The Breeding Success of First- and Third-Generation Hatchery Spring Chinook Salmon Spawning in an Artificial Stream

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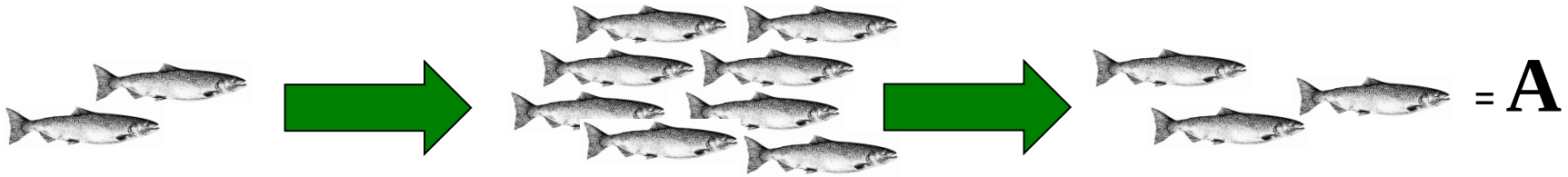
• **Does continued exposure to artificial culture lead to genetic changes that decrease the ability of hatchery origin salmonids to spawn and produce offspring under natural conditions?**

Operational Definition Of Supplementation



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?

Key Assumption Of Supplementation:

Hatchery-Origin Fish Are Reproductively Competent When Allowed To Spawn Under Natural Conditions

Photo: Oceanmdx
www.skyscrapercity.com

Wild and Hatchery Salmon Experience Profound Environmental Differences

Reproduction

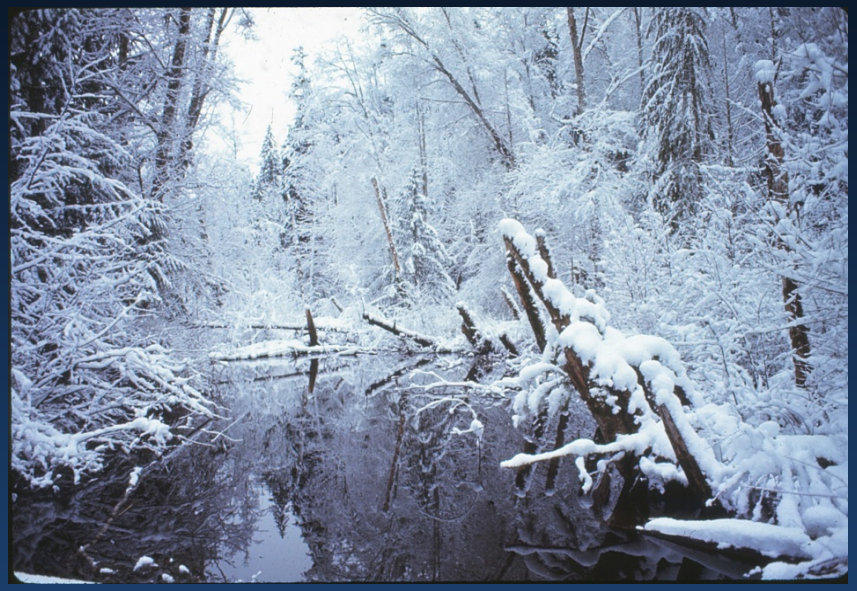
Natural Reproduction

Artificial Reproduction

Incubation

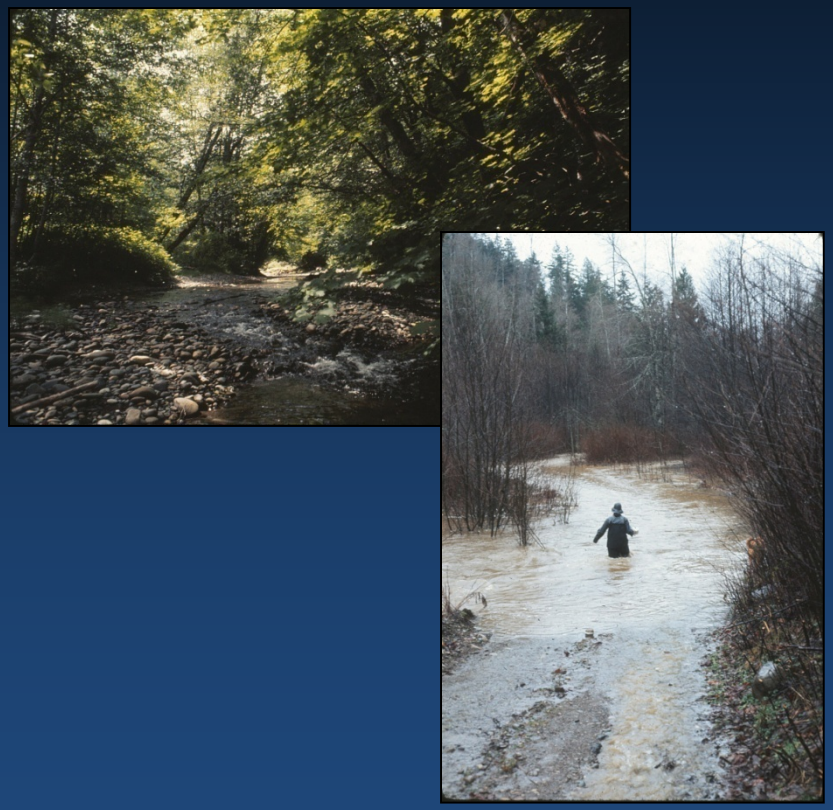
FACTOR	NATURAL	HATCHERY
Density	Low	High
Substrate	Gravel	Usually Plastic
Water Flow	Low	High
Light Level	None	Low to Moderate
Natural Foods	Present	Not Present
Temperature Regimes	Variable	Constant to Variable
Volitional Emergence	Yes	Usually No

Rearing Conditions



FACTOR	NATURAL	HATCHERY
Density:	Low	High
Habitat:	Complex	Simple
Food:	Diverse	Uniform
Predators:	Present	Absent
Flow:	Variable	Low & Constant
Movement:	Volitional	Constrained

Degree Of Variation



Natural Environments Are Often Quite Variable

Hatchery Environments Are Relatively Constant

Potential Effect Of These Differences

❖They May Cause Genetic Change

Via: **Relaxation Of Selection For Traits Favored In The Wild Environment,**

Directed Selection For Traits Favored In The Hatchery Environment,

& **Genetic Drift**

❖And Non-Genetic Phenotypic Changes

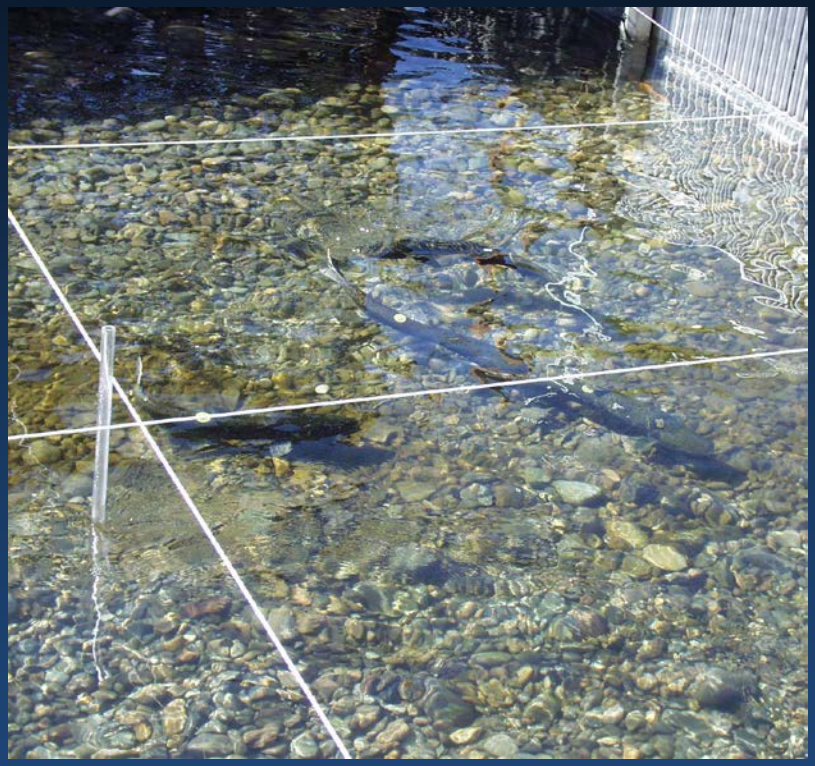
Initial Study Findings: H vs W

1) **Hatchery & Wild Females Had Similar Egg Deposition Rates**

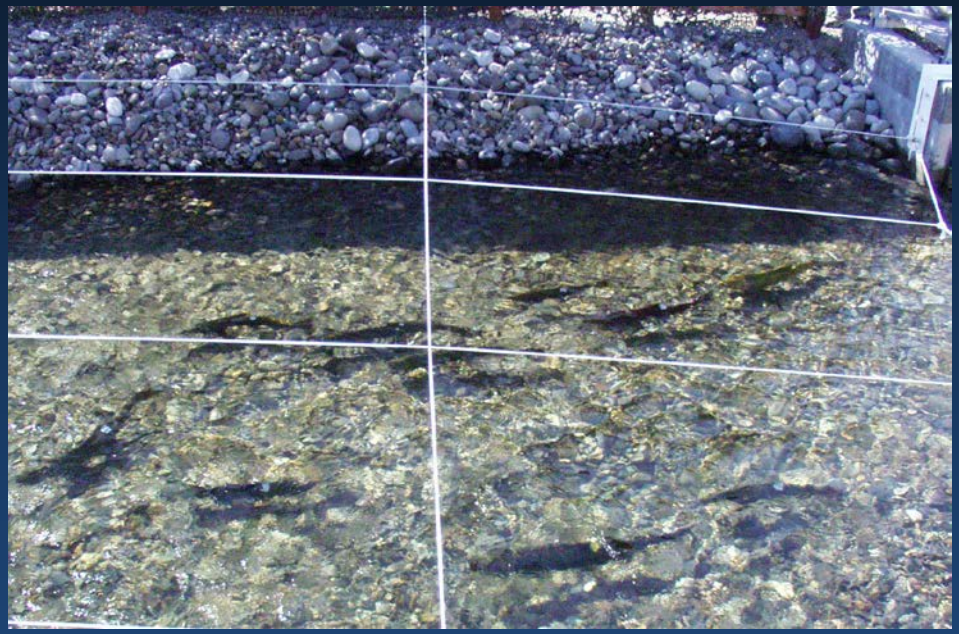
2) **Wild Females Had Higher Egg-to-Fry Survival Rates (~ 6%) Than Hatchery Females**

3) **Wild and Hatchery Males Had Similar Breeding Success Values**

4) **In Our Experimental Setting First-Generation Hatchery Effects Were Low**



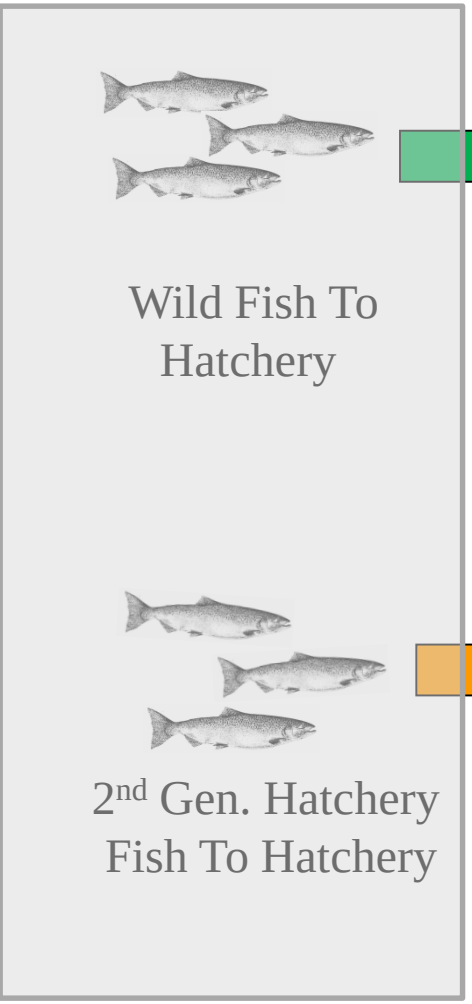
Why Test 1st Generation vs 3rd Generation Fish?



Wild & 1st Generation Hatchery Fish Experienced Different Early Environments

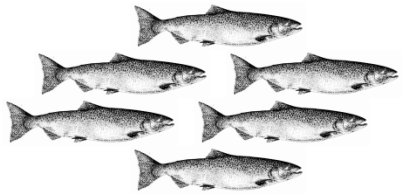
Therefore:

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

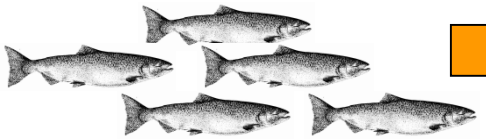


Wild Fish To Hatchery

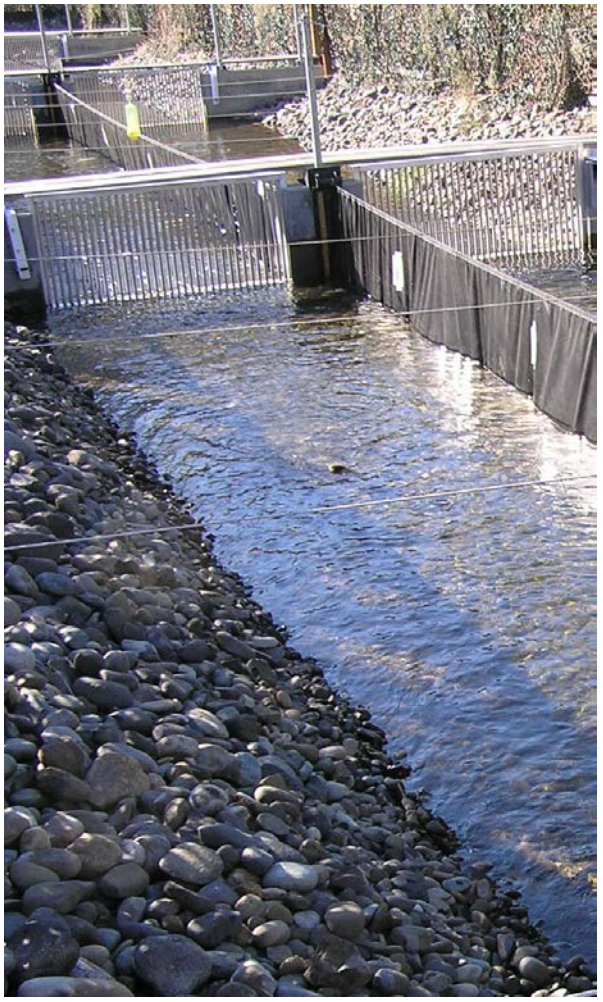
2nd Gen. Hatchery Fish To Hatchery



1st Generation Hatchery Adults



3rd Generation Hatchery Control Adults



Fish Being Compared

Types of Fish Used

- **First-Generation Hatchery:** **Derived From Natural Origin Parents**
- **Third-Generation Hatchery:** **Derived From 2nd Generation Hatchery Control Parents**

Life History Types Placed Into The Stream

Hatchery & Wild 4 & 5 yr –old
Males & Females:
("Large Anadromous Fish")

Artificial Stream At Cle Elum

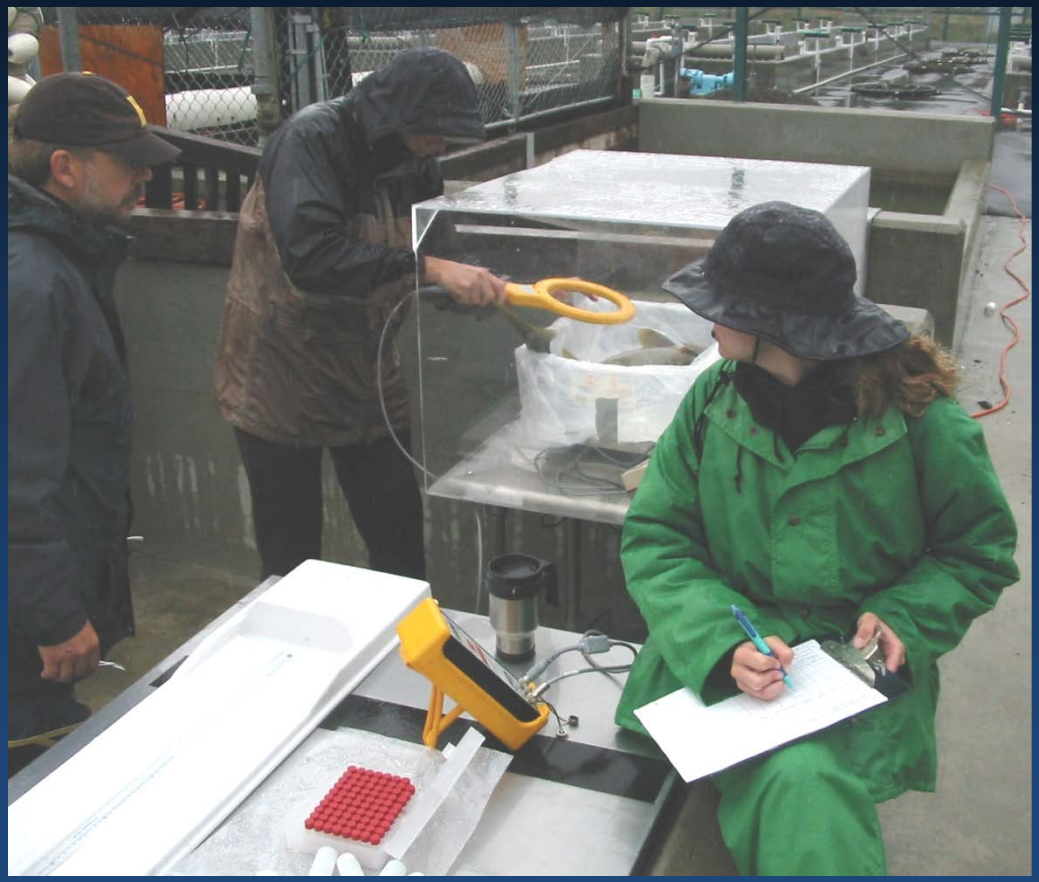
Dimensions and Water Flow
127 m long x 7.9 m wide
Water Velocity 0.1 – 2.0 m/s
Discharge 0.37m^3/s
Mean Depth 0.4 m

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)

Prior To Placement, Each Fish Was:



Tagged and Fin Material Was Removed For Later DNA Extraction

They Were Then Released Into The Stream...

...And Observations Made

2010-2013

- **Use homogenous replicates of 1st and 3rd generation fish**
- **Each replicate contained four males and four females**
- **2 replicates per section**
- **6 total sections**

- **The goal is produce 24 test groups of each type of fish in order to have enough statistical power to detect subtle (> 20%) differences in breeding behavior and offspring production.**

Year	1st Generation	3rd Generation
2010	6 groups	6 groups
2011	6 groups	6 groups
2012	6 groups	6 groups
2013	6 groups	6 groups

Comparisons made between 1st and 3rd generation hatchery fish:

- **Spawning ground longevity**
- **Body size**
- **Fecundity**
- **Reproductive behavior**
- **Fry production**

To Date

For 2010 spawners:

- **67,235 fry were produced**
- **7,135 were collected for use in pedigree assessments**
- **2,920 fry were actually pedigreed**
- **of which 89% were successfully assigned to the spawning adults**

Results To Date

In 2010, 1st generation females and males had sign. longer spawning ground longevities

In 2011, no significant difference

Results To Date

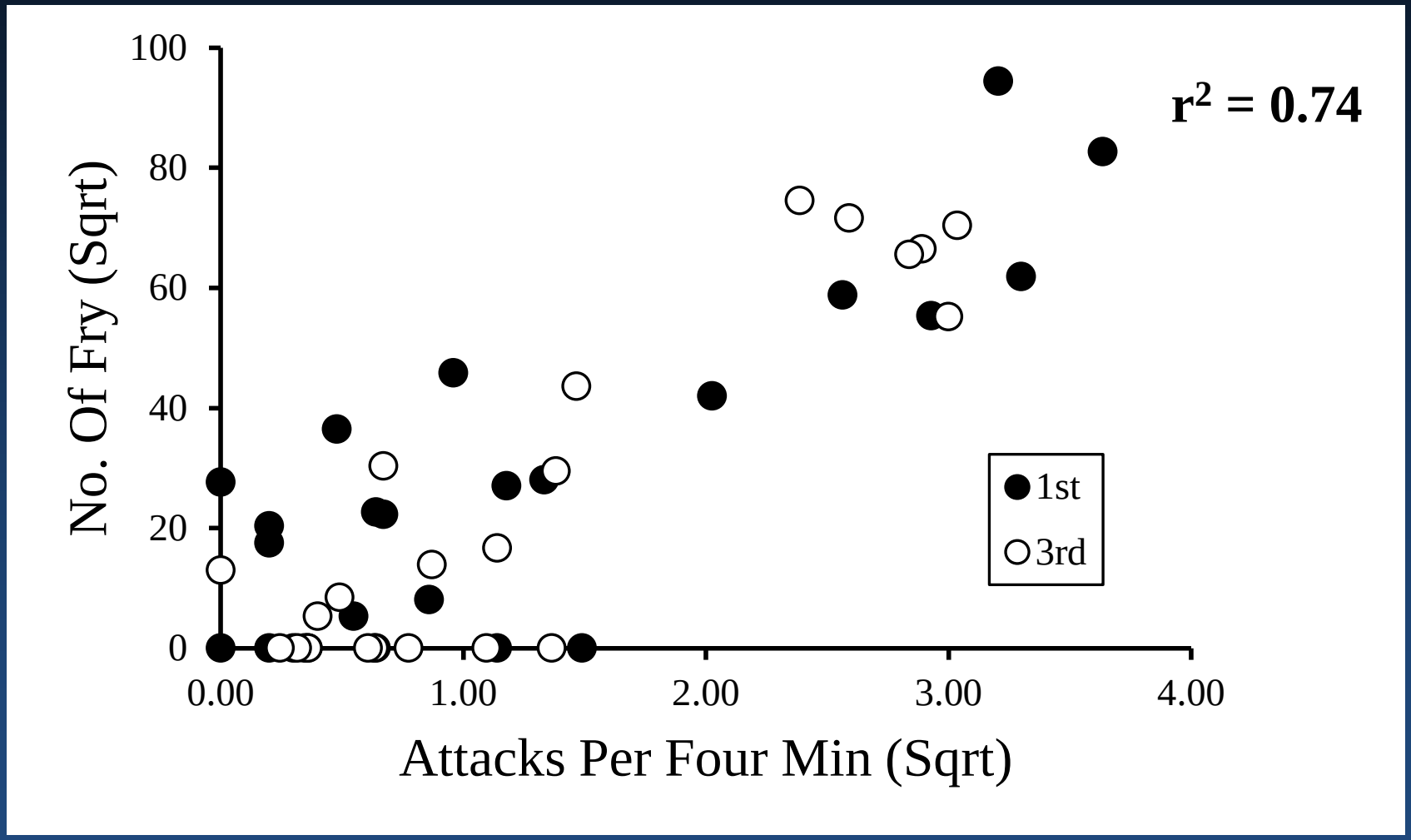
- **No sign. differences in the FLs of first and third generation fish in 2010 or 2011.**

- **However, in both years first generation females had greater average fecundities.**

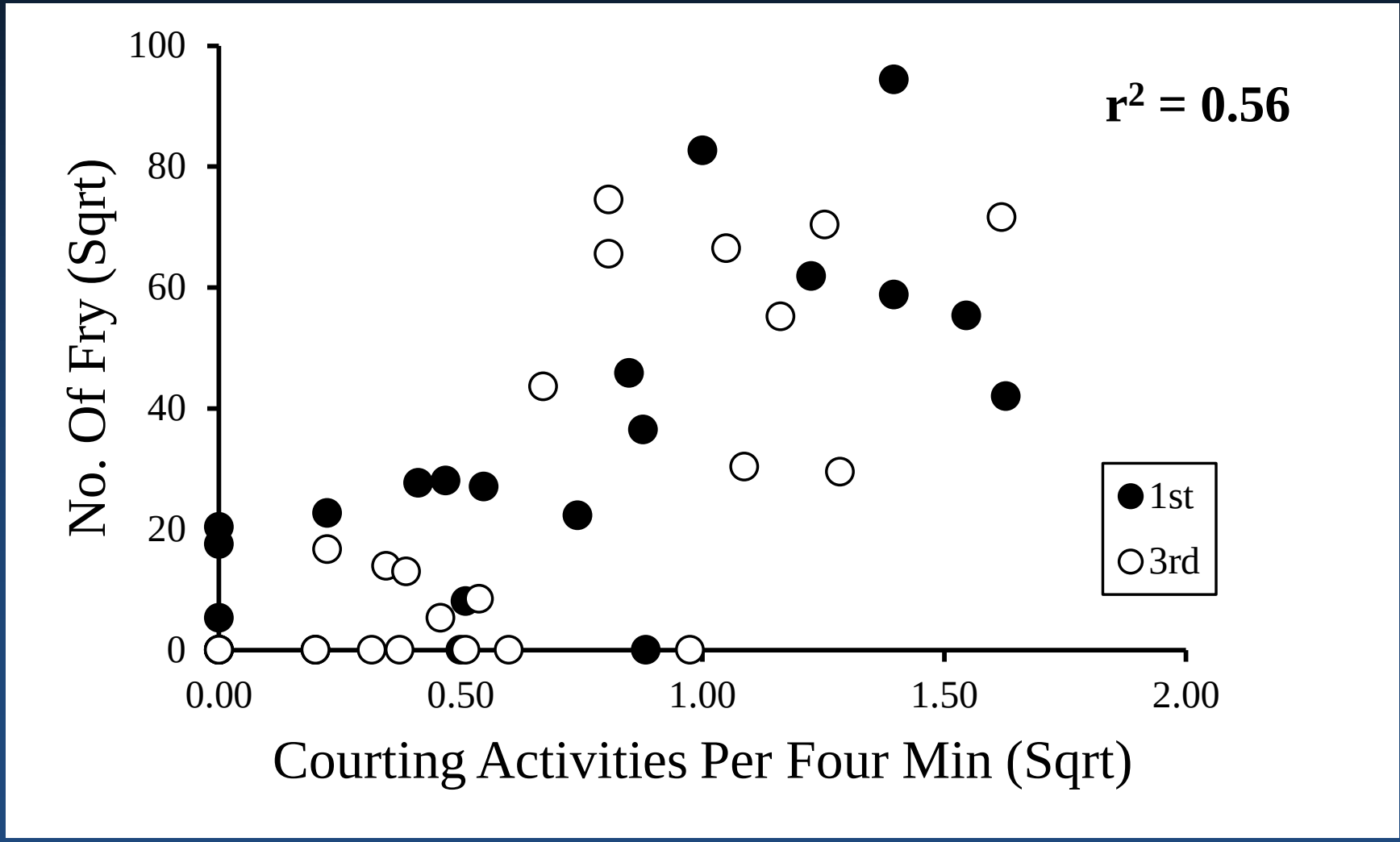
Results To Date

Brood Year	Female Type	N	Mean Fecundity	
2010	1st Generation	24	4361	**9.7%**
	3rd Generation	24	3975	
2011	1st Generation	24	4165	**7.5%**
	3rd Generation	24	3873	

Male aggression vs. Fry production in first and third generation hatchery males in 2010.



Male courting frequency vs. Fry production in first and third generation hatchery males in 2010.



Results To Date

- No significant differences due to the number of generations of hatchery culture in either male or female:
  - aggression
  - courting or digging frequencies

Results To Date

- **First and third generation females did not significantly differ in:**
  - **egg deposition,**
  - **fecundity-to-fry survival rate, or**
  - **absolute fry production.**

Caveats

- Only one year (2010) of fry production data and two years of spawner behavioral data analyzed.
- These results should be regarded as preliminary and subject to change.
- Additional homogenous test groups containing first and third generation hatchery fish will be placed into the stream in 2012 and 2013.

Acknowledgments

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