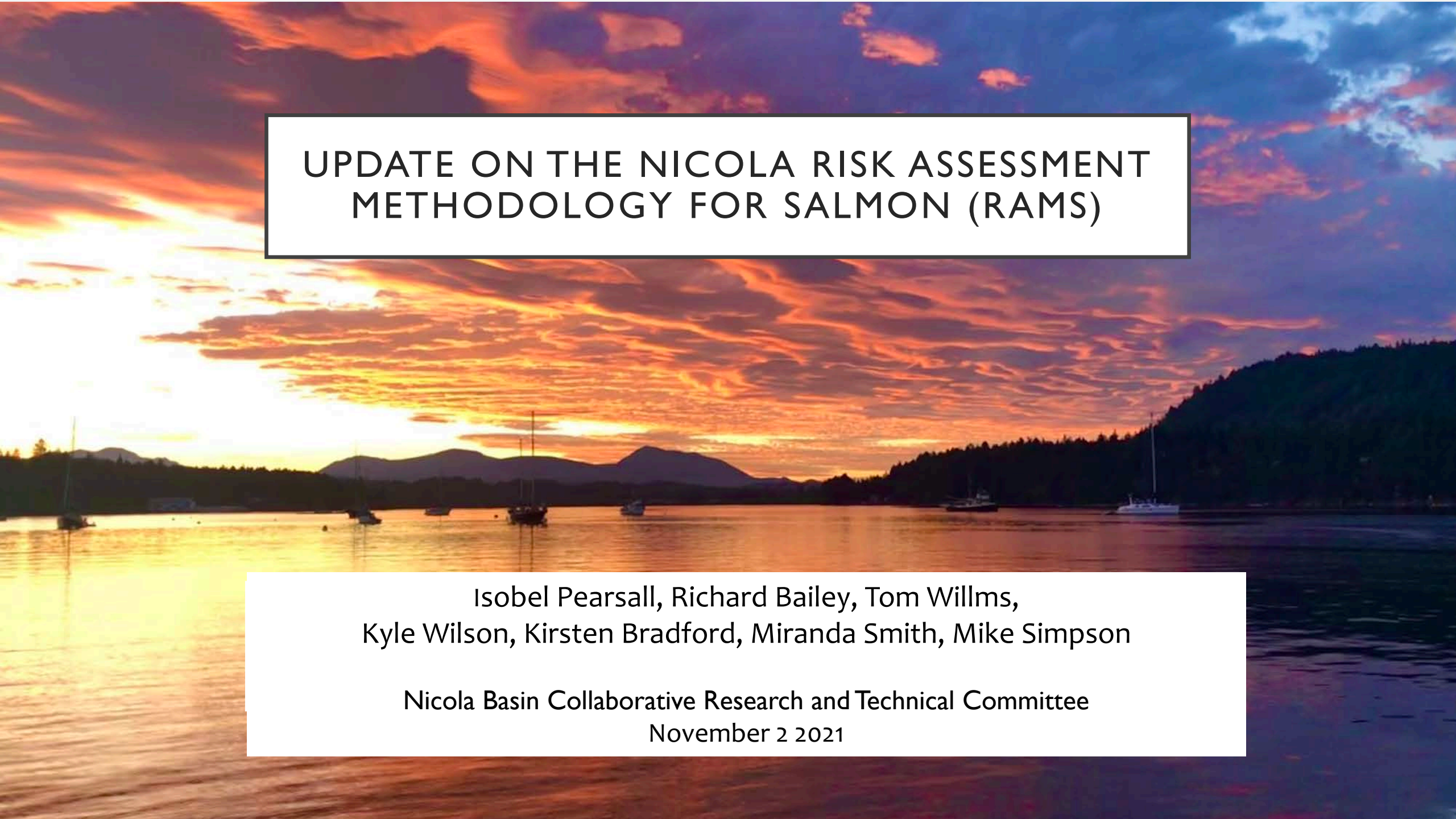


UPDATE ON THE NICOLA RISK ASSESSMENT METHODOLOGY FOR SALMON (RAMS)

Isobel Pearsall, Richard Bailey, Tom Willms,
Kyle Wilson, Kirsten Bradford, Miranda Smith, Mike Simpson

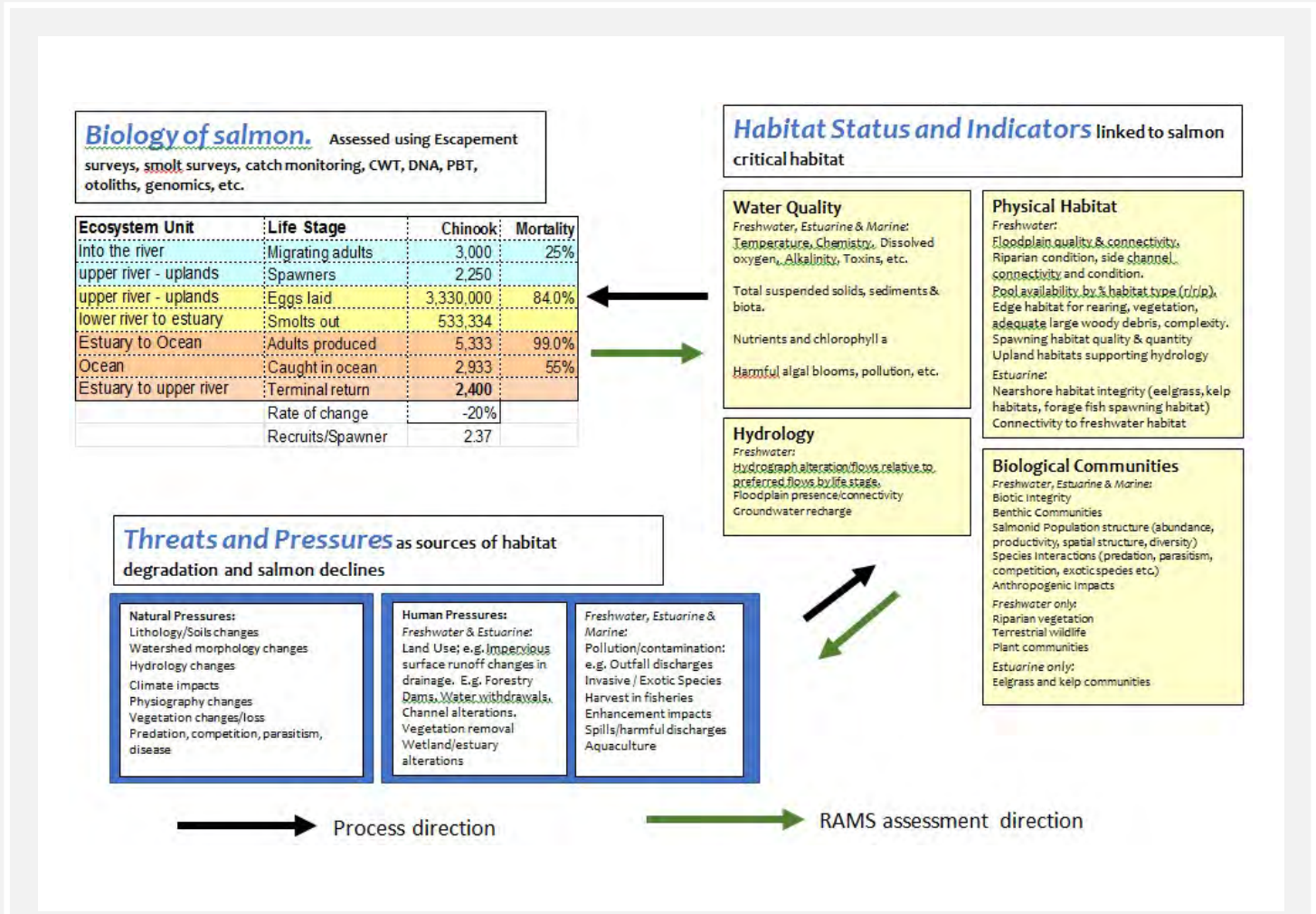
Nicola Basin Collaborative Research and Technical Committee
November 2 2021

RAMS

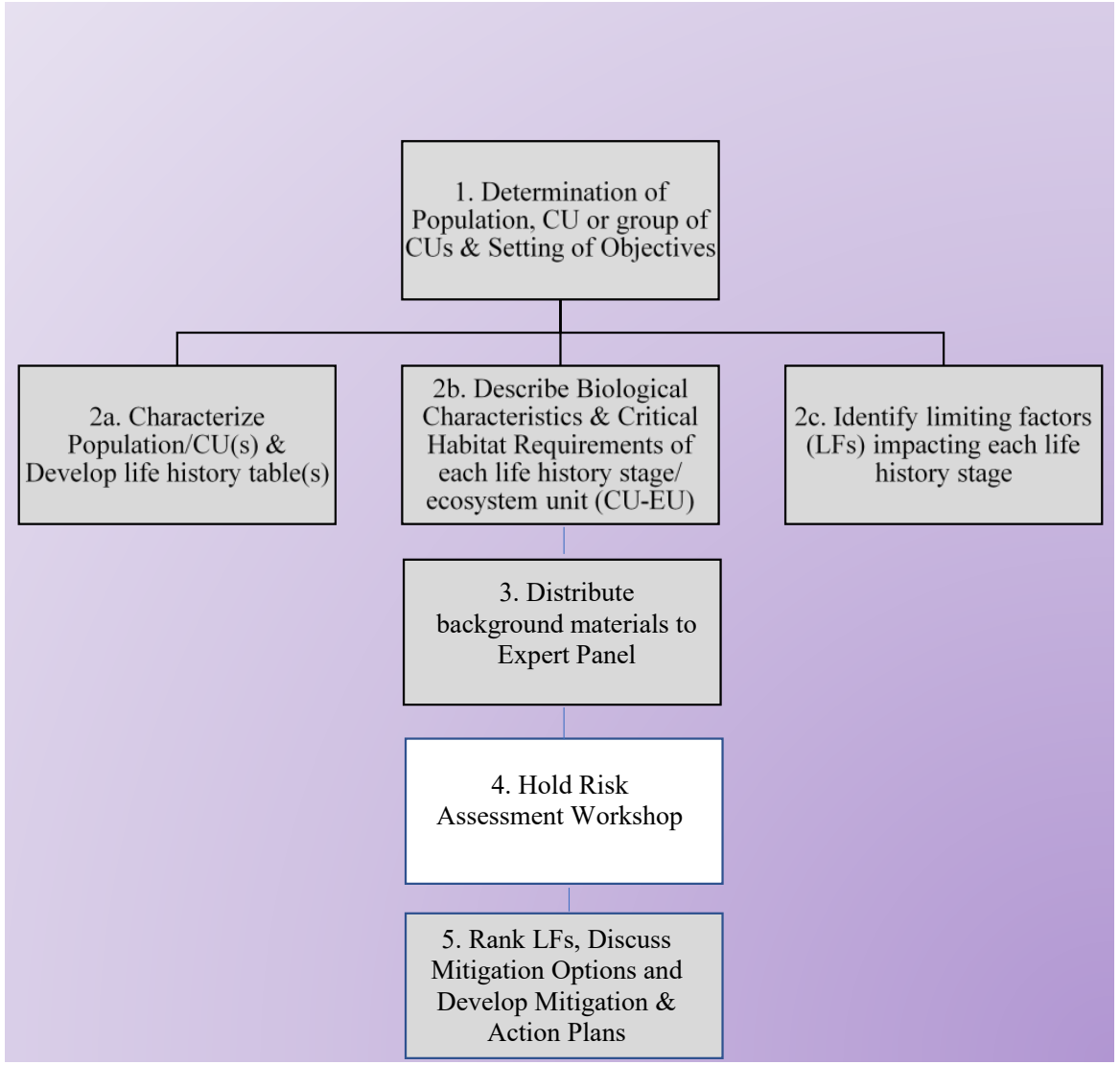
- What is RAMS?
  - A method designed to determine and prioritize the factors limiting the productive capacity of Pacific Salmon populations/stocks/CUs/MUs
- How?
  - A process based on Vision/goals -> Status -> Limiting Factors -> Options -> Action Plans ->Strategic Plans
  - Integrating expertise from stock and habitat specialists with LEK/IK to achieve consensus on risks and actions
  - Simple, scalable, adaptive, precautionary and repeatable process

HOW TO VIEW RISK

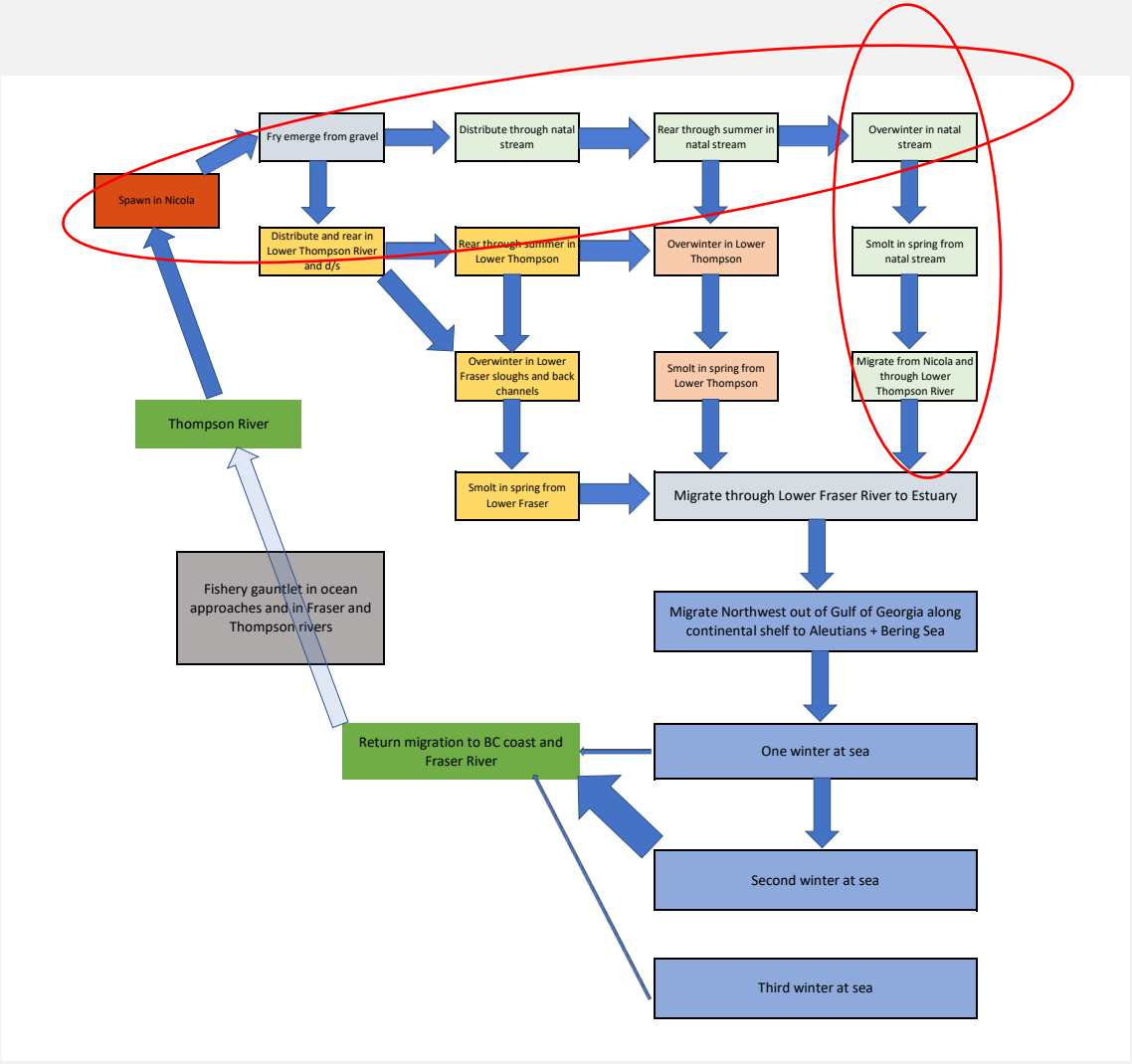
- Stock specialists focus on salmon stocks
- Habitat specialists focus on habitat indicators
- RAMS focus on salmon interactions with critical habitat
- SARA focus on threats



RAMS PROCESS SIMPLIFIED



SCOPE OF RAMS FOCUS



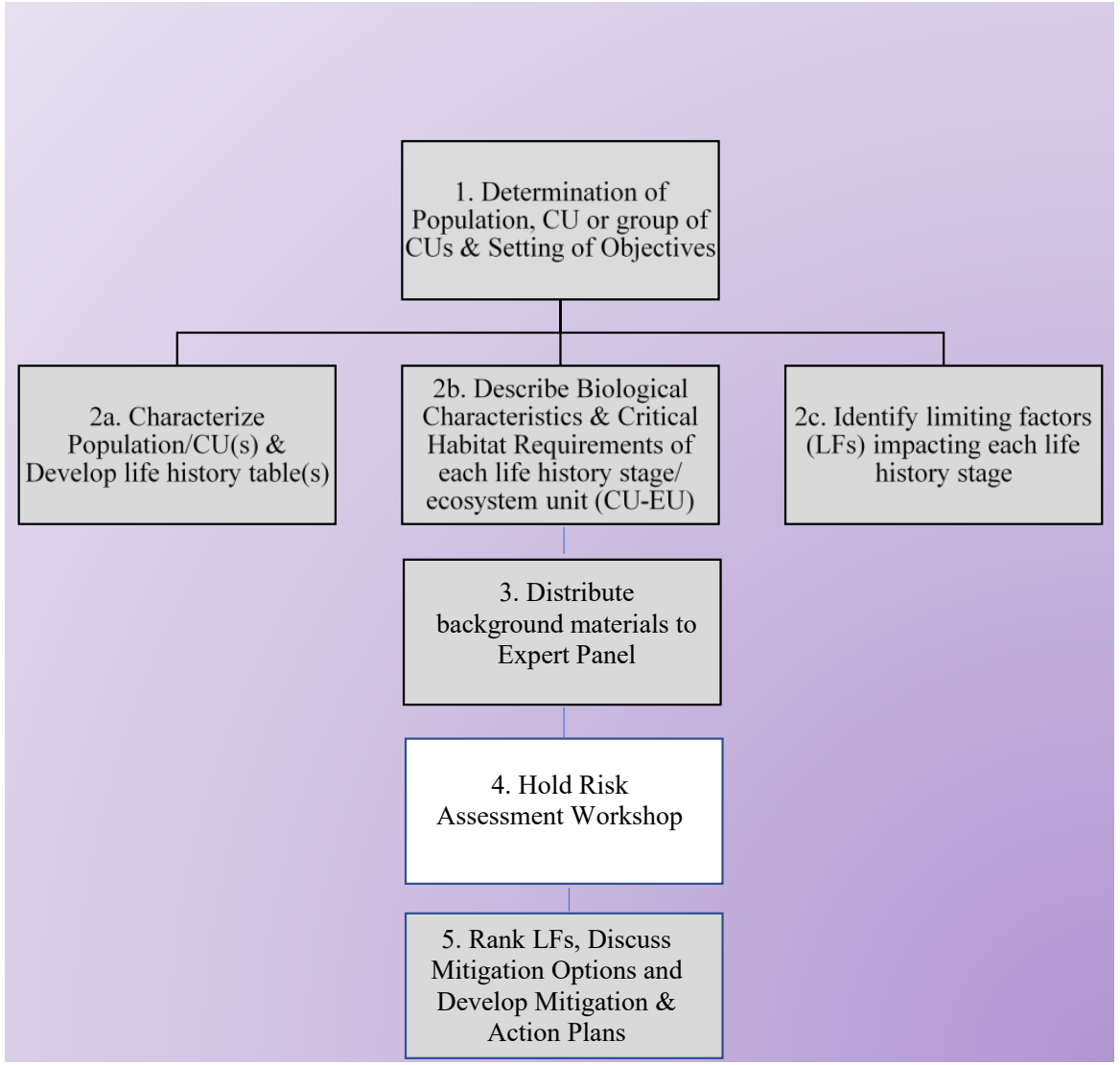
RAMS 1: Nicola Basin Chinook

- Terminal migration & spawning
- Incubation
- Freshwater Rearing

RAMS 2: Thompson

RAMS 3: Lower Fraser

RAMS PROCESS SIMPLIFIED



STOCK CHARACTERIZATION- RICHARD BAILEY

NICOLA BASIN RAMS

Chinook Stocks, Life Histories

&

Stock Assessment Information

Richard Bailey

RAMS USES A LIFE CYCLE MODEL TO ASSESS BENEFIT OF REDUCING MORTALITY AT EACH LIFE STAGE

time period	life stage	Chinook	Mortality	Potential limiting factors
March - July	terminal return	500	10.0%	LF1: estuary predation
April - July	upstream migration		3.0%	LF2: delay or limited access; LF3: obstructions; LF4: aggradation; LF5: loss of habitat
April - July	upstream migration		1.0%	LF6: high temp; LF7: water quality
May - June	upstream migration		7.0%	LF8: illegal fishing
Sept - Oct	Spawning		8.0%	LF9: habitat quality; LF10: Disturbance; LF11: disease
Sept - Oct	Spawning	350	1.0%	LF12: spawner predation
Oct - Feb	egg incubation	700,000	33.7%	LF13: sediment; LF14: early emergence; LF15: dewater redds; LF16: scour
Oct - Feb	egg incubation		8.0%	LF18: overspawn; LF19: natural egg predation
Oct - Feb	egg incubation		0.0%	LF20: redd disturbance (non-human); LF21: redd disturbance (human)
Feb - July	early rearing		12.0%	LF22: water quality; LF23: instream complexity; LF24: low water; LF25: high water
Feb - July	early rearing		18.0%	LF26: lack of food; LF27: competition - invasive species; LF28: competition - native species; LF29: predation
Feb - July	early rearing		5.0%	LF30: disturbance; LF30.5: Aquifer drawdowns
Feb - July	early rearing		2.0%	LF31: disease
Feb - July	early rearing	114,450	5.0%	LF32: hatchery introgression
April - July	estuary rearing		25.0%	LF33: lack of food; LF34: predation; LF35: competition/predation from exotics
April - July	estuary rearing		25.0%	LF37A-C: foreshore, intertidal and subtidal habitat;
April - July	estuary rearing	56,081	1.0%	LF38: industrial affects; LF39: disturbance
Aug - Year 2	early ocean rearing		25.0%	LF40: lack of food; LF41: water quality
Aug - Year 2	early ocean rearing	2,289	22.0%	LF42: competition; LF43: nearshore predation
Year 2 - 4	Ocean rearing		0.7%	LF44: offshore predation; LF45: competition with invasives
Year 2 - 4	Ocean rearing	801	0.6%	LF46: offshore habitat; LF47: pollutants; LF48: disease; LF49: harmful algae blooms
Year 2 - 4	Ocean rearing	500	37.6%	LF50: fishing
	Terminal return	500		
	Rate of Change	0.0%		

Assess biological impact by eliminating or reducing that source of mortality.

HABITAT CHARACTERIZATION- TOM WILLMS

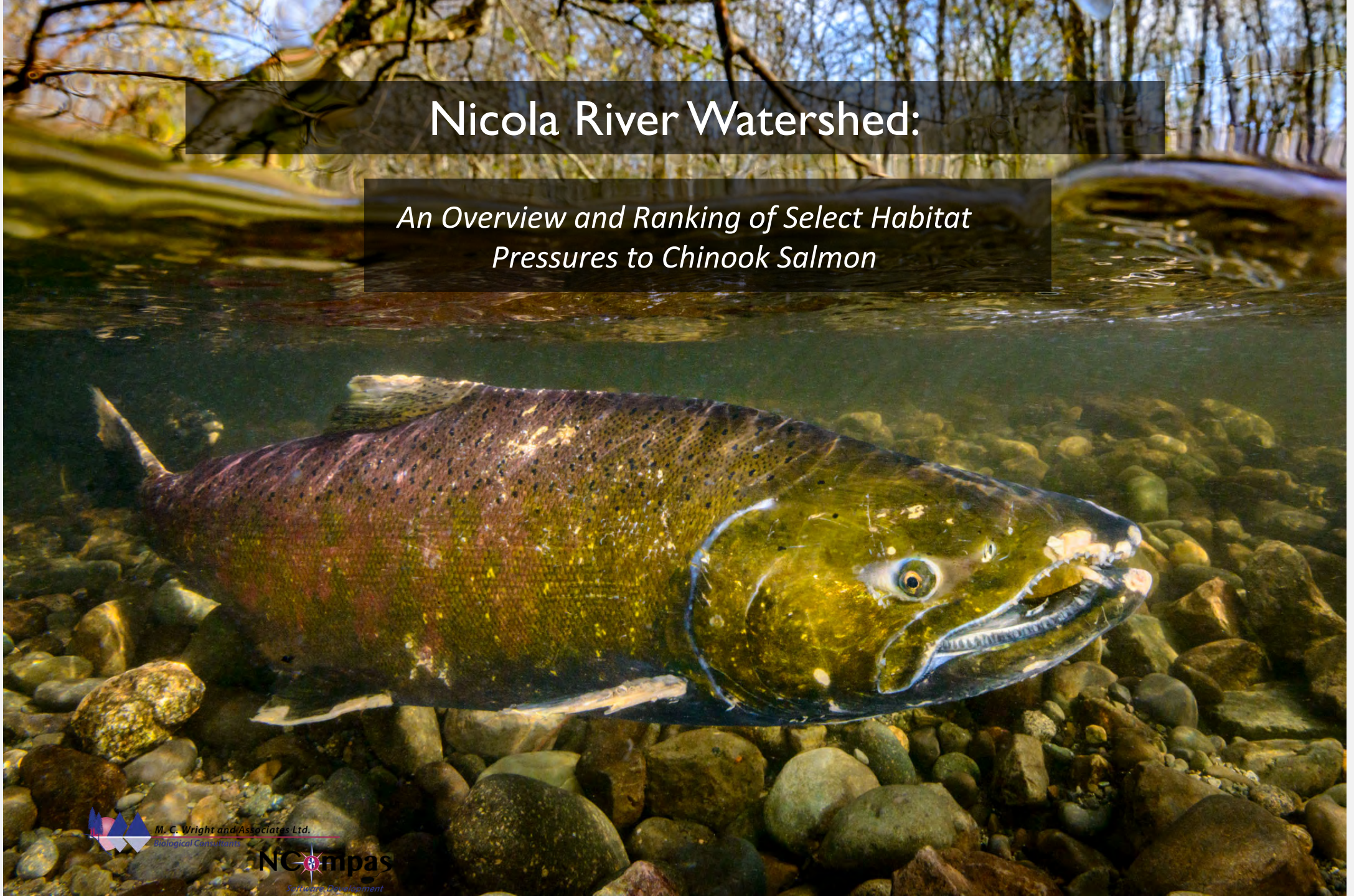
HABITAT PRESSURE AND STATE INDICATORS

Indicators collated from Smith et al. (2016)
Stream & Lake Pressure Indicators

Indicator	Why is it important?	How to obtain	How to calculate	Benchmarks
Land Cover Alterations	Total land cover alteration captures potential changes in cumulative watershed processes such as peak hydrologic flows and sediment generation that can affect downstream spawning and rearing habitats. Alterations can be categorized by agriculture, urbanization, forestry, fire disturbance, mining activity, and road development.	Watershed statistics can be obtained from DataBC Baseline Thematic Mapping (BTM), Vegetation Resource Index (VRI), Freshwater Atlas (FWA) Wetlands, RESULTS Openings, Historical Fire Polygons, forest age layers, Google Earth, orthophotos or satellite imagery e.g. Esri DigitalGlobe Vivid 2016 satellite imagery.	Metric is percent by land use.	The total area of land cover alteration in the watershed can be used to assess the risk to the watershed posed by this pressure indicator. This can be done comparing watersheds/ systems as having high, medium or low levels of land cover alterations.
Watershed Road Development	Watershed road density is positively correlated with land-use within a watershed, and is an indicator of overall watershed development. Road construction in a watershed may increase fine sediment deposition into streams and lakes, reduce aquatic invertebrate diversity, affect aquatic connectivity, and channel morphology (Tschaplinski, 2010; Brown et al, 2013).	GIS layers can be obtained from the LDRW, local forestry companies, e.g. the Digital Road Atlas layer; Forest Tenure roads; satellite imagery of the CU/watersheds such as Esri DigitalGlobe Vivid 2016; high resolution orthophotographs.	Road development densities can be determined by dividing the total length of roads in each watershed by the watershed area. Thus the metric is road density in km/km^2	Stalberg et al. (2009) suggested the following benchmarks: <0.4 km/km^2= lower risk >0.4 km/km^2 = higher risk
Stream Crossing Density	Stream crossings have the potential to impede fish passage through interfering with or blocking access to upstream spawning or rearing habitats (and therefore reducing the total amount of habitat salmonid habitat in a watershed (Harper and Quigley, 2000)). These crossings have also been known to increase sediment delivery to streams through the provision of direct pathways to aquatic habitats (Brown et al, 2013).	Stream crossing information may be obtained from the Provincial Stream Crossing Inventory System (PSCIS). Stream and lakes may be mapped using the DataBC "TRIM Stream Lines - 1:5,000" and "Freshwater Atlas Lakes" layers.	Stream crossing density can be calculated for each sub-basin /watershed by dividing the total number of crossings present in each sub-basin/watershed by the sub-basin/watershed area.	Watershed stream crossings density can be compared among watersheds/basins/sub-basins

Nicola River Watershed:

An Overview and Ranking of Select Habitat Pressures to Chinook Salmon

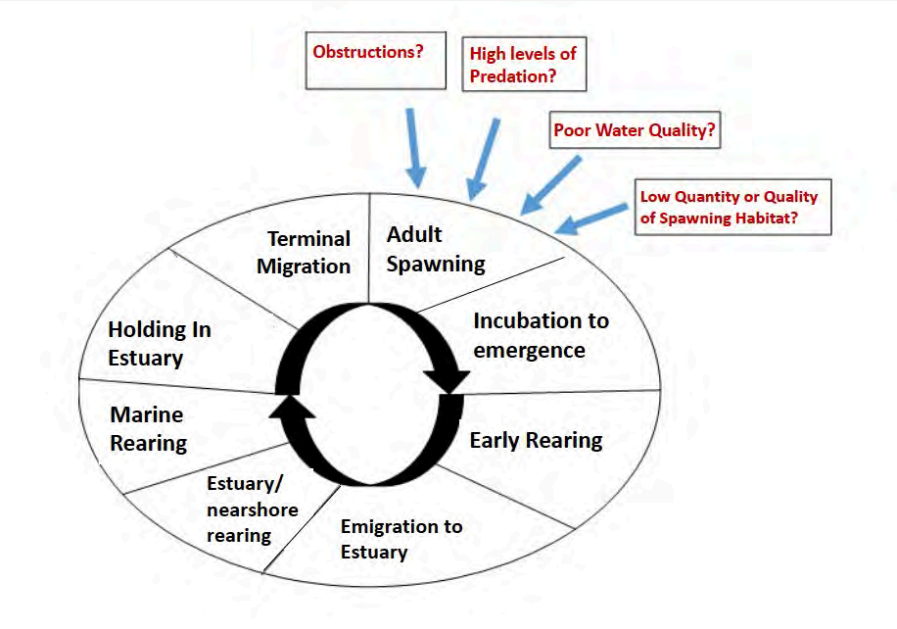


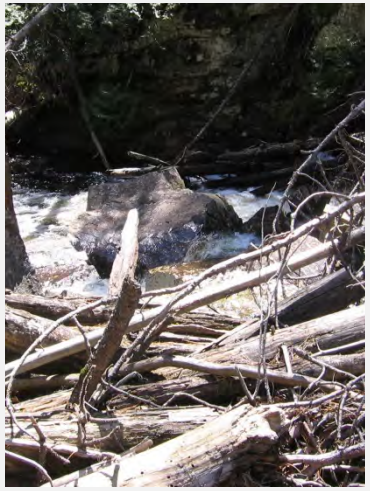
M. C. Wright and Associates Ltd.
Biological Consultants

NCompas
Syntactic Development

WHAT ARE LIMITING FACTORS?

- Alternative hypotheses for losses of productivity and capacity resulting in declines
- LFs impact critical habitat and different life history stages of Pacific salmon





CRITICAL HABITAT REQUIREMENTS & LIMITING FACTORS TABLES

INFORMATION TABLES FOR CRITICAL HABITAT REQUIREMENTS, GENERIC LIMITING FACTORS, BENCHMARKS AND INDICATORS FOR NICOLA STREAM TYPE CHINOOK SALMON

Stream type Chinook

ADULT TERMINAL MIGRATION & SPAWNING * NOTE, EACH INFORMATION TABLE IS FOLLOWED BY A COPY OF THE SAME TABLE BUT WITH SPECIFIC INFORMATION FOR THE SYSTEMS IMPORTANT TO CHINOOK WITHIN THE NICOLA WATERSHED

Critical Habitat Requirements	Limiting Factors	Factors Affecting Habitat Features	Benchmarks	Potential Indicators	Details
1. Safe holding habitat in confluence of Thompson-Nicola prior to upriver migration into the Nicola River	**LF1**: Unsanctioned fisheries in the confluence of Thompson- Nicola	-Lack of suitable holding habitat -Lack of riparian cover -Low water levels allowing easy access to migrating fish -High water temperatures delaying migration -Lack of escape habitat -Lighting -Poaching, lack of monitoring and enforcement	-Hicks (2002) suggested that barriers to migration exist for Chinook salmon when maximum daily water temperatures are greater than 21-22°C	-Area of habitat -Riparian cover -Water temperatures & flows -Presence of poachers	-Chinook may wait for ideal temperature or flow levels before entering into a system to start their freshwater migration- thus warming waters or low water depths may cause delays and increase ability for fishers to catch adults. Therefore, this factor is linked to LF2 and 3.
2. Adequate flows to facilitate upstream passage of spawners	**LF2:** Limited or delayed spawner access	-Lack of storage -Drought conditions -Water diversion for industrial, domestic, resource development e.g. logging -Reservoir operation -Sediment aggradation reduces	-Maximum sustained current velocity for adult upstream migration is 240 cm/s. (Thompson, 1972 in Allen and Hassler 1986). -Obstacle current maximum during adult upstream migration is 610 cm/s (Weaver, 1963 in Allen and Hassler, 1986). -Observed spawning at velocities ranging from 30 -76 cm/s (Briggs, 1953 in Healey, 1991). Observed Chinook spawning at velocities ranging from 37 to 189 cm/s and averaging over 100 cm/s (Chapman et	-Discharge (cms) -Water withdrawals -Road density -Level of discharge in cms -Density of road crossings -Volume of water extraction -Land alteration	-Drought conditions and low river water levels can result in slowed migration rates, leaving fish vulnerable to predation/poaching etc. as well as increased pre-spawn mortality.

ADULT TERMINAL MIGRATION & SPAWNING

NOTES FOR NICOLA

Critical Habitat Requirements	Limiting Factors	Potential Indicators	Nicola, Spius, Guichon, Clapperton, Coldwater, Spahomin
1. Safe holding habitat in confluence of Thompson-Nicola prior to upriver migration into the Nicola River	**LF1**: Unsanctioned fisheries in the confluence of Thompson-Nicola	-Area of estuarine habitat -Riparian cover -Water temperatures & flows -Presence of poachers	For Nicola- the "estuary" is the confluence of the Thompson and Nicola Rivers.
2. Adequate flows to facilitate upstream passage of spawners	**LF2:** Limited or delayed spawner access	-Discharge (cms) -Water withdrawals -Road density -Year and level of discharge < __x__ cms between fall and spring (may vary by system) -Density of road crossings -Volume of water extraction -Land alteration	- In the Nicola, climate change is having a very significant effect on the precipitation patterns and hydrology in the Nicola Watershed leading to drier and more prolonged periods of low flows through the summer and winter in some years. -There are low flows in April, and low summertime and fall flows that affect Chinook. Migration barriers can occur on both the mainstem and tributaries because of low flows through fall- pulses of water are required to mitigate this issue. -Attraction flows for Chinook migration in Aug to early Sept in the mainstem require adequate cold water to be effective. -Flows in this region have been impacted by forest harvesting and mountain pine beetle (MPB) is an added concern: decreases in forest cover due to MPB results in more snow accumulation in dead forests, and in clearcut areas. -Earlier snowmelt leads to increased, faster and earlier runoff, which is also less synchronized at different elevations - During typical drought periods (1 in 10 year event), every sub-basin in the Nicola Watershed has a water deficit through the summer and fall (July to October) and therefore there is insufficient water to meet irrigation and instream flow requirements even when dam storage is factored in. -Upstream migration is likely fine as long as flows >4cms but there are times when mainstem passage can be compromised by low flow Issue is much more temperature, except in upper Nicola, lower Coldwater and lower Spius (R Bailey pers. comm) -The Nicola River hydrograph exhibits a pattern typical of snow-dominated regimes. Peak flows are experienced in late April – early May. -Fall flooding, characteristic of rain-dominated hydrographs of coastal BC, have historically been minimal but risk of flooding is much higher now as a result of MPB salvage harvesting which has resulted in elevated Equivalent Clearcut Area (ECA) and harvesting adjacent to streams in higher elevation Sub-basins, Basins and Watersheds (Lewis 2016) -Key flow information from Warkentin et al. (2020) for the Nicola Watershed (as related to habitat):

INCUBATION

Critical Habitat Requirements	Limiting Factors	Factors Affecting Habitat Features	Benchmarks	Potential Indicators	Details
1.Good water quality conditions	**LF17a:** High suspended sediment loads that reduce egg to fry survival and emergence of alevins **LF17b:** Non-optimal water temperatures that reduce fry survival by changing emergence time in relation to food availability **LF17c:** High levels of pollutants or toxins that reduce egg to fry survival **LF17d:** Low DO which reduces egg to fry survival	-Riverside development and natural erosion -Unstable and eroding channel banks that release fine sediments -Logging, landslides -Lack of riparian cover -Climate change -Industrial and human development	-TSS < 25_mg/L in 24 hrs when background is ≤ 25 mg/L (Stalberg et al., 2009) at established sampling sites in the middle and lower reaches of the mainstem -Target WQ parameters: DO: 5-9 mg/L. Egg mortality increases rapidly at DO concentrations below 13 ppm averaging 3.9% at 13 ppm and 37.9% at less than 5 ppm (Gangmark and Bakkala ,1960 in Healey, 1991). As percent saturation decreases during incubation, growth decreases and abnormalities and mortality increase. Lower lethal limit = 1.6 mg/l (Silver *et al.*, 1963 in Allen and Hassler, 1986). The lower limit of DO concentration for developing embryos is 2.5 mg/l at temperatures less than 7 °C; optimal levels are greater than 8 mg/l at temperatures between 7 and 10 °C and greater than 12 mg/l at temperatures over 10 °C (Raleigh *et al.*, 1986). -Minimum requirements of dissolved oxygen for eyed or hatched fish eggs from October to May (minimum of 11.2 mg/L), and alevins or juvenile fish from June to September (minimum of 8.0mg/L) (Obee, 2011). As percent saturation decreases during incubation, growth decreases and abnormalities and mortality increase. Lower lethal limit = 1.6 mg/l. -Temperature range for the incubation of Chinook eggs is from 4.5 to 12.8 °C.	-Total suspended solids during high flows -Depth of fine substrates over redds -Linear measure of eroding silt banks -% Egg to emergent fry survival -mg/L of DO -Water temperatures at emergence - Permitted waste management discharges -Level of intact riparian area -Road density -Water chemistry	-Pacific salmon eggs have a high surface area to volume ratio so are sensitive to reduced oxygen levels -Incubation temperatures outside the ideal range can cause hatching and emergent times that reduce survival. -In extreme cases, freezing of redds can result in the loss of all eggs in the affected areas. Although Chinook eggs and alevins can withstand a wide fluctuation in temperature, decreased survival and impaired development occurs at incubation temperatures below 5.0 °C and above 15 °C. -Healthy riparian vegetation helps moderate extreme high and low temperatures.

INCUBATION

Critical Habitat Requirements	Limiting Factors	Potential Indicators	Nicola, Spius, Guichon, Clapperton, Coldwater, Spahomin
1.Good water quality conditions	**LF17a:** High suspended sediment loads that reduce egg to fry survival and emergence of alevins **LF17b:** Non-optimal water temperatures that reduce fry survival by changing emergence time in relation to food availability **LF17c:** High levels of pollutants or toxins that reduce egg to fry survival **LF17d:** Low DO which reduces egg	-Total suspended solids during high flows -Depth of fine substrates over redds -Linear measure of eroding silt banks -% Egg to emergent fry survival -mg/L of DO -Water temperatures at emergence - Permitted waste management discharges -Level of intact riparian area -Road density -Water chemistry	- Spius Creek water temperatures averaged 3-5 degrees C less than at the lower site, but both followed a similar pattern, generally responding to air temperature and precipitation. At upper and lower sites, maximum water temperature coincided with the first major freshet. Water was neutral, soft and clear and the dominant ions were calcium, magnesium, silica and sodium. Levels of hardness and total alkalinity were marginally lower than recommended values for salmonid incubation in June water samples. Conductivity values were lower than recommended levels in all samples. Nutrient levels were generally low; a slight increase in concentration of total phosphate was noted in the May sample. Elevated concentration of suspended solids during peak discharge in May exceeded recommended limits but declined to an acceptable level in June. All other chemical parameters were within recommended limits for intensive culture of salmonids (Scott-Olmsted, 1985). - Coldwater river: Water temperatures at the upper site averaged 0.5=2.0C less than at the lower site, both followed similar pattern, responding to air temperature and precipitation. At both sites, maximum water temperatures were correlated with high maximum air temperatures but not with discharge. Coldwater river was slightly alkaline and turbid. Dominant ions were calcium, magnesium, silica and sodium. Conductivity values were lower than recommended levels in all samples. Nutrient levels were low with the exception of total phosphate in May and June samples (possibly because of agriculture runoff). Suspended solids and aluminum exceeded recommended limits during May and June during increasing discharge. All other chemicals parameters were within recommended limits. (Scott-Olmsted, 1985). - The Nicola River site water was slightly alkaline, well buffered and turbid. Dominant ions were calcium, magnesium, sodium and silica. Nutrient levels were low with the exception of total phosphate which exceeded recommended levels for salmonid culture in may and June (likely due to agriculture). Suspended solids and aluminum levels exceeded recommended limits during peak discharge in May and June. All other chemical parameters were within recommended limits (scott-Olmsted, 1985). - Highest densities of juvenile chinook are found in Reach 2 (Spius Creek to Coldwater River) contributing ~40% of total Niolca River smolt carrying capacity. Reach N! (Thompson River to SPius Creek) contributes another 40%. Other reaches may be limited by high summer water temperatures, particularly in August (Kosakoski and Hamilton, 1982).

EARLY REARING

Critical Habitat Requirements	Limiting Factors	Factors Affecting Habitat Features	Benchmarks	Possible Indicators	Details
1.Suitable water temperature, TSS, dissolved oxygen levels, pH, hardness, supersaturation	**LF25:** a) High water temperature combined with low DO in the lower mainstem river and off channel areas can suffocate fry or reduce overall fitness during the early summer/fall b) High water temperature in the mainstem and off channel areas **LF 26:** Toxic water quality conditions can increase fry mortality or reduce fitness.	-Industrial development, waste discharge, spills, input from sewage, septic systems and agriculture -Bank erosion and suspended sediment loads can be exacerbated by forestry, rural land clearing and urban development -Air temperature, nitrogen and pH levels, municipal/ domestic sewage discharge, agricultural activities, urban development, effluent from fish hatchery operations throughout the watershed -Climate change -Acid Rain	-Target WQ parameters: DO: 5-9 mg/L, water Temp: Rearing: 15C (Richter and Kolmes, 2005). Chinook upper optimum temp (UOTR) is 14C, Impairment Temp (IT) is 20 C. -Positive growth of juveniles occurs between 4.5 and 19.1°C, maximum growth occurs at 14.8°C, distribution is limited >22C and upper lethal limit occurs when temperatures >25.1°C (McCullough, 1999). -Observed temperature range for juvenile Chinook is from 0 to 24°C with an optimal range of from 12 to 18 °C (Raleigh *et al.*, 1986). -Sedimentation: Levels of 509 to 1217 ppm are fatal to juveniles. Levels of 500 ppm result in stress responses. Levels of 100 to 300 ppm result in reduced feeding. -Suspended sediment levels of 100-300 ppm result in reduced feeding of juveniles, level of 500 ppm result in stress response in juveniles and levels >500 ppm are fatal to juveniles (Lloyd, 1987). -The BC generalized depth and velocity habitat suitability index curves for Chinook suggest optimum Chinook stream rearing habitats would have depths ≥ 18 cm and velocities ranging from 15–50 cm/s (Burt, 2006). -Davis (1975) noted that fry/juveniles function without impairment at DO levels of 7.75 mg/l, show initial oxygen distress at 6.00 mg/l, and widespread impairment	-Water quality monitoring that includes water temperature, DO levels and suspended sediment levels. - Permitted waste management discharges -% watershed altered by development type, road density	-Once hatched, alevins are sensitive to dissolved oxygen and carbon dioxide concentrations. They will migrate towards adequate DO levels if necessary (>6 mg/L). As well, a buildup of CO_2 around an alevin induced "ventilation" swimming to circulate more water and dissipate the CO_2 (Barnes, 1969 in Quinn, 2005). -Conversely, some water turbidity as a result of sediment may be beneficial due to reduced visibility of the juveniles to predators -Road density results in greater sedimentation

EARLY REARING

Critical Habitat Requirements	Limiting Factors	Possible Indicators	Nicola, Spius, Guichon, Clapperton, Coldwater, Spahomin
1.Suitable water temperature, TSS, dissolved oxygen levels, pH, hardness, supersaturation	**LF25:** a) High water temperature combined with low DO in the lower mainstem river and off channel areas can suffocate fry or reduce overall fitness during the early summer/fall b) High water temperature in the mainstem and off channel areas **LF 26:** Toxic water quality conditions can increase fry mortality or reduce fitness.	-Water quality monitoring that includes water temperature, DO levels and suspended sediment levels. - Permitted waste management discharges -% watershed altered by development type, road density	-There has been considerable loss of riparian vegetation along the Nicola River, which has reduced stream shading and resulted in warmer stream temperatures during summer. Additional thermal stresses are imposed due to flows being reduced by water withdrawals for irrigation and other land use practices, resulting in greater daily temperature variations (Walthers and Nener 1997). Also, frequent destabilization of stream banks has resulted in wider channels and shallower waters being more susceptible to warming during summer. Studies by Walthers and Nener (1997) suggest that salmonid production in both the Nicola and Coldwater rivers are constrained by relatively high water temperatures, with the distribution of fish influenced by local variations in water temperatures as fish tend to seek cooler areas with groundwater inflows, shade, and other features. -Warkentin (2020) found that steam locations with larger upstream catchment areas had higher maximum temperatures as well as greater climate sensitivity to air temperatures. Sites with more riparian vegetation cover had lower climate sensitivity. Streams with 100% riparian forest cover had maximum temps ~1.2°C lower than streams without riparian cover. Many smaller tributaries contribute cool water to the mainstem in the warmest days of summer and are less sensitive to warm regional air temperatures. -During summer 2015, the Nicola Basin experienced severe drought conditions following a winter with low record snowpack and low precipitation and high temperatures in spring and summer. Discharge in Coldwater River fell below the Theoretical Critical Level (TCL) for juvenile salmon triggering a fish protection order (limited/banned surface withdrawals) (Schick et al., 2016) - Study looked at long term juvenile abundance data and examined to what extent in annual summer drought intensity (measured by discharge/temperature) explains juvenile chinook abundance given the influence of stock size (brood spawners). No one index of summer drought or winter flow explained any more of the variation in juvenile abundance than any other. Data had limited number years in the stock-recruitment time series, making it difficult to draw statistical conclusions.
2.Adequate food supply	**LF27:** Mortality or fitness impacts as a	-Abundance and composition of drifting and	- Nicola Dam has attenuated high peak flows over a longer time- so high flows during freshet have increased. This has led to increased erosion and turbidity that may decrease aquatic productivity downstream. -In general, however, these systems are productive, not like coastal rivers. The Nicola is also eutrophied by treated sewge and agricultural runoff (R. Bailey, pers.comm)

NICOLA BACKGROUNDER

NICOLA WATERSHED: BACKGROUNDER FOR RISK ASSESSMENT

Photograph By WIKIMEDIA CREATIVE COMMONS

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 upcoming RAMS workshop is to solicit input on the limiting factors that may affect Nicola Basin Chinook freshwater survival and to determine their relative impacts on production as well as identifying where critical knowledge gaps occur. Nicola Basin Chinook includes Chinook in the Nicola River, Spius Creek, Coldwater Creek and the upper Nicola-Spahomin Creek populations. Ranking of the factors posing the highest risk to current productivity of Nicola Basin 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 Chinook of the Nicola Basin through remediation, restoration and/or conservation.

BACKGROUND:

The Nicola River is a tributary of the Thompson River and is a sixth order stream located in the interior of southern British Columbia (Figure 1). The entire Nicola watershed covers an area of 7211 km², with the mainstem approximately 188.5 km in length (MOE 2021). The Nicola River produces early-run Chinook, Coho, and steelhead to the Thompson and Fraser River. Important tributaries to the Nicola for salmonids include the Coldwater River and Spius, Maka, Spahomin, Quilchena, Clapperton and Guichon creeks. The Coldwater River is the largest tributary, draining an area of 914km and is the most important stream for Coho and early-run Chinook, as well as steelhead in the Nicola watershed.

Nicola Lake is the largest lake in the watershed (area 2,500 hectares), with its outlet controlled by a dam for irrigation purposes. The majority of salmonid production occurs downstream of Nicola Lake; although there is potential for production upstream, it is seasonally sporadic due to insufficient water during summer.

Historically, the Nicola River was an important contributor to interior Fraser River salmon production. However, current salmon escapement to the Nicola system is depressed: Interior Fraser River Coho stocks were COSEWIC listed in 2002, a designation which prompted the need for immediate recovery goals to be established by the Interior Fraser Coho Recovery Team (DFO 2006)[1]. In addition, Bull Trout are listed as a Species of Concern by British Columbia Conservation Data Centre; and Nicola River steelhead, which are an important component of the Thompson River stocks, are regarded as an extreme conservation concern by the Ministry of Environment (MOE).

Figure 1. A map of the Nicola Valley showing sub basins (blue), First Nation communities, parks and municipalities. From the Nicola Watershed Characterization report (ESSA Technologies Ltd. and Fraser Basin Council 2019)

Nicola Basin Climate & Vegetation:

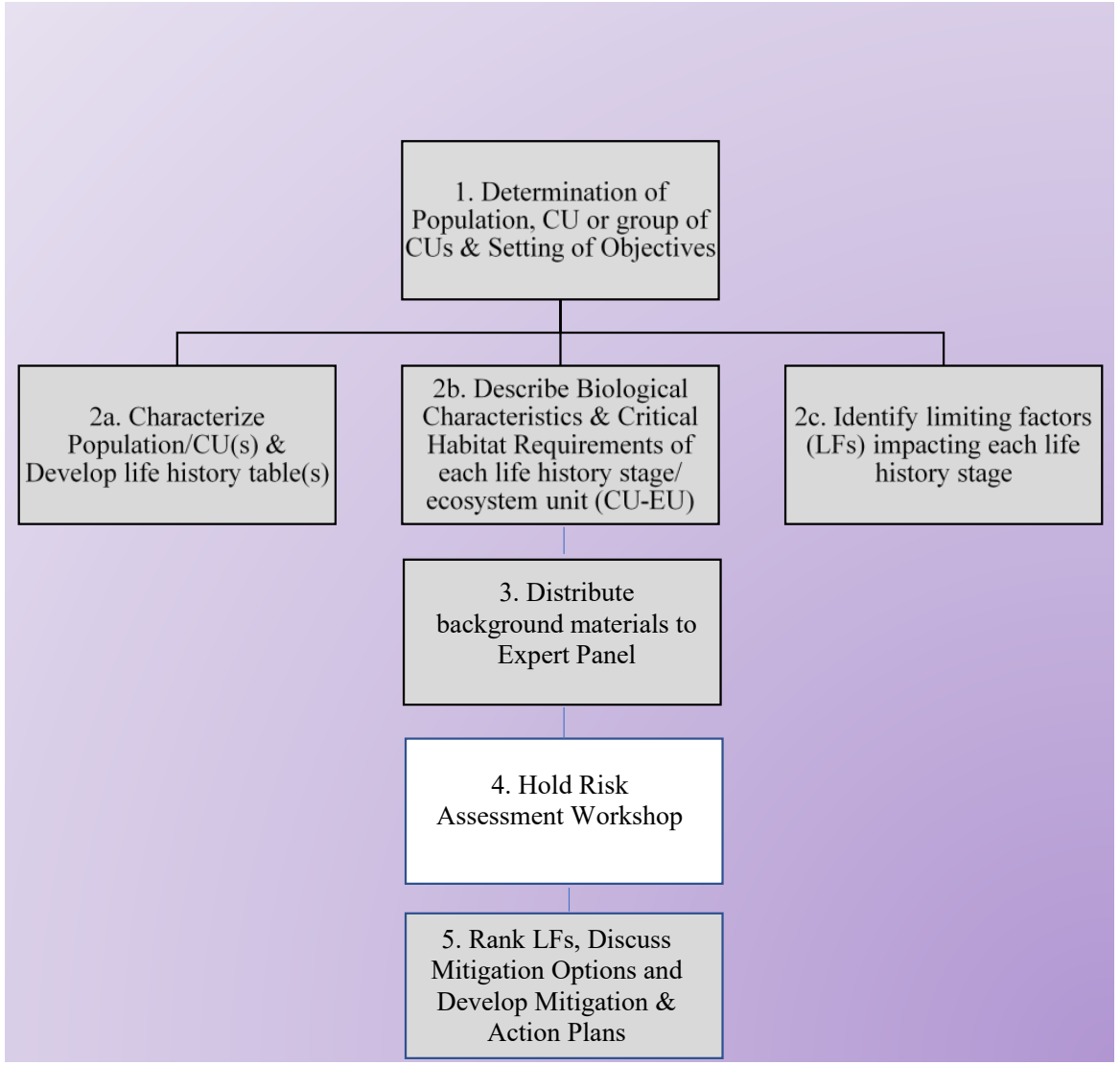
Elevations in the Nicola Basin vary from approx 230 m at the Thompson confluence to 2,300 m near the Pennask Lake summit, resulting in a broad range of microclimates in this watershed. Most of the region is very arid, with very hot summers though the high altitude in this area results in cooler winters than in the surrounding basins. The entire basin also receives less rainfall than nearby areas, as it is in a rain shadow. The basin is also associated with three major valley surficial aquifers (Guichon, Coldwater and Nicola Valley) which provide base flows for the rivers.

Low elevation areas on the lee side of the Cascade Mountains are dry (precipitation between 200 to 300 mm per annum) with hot summers and cool winters, whereas higher elevations are relatively wet (upwards of 400 mm per annum) and cool in all seasons. Plateau areas have hot summers and cool winters, while valleys have daytime temperatures of more than 16°C for five months of the year and periods of hot weather with temperatures in excess of 32°C are frequent during July and August. This usually corresponds with low rainfall, high evaporation rates, and low river flows that places stress on the natural riverine ecology and on agricultural crops due to large moisture deficits. Occasionally in winter, Arctic air enters the area bringing clear skies and cold temperatures, sometimes as low as -35°C. Frost free periods range between 110-120 days in the Nicola Valley while growing degree days vary between 1500 and 1700. In the higher lying areas and in the Coldwater River Valley these values are about 10 to 20 percent lower.

Snow depths increase with elevation and have a significant influence on the potential supply of water in the Nicola River Basin. The hydrograph for the Nicola, Coldwater, and Spius Creek are all driven by snowmelt. Generally, the largest snowpacks and therefore water yields occur in the Spius Creek and Coldwater River, draining the Cascade Mountains. Lesser snowpacks occur in the Guichon , Clapperton and Upper Nicola sub-

[1] Interior Fraser Coho Recovery Team. 2006. Conservation Strategy for Coho salmon (*Oncorhynchus kisutch*), Interior Fraser River populations. Fisheries and Oceans Canada

RAMS PROCESS SIMPLIFIED



NICOLA CHINOOK LIMITING FACTORS RISK ASSESSMENT SCORING PROCEDURE

Isobel A. Pearsall

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STRAW DOG SCORING

- Tom Willms, Richard Bailey, Kyle Wilson, Paul Mozin, Rich McCleary, Chuck Parken, Nicole Trouton & Kaitlyn Dionne, Mike Simpson

- First cut
  - Scores
  - Discussion
  - Key gaps
  - Action items

- Adult: 18LF- 1H & 1M
- Incubation: 12LF- 2H & 2M
- Freshwater Rearing: 20LF- 4VH, 1H & 7M

ADULT MIGRATION & SPAWNING

			NICOLA BASIN CHINOOK												
			IDENTIFIED RISKS. These factors will affect the productive capacity of spring chinook salmon in the Nanaimo Watershed.			CONSENSUS RISK SCORES. For each limiting factor these scores are a result of discussion between experts.					OVERALL BIOLOGICAL RISK.		FUTURE OUTLOOK. Biological risk with climate change.		
Ecosystem Unit:	Life History Phase:	Life History category	Life History Requirement - Critical Habitat	Sort order by LF	Issue or Limiting factor	SPATIAL SCALE What % of the critical habitat is affected? (1 low to 5 high)	TEMPORAL SCALE how often in 10 years will this happen? (1 rarely to 5 frequent)	IMPACT What will be the change in returning adults? 1=low to 5=high	CONFIDENCE How much confidence do you have in this scoring? L=low, M=medium, H=very	Current Biological Risk category	Likelihood score based on both spatial and temporal... 1=not likely to 5=very likely	Current Biological Risk Category (numerical)= likelihood x impact. 1=low to	Current Trend 1=decrease 5=signif increase	Future trend (over the next 50 years). 1= decreasing 5= significant increase	Future Biological Risk Category
TERMINAL MIGRATION AND SPAWNING															
	adult	terminal adult migration and spawning	**Clear and safe passage with adequate refuge habitat**	6	LF6: Loss of good quality refuge habitat and safe migration route through the river due to channelization,	5	5	3	L	High			4	4	Very High
	adult	terminal adult migration and spawning	**Suitable water quality**	7	LF7: High water temperatures in the river during the late summer/early fall migration period can increase migration mortality and sublethal stress	5	5	2	H	Moderate			5	5	Very High
	adult	terminal adult migration and spawning	**Low levels of predation during migration and spawning**	13b	LF13b: Mortality due to unsanctioned fisheries during migration and at spawning grounds	5	5	2	M	Moderate			5	4	High
	adult	terminal adult migration and spawning	**Lack of anthropogenic disturbance**	14a	LF14a: Disturbance to natural migration activity due to anthropogenic restoration impacts	5	3	2	M	Moderate			3	3	Moderate
Thompson-Nicola Confluence	adult	terminal adult migration and spawning	**Safe holding habitat at confluence of Thompson-Nicola**	1	LF1: Unsanctioned fisheries in the confluence of Thompson-Nicola	3	5	2	L	Low			4	5	High
	adult	terminal adult migration and spawning	**Low levels of predation during migration and spawning**	13a	LF13: Mortality due to predation at spawning grounds	5	5	1	L	Low			5	4	Moderate
	adult	terminal adult migration and spawning	**Lack of disease during migration and spawning**	15	LF15: Sublethal impacts due to disease	2	5	2	L	Low			5	4	Moderate
	adult	terminal adult migration and spawning	**Adequate flows to facilitate upstream passage of spawners**	2	LF2: Limited or delayed spawner access	2	2	1	M	Very Low			4	5	Moderate
	adult	terminal adult migration and spawning	**Availability of high quality and sufficient quantity spawning habitat**	10	LF10: High suspended sediment loads can reduce spawning habitat quality by compacting gravel and reducing interstices critical for egg deposition and incubation	2	2	1	L	Very Low			4	5	Moderate
	adult	terminal adult migration and spawning	**Lack of anthropogenic disturbance**	14b	LF14b: Disturbance to natural spawning activity due to anthropogenic impacts	2	2	2	M	Very Low			5	5	Moderate
	adult	terminal adult migration and spawning	**Dynamic equilibrium in channel morphology, maintenance of channel capacity, adequate channel depths and natural level of sediment transport.**	5	LF5: Aggradation creates a migration barrier in the river during adult migration	5	2	2	L	Very Low			4	4	Low
	adult	terminal adult migration and spawning	**Suitable water quality**	8	LF8: Poor water quality conditions during the late summer/early fall migration					Very Low					Low

FRESHWATER INCUBATION

WATER INCUBATION														
egg - alevin	Freshwater incubation. Egg to fry survival.	**Minimal predation of eggs and alevins**	24	LF24: Predation of eggs, alevins and fry/smolts by fish (sculpins, brown trout) and birds (mergansers)	5	5	3	H	High	3	4	4	Very High
egg - alevin	Freshwater incubation. Egg to fry survival.	**Suitable flow regime**	20	LF20: Lower low flows that dewater redds and reduce incubation survival	5	2	5	M	High	3	3	4	High
egg - alevin	Freshwater incubation. Egg to fry survival.	**Appropriate spawning gravel**	22	LF22: Egg mortality due to inadequate spawning gravel, or as a result of gravel instability	3	2	4	M	Moderate	4	4	4	High
egg - alevin	Freshwater incubation. Egg to fry survival.	**Good water quality conditions**	16	**LF16:** High suspended sediment loads that reduce egg to fry survival and emergence of alevins	3	4	3	M	Moderate	4	3	3	Moderate
egg - alevin	Freshwater incubation. Egg to fry survival.	**Stable flow regime**	21	LF21: More frequent and higher peak flows over winter can scour/disturb redds	4	3	4	M	Moderate	4	3	3	Moderate
egg - alevin	Freshwater incubation. Egg to fry survival.	**Good water quality conditions**	17a	**LF17a:** Increased numbers of ice days resulting in mortality of eggs and alevins	5	2	3	M	Moderate	3	3	3	Very Low
egg - alevin	Freshwater incubation. Egg to fry survival.	**Good water quality conditions**	18	**LF18:** High levels of pollutants or toxins that reduce egg to fry survival	5	3	3	M	Low	3	3	3	Low
egg - alevin	Freshwater incubation. Egg to fry survival.	**Good water quality conditions**	17b	**LF17b:** Non-optimal water temperatures that reduce fry survival by changing emergence time in relation to food availability	3	3	3	L	Very Low	3	3	3	Very Low
egg - alevin	Freshwater incubation. Egg to fry survival.	**Good water quality conditions**	19	**LF19:** Low DO which reduces egg to fry survival	3	3	3	M	Very Low	3	3	3	Very Low
egg - alevin	Freshwater incubation. Egg to fry survival.	**Minimal disturbance to redds**	23	LF23: Reduced egg to fry survival due to churn or other salmonid overspawn	3	3	3	H	Very Low	3	3	3	Very Low
egg - alevin	Freshwater incubation. Egg to fry survival.	**Lack of invasive species**	25	LF25: Egg/alevin mortality due to redd disturbance by invasive or expanding endemic species (e.g. didymo)	5	3	3	M	Very Low	3	3	3	Very Low
egg - alevin	Freshwater incubation. Egg to fry survival.	**Lack of anthropogenic disturbance**	26	LF26: Egg mortality due to redd disturbance by humans	3	3	3	H	Very Low	3	3	3	Very Low

FRESHWATER REARING

FRESHWATER REARING																	
	fry	Freshwater rearing. Fry to smolt.	**Adequate instream complexity and riparian complexity**	32	LF32: Mortality or fitness impacts as a result of inadequate in-stream complexity and riparian complexity	5	5	4	H				3	4			
	fry	Freshwater rearing. Fry to smolt.	**Natural flow regime**	35	LF35: Low flows reduce seasonally available off channel and tributary rearing habitat.	5	5	5	H				4	5			
	fry	Freshwater rearing. Fry to smolt.	**High quality rearing habitat with good instream complexity**	42	LF42: Lack of high quality rearing habitat throughout the river both mainstem and side channels and tributaries	5	5	4	H				5	5			
	fry	Freshwater rearing. Fry to smolt.	**Absence of negative hatchery impacts**	46	LF46: Mortality or fitness impacts as a result of hatchery introgression	5	5	4	H				3	4			
	fry	Freshwater rearing. Fry to smolt.	**Good water quality conditions**	27	**LF27:** High water temperature combined with low DO can suffocate fry or	5	5	3	L	High			4	4			
	fry	Freshwater rearing. Fry to smolt.	**Good water quality conditions**	30	**LF30:** High levels of sedimentation leading to clogging of interstitial spaces and loss of rearing habitat	3	3	3	M	Moderate			4	5			
	fry	Freshwater rearing. Fry to smolt.	**Natural flow regime**	34	LF34: Higher and earlier flows that prematurely displace juveniles downstream and reduce overall fry survival	5	3	2	M	Moderate			5	5			
	fry	Freshwater rearing. Fry to smolt.	**Adequate food supply**	31	LF31: Mortality or fitness impacts as a result of lack of food	4	4	2	L	Moderate			4	4			
	fry	Freshwater rearing. Fry to smolt.	**Adequate water levels and connectivity**	33	LF33: Increased use of low quality OC habitats	3	3	3	L	Moderate			3	4			
	fry	Freshwater rearing. Fry to smolt.	**Low levels of predation to fry**	40	LF40: Mortality as a result of high levels of predation in the river	5	5	2	M	Moderate			4	4			
	fry	Freshwater rearing. Fry to smolt.	**Unrestricted migration and passage: mainstem, off channel and tributary habitat**	43	LF43: Lack of access to historical tributary and off channel habitat.	4	3	3	M	Moderate			3	4			
	fry	Freshwater rearing. Fry to smolt.	**Good water quality conditions**	29	LF29: Toxic water quality conditions can increase fry mortality or reduce fitness.	3	3	3	L	Moderate			3	3			
	fry	Freshwater rearing. Fry to smolt.	**Low levels of fish disease**	41	LF41: Mortality or fitness impacts as a result of disease	2	3	3	L	Low			3	3			
	fry	Freshwater rearing. Fry to smolt.	**Lack of anthropogenic disturbance**	45	LF45: Mortality or fitness impacts as a result of anthropogenic disturbance	1	3	2	M	Low			3	3			

FRESHWATER REARING CONTD.

	fry	Freshwater rearing. Fry to smolt.	**Absence of invasive species**	36	LF36: Mortality or fitness impacts as a result of competition or predation from Aquatic Invasive Species (AIS)	1	1	1	L	Very Low			4	5	Moderate
	fry	Freshwater rearing. Fry to smolt.	**Good water quality conditions**	28	**LF28:** Low water temperature and lack of groundwater influx resulting in ice in interstitial spaces	1	2	3	L	Very Low			4	4	Low
	fry	Freshwater rearing. Fry to smolt.	**Absence of invasive species**	37	LF37: Alteration of natural riparian structure and ecological integrity as a result of colonization of invasive species	1	1	1	M	Very Low			3	3	Very Low
	fry	Freshwater rearing. Fry to smolt.	**Absence of invasive species**	38	LF38: Impacts to juvenile migration as a result of invasive plant species	1	1	1	M	Very Low			3	3	Very Low
	fry	Freshwater rearing. Fry to smolt.	**Low levels of competition with other wild salmon/ hatchery fry /other species**	39	LF39: Mortality or fitness impacts as a result of competition with other salmon, hatchery fry/smolts and/or other species	1	1	1	H	Very Low			3	3	Very Low
	fry	Freshwater rearing. Fry to smolt.	**Unrestricted migration and passage: mainstem, off channel and tributary habitat**	44	LF44: Limited juvenile passage at lake fishway, tributary culverts etc	1	1	2	M	Very Low			3	3	Very Low

NEXT: RAMS WORKSHOP

- Entire Collaborative invited
- 1.5 days
- Develop common understanding
- Discuss high risk limiting factors posing risk to the productivity of salmon in the watershed/CU
- Flag any low risk limiting factors that may be important but difficult to score due to lack of knowledge
- Identify knowledge gaps
- Develop a plan to mitigate high-risk components through a series of action items

NEXT STEPS

- Hire facilitator
- Doodle poll for workshop dates
- Indigenous perspectives –interviews?
- Circulate straw dog scores for final check with panel
- Collate materials and send to Collaborative

OUTPUTS / LEGACY

- General consensus ranked list of factors limiting productivity and knowledge gaps
- Strategic Plan ‘owned’ by local group. Incorporates prioritization and sequencing of appropriate restoration actions
- Specific action plans for highest risks, e.g. fishery plans, hatchery plans, restoration plan, water use plan, etc.