

# Variation in minijack rate among Columbia River Basin Chinook salmon hatchery populations

Photo by Chris Pietsch/Register-Guard

Don Larsen, Deborah Harstad,  
and Brian Beckman  
NOAA Fisheries, Seattle WA



ARTICLE

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

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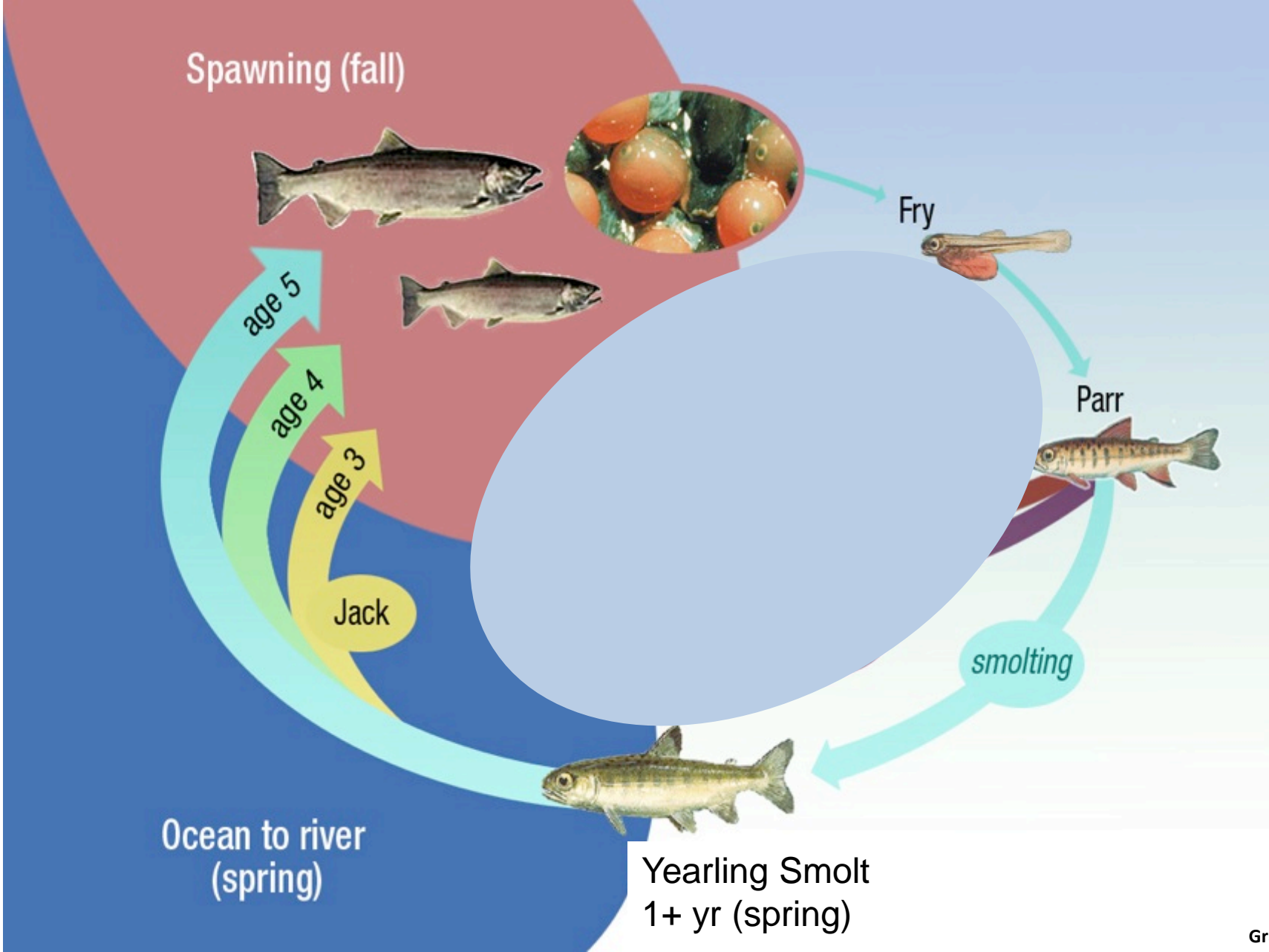
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### **Abstract**

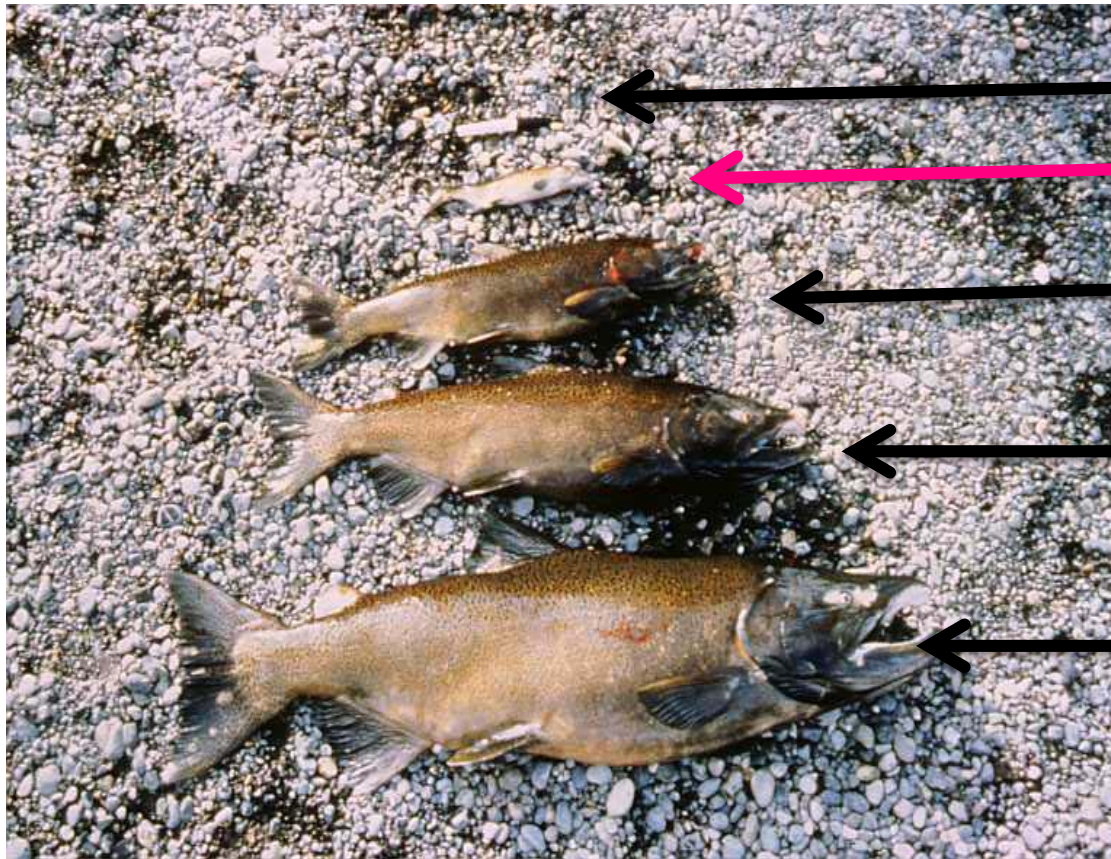
**In Columbia River spring and summer Chinook Salmon *Oncorhynchus tshawytscha*, age of male maturation ranges from age 1 (microjack), 2 (minijack), 3 (jack), to 4 or 5 (adult) years. The presence of minijacks has been noted in several experimental studies and documented for a few hatchery programs; 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.**

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# Hatchery spring/summer Chinook life history



# What is a Minijack?



**“Sharpie”**

**Age-2 “Minijack”**

**Age-3 “Jack”**

**Age-4 “Adult”**

**Age-5 “Adult”**

- Maturation of males in Chinook salmon is a plastic trait that can occur at variable ages

# What do we know about minijacks in Chinook salmon?

## Minijack Rates:

- **Wild:** naturally-occurring phenotype; hard to quantify
- **Hatchery-/Experimentally-reared:** 11.5 to 93%

## Factors that affect maturation:

- Genetic component (Hard et al. 1985, Heath et al. 1994)
- Growth rate (Clark and Blackburn 1994, Silverstein et al. 1998)
- Energy stores (lipid) (Shearer and Swanson 2000)
- Genotype\*Growth (Aubin-Horth and Dobson 2004, Piche et al. 2008)

# **Study Objective:** Document production of minijacks in yearling spring and summer Chinook salmon in Columbia Basin hatchery populations.

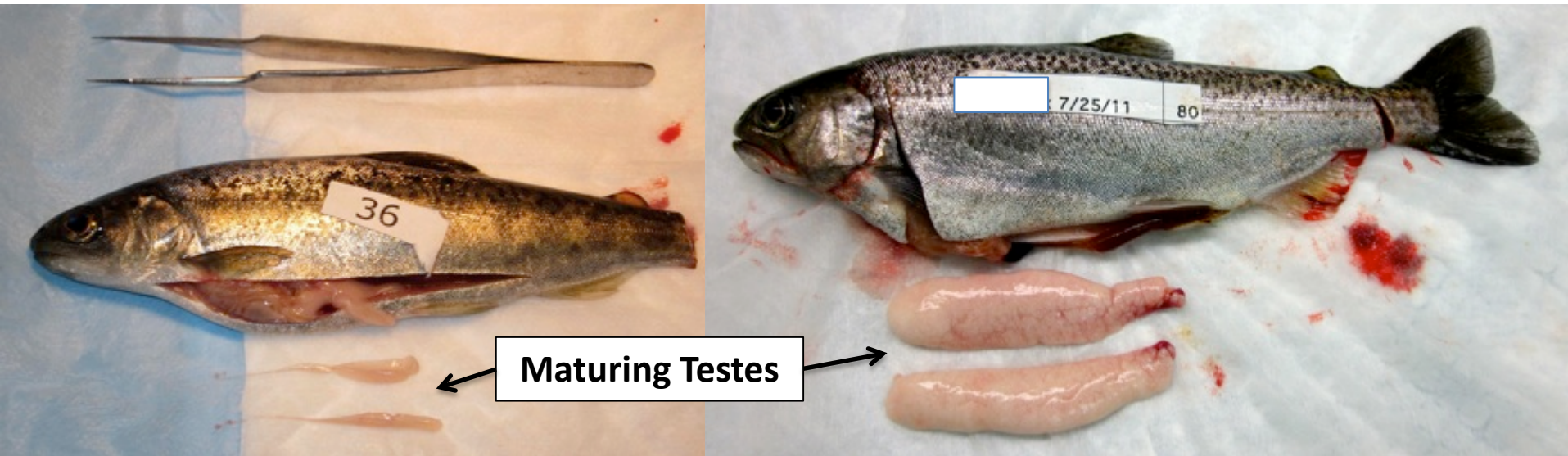


# How to detect a minijack?

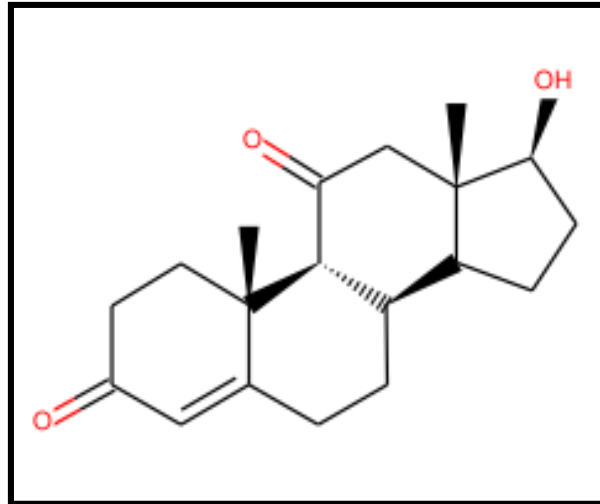
- Visual inspection of the testes

Late Spring (prior to Fall Spawn)

Summer (prior to Fall spawn)



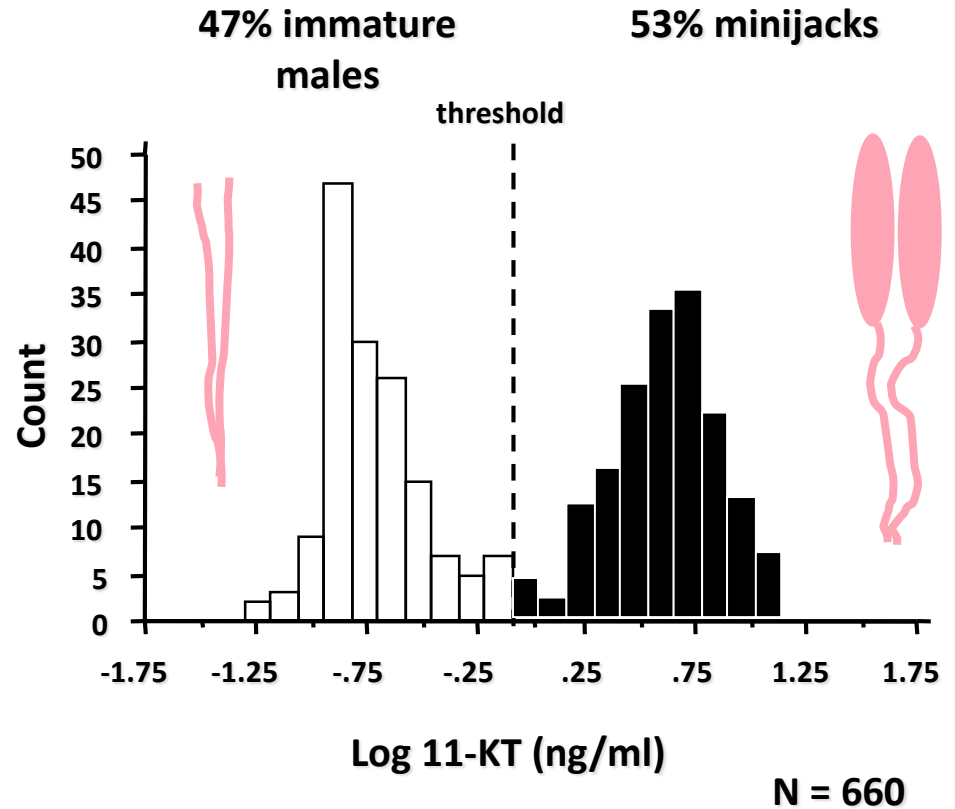
# Plasma 11-ketotestosterone (11-KT)



- Major androgen in teleost fish
- Regulates spermatogenesis
- This hormone tells us which male fish are minijacks

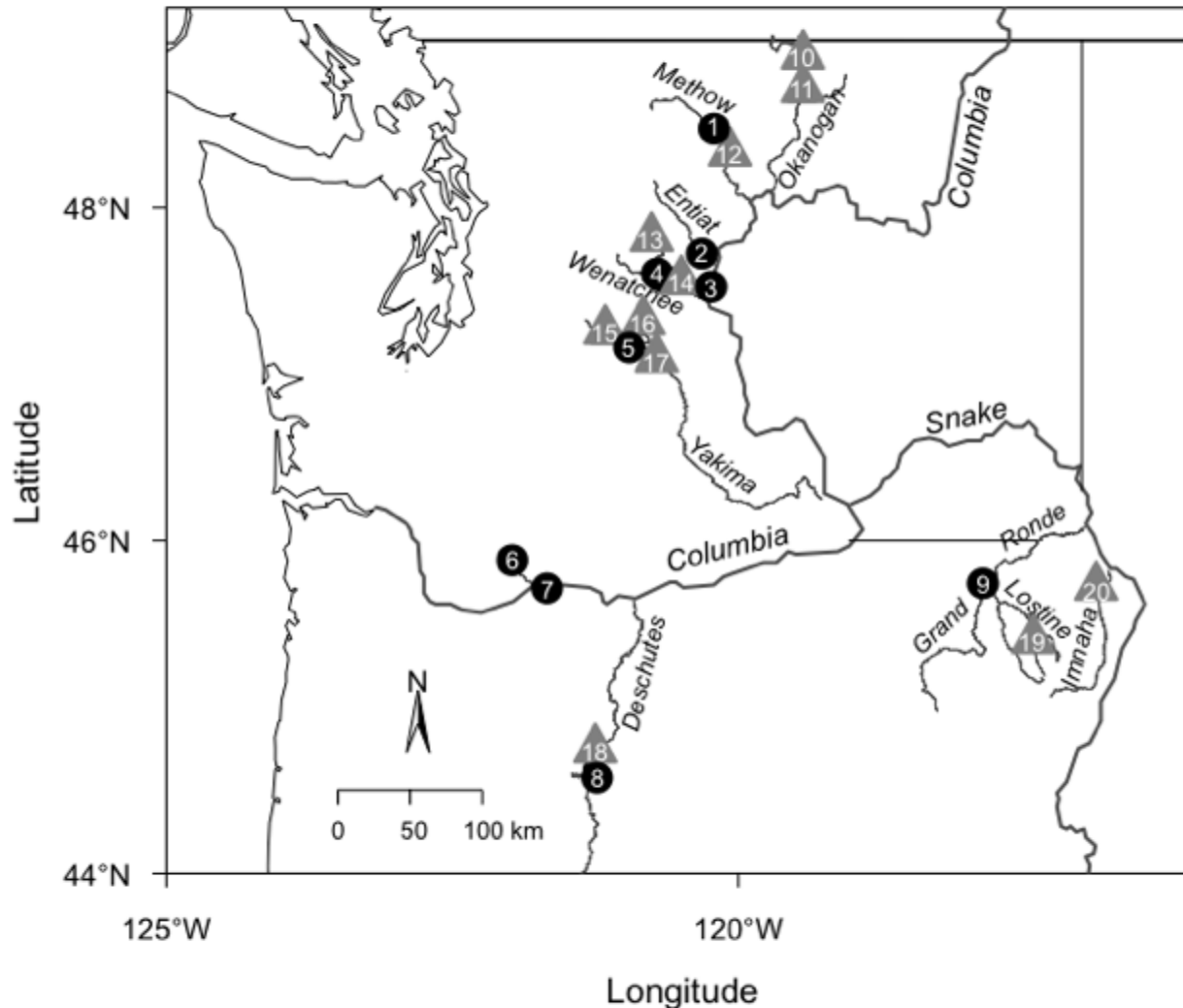


# Census hundreds of fish prior to release from the hatchery



# 9 Spring Chinook hatchery programs

## 5 Summer Chinook hatchery programs



- BYs: 1999-2010

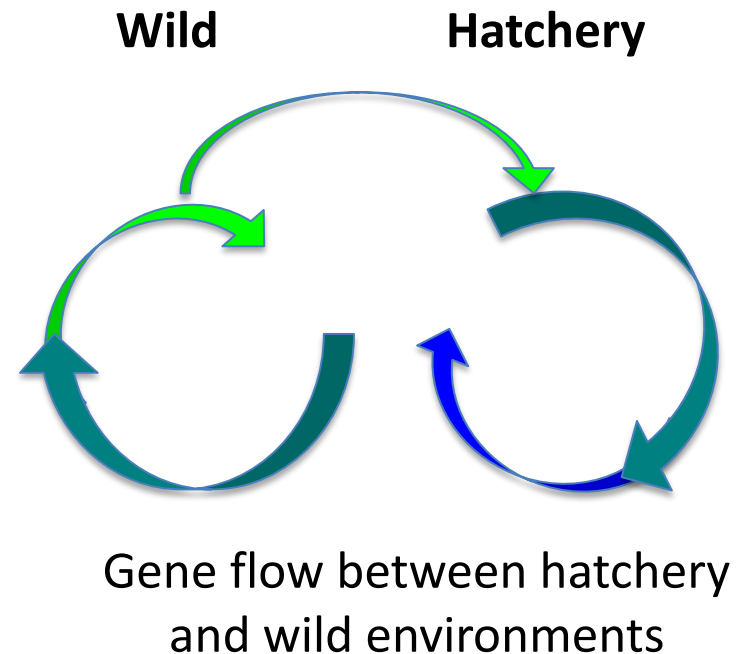
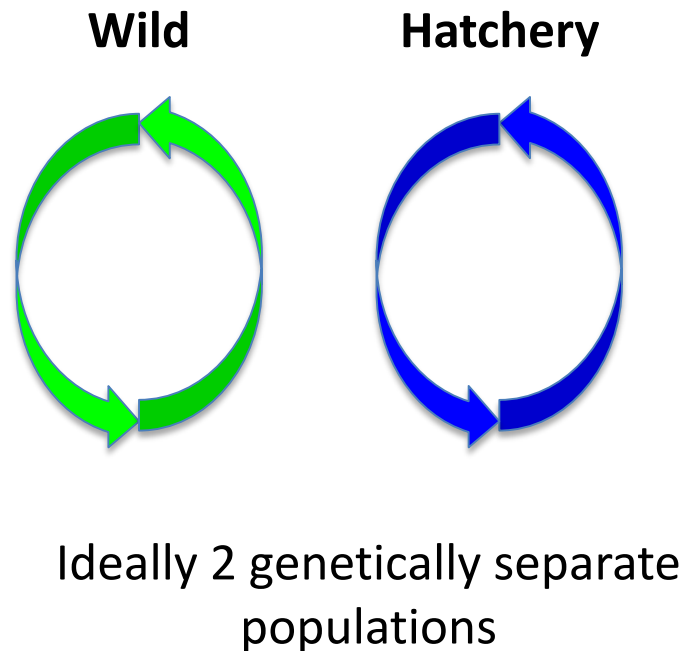
- # of years sampled ranged from 1 to 12 years

● Hatchery Facility

▲ Acclimation Site

# Hatchery Program Definitions

- Segregated: uses only hatchery-origin adults for broodstock
- Integrated: uses some degree of natural-origin adults for broodstock

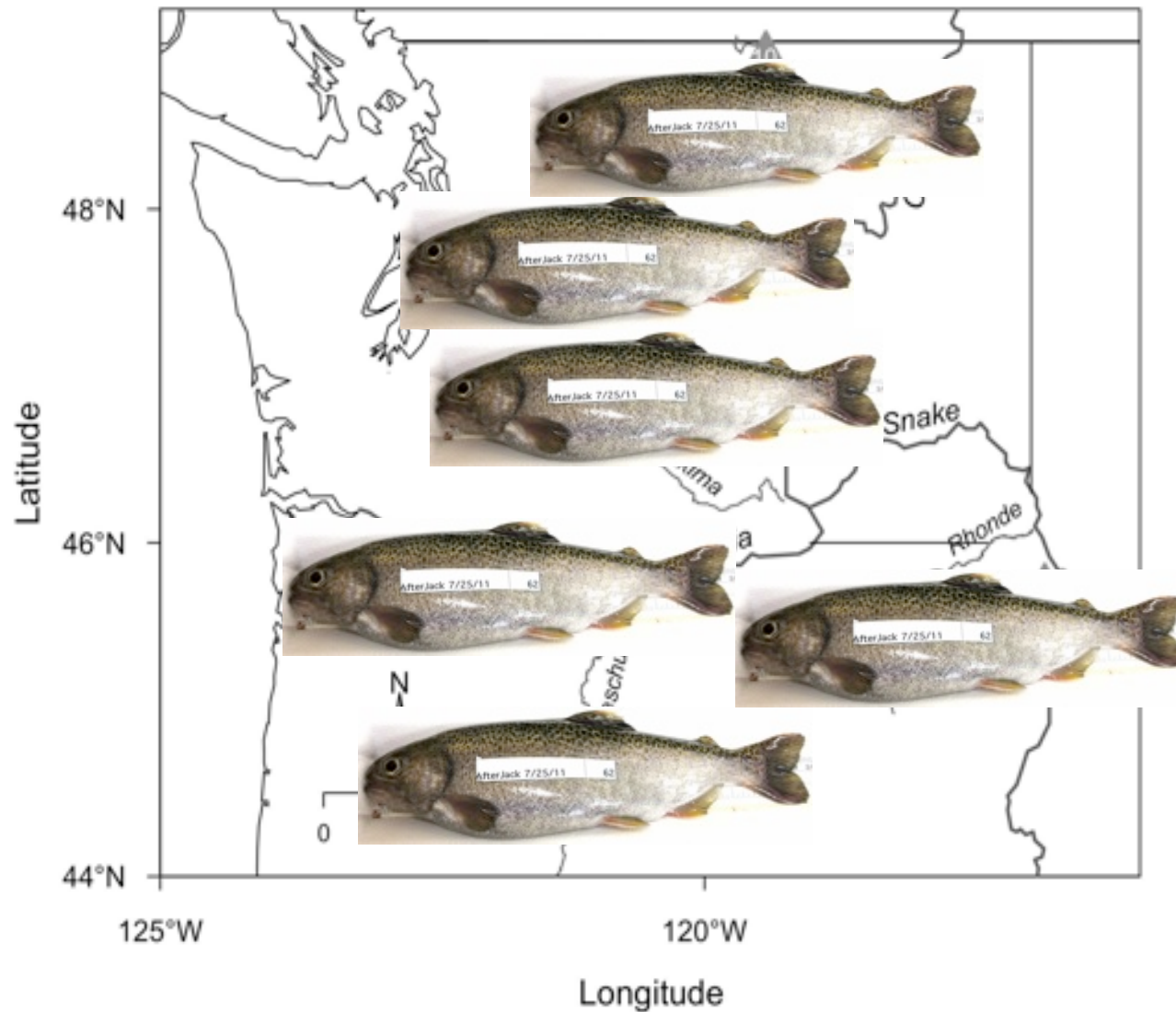


# Methods: 300 fish/minijack screen



- Size at release (fork length, mm)
- Collect blood plasma
- Visual inspection of gonads to determine sex of fish
- Assay plasma of males for 11-KT

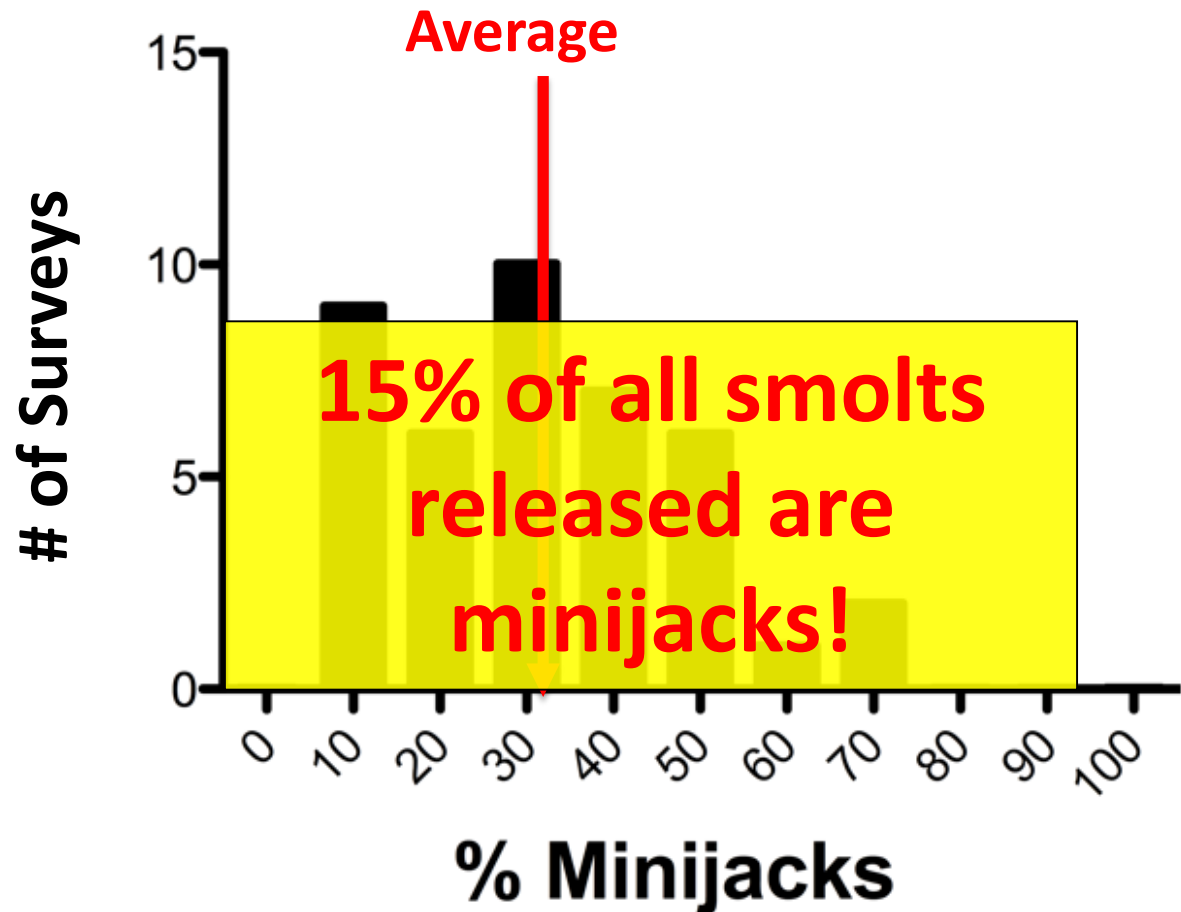
➤ Minijacks observed in all hatchery programs



# Spring Chinook:

Minijack rate averaged **31%** (of males)

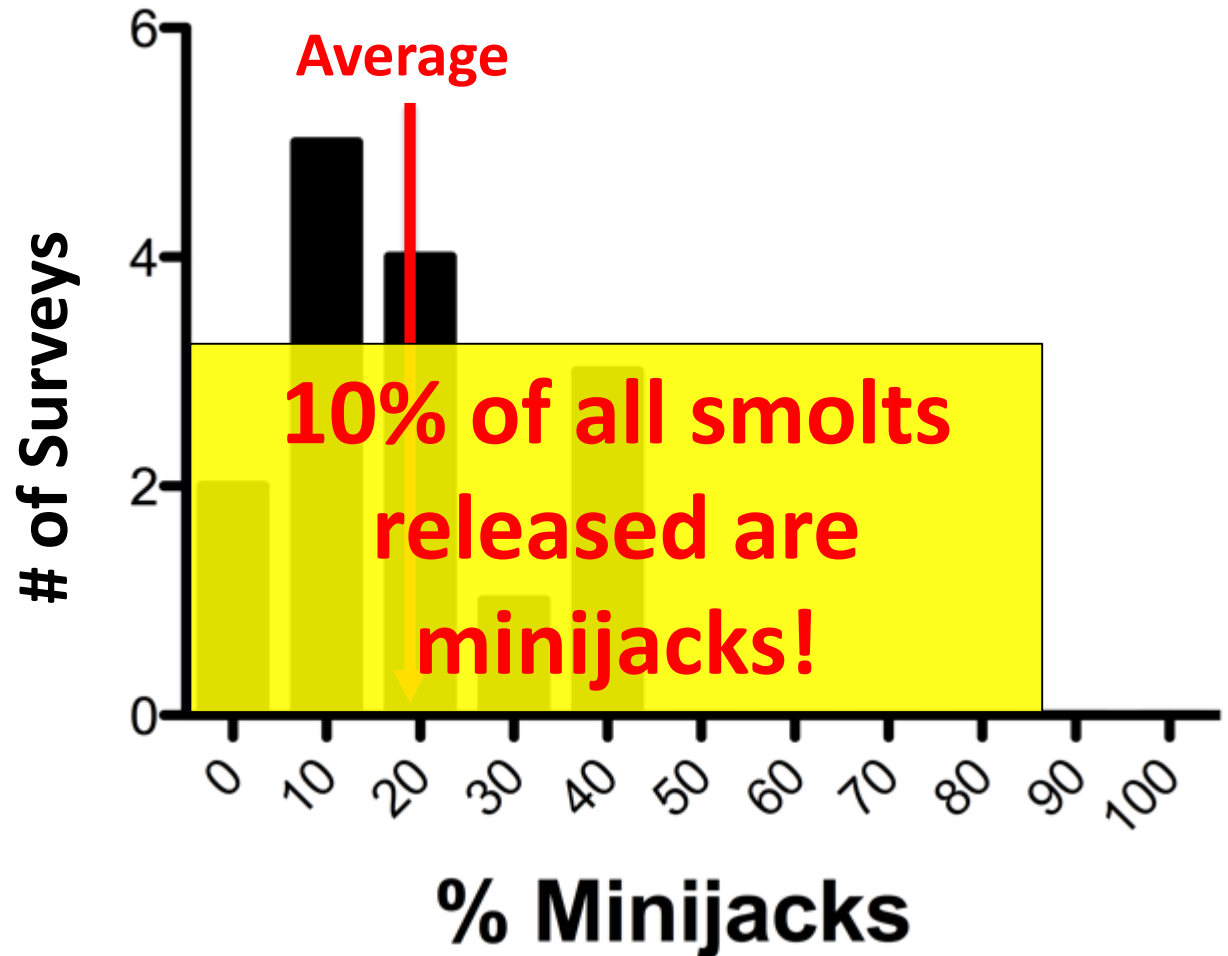
Range:  
7.9 - 71.4%



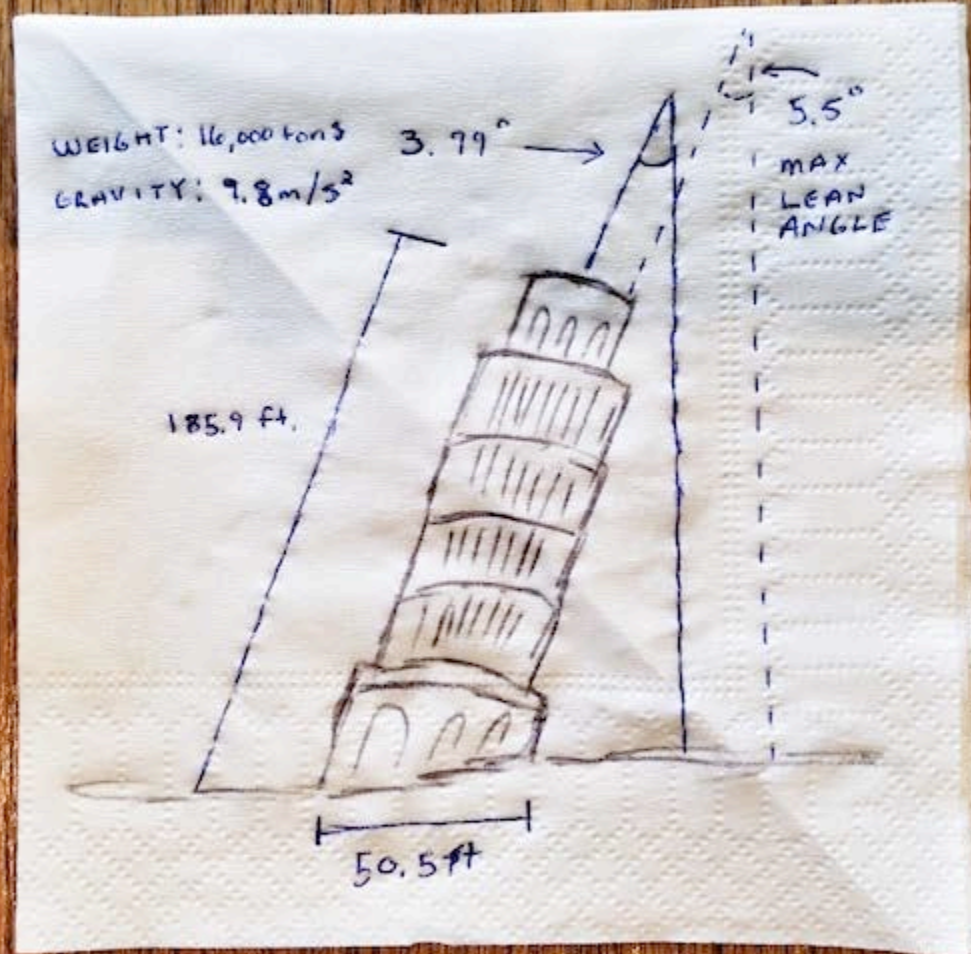
# Summer Chinook:

Minijack rate averaged **19%** (of males)

Range:  
4.1 – 40.1%

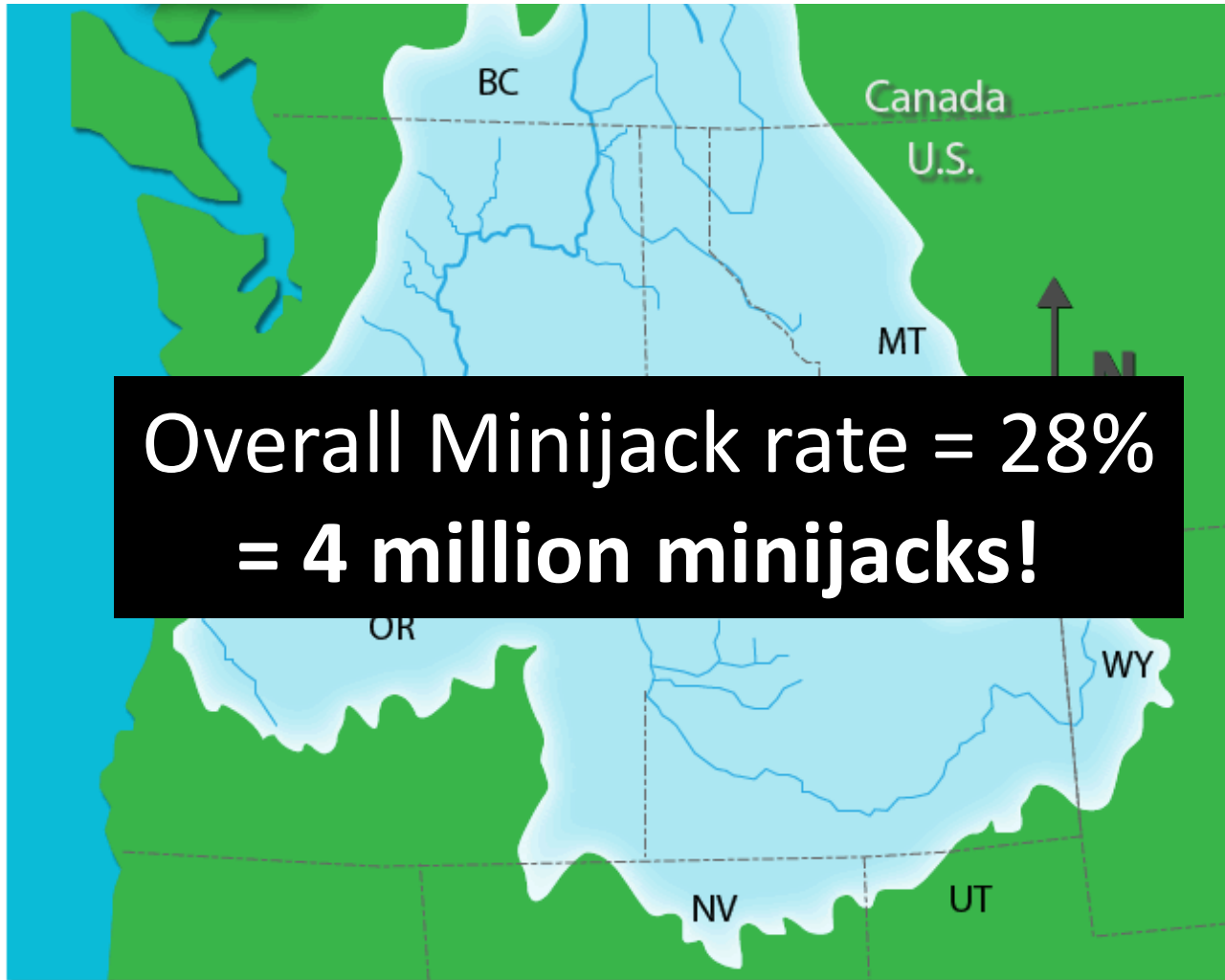


# Can we model these results?





# 31 million yearling spring/summer Chinook salmon released annually in the Columbia River Basin (Columbia River DART)



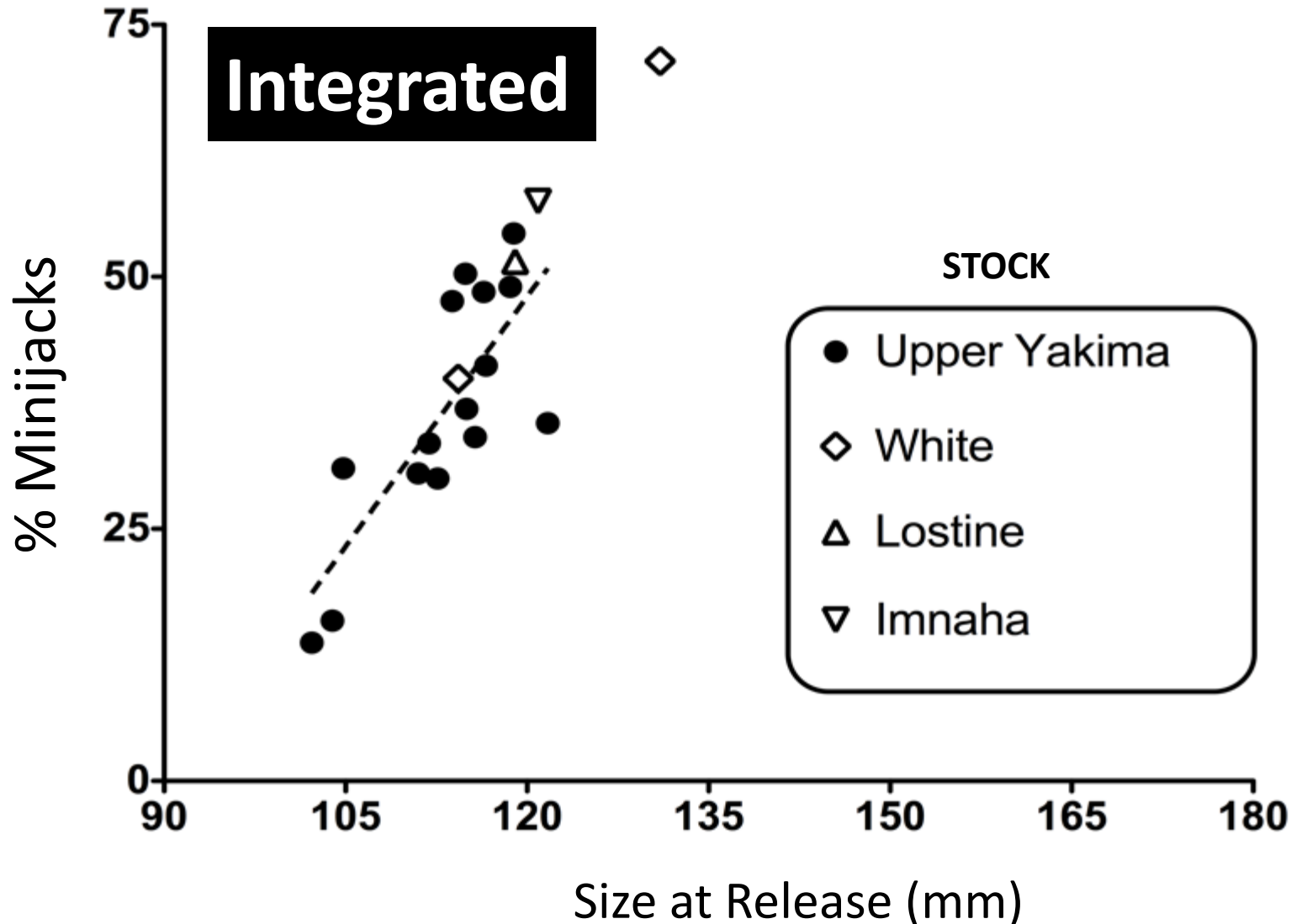


# Factors Affecting Minijack Rates: **Growth**

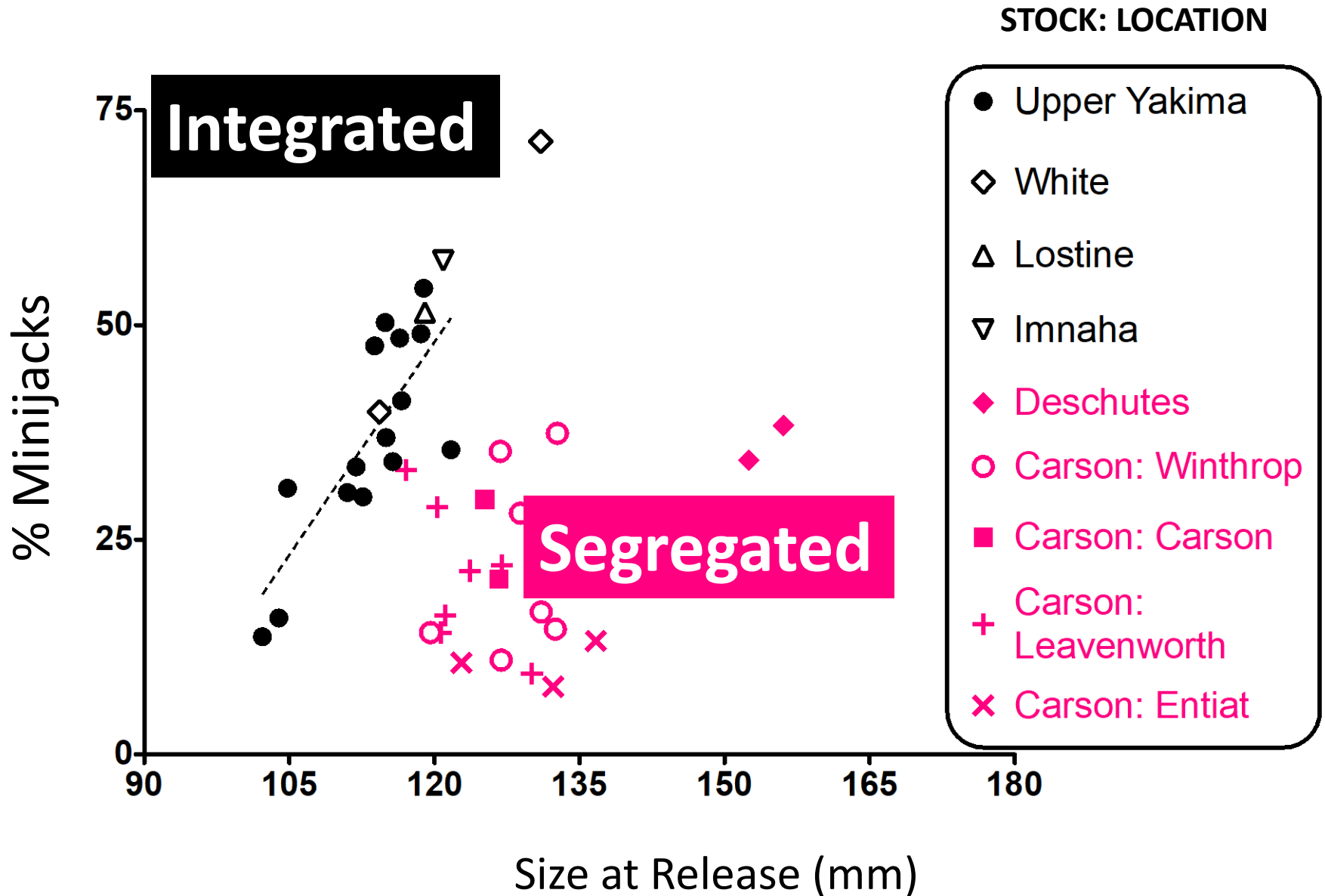
- Size at release



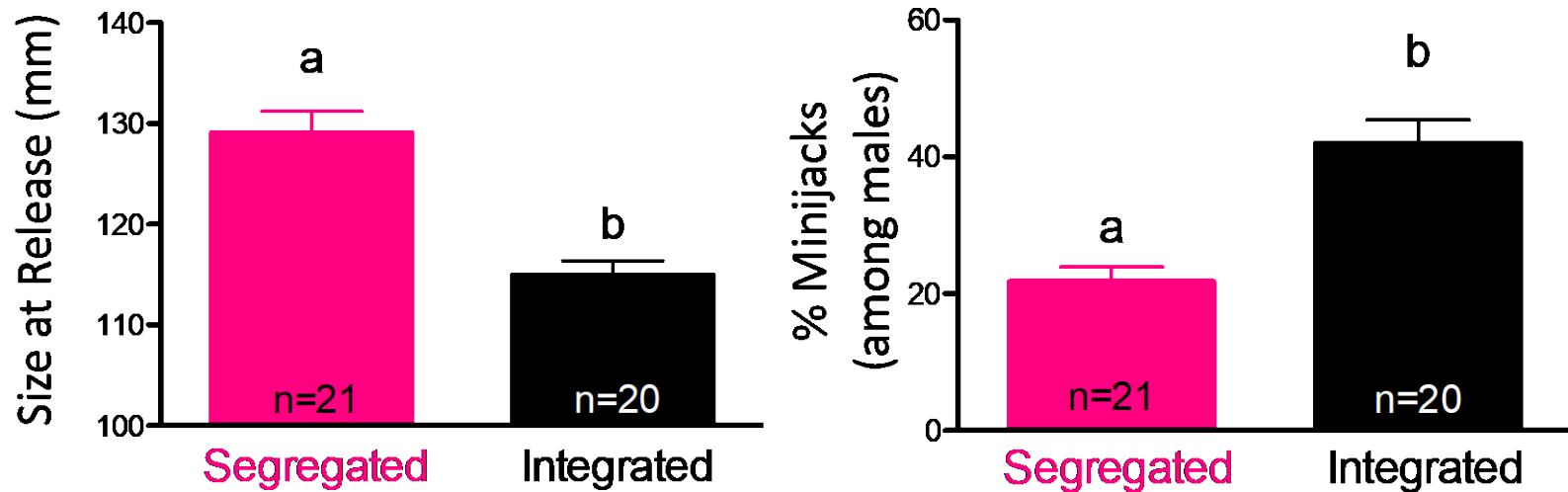
# Spring Chinook: Minijack rate is strongly correlated with size at release



# Spring Chinook: Not so simple

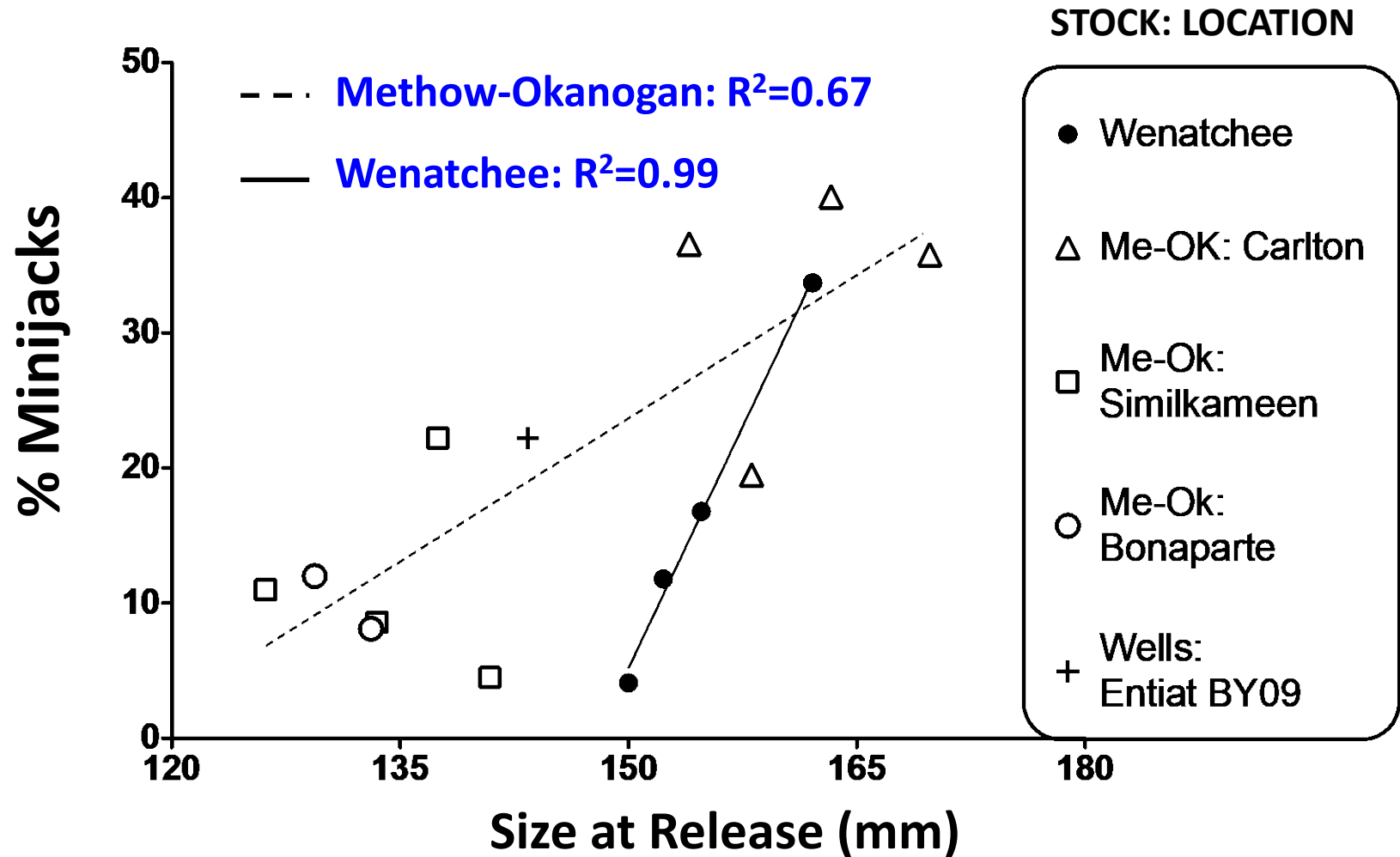


# Integrated spring Chinook hatchery populations sampled had higher minijack rates, even with smaller size at release



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

# Summer Chinook: Size at release again correlated with minijack rate for integrated stocks





# Trade-off between growth and Minijack rate



# What does it mean?

- Integrated programs produce ~30-70% minijacks
- For integrated programs (supplementation and captive brood): This is a cautionary tale that trying to produce larger smolts to increase smolt survival may result in the production of more minijacks. May need to tailor rearing to accommodate this sensitivity
- For segregated programs: This study suggests that domestication selection may have changed the relationship between growth and minijack rates in these fish. Segregated programs may be able to release larger smolts

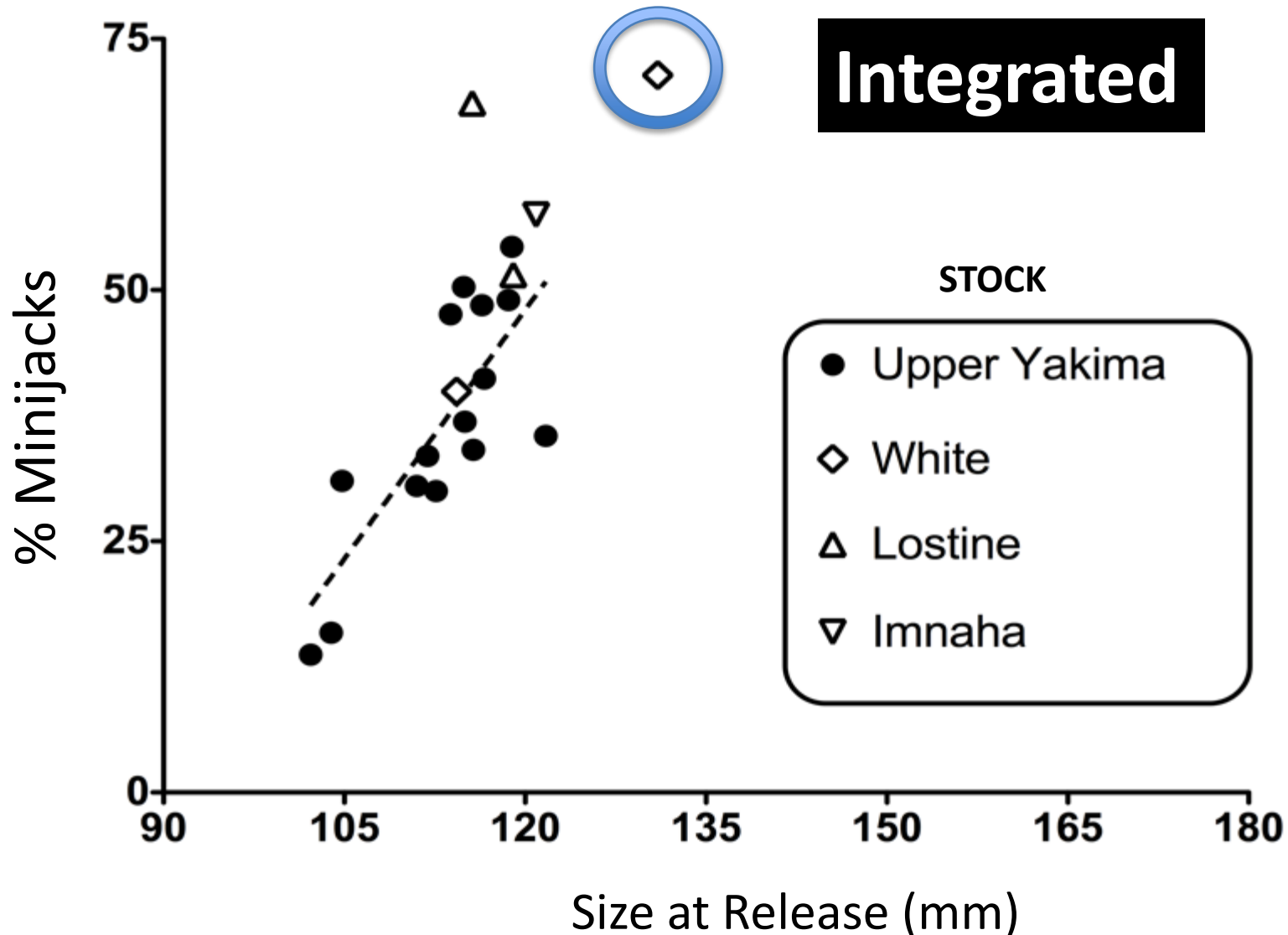


# Potential consequences of high minijack rates

- **Loss of adult production**
- **Ecological impacts**
- **Alter accuracy of Smolt-to-adult (SAR) return rates**
- **Straying?**
- **Genetic impacts**



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



# Minijacks were recently implicated in the low RRS of Wenatchee Basin hatchery fish spawning in the wild



## LETTER

### Early male maturity explains a negative correlation in reproductive success between hatchery-spawned salmon and their naturally spawning progeny

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#### Keywords

Captive propagation; domestication; early maturity; hatchery; parentage; selection; supportive breeding.

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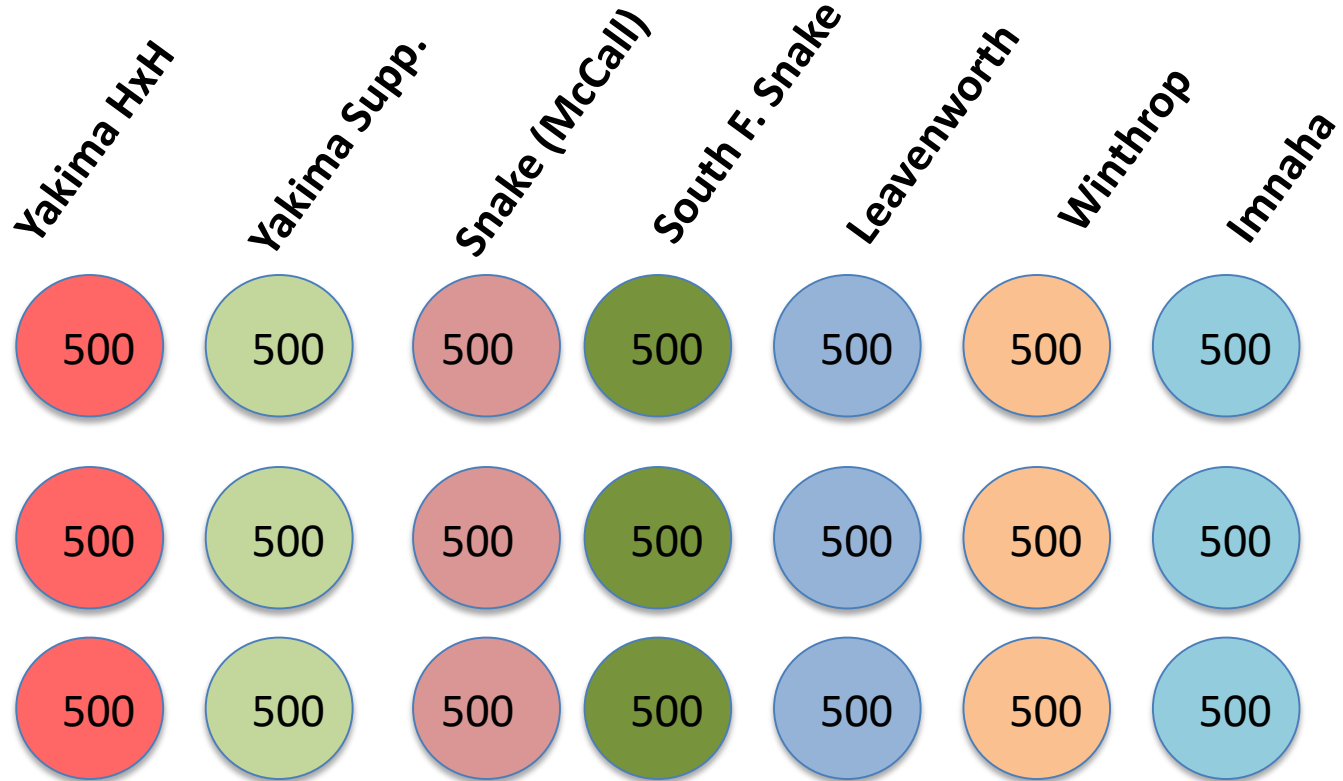
#### Editor

Marc Mangel

#### Abstract

Adaptation of plants or animals to captivity is a risk associated with any captive breeding program that has the intent of returning organisms to the wild. The risk is particularly acute for species that are captively bred and released on a large scale, as is the case for many species of fish. Several studies, particularly in salmonids, have reported rapid adaptation of populations to captivity, but the mechanisms of such adaptations are not always clear. We evaluated a large three-generation pedigree of an artificially supplemented salmon population, and found that the fish with the highest reproductive success in captivity produce early maturing male offspring that have lower than average reproductive success in the wild. In contrast to an earlier study of steelhead trout, we found little evidence that parental origin of the captive spawners influenced the subsequent reproductive success of their naturally spawning progeny.

# What's next?



**Common Garden Rearing Experiment**

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Round Butte Hatchery  
Lookingglass Hatchery  
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## NW Fishletter #333 June 5, 2014

### [3] Minijacks -- A Major Headache At Some Hatcheries

Three NOAA Fisheries researchers from the agency's science center in Seattle have taken a fresh look at some Northwest hatcheries and found a troubling tendency that is likely hampering some regional supplementation efforts.

The researchers say the production of large numbers of young Chinook called "minijacks," young males that mature so early they never leave their river of origin before returning to their early rearing grounds, show extremely low reproductive success. Jack Chinook are sexually precocious males that return early as well, but they spend one year at sea.

Published in the April 30 online edition of *Transactions of the American Fisheries Society*, the paper, "Variation in Minijack Rate among Hatchery Populations of Columbia River Basin Chinook Salmon," found a tenfold variation in minijack rates among several spring and summer Chinook hatcheries in the Columbia Basin. It was authored by Deborah Harstad, Donald Larsen and Brian Beckman.

Since growth rates at hatcheries are influenced by diet, water temperature and feeding rates, young males can mature much earlier than in the wild. In some cases, like the White River captive broodstock program in the Wenatchee Basin, minijacks accounted for more than 71 percent of the return from the 2009 brood year.

The authors said the high minijack rate for the White River program was greater than two times the overall rate for all the spring Chinook release groups they reviewed, and demonstrated that the White River fish "probably experienced high growth at a critical period when growth influences the onset of maturation."

A flagship research hatchery in Cle Elum, Wash., operated by the Yakama Tribe, sported a 48.5-percent minijack rate from the 2010 brood year, while the Carson Hatchery not far above Bonneville Dam, produced 30 percent minijacks from the 2009 brood.

In 2009, the Winthrop Hatchery had a minijack rate of only 14.6 percent, and the Leavenworth Hatchery 21.4 percent. In northeast

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What we do know about minijack rates between hatchery and wild fish at CESRF and Prosser Dam

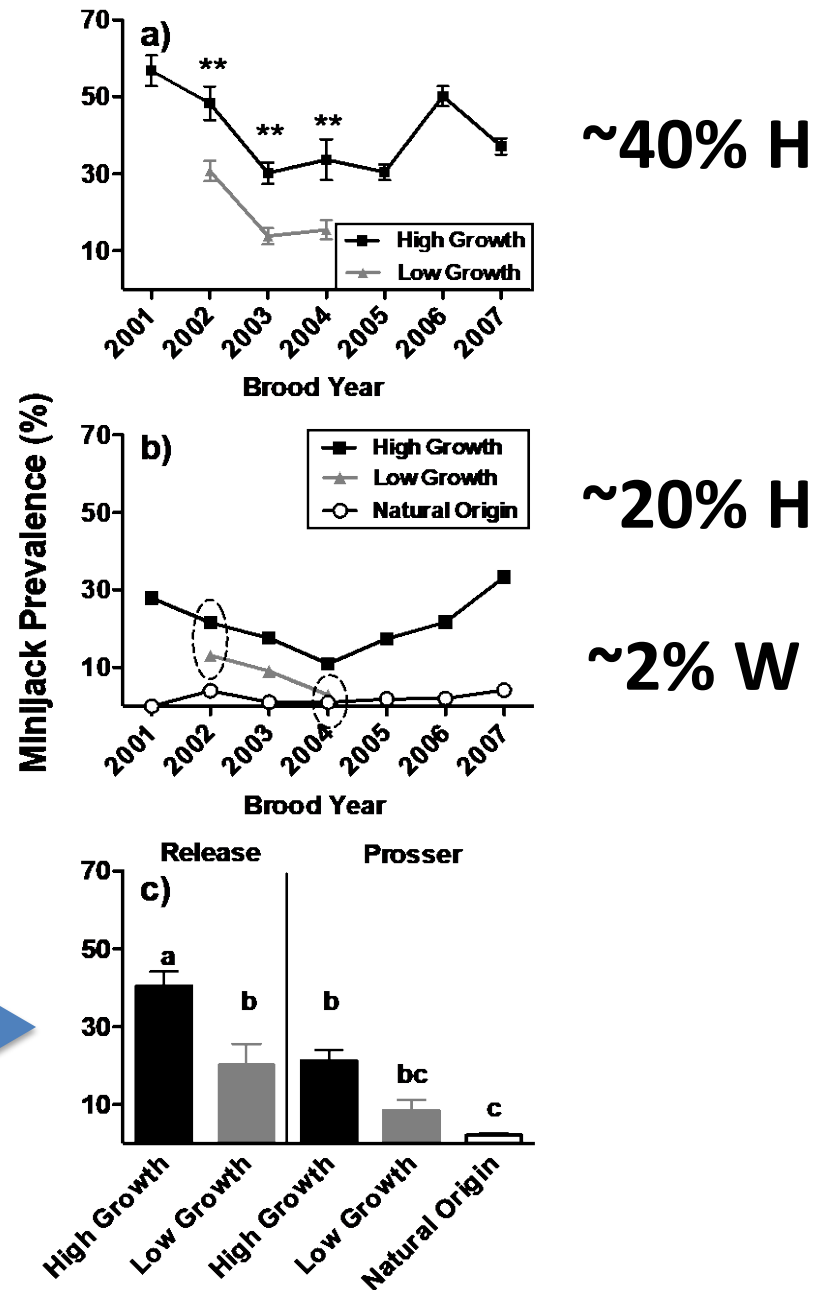
CESRF MJ rates at release



MJ rates at Prosser



Summary →



Larsen et al. 2013 TAFS

Figure 5.



What we do know about sex ratios between hatchery and wild fish from CESRF and Prosser Dam

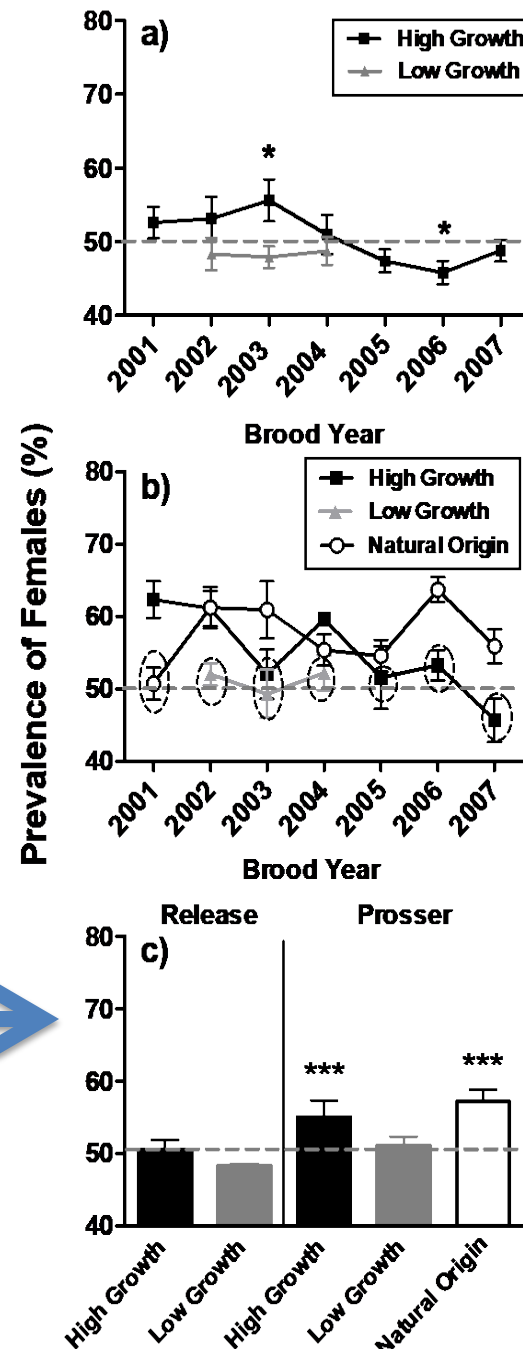
CESRF sex ratio at release



Sex ratio at Prosser



Summary →



50:50 H  
F:M

56:44 H

58:42 W

Figure 8.