Northwest Power and Conservation Council

June 28, 2012

MEMORANDUM

TO: Fish and Wildlife Committee members

FROM: Peter Paquet, Manager Wildlife & Resident Fish

SUBJECT: NOAA hatchery supplementation considerations

Barry Berejikian and Tom Flagg from NOAA Fisheries Manchester Lab will brief the Committee on their work on supplementation. Topics covered will include:

- Background, rationale, and results for the supplementation work at the Manchester Research Station.
- Overview of NOAA interest and approach to the supplementation question.
- A summarization of literature on reproductive success and description of the rationale and results for their studies

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Fitness of hatchery and wild anadromous salmonids and hatchery reform research

Barry Berejikian

NOAA Fisheries

Northwest Fisheries Science Center

Resource Enhancement and Utilization Technologies Division

Manchester Research Station

Topics for today

1) Review relative fitness of hatchery and wild anadromous salmonids (what does it tell us and what doesn't it tell us)

2) Steelhead suffer greater fitness loss: why, and what might be done about it?

3) Approaches to determining the effects and effectiveness of supplementation

RASP (1992) definition of supplementation

The use of artificial propagation in an attempt to:

1.maintain or increase natural production, while

2.maintaining the long-term fitness of the target population, and

3.keeping the ecological and genetic impacts on natural populations within specified biological limits"

Relative fitness

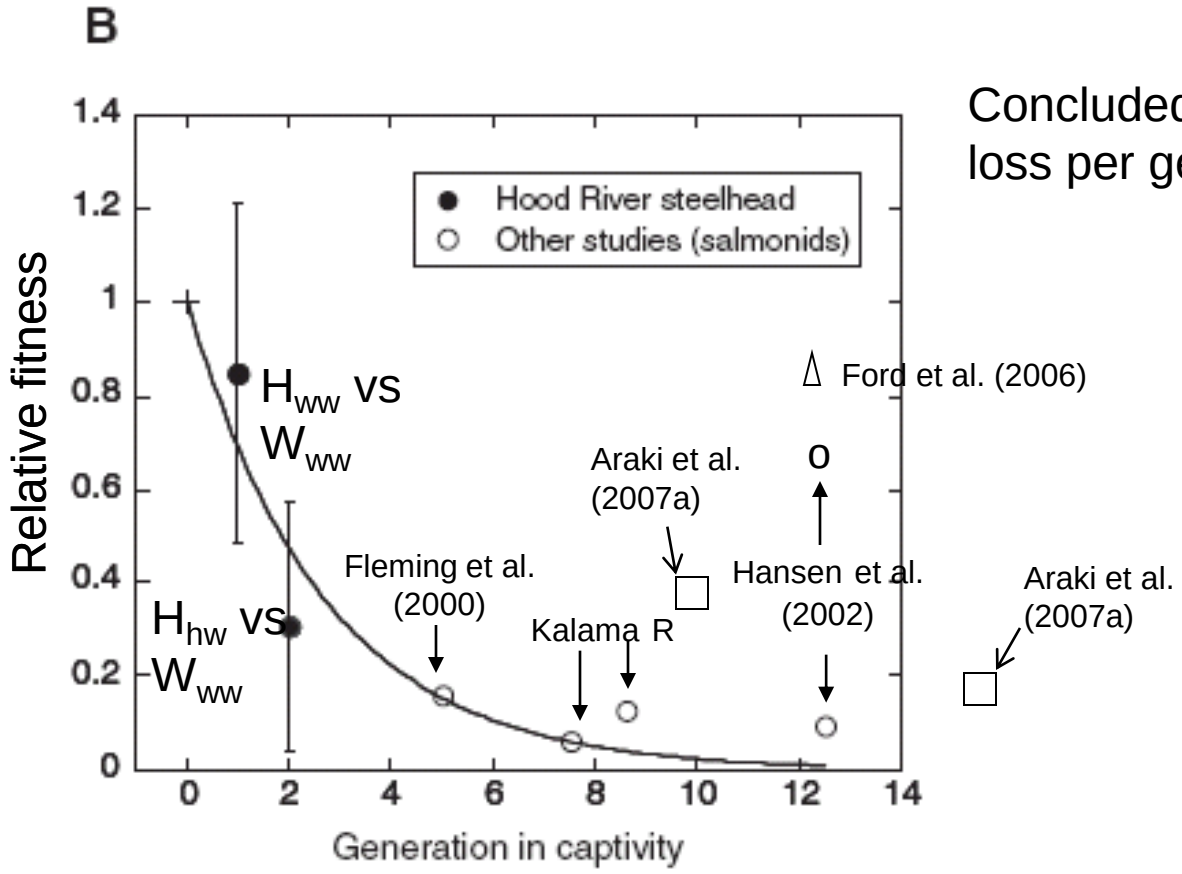
- Also “relative reproductive success”: $(R/S_h)/(R/S_w)$
- Life stage: adult-to-juvenile or adult-to-adult
- Hatchery fish: born in the hatchery
- Wild or natural-origin fish: born in the natural environment
- Hatchery generations: number of generations the hatchery had been operating

Re-visiting Hood River RRS studies

- RRS of H_{ww} / W_{ww} = 0.85 (Araki et al. 2007b Science)
- RRS of H_{hw} / H_{ww} = 0.55* (Araki et al. 2007b Science)
- RRS of W_{hh} / W_{ww} = 0.37* (Araki et al. 2009 Biol. Lett.)

*Indicates a genetic basis for fitness loss in one generation

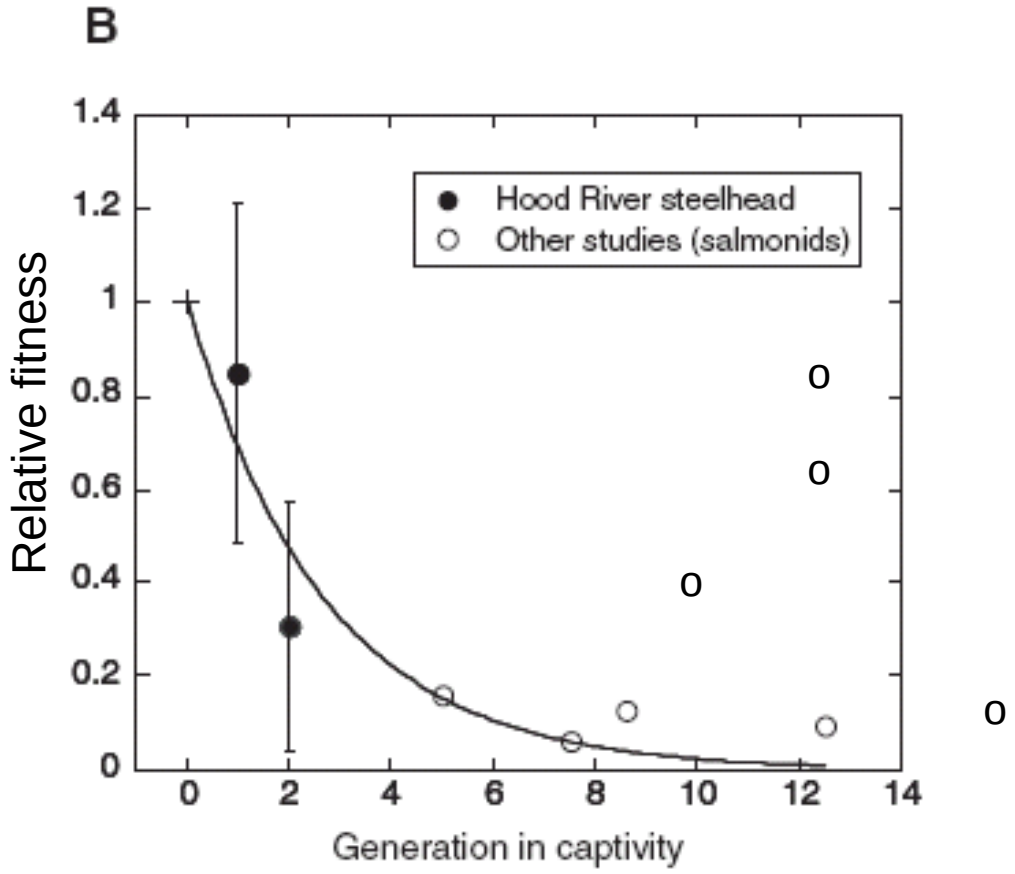
Re-visiting Hood River RRS studies



Concluded 37% fitness loss per generation

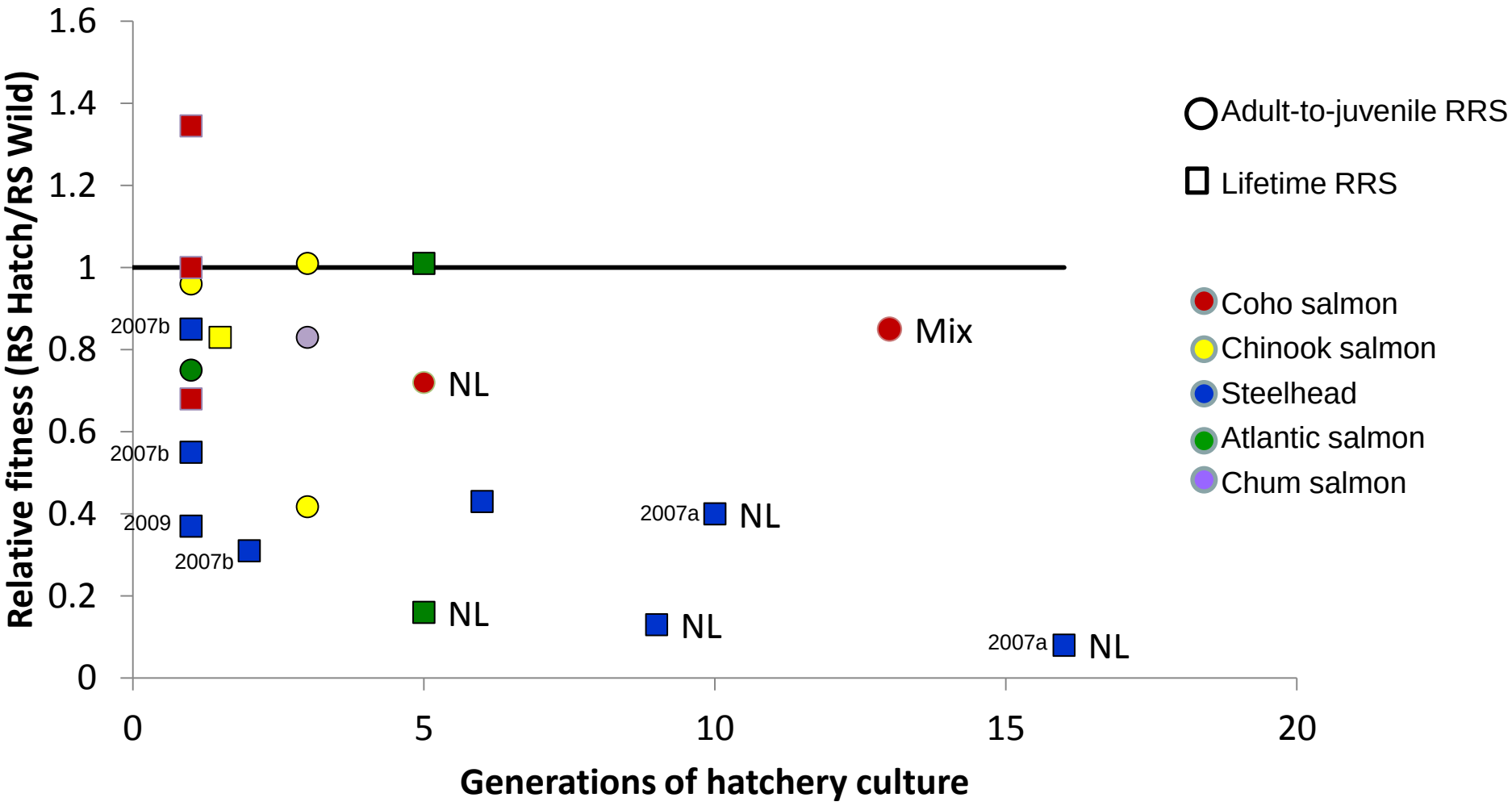
From Araki et al. 2007b. Science 318:100-103 (Figure 2b)

Revisiting Hood River RRS studies

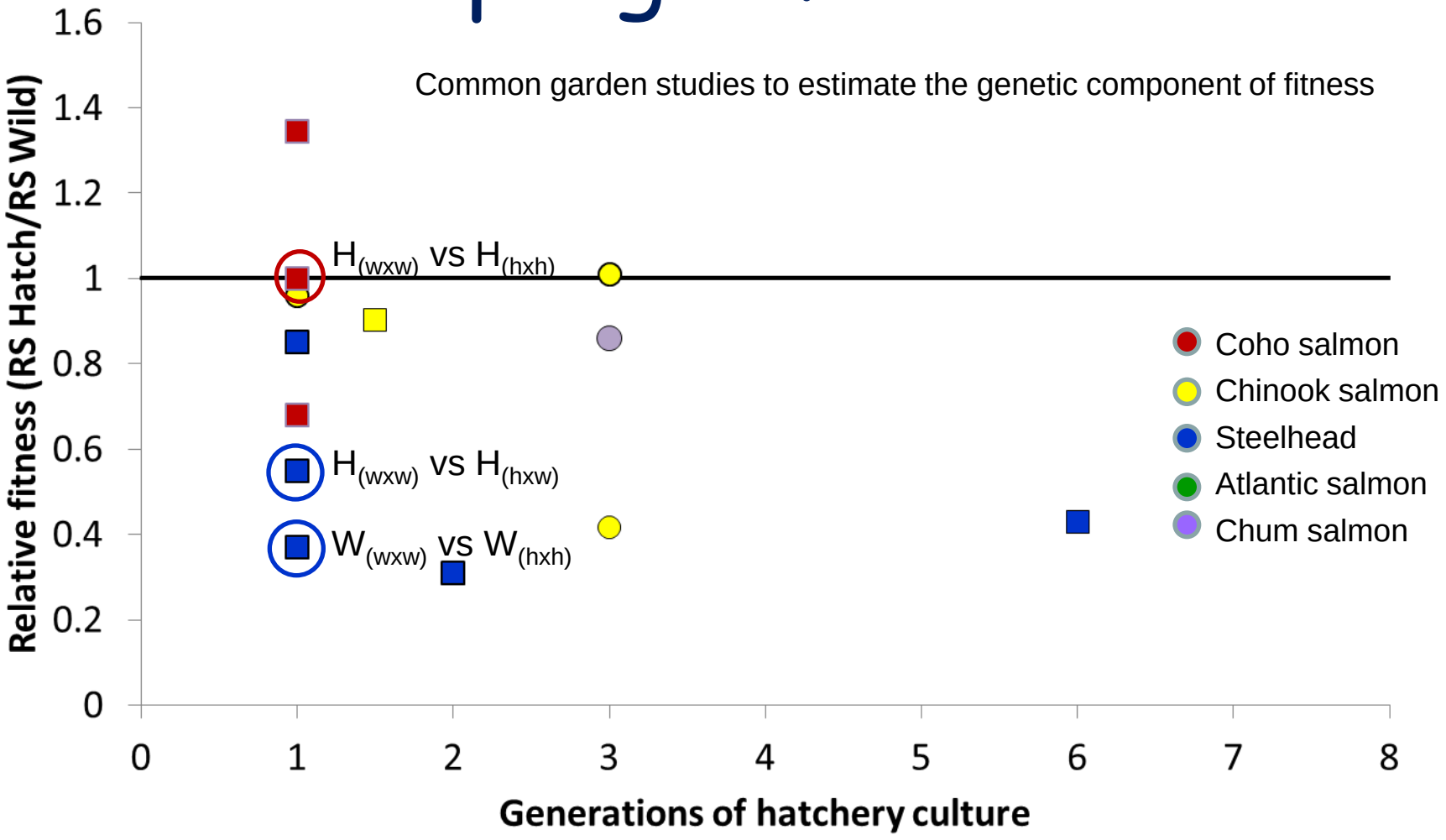


From Araki et al. 2007. Science 318:100-103 (Figure 2b)

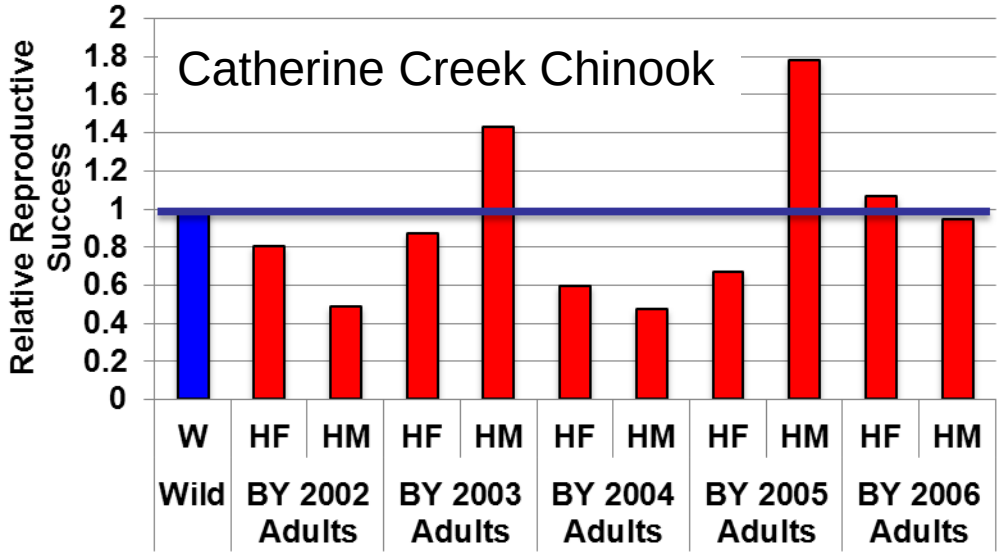
Review of RRS



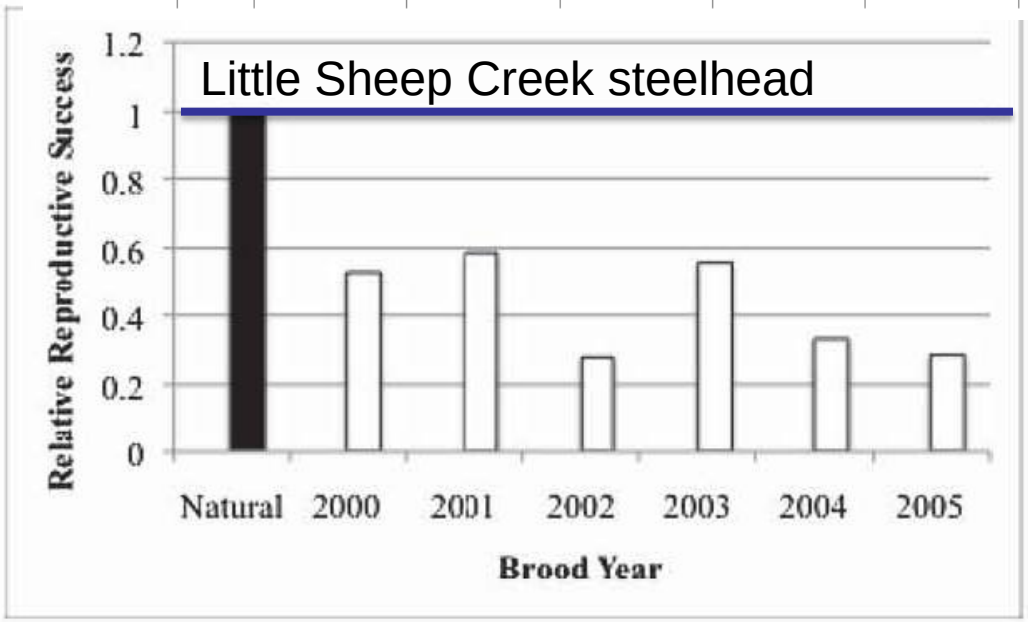
RRS in PNW supplementation programs



Steelhead and Chinook RRS in NE Oregon

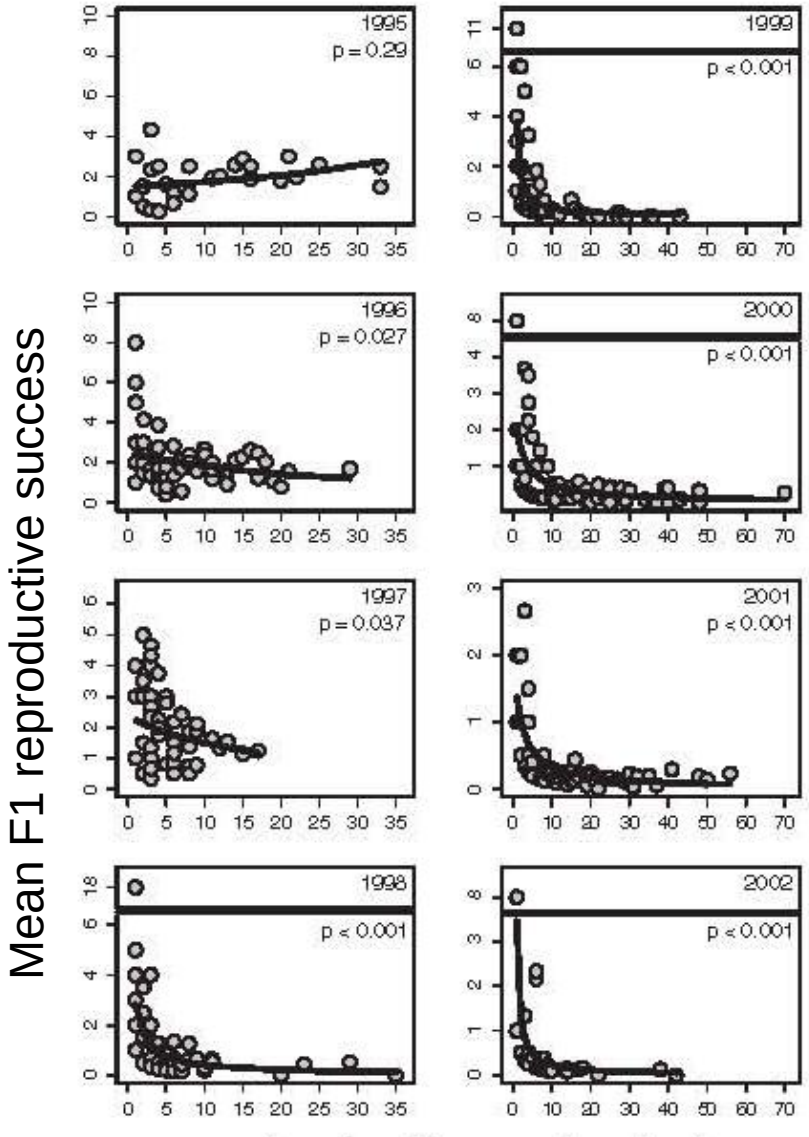


Overall mean = 0.83
(Bernston et al. unpublished)



Overall mean = 0.43
Bernston et al. 2011. TAFS

What's going on with steelhead?



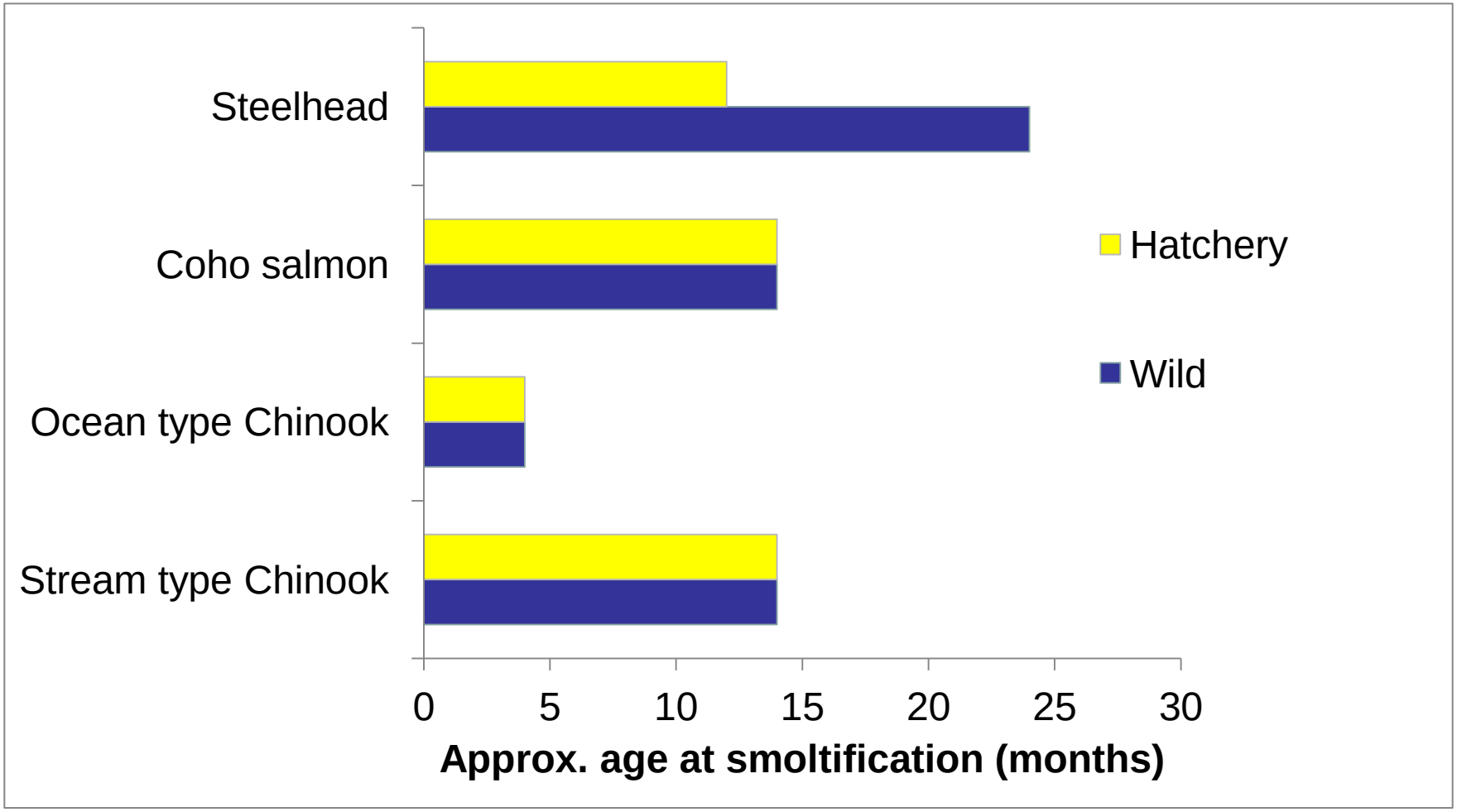
- Domestication selection hypothesized as a key mechanism *(Berejikian et al. 1996, Reisenbichler et al. 2004, Araki et al. 2008, Fraser 2008)*
- Christie et al. (2011): More Hood River results
- Potential causes
  - Artificial breeding (e.g., no mate selection)
  - Altered juvenile rearing regimes

What to do?

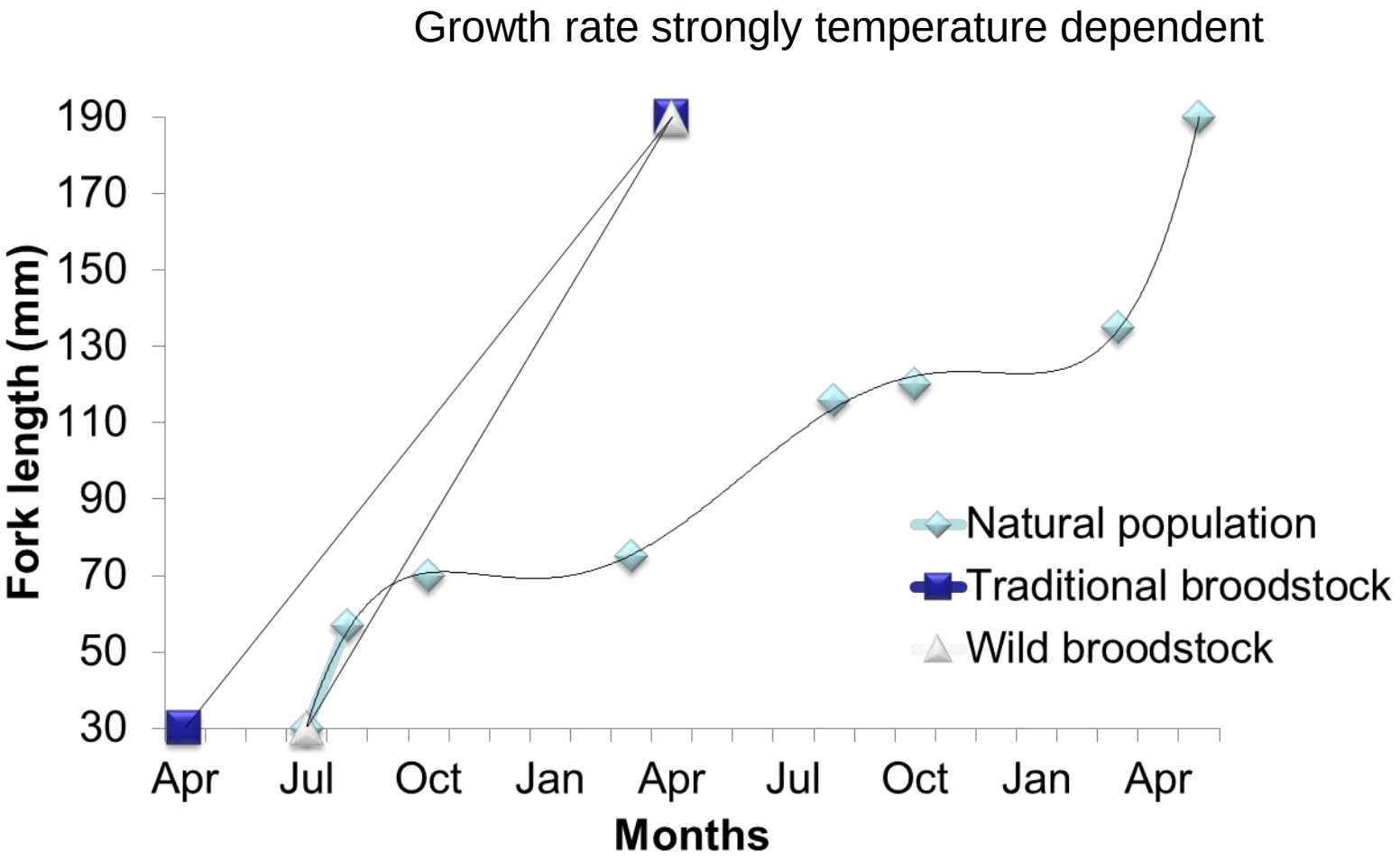
“Determining which traits are under selection and whether captive breeding programs can be modified to mitigate those selection pressures will be the next big challenge for improving the science of captive breeding.” (Christie et al. 2011)

“Parallel studies designed to identify the ecological, behavioral, and physiological factors responsible for fitness of hatchery fish in nature could suggest ways to make supplementation more successful in the long term. (Waples et al. 2007)”

Age-at-smoltification in hatchery and wild salmon and steelhead



Growth rates and smoltification



Research to Advance Hatchery Reform (BPA Project 199305600*)

Hatchery-scale experiment

Collaborators

USFWS
NOAA/NWFSC
UW
USGS
WDFW

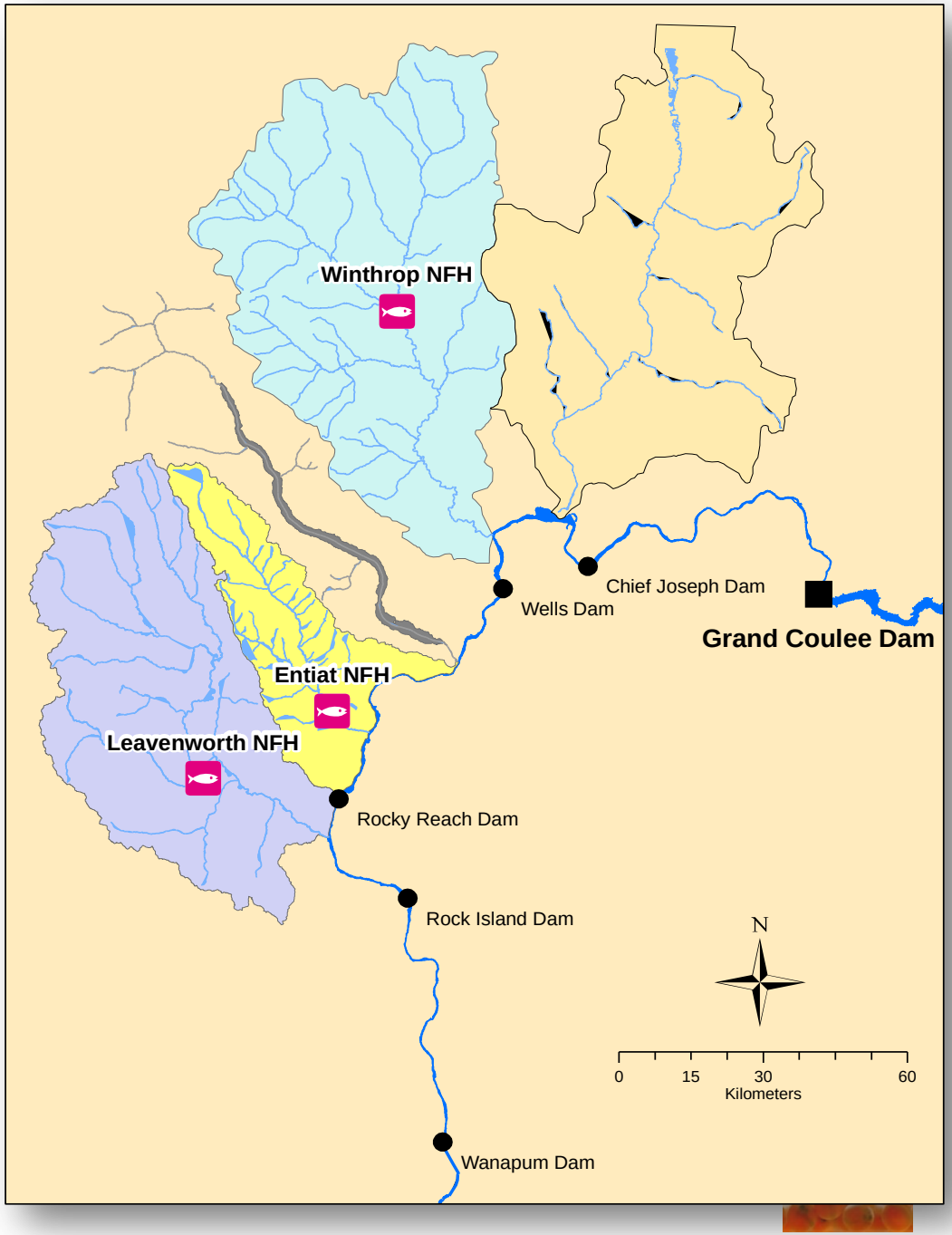
Funding

BPA
BOR
USFWS
NOAA

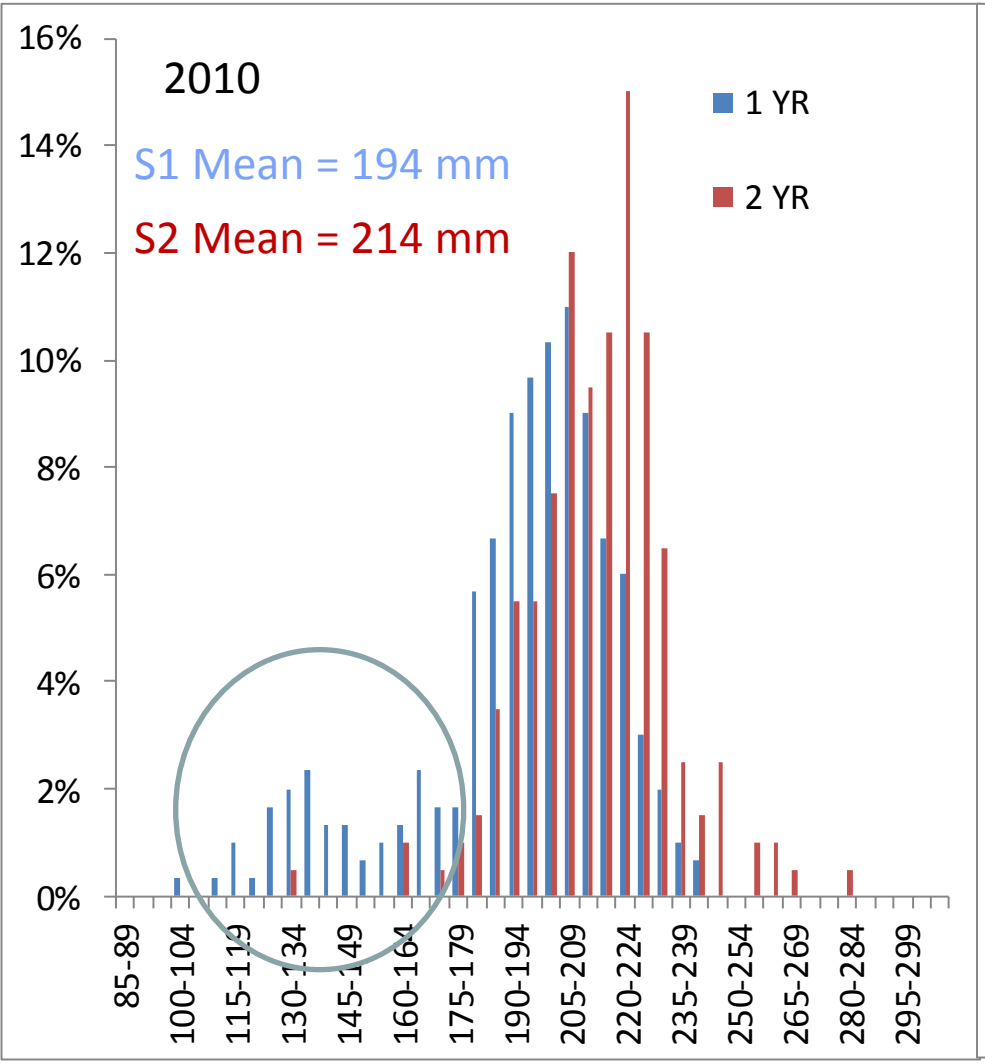
Laboratory-scale experiment

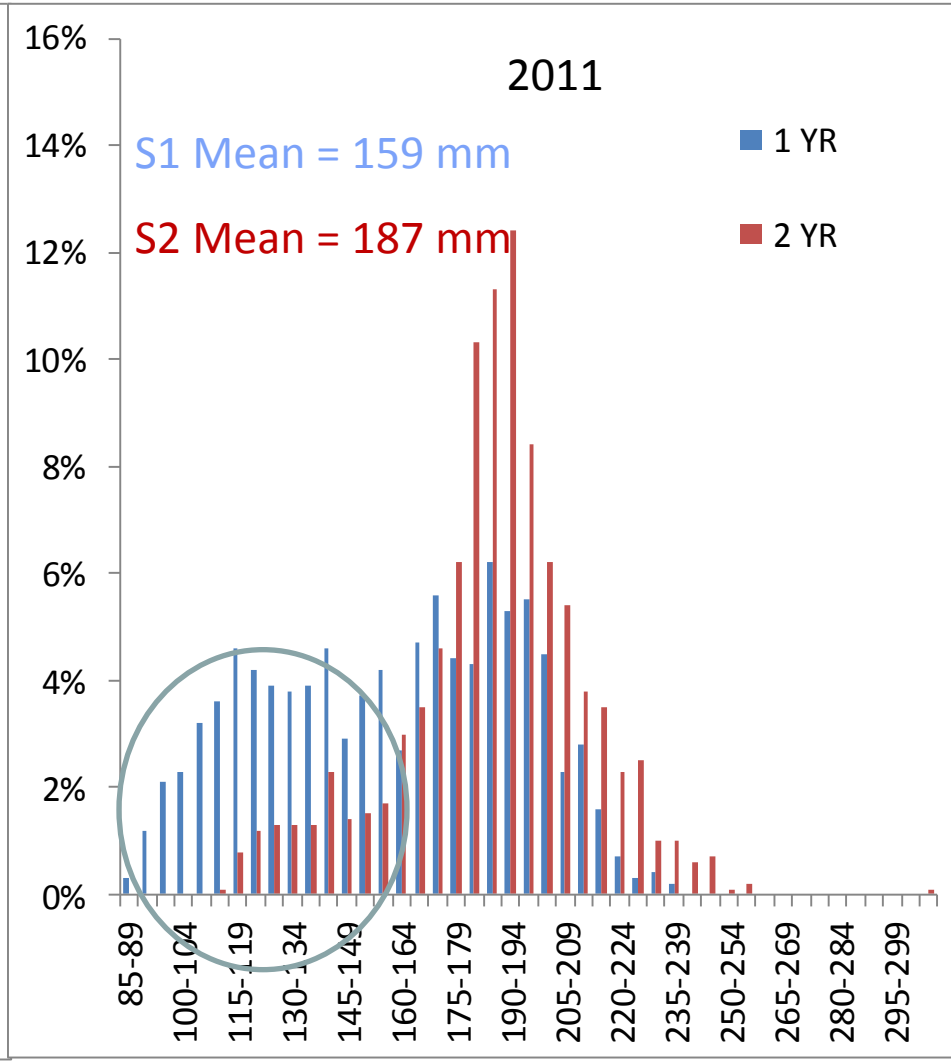
* Relevant RPAs: 39, 40, 63.2, 63.4

Winthrop National Fish Hatchery

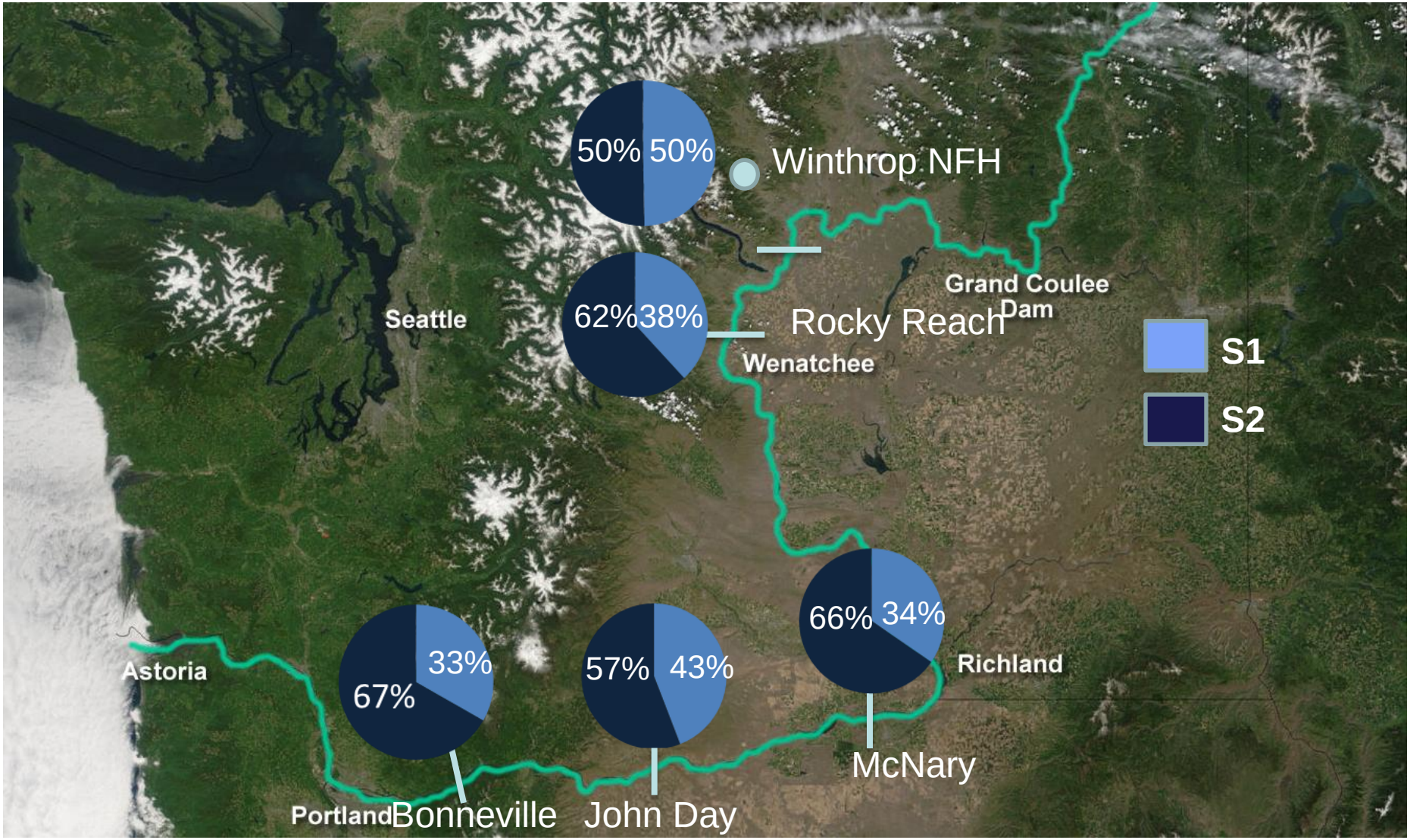


Winthrop National Fish Hatchery smolt size at release

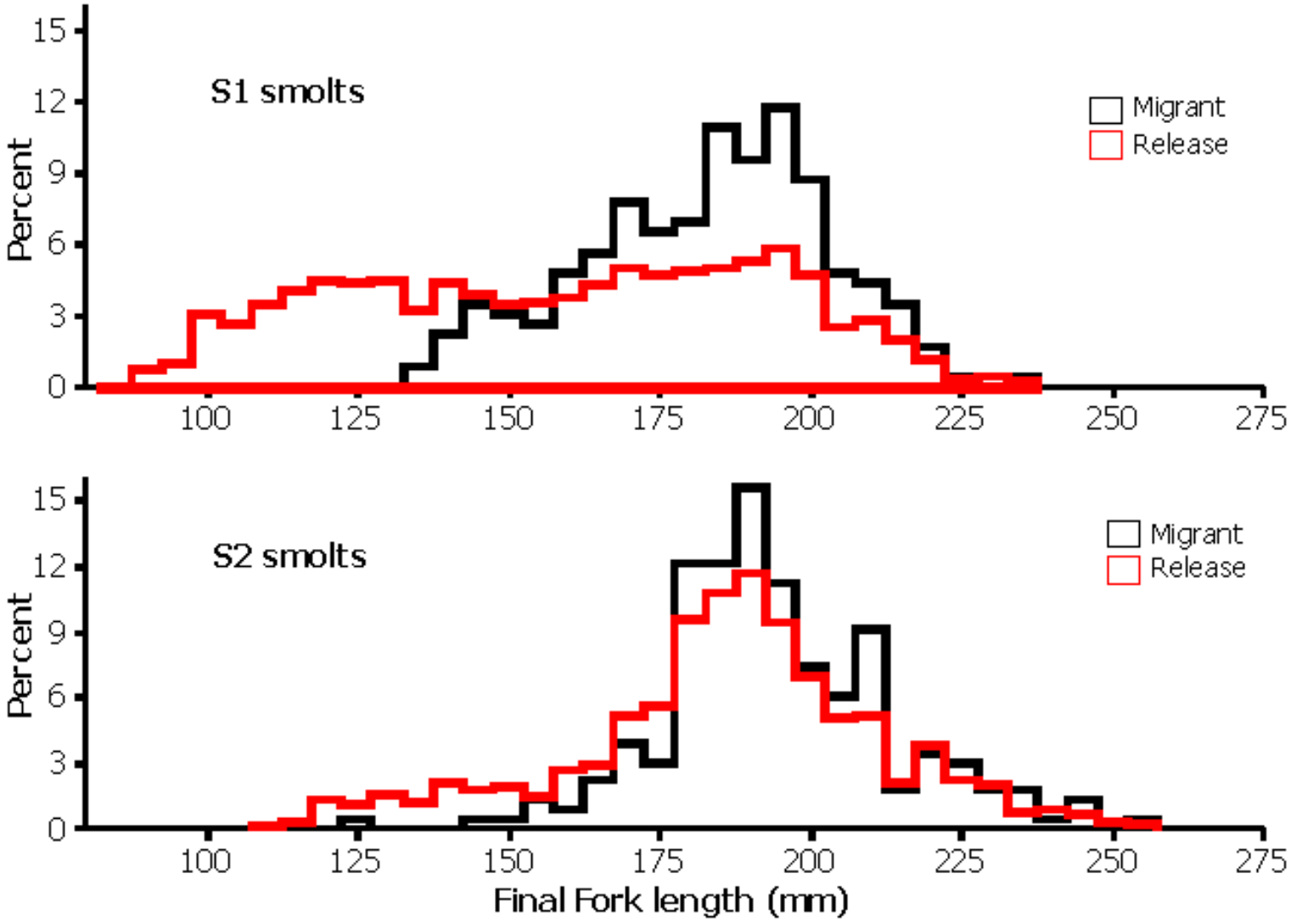




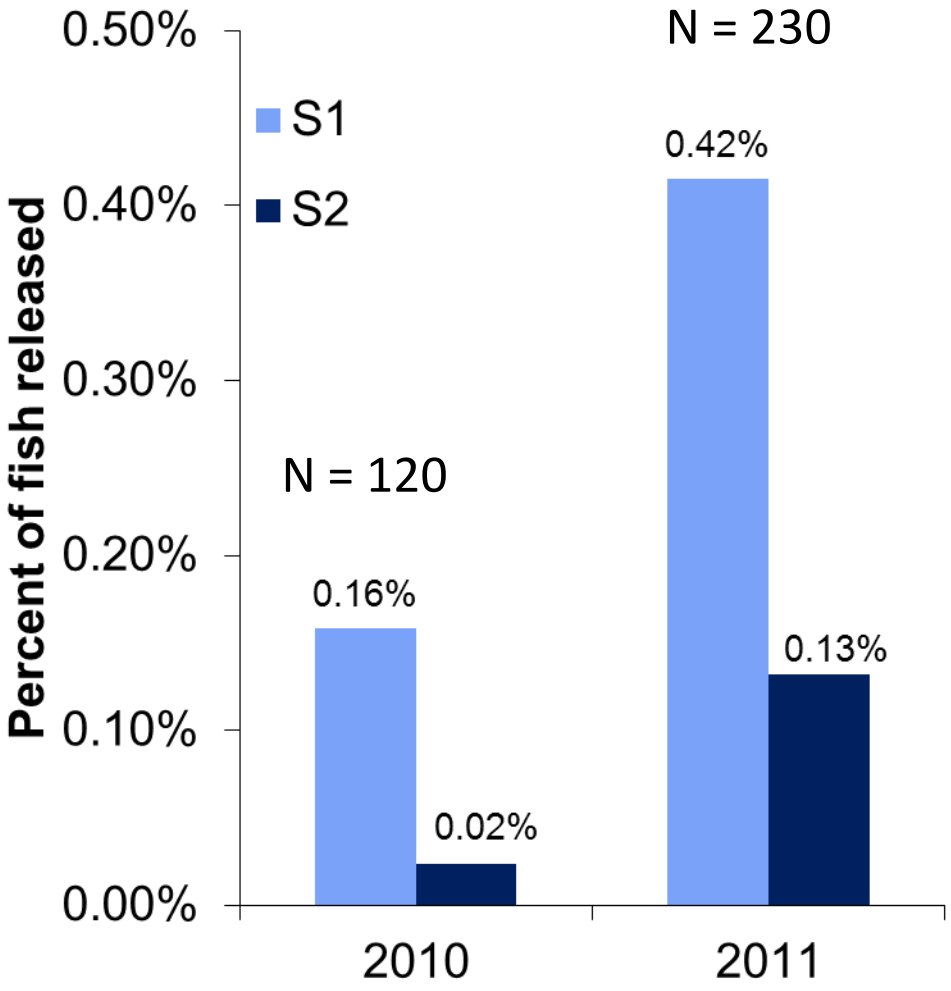
S1 vs S2 PIT-tag detections (2011 release year)



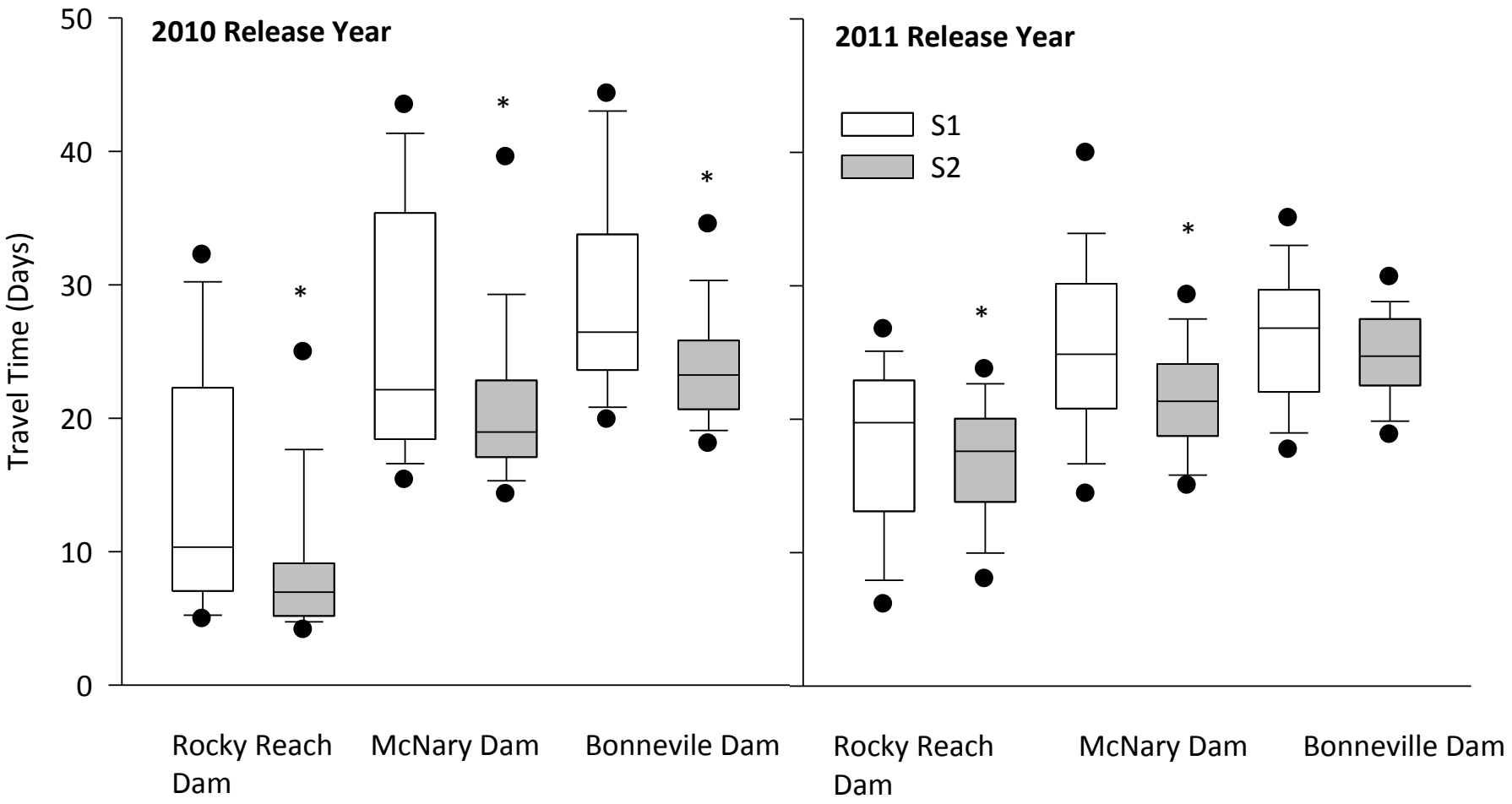
Selection on body size after release



Summer residuals (Aug – Sep)



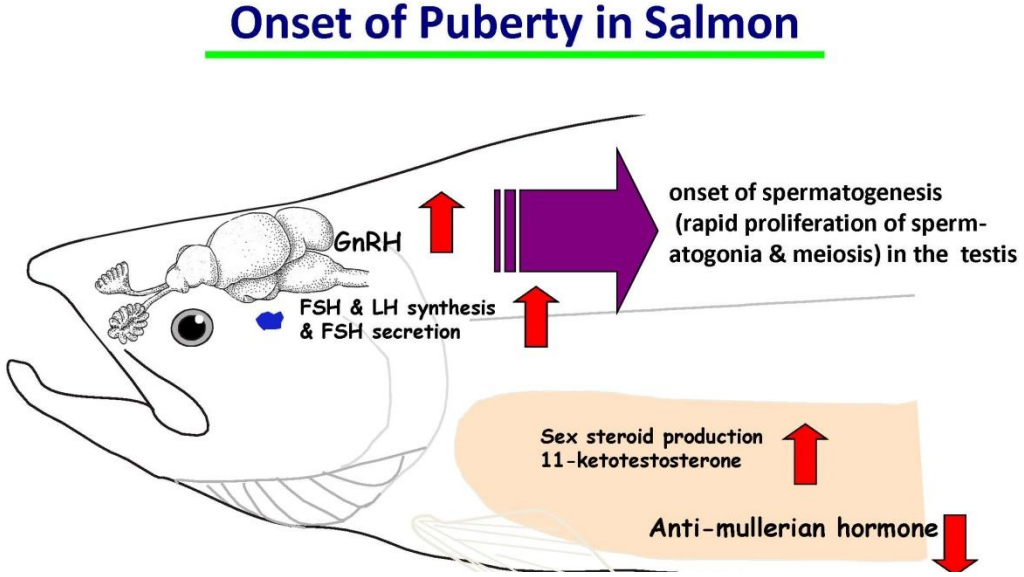
Travel Time


2010 Release Year
2011 Release Year
S1
S2
Travel Time (Days)
50
40
30
20
10
0
Rocky Reach Dam
McNary Dam
Bonnevile Dam
Rocky Reach Dam
McNary Dam
Bonneville Dam

Causes of residualism

- Smoltification
  - Morphology
  - Gill Na-K ATPase Activity
  - mRNAs for two forms of ATPase

- Male Maturation
  - GSI
  - Plasma 11-KT
  - Histology
  - Pituitary LH and FSH
  - Testis AMH



Approaches to answer the big hatchery questions

Recommendations for Broad Scale Monitoring to Evaluate the Effects of Hatchery Supplementation on the Fitness of Natural Salmon and Steelhead Populations

Final Draft Report of the Ad Hoc Supplementation Monitoring and Evaluation Workgroup*

Peter F. Galbreath[1], Chris A. Beasley[2], Barry A. Berejikian[3], Richard W. Carmichael[4], David E. Fast[5], Michael J. Ford[3], Jay A. Hesse[6], Lyman L. McDonald[7], Andrew R. Murdoch[8], Charles M. Peven[9], David A. Venditti[10]

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[3] Northwest Fisheries Science Center, NOAA-Fisheries
[4] Oregon Department of Fish and Wildlife
[5] Yakima Klickitat Fisheries Project, Yakama Nation
[6] Department of Fisheries, Nez Perce Tribe
[7] Western EcoSystems Technology, Inc.
[8] Washington Department of Fish and Wildlife
[9] Fisheries Program, Chelan Public Utility District
[10] Idaho Depart of Fish and Game

April 4, 2008

* Workgroup members participated as individuals, not as agency representatives. The report's content, conclusions and recommendations are solely those of the workgroup.

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EW PANEL
eting held
, 2003
es Science Center
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s available on the RSRP web site, but as a
vidual reports.

iversity of Washington, chair
Florida State University
University of California – San Diego
Princeton University
University of California – Santa Barbara
Dalhousie University

erson NOAA Fisheries liaison, RSRP report coordina

Recovery Science Review Panel

y Science Review Panel (RSRP) was convened by NOAA Fisheries to g
al aspects of recovery planning for listed salmon and steelhead species thr
e panel consists of six highly qualified and independent scientists who perfo

w core principles and elements of the recovery planning process being develop
A Fisheries.

2. Ensure that well accepted and consistent ecological and evolutionary principles form for all recovery efforts.

RSRP REPORT, 21-23 JULY 2003

Independent Scientific Advisory Board

Review of Salmon and Steelhead Supplementation

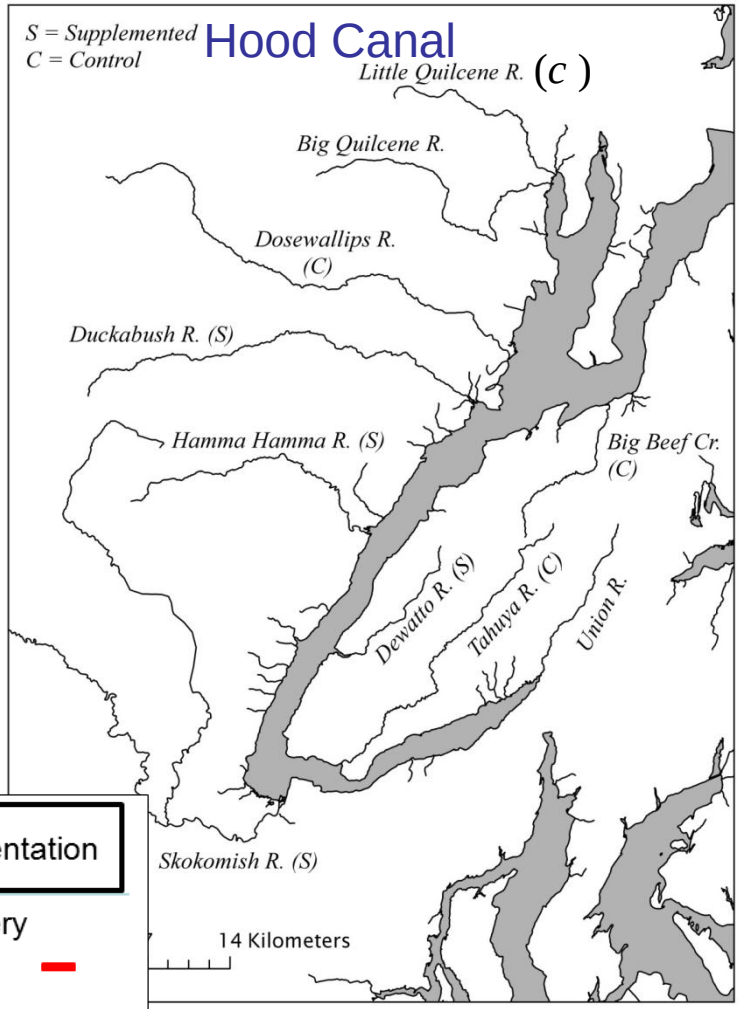
ISAB 2003-03
June 4, 2003

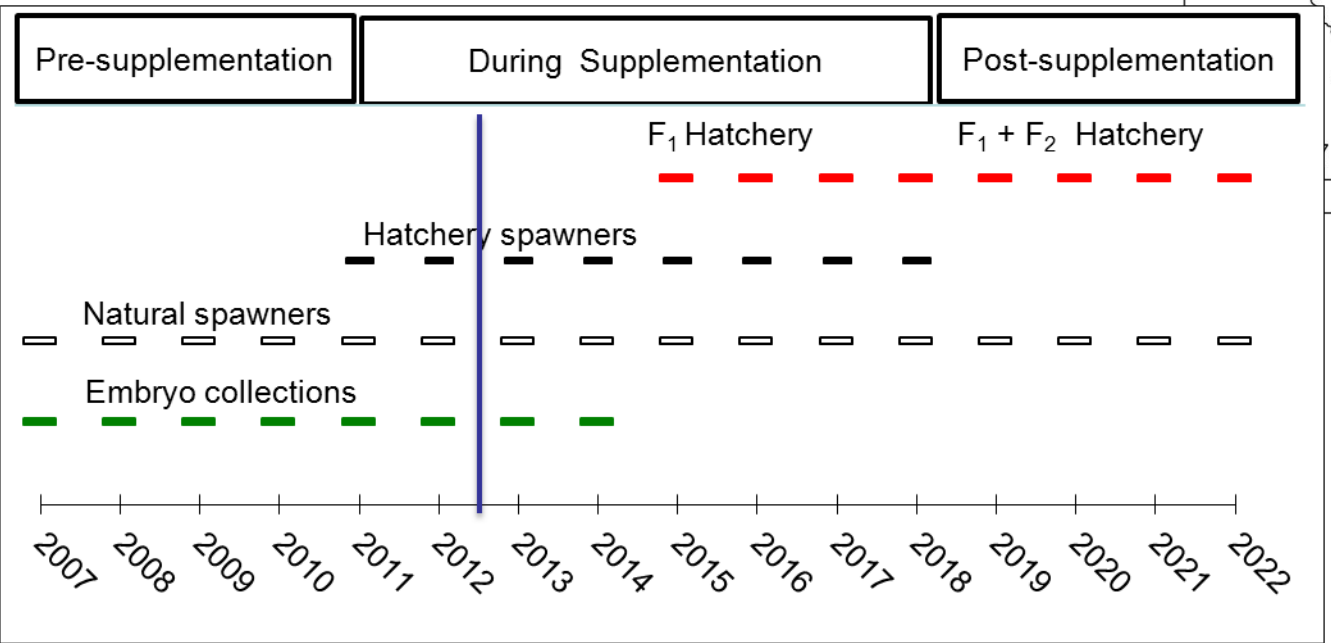
Ad Hoc Supplementation Workgroup Approach

1. Implement targeted RRS studies over a range of program types (PNI values)
2. Large-scale treatment/reference experiment or monitoring to quantify abundance and productivity of natural populations
3. Fund studies to address remaining critical uncertainties
   - Why low fitness
   - When to start and stop supplementation
   - Impacts of genetics (interbreeding) and ecological interactions

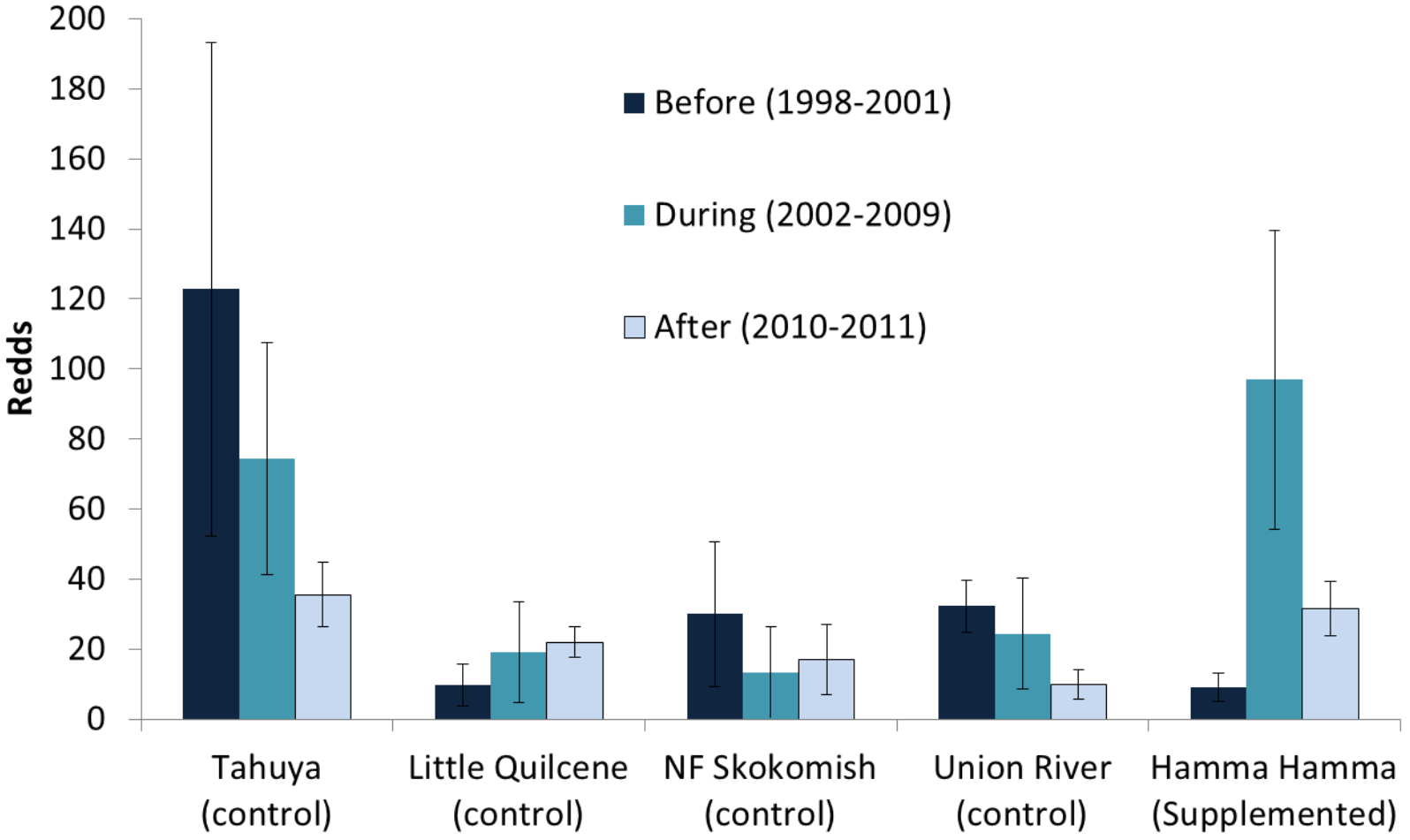
Experimental test of steelhead supplementation

- Replicated before-during-after-control-impact experiment
- Response variables = spawner abundance, fw and marine survival, life history and genetic variation, spatial distribution, spawn timing, etc.





Supplementation effect on abundance in the Hamma Hamma River



Genetic Diversity (Hamma Hamma River Cons. Hatchery)

Summer parr (age-1 and age-2)	N	H_o	Alleles	Rare alleles	Unique alleles	A_r	Mean Nb
Offspring of **wild** spawners pre-supplementation (1998-2001)	224	0.760	177	61	15	17.5	33
Offspring of **wild + hatchery** spawners during supplementation (2002-2004)	241	0.763	176	54	16	17.4	42

D. Van Doornik et al. 2010 Can. J. Fish. Aquat. Sci.

Summary

- Fitness loss appears real, but results vary among species, and it looks worse for steelhead
- Domestication selection likely plays an important role in fitness loss for steelhead
- New methods to mitigate domestication selection and ecological interactions are being developed
- The potential for supplementation to contribute to healthy salmon populations depends on continued development of new approaches