8.2 Evaluating the effects of naturally spawning hatchery salmon

NOAA FISHERIES

Northwest Fisheries Science Center

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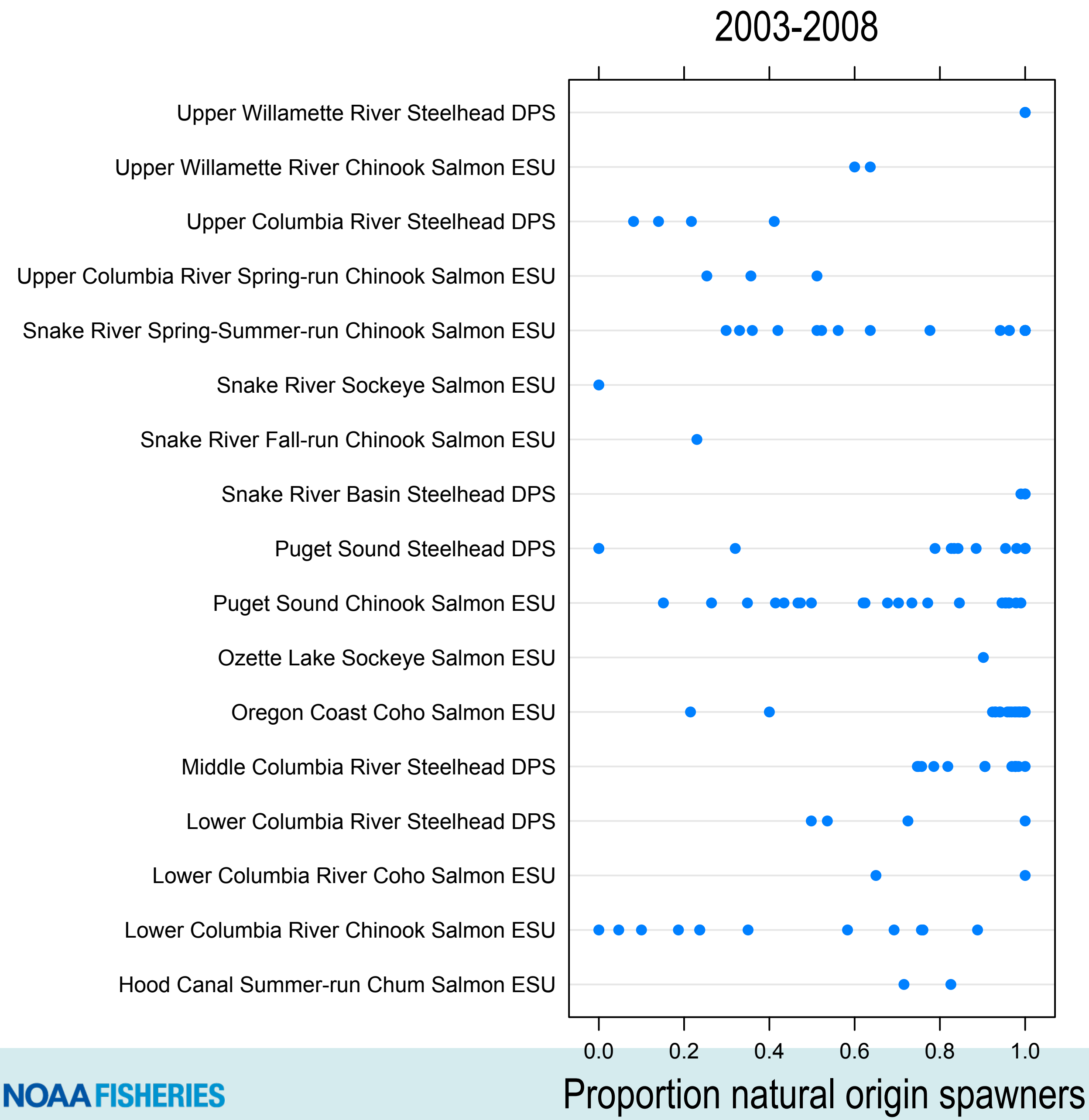
Talk outline

- Background
- Overview of Centers' research
  - Estimating reproductive success and its influences
  - Demographic analysis
  - Modeling and theory
- Connections to management
- Strengths, challenges and opportunities

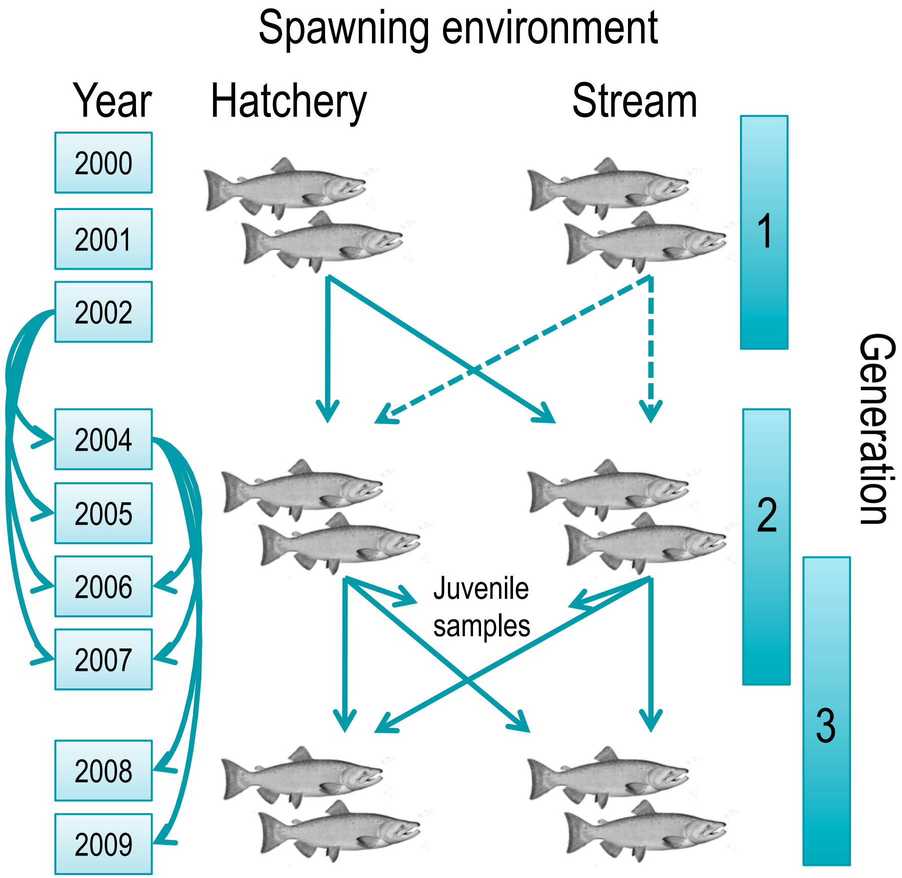
Background

- Long history of hatcheries for mitigation and population substitution
- More uncertainty about benefits to wild fish conservation
  - *In the judgment of the ISRP and the ISAB, the uncertainty concerning both the benefits and the risks of supplementation is sufficiently great to put the merit of supplementation into question as a recovery strategy.* – Independent Science Advisory Board, 2005
- Evaluation of risk and benefits required by 2005 NMFS hatchery policy

Hatchery produced fish are on spawning grounds

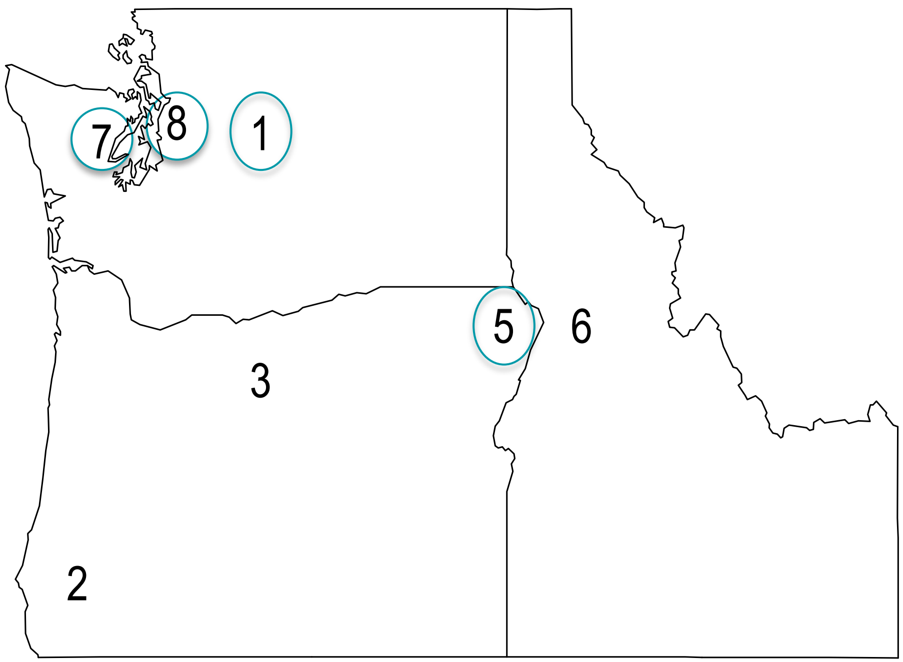


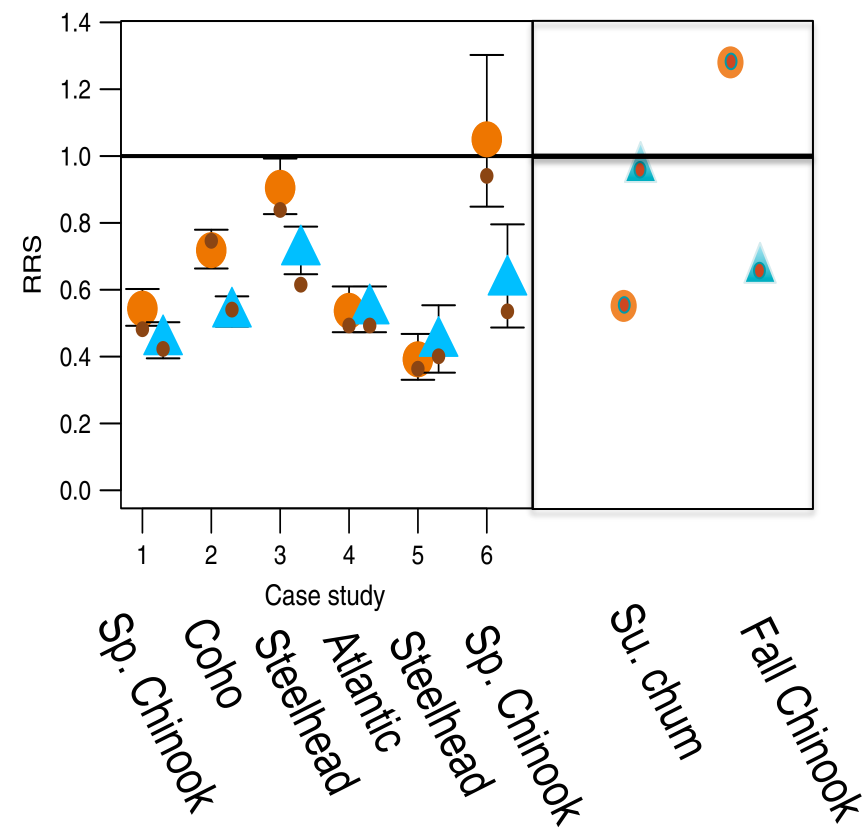
Estimating reproductive success and its influences



$$\text{RRS} = \frac{\text{progeny per hatchery spawner}}{\text{progeny per natural spawner}}$$

Results from multiple studies



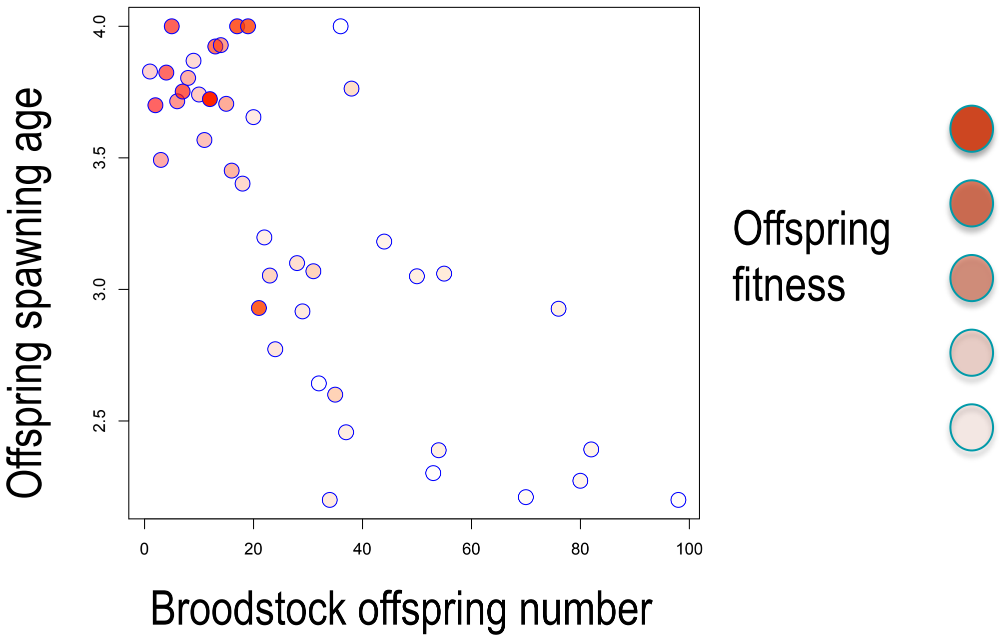


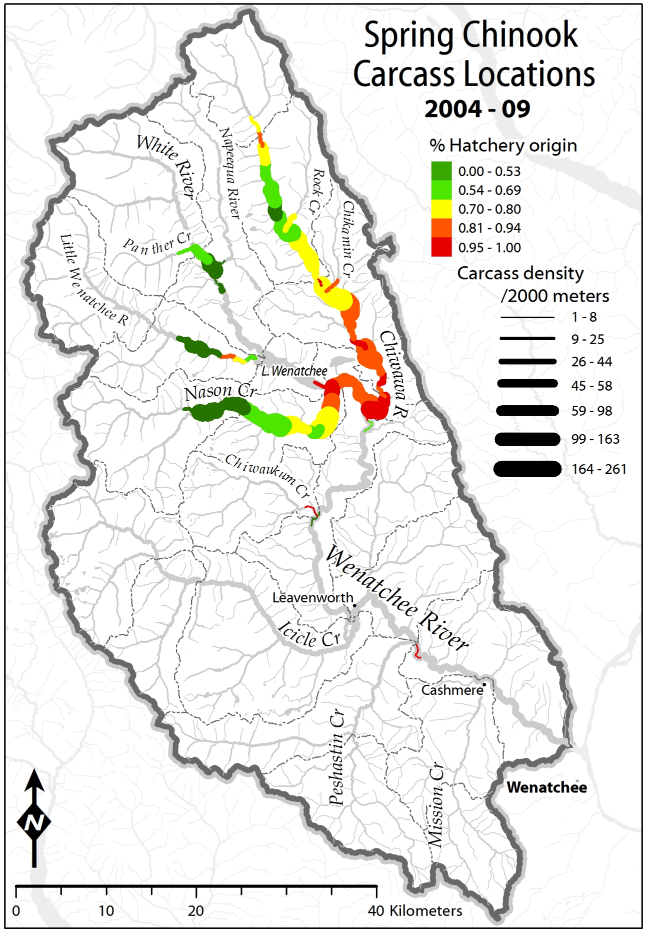
$$\text{RRS} = \frac{\text{progeny per hatchery spawner}}{\text{progeny per natural spawner}}$$

Christie, Ford and Blouin, Evol Appl 2014
Berejikian et al. 2009
Anderson et al. 2013 and Ford unpublished

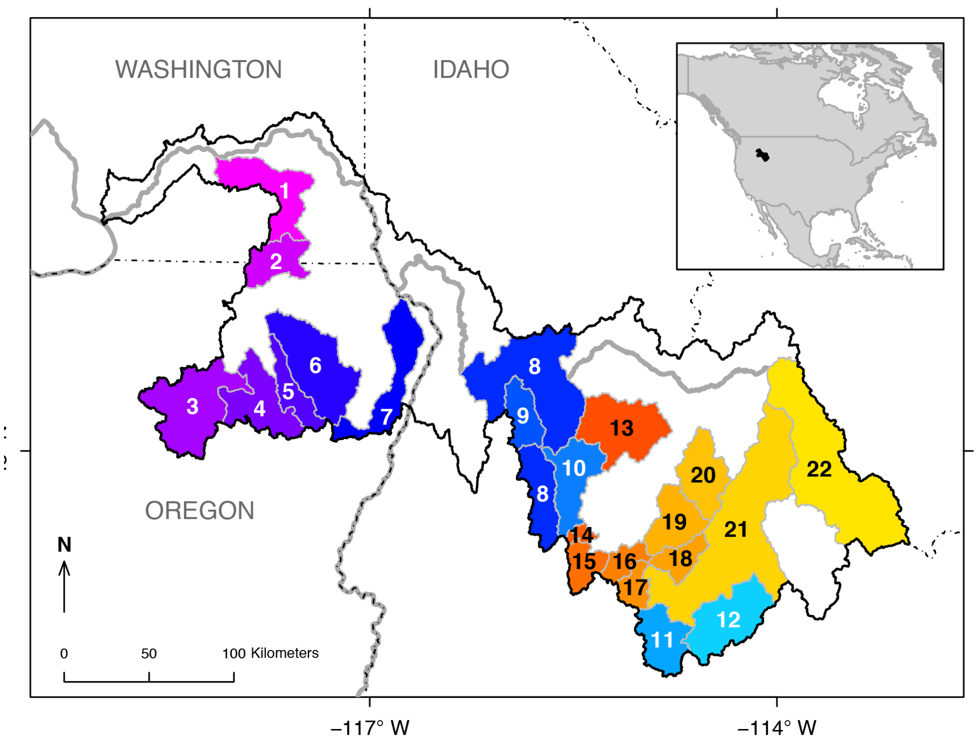
Factors influencing reproductive success

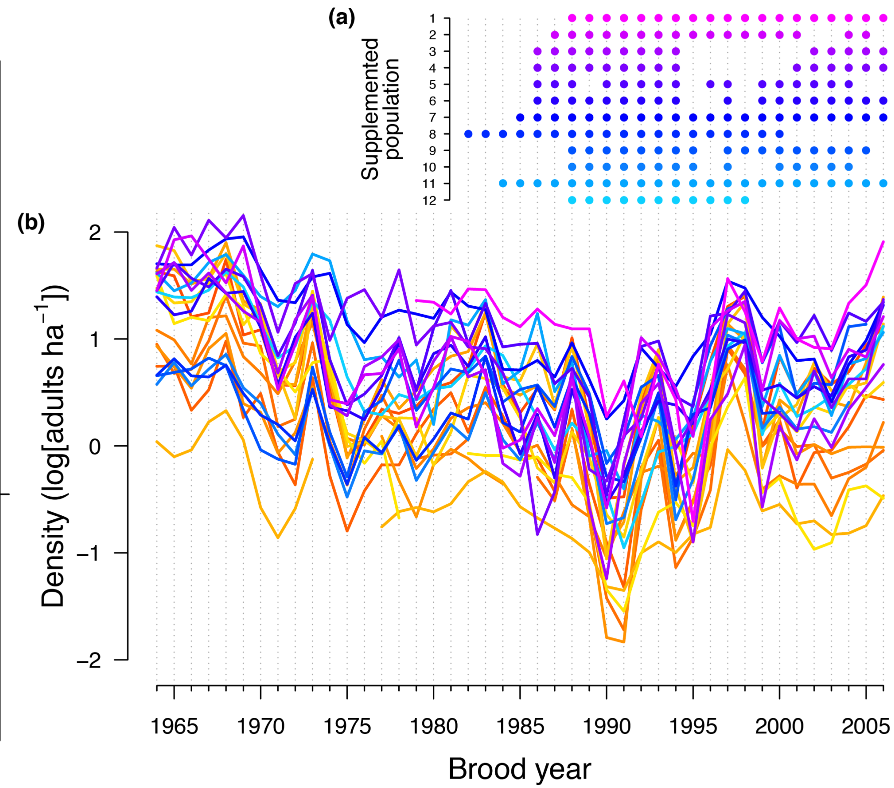
- Spawning location (spring Chinook)
- Age at maturity (spring Chinook)
- Broodstock heritage (steelhead)





Big picture analysis – effects of decades of supplementation?

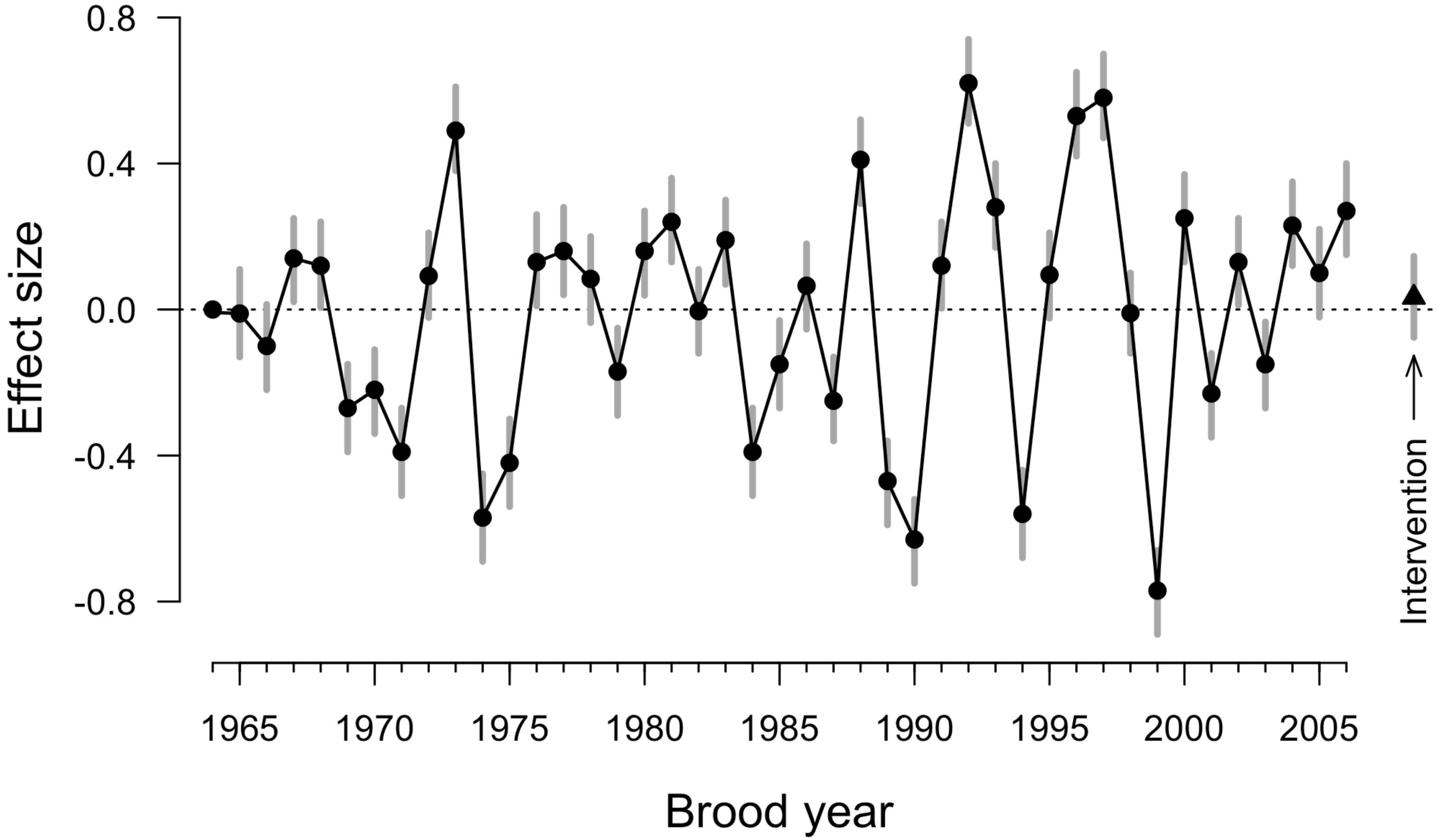




$$X_{i,t} = X_{i,t\text{-}1} + a_t + b_i S_{i,t} + w_{i,t}.$$

Scheuerell et al., Ecology and Evolution 2015

Effect on natural abundance is small

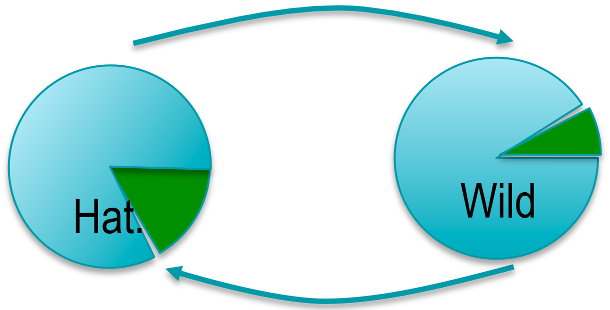


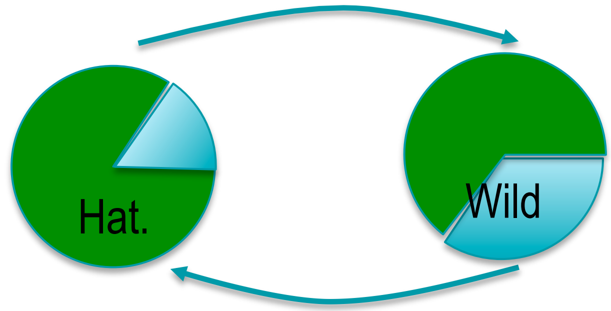
Similar analysis and results in other areas:

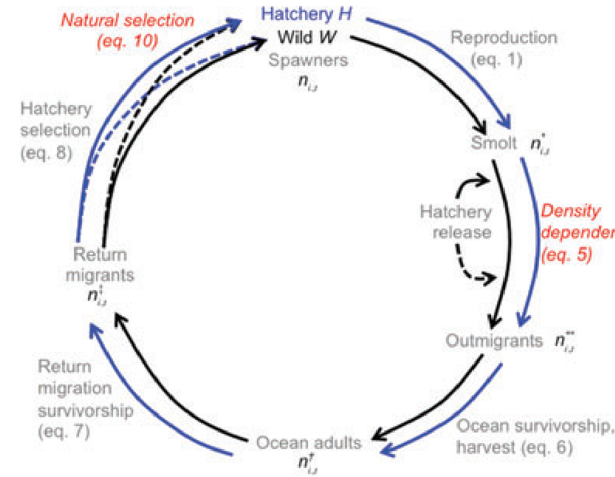
- Snake River sp. Chinook
- Oregon coast coho salmon (Buhle et al. 2009)
- Puget Sound Chinook (Ward et al. 2015)
- General patterns:
  - Small effects supplementation on abundance
  - Negative effects of supplementation on productivity

Modeling domestication - Ford 2002, Baskett and Waples 2013, Baskett et al. 2013

- Gene flow matters
  - More wild fish in hatchery = less domestication
  - More hatchery fish in wild = more change in wild population
- Weak wild populations most vulnerable to negative effects
- Sensitive to timing of selection and density dependence

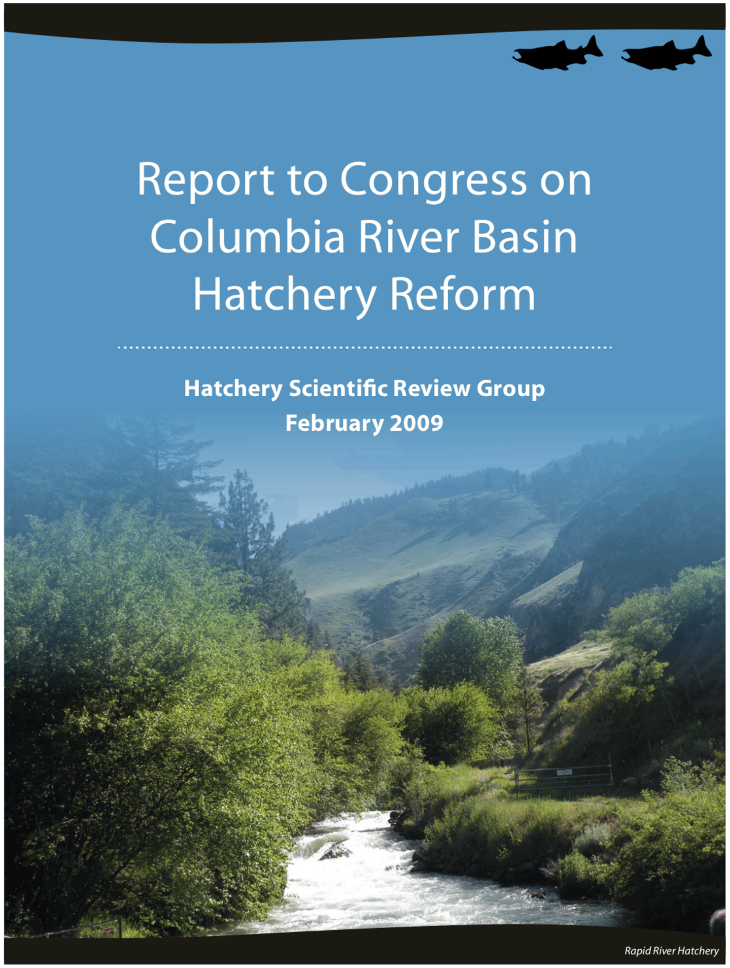






Connections to management – Hatchery Scientific Review Group

- HSRG guidelines for "integrated" hatcheries
  - > 30% hatchery fish in wild
  - > 10% wild fish in hatchery
  - %Hatchery fish in wild < half %Wild fish in hatchery
- Rationale: make sure evolution of combined hatchery/wild population is mostly driven by wild component



Summary

- Hatchery fish reproductive success in nature < wild is typical, even using local broodstock
- Evidence for both environmental and genetic effects and interactions (in different studies)
  - Spawning location
  - Age at maturity
  - Broodstock history
- Demographic analyses:
  - Small effects of naturally spawning hatchery fish on wild population abundance
  - Negative effects on productivity
- Supplementation most (only?) effective at very low densities
- Theory suggests gene flow, selection and when selection occurs in the life cycle are important for domestication

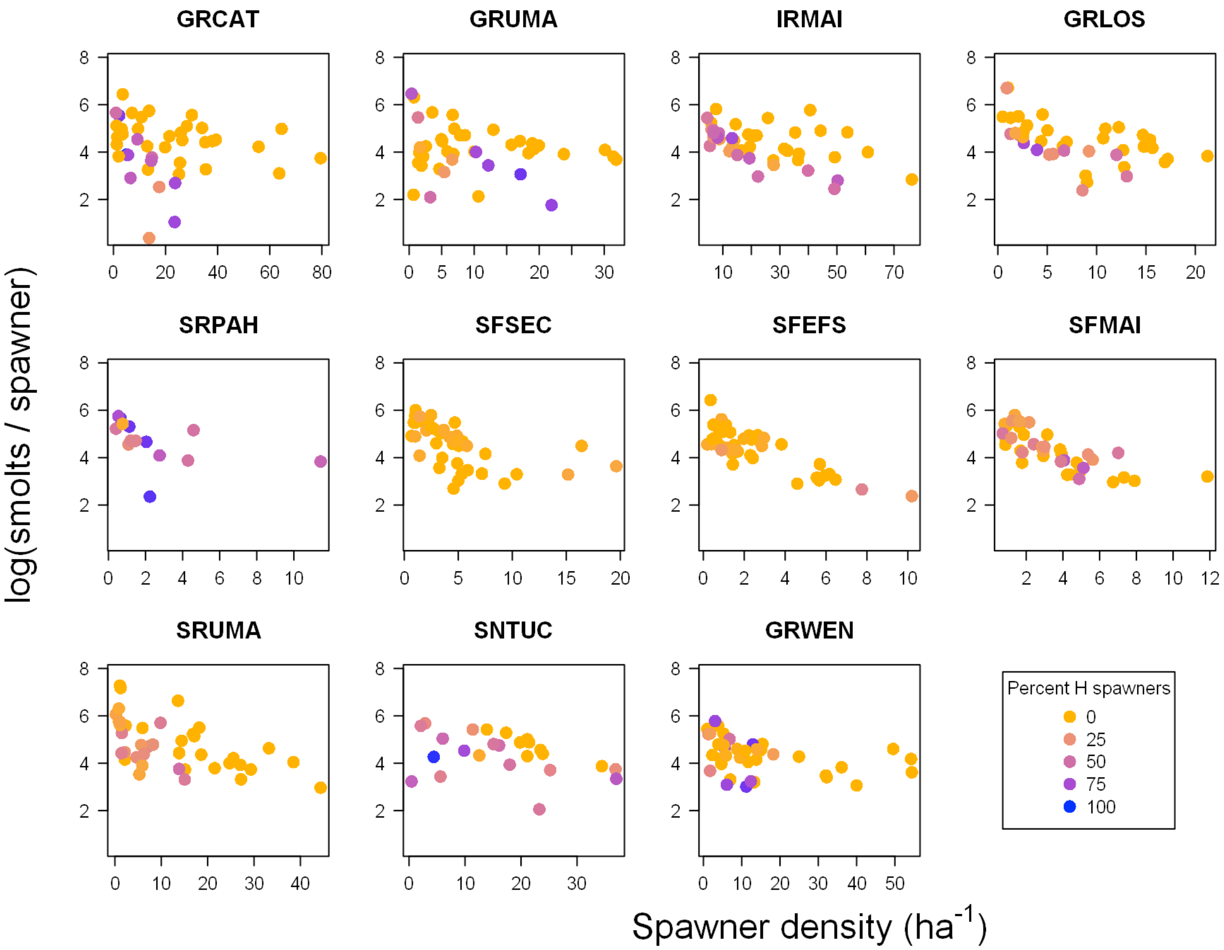
Strengths, challenges and opportunities

- Strengths
  - Active research program that has moved the needle on the problem
  - Science is being used by management
  - Interdisciplinary approach
- Challenges
  - Often controversial topic
  - Conflicts between abundance and diversity
  - Some questions (e.g., large scale interactions) essentially intractable without very large scale and long-term manipulations
- Opportunities
  - Heading toward a consensus among federal, state, tribal agencies on a pragmatic approach to the problem.
  - Greater appreciation for ecosystem interactions and hatcheries (e.g. marine mammals)
  - New technologies such as cheap high throughput sequencing will help address some questions

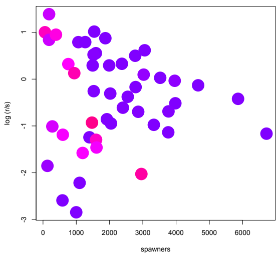
Thank you!

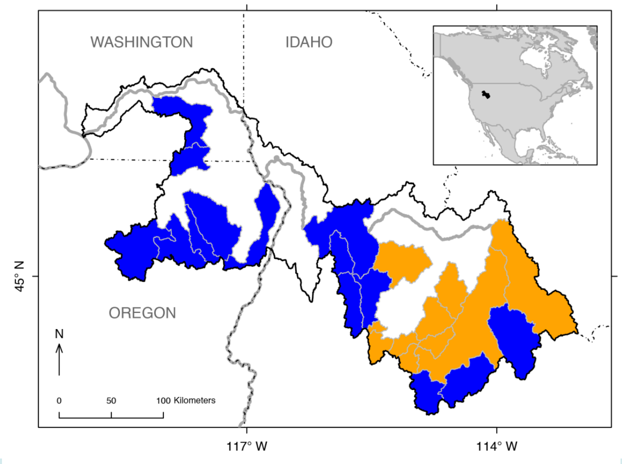
Extra slides

Non-random hatchery density might explain some large scale patterns



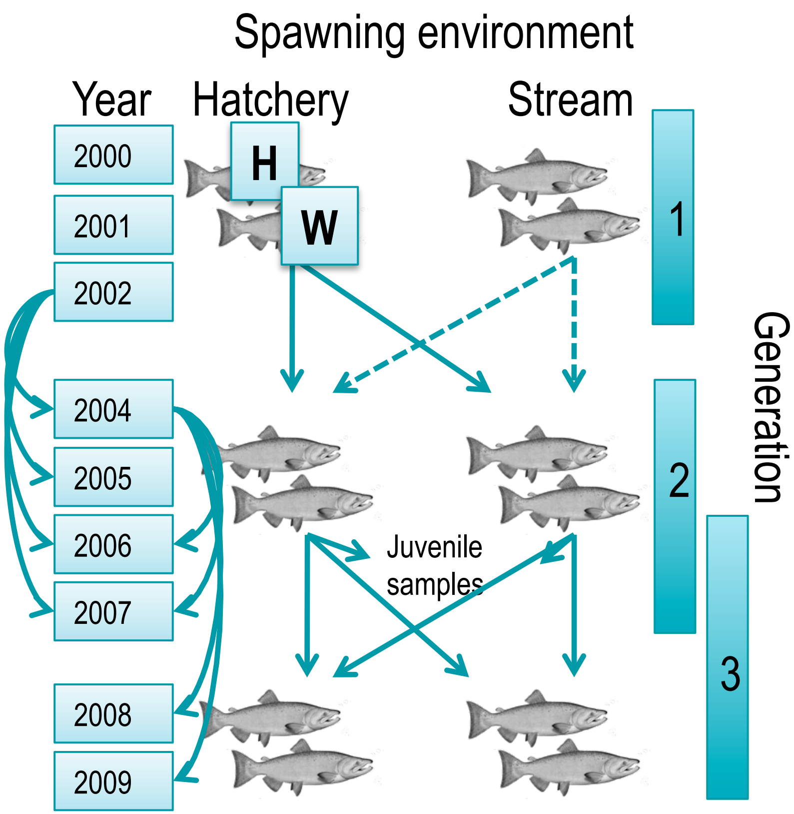
Wenatchee

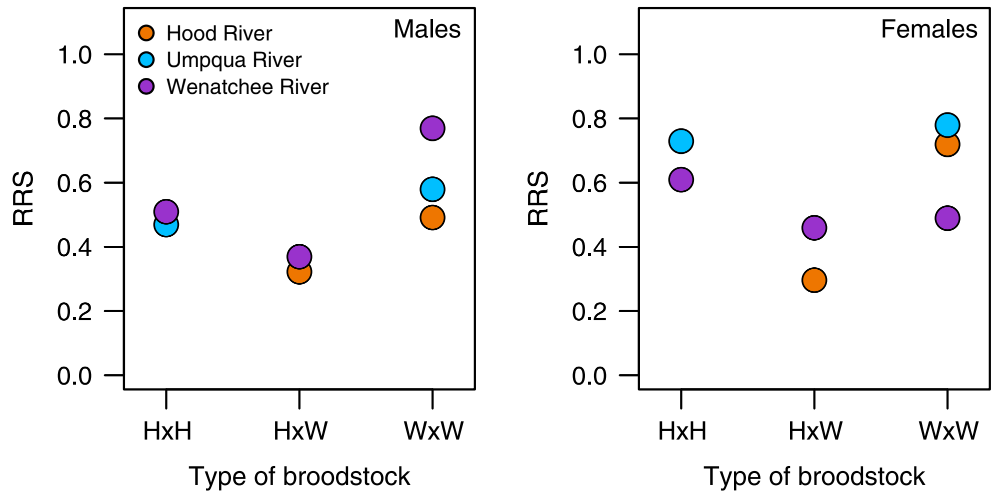




Source: Eric Buhle et al. , NWFSC, in prep

Evidence for genetic cause of low RRS?





Christie et al. 2014

Early maturity