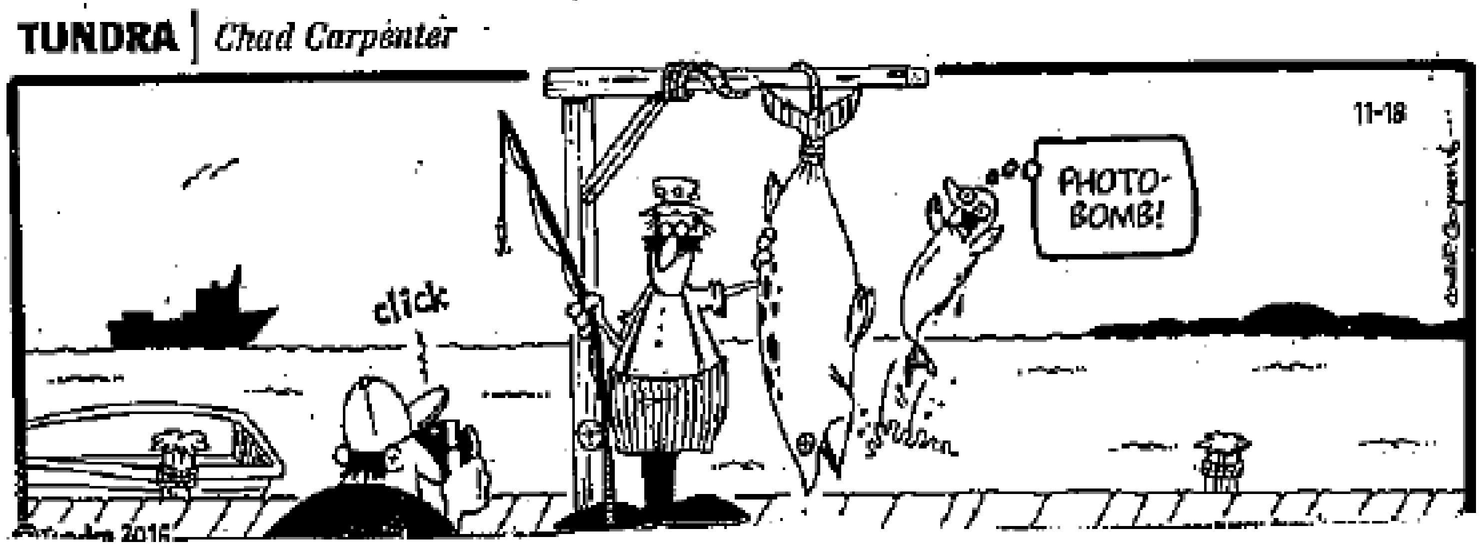


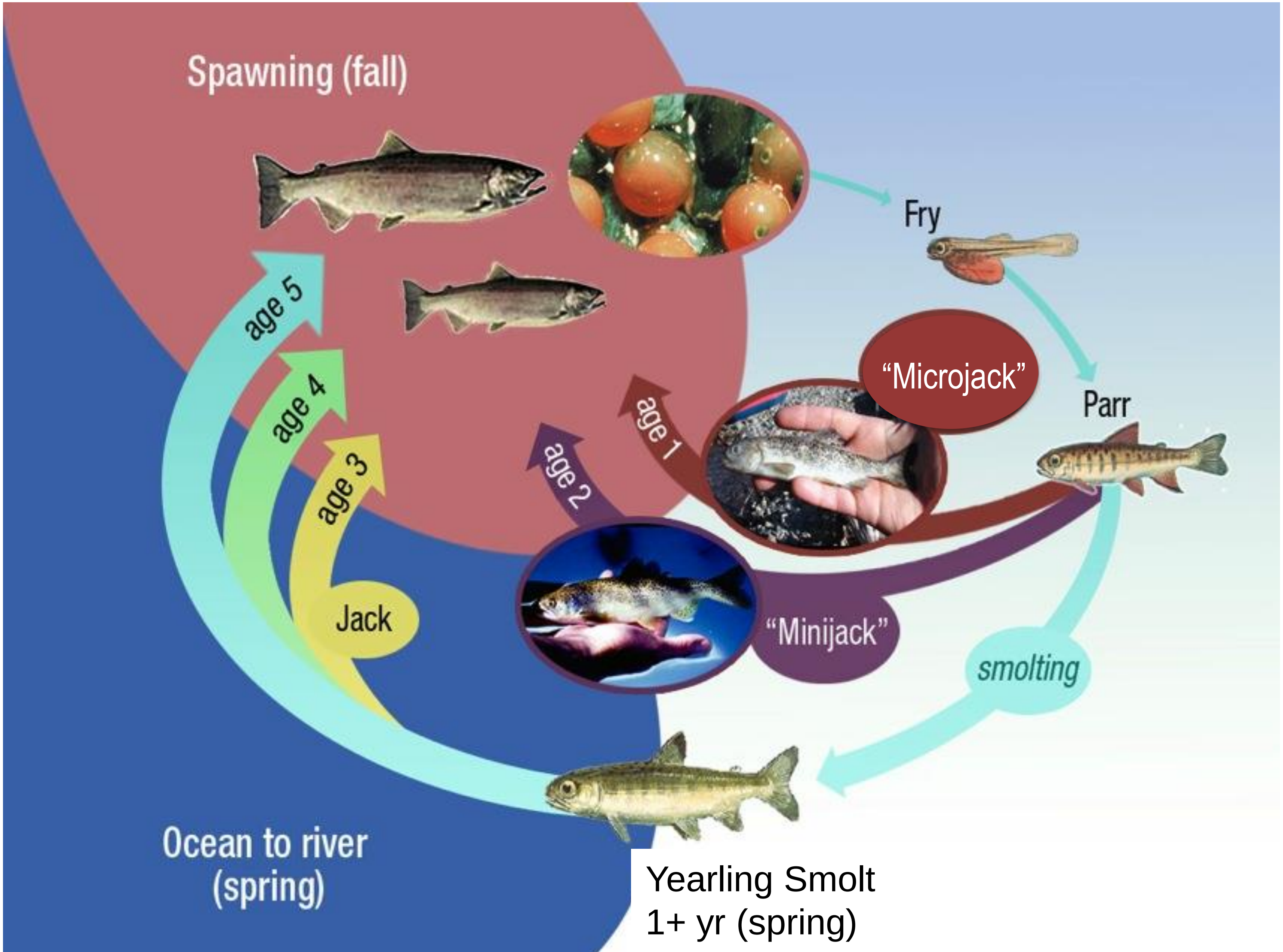
arstad,

production

Outline

- Introduction
- Briefly review previous results from Harstad et al. 2014 as experimental lead in.
- A “common garden” experiment to isolate genetic vs. environmental effects on minijack rate
- The effect of resource competition on minijack rate in integrated and segregated stocks
- Conclusions

Hatchery spring/summer Chinook life history



Variation in Age of Male Maturity

Mature male salmon

Factors Affecting Age of Maturation

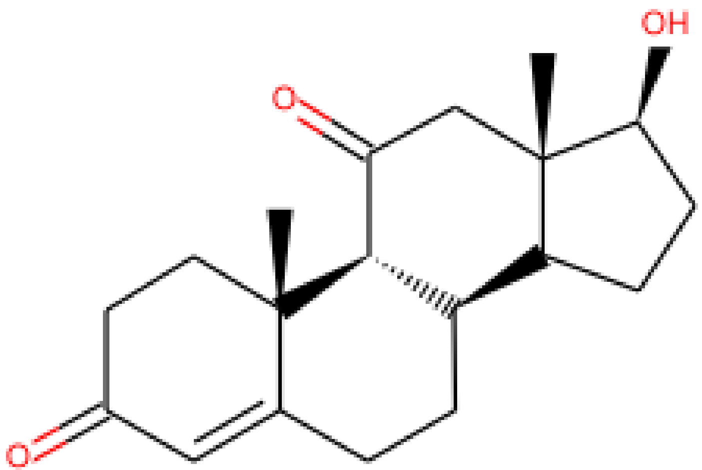
- ✓ Genetics
- ✓ Environment
  - temperature
  - food availability
  - food energy content
- ✓ G x E interaction

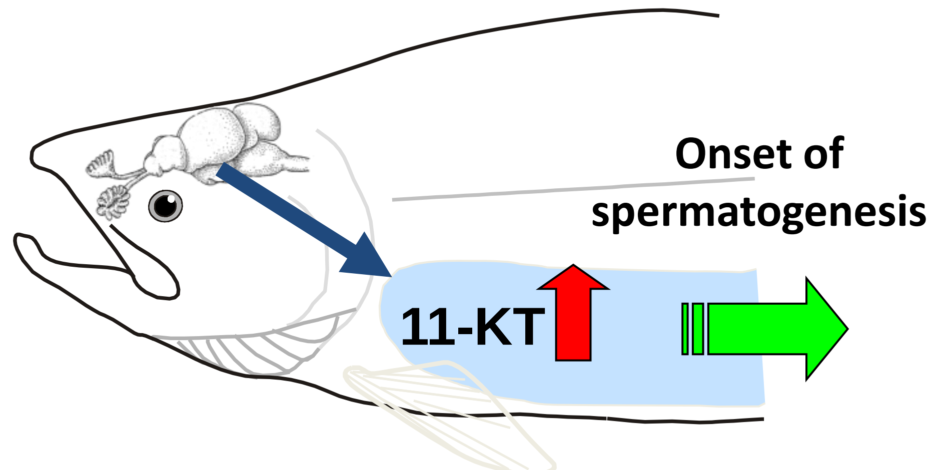
Growth & Body energy stores

The Hatchery environment can significantly influence age of maturation

How to detect a minijack?

Early Spring (prior to Fall Spawn)



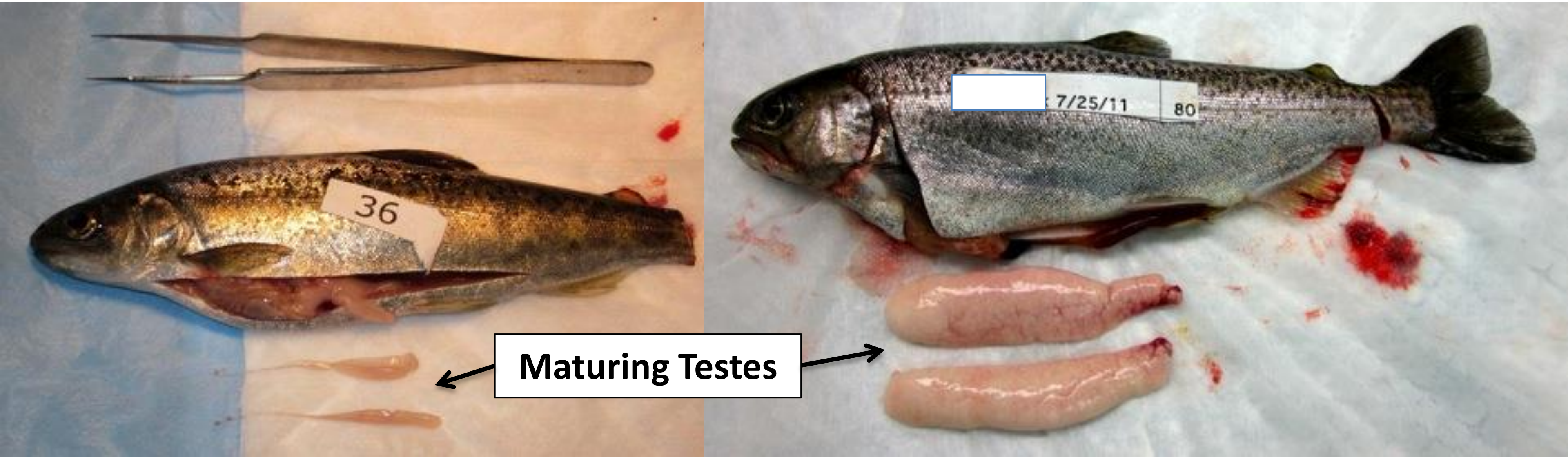


- **11-Ketotestosterone (11-KT)**
- **Major androgen in teleost fish**
- **Regulates spermatogenesis**

How to detect a minijack?

- Visual inspection of the testes

Late Spring (prior to Fall Spawn) **Summer (prior to Fall spawn)**



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American Fisheries Society 2014
ISSN: 0002-8487 print / 1548-8659 online
DOI: 10.1080/00028487.2014.886621

ARTICLE

Variation in Minijack Rate among Hatchery Populations of Columbia River Basin Chinook Salmon

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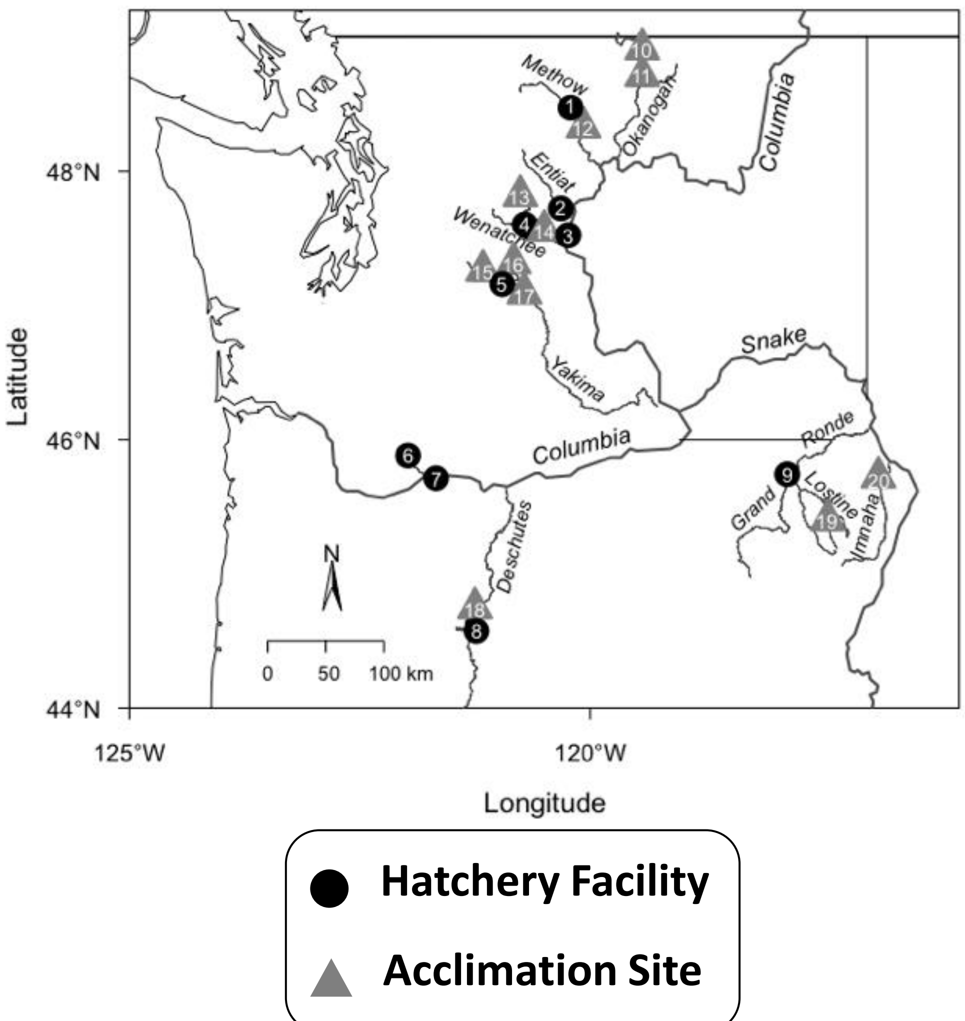
National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest Fisheries Science Center, Environmental Physiology Program, 2725 Montlake Boulevard East, Seattle, Washington 98112, USA

Abstract

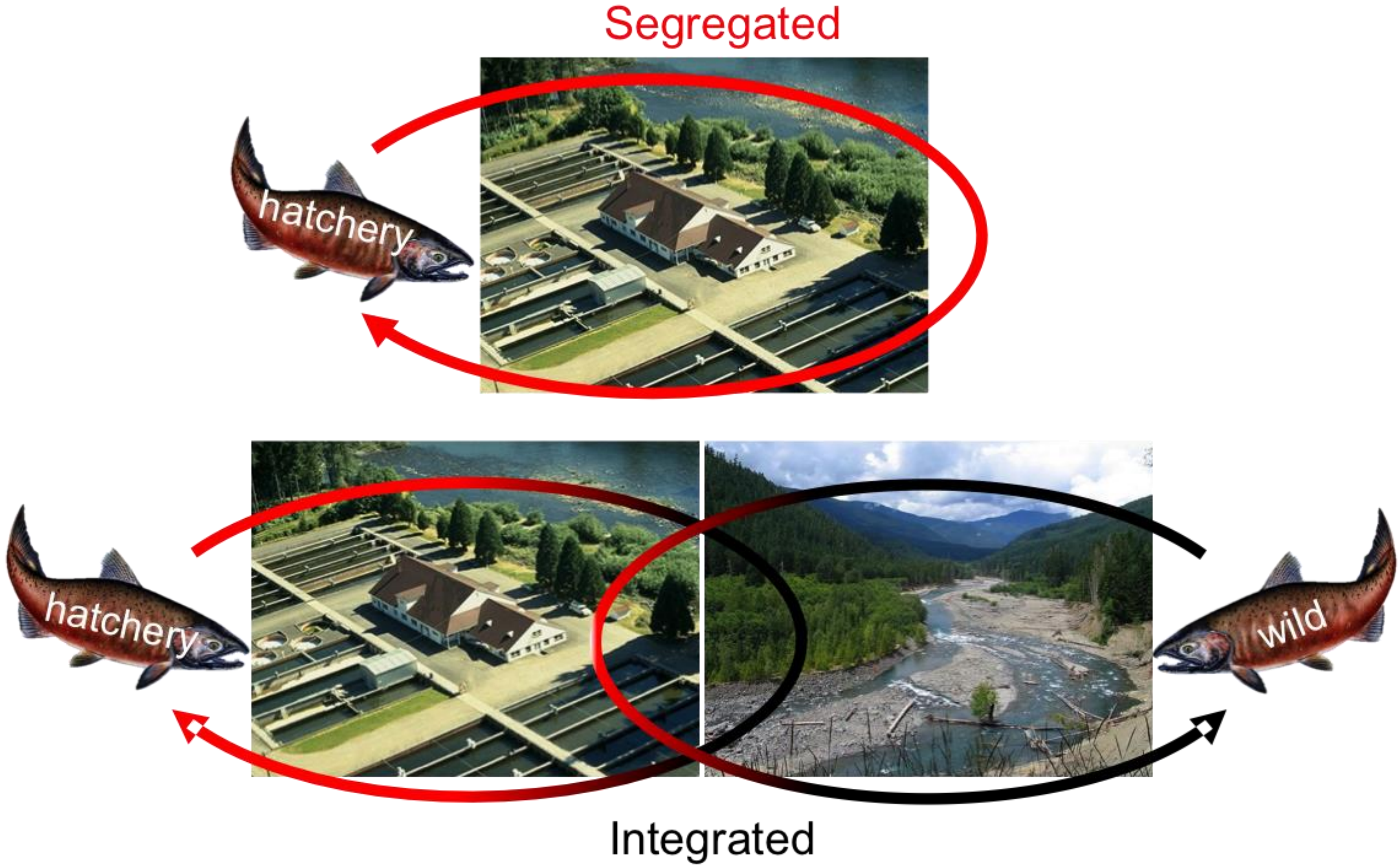
In Columbia River spring and summer Chinook Salmon *Oncorhynchus tshawytscha*, age of male maturation ranges from age 1 (microjack), 2 (minijack), 3 (jack), to 4 or 5 (adult) years. The presence of minijacks has been noted in several experimental studies and documented for a few hatchery programs; but, a comprehensive survey of their occurrence in hatchery production programs has never been conducted. We measured the proportion of minijacks among males released from several spring- and summer-run Chinook Salmon hatchery programs throughout the Columbia River basin among brood years 1999–2010. The hatcheries surveyed included both segregated (uses only hatchery-origin spawners in broodstock) and integrated (includes some degree of natural-origin spawners in broodstock) programs. Minijacks were found in all programs monitored, and rates varied approximately 10-fold across release groups, ranging from 7.9% to 71.4% of males in spring Chinook Salmon programs and from 4.1% to 40.1% of males in summer Chinook Salmon programs. Cumulative growth (i.e., size at release) was found to be positively correlated with minijack rate, but for only the integrated Chinook Salmon programs. Domestication selection may have occurred in segregated spring Chinook Salmon programs, increasing the threshold size for maturation and lowering minijack rates. Elevated minijack rates in Chinook Salmon hatchery programs result in a direct reduction in both the number of male smolts released and potential adult males available for harvest and spawning.

Transactions of the American Fisheries Society 2014

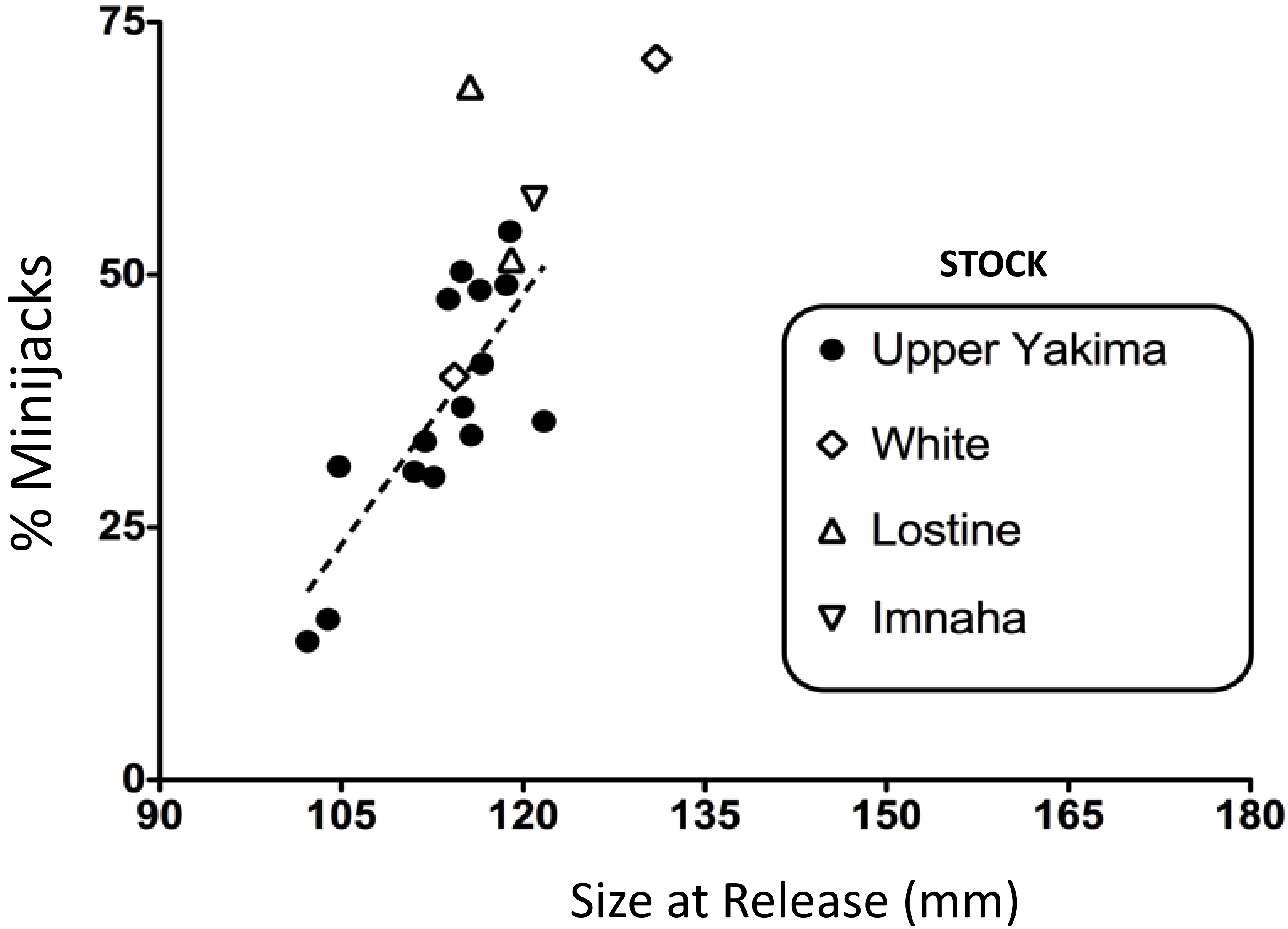
9 Spring Chinook hatchery programs
5 Summer Chinook hatchery programs



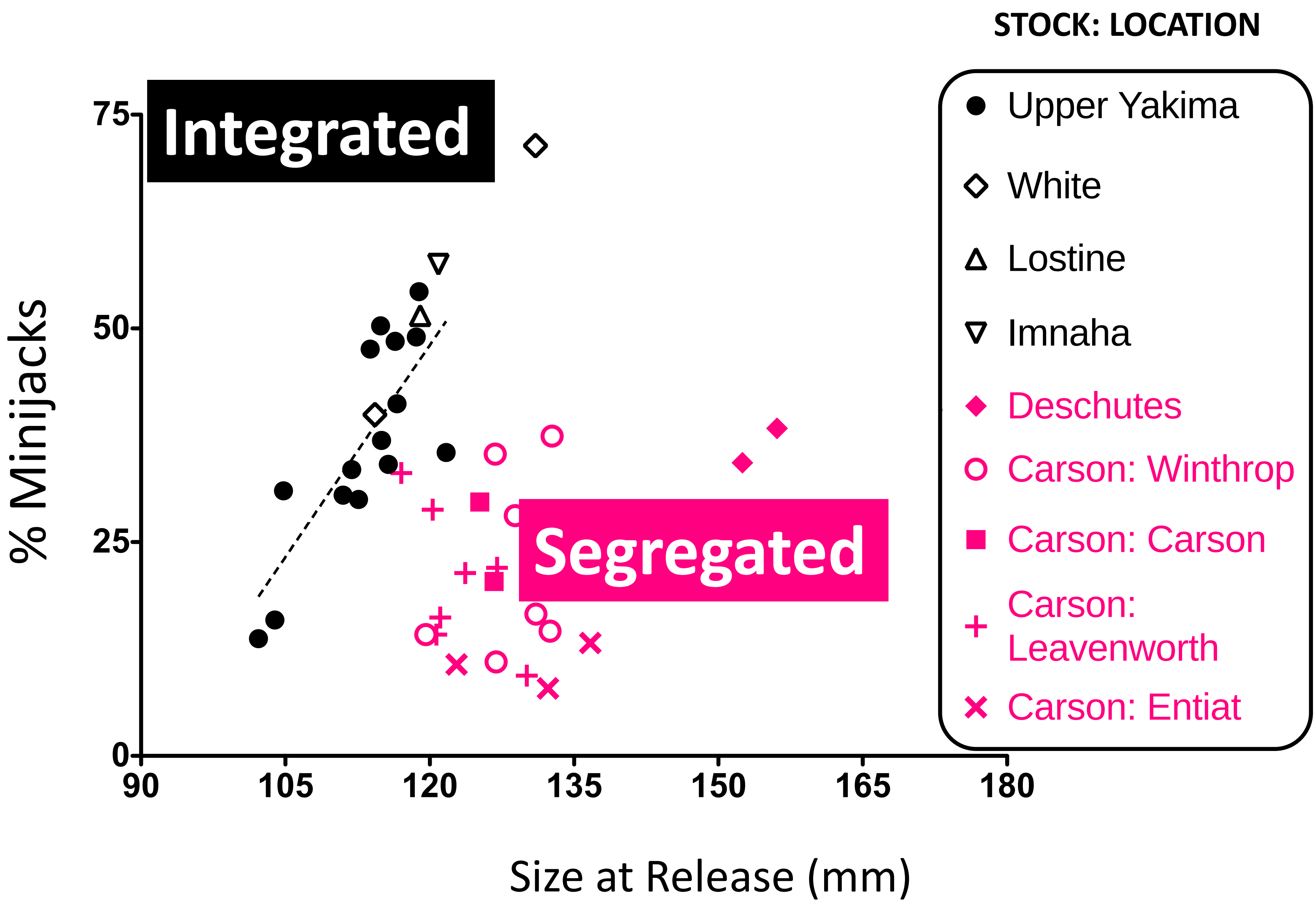
- **BYs: 1999-2010**
- **# of years sampled ranged from 1 to 12 years**


Segregated
hatchery
hatchery
wild
Integrated

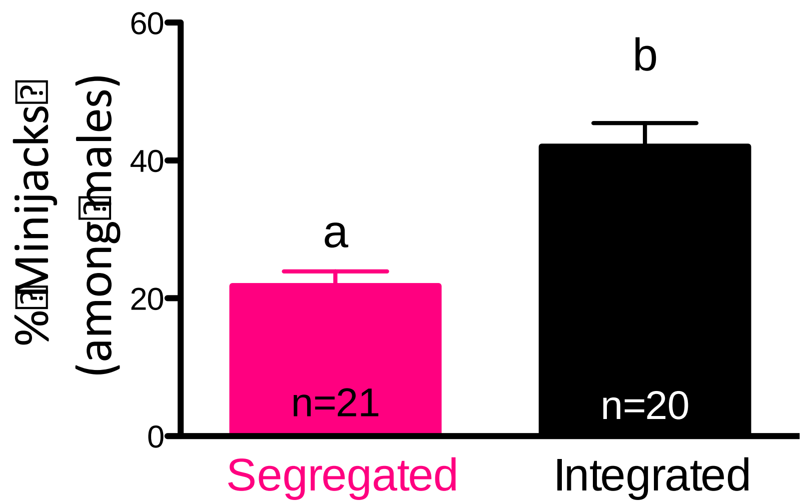
Spring Chinook: Minijack rate is strongly correlated with size at release

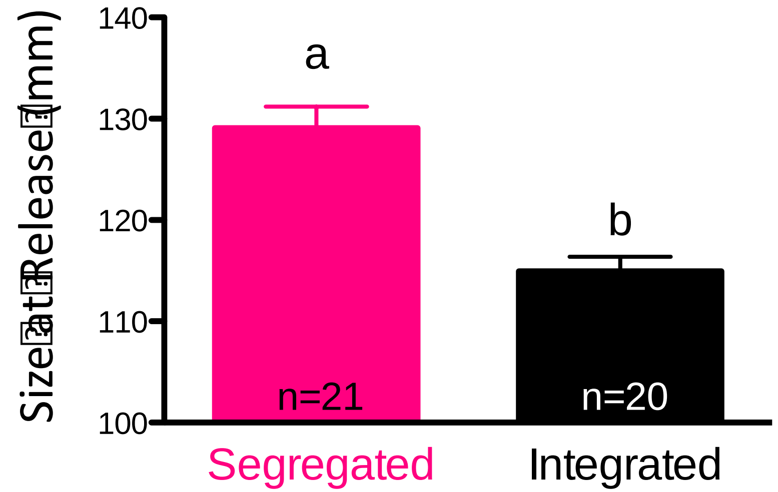


Spring Chinook:



Integrated spring Chinook hatchery populations sampled had higher minijack rates, even with smaller size at release



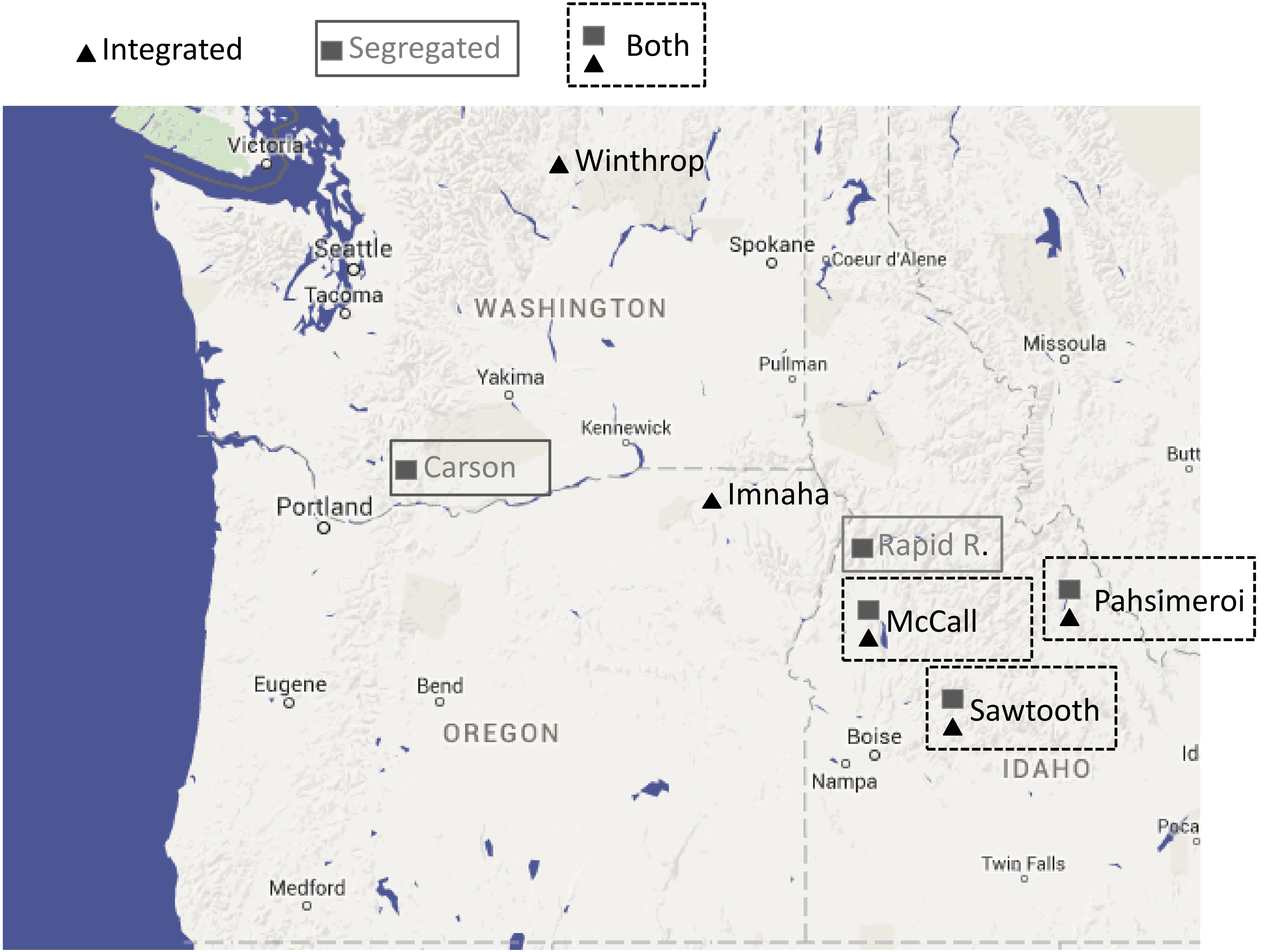


- **These segregated programs have been in place for several decades**
- **An example of domestication selection?**

A valid question:

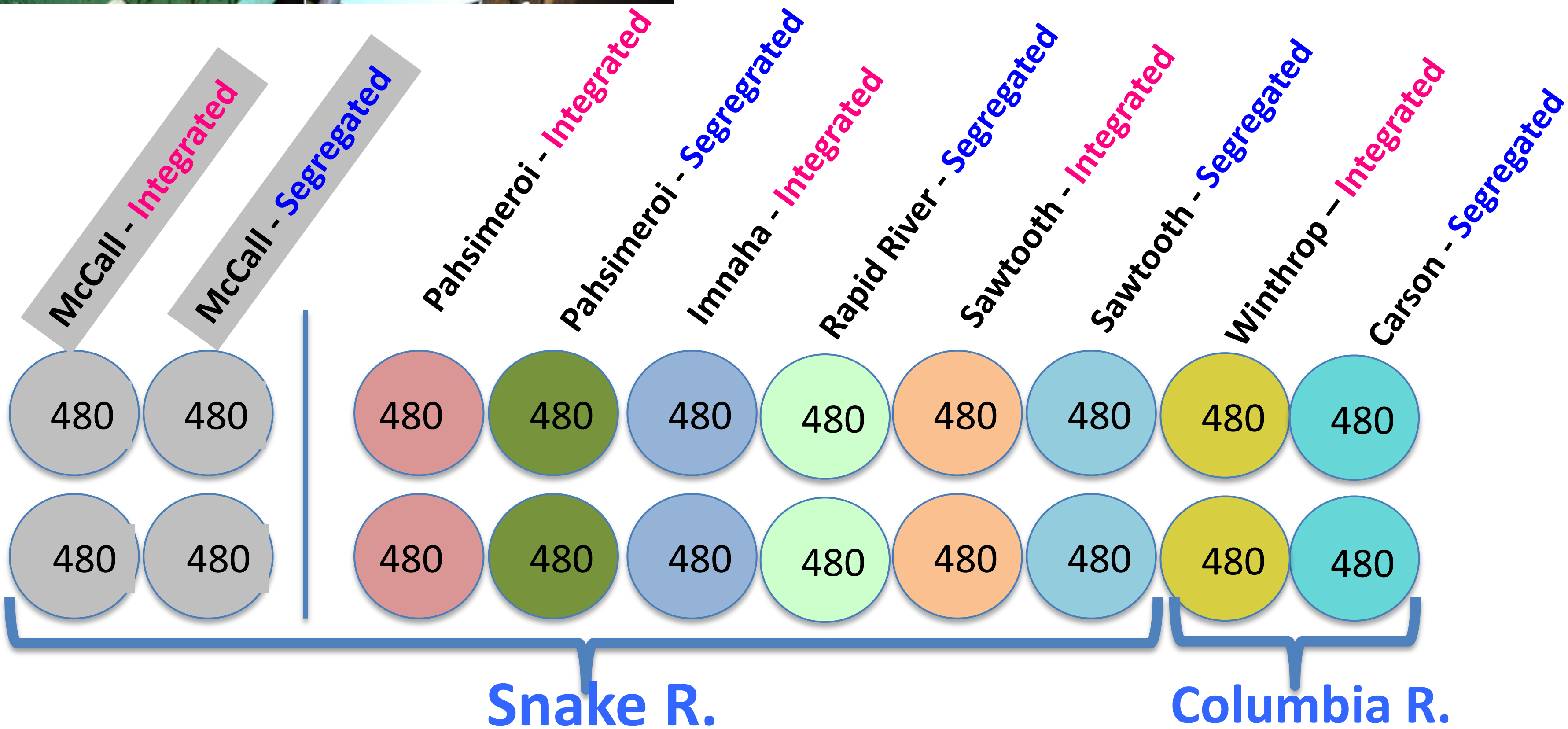
How do you know variation in minijack rate isn't just due to rearing differences at the various hatcheries?

A common garden experimental approach


Integrated
Segregated
Both
Victoria
Winthrop
Seattle
Tacoma
WASHINGTON
Spokane
Coeur d'Alene
Missoula
Pullman
Yakima
Kennewick
Carson
Portland
Imnaha
Rapid R.
Pahsimeroi
McCall
Sawtooth
Eugene
Bend
OREGON
Boise
Nampa
IDAHO
Twin Falls
Medford

Common garden experiment

- Match growth rates
- Compare minijack rates and threshold size at age for maturation



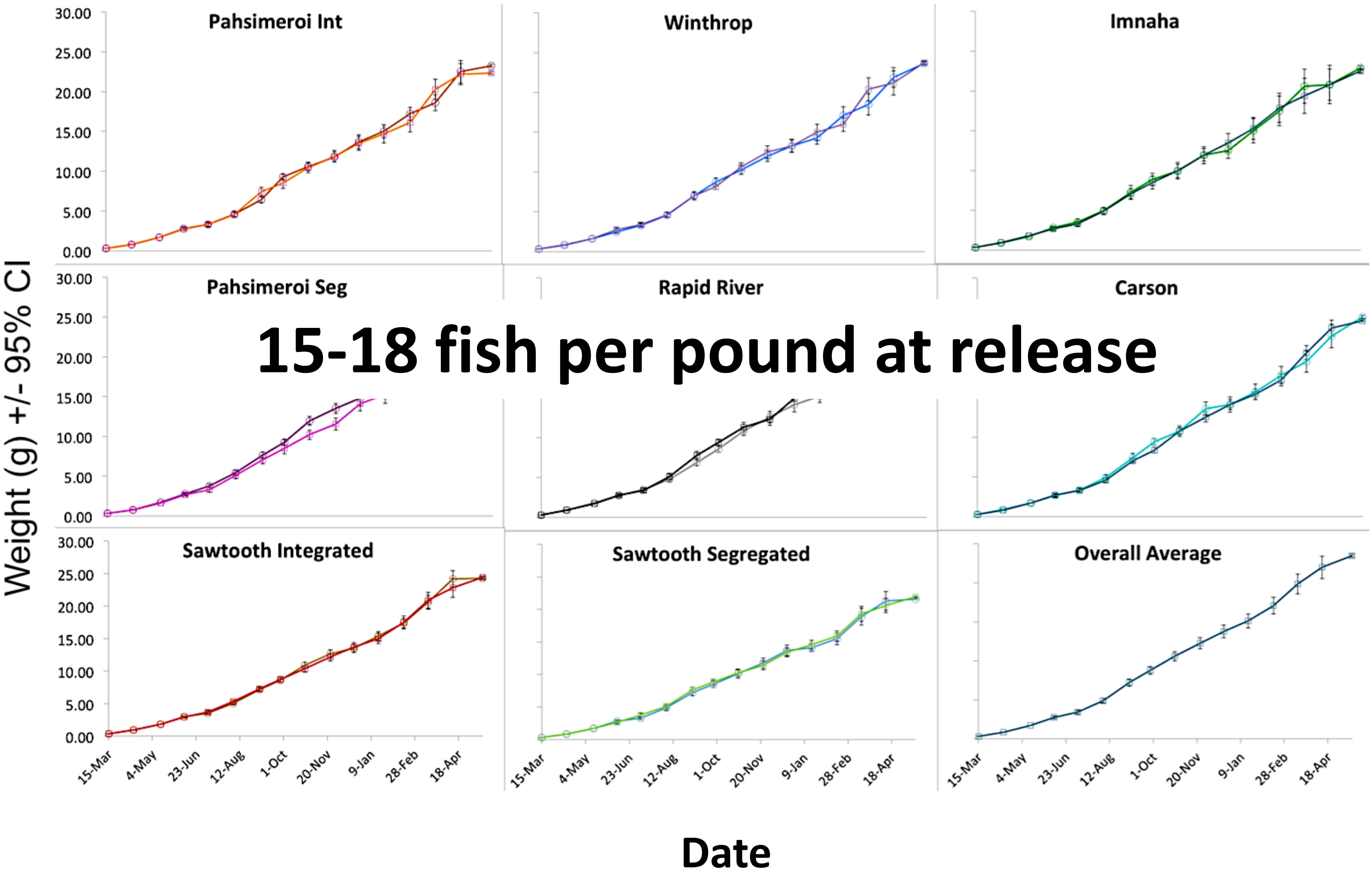
Common garden experiment

PopJack

Populations - Minijacks

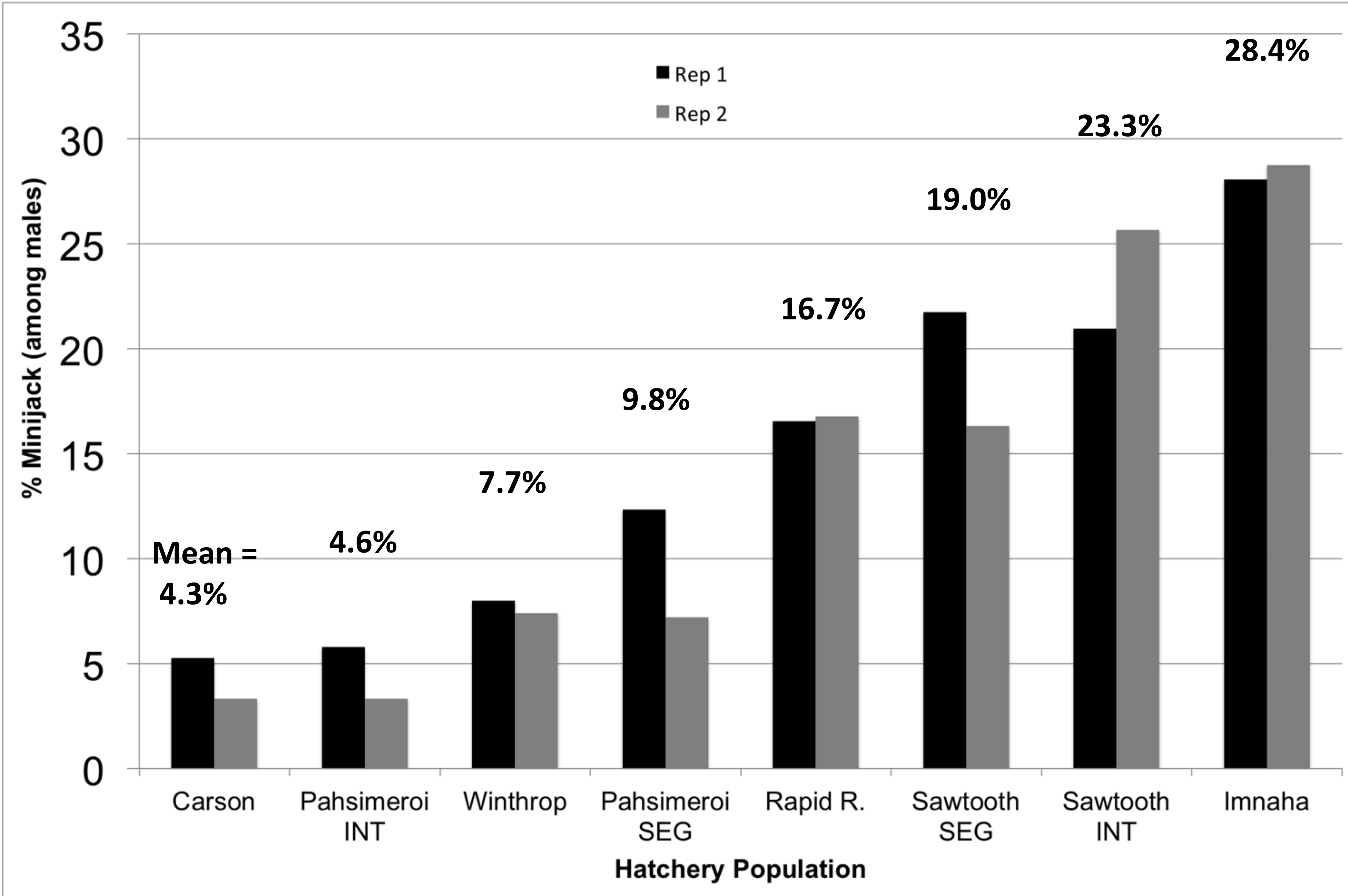
Artwork credit
Abby Fuhrman

Replicate tanks and different populations grew nearly identically

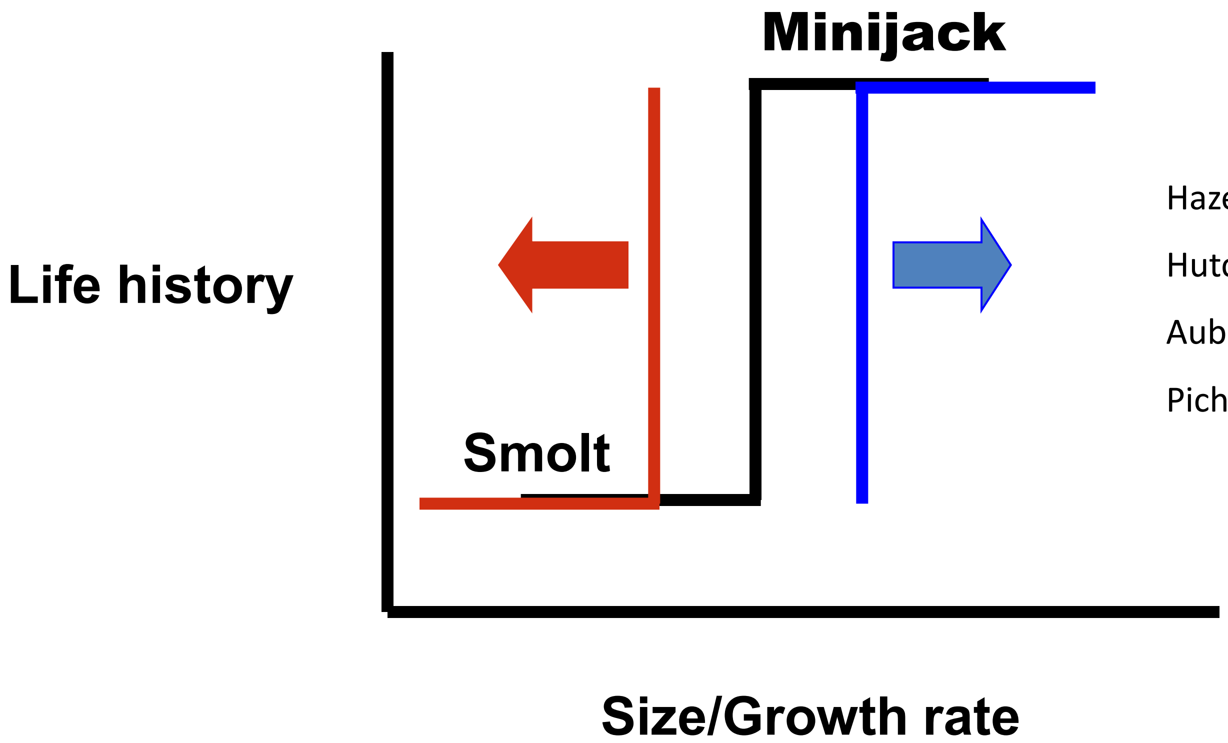


15-18 fish per pound at release

Minijack rates varied by nearly 7-fold



Alternate life-history strategies have been modeled as threshold traits



Hazel et al. 1990

Hutchings and Myers 1994

Aubin-Horth and Dodson 2004

Piche’ et al. 2008

PROCEEDINGS OF THE ROYAL SOCIETY B

BIOLOGICAL SCIENCES

Proc. R. Soc. B (2008) 275, 1571–1575
doi:10.1098/rspb.2008.0251
Published online 15 April 2008

Genetic variation in threshold reaction norms for alternative reproductive tactics in male Atlantic salmon, *Salmo salar*

Jacinthe Piché[1], Jeffrey A. Hutchings[1,*] and Wade Blanchard[2]

[1]*Department of Biology, and* [2]*Department of Mathematics and Statistics, Dalhousie University, Halifax, NS B3H 4J1, Canada*

Alternative reproductive tactics may be a product of adaptive phenotypic plasticity, such that discontinuous variation in life history depends on both the genotype and the environment. Phenotypes that fall below a genetically determined threshold adopt one tactic, while those exceeding the threshold adopt the alternative tactic. We report evidence of genetic variability in maturation thresholds for male Atlantic salmon (*Salmo salar*) that mature either as large (more than 1 kg) anadromous males or as small (10–150 g) parr. Using a common-garden experimental protocol, we find that the growth rate at which the sneaker parr phenotype is expressed differs among pure- and mixed-population crosses. Maturation thresholds of hybrids were intermediate to those of pure crosses, consistent with the hypothesis that the life-history switch points are heritable. Our work provides evidence, for a vertebrate, that thresholds for alternative reproductive tactics differ genetically among populations and can be modelled as discontinuous reaction norms for age and size at maturity.

Keywords: phenotypic plasticity; life-history evolution; mating systems; mature male parr; anadromous males; common-garden experiment

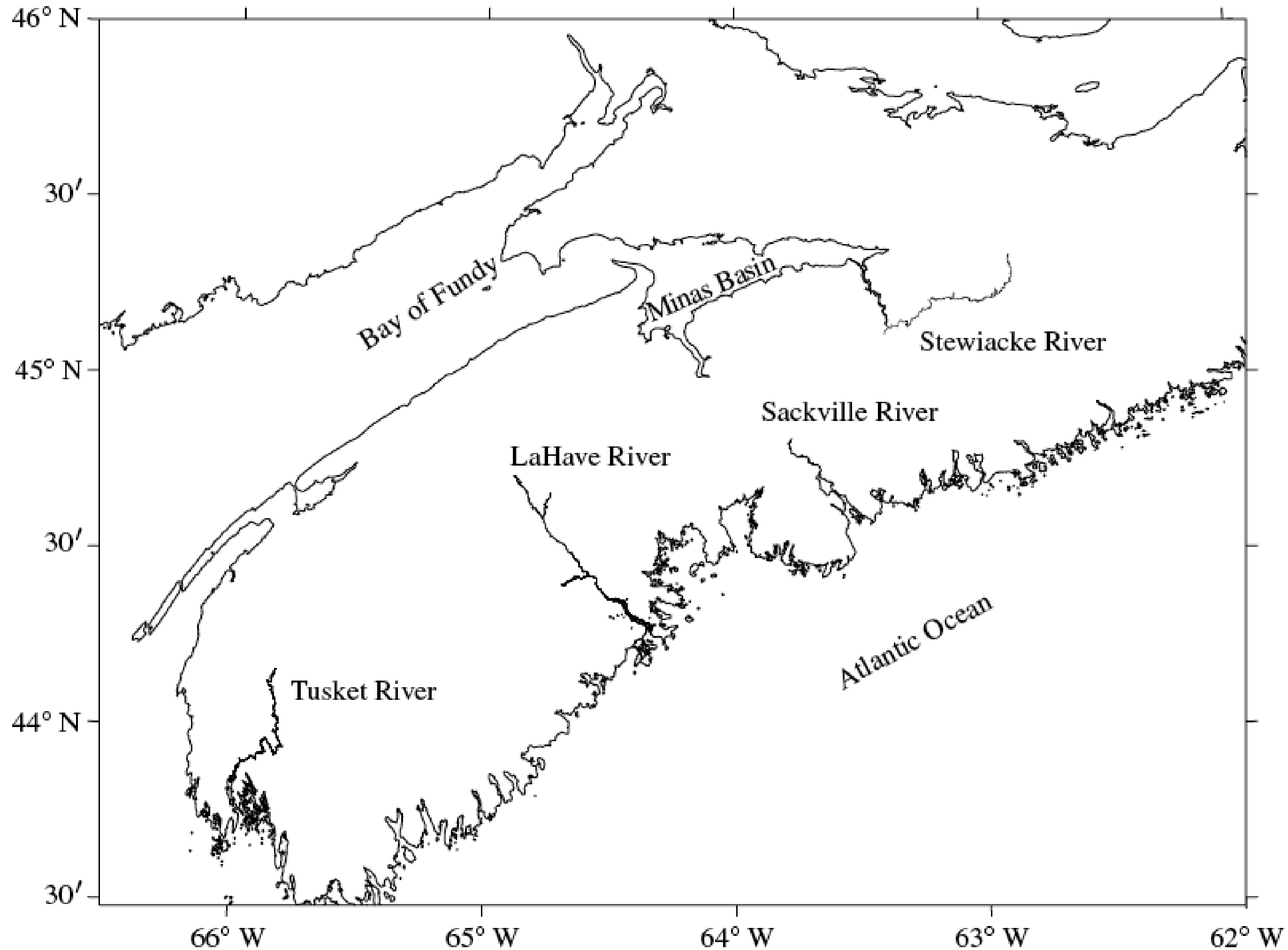


Figure 1. Map of Nova Scotia, Canada, showing the locations of the rivers from which the Atlantic salmon used in pure- and mixed-population crosses were obtained.

Table 3. Differences in size thresholds for male parr maturity among population crosses of Atlantic salmon. (Thresholds are defined as the estimated body size (g), six months after the initiation of exogenous feeding, corresponding to a 50% incidence of maturity (95% CIs are in parentheses).)

population cross	estimated weight (g) at 50% maturity
Stewiacke×Stewiacke	9.4 (6.0,12.8)
Stewiacke×LaHave	9.7 (6.4,13.1)
LaHave×LaHave	14.4 (9.2,19.6)
Sackville×LaHave	12.1 (7.6,16.5)
Sackville×Sackville	7.9 (5.1,10.7)
Tusket×Stewiacke	6.1 (3.1,9.1)
Tusket×LaHave	12.4 (7.3,17.4)

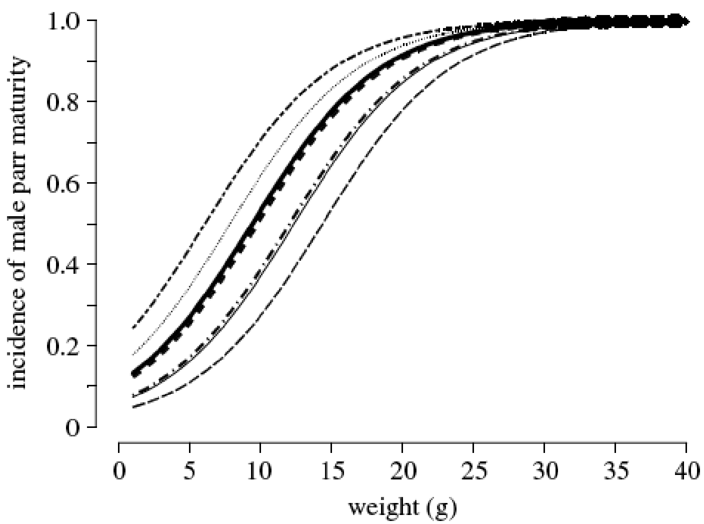
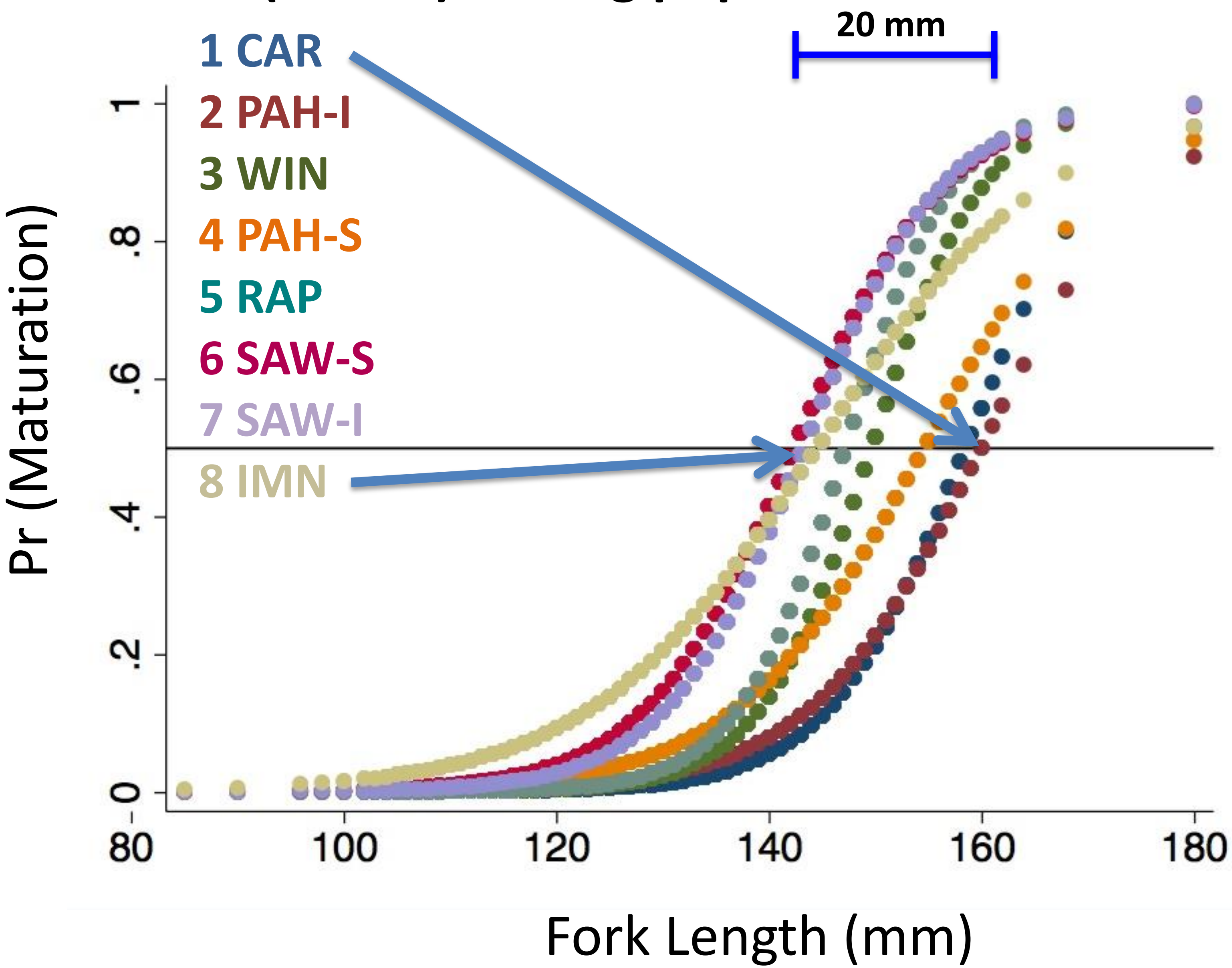


Figure 2. Threshold norms of reaction between incidence of parr maturity and individual growth rate (body weight at seven months) in male Atlantic salmon. Left to right, the reaction norms are for the following population crosses: Tusket×Stewiacke; Sackville×Sackville; Stewiacke×Stewiacke; Stewiacke×LaHave; Sackville×LaHave; Tusket×LaHave; LaHave×LaHave.

- **Logistic regression used to compare threshold growth rate for parr maturation**
- **Thresholds vary among stocks**
- **Common garden experiments with hybrid crosses create intermediate thresholds**
- **Ilustrates the genetic component to the threshold**

Over a 20 mm difference in the size-at-age threshold (PMRN) among populations

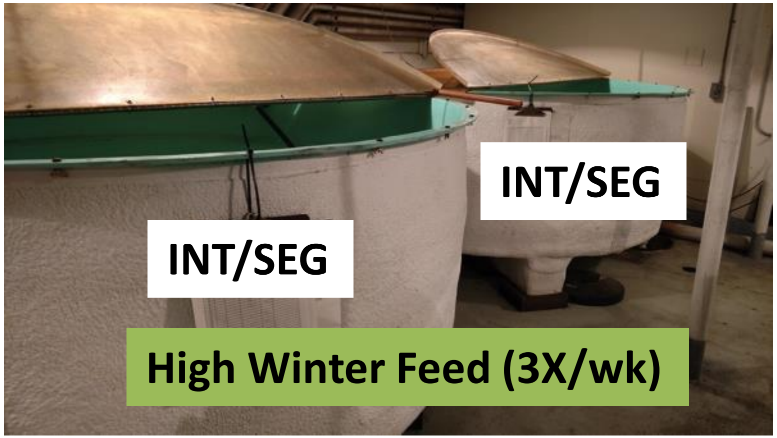


What happened to the McCall fish in the Common Garden study?

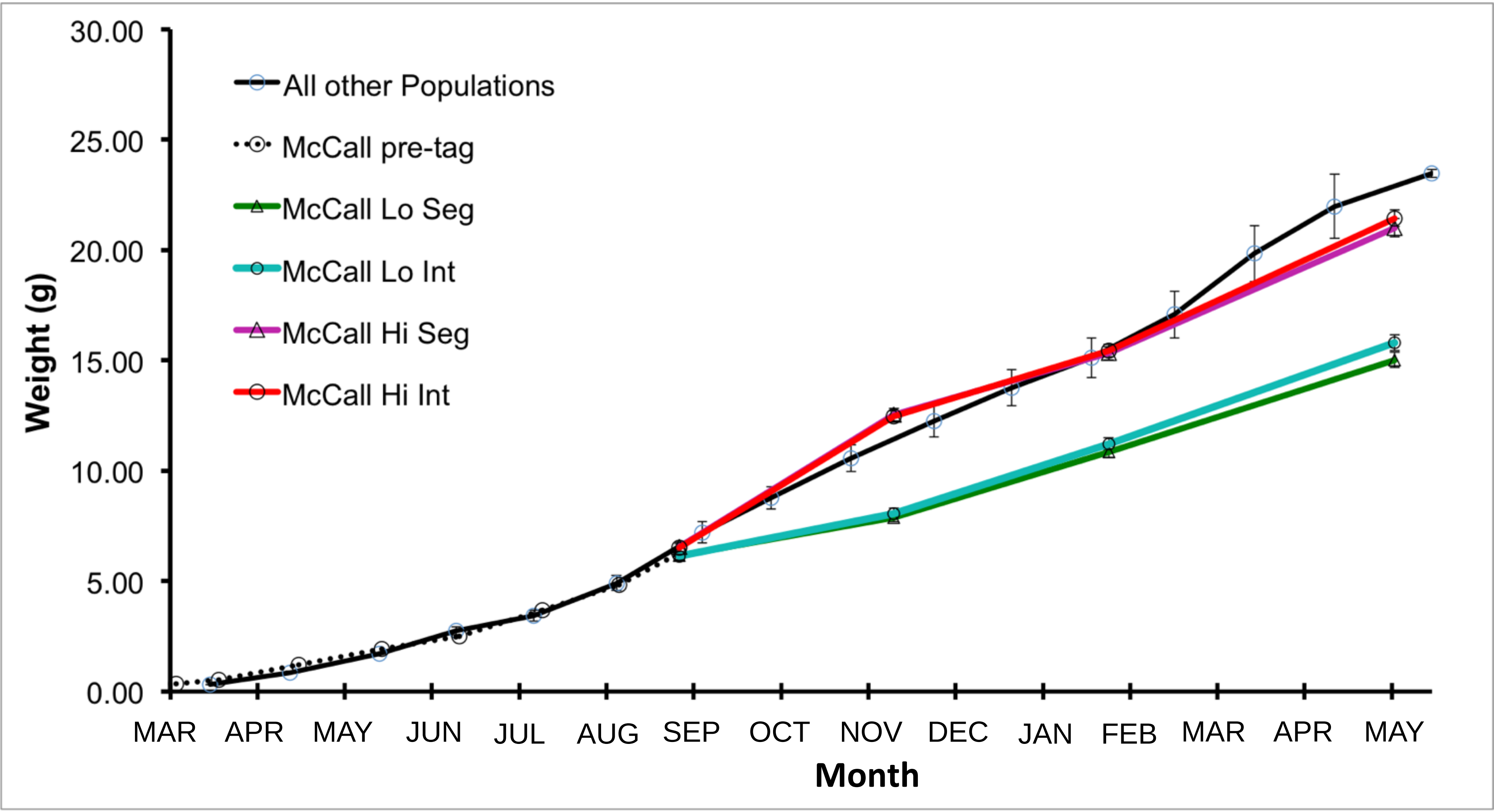
McCall + Minijacks = Mac & miniJacks

Mac & Jacks

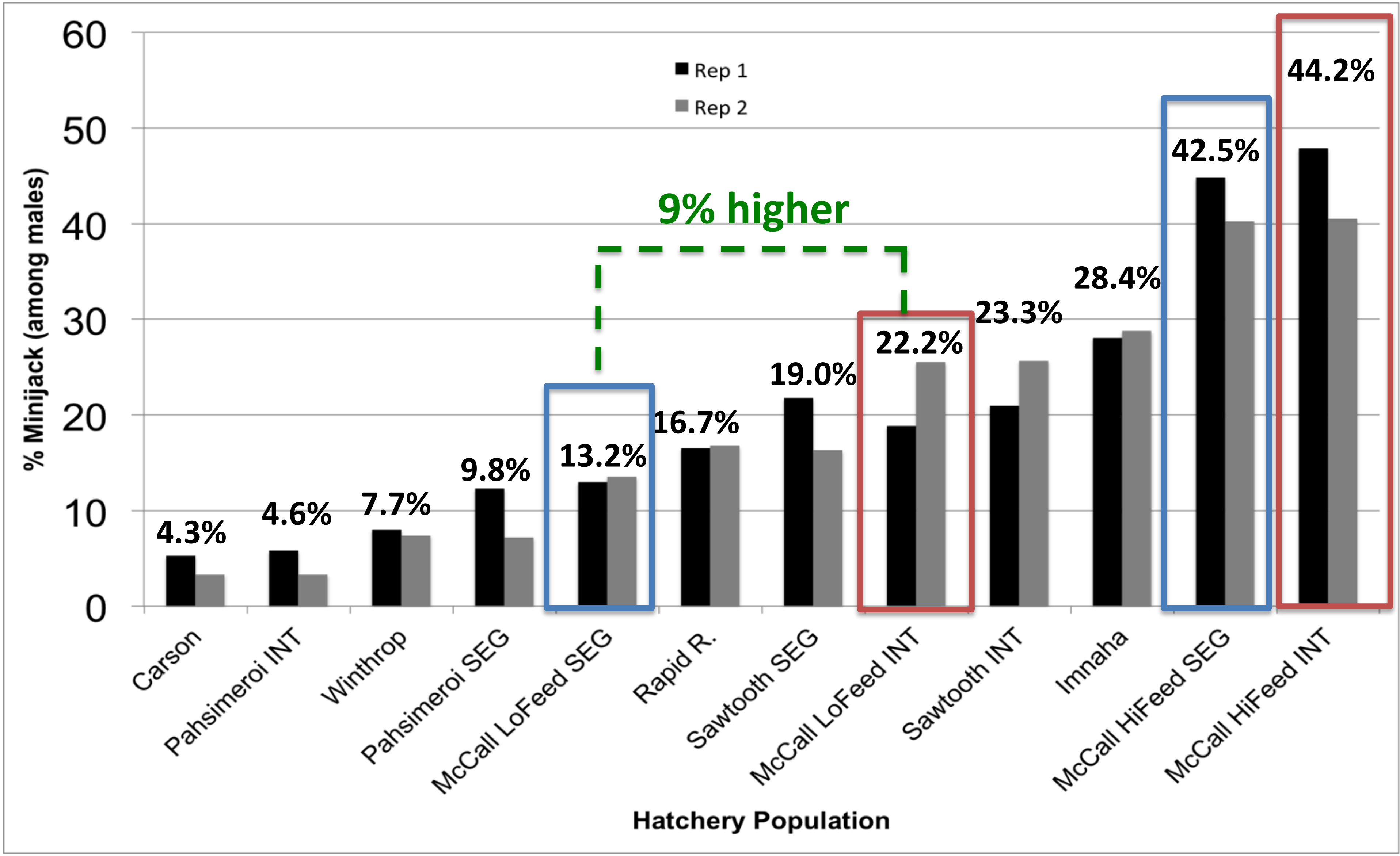
- McCall INT and SEG stocks were ponded in two separate 8 ft. diameter circulars in March
- PIT tagged 2400 fish on Aug. 26-28 (1200 per group)
- Combined Integrated and Segregated into 4 tanks: 2 Hi feed, 2 Lo Feed (600 per tank, 300 INT + 300 SEG) so they can complete.



Common Garden and Mac & Jack combined analysis

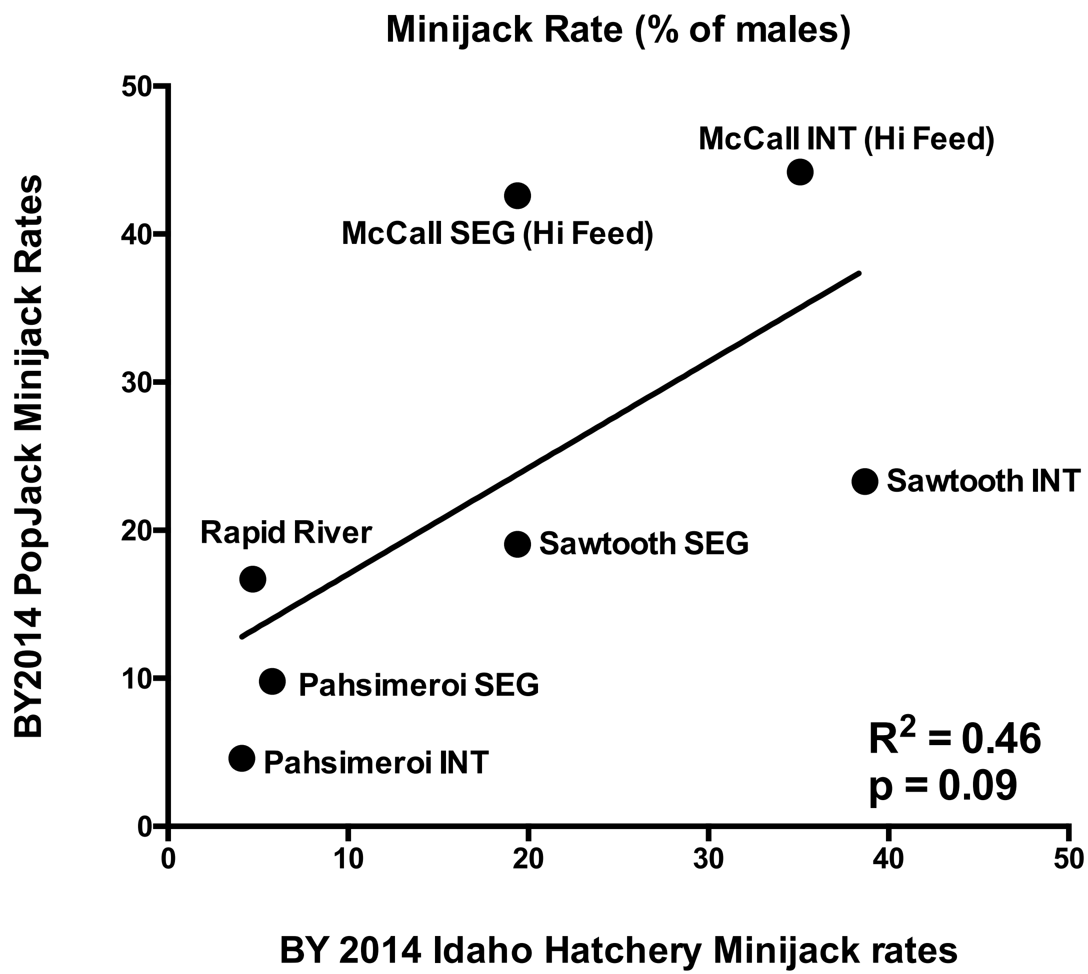


McCall stocks (Hi feed) had the highest MJ rates



How do rates at the hatcheries compare with rates in our laboratory scale studies (PopJack and Mac&Jacks)?

Minijack rates in Hatchery surveys vs. Common Garden/Mac&Jack show some relationship, but not significant



Conclusions

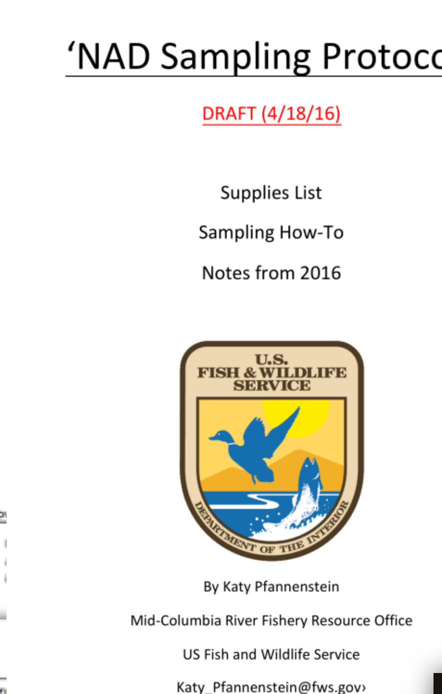
- Different hatchery stocks vary in their “sensitivity” to early male maturation
- Results suggest integrated stocks have a lower MJ/size threshold than segregated stocks
- Mac&Jack-McCall fish are very sensitive to early male maturation.
- Under lower ration conditions integrated McCall stock matured at a higher rate than the segregated stock
- There is a positive (though not significant) relationship between MJ rate at the hatchery and laboratory

Hatchery management implications

- Monitor for early male maturation before release
- Growth profiles in the hatchery may need to be tailored to accommodate variation in sensitivity

Multi-agency, facility specific monitoring

USFWS, WDFW, Grant, Chelan, Douglas PUD



'NAD Sampling Protocols

DRAFT (4/18/16)

Supplies List

Sampling How-To

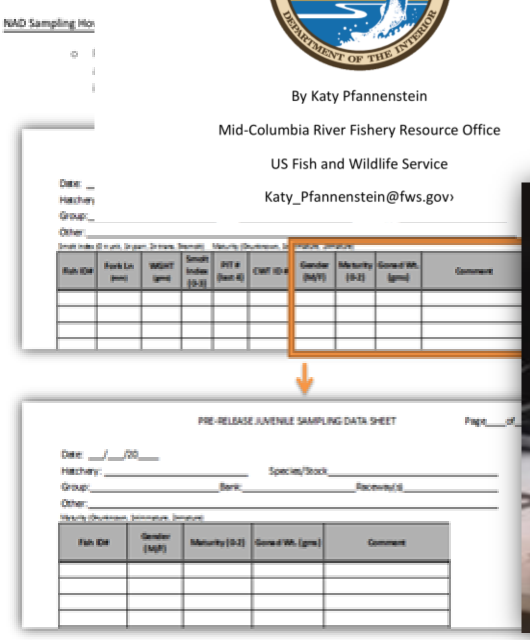
Notes from 2016

By Katy Pfannenstein

Mid-Columbia River Fishery Resource Office

US Fish and Wildlife Service

Katy_Pfannenstein@fws.gov›



NAD Sampling How

PRE-RELEASE JUVENILE SAMPLING DATA SHEET

Date: __/__/20__

Hatchery:

Species/Stock

Group:

Bank:

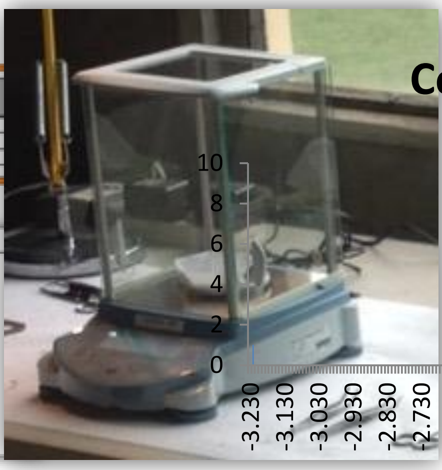
Raceway(s):

Other:

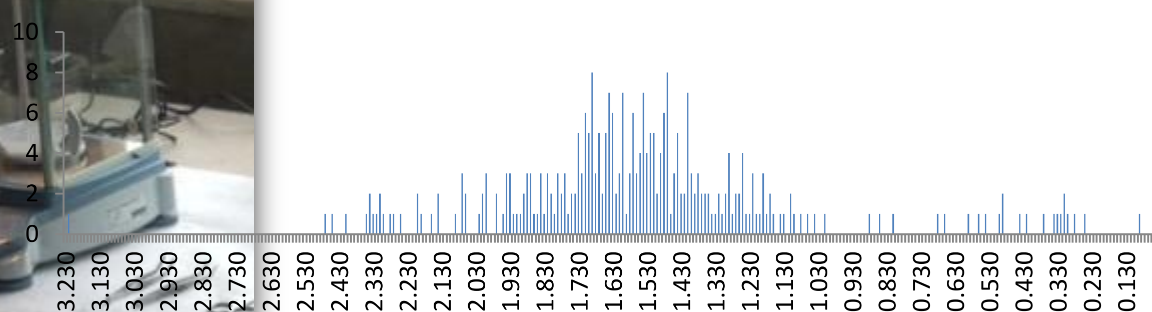
Fish ID#	Fork Ln (mm)	WGHT (gm)	Smolt Index (0-3)	PIT # (last 4)	CWT ID #	Gender (M/F)	Maturity (0-2)	Gonad Wt. (gm)	Comment

Fish ID#	Gender (M/F)	Maturity (0-2)	Gonad Wt. (gm)	Comment

Fish dissection: Cut open belly from vent (shallow incision), cut behind gill, open fish and gently remove guts to expose air bladder. Both male and female gonads are located on the top/edge of the air bladder (orange arrow on mature male).



Combined SCS Log10*GSI Frequency



1. Collect fish from hatchery ponds. Random sample? Keep different ponds separate? CWT? Pit Tag?

Acknowledgements

Agencies, Tribes, PUD's

ODFW
WDFW
IDFG
CTWS
YN
CTUIR
NPT

Funding:

Bonneville Power Administration
Chelan County PUD
Grant County PUD
NOAA Internal Grant

Facilities and Staff:

Cle Elum Hatchery
Winthrop NFH
Entiat NFH
Eastbank NFH
Leavenworth NFH
Carson NFH
Little White Salmon NFH
Round Butte Hatchery
Parkdale
Lookingglass Hatchery
McCall Hatchery
Pahsimeroi Hatchery
Sawtooth Hatchery
Rapid River Hatchery