Breeding Success Of Wild & First Generation Hatchery Spring Chinook In An Artificial Stream

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Artificial Stream At Cle Elum

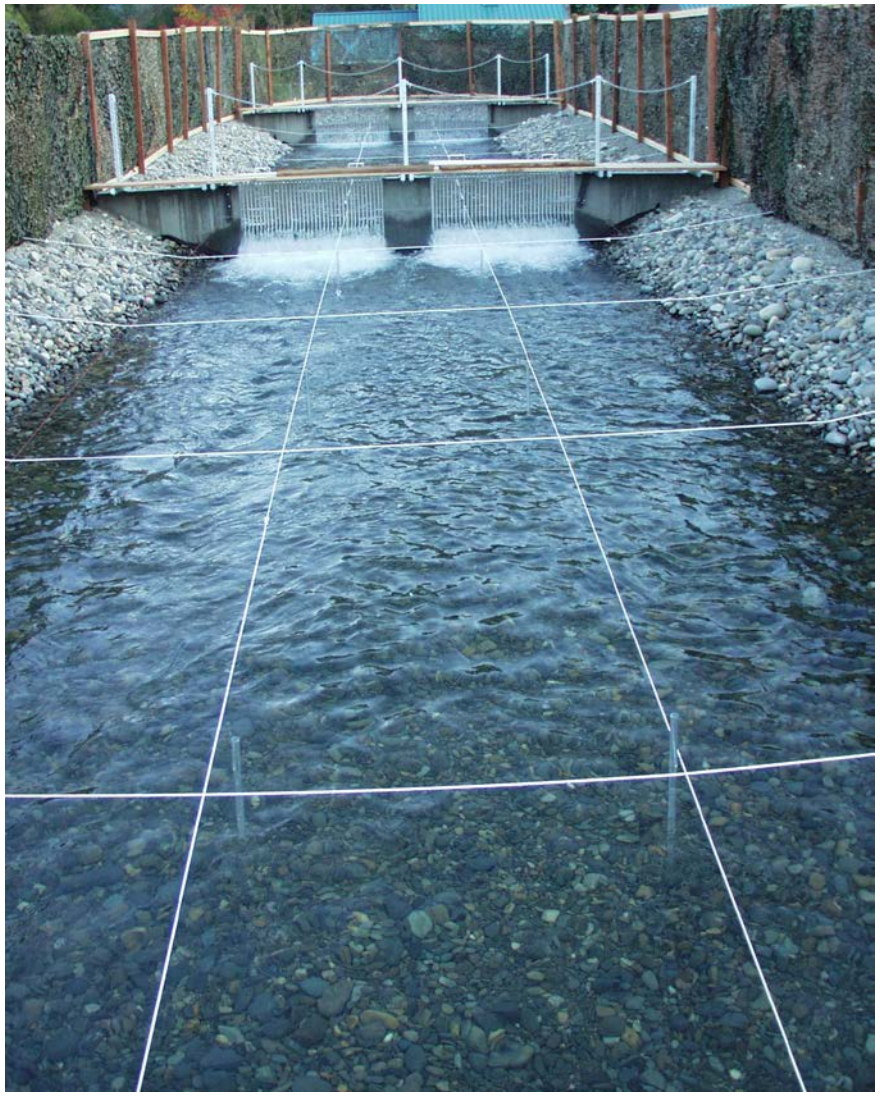
Why An Artificial Stream?

Confounding Factors Can Be Controlled

- **Physical Environment**

(Gravel, Water Velocity & Depth)

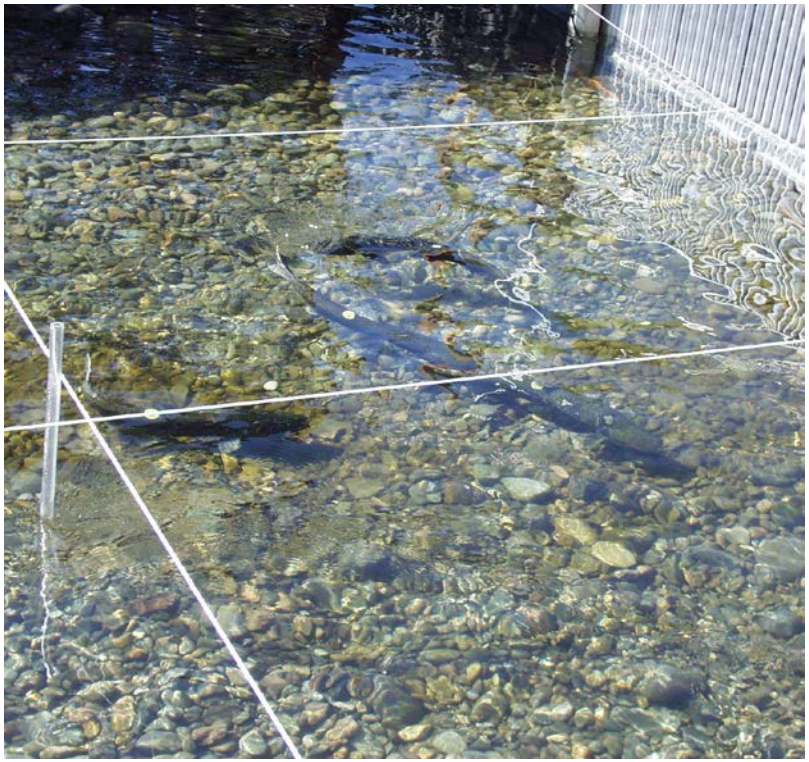
- **Fish (No., Type, Maturation, Condition, Entrance Timing)**
- **DNA (All Adults & Subsample Of Fry)**
- **Behavior (Correlate Individual Behavior with Reproductive Success)**
- **Replication (Similar Conditions For Multiple Groups Of Fish)**



Approach Taken To Evaluate Breeding Success

- Created 7 Independent Test Groups Containing Hatchery- & Wild Fish

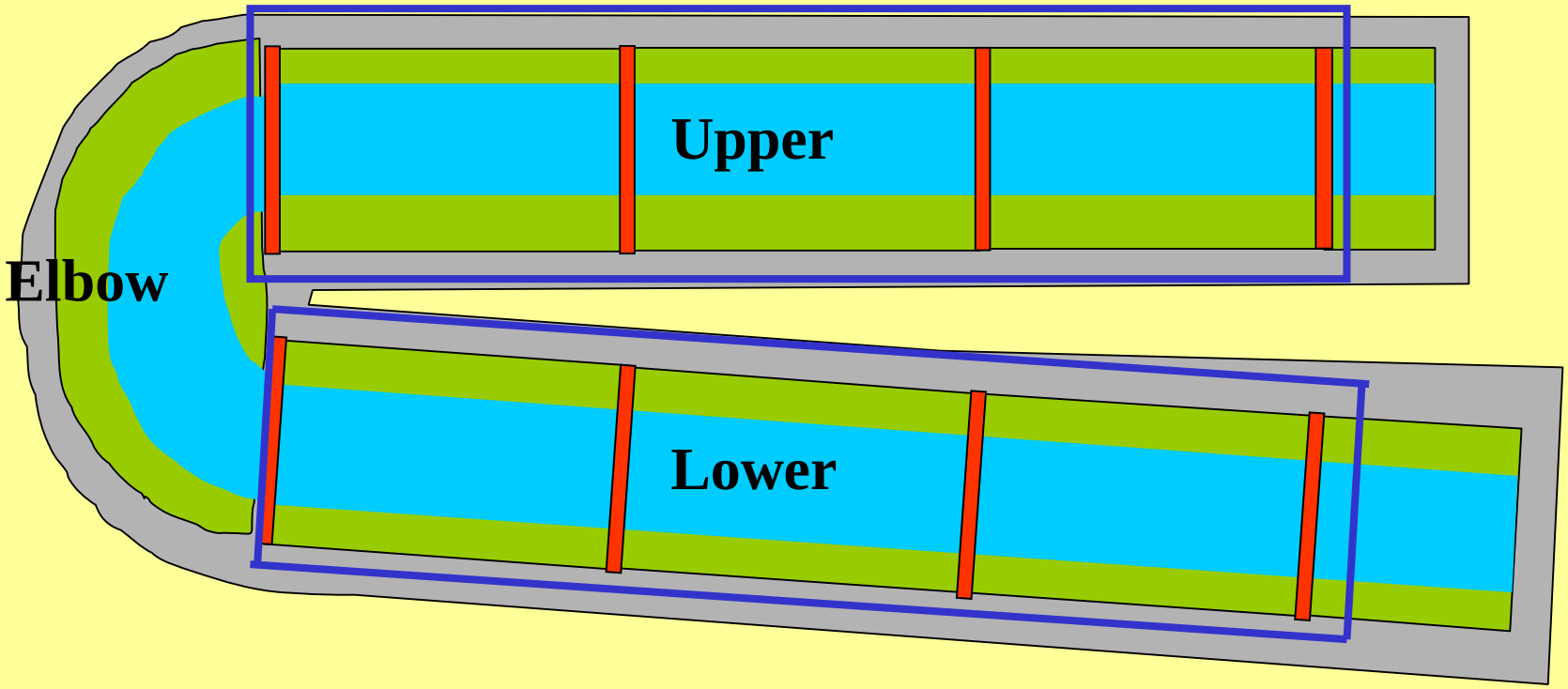
- DNA-based Pedigree Analyses Were Performed On Fry To Estimate Parental Success



Artificial Stream:

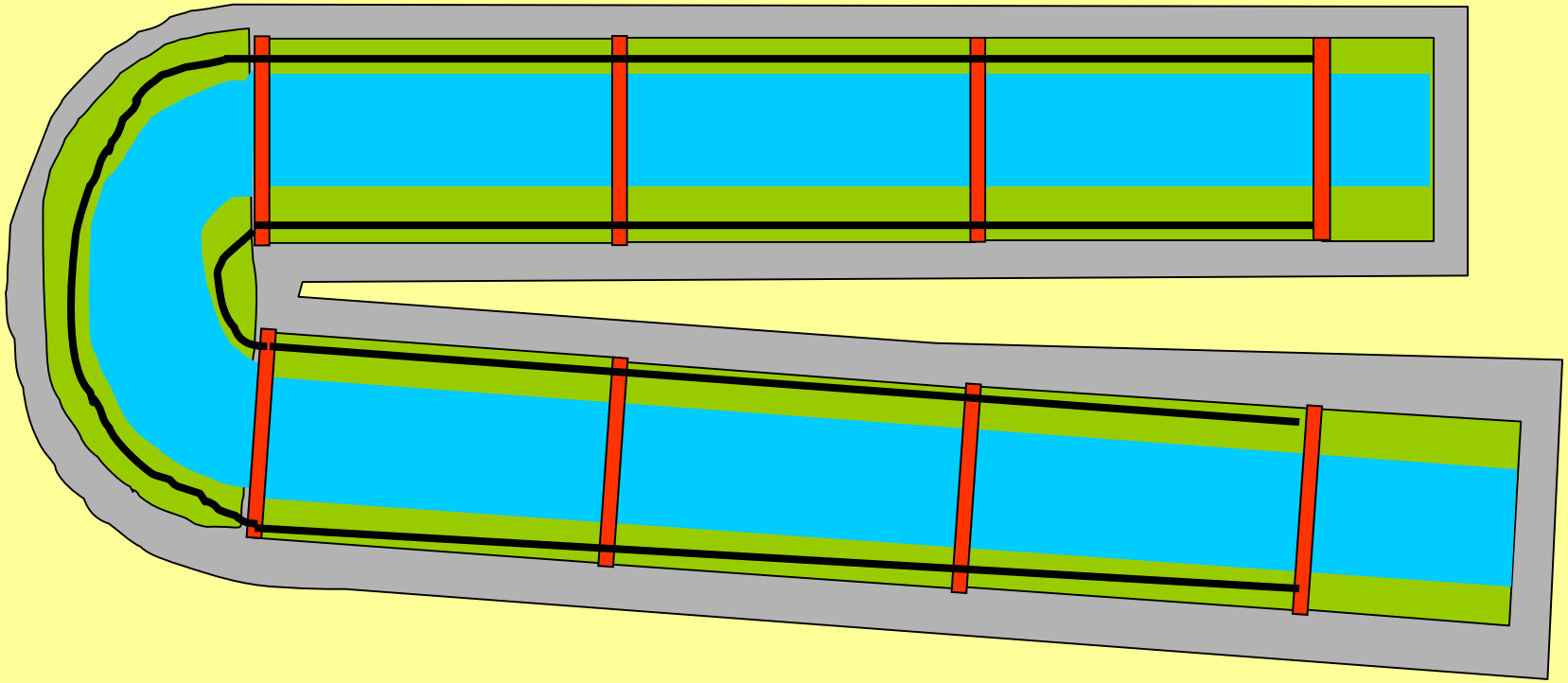
Adult Handling Protocols

Sections Of The Artificial Stream Used In 01 & 02



Upper & Lower Sections Were 4.9 m wide by 45.7 m long

Area Used In 2003, 04, & 05



Entire Stream Dimension Was 4.9 m x 127 m

No. Of Adult Fish Used

Years	No. Of Test Groups	Females		Males	
		Wild	Hatchery	Wild	Hatchery
2001-05	7	76	75	79	76

No Of Fry Used In Pedigree Evaluations

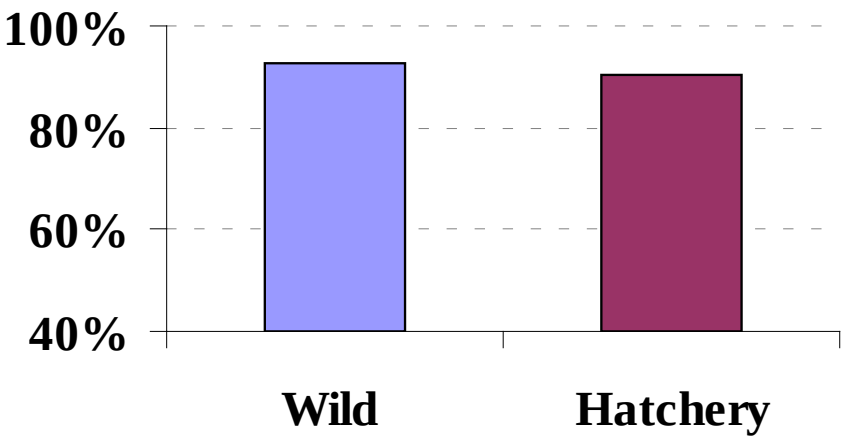
Test Group	No. Of Fry Assigned To Parents
2001A	991
2001B	780
2002A	1566
2002B	1264
2003	2750
2004	2892
2005	2973
Totals	13216

Measures Of Female Breeding Success:

- **Performance Based & Independent Of Total Offspring Production**

Female Breeding Success

% Spawned



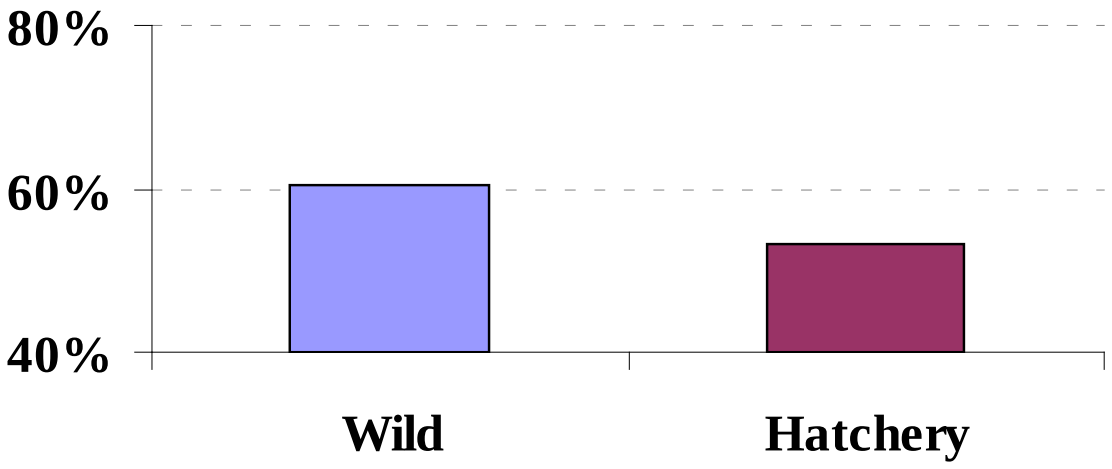
Wild = 93.2%

Hatchery = 89.1%

P = 0.15 paired-*t* test

Female Breeding Success:

% Survival Of Deposited Eggs

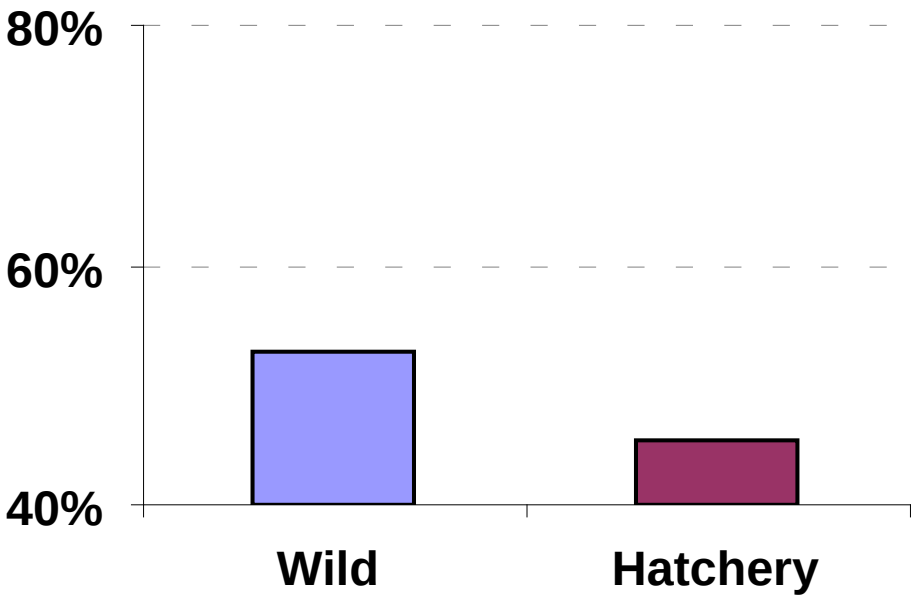


Wild = 60.2%

Hatchery = 54.6%

P = 0.04 paired *t*-test

Female Breeding Success:
Absolute Fecundity To Fry



Wild = 53.4%
Hatchery = 46.3%
P = 0.08 paired-*t* test

Factors Responsible For Differences In Breeding Success

Differences Between Wild & Hatchery Females

- Redd Location (more at tail end of sections)
- Redd Abandonment (less likely to abandon)
- Egg Burial Time (more rapid burial)

Comparing The Breeding Success Of Naturally Spawning Wild- & Hatchery-Origin Male Spring Chinook

Factors Affecting Breeding Success In Hatchery and Wild Males

Capacity To:

a) Find Females & Defend Them From Rivals

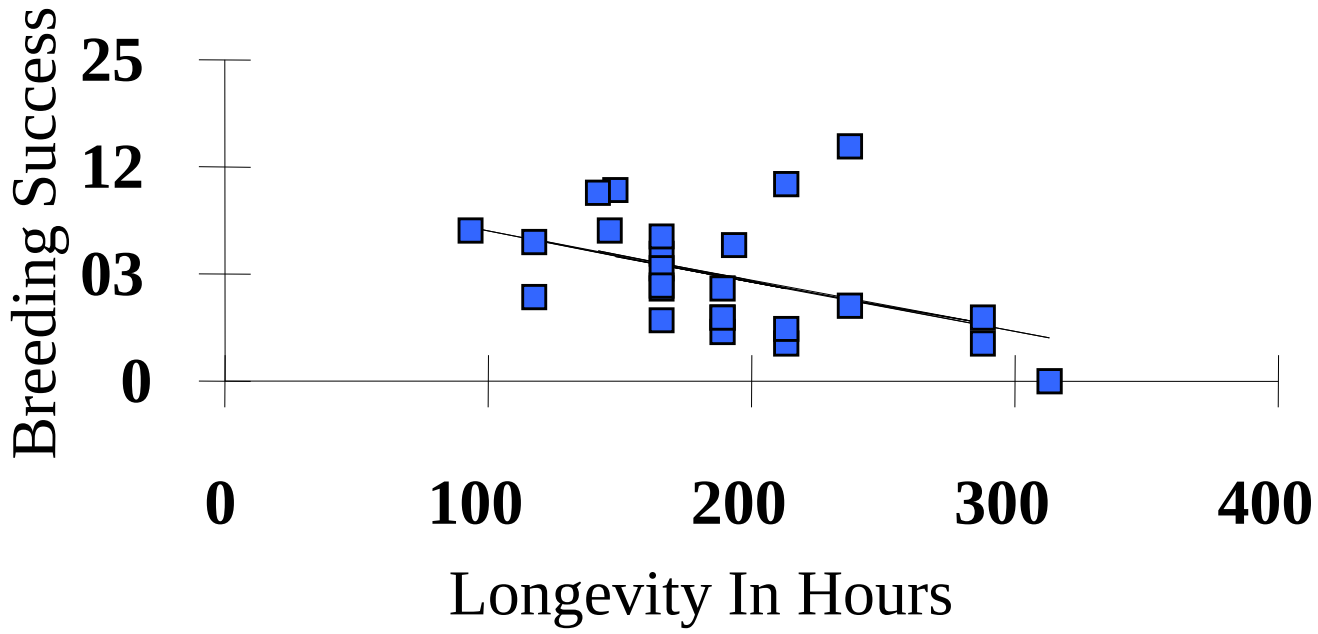
b) Fertilize Eggs

Male Breeding Success = $\frac{\text{No. Of Fry Sired In A Fry Sample}}{\text{No. Of Fry In The Sample}}$

Factors Examined That May Affect Male Breeding Success

Morphological & Physiological	Behavioral
Longevity	Agonism
Body Weight	Courtship

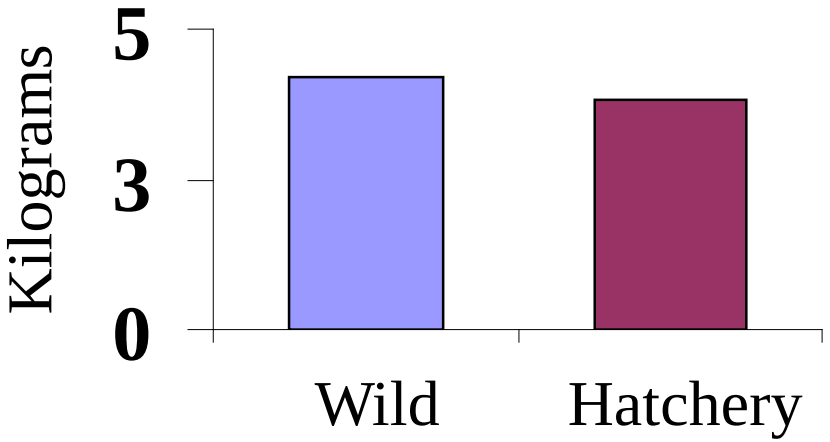
Affect of Male Longevity On Breeding Success



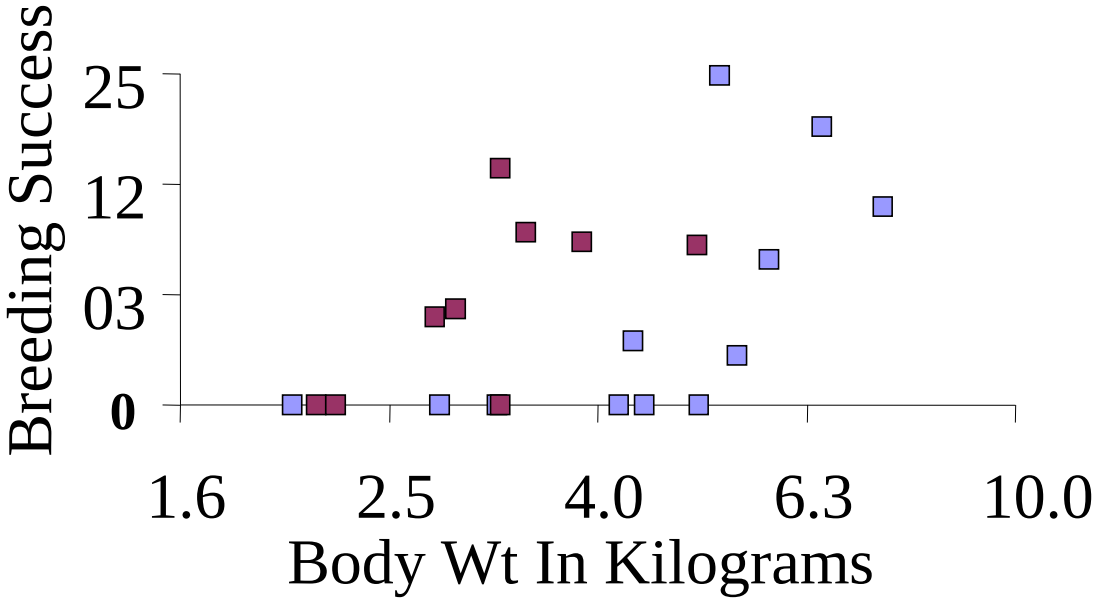
Negative Relationship
Tau = -0.39, P = <0.01

Male Body Weight

Wilds ~ Hatchery
***P* = 0.08**
4.2 kg vs. 3.8 kg
.374 kg Difference



Mean r^2 = .26
***P* = < 0.001**

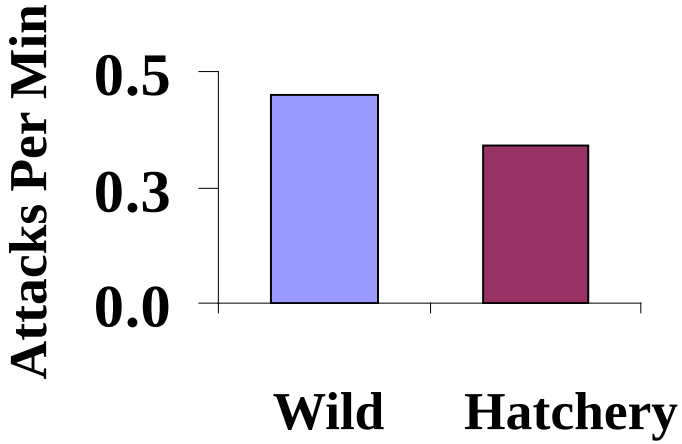


Male Behavior: Agonism

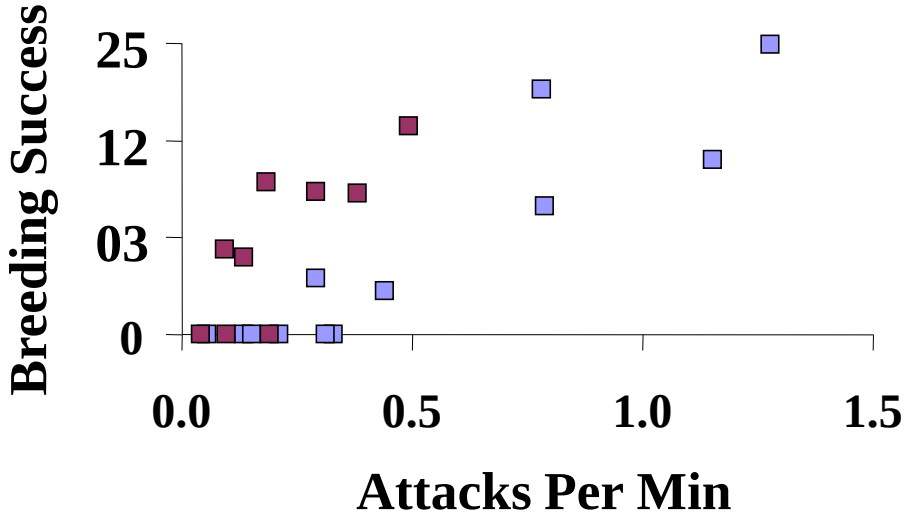
Mean Attacks Per Min = $\frac{\text{Total Attacks Delivered To Opponents}}{\text{Min Observed}}$

Mean Attacks Per Min

Wilds > Hatchery
***P* = 0.015**
0.45 vs. 0.34
0.11 Difference



Mean r^2 = .48
***P* = < 0.001**

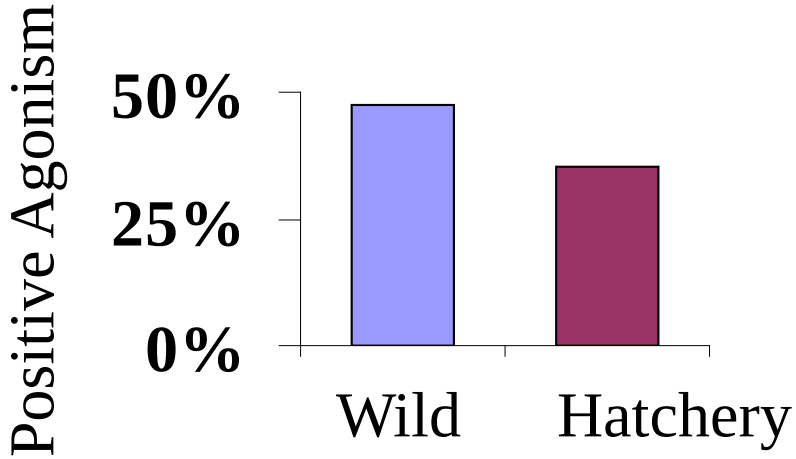


Male Behavior: Agonism

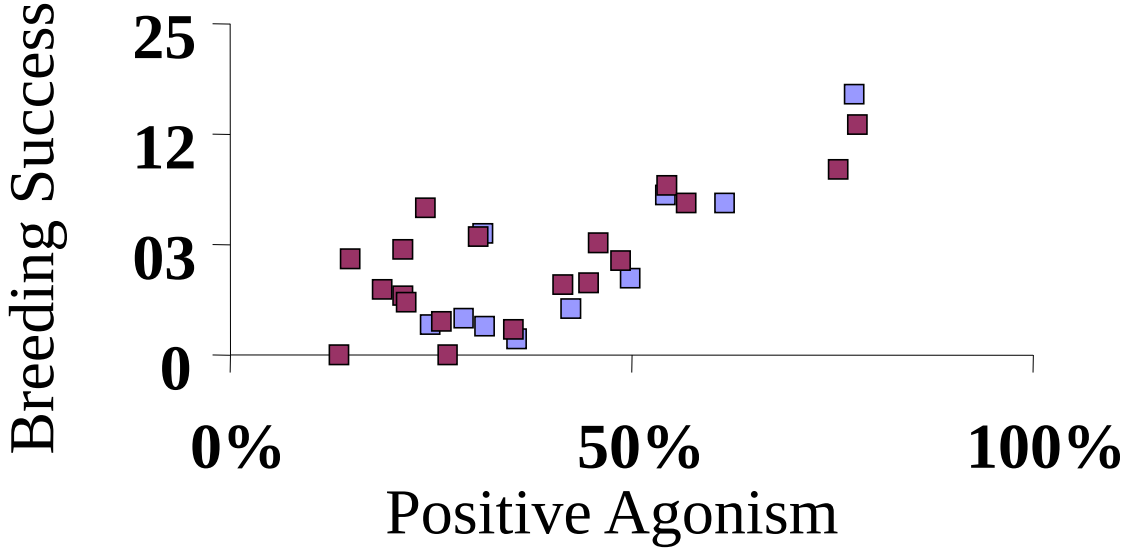
% Positive Agonism = $\frac{\text{Number Of Attacks Delivered To Opponents}}{\text{(No. Attacks Delivered) + (No. Attacks Received)}}$

% Positive Agonism

Wilds > Hatchery
***P* = 0.022**
48% vs. 35%
13% Difference



Mean r^2 = .49
***P* = < 0.001**

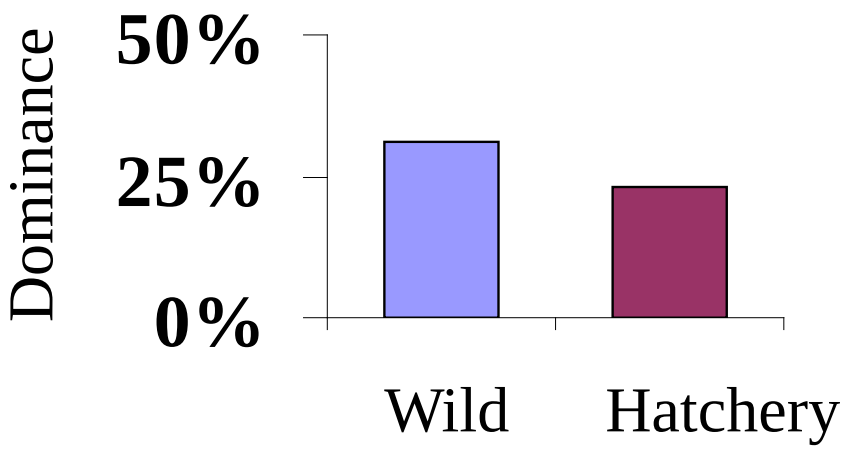


Male Behavior: Agonism

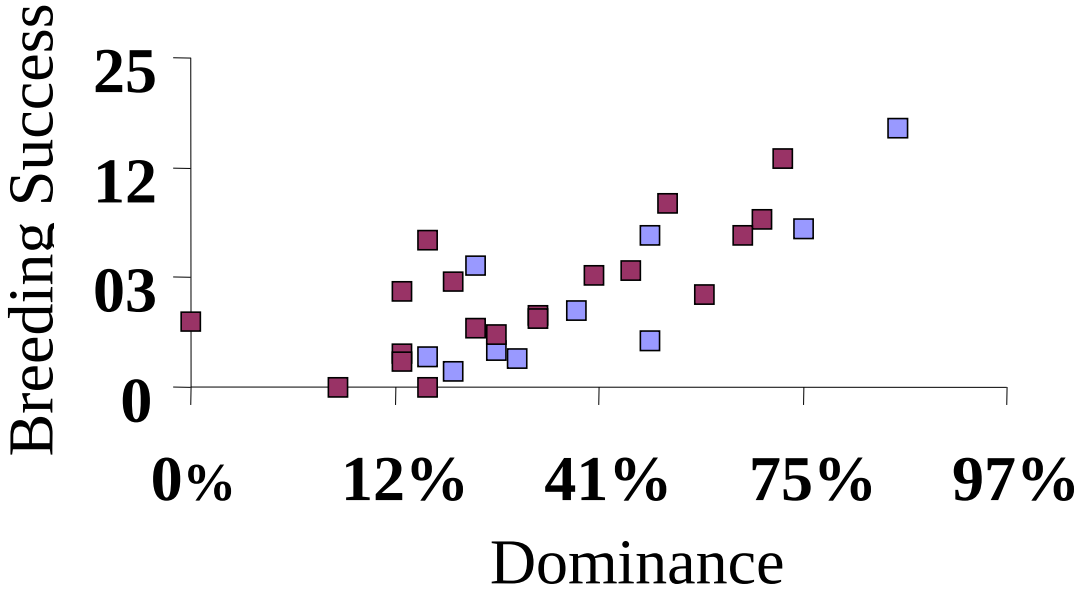
$$\text{Dominance} = \frac{\text{Number Of Males Dominated}}{(\text{Total Males In Test Group}) - 1}$$

Dominance

Wilds > Hatchery
***P* = 0.022**
31% vs. 23%
8% Difference



Mean r^2 = .46
***P* = < 0.001**

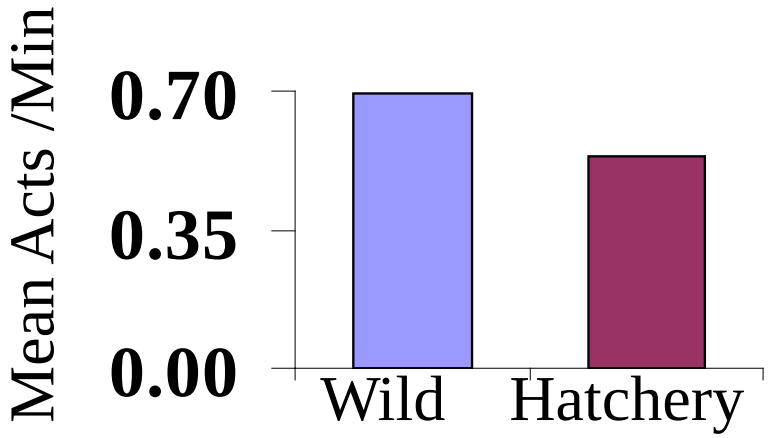


Male Behavior: Courting

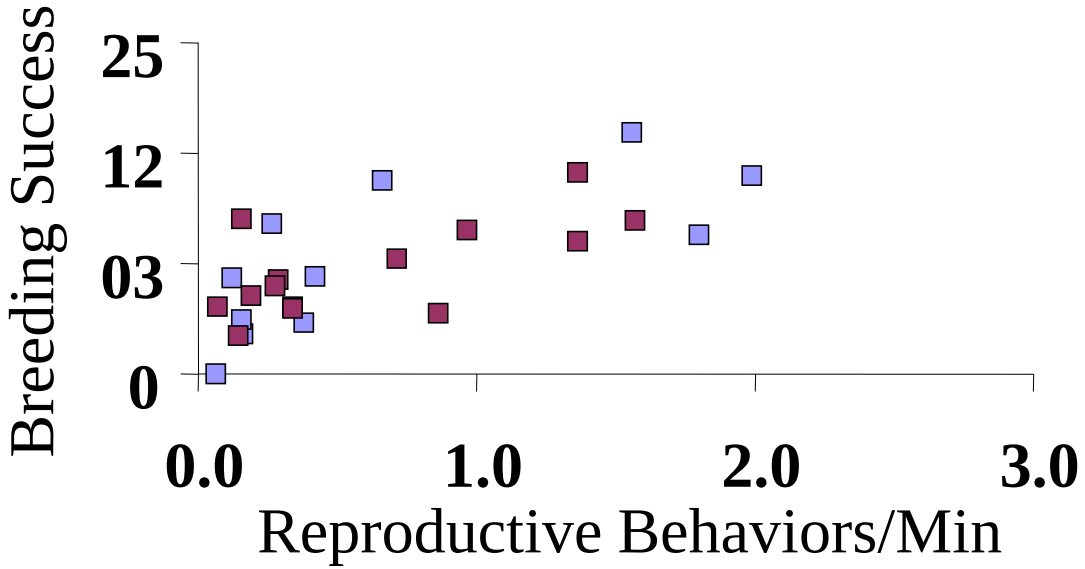
Mean Reproductive Behaviors Per Min = $\frac{\text{(Courting Acts) + (Delivered Attacks)}}{\text{Min Observed}}$

Mean Reproductive Behavior

Wilds > Hatchery
***P* = 0.04**
0.70 vs. 0.54
.16 Difference



Mean r^2 = .48
***P* = < 0.001**

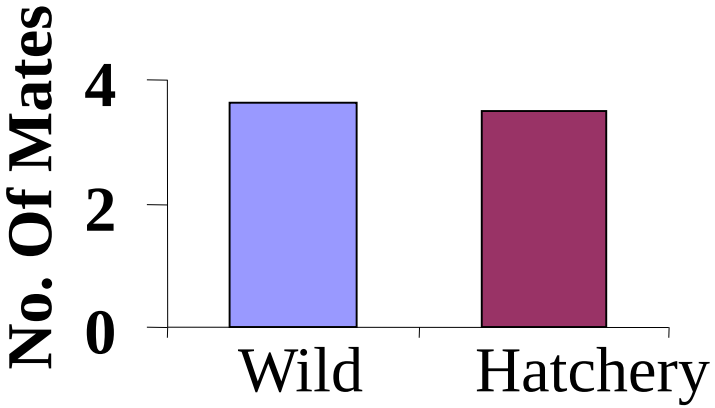


Male Breeding Success

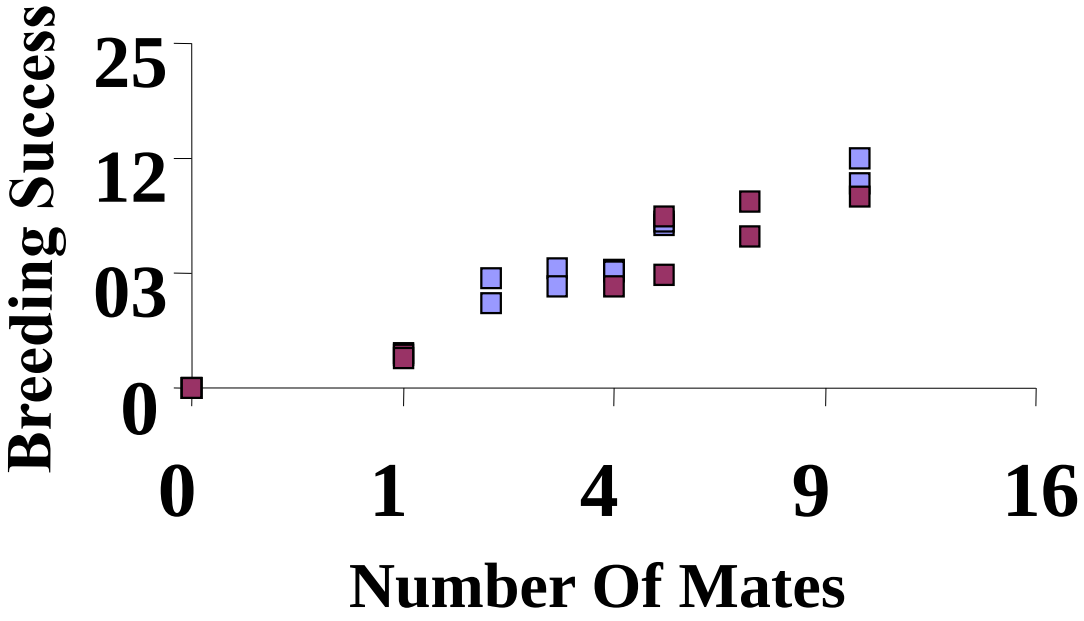
- **Number of Mates**
- **Production of Progeny**

Number Of Mates

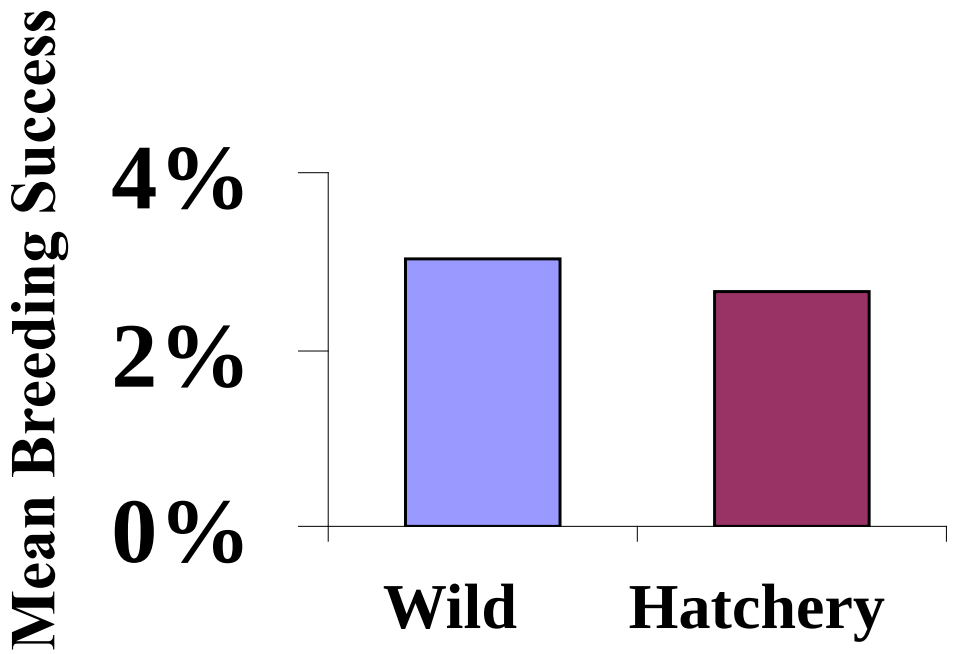
Wilds ~ Hatchery
***P* = 0.39**
3.6 vs. 3.5
0.1 Difference



Mean r^2 = .80
***P* = < 0.001**



Mean Breeding Success



Wilds ~ Hatchery
***P* = 0.22**
3.0% vs. 2.6
0.4% Difference

Differences In Wild & Hatchery Males

- Wild Males Were More Aggressive
- Wild Males Exhibited Greater Dominance Over Rivals
- Wild Males Expressed More Reproductive Behaviors Per Min

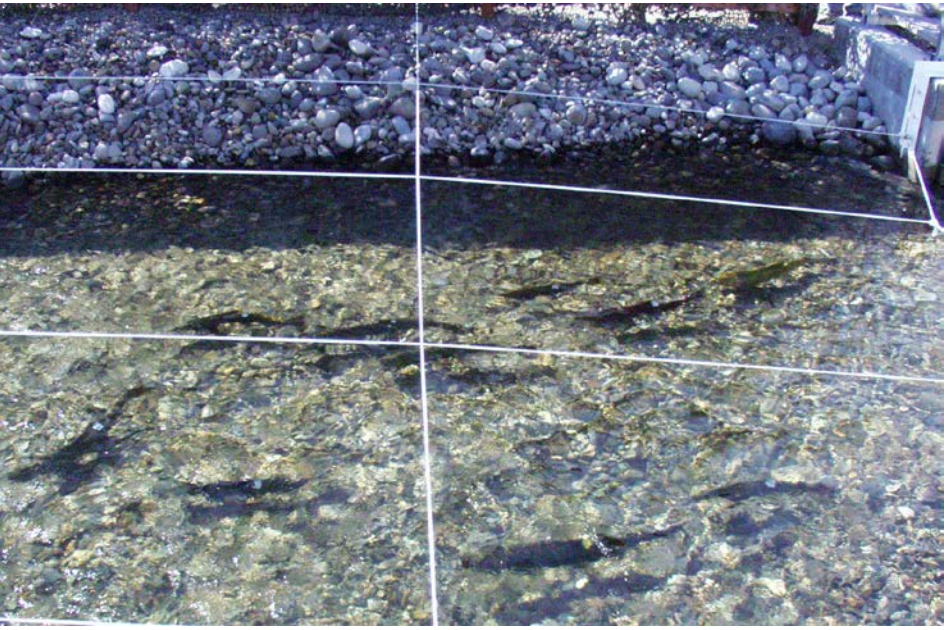
- Wild Males Were Larger Than Hatchery Males (Knudsen et al. 2006)

- No Difference Detected In The Number Of Mates
- No Difference Detected In Breeding Success

- The significance of the differences seen depends upon their origin.

If it is largely genetic then: Repeated Exposure To Artificial Culture May Reduce The Breeding Success Of Hatchery Males

What's Next?



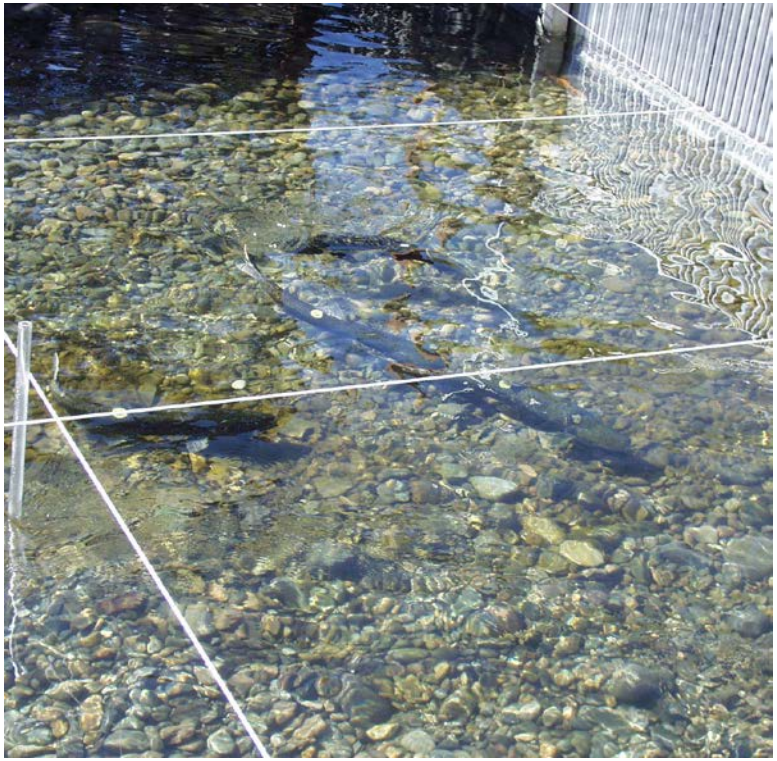
Wild & 1st Generation Hatchery Fish Experienced Different Early Environments

Therefore:

The Relative Importance of Genetic Change & Environmental Effects On Breeding Success Cannot Be Disentangled

On-Going Study

- Create Homogenous Populations Of First- & Second Generation Hatchery Fish
- Allow The Fish To Spawn Naturally
- Determine Survival Of Deposited Eggs & % Fecundity-To Fry Conversion Rates In Each Population



Statistical Approach

3-Factor Mixed Nested ANOVA

Fixed:	Fish Type; 1st & 2nd Generation Hatchery Adults
Random:	Year Location Of Population In The Artificial Stream
Response Variables:	Deposited Egg Survival % Of Absolute Fecundity Converted To Fry

(In This Design Environmental Effects Are Held Constant)

Analytical Goal

Determine The % Of Variation Associated With Fry Production That Is Linked To Each Of Our Factors:

Fish Type: 1ST & 2nd Generation Hatchery Fish

Year: 2006, etc.

Section: 1-1, 1-2, etc.

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