Breeding Success of Wild- And Hatchery-Origin Spring Chinook Salmon Spawning In An Artificial Stream

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Cle Elum Supplementation Research Facility

Established in 1997

Built For Two Purposes:

- ❖ Supplement Upper Yakima River Spring Chinook

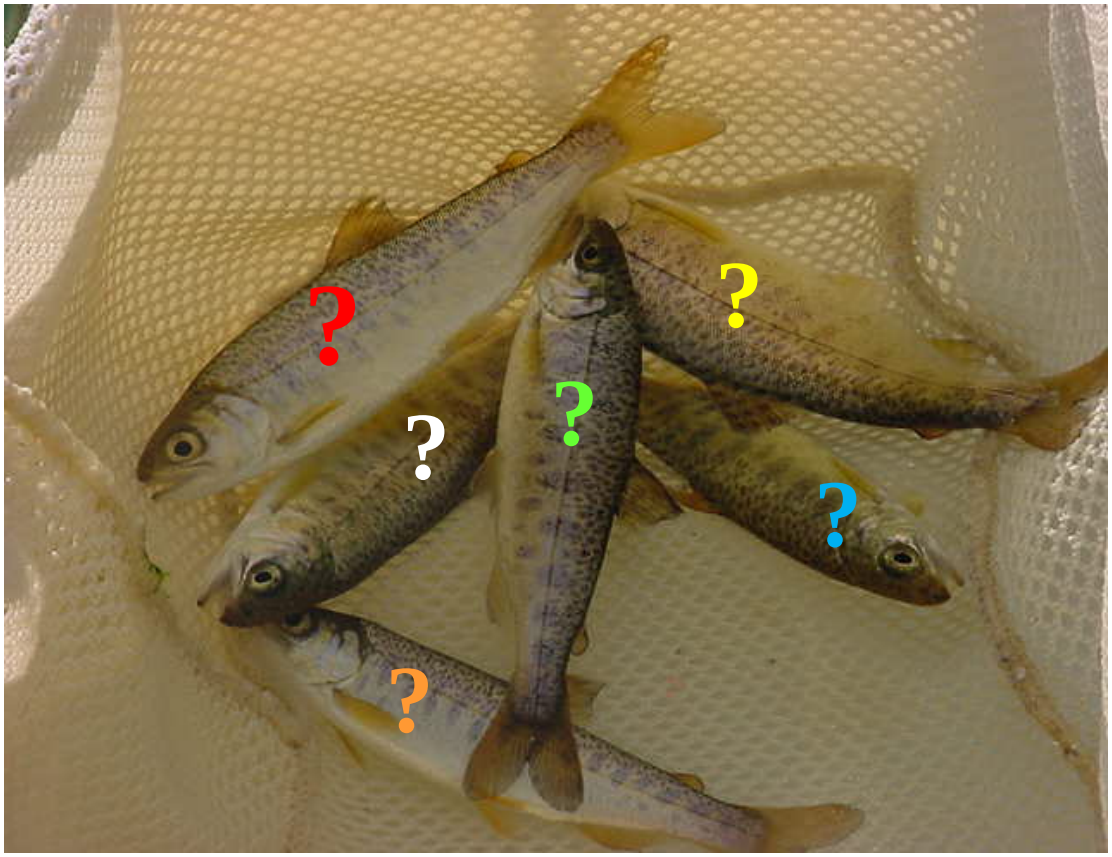
- ❖Serve As A Salmon Supplementation Research Facility

Spring Chinook Research Questions

❖Test Alternative Rearing Treatments

❖Track Inadvertent Domestication

(Quantify **Behavioral**, **Physiological** & **Morphological** Effects Of Hatchery Exposure On Juveniles & Adults)



One Of The Domestication Questions Was:

Have Hatchery Conditions Created A Difference In The Breeding Success Of Hatchery & Wild Spring Chinook?

Types of Fish Used

- Wild: Native Upper Yakima River Spring Chinook With Little Or No Hatchery History
- Hatchery: First-Generation , Derived From Native Upper Yakima River Spring Chinook (Local Stock)

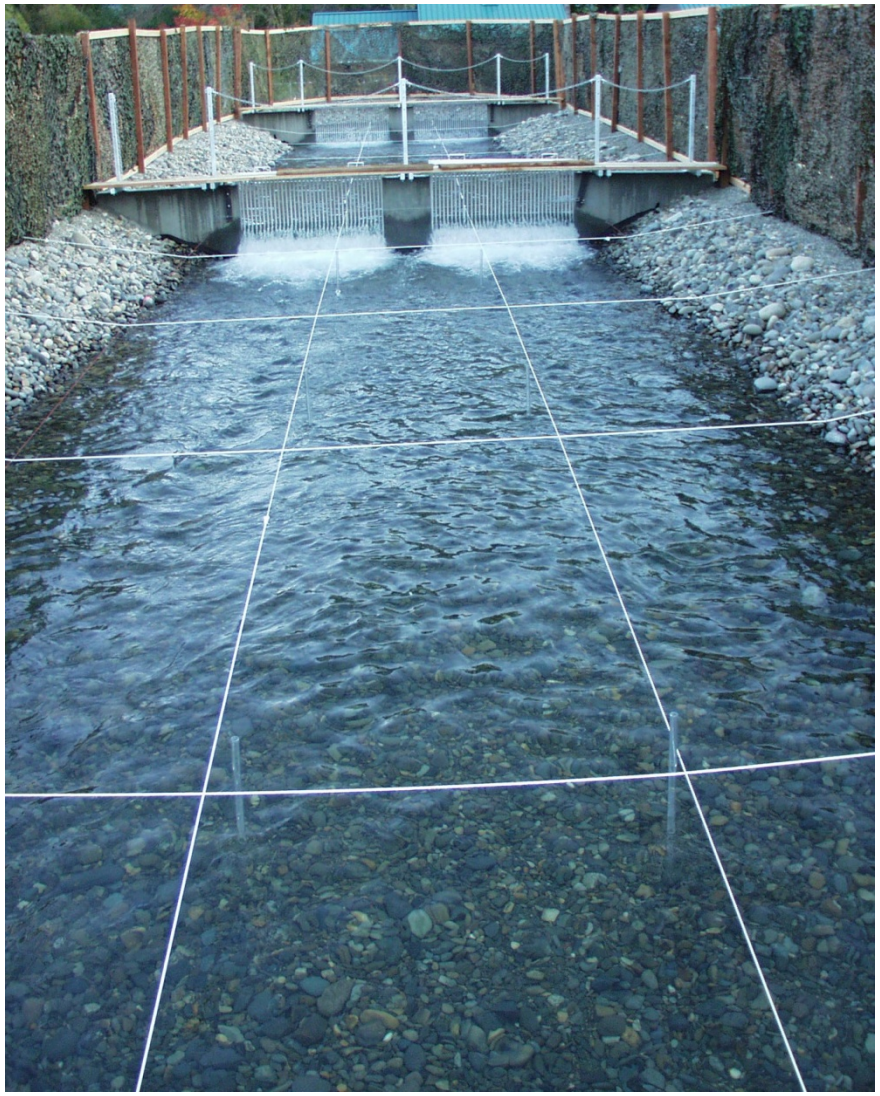
Artificial Stream At Cle Elum

Dimensions and Water Flow
127 long x 7.9 m wide
Water Velocity 0.1 – 2.0 m/s
Discharge 0.37m^3/s
Mean Depth 0.4 m

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 Fish Origin & Breeding Success)**

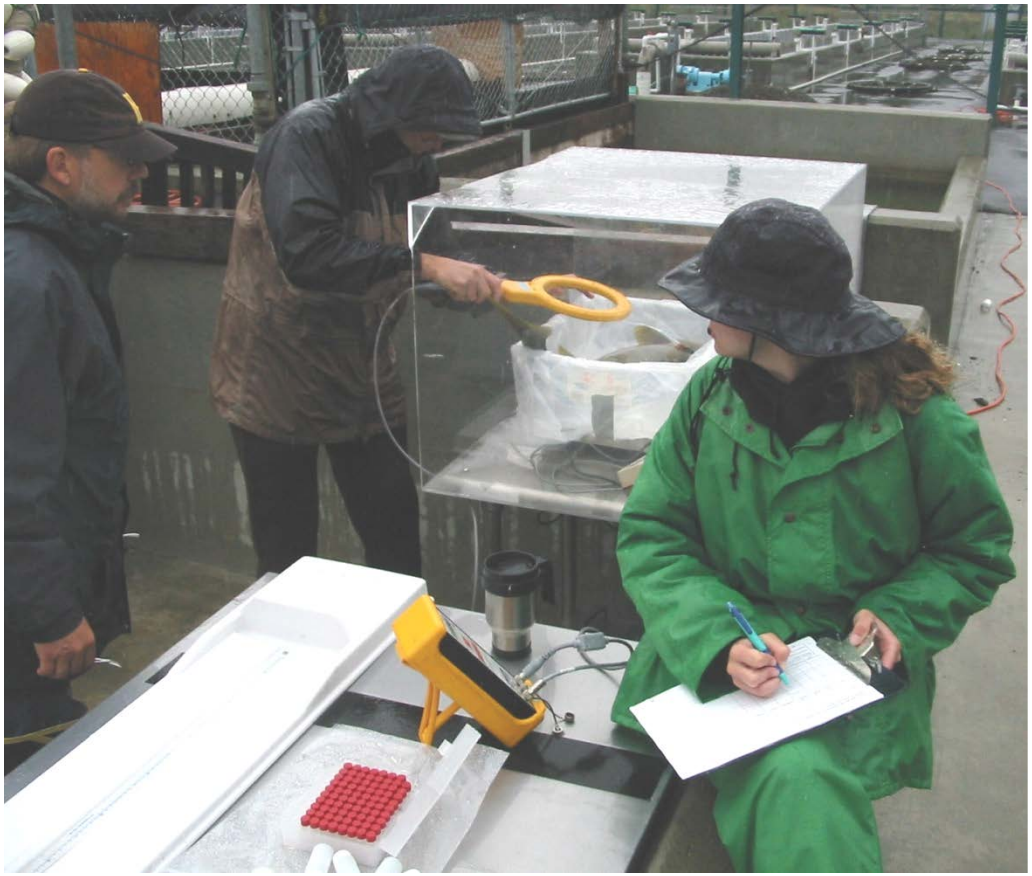


Types Of Fish Placed Into The Stream

Hatchery & Wild 3, 4 & 5 yr-olds Males & Females

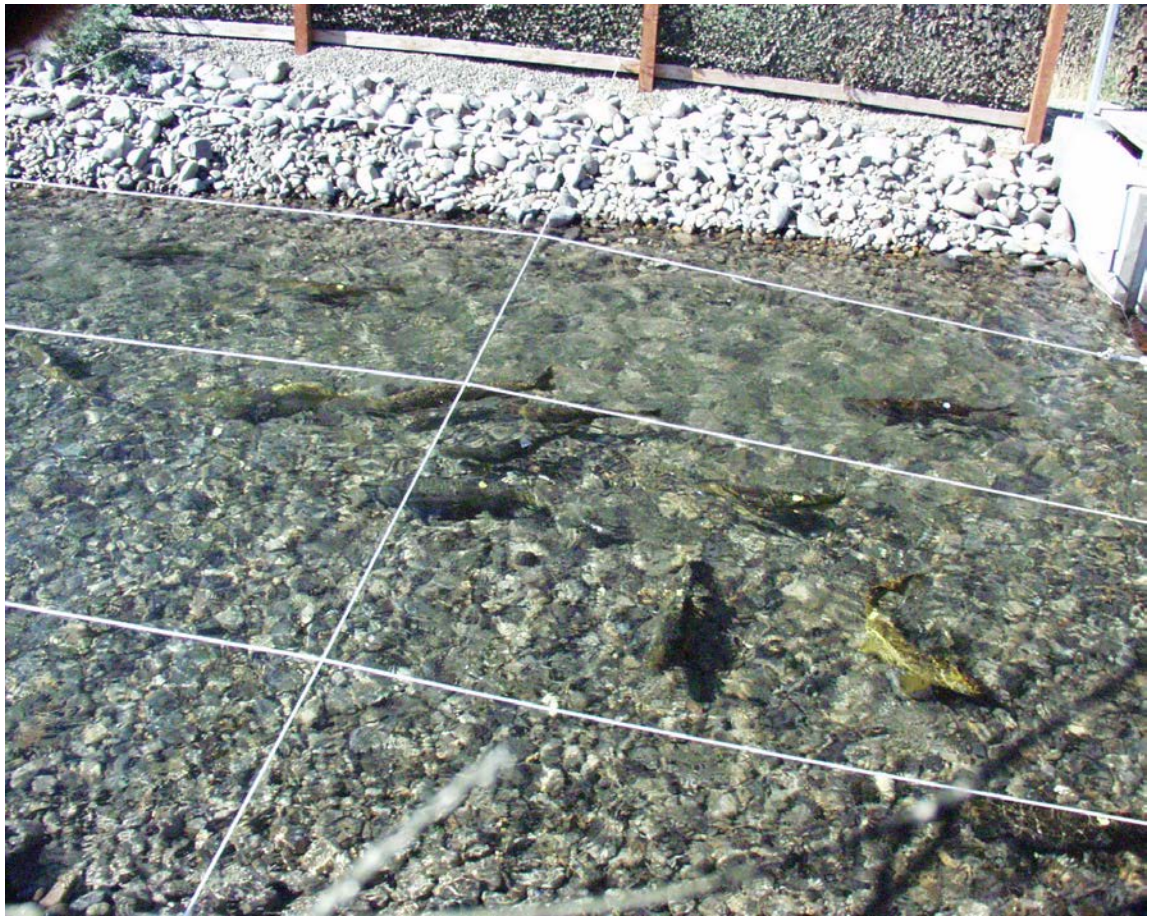
Hatchery & Wild Precocious Males

Prior To Placement, Each Fish Was:



And, A Small Bit Of Fin Material Was Removed For Later DNA Extraction

They Were Then Released Into The Stream & Spawned Under Quasi-Natural Conditions



Data Sources

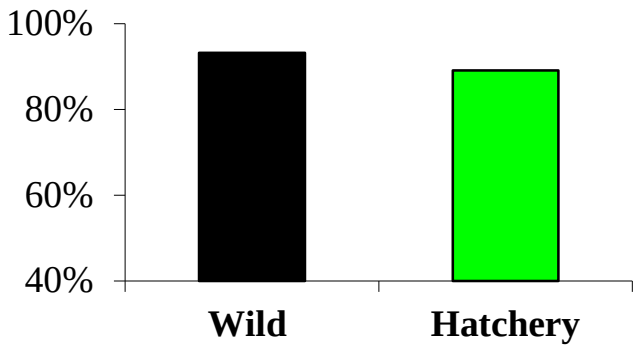
Typ	DNA Pedigree Results	Fry Produced	Number Sampled	Number Analyzed	Number Assigned	% Assigned	OTAL
		350,439	**30,683**	**13,779**	**13,216**	**96%**	**387**

Definition of Female Breeding Success

- Capacity to Deposit Eggs

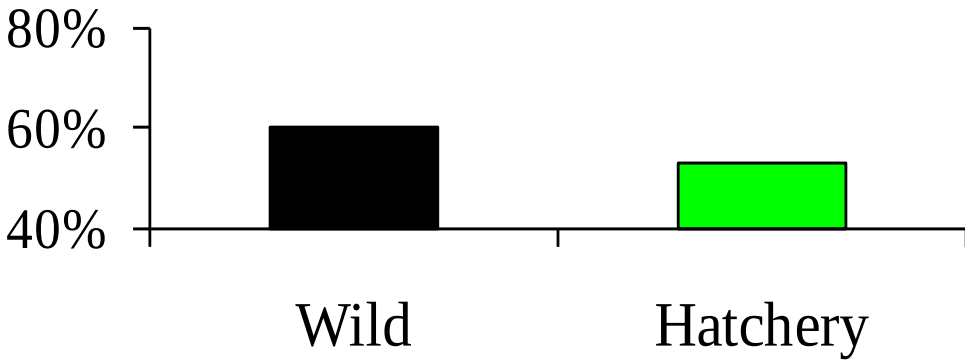
- Survival of Deposited Eggs To The Fry Stage

Egg Deposition



Wild = 93.2%
Hatchery = 89.1%
P = 0.15 paired-*t* test

Survival Of Deposited Eggs

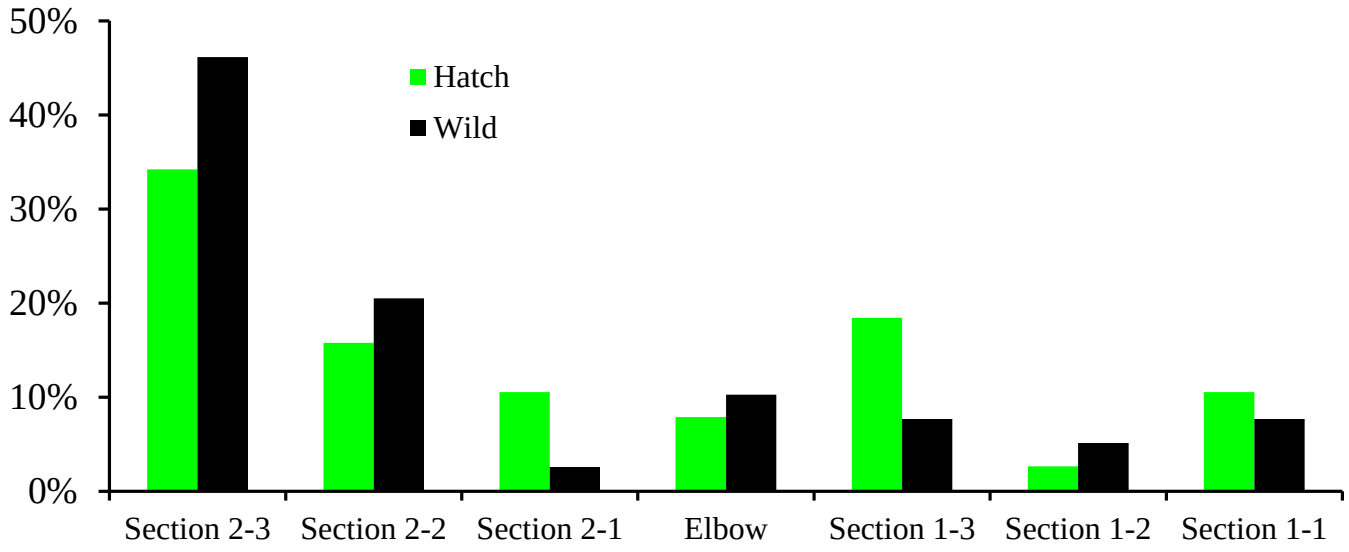


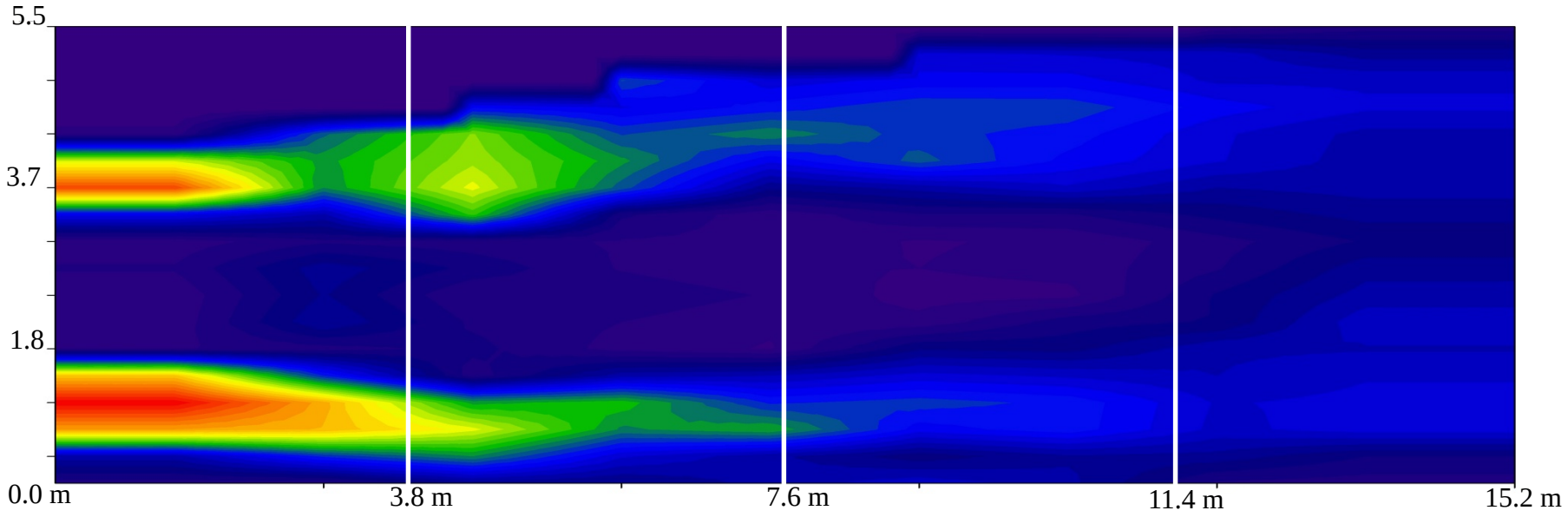
Wild = 60.2%
Hatchery = 54.6%
P = 0.04 paired *t*-test

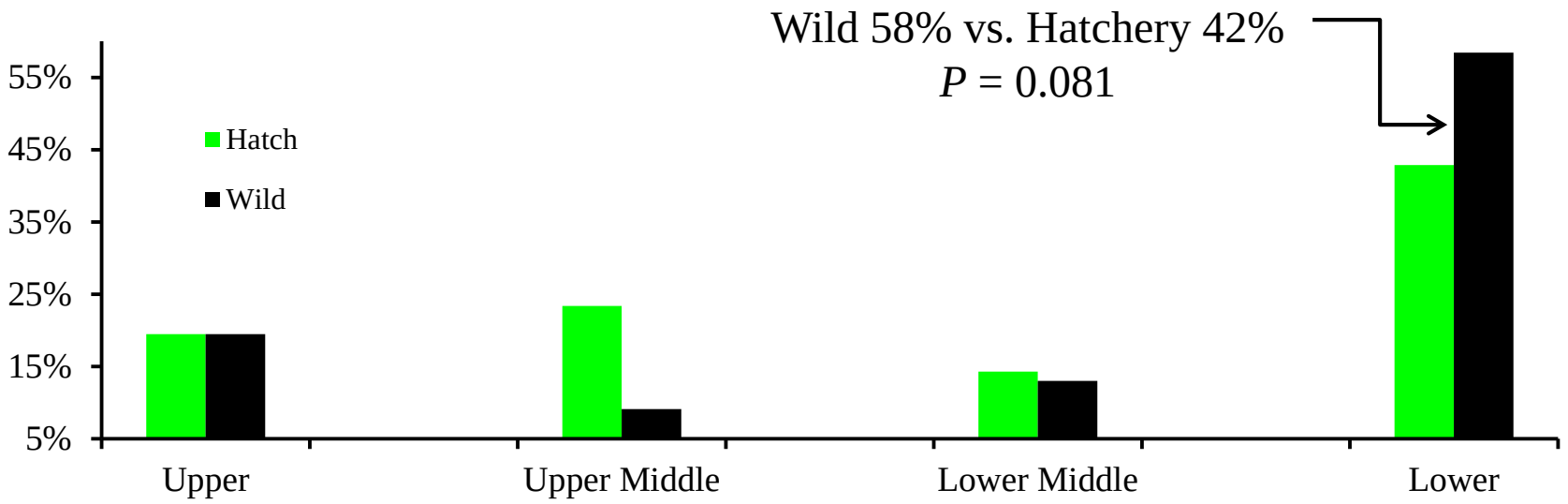
Factors Affecting Egg-To-Fry Survival Rates

- Redd Location
- Nest Construction & Egg Burial
- Redd Defense

Distribution Of Hatchery and Wild Females Throughout The Observation Stream



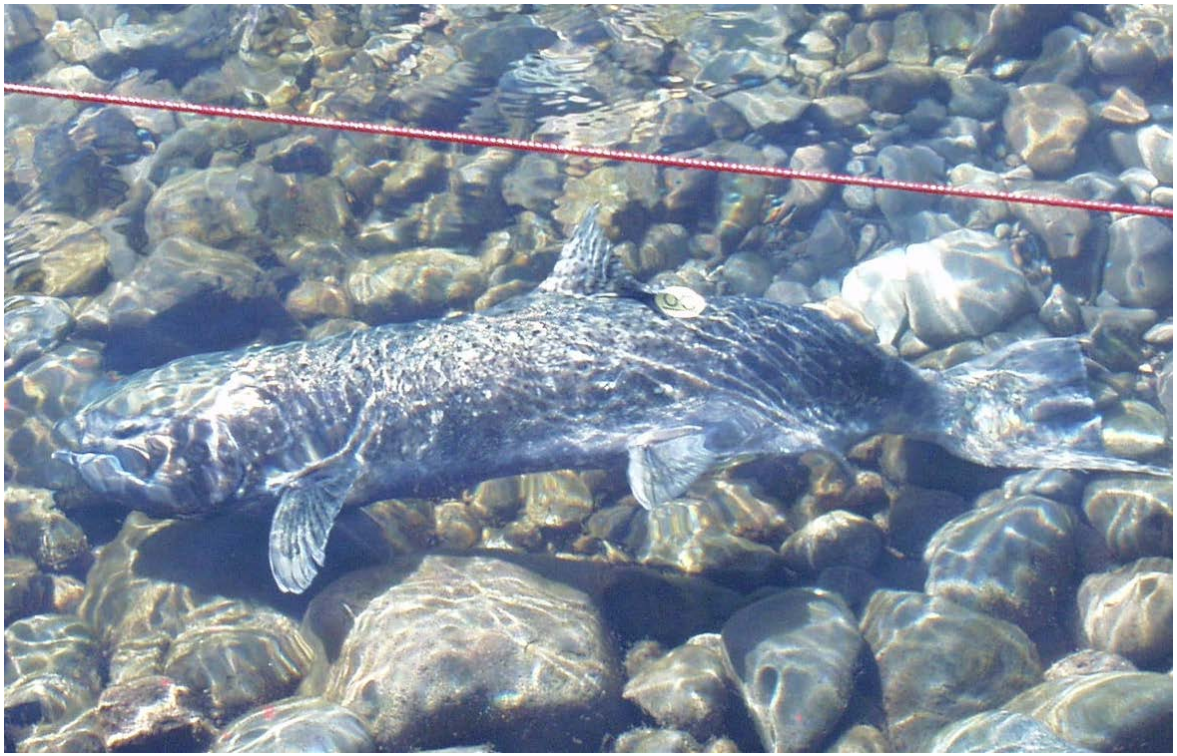


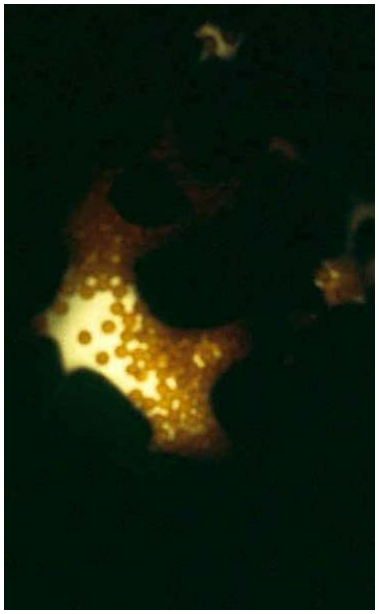


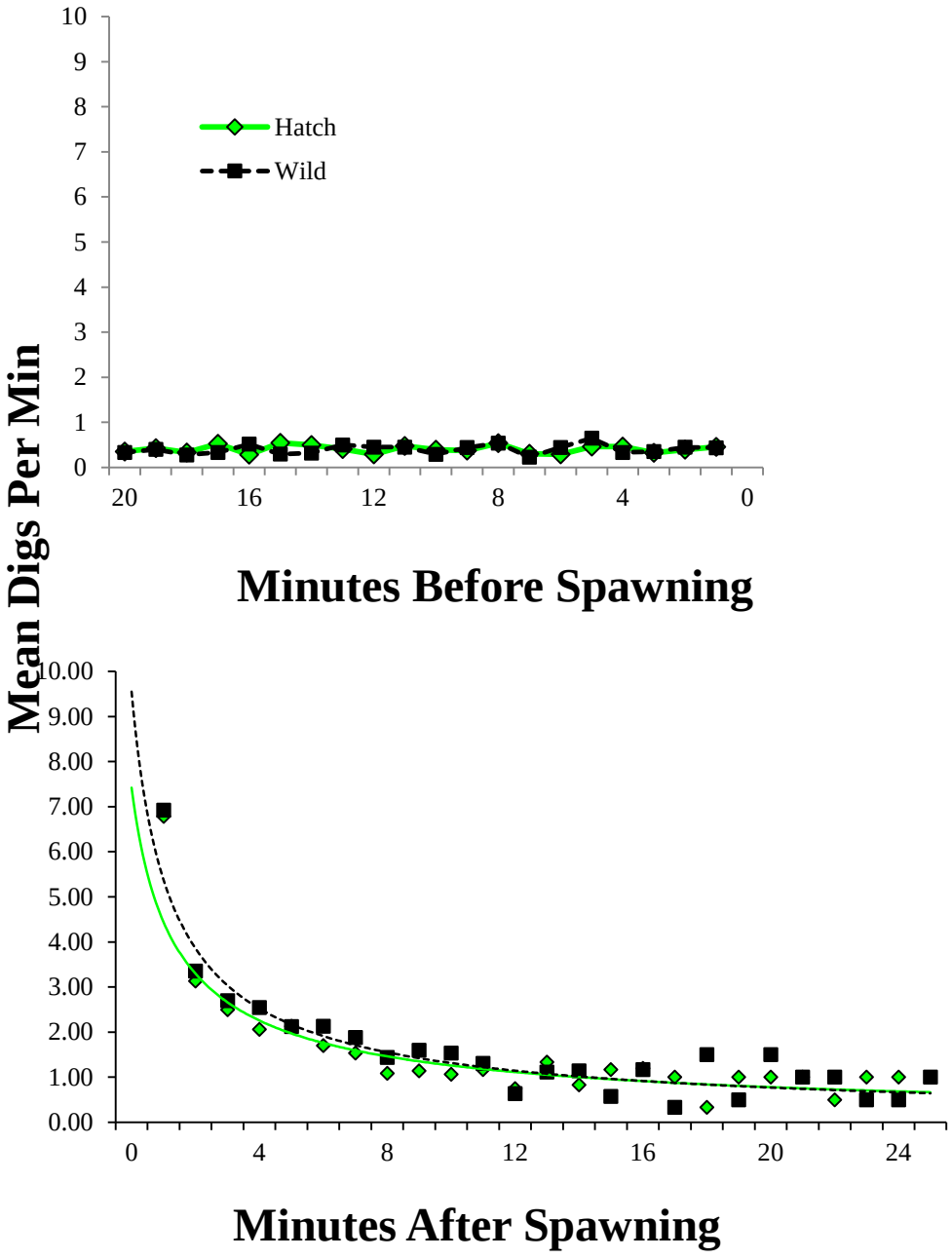
Redd Locations Of Hatchery & Wild Females

Nest Construction Activities Compared

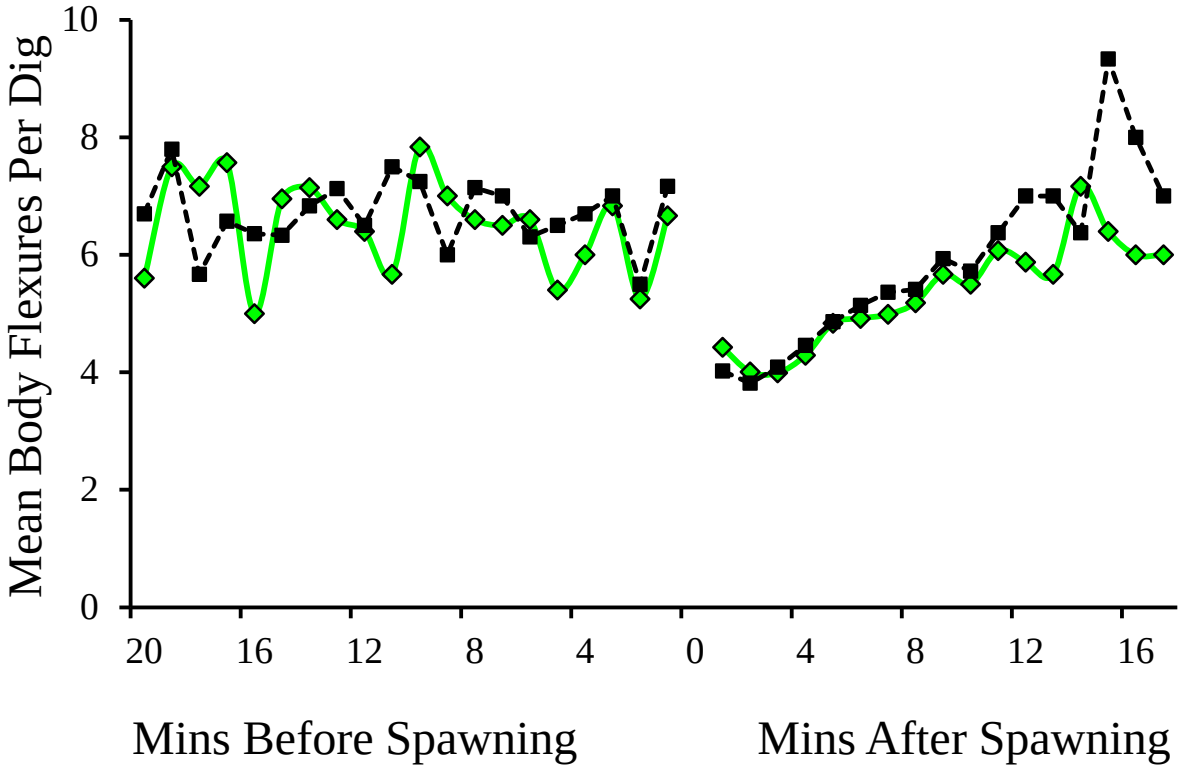
- **Digging Frequency**
- **Body Flexures Per Dig**
- **Egg Burial**



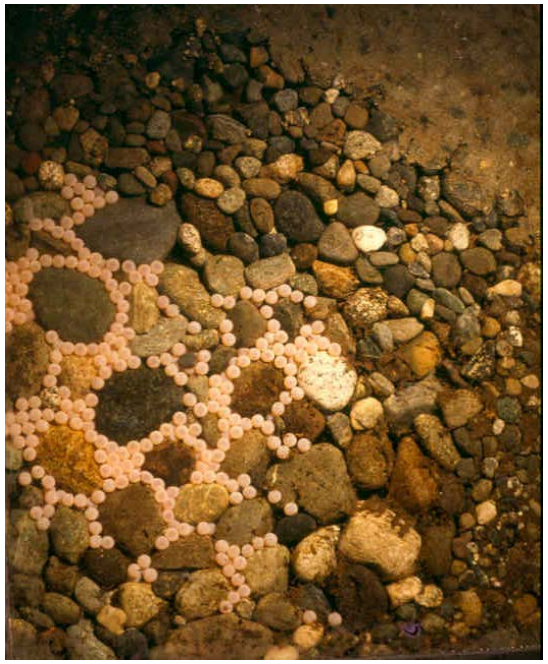


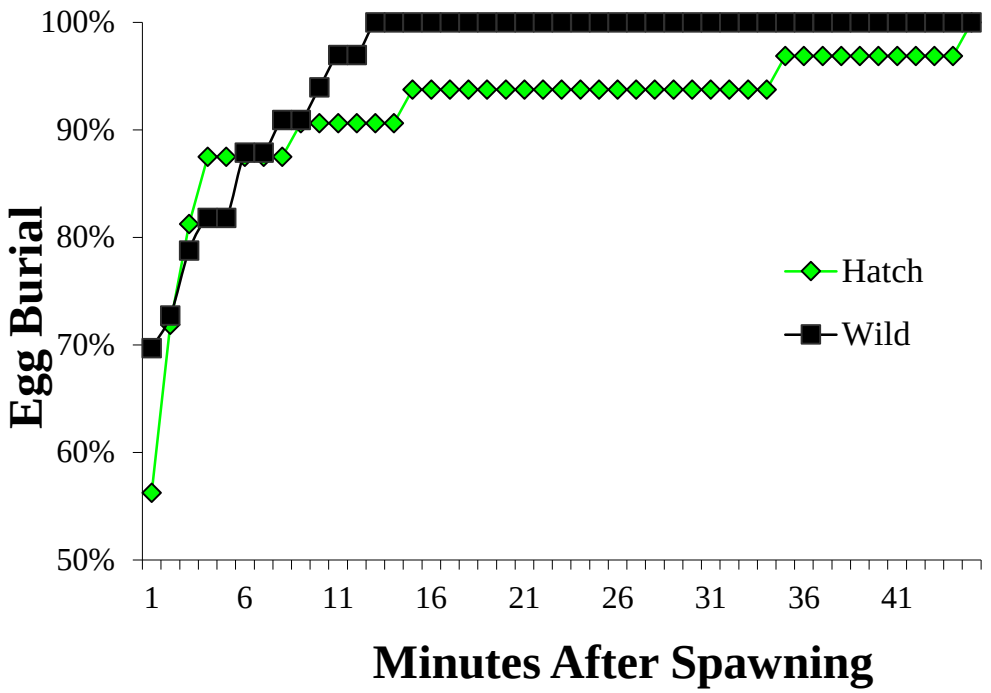

Mean Digs Per Min
10
9
8
7
6
5
4
3
2
1
0
Hatch
Wild
20
16
12
8
4
0
Minutes Before Spawning
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0
4
8
12
16
20
24
Minutes After Spawning

Body Flexures Per Dig Before & After Spawning



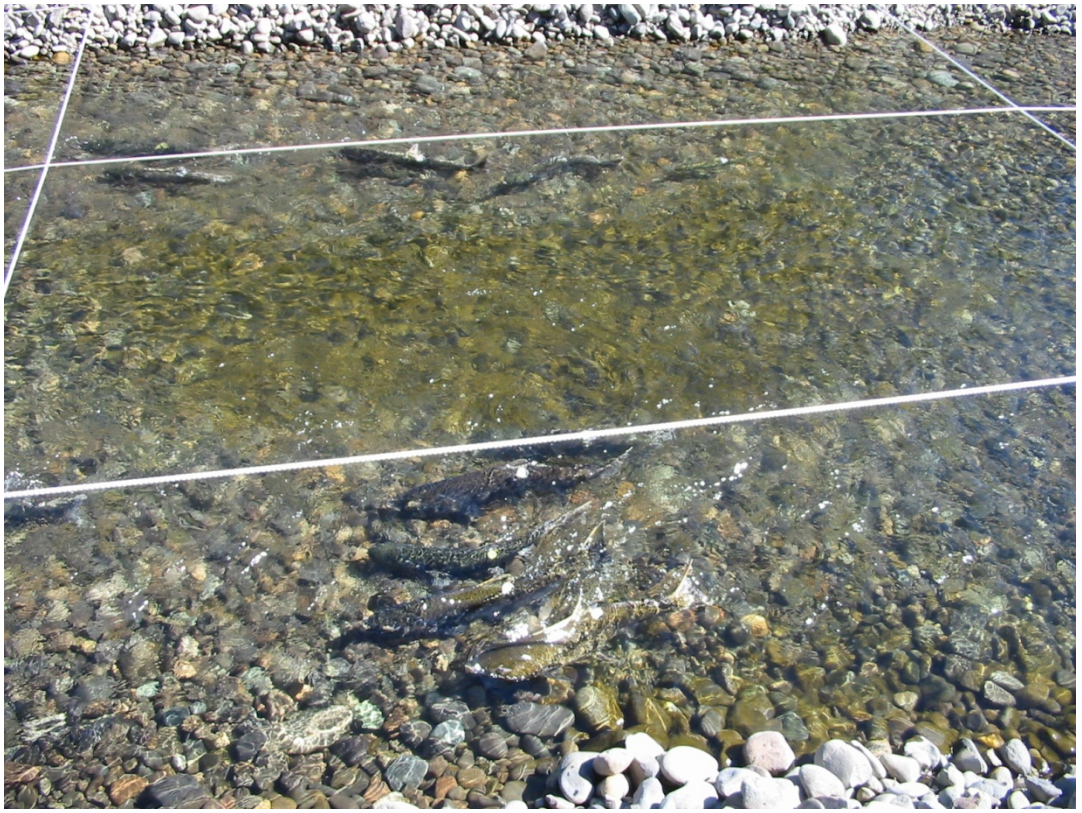
Egg Burial Times For Hatch & Wild Females



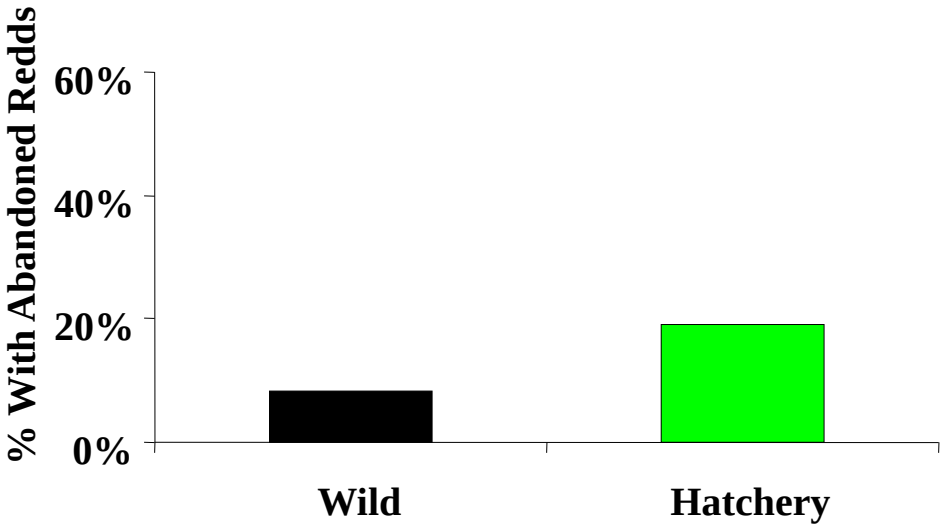


Redd Abandonment

Leaving A Redd Unguarded For >24hrs



Female Origin &Redd Abandonment



8% vs. 20% (*P* = 0.059)

Definition Of Male Breeding Success

Fry Production As Estimated By A DNA-based Pedigree Analysis

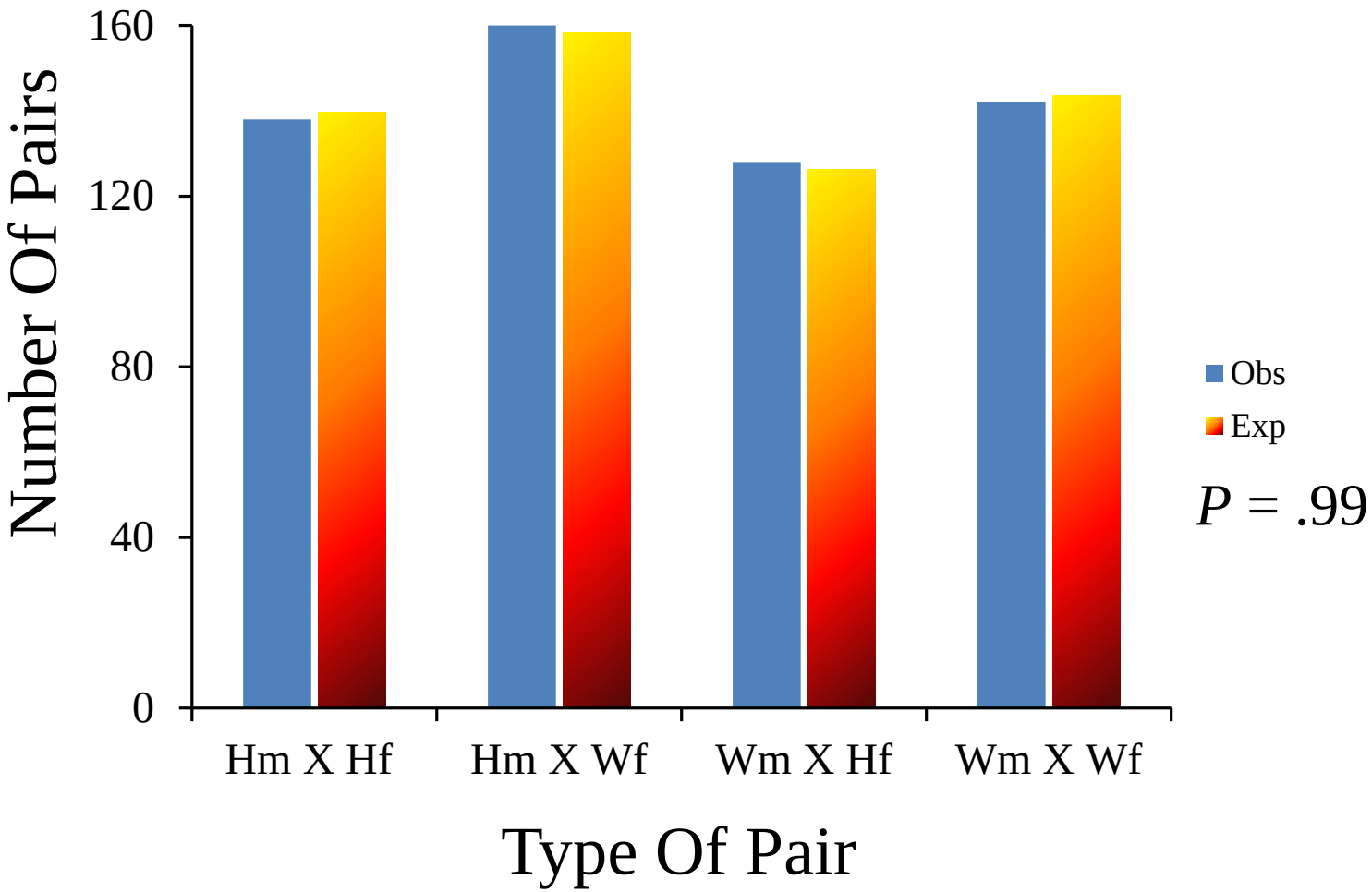
Male Breeding Success Depends Upon:

Mate Choice

Behavior & Gamete Viability

Relative Size

Mate Choice By Female Origin



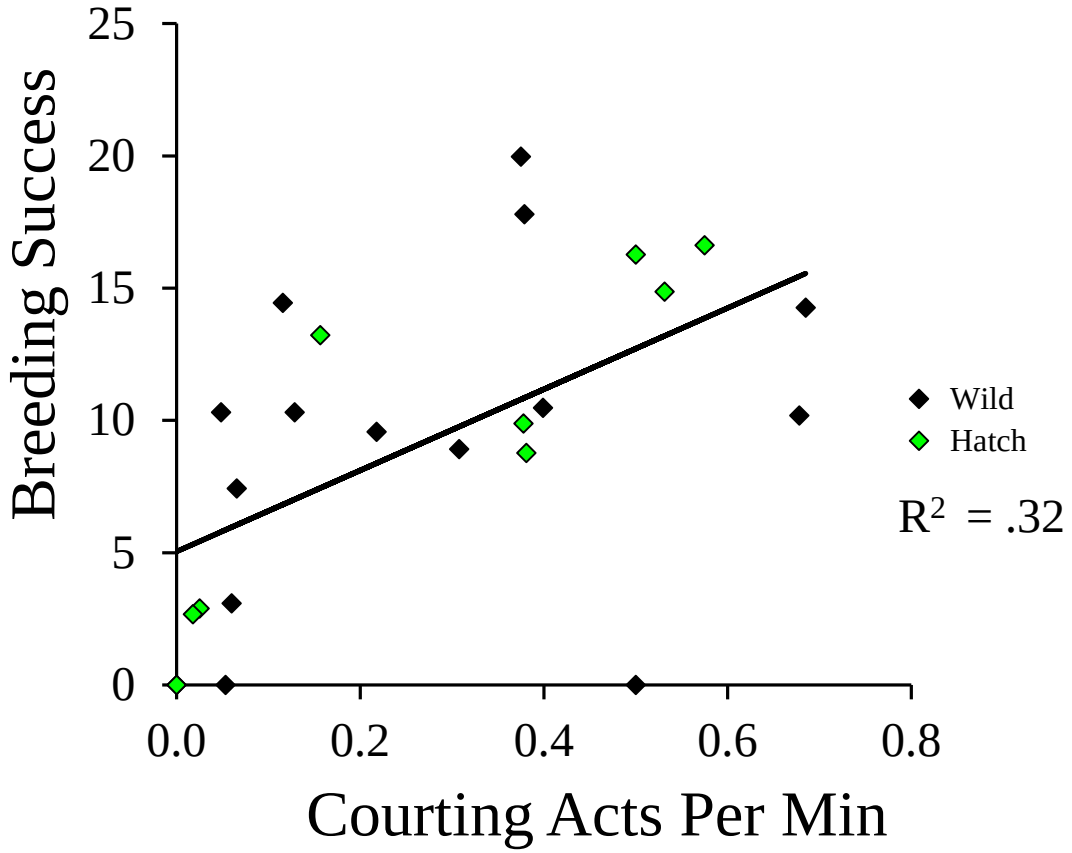
Male Behavior: Courting

Mean Courting Acts Per Min

No Difference Between Hatchery & Wild Males

H = .20 acts/min
W = .25 acts/min

P = 0.16



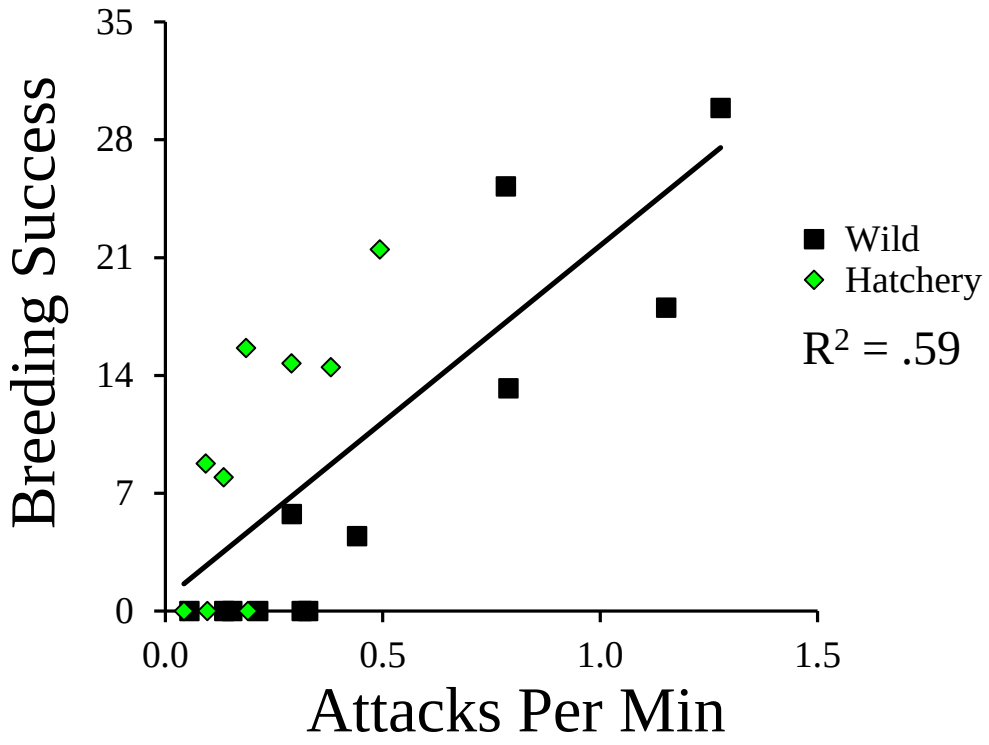
Male Behavior: Agonism

Attacks Per Min

Wild > Hatchery

H = .34 attacks/min
W = .45 attacks/min

P = 0.015



Male Breeding Success

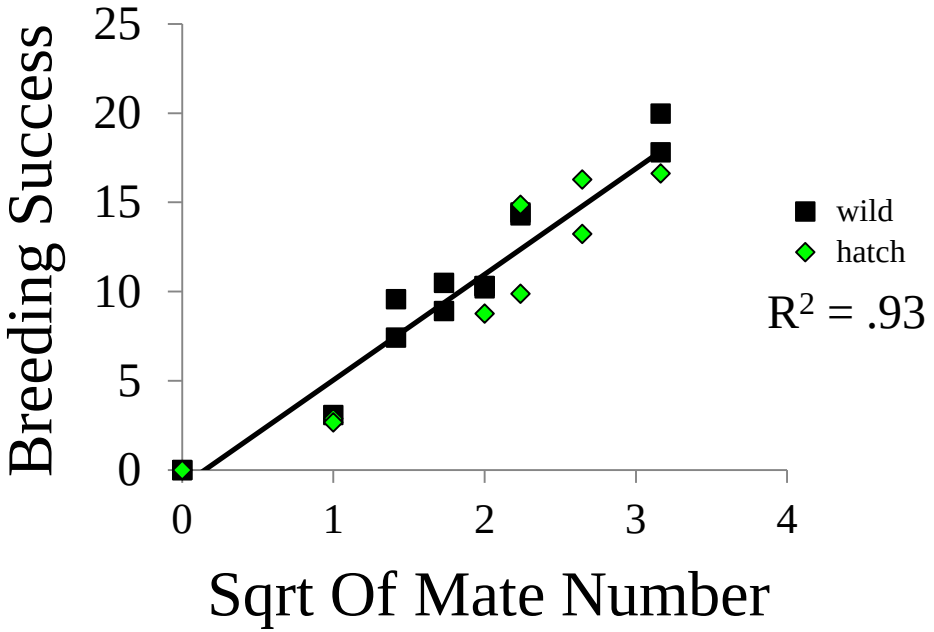
- Number of Mates
- Production of Progeny

Number of Mates

No Difference Between Hatchery & Wild Males

H = 3.5 Mates/male
W= 3.6 Mates/male

P = 0.79

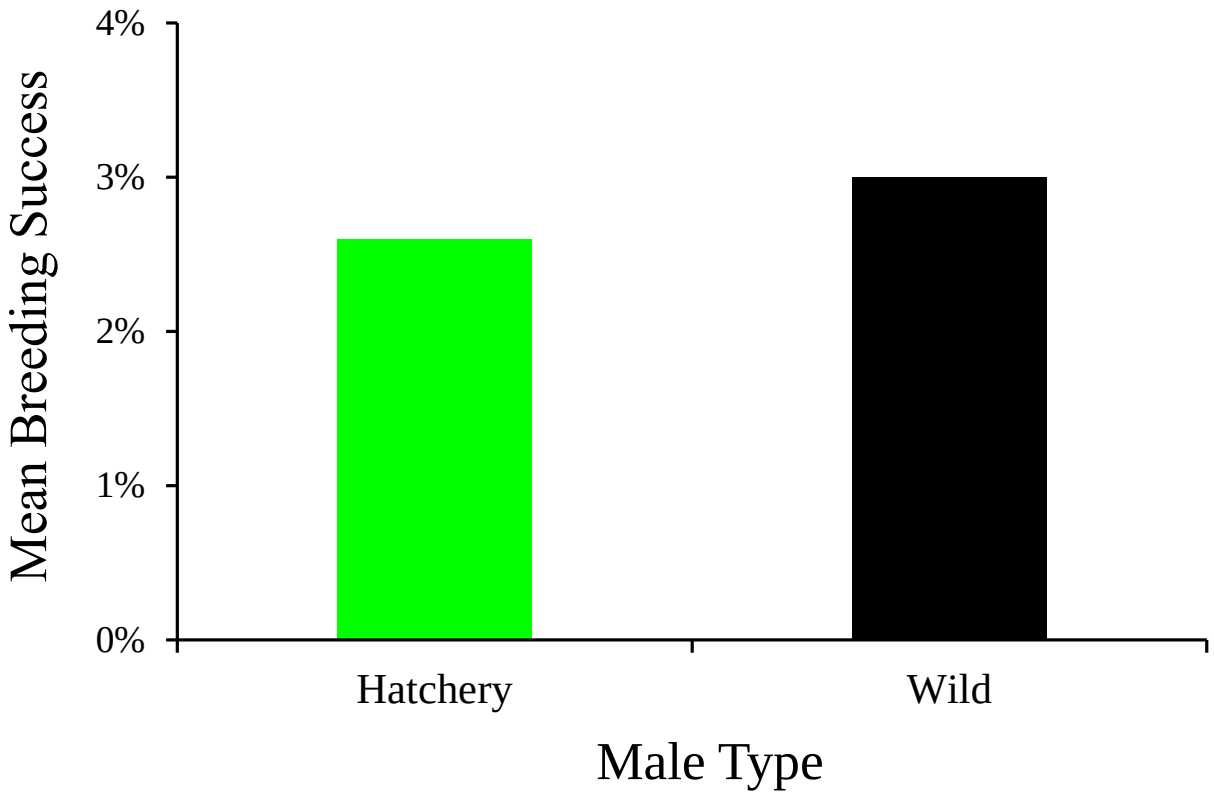


Mean Breeding Success

No Difference Between
Hatchery & Wild Males

H = 2.6%
W = 3.0%

P = .22



Jack & Precocious Male Abundance May Increase Due To Artificial Culture

At The Cle Elum Supplementation Research Facility:

- 37 – 49% Of All Males Matured At Age 2 (Larson et al. 2004)
  125,000/yr (Pearsons et al. 2009)

- Jacks increased From 8.5% To 22.9% After One Generation Of Culture (Knudsen et al. 2006)

- Similar Decreases in Male Age At Maturity Have Been Observed In Other Hatcheries (e.g. Mullan et al. 1992)

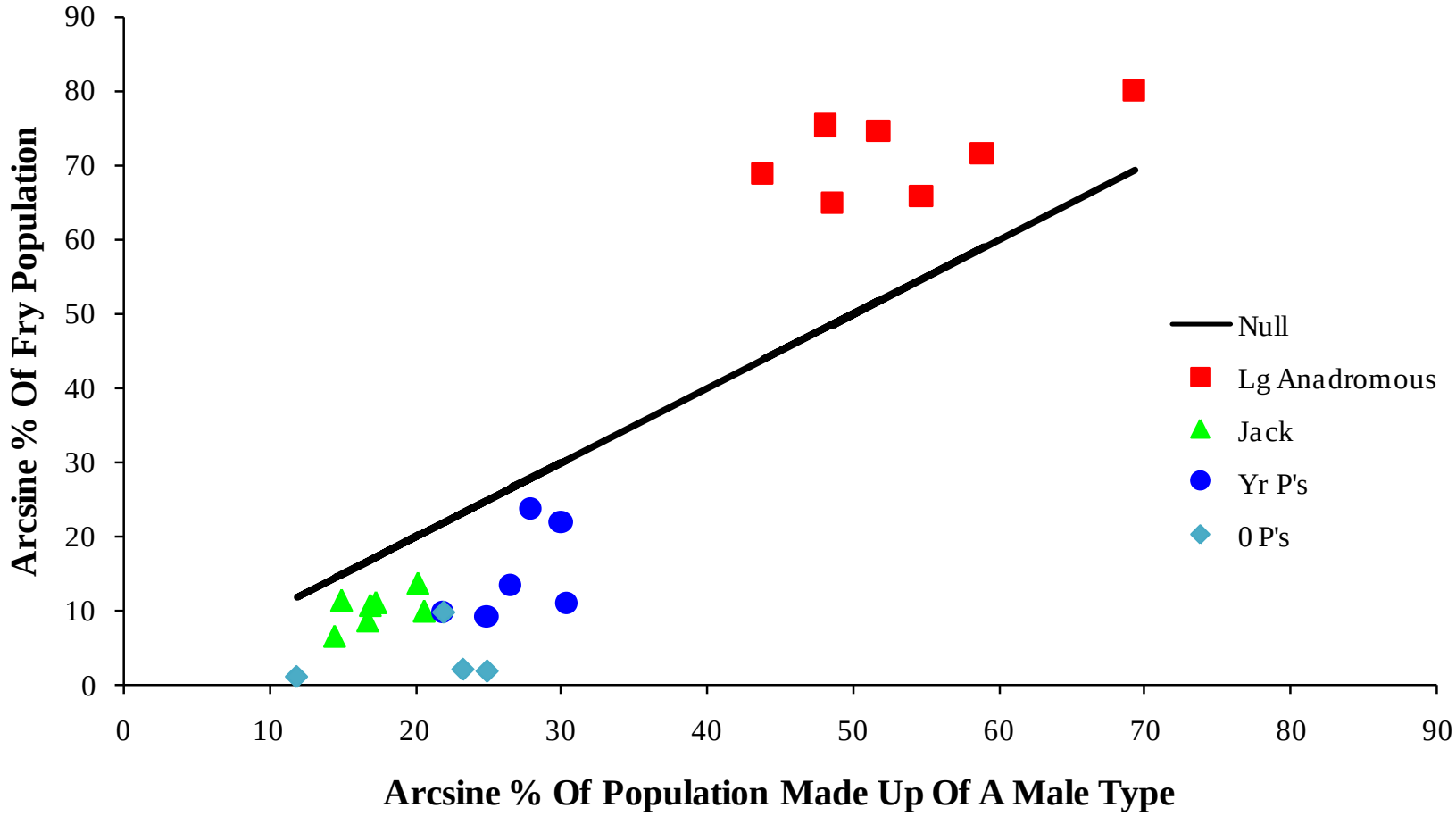
What Genetic Effects Might Enhanced Numbers Of Early Maturing Males Have On Wild Spring Chinook Populations?

1) Must Know Their Abundance On The Spawning Grounds, and

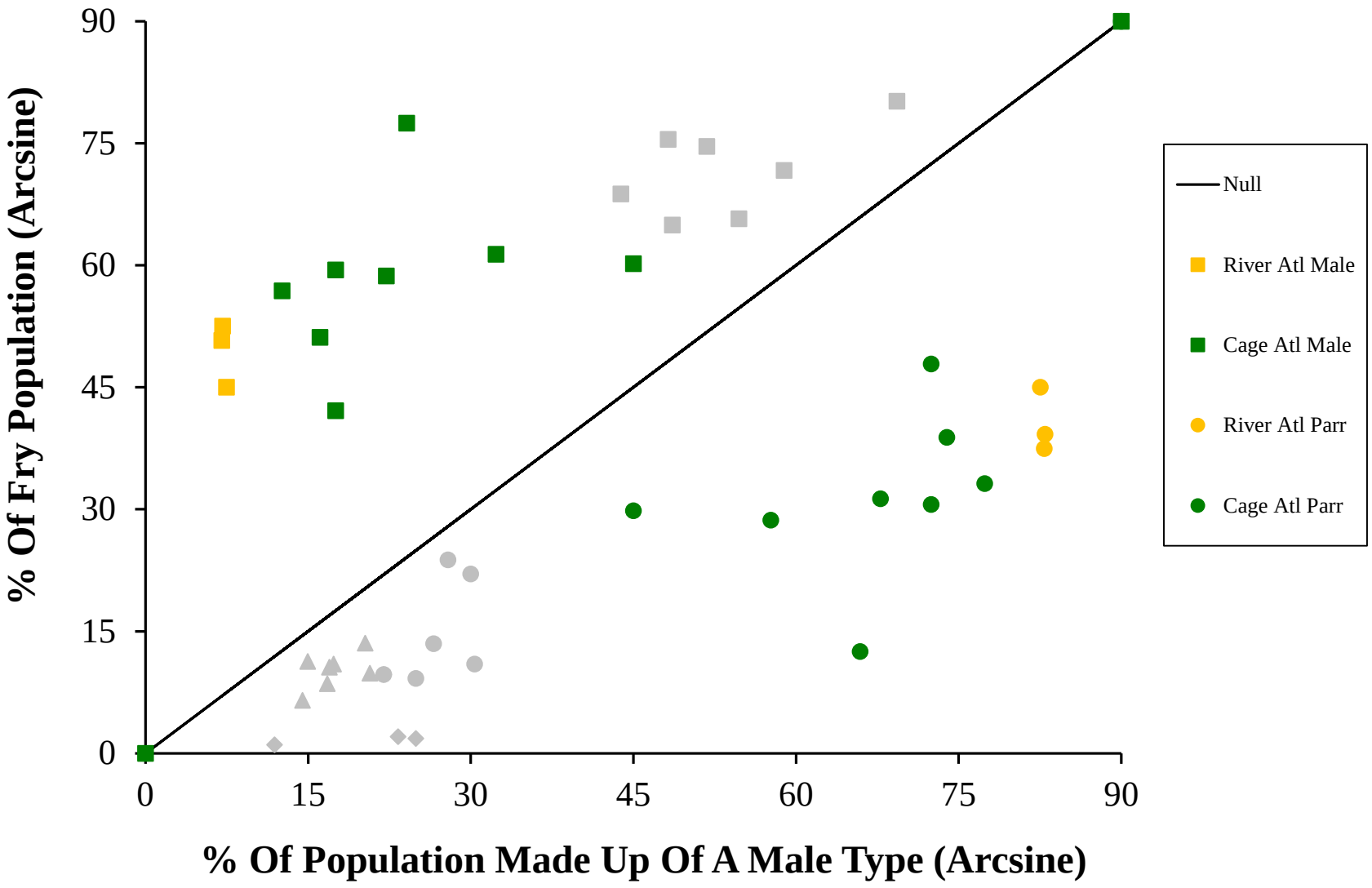
2) **Their Relative Breeding Success Under Natural Conditions**

Prevalence Of Male Life History Types & Progeny Production

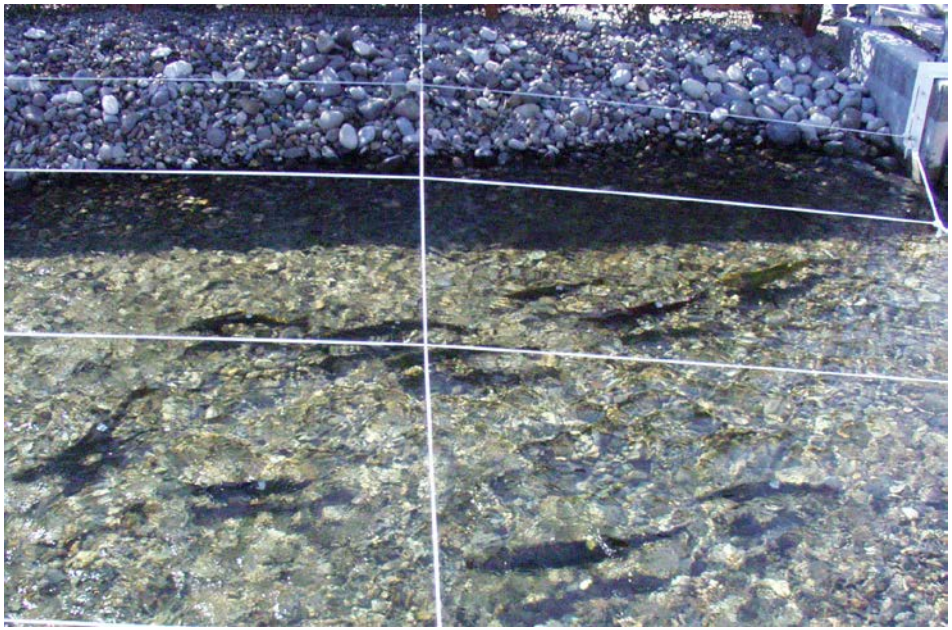
% Male Life History Type Vs. Progeny Paternity



% Male Life History Type Vs. Progeny Paternity



New Work



BECAUSE

Wild & 1st Generation Hatchery Fish Experienced Different Early Environments

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

Current Research Question For Adult Breeding Success:

Does Artificial Culture Cause Genetic Change?

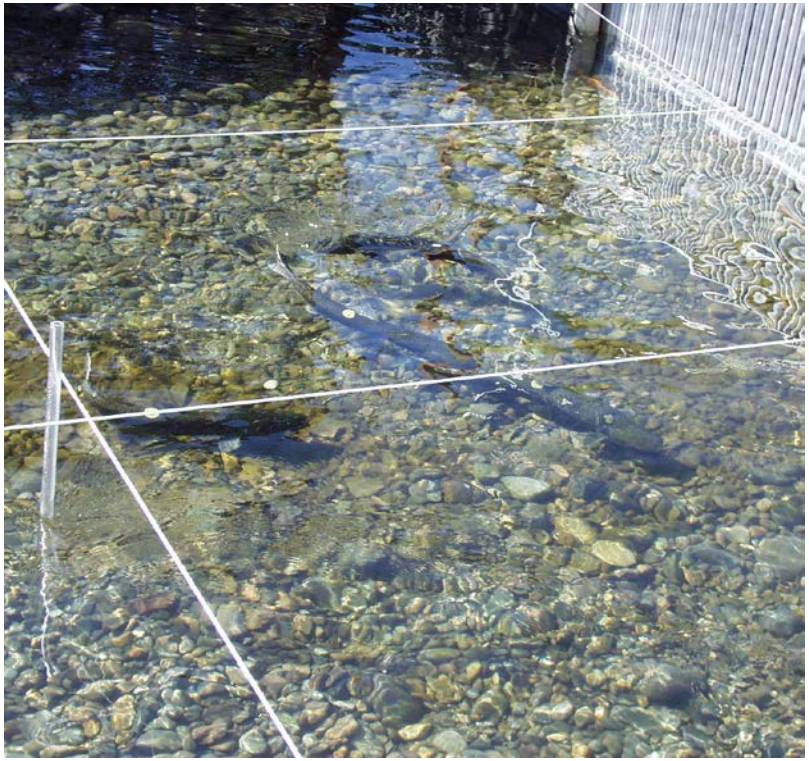
If It Does, How Much Occurs Per Generation Of Hatchery Exposure?

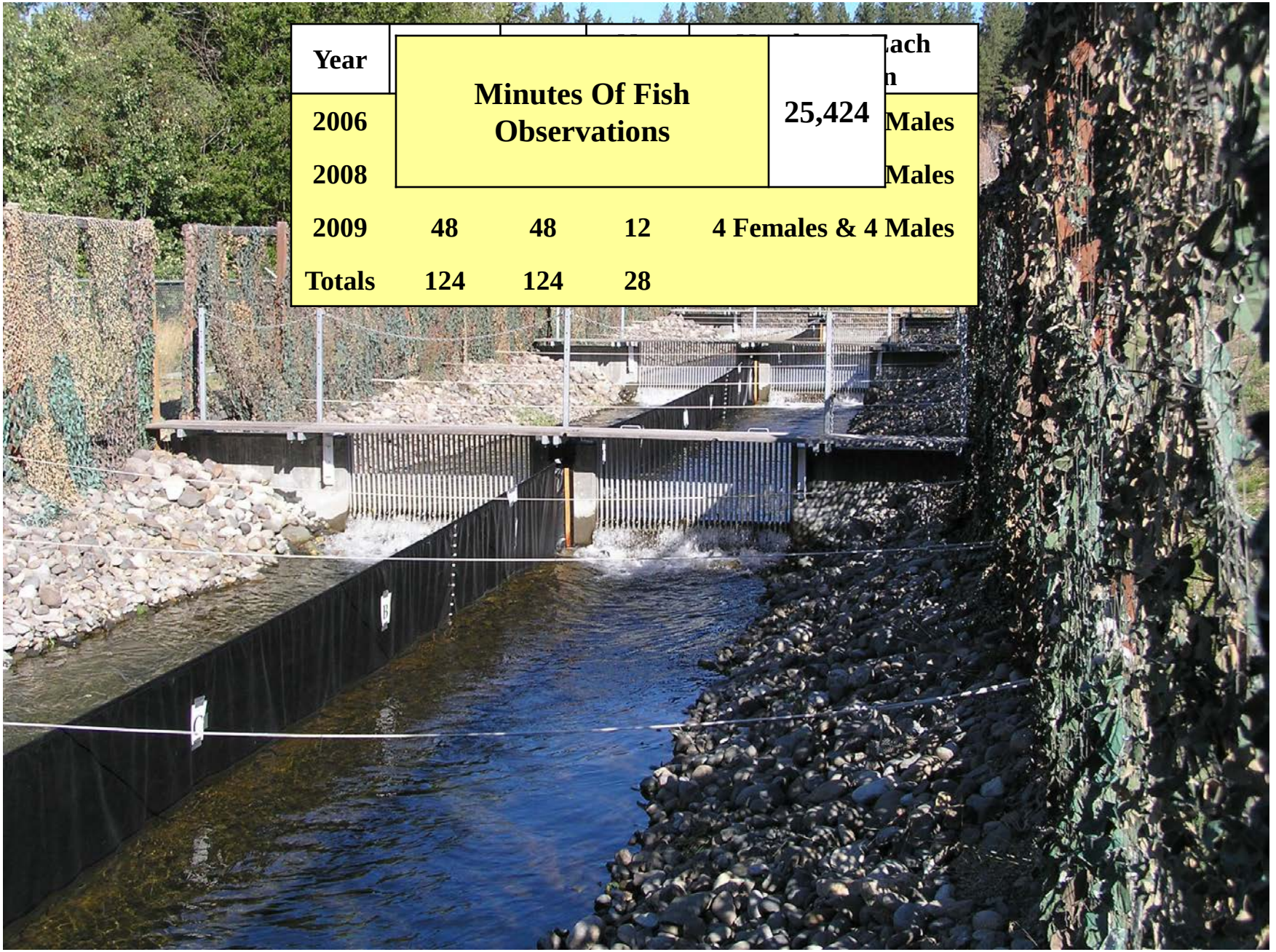
Experimental Approach

- Create Homogenous Populations Of First- & Second Generation Hatchery Fish In The Artificial Stream

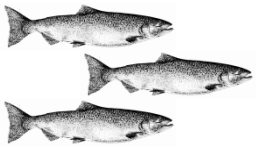
- Allow The Fish To Spawn Naturally

- Compare Their Behavior & Offspring Production

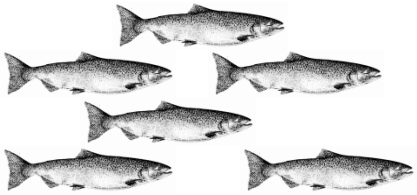




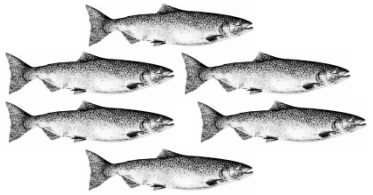
Year				ach n
2006	Minutes Of Fish Observations		25,424	Males
2008				Males
2009	48	48	12	4 Females & 4 Males
Totals	124	124	28	



Wild Fish To Hatchery

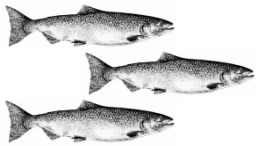


1st Generation Hatchery Adults To The Wild

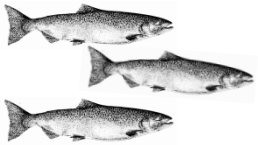


NORs From 1st Generation Hatchery Parents

= **A**



Wild Fish To Wild



Wild Fish To Wild

Wild Fish To Wild

= **B**

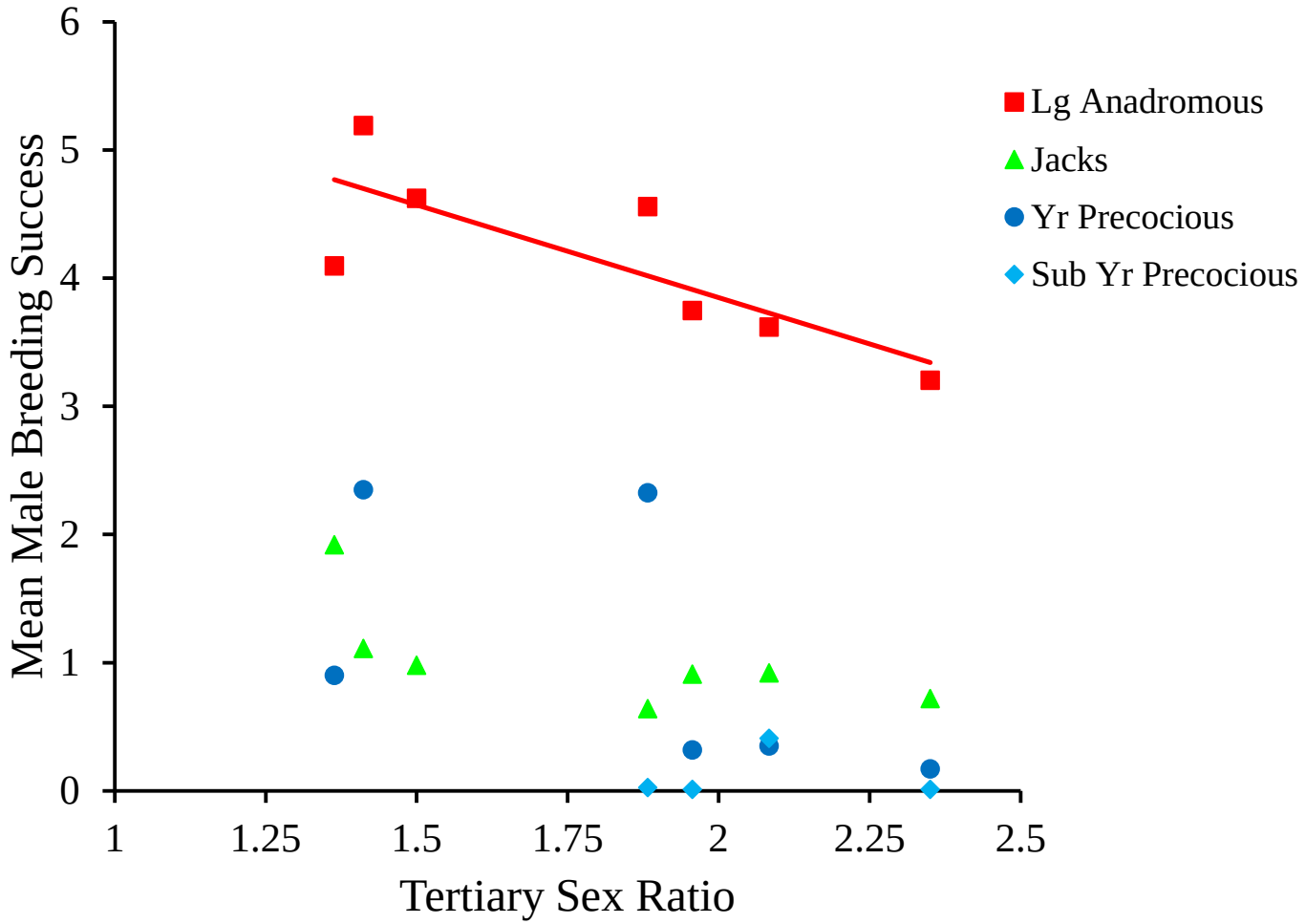
Is A > B?

Summary Of Differences Between Hatchery & Wild Females

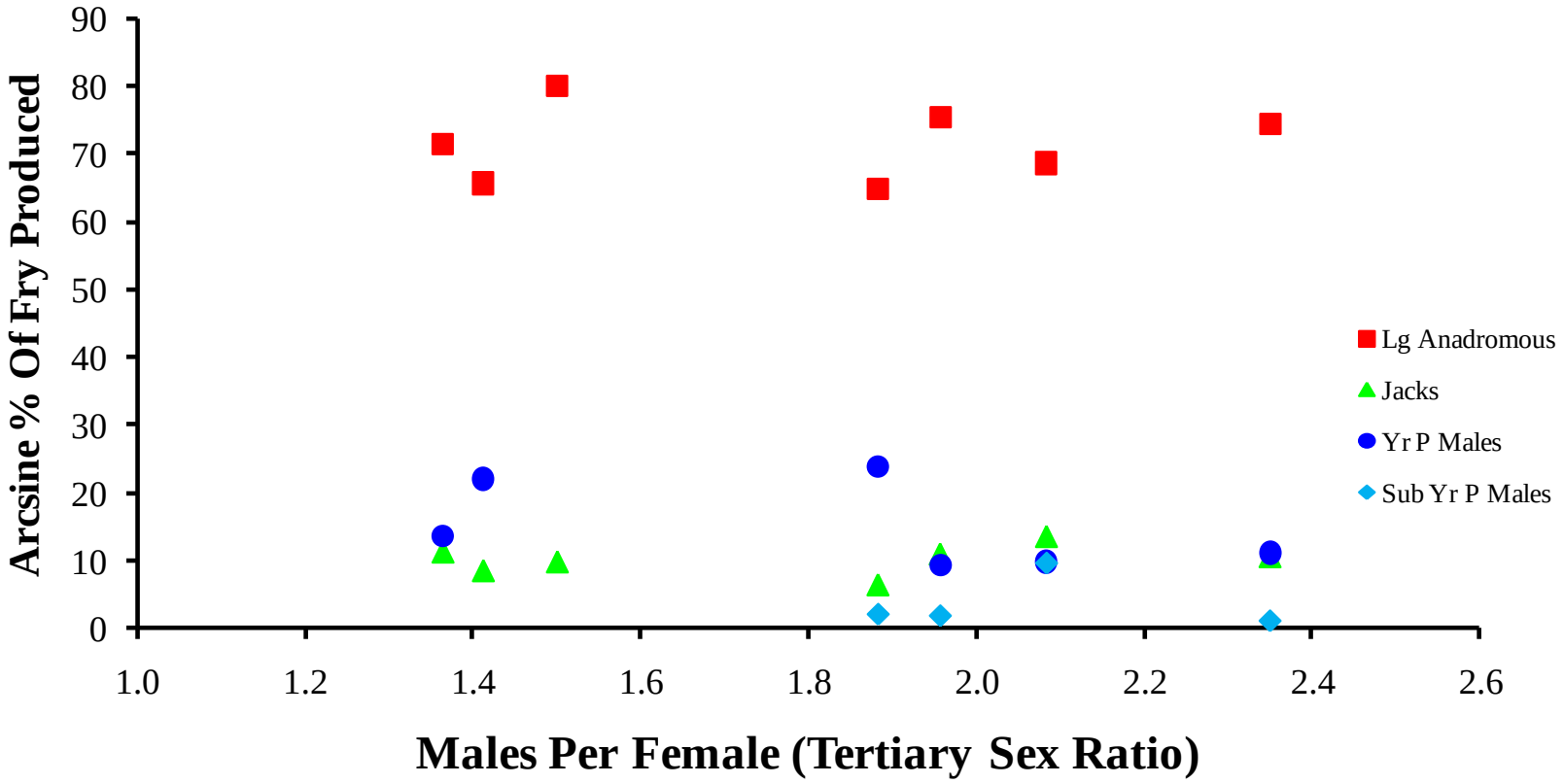
Wild Females:

- **Preferred Different Areas For Redds**
- **Were Less Likely To Abandon Their Redds**
- **More Efficient At Egg Burial**

Effect Of Tertiary Sex Ratios On Individual Male Breeding Success



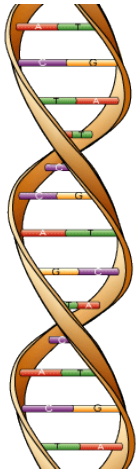
Tertiary Sex Ratios Vs. Progeny Paternity



There Are Differences In The Early Life History & Environments of Hatchery & Wild Salmon

Potential Effects Of Differences

And Those Differences May Cause Genetic Change



Via:

Relaxation Of Selection Pressures,

Directed Selection For Traits Favored In A Hatchery Environment,

& Genetic Drift