



# RISK ASSESSMENT METHOD FOR SALMON (RAMS)

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# RAMS

- What is RAMS?
  - A method designed to determine the factors limiting the productive capacity of Pacific Salmon stocks/ populations/CUs
- How?
  - A process based on Vision/goals -> Status -> Limiting Factors -> Options -> Action Plan
  - Integrating expertise from stock and habitat specialists with LEK/ATK to achieve consensus on risks and actions
  - Simple, repeatable process
- Why?
  - WSP sustainability -> WSP red CU guidance -> Bill C68 -> SARA listing process threats assessment
  - Prioritization of actions based on agreement of the bottlenecks
  - Cost-benefit

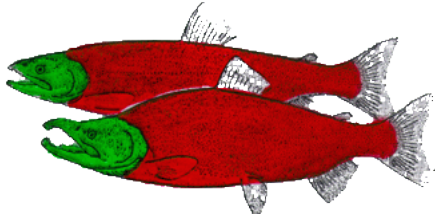


# Where: Various scales...

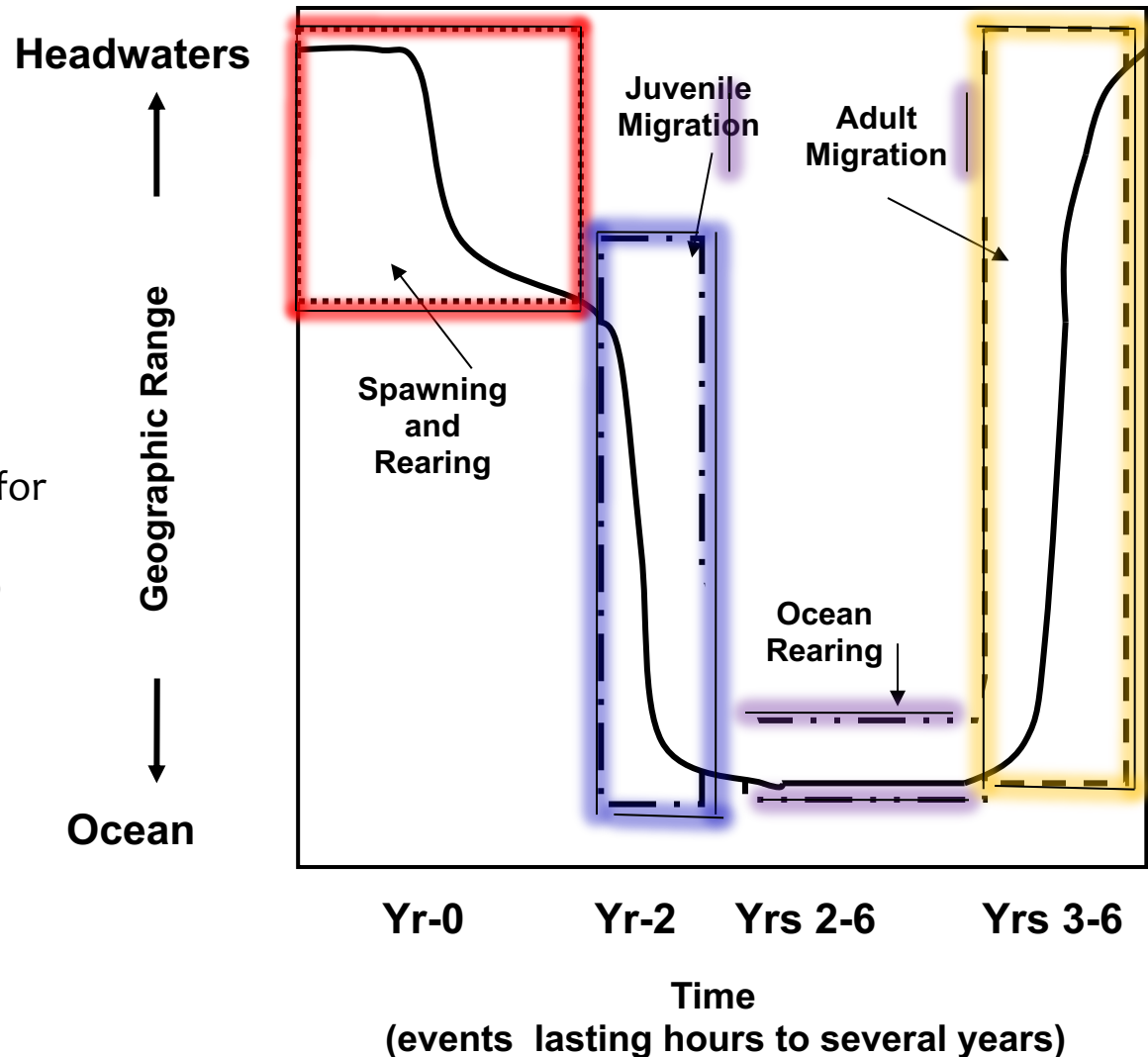
- Cowichan Chinook watershed and estuary. Marine through PSF SSMSP
- Sakinaw Sockeye
- WCVI chinook management unit:
  - SWVI CU; 11 watersheds in San Juan, Barkley, Clayoquot.
  - Nootka-Kyuquot CU; 7 watersheds
  - Quatsino CU; planned
  - Marine planned
- WCVI other
  - 3 Sockeye CUs in Barkley
  - Kennedy Lake Sockeye CU
- Salmon River Coho, Chilliwack planned.
- Nanaimo River Chinook



# Critical connection between salmon & the ecosystem

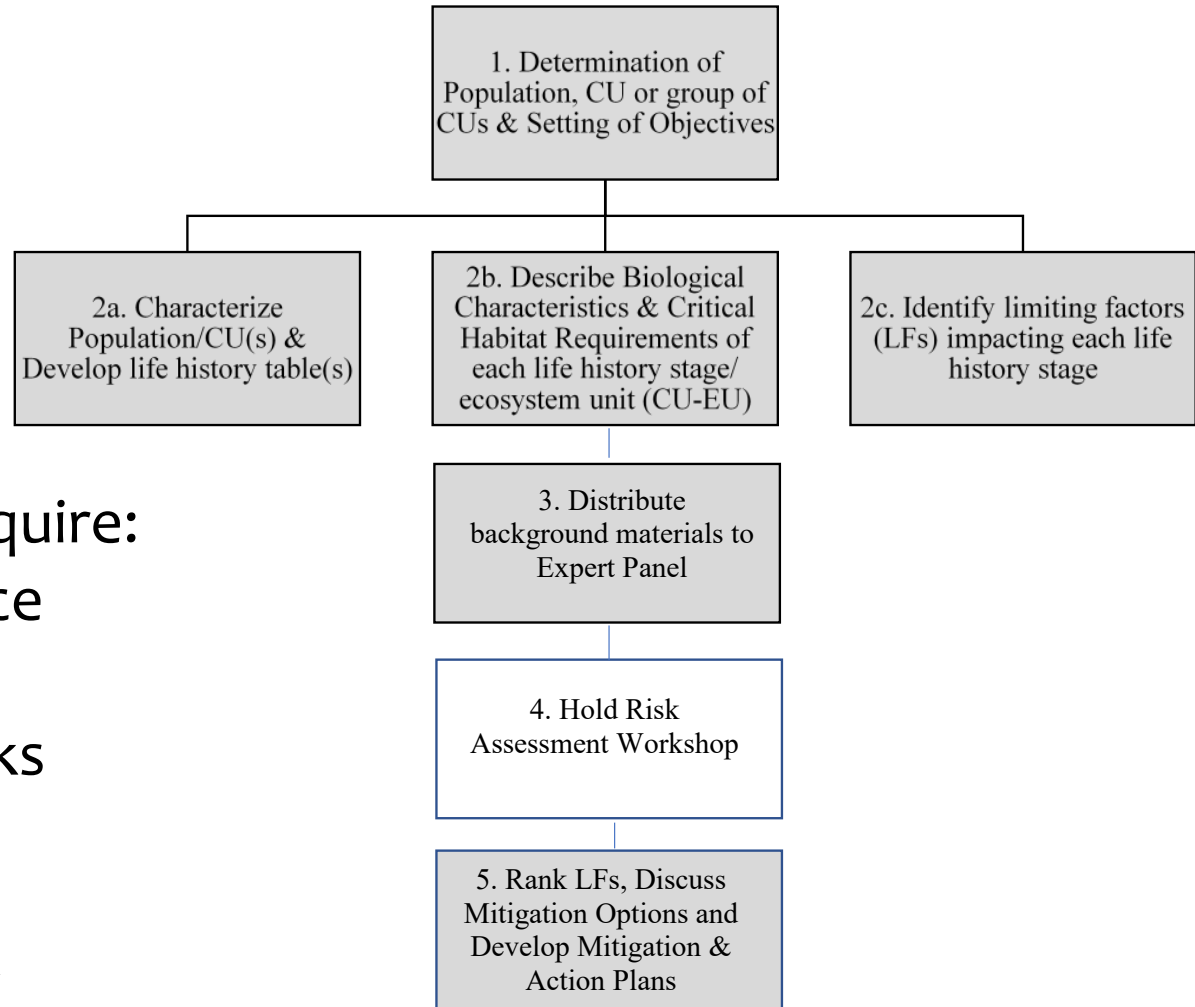


Salmon viewed as a keystone species & important indicator for watershed planning and ecosystem health outside DFO





# RAMS Process simplified...



## Winning conditions require:

- Effective Governance
- Policy Framework
- Knowledge to id risks
- Willingness to act
- Funding
- Capacity to monitor

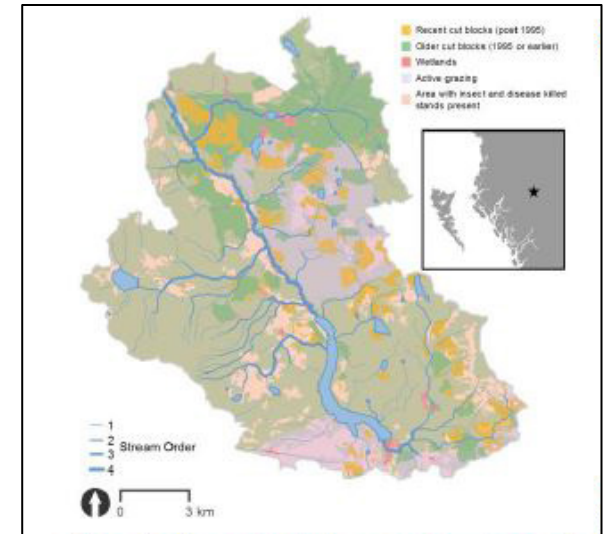
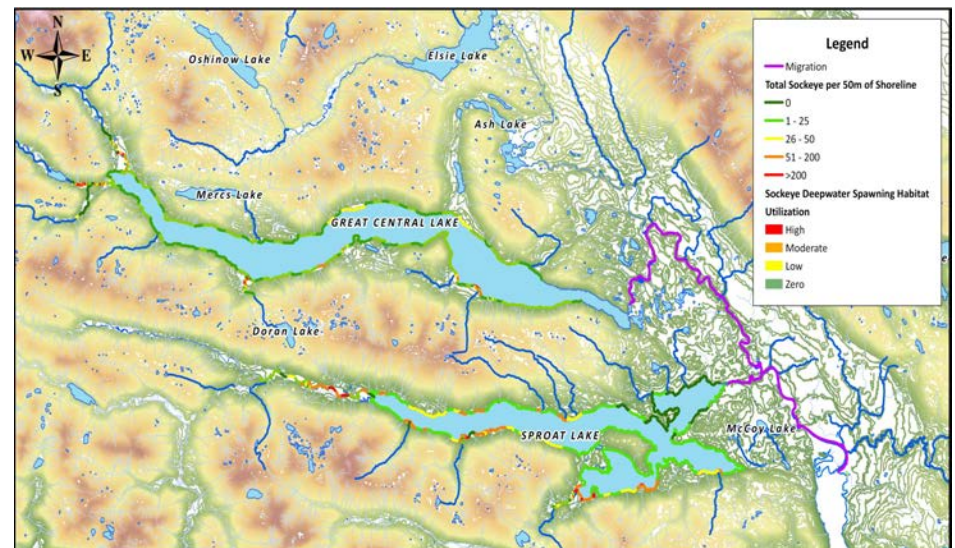
## Vision & Goals

- What is the vision/goals for the stock/species in question?
- Linkage to community planning and salmon as a keystone indicator of ecosystem health
- Usually completed before the RAMS workshop

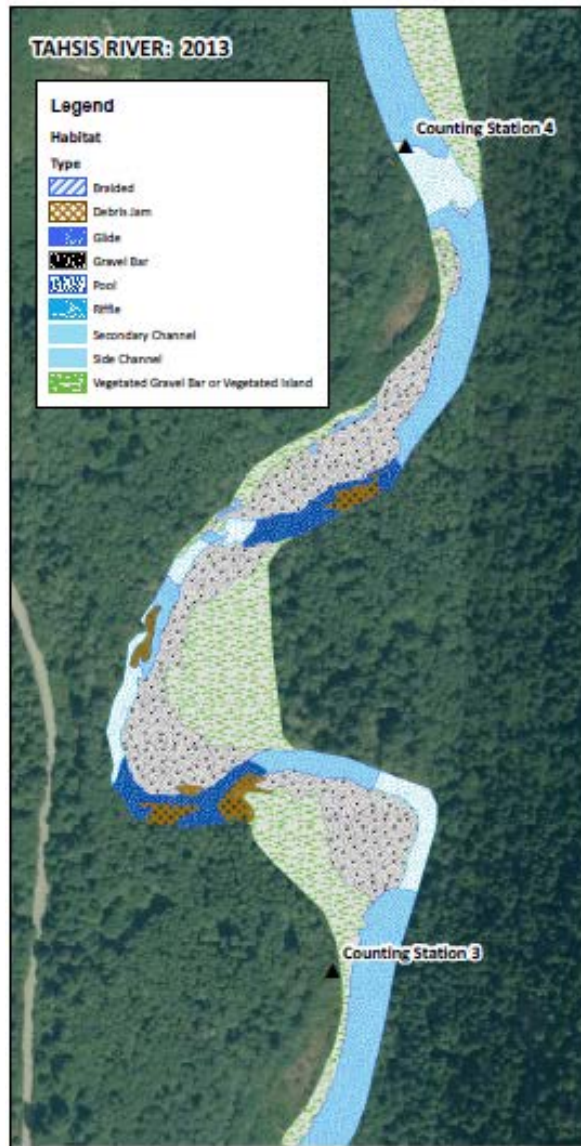
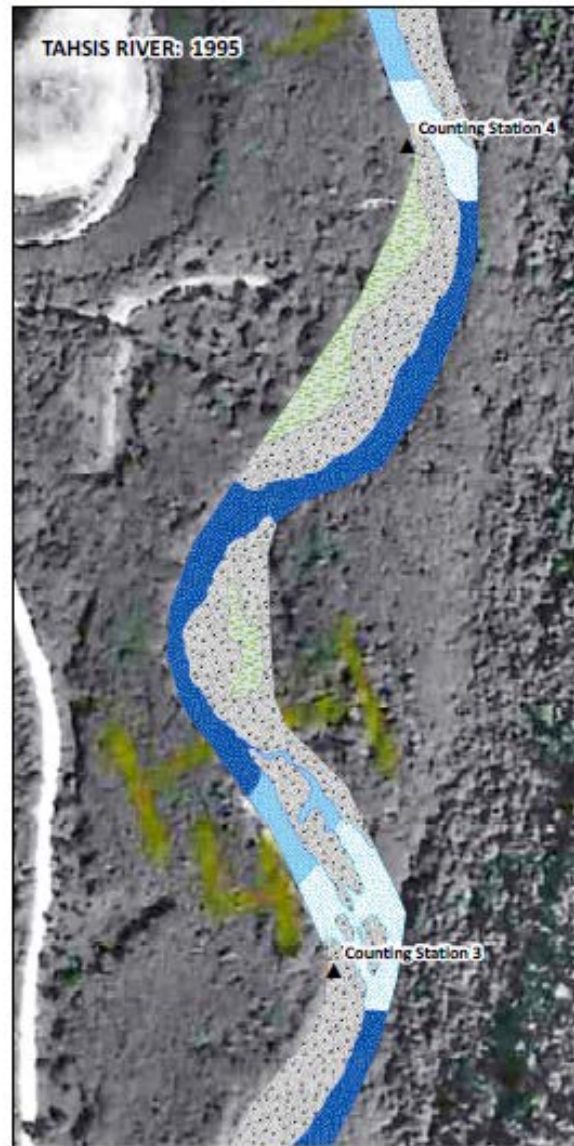


# Stock and Habitat Status

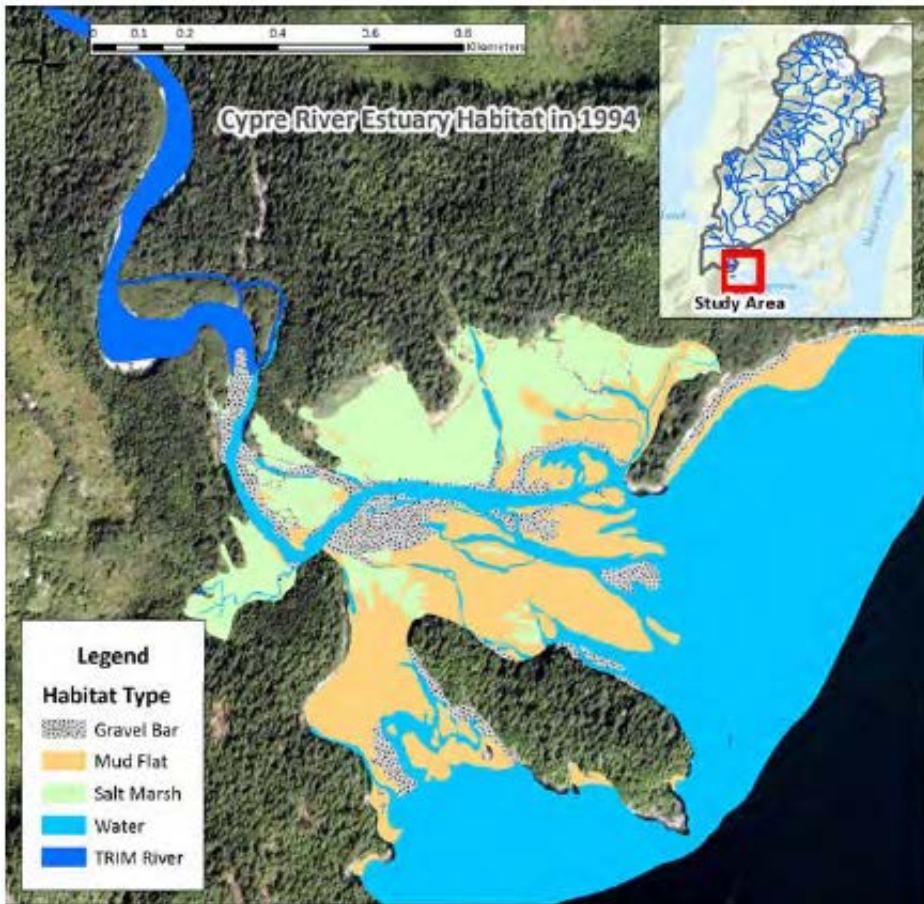
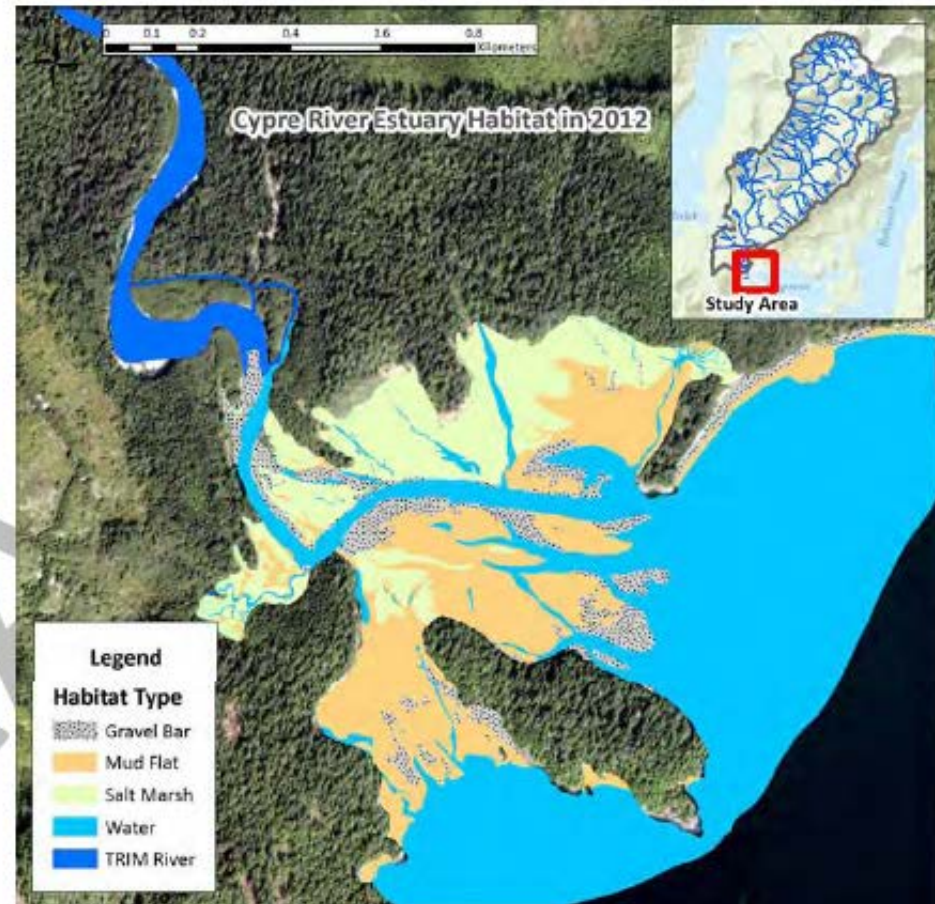
- Collate Stock status and biological characteristics
- High level habitat indicator status (e.g. ESSA report cards)
- Status of critical habitat and identification of key biological factors
- Include other relevant information such as fishery impacts, hatchery influence, etc
- General review of critical habitat including changes over time



# Ex. River changes over time. Tahsis R... 2013,1995,1980



# Ex. Estuary changes.    Cypre River Estuary: 1994, 2012



# How to view risk

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

## State of Salmon.

### Biological indicators for each salmon life stage.

Assessed using Escapement surveys, smolt surveys, catch monitoring, CWT, DNA, PBT, otoliths, genomics, etc.

| Ecosystem Unit         | Life Stage       | Chinook   | Mortality |
|------------------------|------------------|-----------|-----------|
| Into the river         | Migrating adults | 3,000     | 25%       |
| upper river - uplands  | Spawners         | 2,250     |           |
| upper river - uplands  | Eggs laid        | 3,330,000 | 84.0%     |
| lower river to estuary | Smolts out       | 533,334   |           |
| Estuary to Ocean       | Adults produced  | 5,333     | 99.0%     |
| Ocean                  | Caught in ocean  | 2,933     | 55%       |
| Estuary to upper river | Terminal return  | 2,400     |           |
|                        | Rate of change   | -20%      |           |
|                        | Recruits/Spawner | 2.37      |           |

## Status of Freshwater and Estuarine Ecosystems

### Habitat State Indicators linked to salmon critical habitat

#### Water Quality

Freshwater, Estuarine & Marine:  
Temperature, Chemistry, Dissolved oxygen, Alkalinity, Toxins, etc.

Total suspended solids, sediments & biota.

Nutrients and chlorophyll a

Harmful algal blooms, pollution, etc.

#### Hydrology

Freshwater:  
Hydrograph alteration/flows relative to preferred flows by life stage.  
Floodplain presence/connectivity  
Groundwater recharge

#### Physical Habitat

Freshwater:  
Floodplain quality & connectivity.  
Riparian condition, side channel, connectivity and condition.  
Pool availability by habitat type (r/r/p).  
Edge habitat for rearing, vegetation, adequate large woody debris, complexity.  
Spawning habitat quality & quantity  
Upland habitats supporting hydrology  
Estuarine:  
Nearshore habitat integrity (eelgrass, kelp habitats, forage fish spawning habitat)  
Connectivity to freshwater habitat

#### Biological Communities

Freshwater, Estuarine & Marine:  
Biotic Integrity  
Benthic Communities  
Salmonid Population structure (abundance, productivity, spatial structure, diversity)  
Species Interactions (predation, parasitism, competition, exotic species etc.)  
Anthropogenic Impacts  
Freshwater only:  
Riparian vegetation  
Terrestrial wildlife  
Plant communities  
Estuarine only:  
Eelgrass and kelp communities

## Threats and causal mechanisms

### Assessed using Pressure Indicators and sources of habitat degradation

#### Natural Pressures:

Lithology/Soils changes  
Watershed morphology changes  
Hydrology changes  
Climate impacts  
Physiography changes  
Vegetation changes/loss  
Predation, competition, parasitism, disease

#### Human Pressures:

Freshwater & Estuarine:  
Land Use; e.g. Impervious surface runoff changes in drainage. E.g. Forestry  
Dams, Water withdrawals, Channel alterations.  
Vegetation removal  
Wetland/estuary alterations

#### Freshwater, Estuarine & Marine:

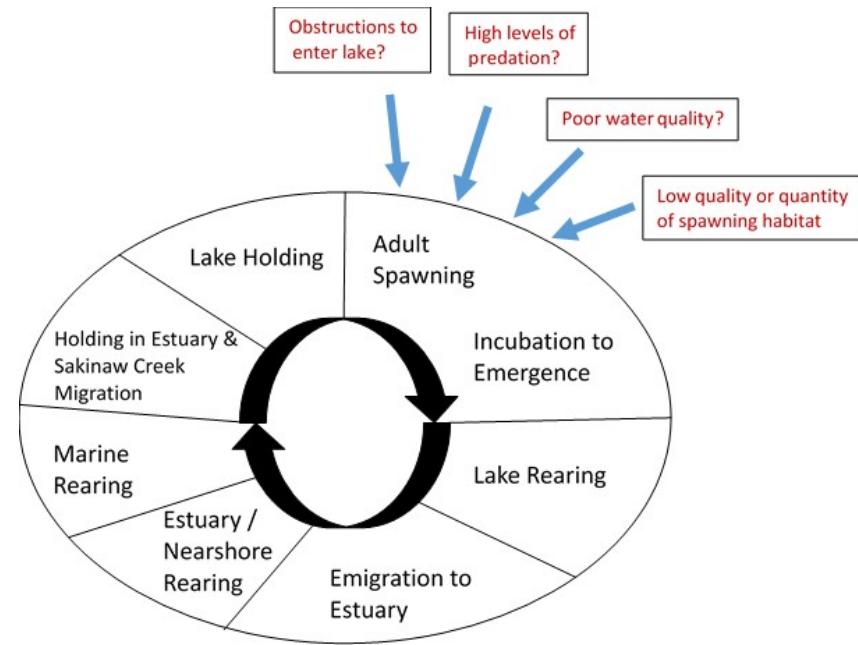
Pollution/contamination: e.g. Outfall discharges  
Invasive / Exotic Species  
Harvest in fisheries  
Enhancement impacts  
Spills/harmful discharges  
Aquaculture

Process direction

RAMS assessment direction

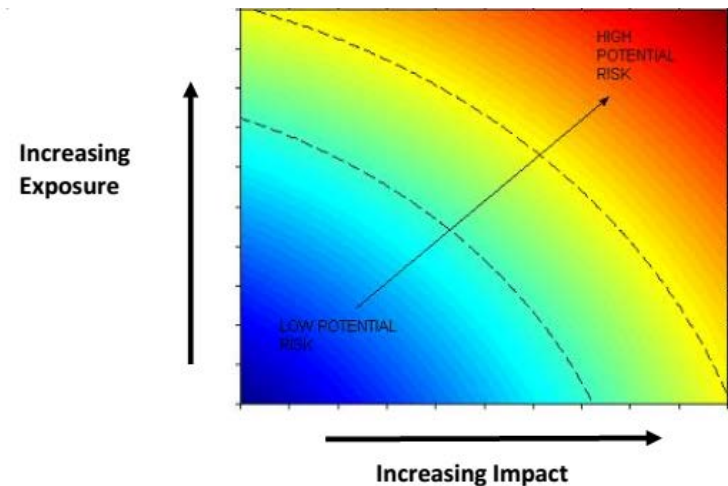
# Limiting factors

- Gather information on limiting factors impacting critical habitat and life history stages of Pacific salmon



# Hold Risk Workshop

- Include technical, local & traditional expertise
- Risk scoring based on likelihood (spatial & temporal extent) & biological impact & trend 50 years into future
- Usually “swim up the river” or get bird’s eye view in GIS format & document factors affecting each life stage
- Identify knowledge gaps





# Workshop 1 Objectives

- Develop a common understanding of the status of salmon stocks within the Nicola River watershed
- Identify and rank the major limiting factors posing risk to the productivity of salmon in this watershed
- Discuss risk posed by climate change based on long-term forecast models and determine the impact this may have to evolving risk factors within the watershed
- Identify knowledge gaps within available data
- Prioritize conservation efforts based on outcome of risk scoring procedure
- Develop a plan to mitigate high-risk components through a series of action items
- Identify funding sources to support risk mitigation plan

# EXAMPLE RAMS workshop Agenda

## Day 1

| Time  | Items                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 8:30  | Coffee and light breakfast                                                                                                                                                                                                                                                                                                                                                                                                                              |
| 9:00  | Opening Prayer                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 9:15  | Welcome and RAMS Introduction <ul style="list-style-type: none"><li>- Introduction to the RAMS process</li><li>- Specific goals for the 2 day workshop</li></ul>                                                                                                                                                                                                                                                                                        |
| 9:45  | Agree on a common vision and goals for the Nicole Watershed                                                                                                                                                                                                                                                                                                                                                                                             |
| 10:30 | Coffee break                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| 10.45 | Create Common Understanding <ul style="list-style-type: none"><li>- High level overview including stock information (past and current), fish health, harvest</li><li>- Freshwater habitat status overview</li><li>- What changes in land use/ pressures to salmon and salmon habitat have been observed by participants</li><li>- Discussion of current and potential future risks to salmon and salmon habitat in the Salmon River Watershed</li></ul> |
| 11:20 | Introduction to the RAMS Scoring Process                                                                                                                                                                                                                                                                                                                                                                                                                |
| 12:00 | Lunch                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 1:00  | Scoring with integrated discussion                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 2:30  | Break                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 2:45  | Scoring Continued                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| 3:30  | Completion of Scoring <ul style="list-style-type: none"><li>- Synopsis of day's achievements</li><li>- Discussion of progress and aims of Day 2</li></ul>                                                                                                                                                                                                                                                                                               |



# EXAMPLE RAMS workshop Agenda

## Day 2

| <b>Time</b>  | <b>Items</b>                                                                                                                                                                                                |
|--------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>8:30</b>  | Coffee and light breakfast                                                                                                                                                                                  |
| <b>9:00</b>  | Summary of Day 1 <ul style="list-style-type: none"><li>- Review of scoring</li><li>- Successes and/or areas for further discussion</li></ul> Introduction to the goals of Day 2                             |
| <b>9:15</b>  | Continuation of Scoring                                                                                                                                                                                     |
| <b>10.45</b> | Coffee Break                                                                                                                                                                                                |
| <b>11.00</b> | Continuation of Scoring                                                                                                                                                                                     |
| <b>12.00</b> | Lunch                                                                                                                                                                                                       |
| <b>1.00</b>  | Continuation of Scoring                                                                                                                                                                                     |
| <b>2.30</b>  | break                                                                                                                                                                                                       |
| <b>2:45</b>  | Continuation of Scoring                                                                                                                                                                                     |
| <b>3:30</b>  | Final discussion of original objectives and progress made <ul style="list-style-type: none"><li>- Overview of achievements</li><li>- Discussion of final action items and plan for moving forward</li></ul> |



# Nanaimo River

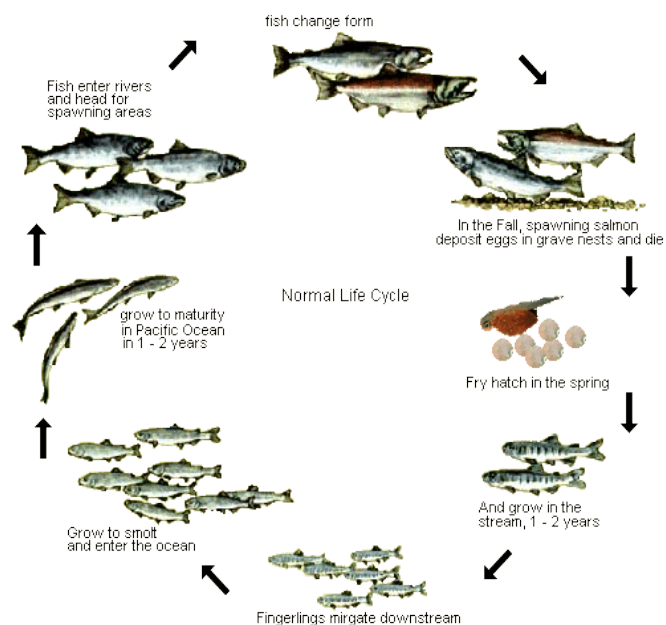
## Limiting Factors Risk Assessment Scoring Procedure



## RISK ASSESSMENT METHODOLOGY

- Designed to determine the factors limiting the productive capacity of Spring Run Chinook and other Pacific salmon in the Nanaimo Watershed
  - Scoping stage
  - Risk assessment scoring
  - Ranking of limiting factors

# Scoping Step 1. Characterize the population of interest & develop the life history table



| Ecosystem Unit   | Life History Phase        | Estimated mortality rate | Estimated relative abundance |
|------------------|---------------------------|--------------------------|------------------------------|
| 1. Uplands       | Spawner                   |                          |                              |
|                  | Eggs                      |                          |                              |
| 2. Lower river   | Fry                       |                          |                              |
| 3. Estuary       | Smolt                     |                          |                              |
| 4. Ocean         | Ocean year 1              |                          |                              |
|                  | Mature migrant (recruits) |                          |                              |
| 5. Terminal area | Terminal migrant          |                          |                              |
| 6. River         | In-river migrant          |                          |                              |
| 7. Uplands       | Spawner                   |                          |                              |

Number of Spawners =  $S$

This estimates the  $\beta$  statistic (capacity parameter of Ricker curve)

Number of Recruits =  $R$

$R/S$  is estimate of  $\alpha$ , a measure of the productivity of the population

# RAMS uses a life cycle model to assess benefit of reducing mortality at each life stage.

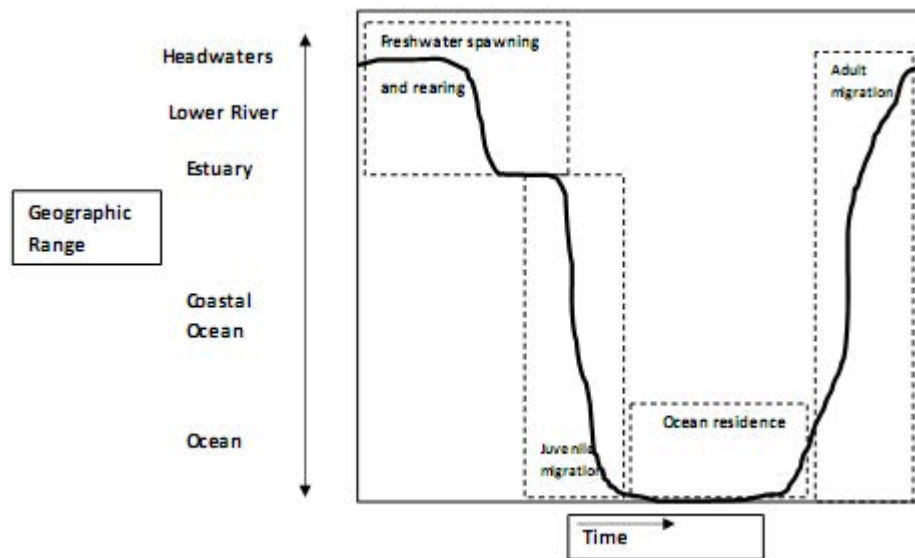
| Ecosystem Units            | Life Stage/metric      | Chinook abundance | Average Mortality |
|----------------------------|------------------------|-------------------|-------------------|
| estuary                    | migrating adults       | 500               |                   |
| estuary to spawning areas  | instream mortality     |                   | 30.0%             |
| upper river spawning areas | spawners               | 350               |                   |
| upper river spawning areas | eggs per female        |                   | <b>4000</b>       |
| upper river spawning areas | eggs in gravel         | 700,000           |                   |
| upper river to estuary     | egg to smolt mortality |                   | 83.7%             |
| estuary                    | smolts                 | 114,450           |                   |
| estuary to ocean           | marine survival        |                   | 99.3%             |
| ocean                      | Recruits               | 801               |                   |
| ocean                      | fishing mortality      |                   | 37.6%             |
|                            | terminal return        | 500               |                   |
|                            | Rate of change         | 0.0%              |                   |

Objective to turn rate of change positive.

Model uses knowns (bold numbers)... spawner escapement generally known, use fecundity, sex ratio and prespawn mortality to estimate egg deposition, known fishery exploitation rate allows reconstruction from escapement to total adults and marine survival. Freshwater mortality is then easily calculated from these knowns. Models vary from simple to complex including multiple ages, maturation, hatchery interactions, etc.



## Step 2. Describe Biological Characteristics & Requirements of each Life-History Stage/ Ecosystem Unit



1. Terminal Migration and Spawning (returning adults)
2. Freshwater Incubation (eggs-alevins)
3. Freshwater Rearing (fry and smolts)
4. Migration and/or Rearing in the Estuary and Marine Areas (smolts, subadults, adults)



# TERMINAL MIGRATION & SPAWNING PHASE

## Requirements

1. Safe holding habitat in estuary and lower river prior to upriver migration
2. Adequate flows to facilitate upstream passage of spawners
3. Unrestricted access
4. Stable channel morphology, maintenance of channel capacity and natural level of sediment transport
5. High quality migration route with adequate refuge habitat
6. Suitable water quality
7. Availability of high quality and sufficient quantity spawning habitat
8. An agreed -upon and enforceable Fishing Plan
9. Lack of invasive plant and animal species affecting spawning habitat
10. Low levels of anthropogenic disturbance
11. Low levels of predation during migration and spawning



## Step 3. Relate limiting factors to life-history model.

- a. Gather limiting factors
- b. Relate the impacts of stressors to the life-history model



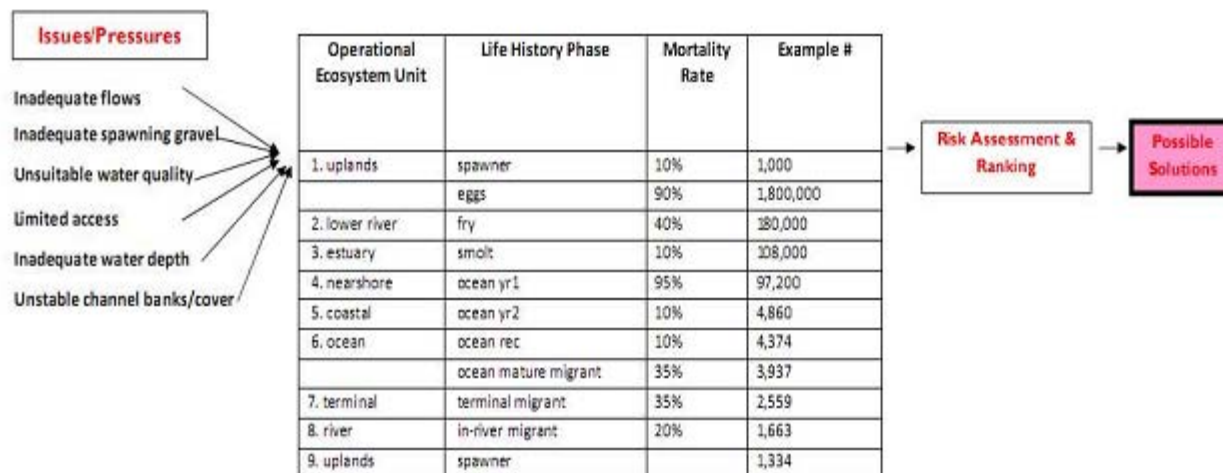
# LIMITING FACTORS:

## In-River Spawner Migration and Spawning

- LF1: Predation of adults in the estuary and lower river by pinnipeds
- LF2: Limited or delayed spawner access due to low flows
- LF3: Potential delays in upstream migration due to the fishways, enumeration structures etc
- LF4: Aggradation creates a migration barrier in the lower rivers during summer and early fall period.
- LF5: Loss of safe migration route through the lower rivers due to channelization, loss of habitat complexity and instream cover features
- 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
- LF7: Poor water quality conditions during the late summer/early fall migration period (low DO, coliform levels, deleterious substances)
- LF8: Lack of high quality and quantity of spawning habitat
- LF9: Mortality due to unauthorized fishing
- LF10: Disturbance to natural spawning activity due to anthropogenic impacts
- LF11: Mortality due to predation at spawning grounds
- **New LF: xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx**



# RELATE THE IMPACTS OF STRESSORS TO THE LIFE-HISTORY MODEL



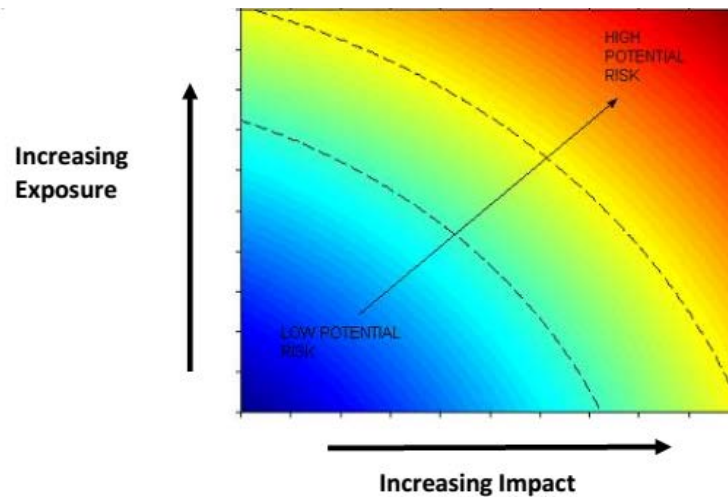
# Can delineate the life cycle into finer time and space... with increased uncertainty.

| 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.

## LEVEL 1 RISK ASSESSMENT SCORING

- Exposure (likelihood) 1-5-  
spatial, temporal
- Consequence (impact) 1-5
- Risk =  
 $\text{Exposure} \times \text{Consequence}$
- 2 time passes- current & 50  
years into future





# Spatial Scale

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



# Temporal Scale

| Score         | Frequency                                          |
|---------------|----------------------------------------------------|
| 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)                   |



## Exposure (Likelihood)

| Exposure      | Product of spatial and temporal scale scores |
|---------------|----------------------------------------------|
| Low (1)       | 1                                            |
| Moderate (2)  | 2 to 5                                       |
| Medium (3)    | 6 to 9                                       |
| High (4)      | 12 to 16                                     |
| Very High (5) | 20 to 25                                     |



# Consequence (Impact) Scores

| Level    | Score | Description                                 |
|----------|-------|---------------------------------------------|
| Minor    | 1     | Less than 10% decline in population returns |
| Moderate | 2     | 11-20% decline in population returns        |
| Major    | 3     | 21-30% decline in population returns        |
| Severe   | 4     | 31-50% decline in population returns        |
| Critical | 5     | 50% + decline in population returns         |



# Confidence

| Confidence | Rationale                                                                                                                                                                                |
|------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Low        | <ul style="list-style-type: none"><li>• Data exist but are considered poor, or conflicting, or</li><li>• No data exist, or</li><li>• Substantial disagreement among experts</li></ul>    |
| Med        | <ul style="list-style-type: none"><li>• Data exist but some key gaps</li><li>• Some disagreement between experts</li></ul>                                                               |
| High       | <ul style="list-style-type: none"><li>• Data exist and are considered sound, or</li><li>• Consensus between experts, or</li><li>• Risk is constrained by logical consideration</li></ul> |



# Calculation of Risk

| Biological Risk | Value    | Action                                                                                                      |
|-----------------|----------|-------------------------------------------------------------------------------------------------------------|
| Low (1)         | 1        | No enhanced management needed; level 1 assessment is sufficient                                             |
| Moderate (2)    | 2 to 5   | Full justification needed; no specific enhanced management strategy needed                                  |
| Medium (3)      | 6 to 9   | Some additions to current management needed, Level 2 risk assessment and full performance report needed     |
| High (4)        | 12 to 16 | Increases to current management probably needed, Level 2 risk assessment and full performance report needed |
| Very High (5)   | 20 to 25 | Significant additional management needed, Level 2 risk assessment and full performance report needed        |



# Current and Future Trends

**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).



# Barkley Sockeye Risk Assessment

| 1. Great Central Sockeye CU                                                                       |                                                                                                            |                                                                         |                           |
|---------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|---------------------------|
| DESCRIPTION OF FACTOR                                                                             |                                                                                                            | BIOLOGICAL RISK calculated for each factor limiting productive capacity |                           |
| Life History Requirement                                                                          | Issue/Limiting factor & id number                                                                          | Current Biol Risk category                                              | Future Biol Risk category |
| <b>A. Terminal Migration &amp; Spawning</b>                                                       |                                                                                                            |                                                                         |                           |
| 2. Large volume of preferred water (VOPW, low temp, high O2) in estuary                           | LF2: Significant reductions of VOPW in inlet & estuary with chronic to impacts on adult "fitness".         | Moderate                                                                | High                      |
| 4. Favorable temperatures for low stress passage                                                  | LF4: High temps slow or stop upstream migration                                                            | Moderate                                                                | Very High                 |
| 11b. Spawning habitat quantity sufficient to fully "seed" fry rearing habitat. TRIB SPAWNERS ONLY | LF12B: Inadequate TRIB spawning habitat (i.e. CU production potential limited by initial fry recruitment). | Moderate                                                                | Moderate                  |

| 2. Sproat Sockeye CU                                                                              |                                                                                                            |                                                                         |                           |
|---------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|---------------------------|
| DESCRIPTION OF FACTOR                                                                             |                                                                                                            | BIOLOGICAL RISK calculated for each factor limiting productive capacity |                           |
| Life History Requirement                                                                          | Issue/Limiting factor & id number                                                                          | Current Biol Risk category                                              | Future Biol Risk category |
| <b>A. Terminal Migration &amp; Spawning</b>                                                       |                                                                                                            |                                                                         |                           |
| 2. Large volume of preferred water (VOPW, low temp, high O2) in estuary                           | LF2: Significant reductions of VOPW in inlet & estuary with chronic to impacts on adult "fitness".         | Moderate                                                                | High                      |
| 4. Favorable temperatures for low stress passage                                                  | LF4: High temps slow or stop upstream migration                                                            | Moderate                                                                | Very High                 |
| 11b. Spawning habitat quantity sufficient to fully "seed" fry rearing habitat. TRIB SPAWNERS ONLY | LF12B: Inadequate TRIB spawning habitat (i.e. CU production potential limited by initial fry recruitment). | Moderate                                                                | Moderate                  |

| 3. Henderson Sockeye CU                                                                           |                                                                                                            |                                                                         |                           |
|---------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|---------------------------|
| DESCRIPTION OF FACTOR                                                                             |                                                                                                            | BIOLOGICAL RISK calculated for each factor limiting productive capacity |                           |
| Life History Requirement                                                                          | Issue/Limiting factor & id number                                                                          | Current Biol Risk category                                              | Future Biol Risk Category |
| <b>A. Terminal Migration &amp; Spawning</b>                                                       |                                                                                                            |                                                                         |                           |
| 9. Stable channel banks and stable coarse bedload transport                                       | LF10: Riparian disturbance resulting in bank erosion, increased bedload.                                   | Very High                                                               | Very High                 |
| 11b. Spawning habitat quantity sufficient to fully "seed" fry rearing habitat. TRIB SPAWNERS ONLY | LF12B: Inadequate TRIB spawning habitat (i.e. CU production potential limited by initial fry recruitment). | High                                                                    | Very High                 |
| 11. Spawning habitat quantity sufficient to fully "seed" fry rearing habitat. BEACH SPAWNERS ONLY | LF12: Inadequate BEACH spawning habitat (i.e. CU production potential limited by initial fry recruitment). | Moderate                                                                | High                      |



|                                                                                                   |                                                                                                                       |          |          |
|---------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|----------|----------|
| 9. Stable channel banks and stable coarse bedload transport                                       | LF10: Riparian disturbance resulting in bank erosion, increased bedload.                                              | Low      | Moderate |
| 5. Unrestricted access through fishways, enumeration structures etc                               | LF5: Delays at fishways and during passage through fish counters                                                      | Low      | Low      |
| 7. Open access at all points to holding and/or spawning areas.                                    | LF8: Temperature or structural blockages delay access to beach spawning areas during late Sept-Nov spawning interval. | Low      | Low      |
| 11. Spawning habitat quantity sufficient to fully "seed" fry rearing habitat. BEACH SPAWNERS ONLY | LF12: Inadequate BEACH spawning habitat (i.e. CU production potential limited by initial fry recruitment).            | Low      | Low      |
| 1. Safe holding habitat in estuary                                                                | LF1: Large losses from seals.                                                                                         | Very Low | Low      |
| 3. Adequate maintenance flows to facilitate upstream passage of spawners                          | LF3: Low flows delay, prevent passage at control points (e.g. Henderson rapids) & increases pre-spawn losses.         | Very Low | Low      |

|                                                                                                   |                                                                                                               |          |          |
|---------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|----------|----------|
| 3. Adequate maintenance flows to facilitate upstream passage of spawners                          | LF3: Low flows delay, prevent passage at control points (e.g. Henderson rapids) & increases pre-spawn losses. | Low      | High     |
| 9. Stable channel banks and stable coarse bedload transport                                       | LF10: Riparian disturbance resulting in bank erosion, increased bedload.                                      | Low      | Moderate |
| 5. Unrestricted access through fishways, enumeration structures etc                               | LF5: Delays at fishways and during passage through fish counters                                              | Low      | Low      |
| 11. Spawning habitat quantity sufficient to fully "seed" fry rearing habitat. BEACH SPAWNERS ONLY | LF12: Inadequate BEACH spawning habitat (i.e. CU production potential limited by initial fry recruitment).    | Low      | Low      |
| 1. Safe holding habitat in estuary                                                                | LF1: Large losses from seals.                                                                                 | Very Low | Low      |
| 5. Unrestricted access through fishways, enumeration structures etc                               | LF6: Structural Blockages                                                                                     | Very Low | none/Unk |

|                                                                                |                                                                                                                 |          |          |
|--------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|----------|----------|
| 1. Safe holding habitat in estuary                                             | LF1: Large losses from seals.                                                                                   | Moderate | Moderate |
| 7. Open access at all points to holding and/or spawning areas.                 | LF8: Temperature or structural blockages delay access to spawning areas during late Sept-Nov spawning interval. | Moderate | none/Unk |
| 3. Adequate maintenance flows to facilitate upstream passage of spawners       | LF3: Low flows delay, prevent passage at control points (e.g. Henderson rapids) & increases pre-spawn losses.   | Low      | High     |
| 4. Favorable temperatures for low stress passage                               | LF4: High temps slow or stop upstream migration                                                                 | Low      | High     |
| 5. Unrestricted access through fishways, enumeration structures etc            | LF6: Structural Blockages                                                                                       | Low      | Moderate |
| 8. Adequate channel depth including frequency of deep holding pools with cover | LF9: Shallowing or loss of "predation-free", summer holding "pools" due to sediment infill.                     | Low      | Moderate |



|                                                                                |                                                                                             |          |          |
|--------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|----------|----------|
| 5. Unrestricted access through fishways, enumeration structures etc            | LF6: Structural Blockages                                                                   | Very Low | none/Unk |
| 6. VOPW ensures low stress, predator & pathogen free, lake refuge.             | LF7: Reductions in the lake VOPW                                                            | Very Low | none/Unk |
| 8. Adequate channel depth including frequency of deep holding pools with cover | LF9: Shallowing or loss of "predation-free", summer holding "pools" due to sediment infill. | Very Low | none/Unk |
| 14. Lack of anthropogenic disturbance                                          | LFnew: Direct disturbance of fish by human activities.                                      | Very Low | none/Unk |
| 10. Suitable water quality-levels of bacteria and toxic substances             | LF11: Poor water quality                                                                    | Very Low | none/Unk |
| 12. Low levels of predation on adults.                                         | LF13: High proportion of spawners lost to bears                                             | Very Low | none/Unk |
| 13. Compliance and good management                                             | LFnew: unreported catch / poaching / misallocation from DNA                                 | Very Low | none/Unk |

|                                                                                |                                                                                                                 |          |          |
|--------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|----------|----------|
| 6. VOPW ensures low stress, predator & pathogen free, lake refuge.             | LF7: Reductions to lake VOPW                                                                                    | Very Low | Low      |
| 7. Open access at all points to holding and/or spawning areas.                 | LF8: Temperature or structural blockages delay access to spawning areas during late Sept-Nov spawning interval. | Very Low | none/Unk |
| 8. Adequate channel depth including frequency of deep holding pools with cover | LF9: Shallowing or loss of "predation-free", summer holding "pools" due to sediment infill.                     | Very Low | none/Unk |
| 14. Lack of anthropogenic disturbance                                          | LFnew: Direct disturbance of fish by human activities.                                                          | Very Low | Low      |
| 10. Suitable water quality-levels of bacteria and toxic substances             | LF11: Poor water quality                                                                                        | Very Low | none/Unk |
| 12. Low levels of predation on adults.                                         | LF13: High proportion of spawners lost to bears                                                                 | Very Low | none/Unk |
| 13. Compliance and good management                                             | LFnew: unreported catch / poaching / misallocation from DNA                                                     | Very Low | none/Unk |

|                                                                         |                                                                                                    |          |          |
|-------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------|----------|----------|
| 2. Large volume of preferred water (VOPW, low temp, high O2) in estuary | LF2: Significant reductions of VOPW in inlet & estuary with chronic to impacts on adult "fitness". | Low      | Low      |
| 13. Compliance and good management                                      | LFnew: unreported catch / poaching / misallocation from DNA                                        | Low      | none/Unk |
| 6. VOPW ensures low stress, predator & pathogen free, lake refuge.      | LF7: Reductions to lake VOPW                                                                       | Very Low | Moderate |
| 5. Unrestricted access through fishways, enumeration structures etc     | LF5: Delays at fishways and during passage through fish counters                                   | Very Low | none/Unk |
| 14. Lack of anthropogenic disturbance                                   | LFnew: Direct disturbance of fish by human activities.                                             | Very Low | none/Unk |
| 10. Suitable water quality-levels of bacteria and toxic substances      | LF11: Poor water quality                                                                           | Very Low | Low      |
| 12. Low levels of predation on adults.                                  | LF13: High proportion of spawners lost to bears                                                    | Very Low | Low      |

# Developing Scenarios for action... reducing mortality in key life stages.

Scenario 1: Reduce fishery harvest of adults by 50%.

Scenario 2: Implement actions which reduce FW mortality from 88.9% to 85.5%

| Time period             | Life Stage             | Chinook | Mortality | potential limiting factors                                             |
|-------------------------|------------------------|---------|-----------|------------------------------------------------------------------------|
| Sep                     | Lower river            | 300     | 20.0%     | inriver fishery and broodstock, say 15% FSC                            |
| Sep-Oct                 | inriver migrants       | 240     | 5.0%      | predation, poaching, temperature stress, lack of water                 |
| late oct - early Nov    | Net upriver spawners   | 225     | 1.2%      | upriver mortality, use goal seek to change mortality so total equals   |
|                         |                        |         | 25.0%     | Total inriver mortality rate                                           |
| Nov                     | upriver eggs laid      | 333,000 |           | set 2 of 3 mortalities and use goal seek to find the 3rd freshwater mo |
| late oct - Feb          | emerging fry           | 99,900  | 70.0%     | scour, siltation, predation, freezing, dewater, oxygen, etc.           |
| March-June              | fry surviving rearing  | 50,949  | 49.0%     | during rearing                                                         |
| April-Aug               | smolts out. leaving r  | 48,402  | 5.0%      | during rearing in lower river predation, cover, food, etc.             |
|                         |                        |         | 85.5%     | Total egg to smolt natural mortality                                   |
| June-Sept               | estuary and nearsho    | 2,161   | 95.5%     | predation, cover, food, competition, disease, parasites, etc.          |
| Oct-Feb, end year 1     | nearshore - migratio   | 1,729   | 20.0%     | predation prior to leaving mouth area                                  |
| year 2 in ocean         | ocean feeders suble    | 1,383   | 20.0%     | jack returns, natural mortality, fishery                               |
| Year 3+ adults produced | ocean feeders & adv    | 968     | 30.0%     | natural mortality esp killer whale and pinniped mortality              |
|                         |                        |         | 98.0%     | Total smolt to adult natural mortality                                 |
|                         | Adults caught in oce   | 339     | 35.0%     | Total marine fishery catch and exploitation rate                       |
|                         | adult return to termin | 629     |           |                                                                        |
|                         | change in terminal r   | 329     |           |                                                                        |
|                         | Rate of change         | 110%    |           |                                                                        |
|                         | Recruits/Spawner       | 4.30    |           |                                                                        |

improved lower river rearing through habitat restoration . increased side channels, increased access, increase edge habitat, riparian area planting, insect productivity increased through reduced silting, etc.

larger smolt leaving the river was more resilient to disease, microbes, and need to find food. We guessed this might increase survival. We could test this!

# Scenario Building & Evaluation

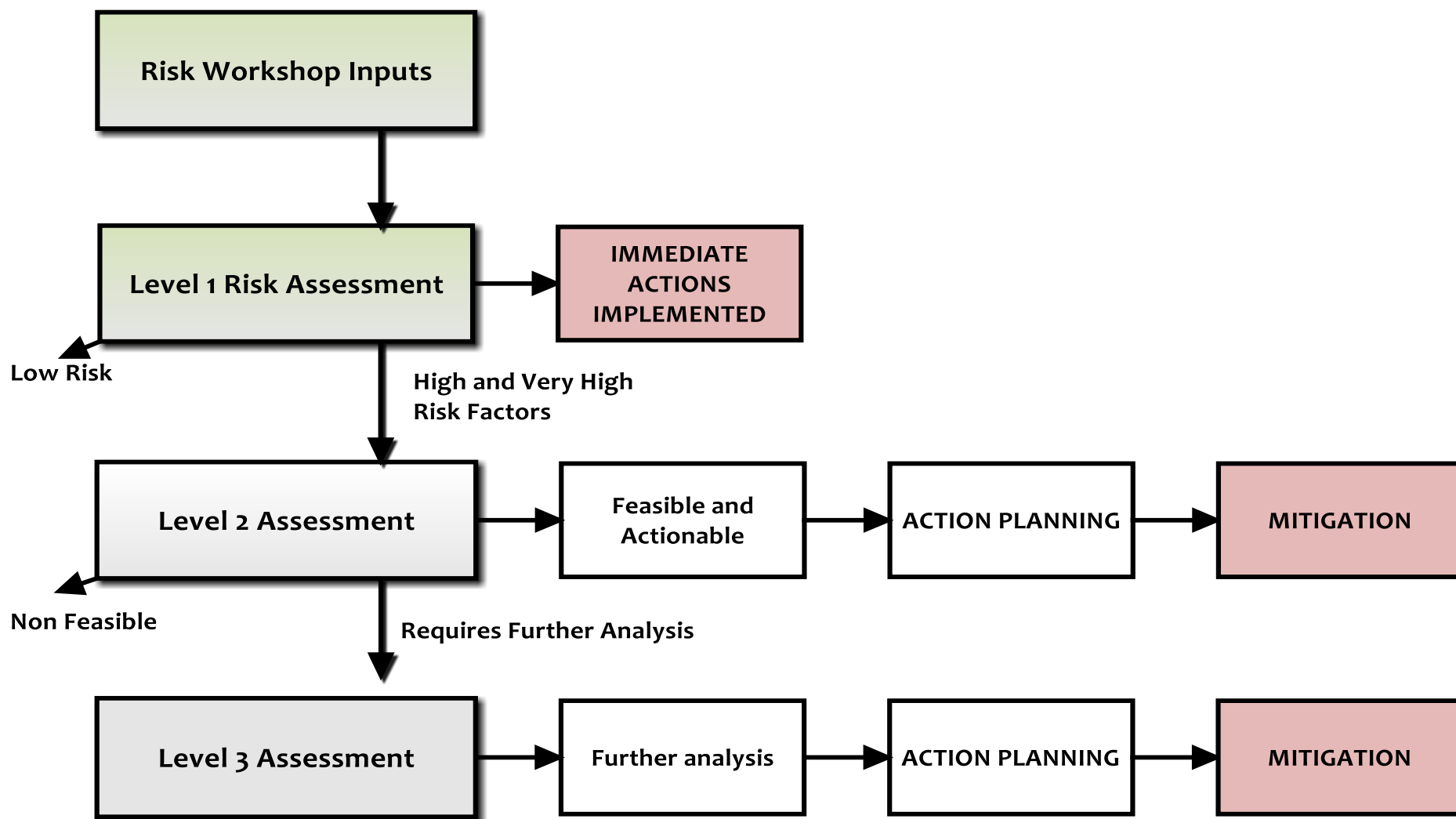
Rank scenarios of actions to address high risk / highest ranked limiting factors

|                   | Action / Limiting factor                   | starting<br>population | terminal<br>return | initial<br>change in<br>terminal<br>return in<br>fish | annual<br>rate of<br>change |
|-------------------|--------------------------------------------|------------------------|--------------------|-------------------------------------------------------|-----------------------------|
| <b>Base case</b>  | current                                    | 300                    | 240                | -60                                                   | <b>-20%</b>                 |
| <b>Scenario 1</b> | Reduce marine harvest by 50%               | 300                    | 303                | 3                                                     | <b>1%</b>                   |
| <b>Scenario 3</b> | eliminate adult pinniped predation by 100% | 300                    | 305                | 5                                                     | <b>2%</b>                   |
| <b>Scenario 2</b> | Improve lower river rearing by 4%          | 300                    | 629                | 329                                                   | <b>110%</b>                 |

- Assess feasibility
- Identify lead jurisdiction
- Develop action plan for agreed actions



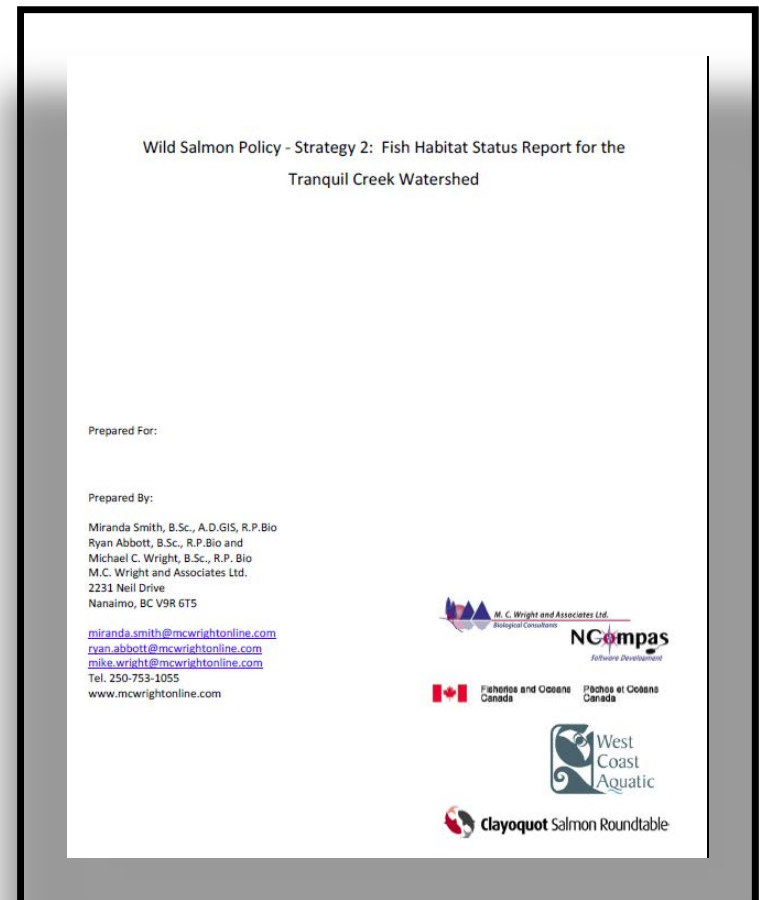
# Moving from Risk Assessment to Action





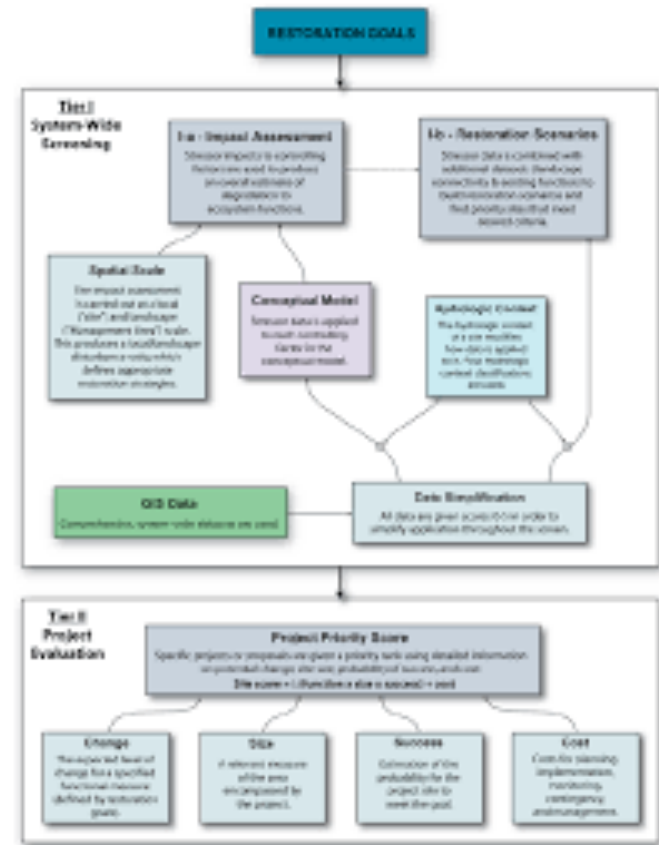
# Outputs / Legacy

- 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.
- RAMS methodology guidance
- Critical habitat guidance



# Action Planning

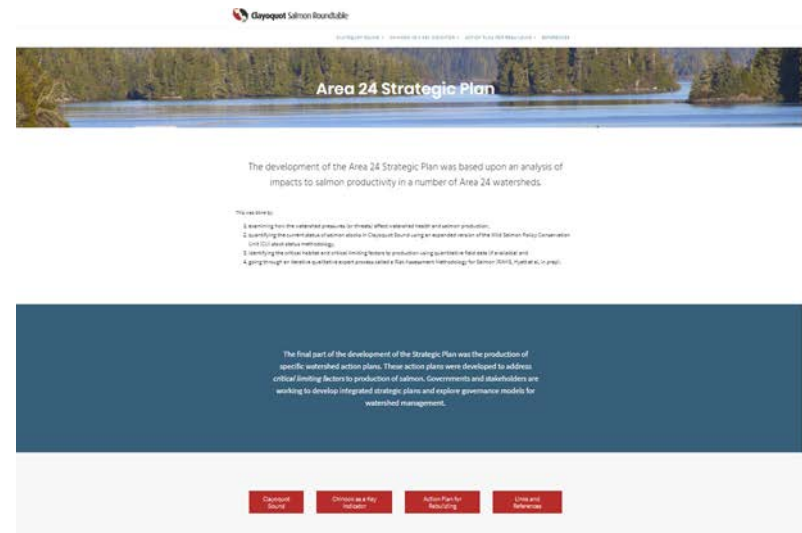
- Action Plan developed to:
  1. Address high priority data gaps
  2. Compare options for restoration based on cost/benefit
  3. Develop a restoration plan
- Influence and action for factors not within DFO jurisdiction:
  1. Local government use of salmon as a keystone indicator species for ecosystem health
  2. Basis for influencing industry, government agencies...





# Cowichan and WCVI Status of Process

- Level 1 RAMS completed many local WCVI populations
- Level 2 RAMS in Cowichan
- Action planning implemented Cowichan
- Roll ups for Clayoquot and Nootka Sound ongoing
- Website development (Cowichan/WCVI roundtables)



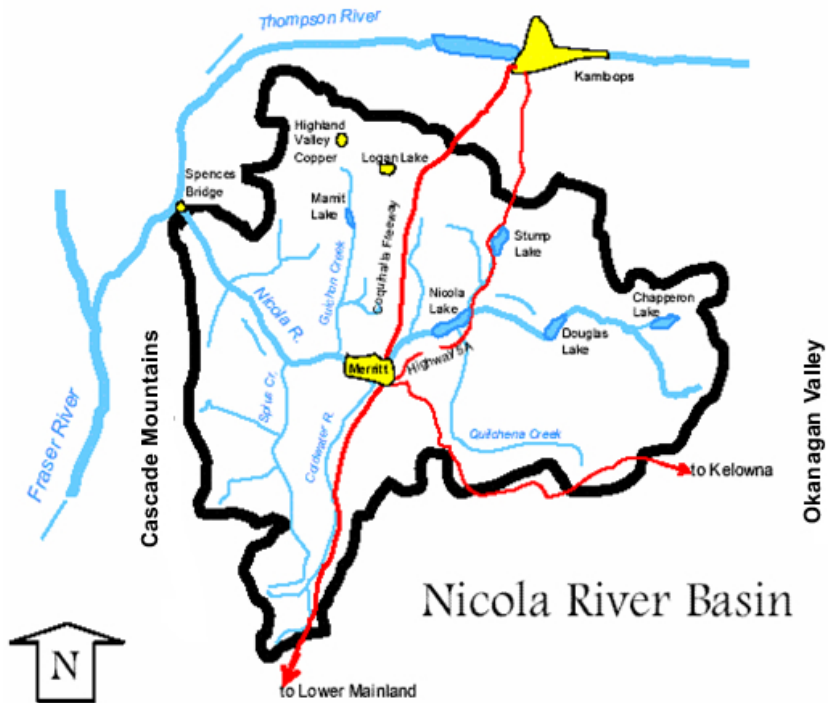


## Lessons Learned

- Need a simple and repeatable process
- Need to develop logical strategies for action ie. begin with upslope restoration as instream and estuarine restoration are impacted by upslope geological and hydrological processes
- Need to develop products that can be modified into funding proposals by local communities



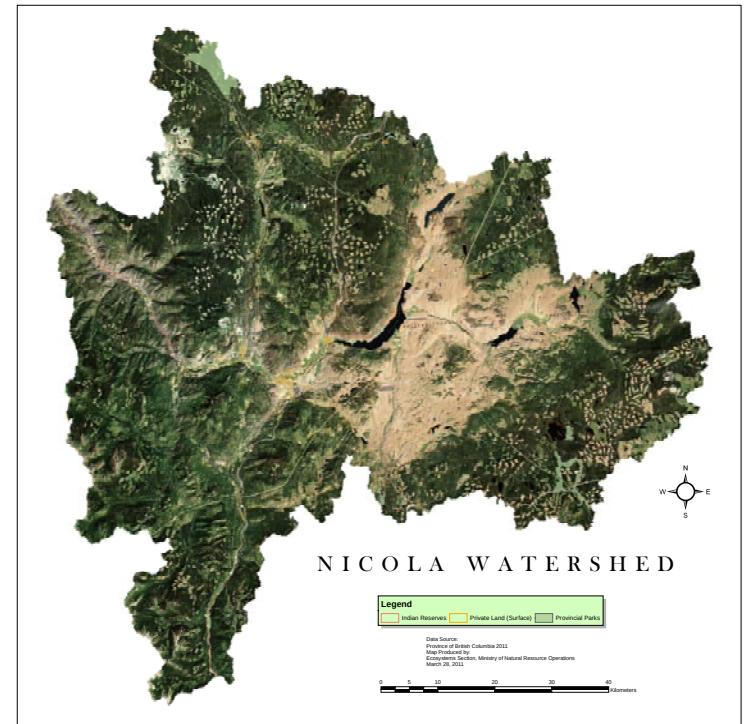
# Nicola Watershed RAMS



- What are the goals? Agree on the scope of the work
- What products/outcomes?

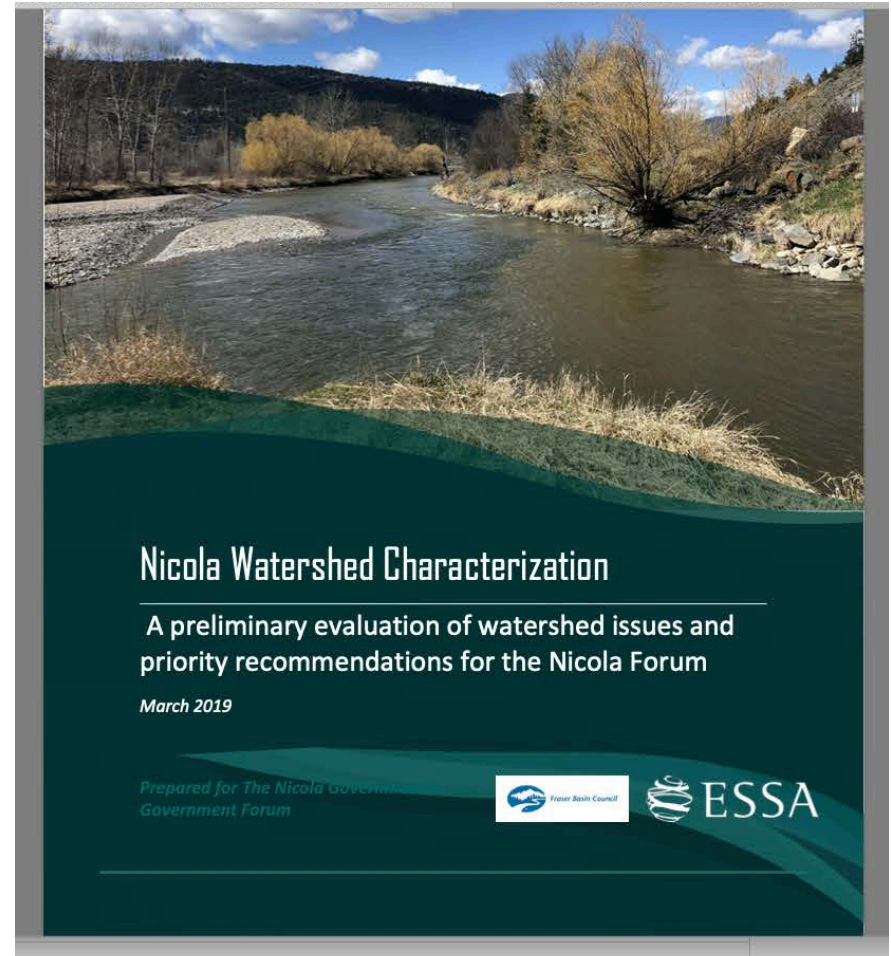
# Data Collation

- Who are subject matter experts?
- What data/reports can be collated?
- Interviews needed?
- Existing drone/lidar/habitat mapping?





- 368 spatial data layers
- Literature review
- Interviews
- Nicola Watershed Data Portal?



# Type of Information needed

- Historical and current stock status
- Biology- run timing, distribution, spawning & rearing areas
- Harvest
- Fish health
- Habitat status report/SHIM
  - GIS maps showing changes over time
  - Water quality data, flow rates, riparian cover & vegetation, pools, LWD, instream complexity, water levels, connectivity, food supply
  - Competitors, predators, invasive species, hatchery fish
  - Blockages, barriers, anthropogenic impacts, watershed road development and stream crossing density, water extraction, permitted waste management discharges, land cover alterations and usage etc
- Climate projections



# Nicola Watershed RAMS Workshop(s)



- Goals of the workshop(s)
- Attendees?
- Where and when?