature migrant (recruits)		
Terminal area	Terminal migrant		
Lake	Holding adult		
Lake	Spawner		

Number of Recruits = R

R/S is estimate of α, a measure of the productivity of the population

Critical Habitat Requirements:

Different life history stages of salmon occur in interconnected habitats and have various requirements during their life history. As part of the risk assessment process, we need to examine the biological requirements for each life history stage, and determine how well these requirements are met in the available habitats available for the population under consideration. This step involves identification of the critical habitat requirements for each life history stage of Nanaimo Summer Chinook.

Gather limiting factors and assess their risk to the Nanaimo Summer Chinook population:

The next step involves the identification of limiting factors and key issues that impact the different life history stages of Nanaimo Summer Chinook.

These lists of limiting factors, organized by life history stage and habitat encountered, are basically a number of alternative hypotheses for declines in salmonids. In many cases, there may be knowledge gaps, incomplete time series and other data gaps, which should be identified.

The list of critical habitat requirements, and the possible limiting factors impacting Nanaimo Chinook are provided as a table below (Table 2). This information is further developed and will be provided as a handout at the workshop.

At the workshop, you will be asked to look over these suggested limiting factors and to provide feedback. We will be interested in suggestions of limiting factors that we have missed. Once we have consensus on the key limiting factors, we will go through the risk assessment scoring process to determine which of the factors result in most biological risk to Nanaimo Summer Chinook productivity.

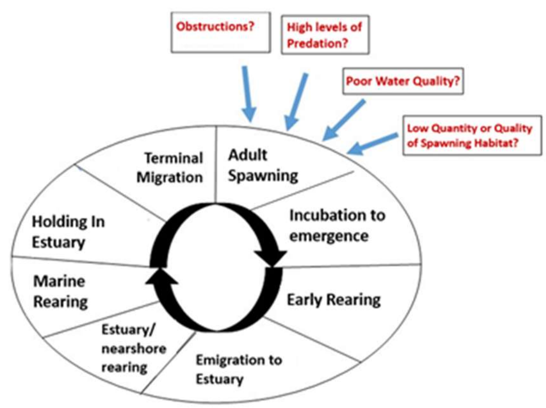


Figure 7. Examples of limiting factors that may impact the adult spawning stage. There will be other threats impacting each of the other life history stages. The goal of the limiting factors analysis is to determine which limiting factors have most impact on Nanaimo Summer Chinook productivity.

NOTE: at the workshop we will be assessing risks in <u>freshwater and estuarine habitats</u> only.

Table 2. Critical habitat requirements and the threats and factors possibly limiting to Nanaimo Summer Chinook salmon productivity.

Requirements	Potential Limiting Factors
Terminal Adult Migration & Spawning	
Safe holding habitat in estuary and lower river	LF1: Predation of adults in the estuary and lower river by pinnipeds
Adequate flows to facilitate upstream passage of spawners	LF2: Limited or delayed spawner access
Unrestricted access	LF3: Potential delays in upstream migration due to the physical barriers (natural or anthropogenic)
Stable channel morphology, maintenance of channel capacity and natural level of sediment transport	LF4: Aggradation creates a migration barrier in the lower river during summer and early fall period.
High quality migration route with adequate refuge habitat	LF5: Loss of safe migration route through the lower rivers due to channelization, loss of habitat complexity and instream cover features
Suitable water quality	LF6: High water temperatures in the lower river and estuary during the late summer/early fall migration period can increase migration mortality and sublethal stress.
Suitable water quality	LF7: Poor water quality conditions during the late summer/early fall migration period (low DO, coliform levels, deleterious substances)
An agreed -upon and Enforceable Fishing Plan	LF8: Mortality due to poaching
Availability of high quality and sufficient quantity spawning habitat	LF9: Lack of high quality and quantity of spawning habitat
Lack of anthropogenic disturbance	LF10: Disturbance to natural spawning activity due to anthropogenic impacts
Lack of disease during migration and spawning	LF11: Pre-spawn mortality due to disease
Low levels of predation	LF12: Mortality due to predation at spawning grounds
Freshwater Incubation: Egg to Fry	
Good water quality conditions	LF13: High suspended sediment loads and low DO that reduce egg to fry survival and emergence of alevins
Good water quality conditions	LF14: Non Optimal water temperatures that reduce fry survival by changing emergence time in relation to food availability
Suitable flow regime	LF15: Lower low flows that dewater redds and reduce incubation survival
Stable flow regime	LF16: More frequent and higher peak flows over winter can scour/disturb redds
Appropriate spawning gravel	LF17: Egg mortality due to asphyxiation and inadequate spawning gravel
Minimal disturbance to redds	LF18: Reduced egg to fry survival due to chum overspawn
Minimal predation of eggs and alevins	LF19: Predation of eggs and alevins by fish (sculpins, trout) and birds (mergansers)
Lack of invasive species	LF20: Egg /alevin mortality due to redd disturbance by invasive or expanding endemic species (e.g. didymo)
Lack of anthropogenic disturbance	LF21: Egg mortality due to redd disturbance by humans

Freshwater Rearing: Fry to Smolt	
Good water quality conditions	LF22: Mortality or fitness impacts as a result of poor water quality (e.g. temperature, TSS, dissolved oxygen levels, pH, hardness, supersaturation)
Clear and safe passage with adequate refuge habitat	LF23: Mortality or fitness impacts as a result of inadequate in-stream complexity and riparian complexity
Adequate water levels and connectivity	LF24: Increased stranding in isolated off- channel habitat and tributaries can occur with rapid decreases in flow
Stable flow regime	LF25: High flows impacting fry and smolts
Adequate food supply	LF26: Mortality or fitness impacts as a result of lack of food
Absence of aquatic invasive species	LF27: Mortality or fitness impacts as a result of competition with AIS
Absence of competition with other species or hatchery fry	LF28: Mortality or fitness impacts as a result of competition, disease,interaction with other species/hatchery fry
Low levels of predation	LF29: Mortality as a result of high levels of predation
Absence of anthropogenic disturbance	LF30: Mortality or fitness impacts as a result of anthropogenic disturbance
Low levels of fish disease	LF31: Mortality or fitness impacts as a result of disease
Absence of negative hatchery impacts	LF32: Mortality or fitness impacts as a result of hatchery introgression
Rearing In The Estuary	
Adequate food supply to minimize competition with hatchery smolts and other stocks for food and habitat	LF33: Low early marine survival of chinook fry and smolts in the estuary / nearshore marine due to the lack of adequate food supply (particularly in first 4 months of marine life) and reduced water quality
Minimal levels of predation	LF34: Predation of smolts in the lower river and estuary
Lack of invasive species	LF35: Mortality of fry and smolts due to predation and competition from AIS
Adequate water temps for smoltification and outmigration	LF36: Mortality or reduced fitness as a result of failure to develop to smolt
Good Habitat complexity	LF37: Loss of good quality foreshore, estuarine and nearshore habitat
Suitable water quality	LF38: Reduced survival due to decreased water quality from ballast dumping, industrial discharge, and sewage effluent in the estuary.
Lack of anthropogenic disturbance	LF39: Mortality or reduced fitness as a result of anthropogenic interference
Marine Phase	
Adequate food supply	LF40: Low marine survival due to inadequate food supply (abundance or value)
Sufficient water quality & environmental conditions	LF41: Low marine survival (<1%) in the Strait of Georgia due to low marine productivity, poor water quality, increase mean water temp
Minimal levels of competition	LF42: Low marine survival as a result of competition for food
Minimal levels of predation	LF43: Low marine survival due to high rate of predation by orcas, pinnipeds
Cover & shelter in nearshore environments	LF44: Low marine survival due to high rate of predation in nearshore environments
Minimal impacts from aquatic invasive species	LF45: Mortality or fitness impacts as a result of competition with aquatic invasive species
Minimal offshore habitat destruction	LF46: Mortality due to impacts related to offshore habitat destruction
Minimal aquatic pollutants	LF47: Mortality or sub-lethal effects as a result of pollutants
Low levels of disease	LF48: Mortality or fitness impacts as a result of disease
Lack of harmful algal blooms	LF49: Mortality or fitness impacts as a result of HABS
Sustainable Fishery impacts	LF50: Mortality due to overfishing

Risk Assessment Scoring Process:

During this workshop, you will examine the key limiting factors that are affecting Summer Chinook returning to the Nanaimo Watershed. An initial scoring of the "exposure" and "impact" for key limiting factors will have been carried out by 2 or 3 anonymous reviewers.

The group will consider these scores, determine whether they agree or not, and a final consensus score will be reached by the group after discussion. These final consensus scores will be placed into an Excel spreadsheet, and automatic calculations will result in a final "Biological Risk Score".

Colour-coding of these scores will enable easy visual interpretation of the level of risk for each limiting factor, with dark red denoting "Very High Risk", pale red "High Risk", orange "Medium Risk" and pale green "Low Risk" or "Very Low Risk".

Scoring the "Exposure" Term

Exposure is based on combining 1) the spatial scale of the limiting factor, and 2) the temporal scale of the limiting factor.

The methodology will require you to use ***your expert opinion and/or knowledge of data or reports*** as you score each of these terms, and then discuss with others in your group to develop a consensus value. Rationale and citation of existing data/reports should be documented. Once these two scores are entered into the Excel Spreadsheet, the final value for the "Exposure" term is automatically calculated.

a. The Spatial Scale Score

Limiting factors are rated in terms of the spatial scale based on the percentage of the critical habitat of a particular life history stage which is affected, or on the percentage of the population itself that is affected (Table 3).

A full rationale should be provided for this score.

By critical habitat, we mean any area of habitat that is necessary for the survival or recovery of Nanaimo Summer Chinook.

Table 3. Spatial Impact Score Guide

Score	Level of spatial scale affected (by life history stage)
Low (1)	Less than 10% of the critical habitat or the population is affected
Moderate (2)	10-20% of the critical habitat or the population is affected
Medium (3)	30-40% of the critical habitat or the population is affected
High (4)	50%-70% of the critical habitat or the population is affected
Very High (5)	80% or more of the critical habitat or the population is affected

b. The Temporal Scale Score

The frequency at which an identified factor limits production of the species is called the "temporal score".

The 5 categories of temporal frequency are described in Table 4 below.

Your opinion on the temporal score should be supported by a short rationale and/or citation of documented knowledge such as data or reports.

Table 4. Temporal Impact Score Guide

Score	Frequency of the limiting factor occurring
Low (1)	Once per decade (Very rare)
Moderate (2)	Twice per decade (Occurs but uncommon)
Medium (3)	Three to four times per decade (Sometimes occurs)
High (4)	5-7 times per decade (Frequent)
Very High (5)	8 + times per decade (Continual)

Scoring the "Impact" Term

The "impact" score is based on the expected magnitude of impact of the factor on the subsequent adult return. Chinook have a complex life history, with each stage susceptible to a myriad of factors which ultimately affect the number of adults returning to the river. The possible impact scores related to change in subsequent return to river are shown in Table 5. Longer term change resulting from impacts on sex ratio, fecundity, age of maturity, size, etc. also could be significant.

Each expert participant will decide upon the impact score for each limiting factor, and then the group as a whole will be required to agree on a score which will be entered into the Excel spreadsheet for that particular limiting factor. Again, the full rationale for how a particular impact score was derived must be provided. If there is disagreement amongst the experts, or if key information is lacking, the Hobday method suggests the highest impact score be assigned to that particular factor.

Table 5. Impact criteria to score potential risk.

Level	Score	Description
Minor	1	Less than 10% change in subsequent return to river.
Moderate	2	11-20% change in subsequent return to river.
Major	3	21-30% change in subsequent return to river.
Severe	4	31-50% change in subsequent return to river.
Critical	5	50% + change in subsequent return to river.

Recording the uncertainty/confidence levels in scores

There is always some level of uncertainty associated with predicting impacts of any limiting factor on fish or fish habitat. Uncertainty can arise due to a lack of information, or could arise when predicting the effectiveness of new or innovative mitigation measures. In addition, there may be synergistic effects where two or more effects in combination express an effect greater than would have been expressed individually. These are difficult to identify and hence have the potential of being overlooked or underestimated.

Acknowledging this uncertainty does not preclude making sound management decisions, but the uncertainly does need to be described and taken into account at this risk assessment stage.

Thus, this risk assessment methodology requires that workshop participants provide confidence ratings for the risk scores that are produced from the Level 1 risk assessment. These ratings may be 1 (low confidence) or 2 (medium confidence) or 3 (high confidence) (Table 6).

Table 6. Confidence Scores

Confidence	Rationale
Low	• Data exist but are considered poor, or conflicting, or • No data exist, or • Substantial disagreement among experts
Med	• Data exist but some key gaps • Some disagreement between experts
High	• Data exist and are considered sound, or • Consensus between experts, or • Risk is constrained by logical consideration

Current and Future Trends

Finally, workshop participants will also be asked to provide scores for the following:

Current Trend –In the context of the last 10 years is this limiting factor increasing, decreasing or showing no trend? Score this between (1) strongly decreasing, (2) somewhat decreasing, (3) stable, (4) somewhat increasing, and strongly increasing (5).

Future Trend – What will be the trend 50 years from today? This will require workshop participants to discuss the predicted impacts of climate change. Score this between (1) strongly decreasing, (2) somewhat decreasing, (3) stable, (4) somewhat increasing, and strongly increasing (5).

ACTION PLANNING:

The risk assessment process allows us to prioritize the key limiting factors that are impacting productivity of Nanaimo Summer Chinook. These factors may be direct threats to the species or its habitat. We will also aim to identify the key causal factors that result in these key threats and risks, as well as a discussion of current and proposed management actions that could lead to their amelioration.