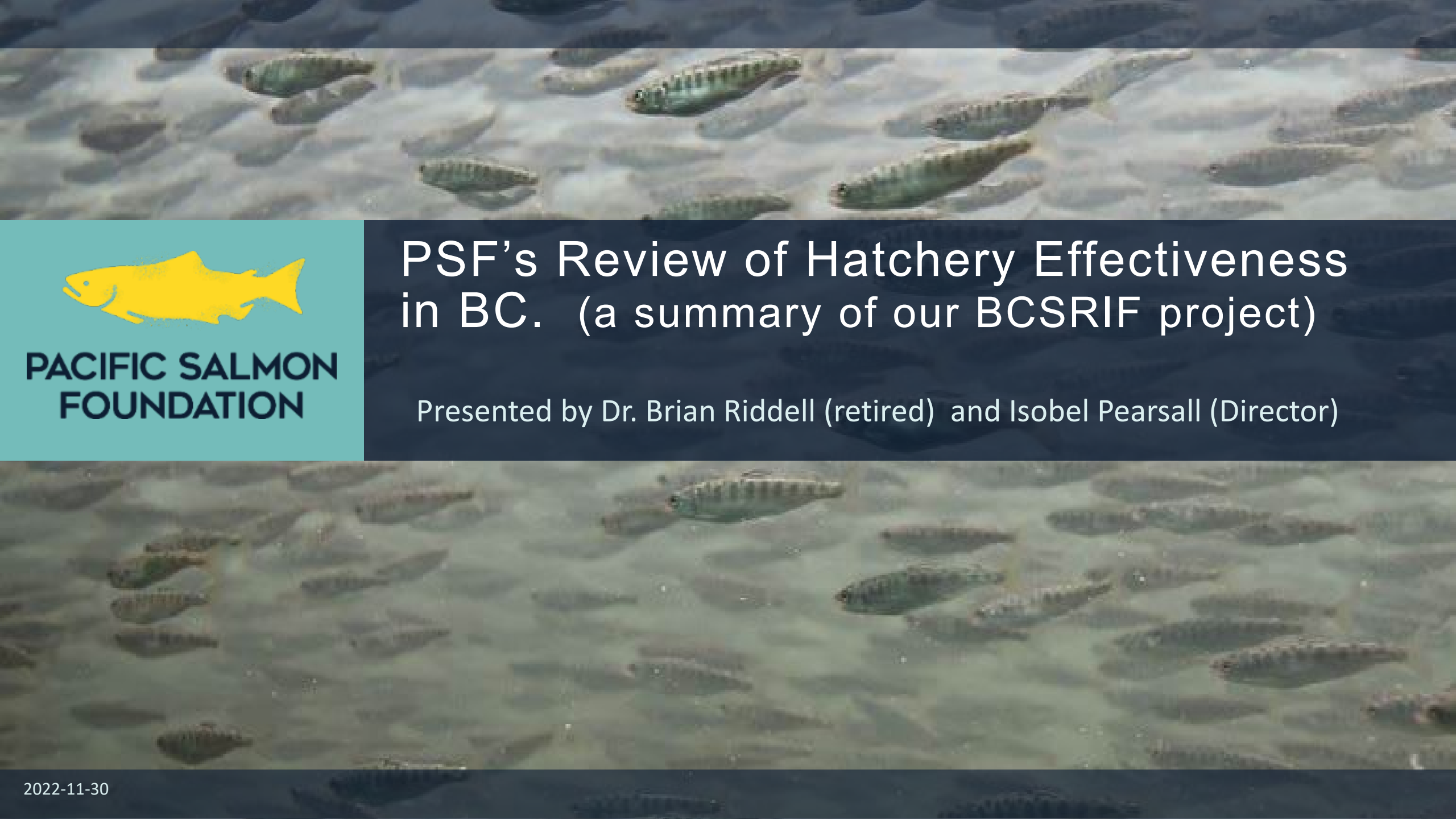


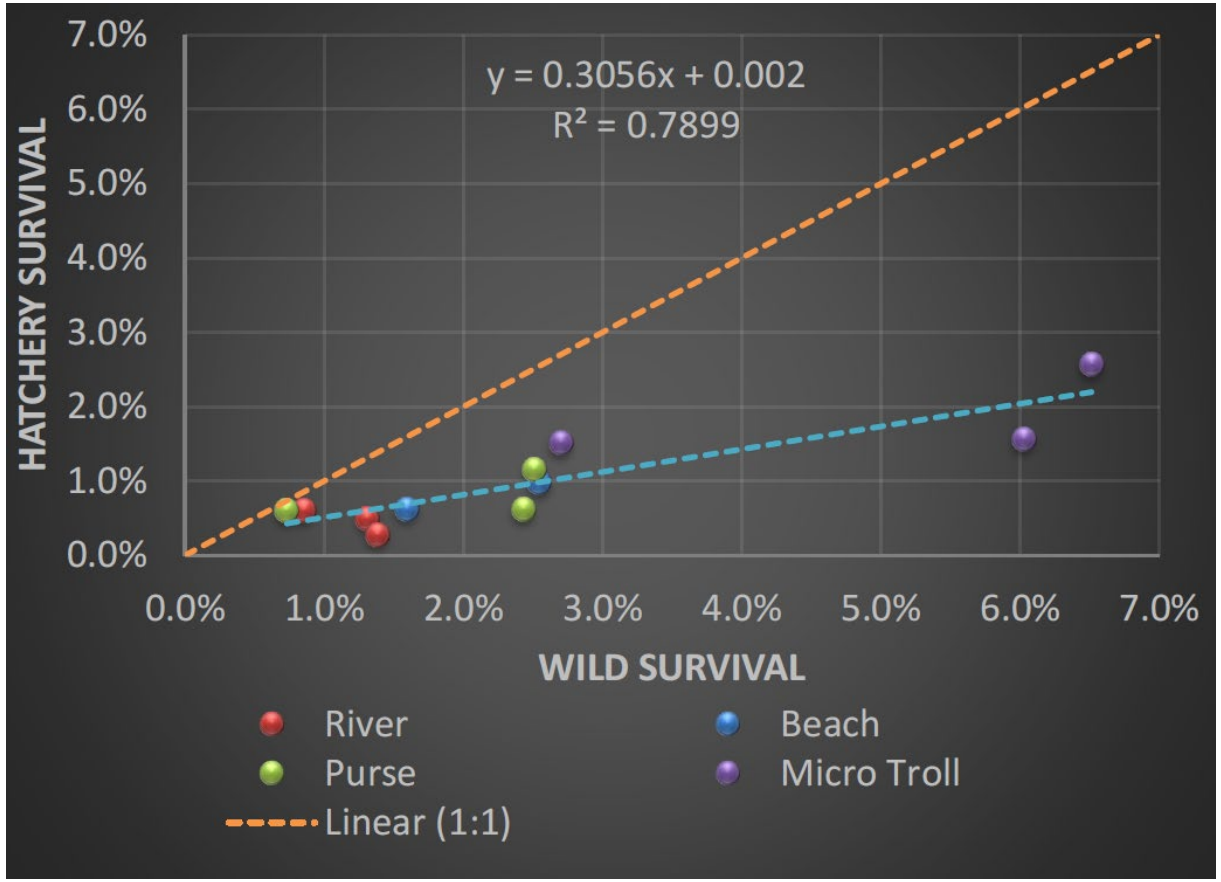
PACIFIC SALMON FOUNDATION

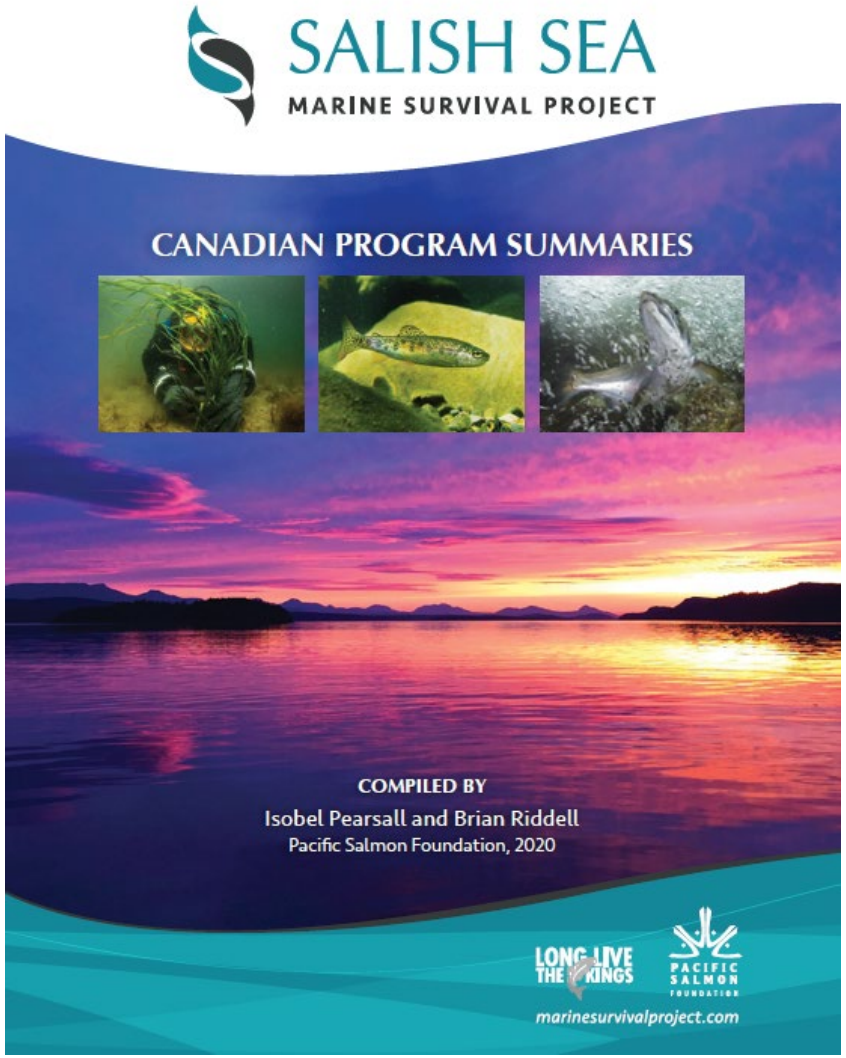
PSF's Review of Hatchery Effectiveness in BC. (a summary of our BCSRIF project)

Presented by Dr. Brian Riddell (retired) and Isobel Pearsall (Director)

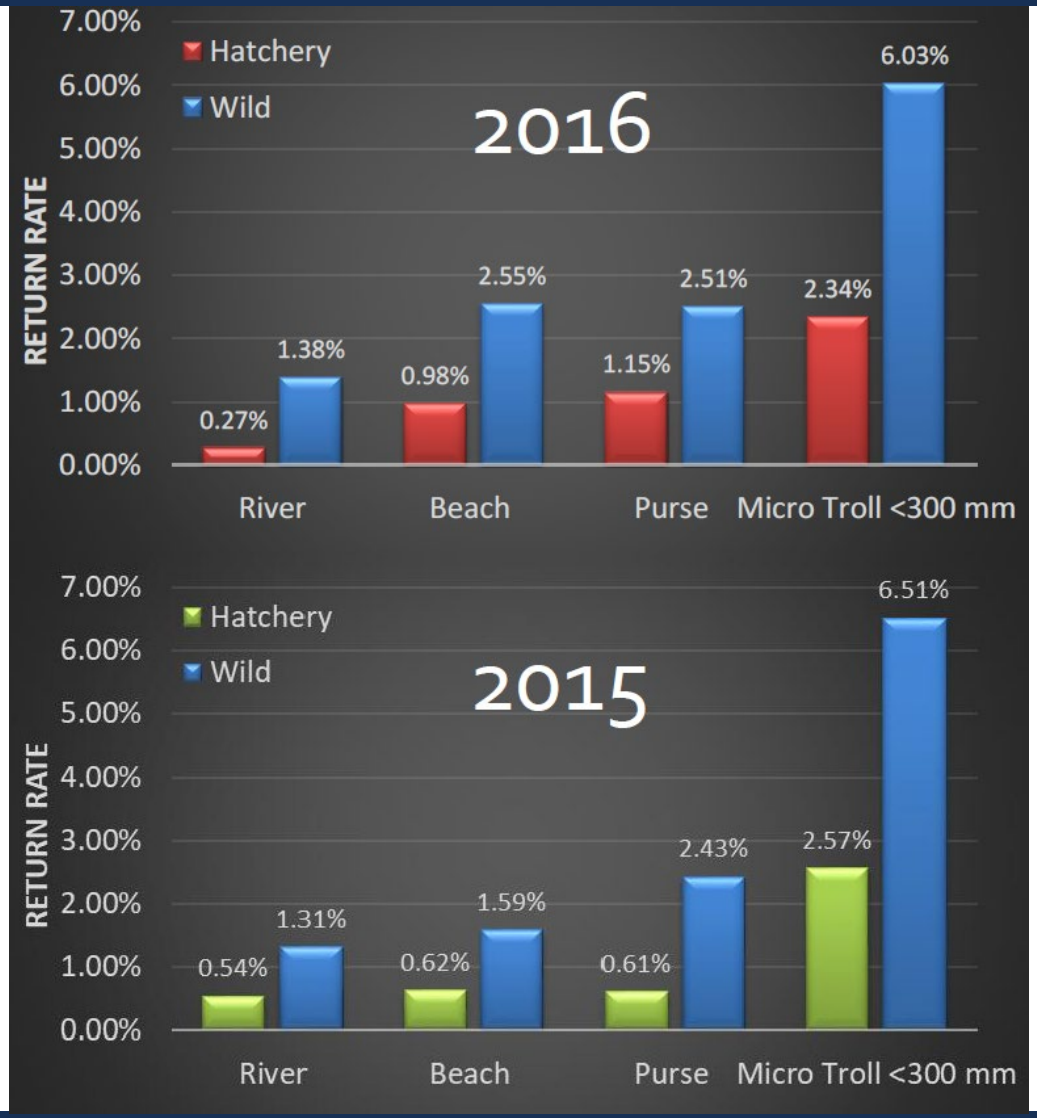
Salish Sea Marine Survival Project

The Hatchery Effectiveness Project developed from the SSMSP and our studies of Cowichan Chinook survival.





Salish Sea Marine Survival Project



2014-2017 over 90,000 PIT tags deployed (paired tests)

PSF's Review Team

PACIFIC SALMON FOUNDATION

BCSRIF: Hatchery Effectiveness Review

Andy Rosenberger, Sam James, Ben Fortini, Ravi Maharaj, Mark Giles, Aimee Lee Houde, Wendy Vandersteen, Cam West, Isobel Pearsall, Jason Hwang, Brian Riddell

Independent science advisory committee: Craig Busack, Mike Ford, Tim Yesaki, Jeff Young, and Dave Willis

Analytical Advisory Group: Jon Moore, Michael Folkes, Sean Cox, Carl Walters

Project Components … separate reports per topic

1. **Molecular tools (Genomics, 2 reports)**
2. **Literature Review (final edits)**
3. **Role of community hatcheries (final edits)**
4. **Release strategies review (accepted, CJFAS)**
5. **Trends in biological traits (complete, in review)**
6. **Hatchery effectiveness (incomplete)**

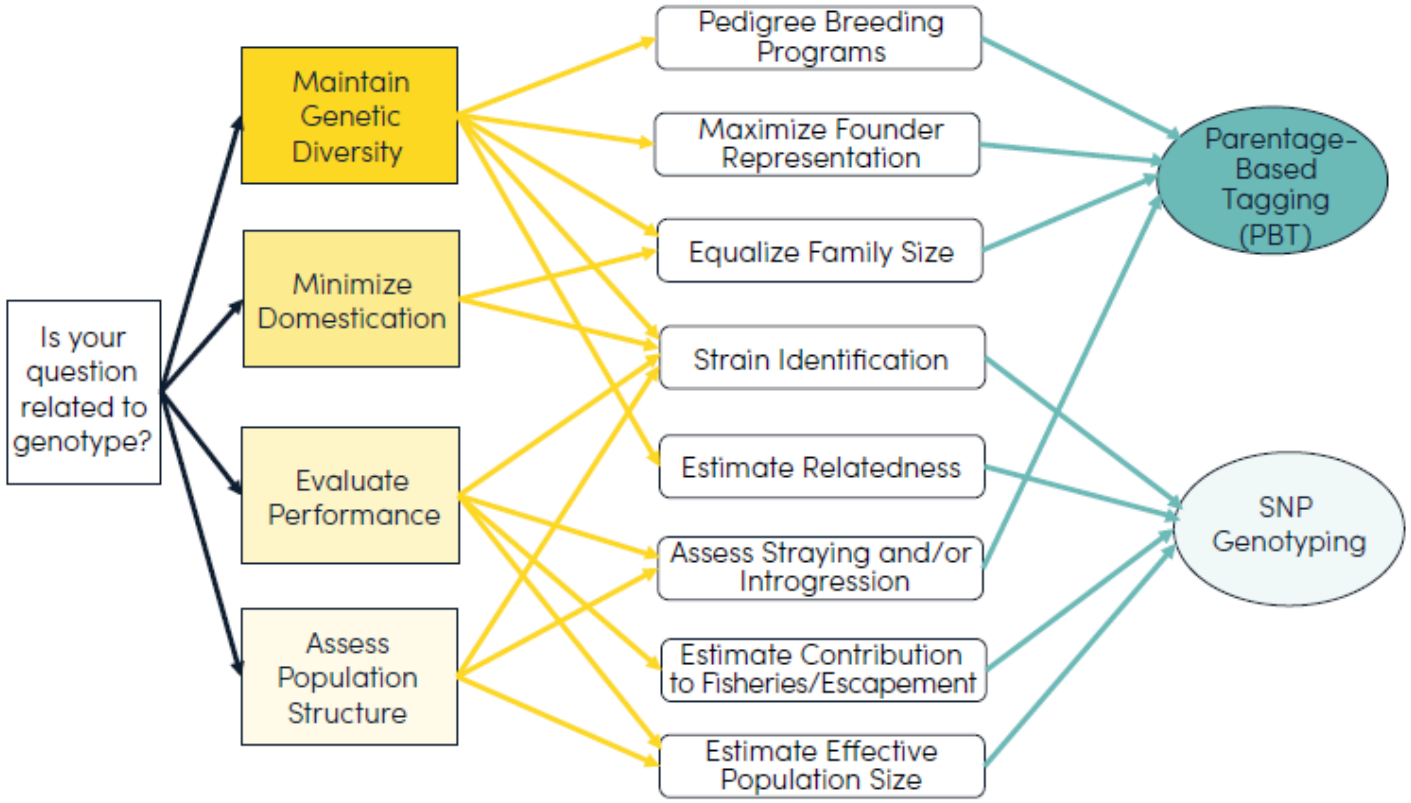
   Harvest and rebuilding
7. **Hatchery-wild interactions (spatial effects, incomplete)**
8. **Spawning Channel Review (incomplete, not included)**

BCSRIF objective summary:

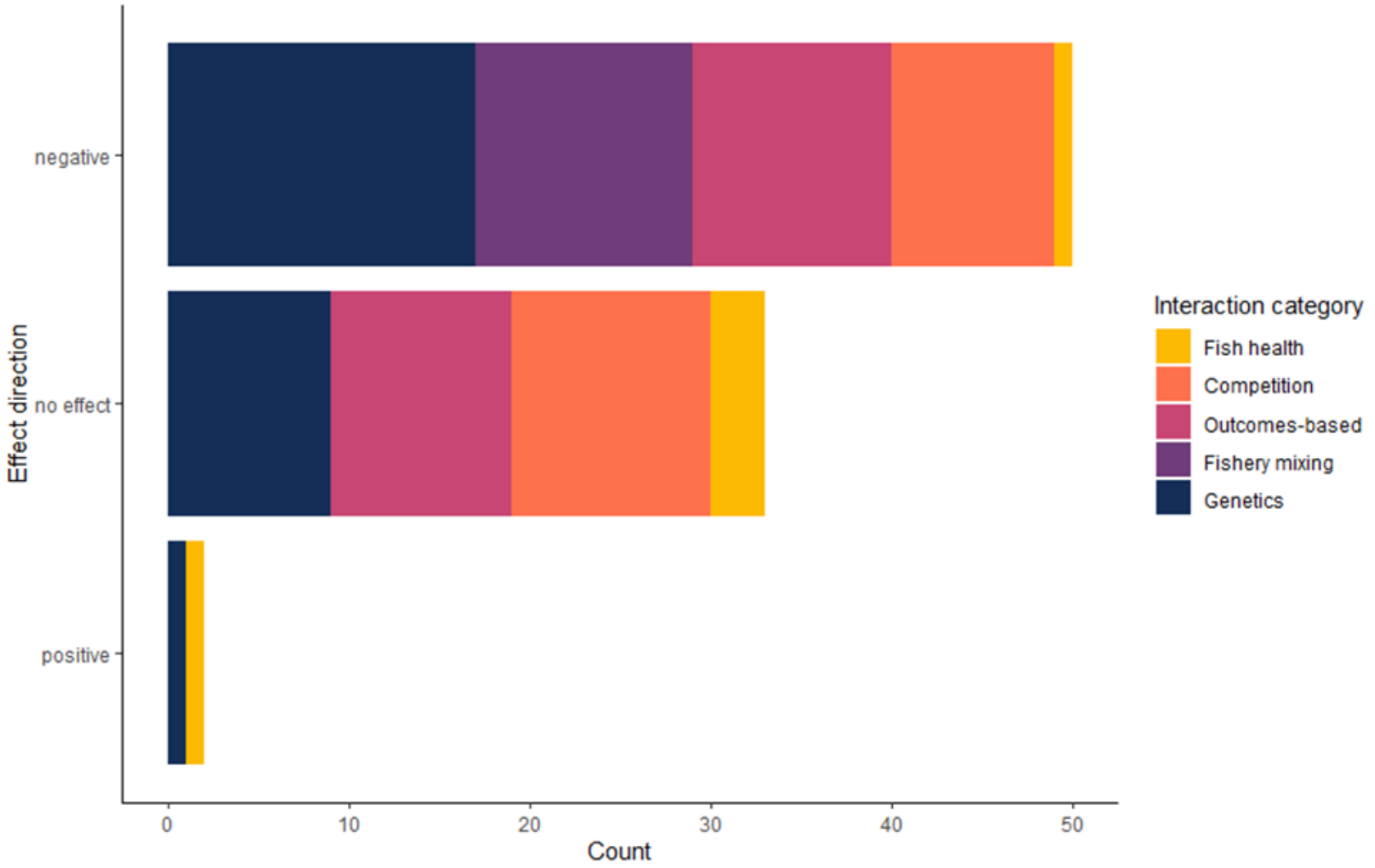
The aim of this project is to examine the effectiveness of current production, identify scientific advancements in recent years that may be applied to increase effectiveness, and ultimately inform the joint production of hatchery-based and wild Pacific salmon for BC communities and ecosystems.

1. Molecular tools ('omics report & applications)

https://www.marinescience.ca/hatchery-effectiveness/reports-and-products/



2. Literature Review (Hatchery x Wild Interactions)



- Screened 1986-2021, 4 science databases, includes Atlantic and Pacific salmon
- 4974 citations screened down to 85 with key words related to ***interactions***
- Categories: Genetics, Competition, Population mixing, Fish Health, and Outcomes (productivity, size at return, and survival rates of wild fish)

3. Community Involvement Program review

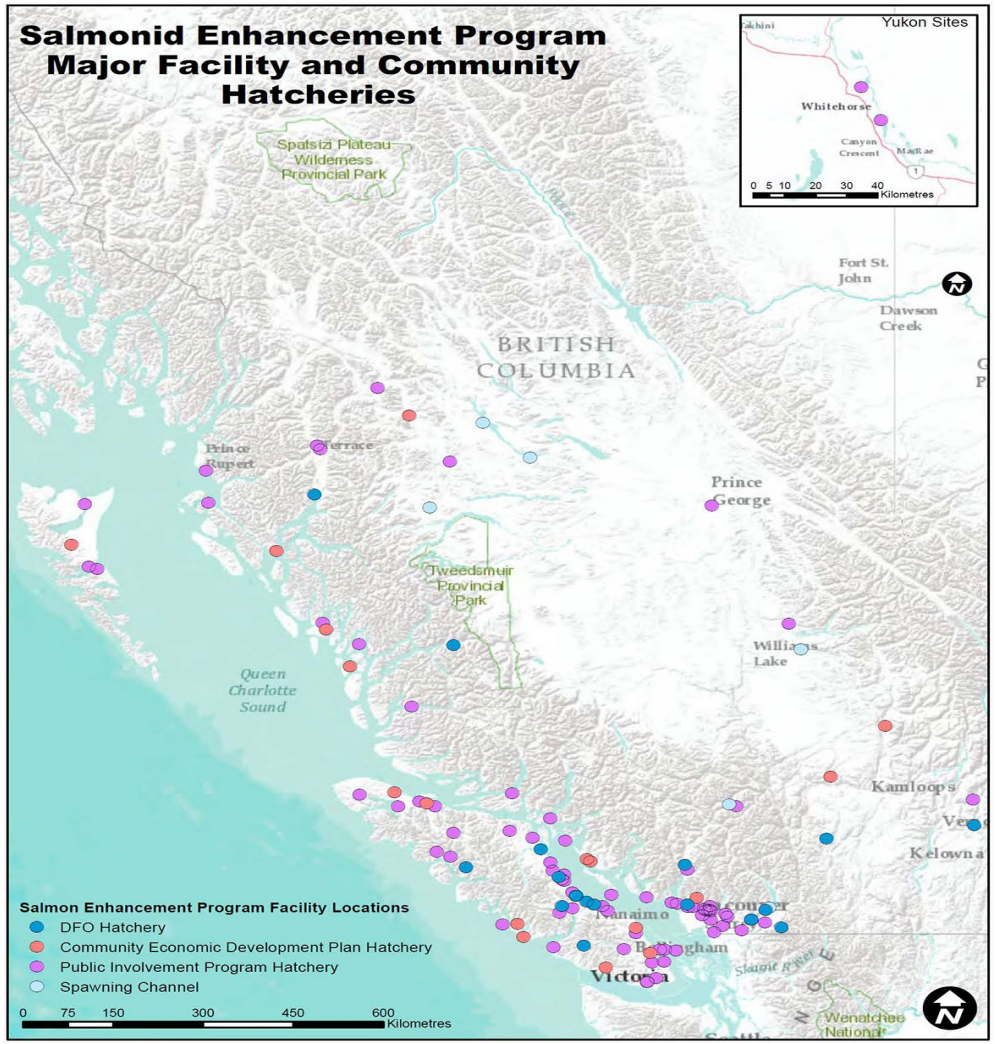
The Salmonid Enhancement Program for BC is a complex of major hatcheries and spawning channels (23 sites), plus the Community Involvement Programs (community-based facilities) supported by Community Advisors (15 in BC).

PSF review involved interviews with 32 CIP facilities that accounted for 44% of all projects and 82% of the total production (all species) from CIP facilities in 2021.

Integrated Fishery Management Plans include tracking of salmonid releases via SEP Post Season Production tables; identifies all releases with an objective to meet.

Major findings:

1) Vast majority of CIP releases consistent with the Plan, but inconsistencies with BMP's were noted.
2) 72% of facilities noted funding as their major issue.
3) Only 37% of projects were 'marked' for any evaluation!
4) PIP projects widely diversified and smaller than CEDP.



3. CIP Review recommendations

1. Increased support necessary, including $$ and staff advice
2. Improve communication between SEP and community organizations
3. Update technology and data sharing (common comment)
4. Ensure Compliance with Best Management Practices , use reviews/audits.
5. Essential to increase resources for evaluation of community projects

4. Release strategies review (complete)

Size and timing of hatchery releases influence juvenile-to-adult survival rates of British Columbia Chinook and coho salmon. Can. J. Fish. Aquat. Science (accepted).

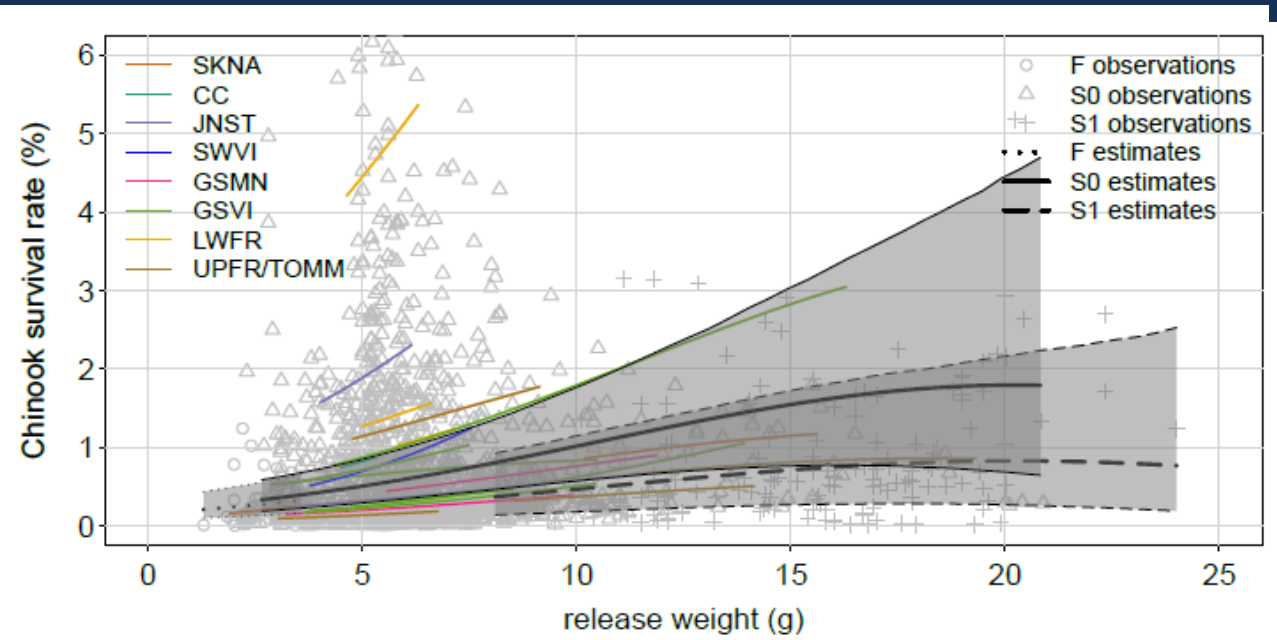
Authorship: James, Samantha, B. Doherty*, S. P. Cox*, I. A. Pearsall, and B. Riddell.
(* Landmark Consulting)

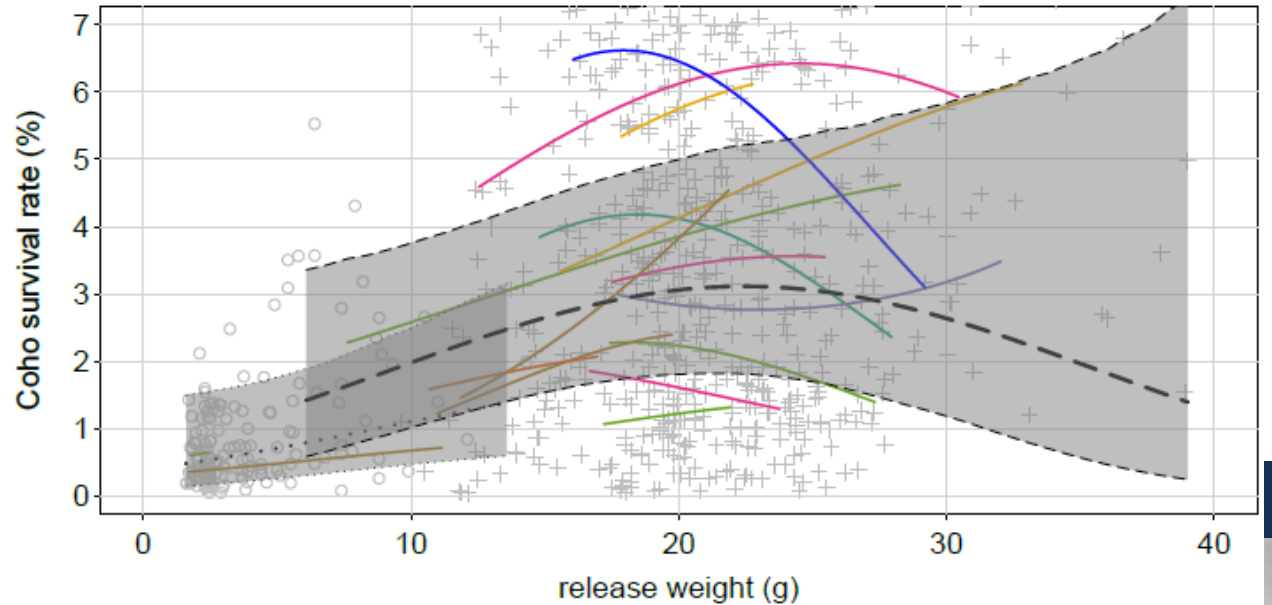
What can we learn for SEP's experience with release strategies to maximize the survival rates of Chinook and coho salmon? Includes 21 Chinook hatcheries, 16 Coho hatcheries, from 1972-2017 releases and recoveries involving multiple releases by year, life stage, and tag groups. Plus covariates for Sea Surface Temperatures, PDO, presences of Harbour seals and Orca, and YEAR Effects.

Extensive variability between hatcheries and years, against a background of declining survival rates between years; small increases in survival possible during this time period but predictability of effects would be very low.

4. Release strategies review

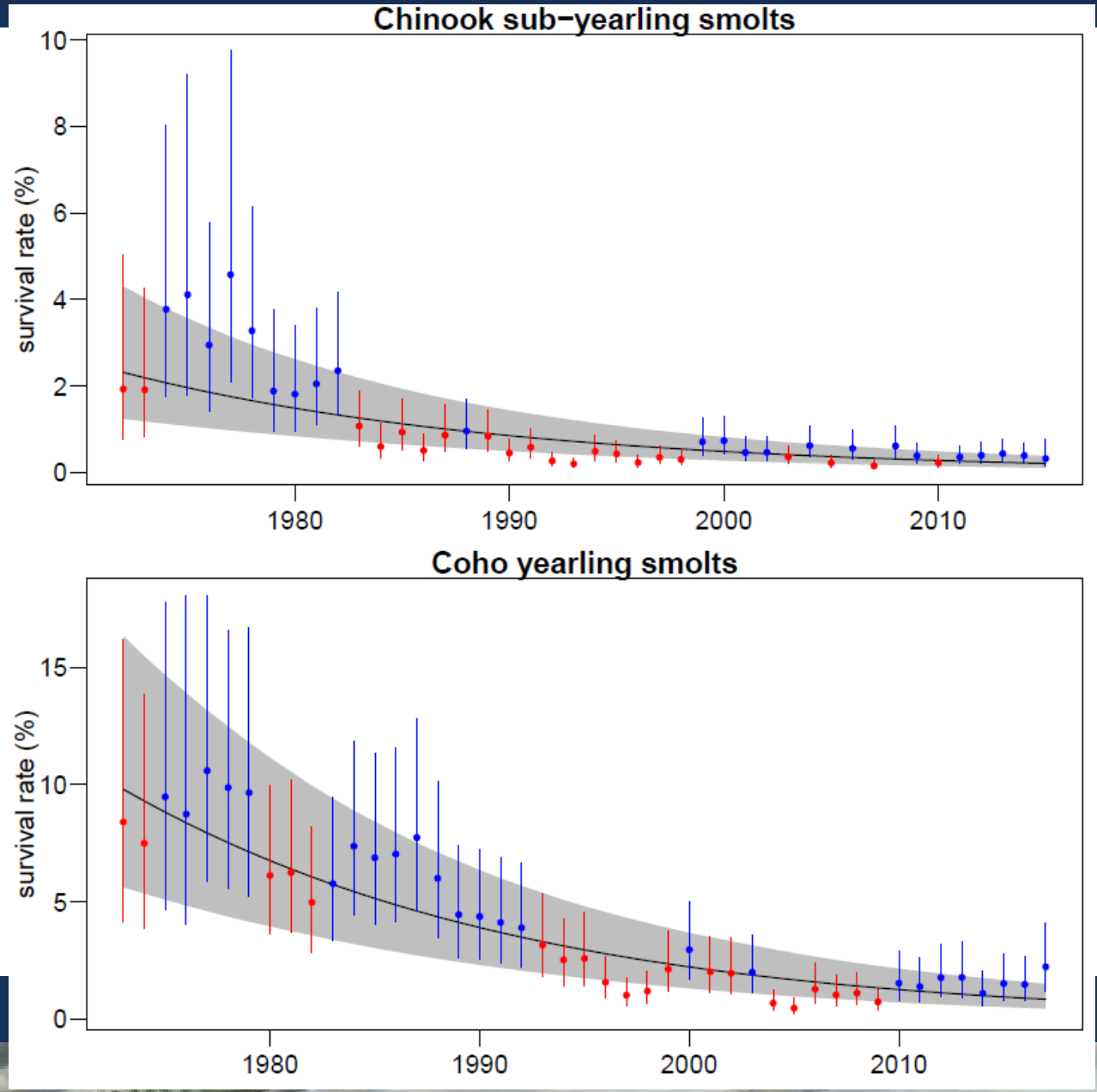
Figure 2. Hatchery average and hatchery-specific survival responses for the central 95% distribution of observed weights-at-release for each hatchery (top: Chinook salmon, bottom: coho salmon). The black line (mean posterior) and shaded areas (95% credible interval) indicate the average weight effect on survival across all hatcheries, while coloured lines show hatchery-specific estimates (MLEs) with different colours for each production area





4. Release strategies review

Figure 5. Linear temporal trends (ϕ_t; black line for mean posterior and grey polygon for 95% credible intervals) in ocean entry year effects on Chinook sub-yearling and coho yearling smolt survival with positive (blue circles) and negative (red circles) random year deviations (Δ^t; mean posterior with lines for 95% credible intervals).



5. Trends in Biological Traits … Key questions

Declines in Chinook stocks detected across the PNW, but extent and causes not well understood in BC

- How are mean size and age changing for BC stocks? (NOTE: time series involved vary between systems and were categorized as short, medium, long)
- How might these be influenced by changes in:
  - Age composition
  - Female composition
  - Size-at-age
  - Size by sex

5. Methods for Trend analyses

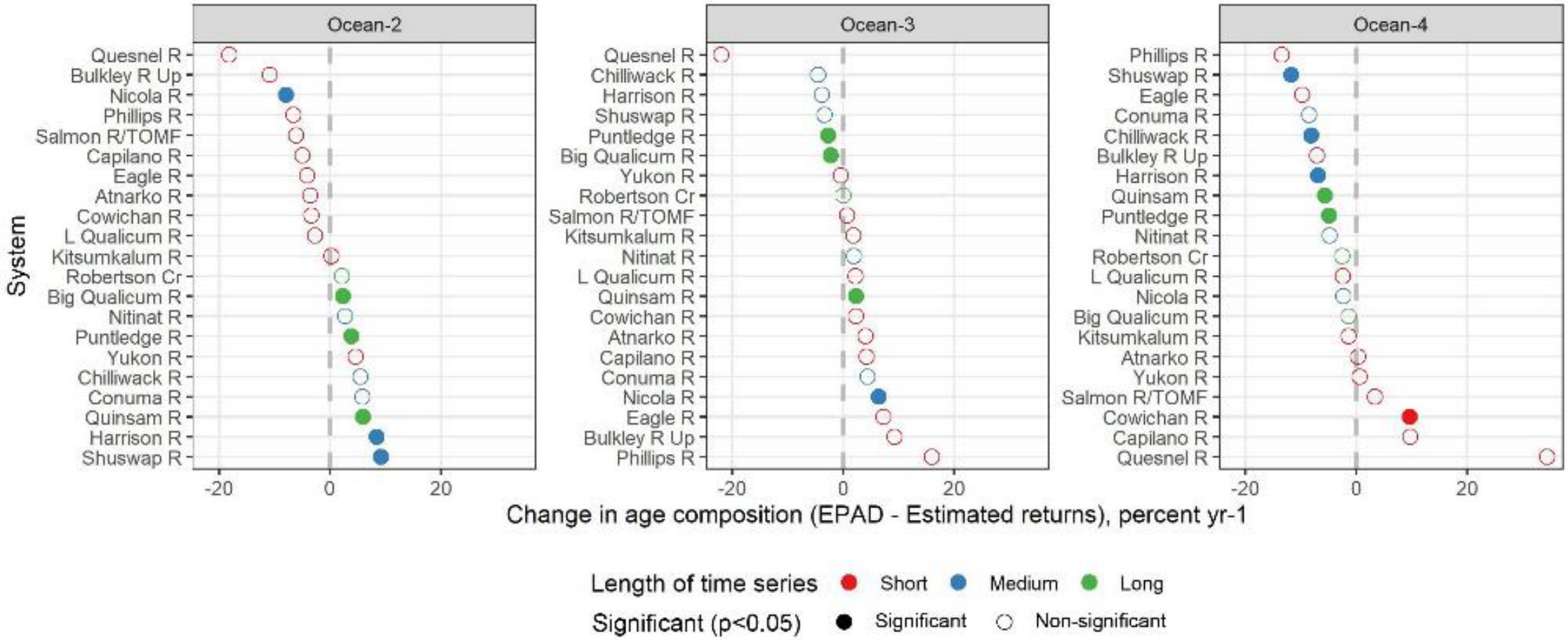
- Individual records of biological data for returning wild and hatchery origin Chinook salmon

System	Age	Sex	POHL

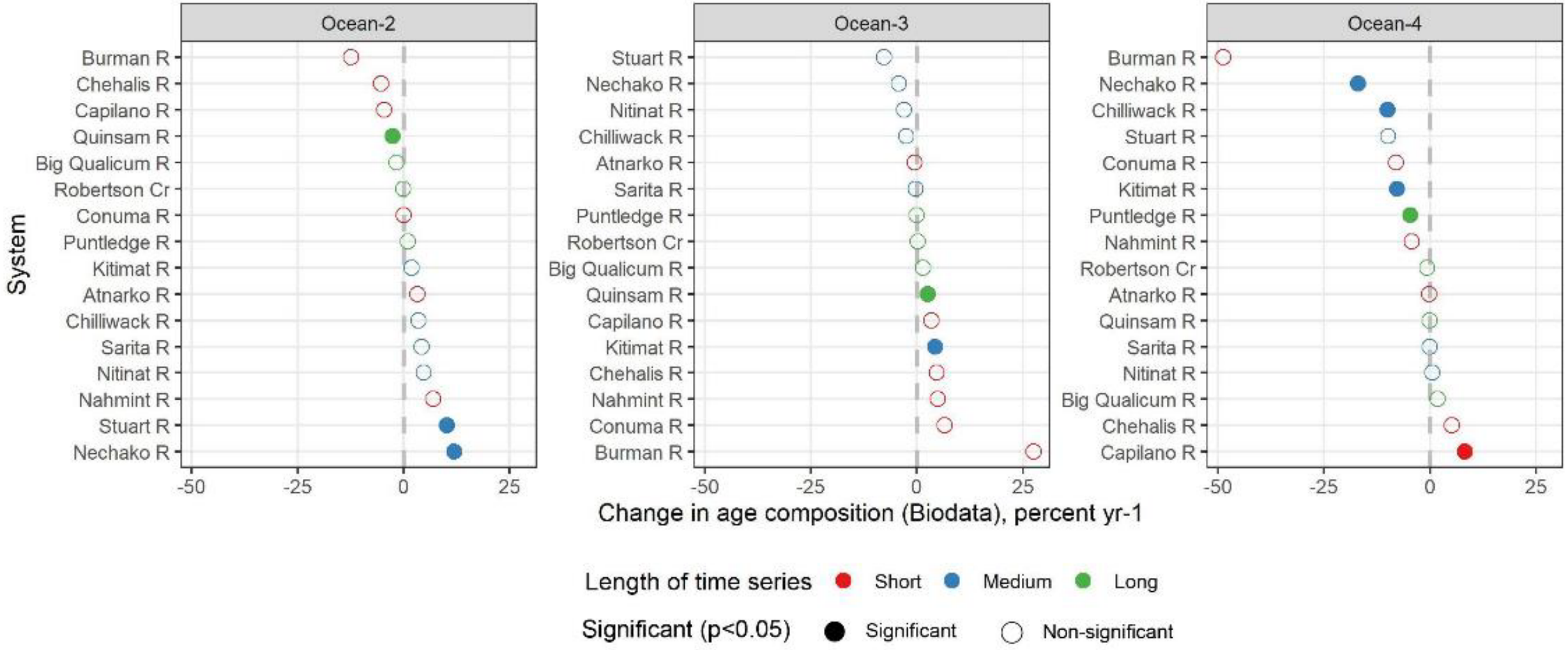
- Composed of a number of databases covering 75 BC Chinook systems

Database source	Source Type
DFO-SEP EnPro	Hatchery
DFO-SEP historical	Hatchery
Kitimat River Hatchery	Hatchery
Nechako Fisheries Conservation Program	Scientific
Regional Mark Information System (Ohlberger et al., 2018)	Fisheries

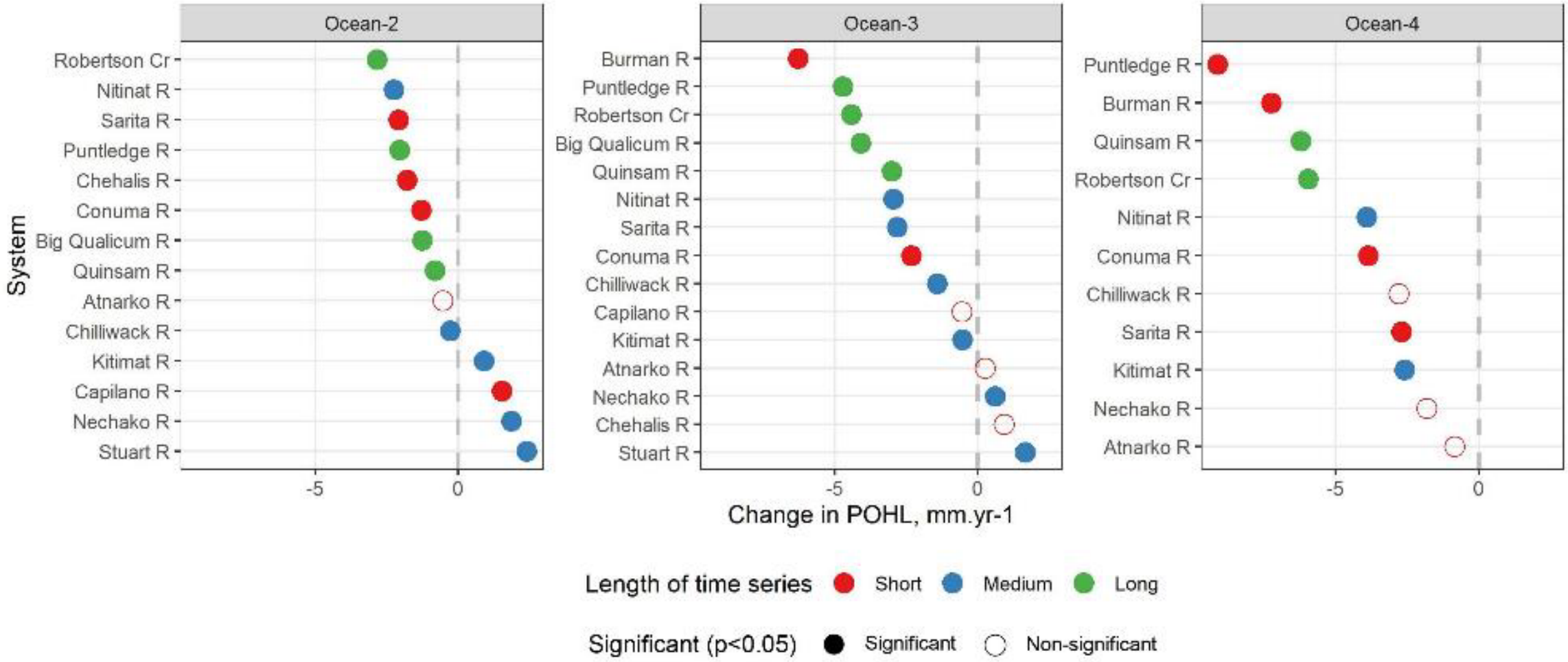
5. Age composition (EPAD – Estimated returns)



5. Age composition (Biodata)



5. Size-at-age (Biodata)



5. Key messages from Biological Trends review

- Need to address data issues as the vast majority of our time was spent on collating data sources (unable to address for coho and chum, and sockeye not even tried)
- EPAD and biodata was very useful, but the latter requires further processing and validation
- Evidence for BC Chinook salmon indicates declines in size @ age and sex, and age@maturity.

6a. Harvest Effectiveness (incomplete, in final draft)

How effective is hatchery production for different objectives?

Harvest

- What are enhanced contributions of CN, CO, CM to harvest?
- Where are hatchery fish caught?
- Are some hatcheries more ‘effective’ than others at producing catch?

Data Needs

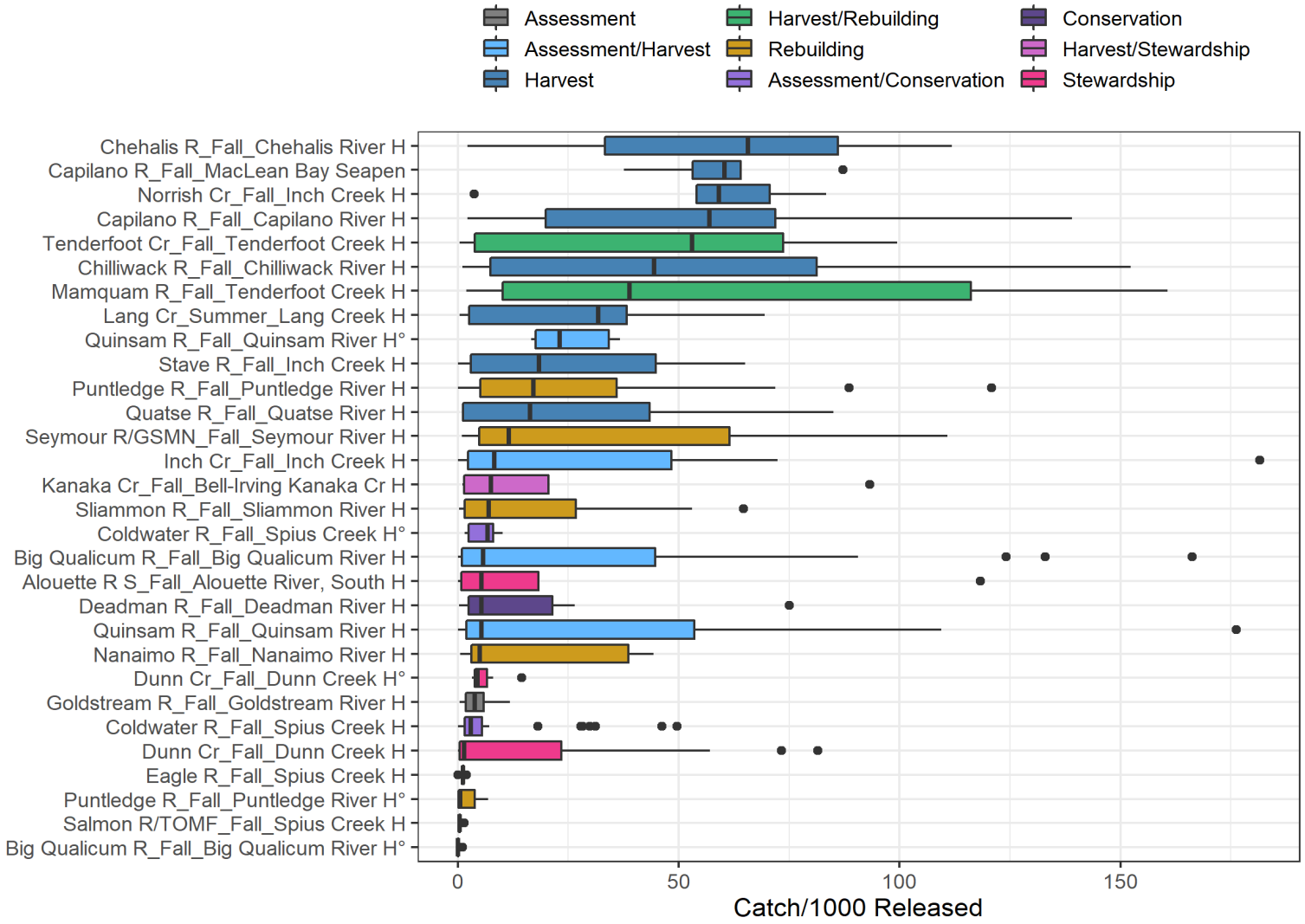
- Total provincial catch
- Total enhanced catch
- Catch distributions
- Fisheries closures
- Escapement data

6a. Harvest Effectiveness

What we can do:

- Total catch + distribution (SBC only)
- Total CWT recoveries + distribution
- Enhanced contribution to escapement
- Catch/1000 releases

Example: ISC Coho



6b. Rebuilding Effectiveness (incomplete, in final draft)

How effective is hatchery production for rebuilding natural production?

Questions:

- Does enhancement for rebuilding increase TOTAL and/or NATURAL ORIGIN and/or WILD spawner abundance?
- What happens after hatchery contribution stopped?
- Are there differences in ‘efficiency’ between systems (returns/release)?
- How is this different between regions and species?

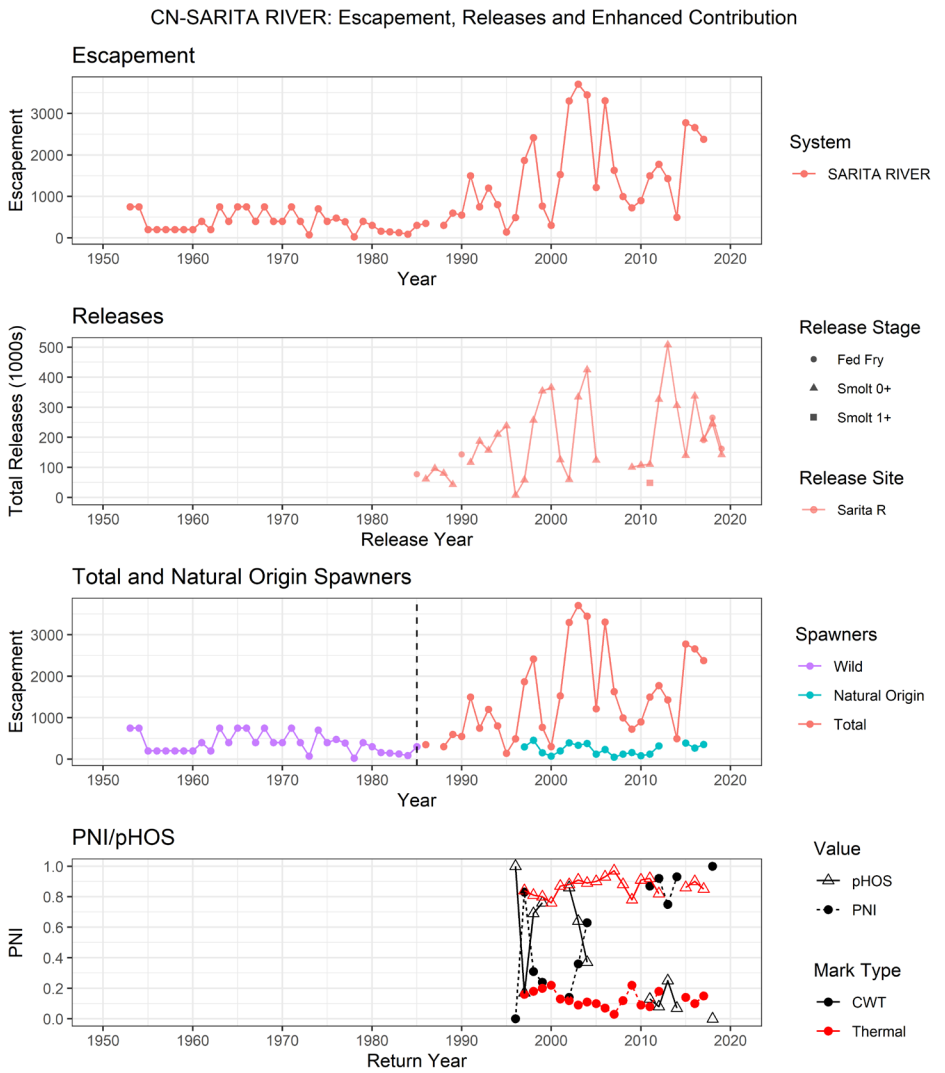
Data Needs:

- Escapement, releases, enhanced contributions, stock specific age structure
- Production objectives (we heard that rebuilding could cover many different reasons)

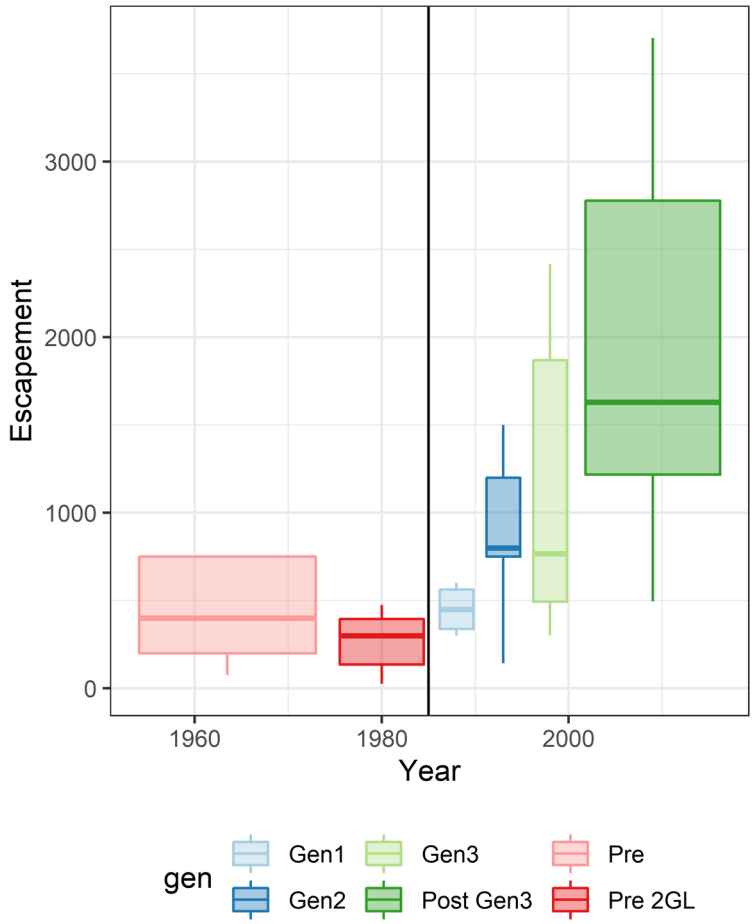
6b. Rebuilding Effectiveness

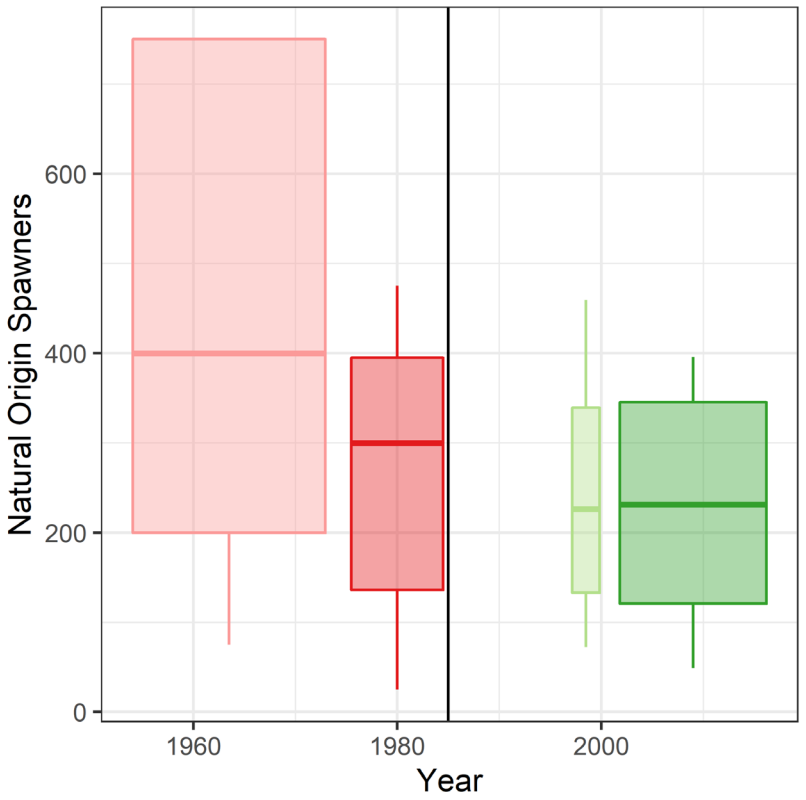
Example system

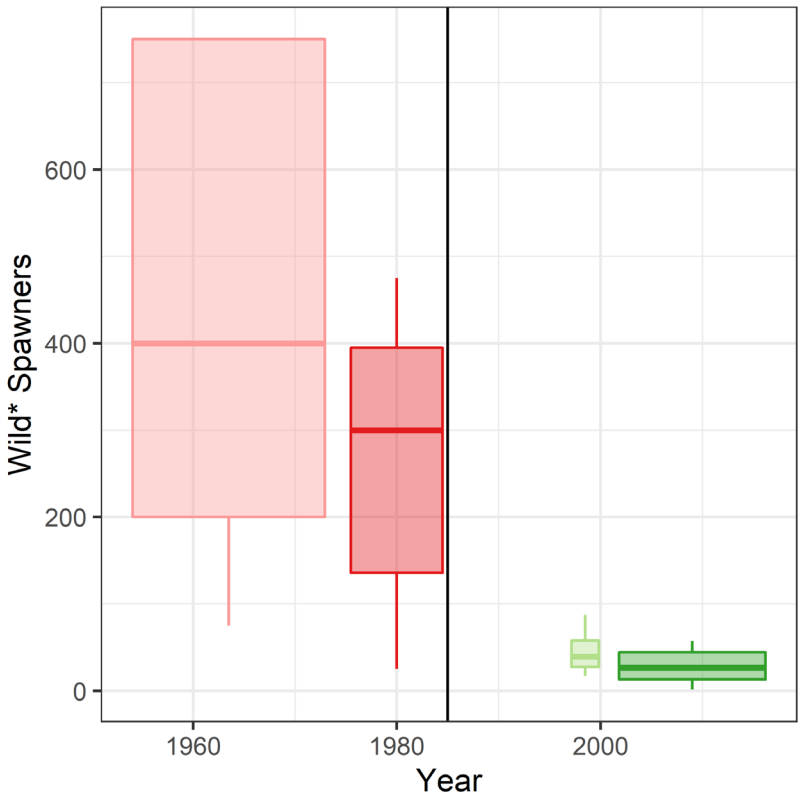
- Each system gets a '**Dashboard**'
- Can compare spawner abundance to releases
- We explore various metrics based on spawner abundance pre/during/post hatchery contributions
- Identify rivers with assessed hatchery influence … pHOS, PNI, etc. (Withler et al. 2018, CSAS report 2018/019)



6b. Rebuilding Effectiveness … over generations







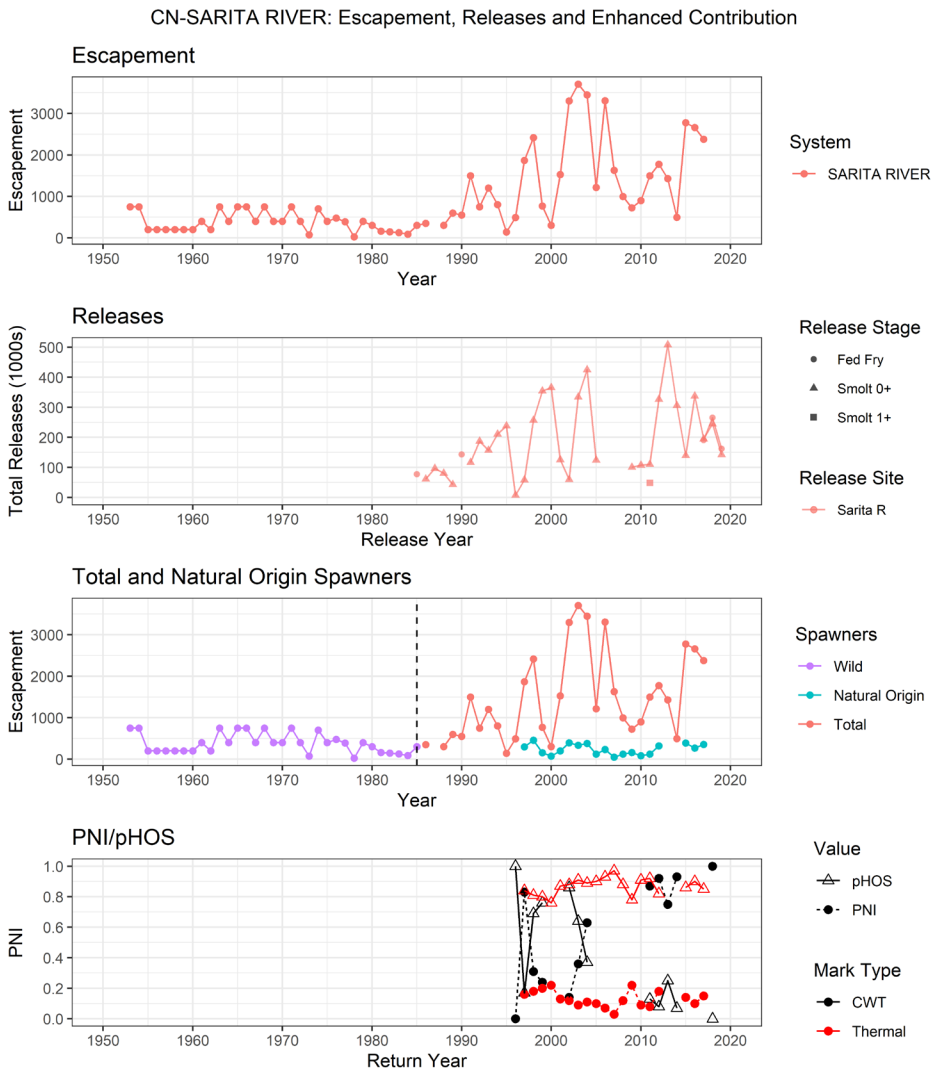
* 2nd generation wild spawners (pNOS[2])

6b. Rebuilding Effectiveness

Back to our questions:

- TOTAL spawner abundance increased
- Number of natural-origin spawners did not
- Wild (pNOS[2]) tiny fraction of escapement now (next generation)
- Highly responsive to hatchery input but lasting effects much less

So then how does this compare to reference streams, other regions and other species?



6b. Rebuilding Effectiveness

Takeaways:

- Few systems with long time-series of data
  - For example, stock specific ages, exploitation rates, enhanced contributions
- Preliminary Results
  - TOTAL spawner abundance typically increases, but not NOS or WILD
  - Many systems very responsive to hatchery production
  - If enhancement stops then spawner abundance declines
  - There are important differences between species and regions

→ Need assessment frameworks for each system that have measurable objectives - from previous meetings with SEP we understand that this is underway!

7. Hatchery-Wild Interactions (incomplete)

Questions:

7a. Are there hatchery influences on nearby wild systems?
- Assess changes in productivity over time and space

7b. Is there spatial coherence in assessment metrics between systems?

Methods
- Use case studies
  - Conuma area Chinook and chum
  - Bella Coola chum
- Use various metrics (e.g., standardized spawner abundance)
- Explore productivity, but many underlying assumptions (age, exploitation)

7a, b. Hatchery-Wild Interactions, Spatial Analyses

Questions:

- What types of metrics would be most appropriate to use?
  - Standardized escapements
  - Standardized total abundance
  - Simple generational averaging (smoothing)

- We may not be able to do all these, but we will have models developed and examples analyzed.

Dataset	Coho		Chum		Chinook	
	CU	Stocks	CU	Stocks	CU	Stocks
Pacific Salmon Explorer	23		21		15	
Nelson et al. 2019						8
Winther et al. 2021						1
Inner South Coast Chum Stock Reconstruction				7		
Total	23		28		24	

7a. Evaluate Hatchery Effects on Wild Salmon Productivity

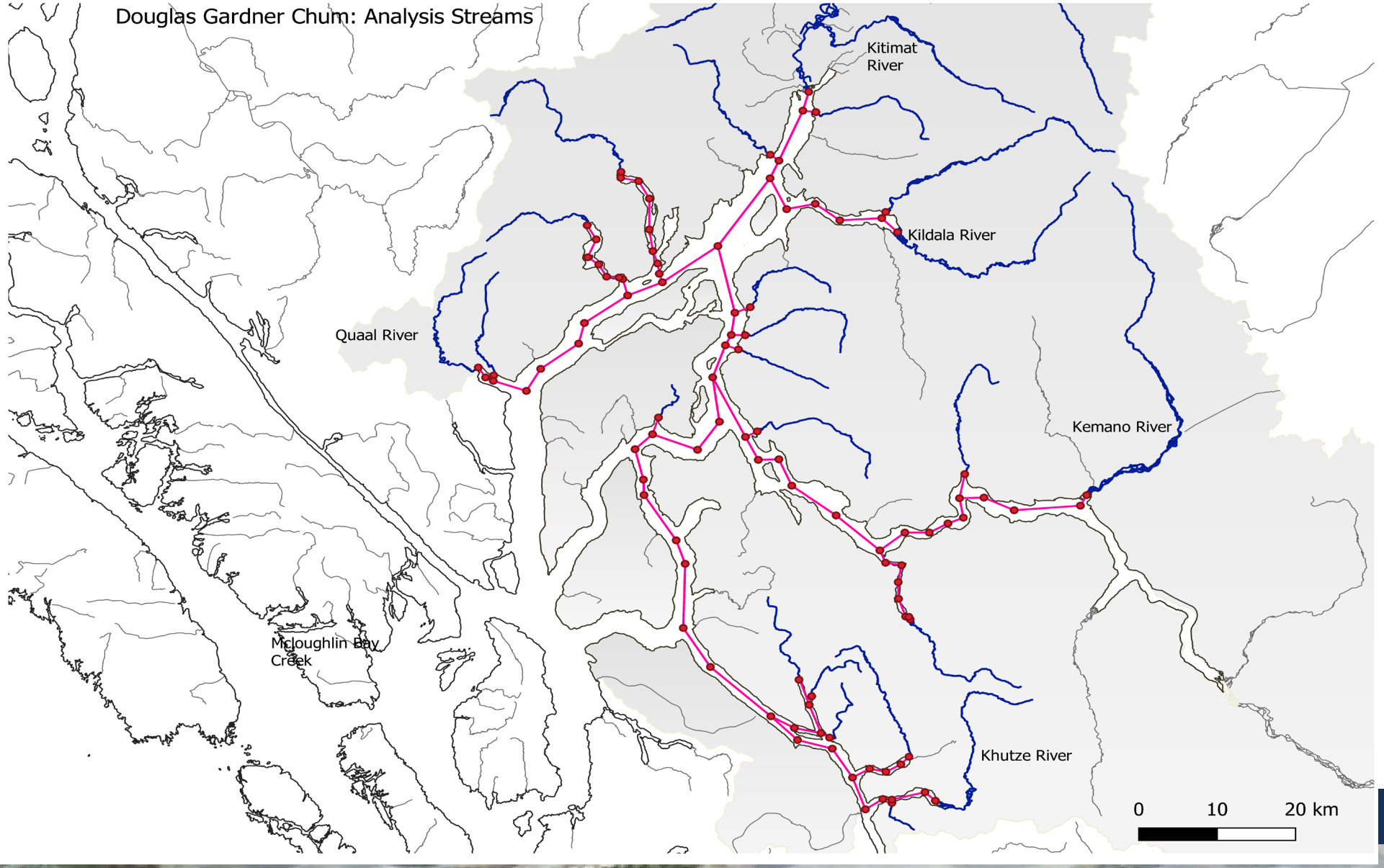
Step 1: Single Conservation Unit/Stock Ricker models

- Standard and time-varying productivity (alpha)
- Correlations in productivity with different indicators of hatchery activity
- Spatial correlations in productivity among CUs/stocks

Step 2: Hierarchical Multi-Conservation Unit/Stock Ricker models

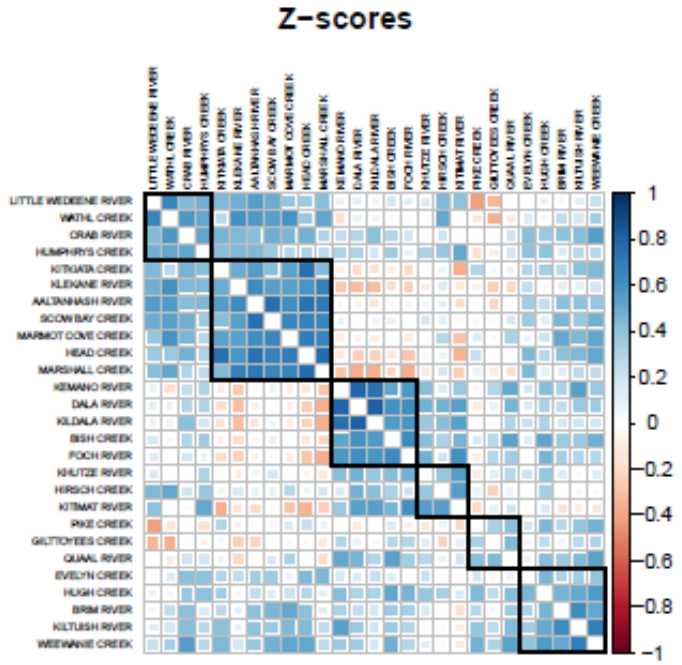
- Add hatchery activity covariates
- Add predator and environmental covariates
- Compare model predictive performance using leave-one-out-cross validation information criterion

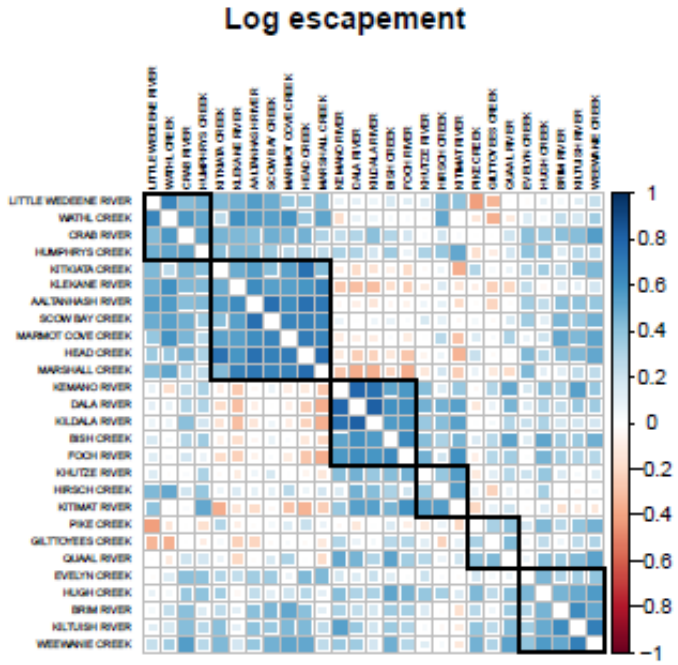
7b. Hatchery Effects on Wild Salmon (spatial effects)

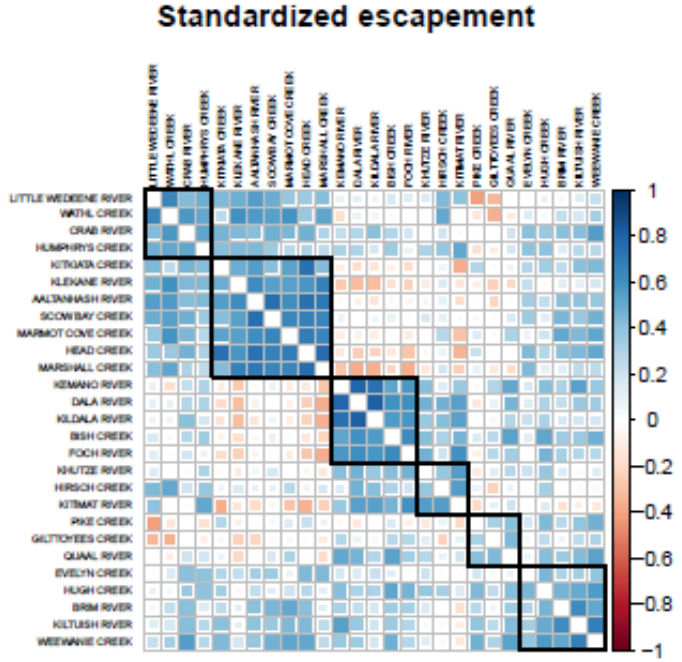


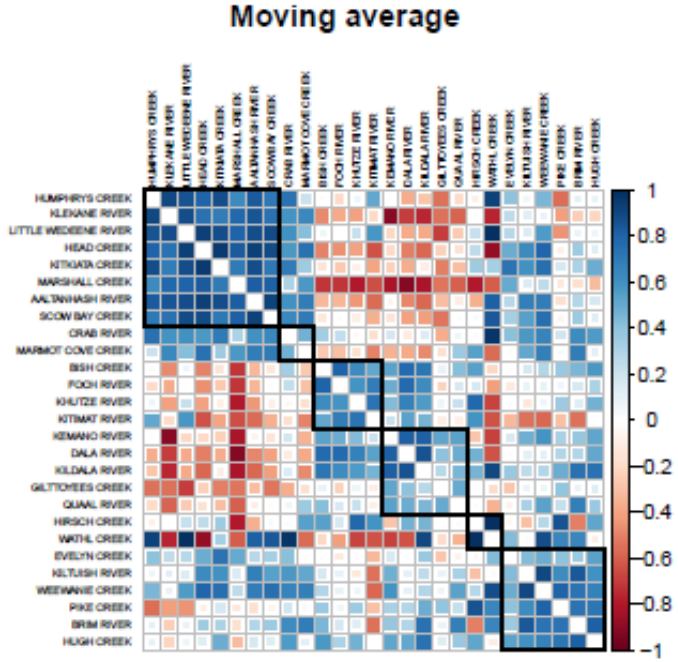
7b. Example

Area 6 Chum, example of spatial analysis within CU's.









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Hatchery Effectiveness Review

Thank You!

Questions and Discussion

2022-11-30