Apr 27th, 1:30 PM - 3:00 PM

Assessing Futures of Two Cowichan River Pacific Salmon Species, Chinook and Coho, Using Scenario Analysis for Cumulative Effects Assessment

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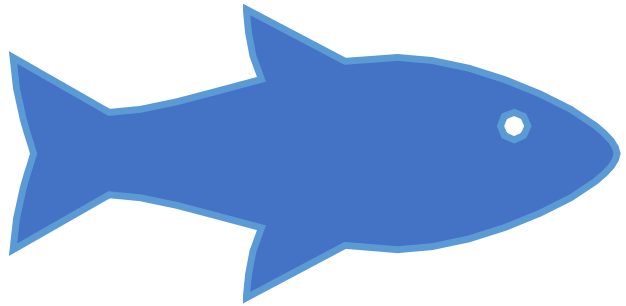

Arman K. Ospan (University of Victoria & Archipelago Marine Research)

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Acknowledgements

This talk is dedicated to the memory of Dr. Johannes Feddema.

We acknowledge with respect the Lekwungen, Songhees, Esquimalt and WSÁNEĆ peoples whose historical relationships with the land and water continue to this day.

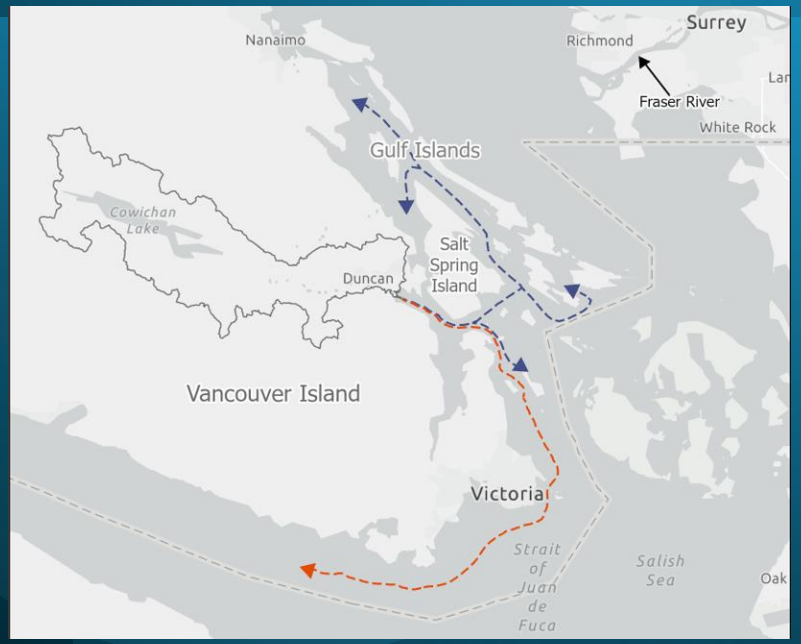
Objectives

- Assess the future of the two Pacific salmon species native to Cowichan River
- Examine how local (land use) and global (climate change) forces act cumulatively to affect salmon survival
- Evaluate scenario analysis combined with quantitative model development as a method for cumulative environmental assessment

Methodology

- We examined linkages between salmon survival, stressors and effect drivers – effect pathways
- We built quantitative models to predict changes in salmon survival in response to changes in effect drivers
- We developed scenarios of divergent futures for the most important drivers
- We applied our models to each scenario to project future salmon survival

Assessment scope



- Geographic scope:
  - Cowichan River watershed, Strait of Georgia, Juan de Fuca Strait, Pacific Ocean
- Temporal boundaries:
  - present & future (2050s)
- Two anadromous Pacific salmon species native to Cowichan River:
  - Chinook salmon (*Oncorhynchus tshawytscha*)
  - Coho salmon (*O. kisutch*)
- Effect indicators:
  - natural survival in both freshwater and marine environments

Present and future scenarios

Climate change:
Based on Global Climate Models (GCM) projections for 2050 using RCP 8.5 (business as usual) scenario

Land use:
Based on the current use, regional plans, trends and land available for future developments

Climate change		
Present day (Base model)	**Future / Moderate**	**Future / Extreme**
1980-2010	10th percentile values of RCP 8.5	90th percentile values of RCP 8.5
Land use		
Present day	**Future / Development**	**Future / Conservation**
27.3% urbanized, clear-cut and agricultural 65.5% forested	61.1% urbanized, clear-cut and agricultural 31.7% forested	5% urbanized, clear-cut and agricultural 87.8% forested

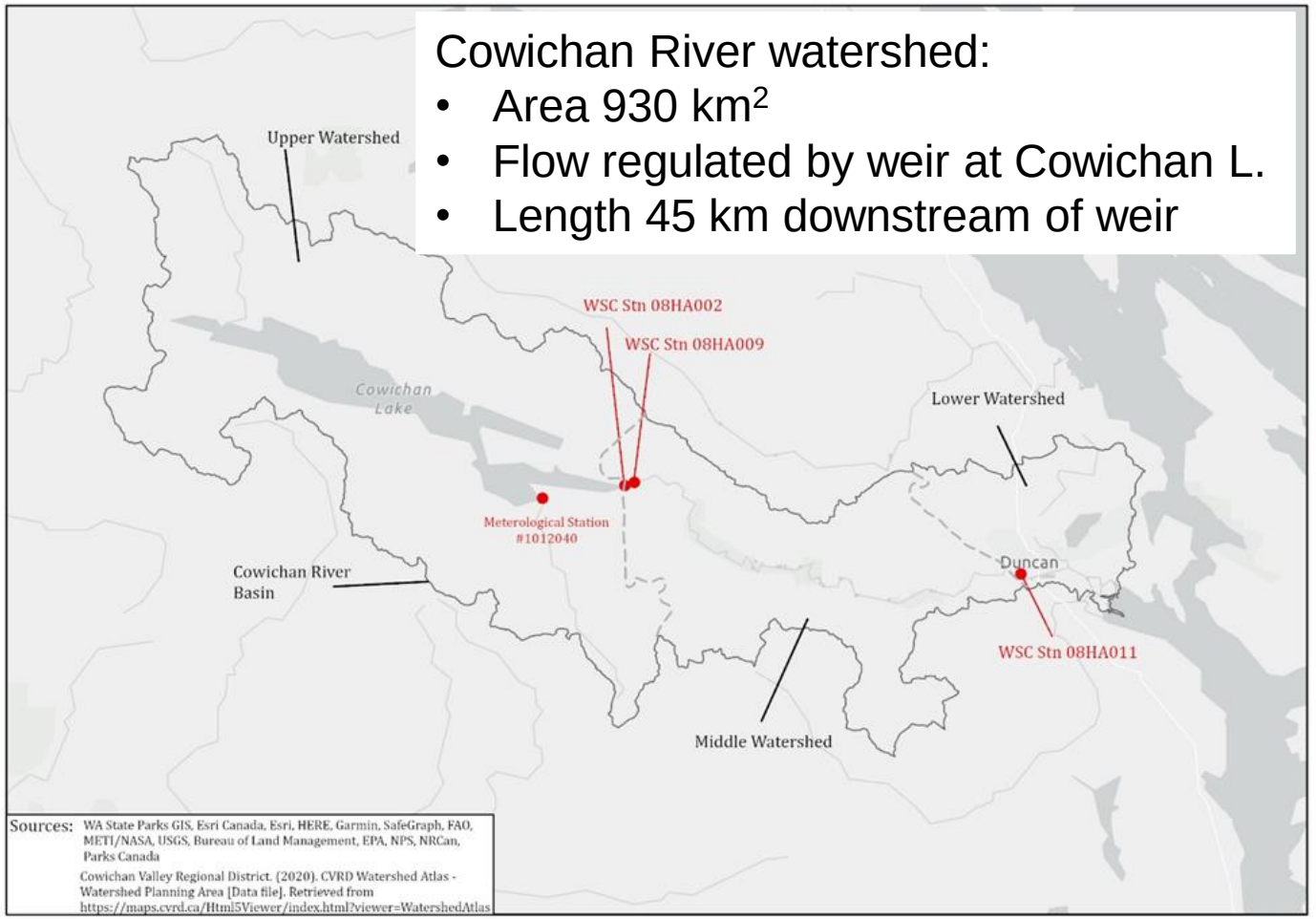
Cowichan Chinook:

- Spawning run Oct-Dec
- Emerge March & May
- Juveniles <90 days in river, leave June-Sept
- 1.5-4.5 yr marine, in Strait of Georgia

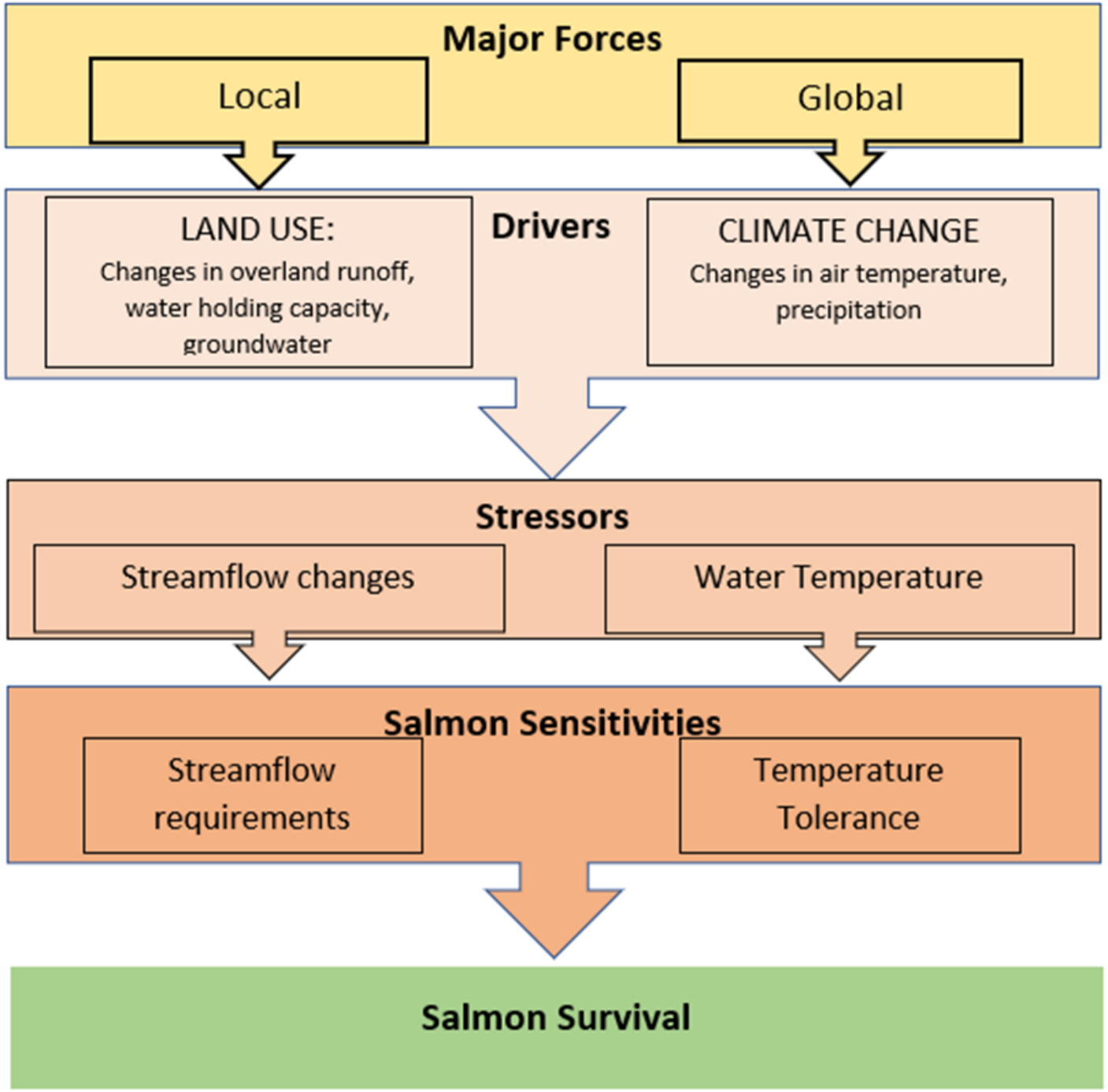
Cowichan Coho:

- Spawning run Oct-Dec
- Emerge March
- >1 yr in river, leave Apr-May, short period in estuary
- Used to spend entire marine phase in SoG; now move through SoG to ocean in Oct-Dec
- <1.5 yr marine

The assessment is based on salmon life histories and physiological thresholds relative to statistical and hydrological models we developed for environmental conditions in their freshwater and marine habitats

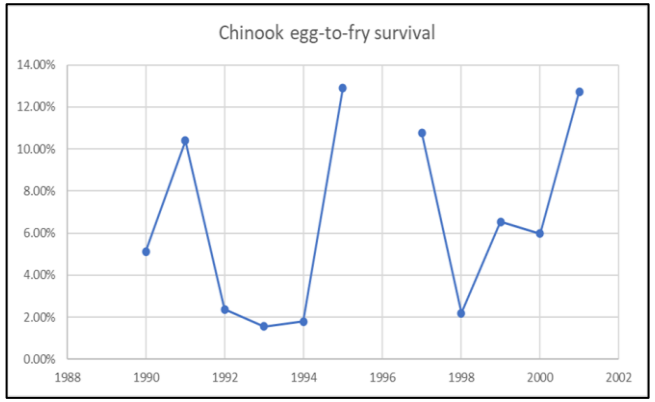


Effect Pathways: Freshwater



Freshwater Environmental Conditions and Development of Salmon Survival Modelling

1. Compilation of survival data (from DFO) and 84 potential environmental variables



2. Selection of environmental variables

- Determine significant relationships of egg-to-fry survival vs. climate and stream flow variables
- Used Pearson correlations, Reverse stepwise linear regression analysis

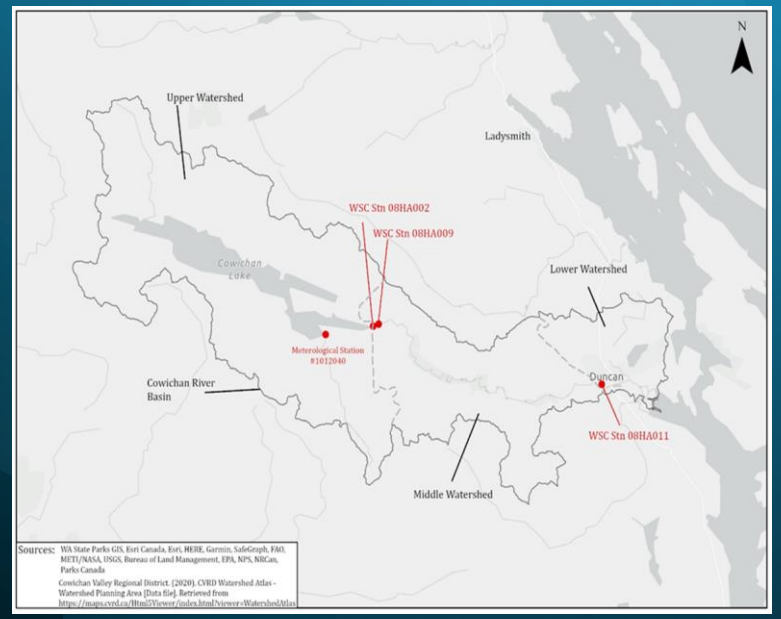
3. Development of threshold-based survival models for coho and chinook

- Determine stage-dependent temperature and streamflow survival thresholds from literature
- Calculate threshold-based survival rates:

$$Survival = \frac{\#\ Days\ within\ thresholds}{Total\ days}$$

- For Chinook, threshold-based survival rates are multiplied by regression-based survival rates
- For Coho, threshold-based survival rates are multiplied by an average survival rate of 3.4% estimated from the literature

Predicting Future Freshwater Temperature and Discharge



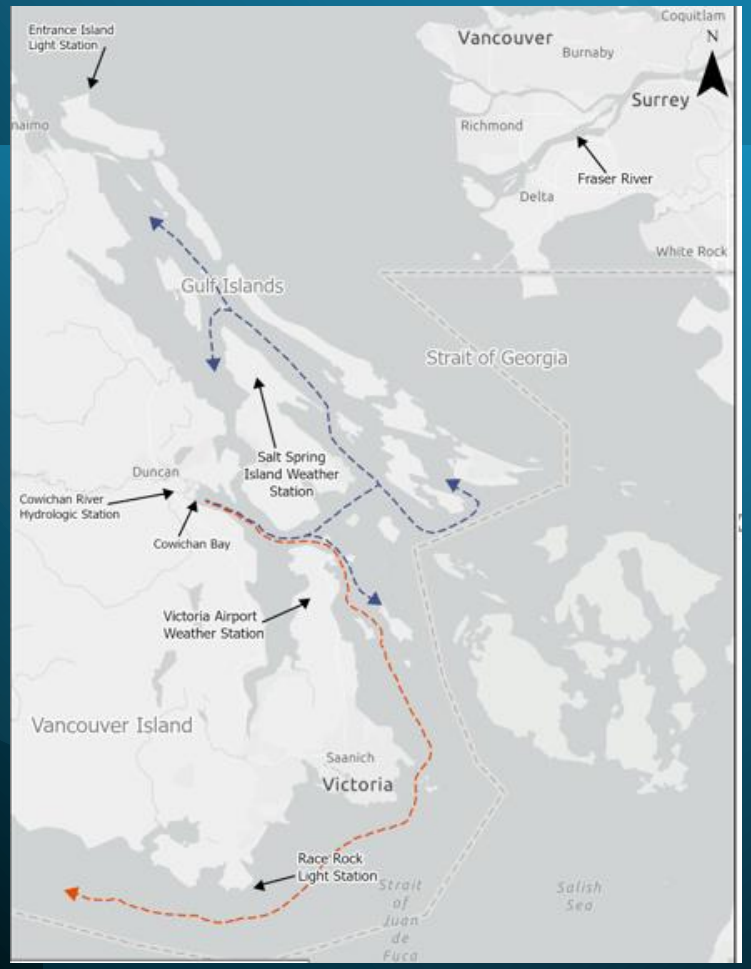
Future discharge conditions were based on a Hydrologic (Water Balance) Model (developed by Dr. Feddema):

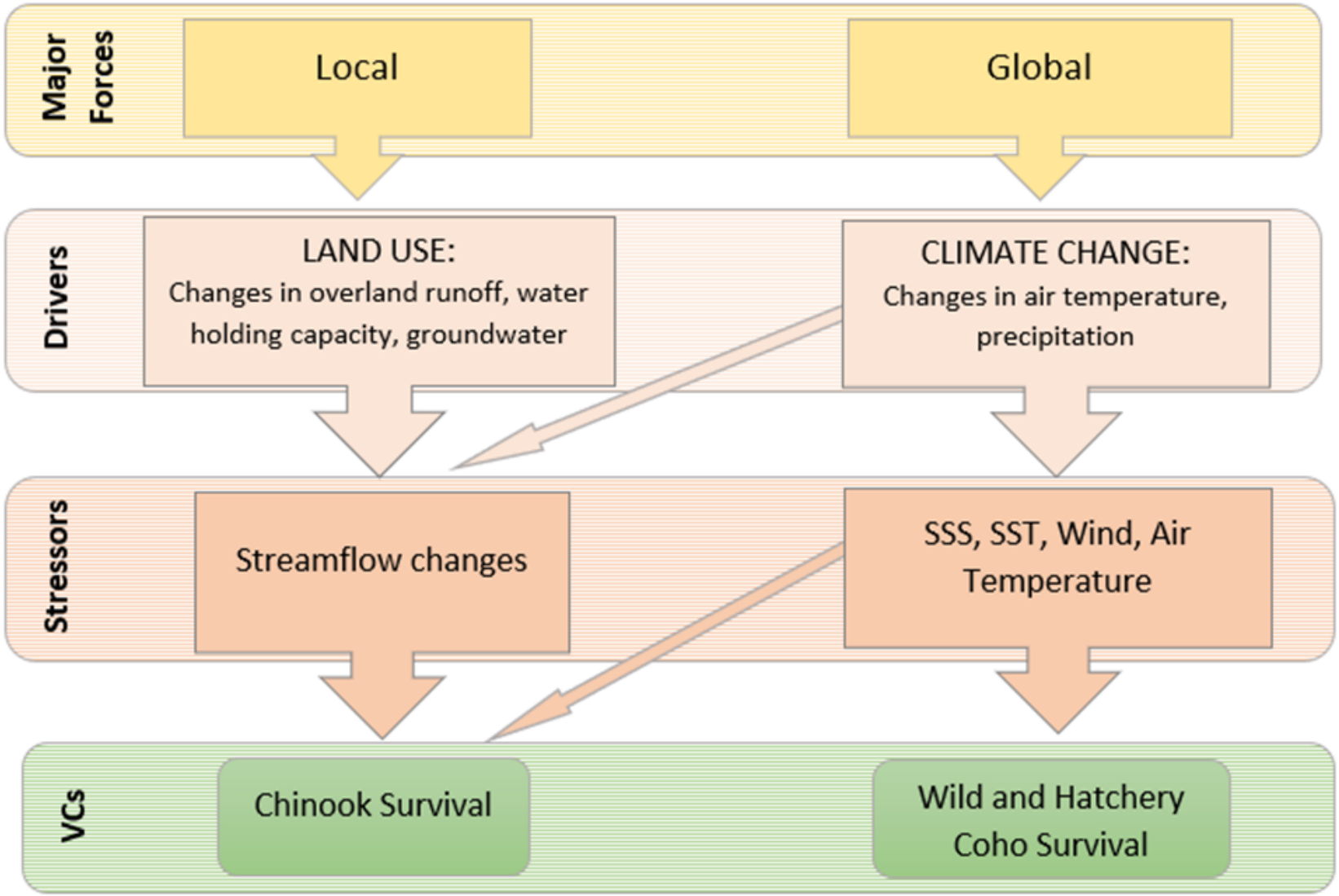
- Input parameters:
  - air temperature and precipitation
  - land use
- Output: streamflow (discharge)
- High explanatory power (based on 30 years data): d_r=0.87, R^2=0.85

Future water temperatures based on a statistical temperature model:

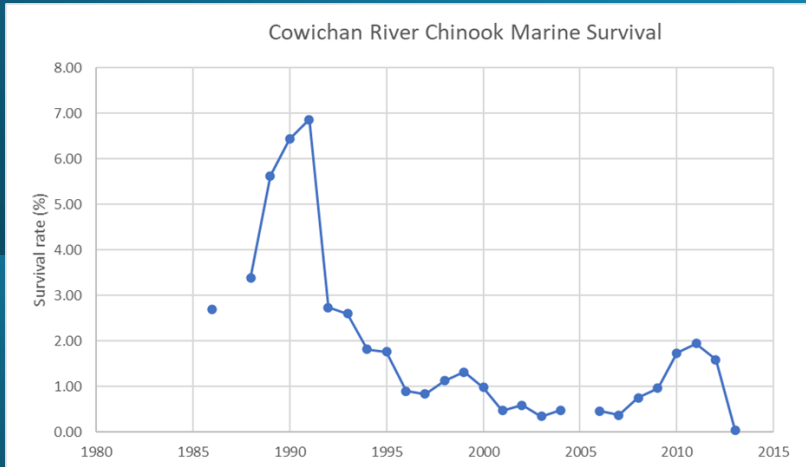
- Pearson correlation with climate and discharge variables and stepwise linear regression analysis
- Resulted descriptors (p<0.05)*:* 20-day average air temperature (direct correlation) and average daily discharge (inverse correlation). R^2=0.94

Pathway Modelling, Marine Environment

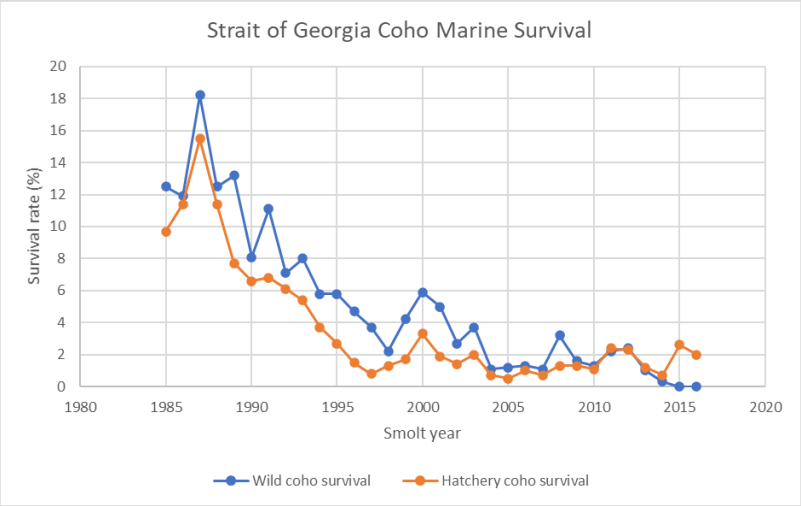




Marine survival
Cowichan Chinook



Cowichan Coho



Marine survival of both Chinook and Coho (wild and hatchery-raised) was strongly correlated ($p < 0.05$) to environmental variables in the first year of marine residence.

Variables that explained >75% of marine survival were:

For Chinook:

- Sea surface temperature (SST) in Strait of Georgia (Entrance Island) in summer (particularly July) (-ve)
- Cowichan River discharge in October (-ve)
- Air temperature in October (mean minimum daily) at Salt Spring Island (+ve)

For Coho:

- Sea surface salinity (SSS) in Juan de Fuca Strait (Race Rock) (+ve)
- Summer air temperature at Victoria Airport (-ve)
- Extreme monthly wind gust speed at Victoria Airport (-ve)

Scenario Development

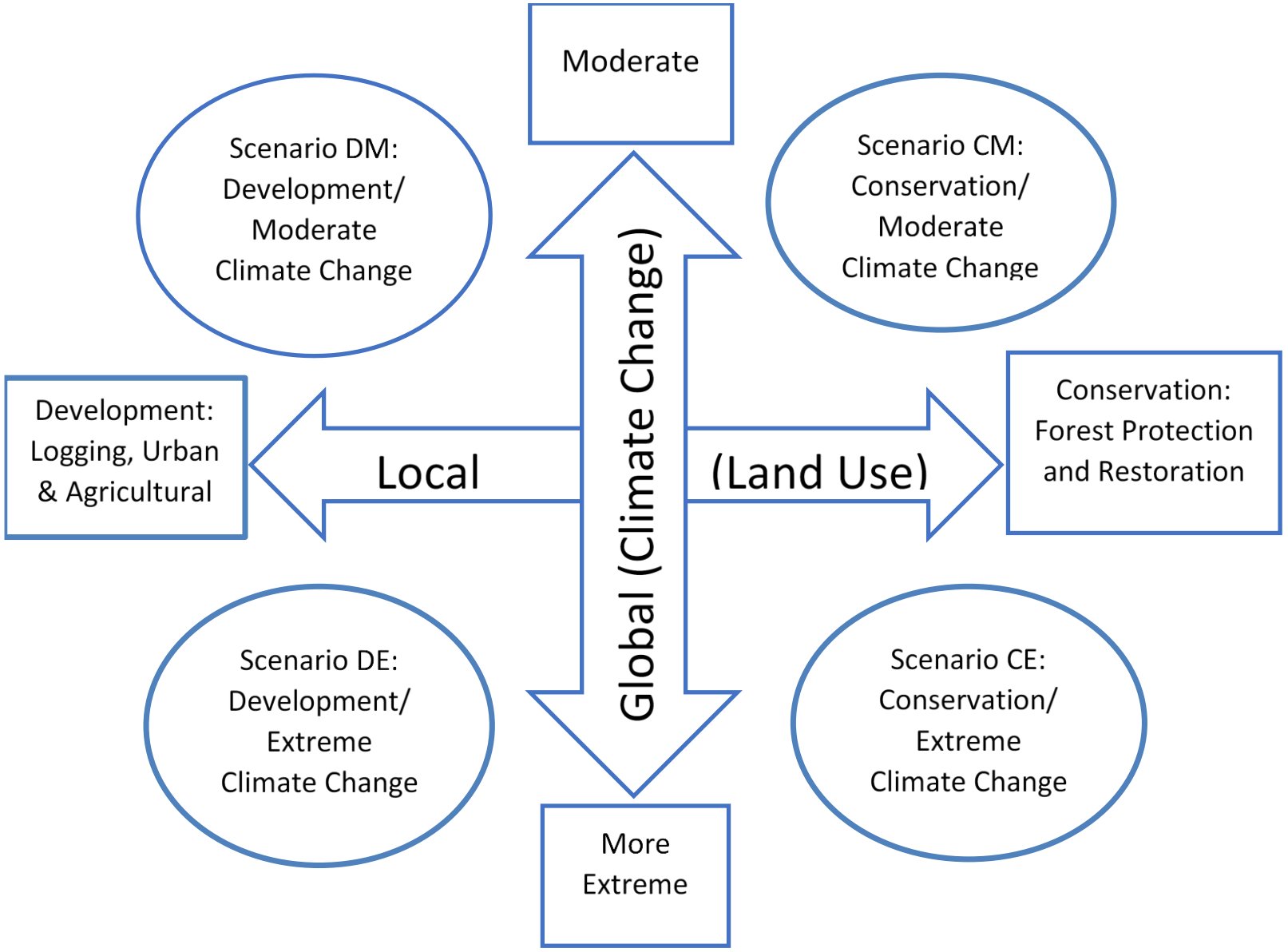
Present-day (base) scenario & 4 futures combining:

Climate change:

- **Moderate**: 10th percentile values of RCP 8.5
- **Extreme** : 90th percentile values of RCP 8.5

Land use:

- **Development:** increase urbanized, clear-cut and agricultural areas
- **Conservation:** increase forested areas



Cowichan River Chinook mean present (base) and projected 2050 survival rates

Land use (Development, Conservation) and Climate change (Extreme, Moderate)

Does not survive in Extreme climate; ~1/3 production in Moderate climate

Scenario	Base	DE	CE	DM	CM
Freshwater survival based on regression (%)	5.79	1.85	2.20	4.17	4.42
Freshwater survival based on thresholds (%)	96.35	88.92	92.92	98.39	98.98
Overall freshwater survival estimate (%)	5.58	1.64	2.04	4.10	4.38
Marine survival (%)	1.30	-0.16	-0.08	0.56	0.63
Overall survival (%)	0.07	-0.003	-0.002	0.02	0.03
Production per spawner	1.46	0.00	0.00	0.47	0.56

Strait of Georgia wild Coho mean present (base) and projected 2050 survival rates

Land use (Development, Conservation) and Climate change (Extreme, Moderate)

Does not survive in Extreme climate; status quo under Moderate climate

Scenario	Base	DE	CE	DM	CM
Freshwater survival based on literature (%)	3.40	3.40	3.40	3.40	3.40
Freshwater survival based on thresholds (%)	81.02	58.36	66.34	86.40	88.52
Overall freshwater survival estimate (%)	2.75	1.98	2.26	2.94	3.01
Marine survival (%)	5.00	-6.32	-6.32	4.77	4.77
Overall survival (%)	0.14	-0.13	-0.14	0.14	0.14
Production per spawner	1.72	0.00	0.00	1.75	1.75

Strait of Georgia hatchery Coho mean present (base) and projected 2050 survival rates

Land use (Development, Conservation) and Climate change (Extreme, Moderate)

Does not survive in Extreme climate; ~1/4 survival in Moderate climate

Scenario	Marine survival (%)
Base Scenario	3.32
Scenario DE	-8.73
Scenario CE	-8.73
Scenario DM	0.88
Scenario CM	0.88

Conclusions

- None of the studied populations are likely to survive in extreme climate change scenarios
- Survival was more affected by climate than by land use
- Freshwater discharge changes associated with land use affected survival less than temperature changes, but both affect freshwater and (significantly for Coho) marine survival
- Survival was better for wild than for hatchery-raised Coho
- The combination of scenario analysis with quantitative modelling is a useful tool for examining cumulative effects associated with a range of possible futures