Key considerations in balancing risk against need in Chinook supplementation

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Recent Reviews of Hatchery Programs

Responsible Approach to Marine Stock Enhancement: An Update

KAI LORENZEN,[1,2,3] KENNETH M. LEBER,[3] and H. LEE BLANKENSHIP[4]

Ecological interactions between wild and hatchery salmonids: an introduction to the special issue

Peter S. Rand · Barry A. Berejikian · Todd N. Pearsons · David L. G. Noakes

Factors that contribute to the ecological risks of salmon and steelhead hatchery programs and some mitigating strategies

Kathryn Kostow

Hatcheries, Conservation, and Sustainable Fisheries—Achieving Multiple Goals: Results of the Hatchery Scientific Review Group's Columbia River Basin Review

P. J. Paquet [a], T. Flagg [b], A. Appleby [c], J. Barr [d], L. Blankenship [e], D. Campton [f], M. Delarm [g], T. Evelyn [h], D. Fast [i], J. Gislason [j], P. Kline [k], D. Maynard [l], L. Mobrand [m], G. Nandor [n], P. Seidel [o] & S. Smith [p]

Main conclusions from review

AN EVALUATION OF THE EFFECTS OF CONSERVATION AND FISHERY ENHANCEMENT HATCHERIES ON WILD POPULATIONS OF SALMON[1]

Kerry A. Naish,[*,2] Joseph E. Taylor, III[†] Phillip S. Levin,[‡] Thomas P. Quinn,[*] James R. Winton,[§] Daniel Huppert,[¶] *and* Ray Hilborn[*]

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- "A key need in this area….. is the development of a strong understanding of the *degree* to which specific activities pose a risk and whether proposed management approaches are effective at reducing these risks"

Aims

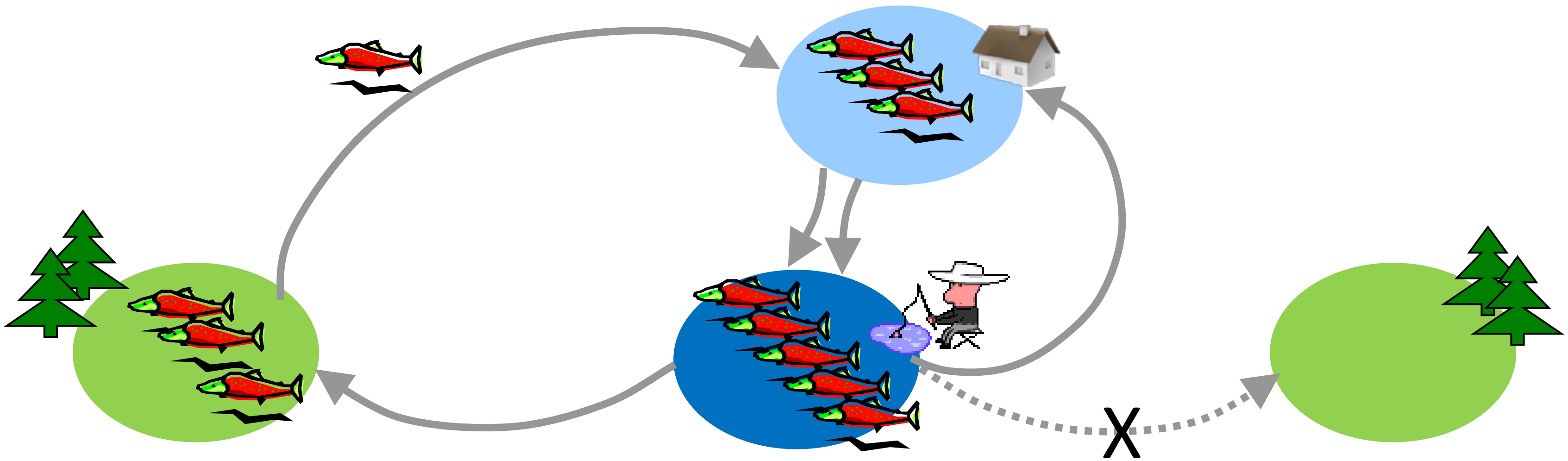
1. Key discussion associated with minimizing risks

2. Examples of outstanding issues

3. Considerations for planning a new program
   - Towards a well designed system that allows research and continual assessment

Release objectives

- Produce surplus fish for fishing opportunity



Integrated Hatchery Aims:

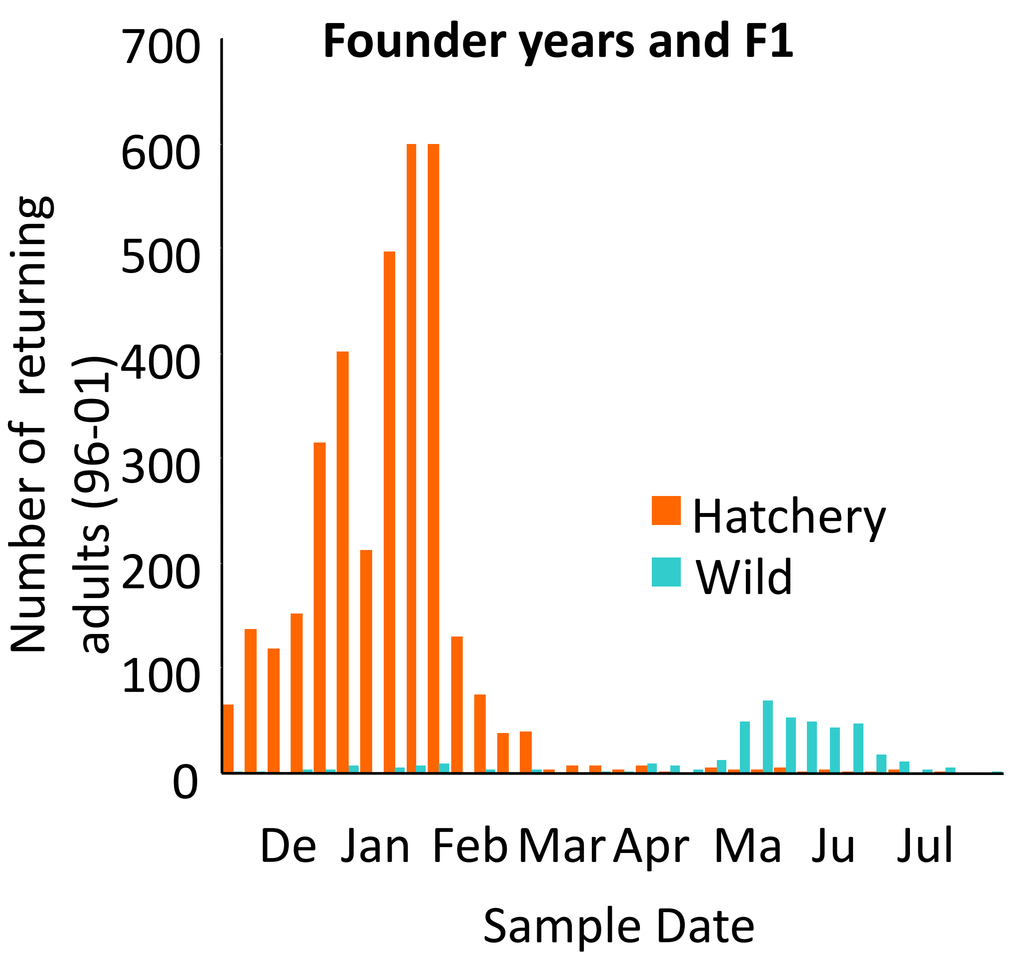
- Genetic constitution and fitness as similar as possible to wild population
- Achieved by gene flow:
  - Wild to hatchery > hatchery to wild

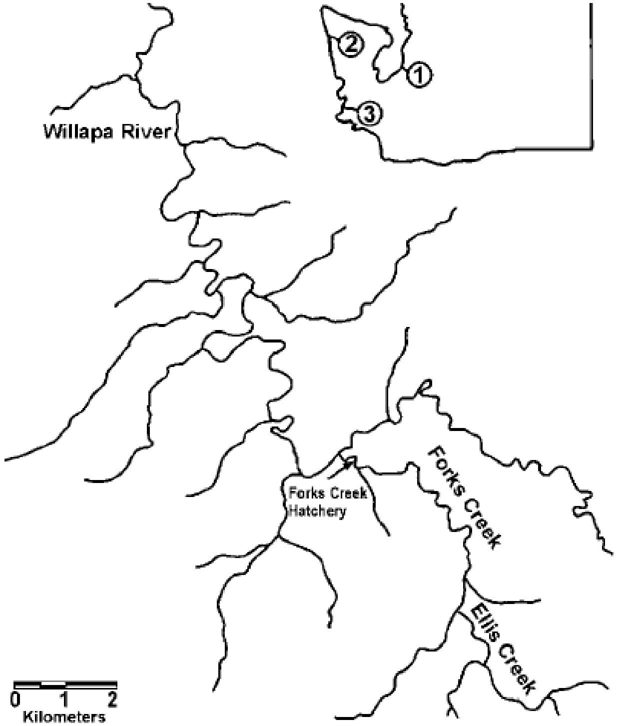
Segregated Hatchery Aims:

- Direct fishing effort away from wild populations
- Little or no spawning in the wild

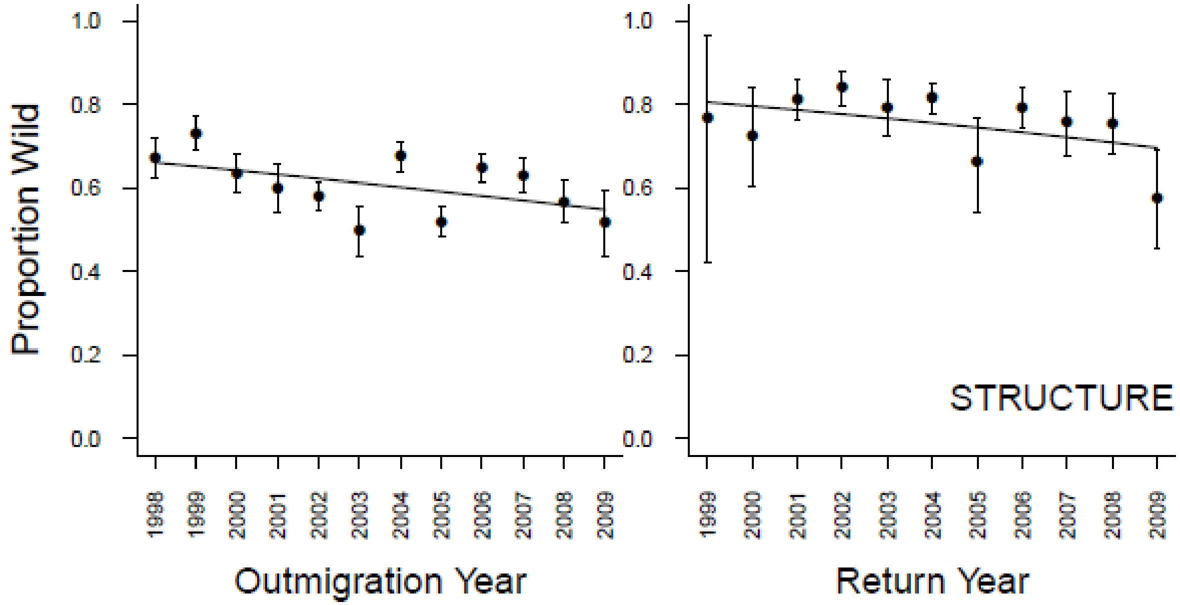
Mobrand et al. 2005

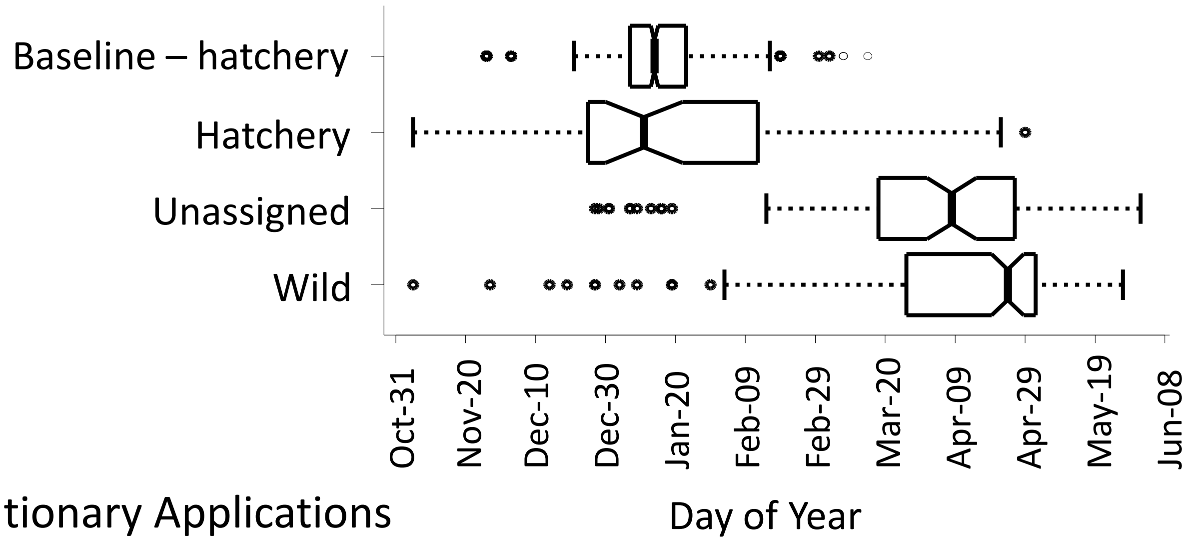
Segregation – a viable approach?





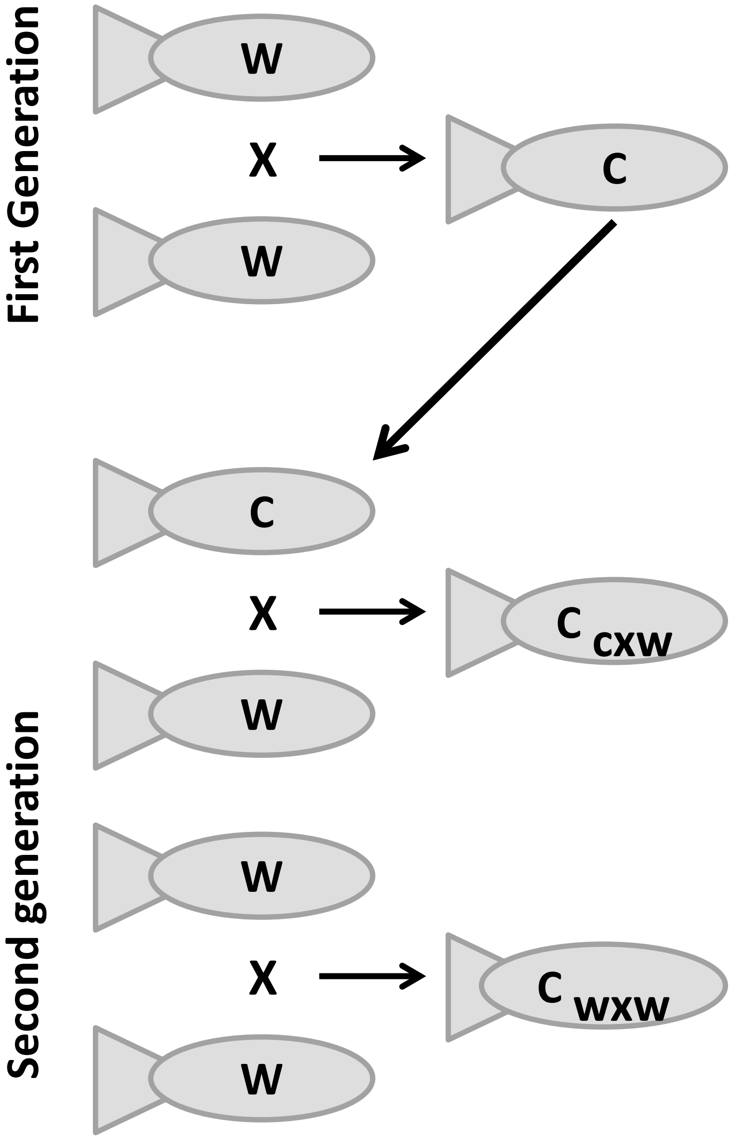
Does segregation by timing work?

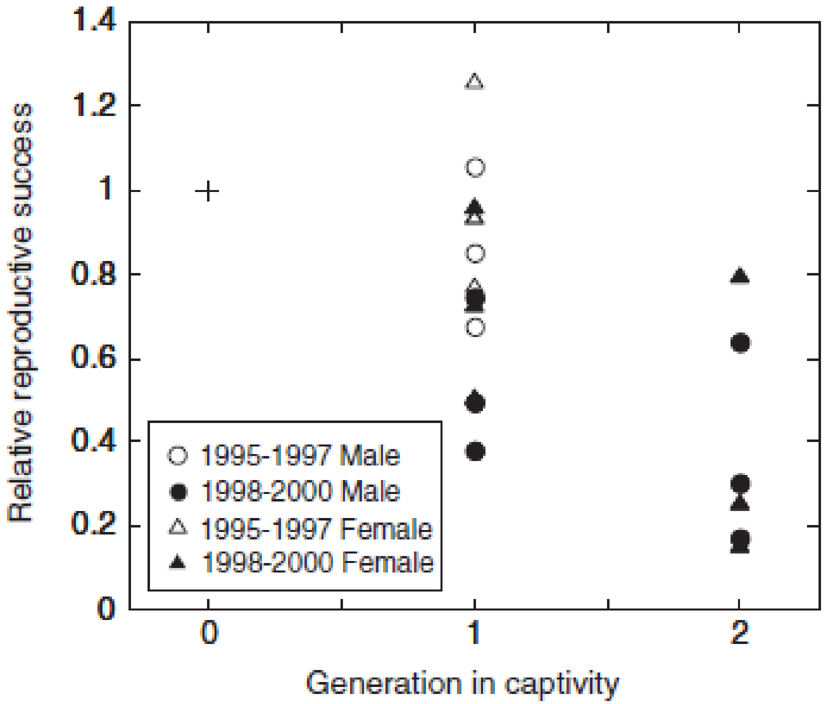




After Seamons *et al.* 2012, Evolutionary Applications

Integrated hatcheries: number generations?





- Decline in fitness observed in a steelhead hatchery over two generations following captive rearing
- *Araki, Cooper & Blouin, Science 2007*

Integrated: subsequent studies

Species	Outcome	References
Steelhead	• Reduced fitness in H descendants spawning in W reduce d W pop size, • Swamping: 40% contributions from W • Domestication selection in one generation	Araki et al. 2008, Christie et al. 2011, Christie et al. 2012
	• No changes in genetic diversity or effective size (Adult to parr)	Van Doornick et al. 2010
	• Methodology: RRS estimates are upwardly biased	Kitada et al. 2011
Chum	H &W similar fitness after 3 generations of culture (spawning channel)	Berejikian et al. 2009

Integrated: subsequent studies

Species	Outcome	Reference
Coho	• Rearing environment (natural vs trad) affects fitness • No genetic explanation for fitness decrease	Chittenden et al. 2010
	• H fish had lower RRS • Fitness of fry release similar to smolt release • Absence of sexual selection in H implicated	Theriault et al. 2011
Chinook	• No fitness difference after one generation of H rearing (lab)	Schroder et al. 2010, 2012
	• H fitness lower than W in established supplementation hatchery • H fish younger, spawned in different habitat	Williamson et al. 2011
	• H fish over a single generation provided a demographic boost • No significant difference in RRS in H&W spawning in W	Hess et al. 2012

Aim of Talk

1. Key discussion associated with minimizing risks

2. Examples of outstanding issues

3. Considerations for planning a new program
   - Towards a well designed system that allows research and continual assessment

Integrated: outstanding questions

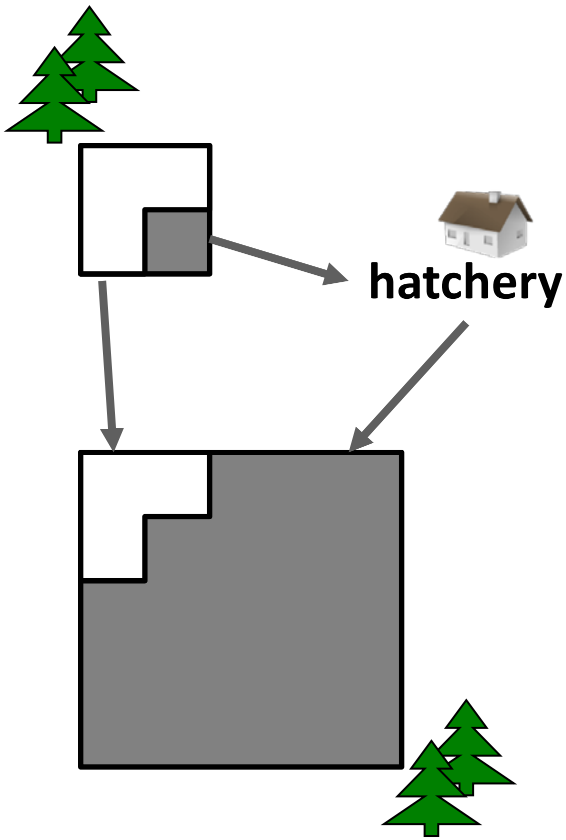
- What are measures of success in supplementation?
  - Is reduced fitness in descendants of hatchery fish acceptable or even desirable?
- Optimal levels of gene flow between Hatchery and Wild fish? Need for experimental approach
- Effects of broodstock collection on wild fish?
- Does long term integration eventually compromise the genetic diversity of a wild population?
- Are hatcheries at risk of becoming pathogen vectors?

Segregated: outstanding questions

- Are there design strategies that prevent negative interactions between hatchery and wild fishes?
- How much gene flow is acceptable if systems fail?
- Effects of broodstock collection on wild fish?
- Mixed stock fisheries
- Are hatcheries at risk of becoming pathogen vectors?

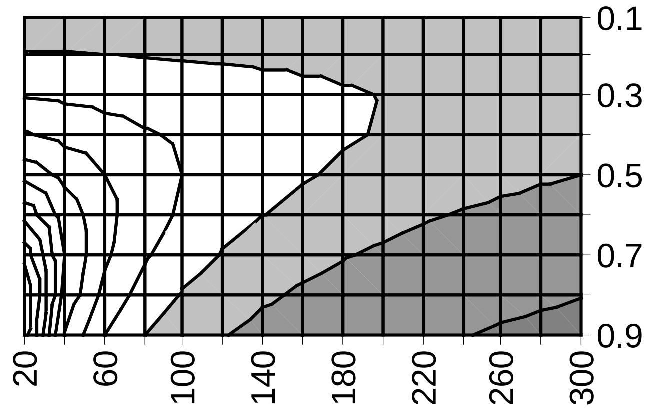
The importance of release sizes

- May affect ability of wild populations to adapt to change
  - Reduction of genetic diversity: the “Ryman – Laikre” effect



Waples & Do 2005

Effective size of hatchery fish = 100



Proportion of hatchery fish in wild population

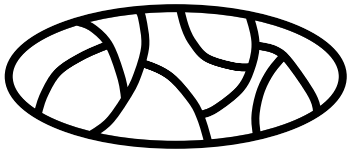
Effective size of wild population

Grey = reduction in effective size of total population compared to unsupplemented population

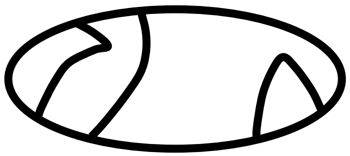
Naish *et al*. 2008

The importance of release sizes

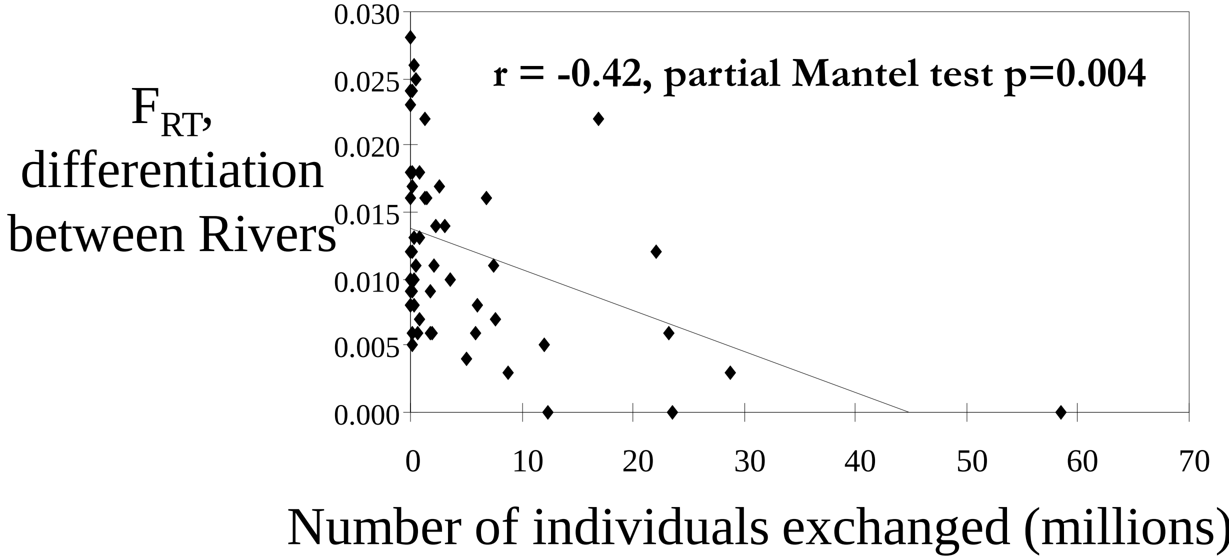
- May reduce population structure (*Utter, 2004)*

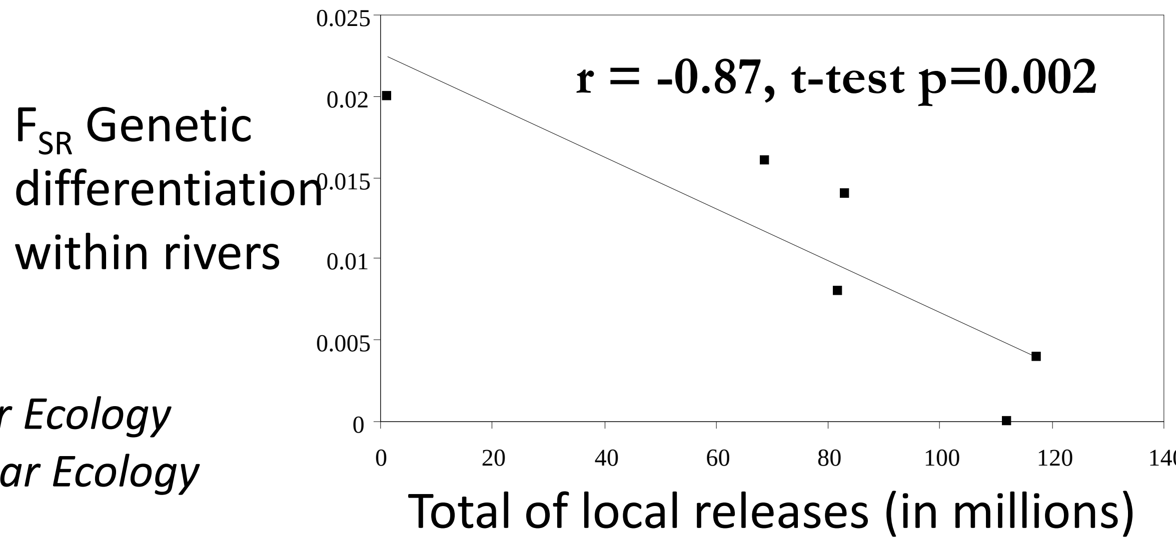


No hatchery releases



Hatchery releases





Eldridge and Naish 2007, Molecular Ecology
See also Marie et al. 2010, Molecular Ecology

Release sizes: Ecological effects

"Many hatchery management strategies that may decrease genetic risks, …., (but they) may not mitigate ecological risk factors, rather they may increase the opportunity for ecological effects to occur." *Kostow 2010*

- Competition, exacerbated by physical differences
- Density dependent mortality
- Residualization
- Carrying capacity, especially in freshwater
- Predation

- Series of recommendations to reduce ecological effects

Release sizes: Ecological effects

"the traditional hatchery paradigm is to release approximately the same number of fish of the same species every year from the same location(s) regardless of ecological conditions. This paradigm occurs in integrated and segregated hatchery programs and generally ignores ecological feedback mechanisms within the environment that can reduce survival of hatchery and wild fish" *Pearsons 2010*

Release strategies should consider;

- Risks to non-target taxa
- Carrying capacity
- Ecological feedback mechanisms

Aim of Talk

1. Key discussion associated with minimizing risks

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Planning a hatchery program

- Stage I: Initial appraisal and goal setting
  - Release objectives
  - Interactions with wild fish
  - Importance of release sizes

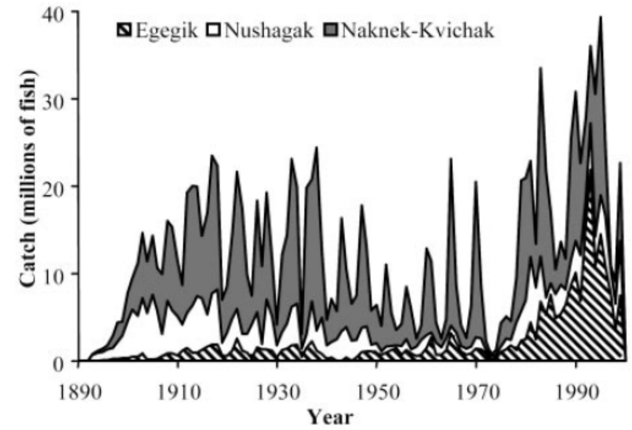
- Stage II: Research and technology development including pilot studies
  - Generating population baselines
  - Designing an experimental system
  - Tagging and tracking hatchery and wild fish

- Stage III: Operational implementation and adaptive management

The responsible approach: after Lorenzen et al. 2010

Knowledge gaps: Baseline data sets

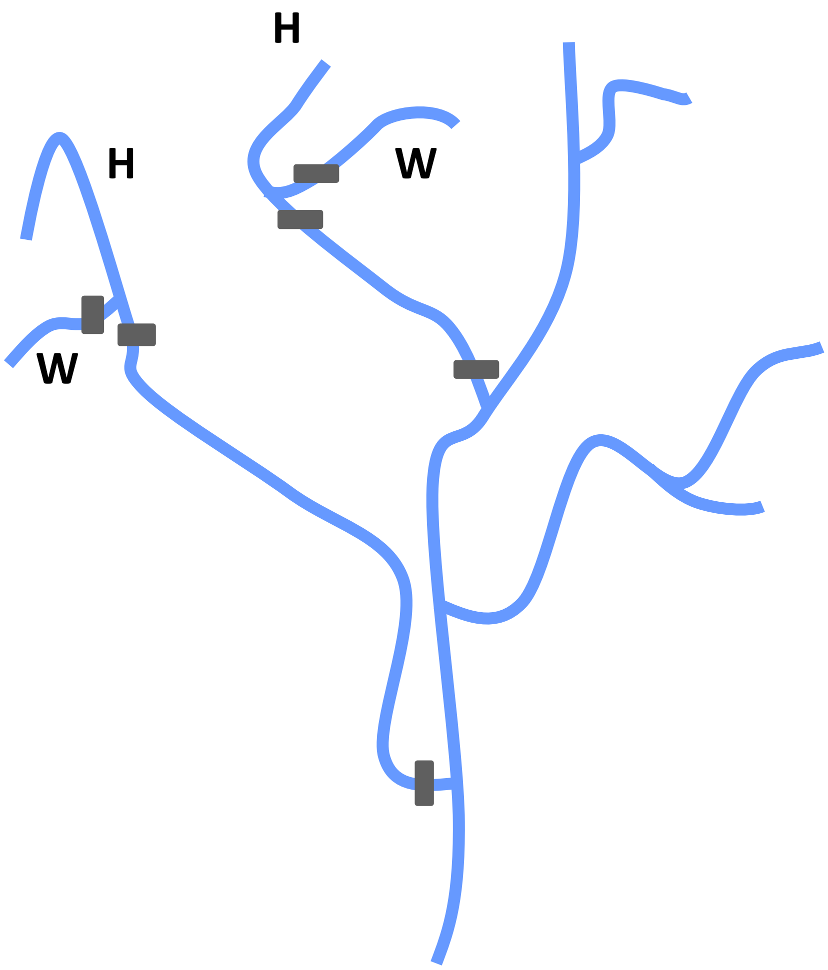
- Maintaining the “portfolio”
  - *(Hilborn et al 2003, Schindler et al. 2010)*



- Evidence for population structure?
- Evidence for local adaptation?
- Evidence for life history variation within and between populations?
- Estimate migration rates between populations
- Evidence for changes in structure over time

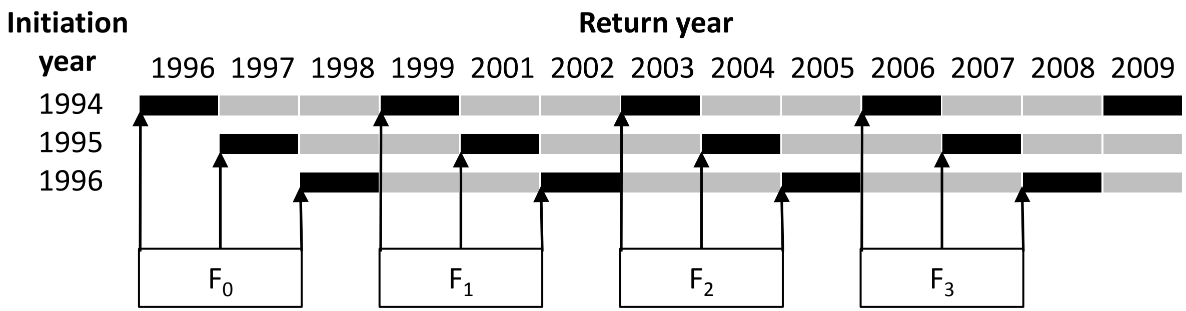
Knowledge gaps: feasibility study

- System that permits effective ongoing research
  - Control streams, free of hatchery influence
  - Continual evaluation
    - "Trigger points"
    - Decide how much change is acceptable
  - Willingness to change or end practices
  - Economic and social analysis

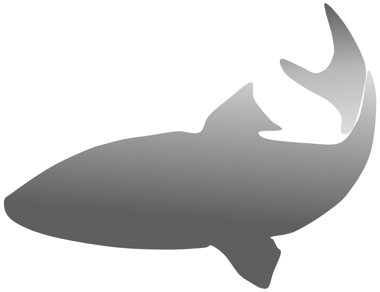


The role of comprehensive long term data

- Measuring phenotypes and pedigrees

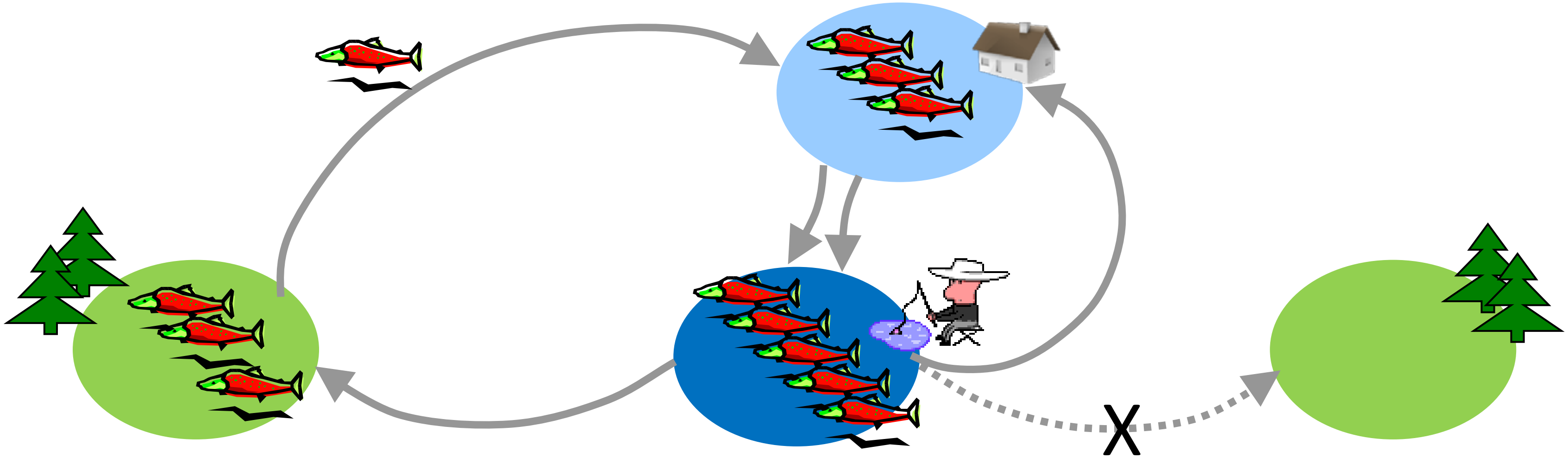


- Pedigree data - beyond RRS :
  - Determine hatchery ancestry and contribution over time (eg Christie et al. 2011)
  - Effective population sizes, rates and impacts of inbreeding (eg Naish et al. Molecular Ecology in press)
  - Estimate selection differentials in hatchery and wild environments (eg Ford et al. 2010, Williamson et al 2011)
  - Estimate stray rates between populations (eg Lin et al. 2011, in prep.)



Thank you!

Summary: balancing risks



Integrated Hatchery Risks:

- Proportion of Hatchery fish breeding in the wild
- Optimal number of generations in program
- Optimal number of wild fish in program (broodstock mining)
- Carrying capacity, competition

Segregated Hatchery Risks:

- Divergent hatchery fish interbreed with wild
- Ecological interactions, carrying capacity
- Mixed stock fisheries and efficacy of mass marking

Summary: Considerations in design

- A research based approach
  - Test principles as well as specifics
  - Continual evaluation
  - "Trigger" points for changing or ending practices

- Comprehensive baselines and monitoring program