# Comparing The Breeding Success Of First- and Second-Generation Hatchery Spring Chinook

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# Cle Elum Supplementation Research Facility

Established in 1997

Built For Two Purposes:

- ❖ Supplement Upper Yakima River Spring Chinook

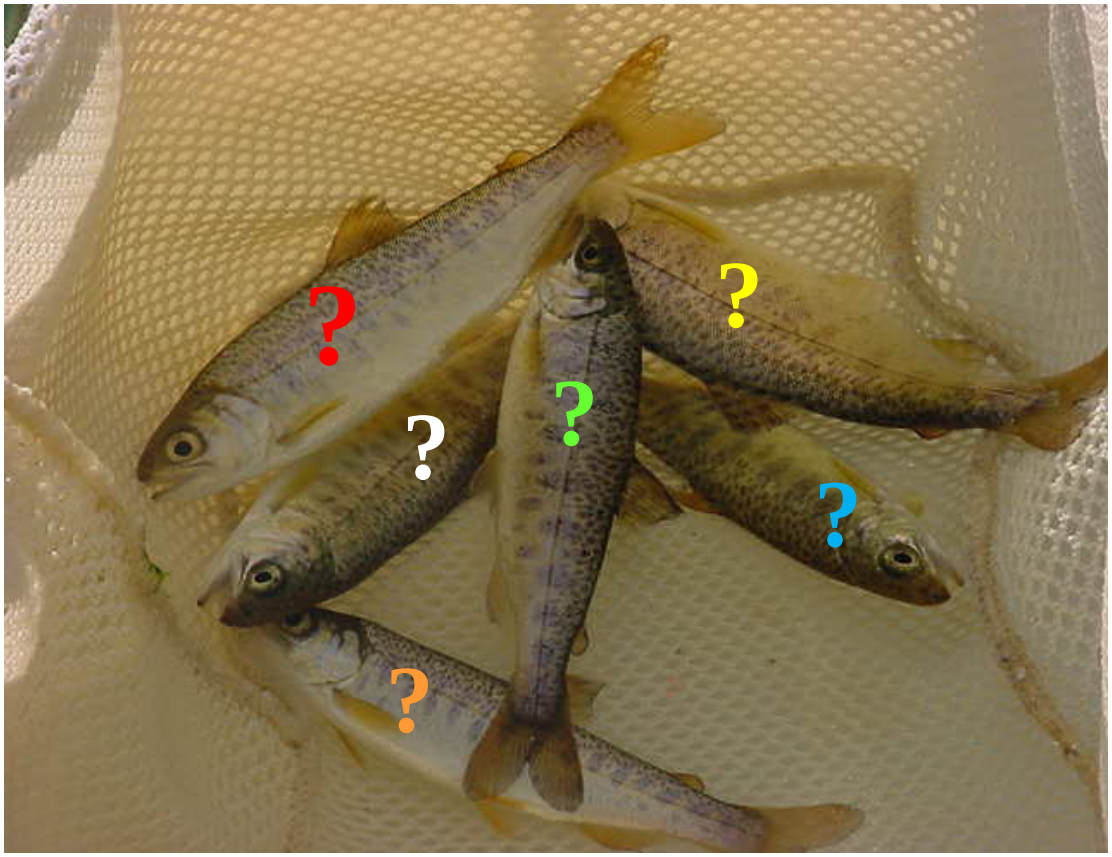
- ❖Serve As A Salmon Supplementation Research Facility

# 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:


Does Artificial Culture Cause Genetic Change That Reduces The Breeding Success Of Hatchery Origin Fish?

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

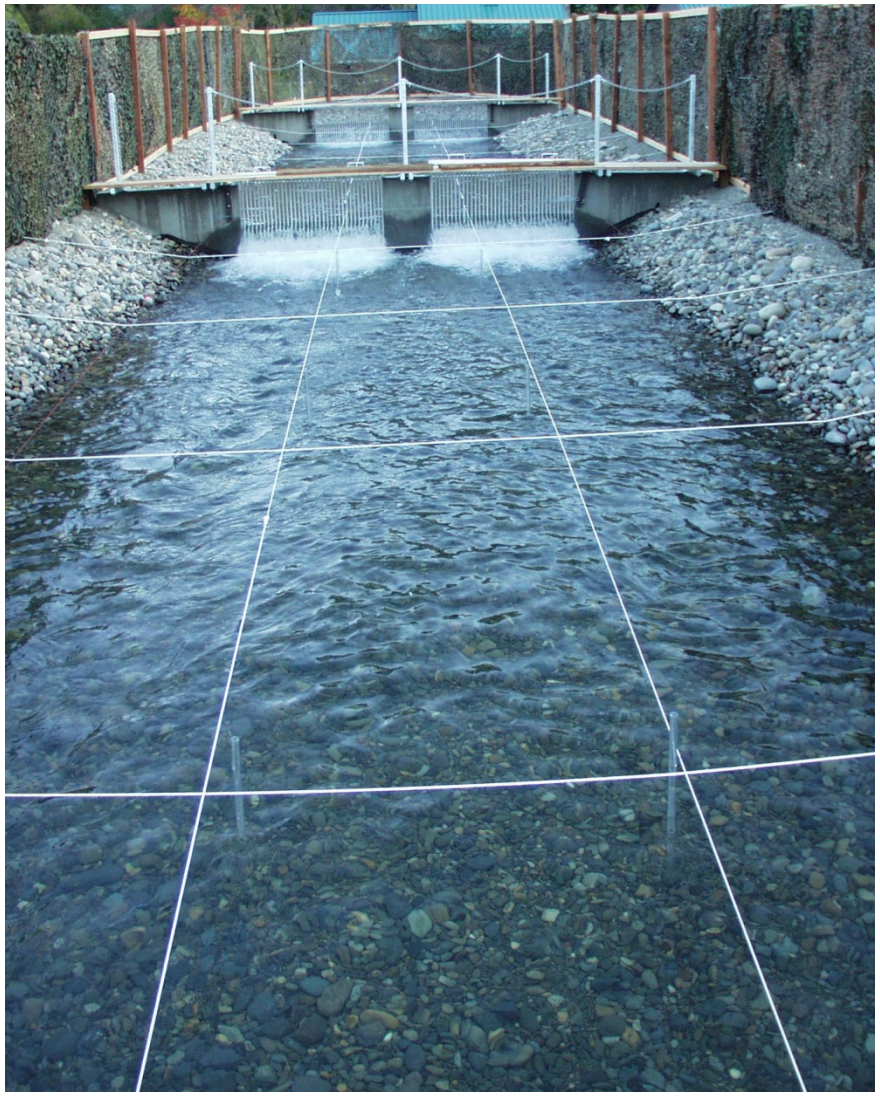
# Artificial Stream At Cle Elum

**Dimensions and Water Flow**
- **127 long x 7.9 m wide**
- **Water Velocity 0.1 – 2.0 m/s**
- **Discharge 0.37$m^3$/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)**

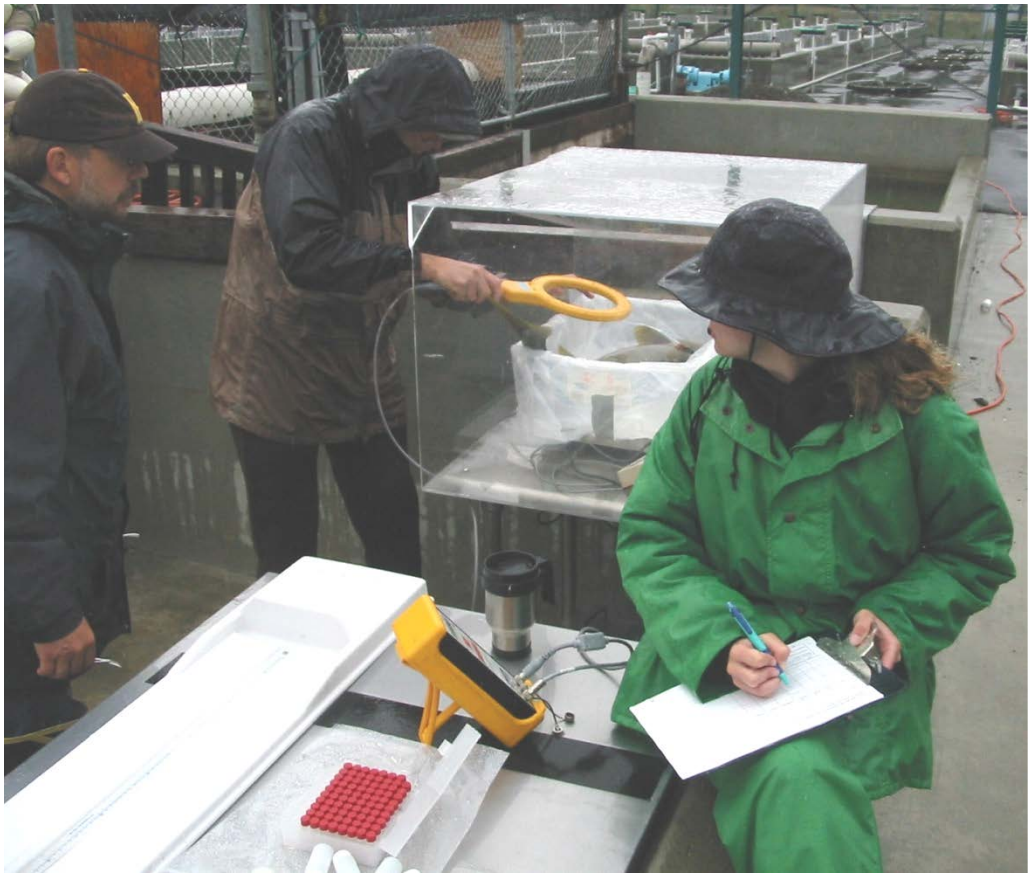


# Types of Fish Used

- Hatchery: **First-Generation,** Derived From Native Upper Yakima River Spring Chinook (Local Stock)

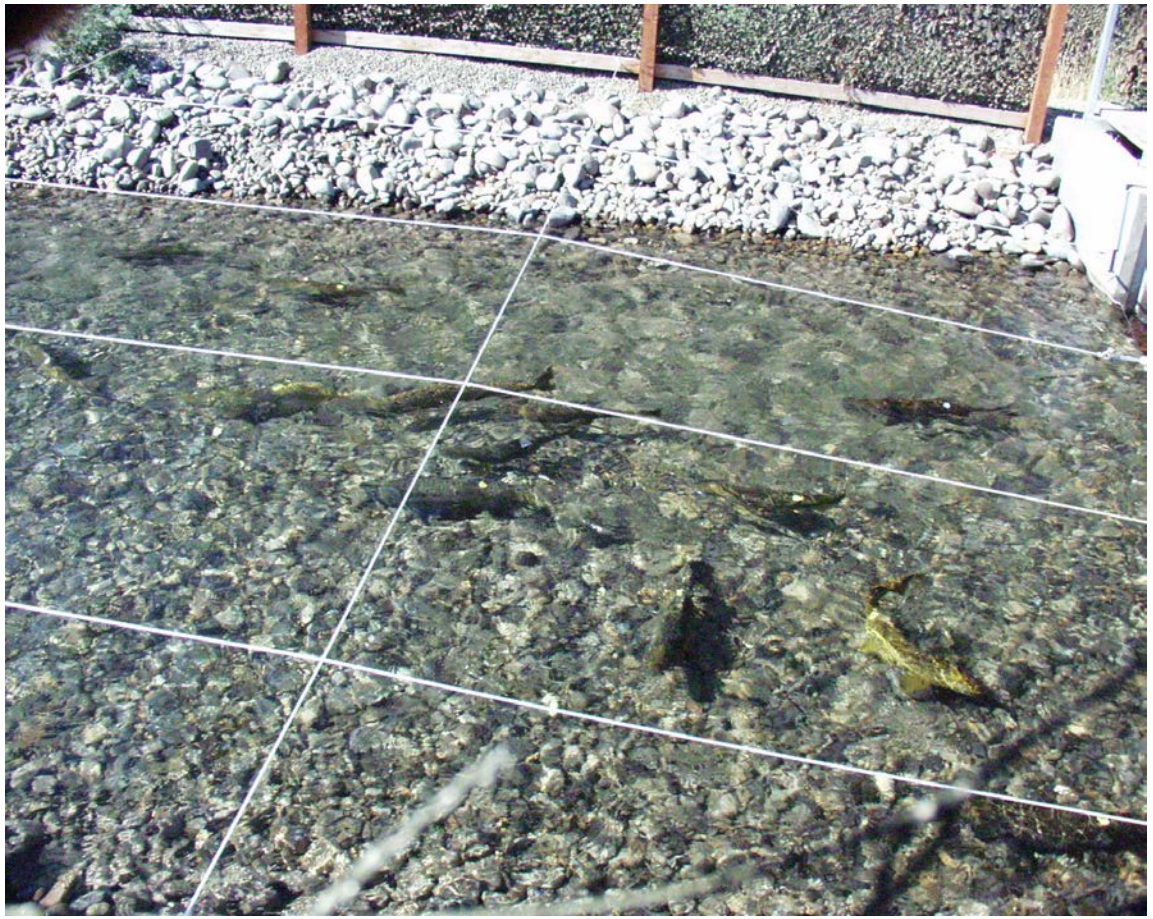
- Hatchery: **Second-Generation** , Derived From The Hatchery Control Line Established At The CESRF

# Prior To Placement, Each Fish Was:



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

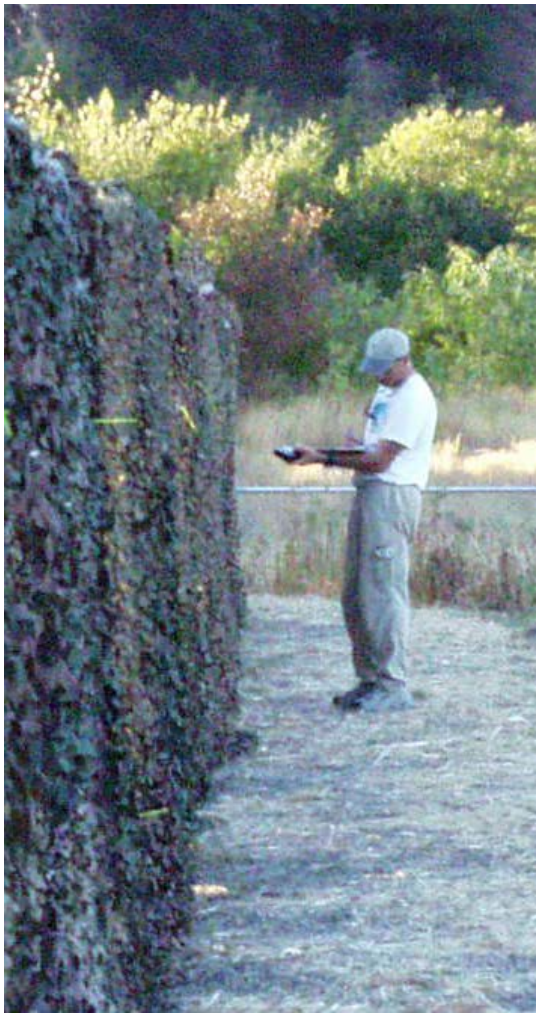
# They Were Then Released Into The Stream & Spawned Under Quasi-Natural Conditions



# Behavioral Observations

- Four-Minute Focused Observations
  - Population
  - Date
  - Time
  - Fish Location
  - Agonistic Behavior
  - Courting Behavior
  - Color Pattern

- Each Fish Was Watched One Or More Times Per Day By Multiple Observers

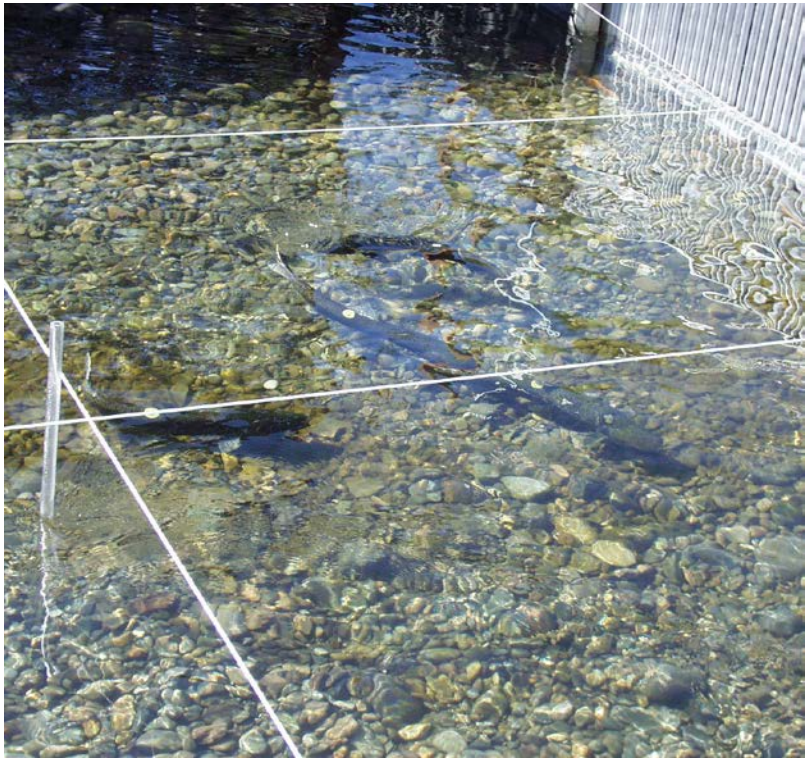


# Experimental Approach

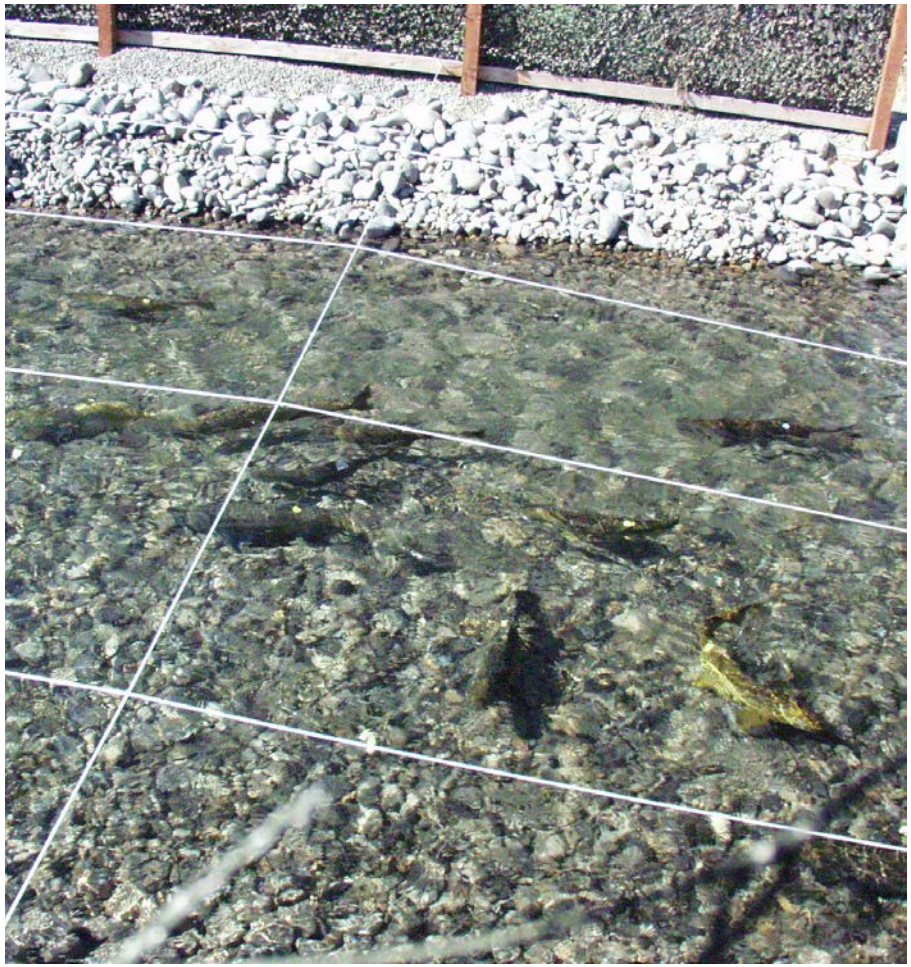
- Create Homogenous Populations Of First- & Second Generation Hatchery Fish In The Artificial Stream

- Allow The Fish To Spawn Naturally

- Compare Their Behavior & Offspring Production



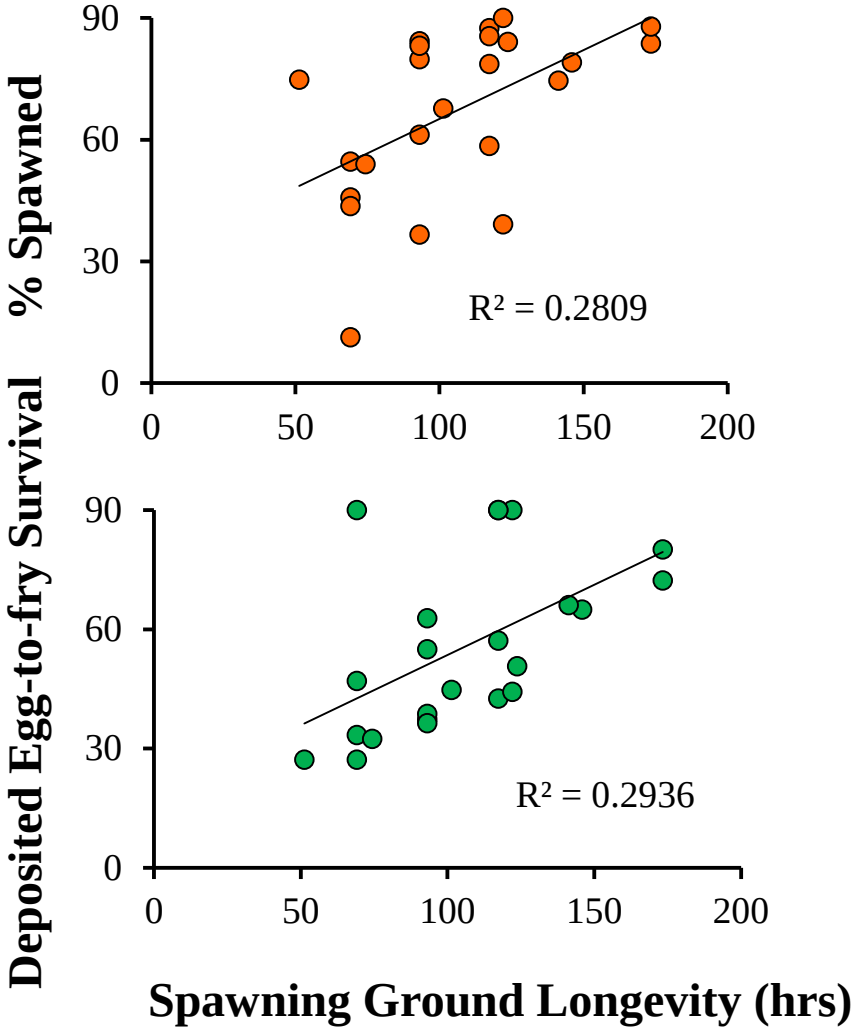
# Traits Examined



- Spawning Ground Longevity
- Size At Maturation
- Fecundity
- Behavior
  - Agonistic
  - Courting
- Egg-to-Fry Survival Rate
- Fry Production

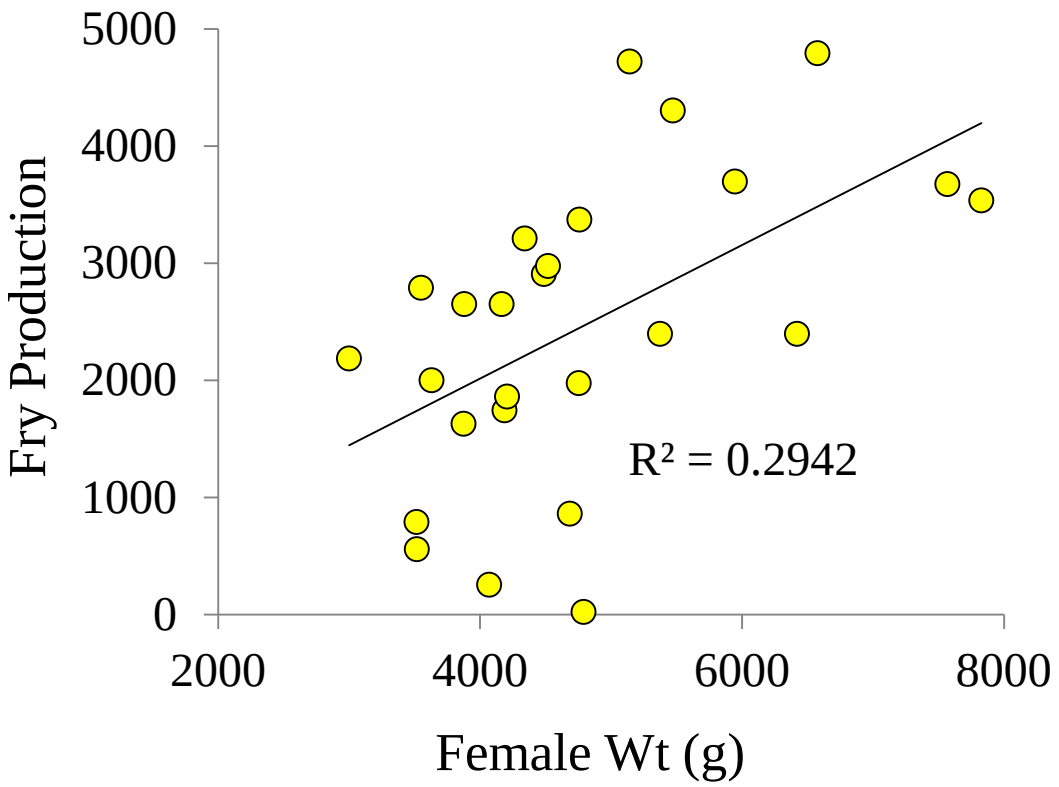
# Spawning Ground Longevity

## Spring Chinook



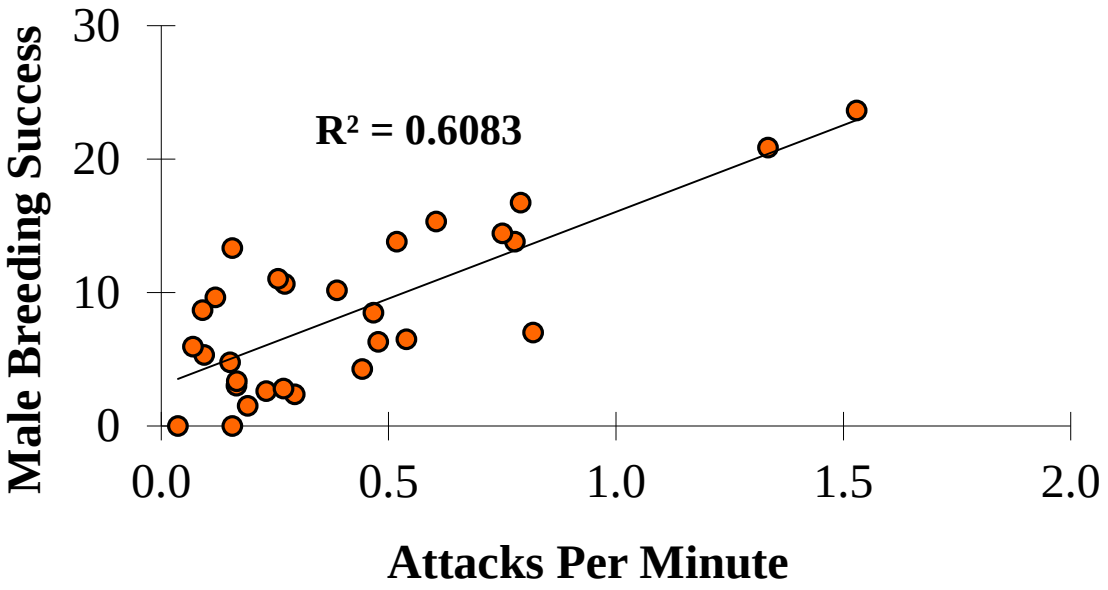
# Female Wt vs. Fry Production In Naturally Spawning
## Upper Yakima River Spring Chinook

| | |
|---|---|
| No. Of Groups | 7 |
| $R^2$ Values | 0.03 to 0.34 |
| Mean Slope | 720 eggs per kilo |



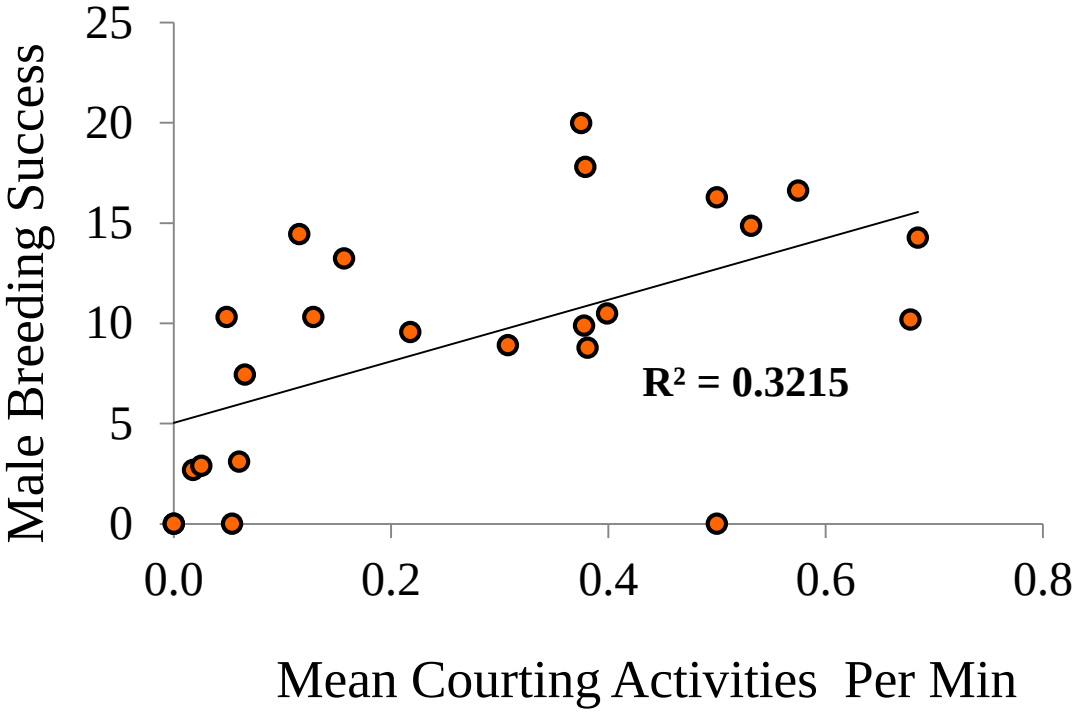
# Attack Frequency vs. Breeding Success

Male Spring Chinook Salmon

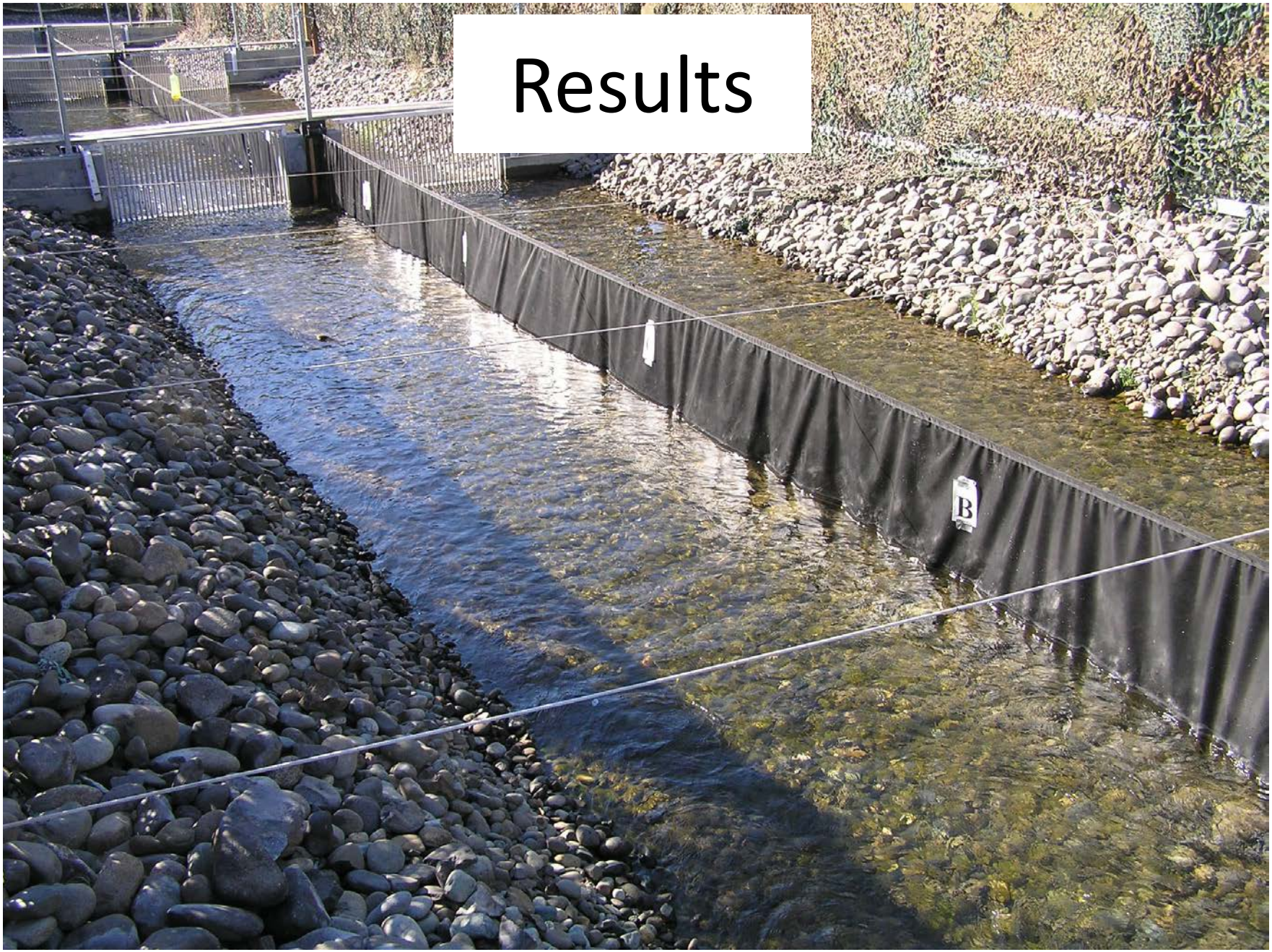


# Courting Frequency vs. Breeding Success

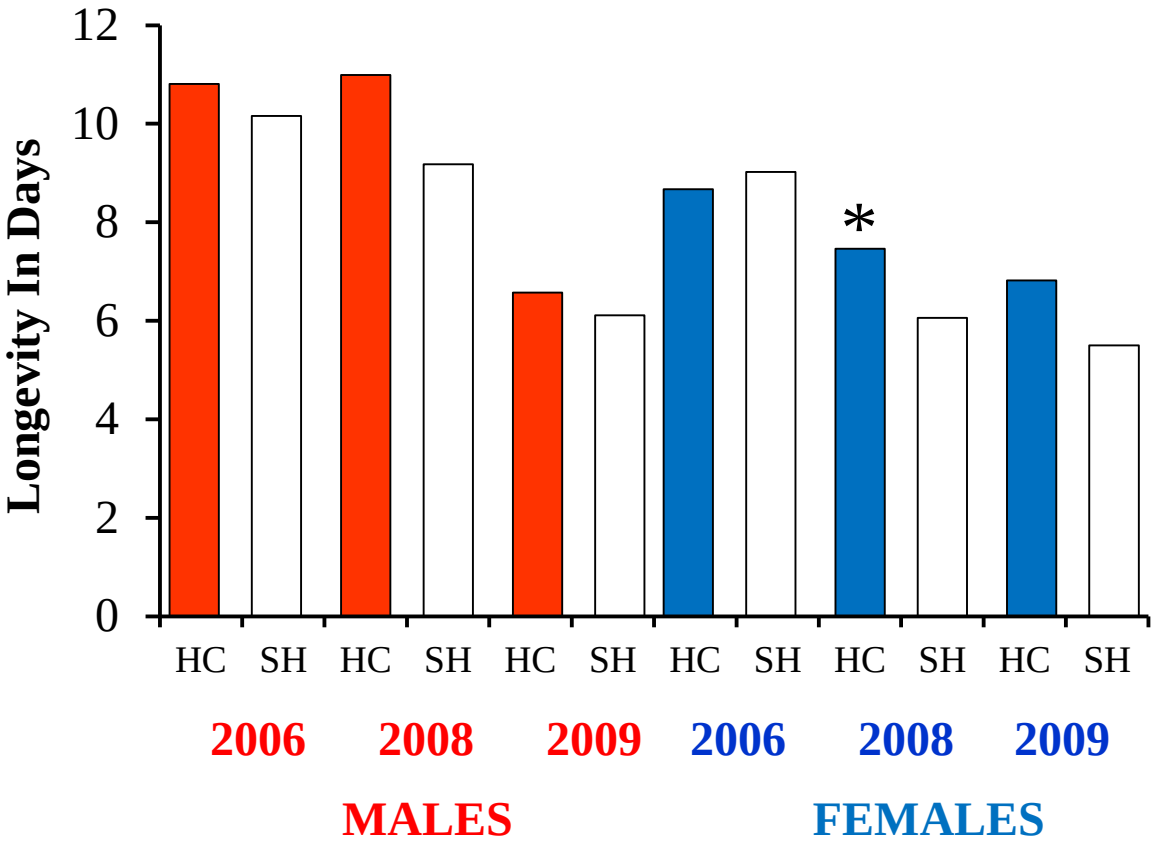
## Spring Chinook



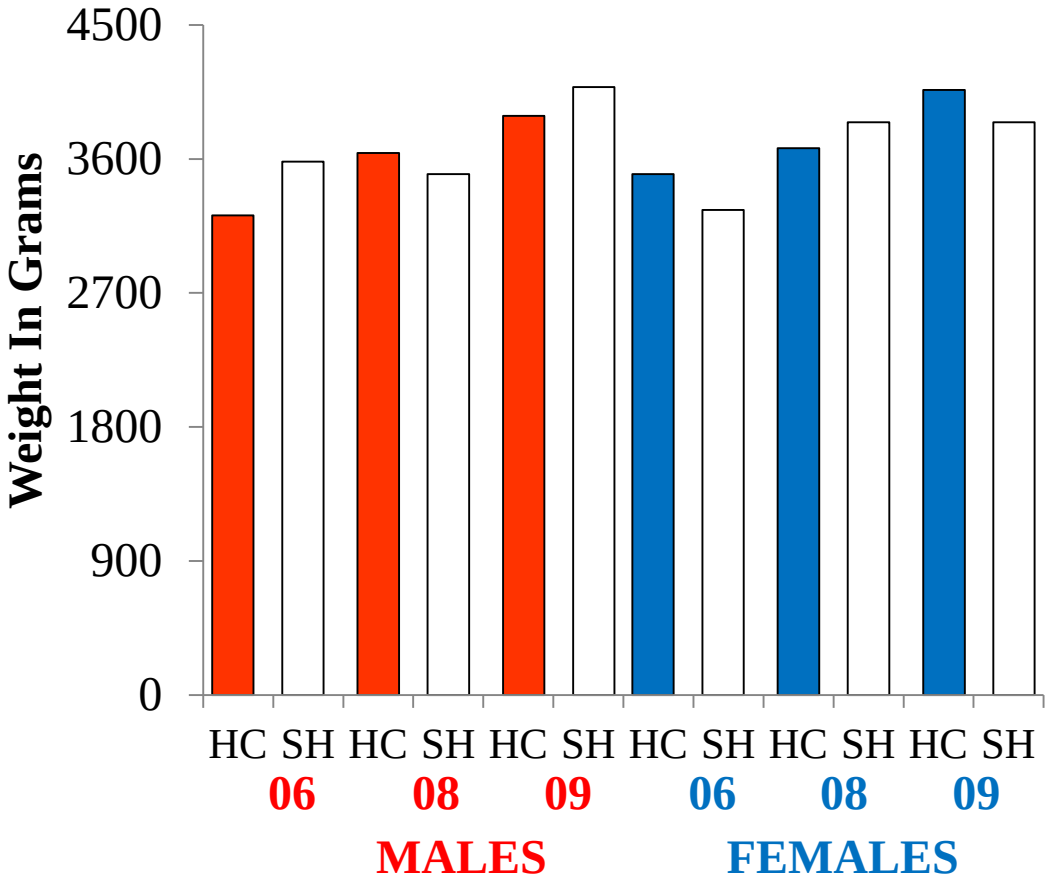
# Results



# Spawning Ground Longevity



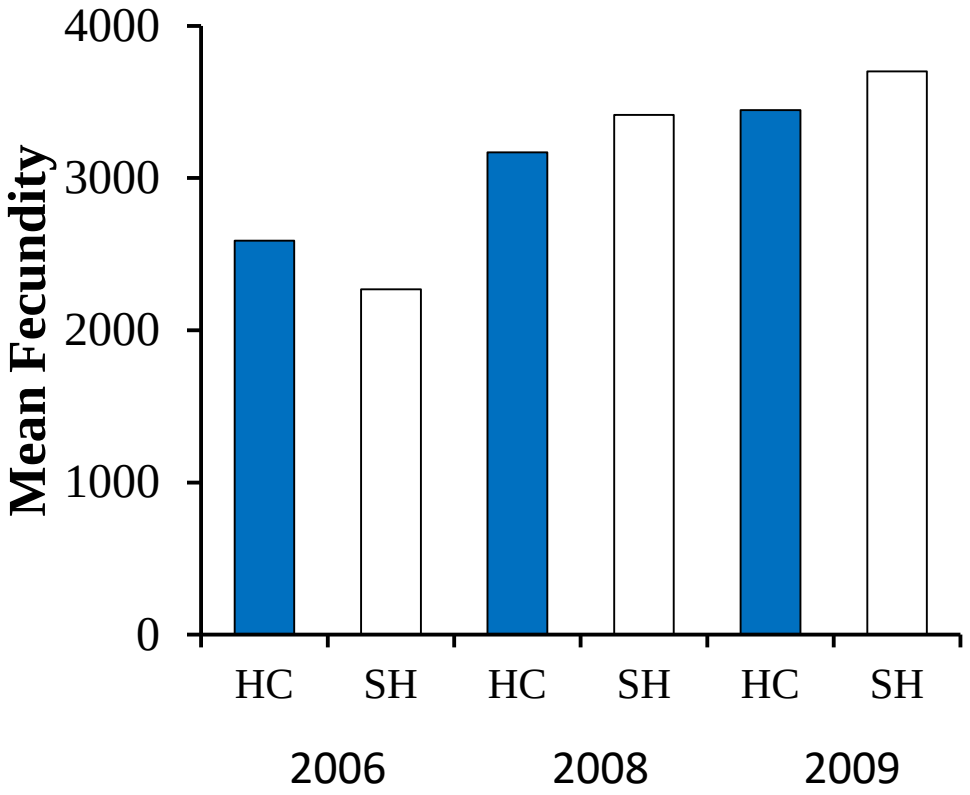
# Size At Maturation



# Mean Fecundity Of Females Placed Into The Artificial Stream

No Difference Between
HC & SH Females
*P* = 0.639

Difference Among Yrs
2009 & 2008 > 2006
*P* <0.001



# 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:

- Attack Frequency
- Courting & Digging Frequencies
- % Egg Deposition
- Egg-to-Fry Survival
- Fry Production

**(In This Design Hatchery Environmental Effects Are Held Constant)**

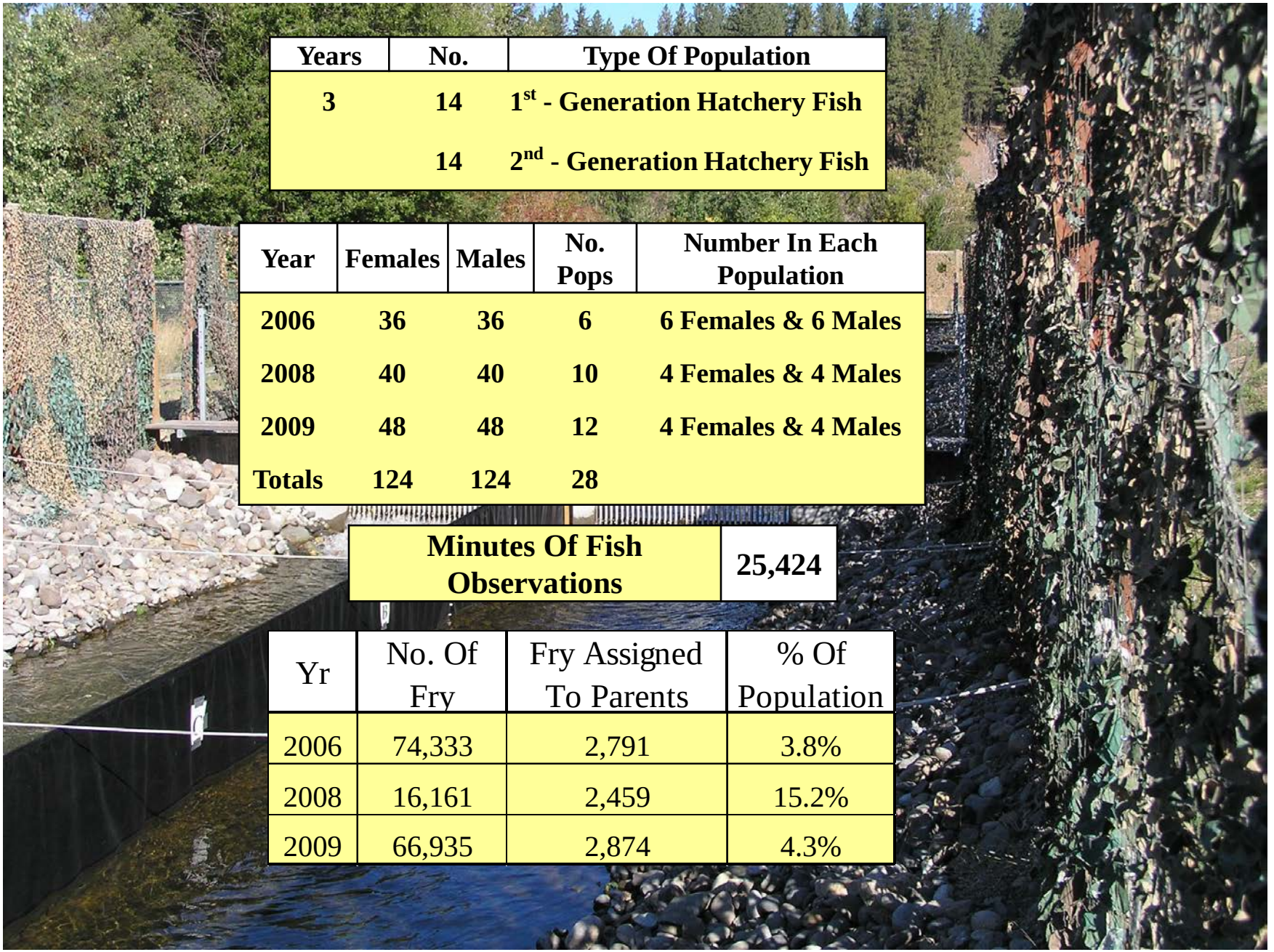
# Analytical Goals

Determine The % Of Variation Associated With Each Trait That Can Be Explained By:

**Fish Type**: 1$^{ST}$ & 2$^{nd}$ Generation Hatchery Fish

**Year**: 2006, 08, & 09

**Artificial Stream Location**



| Years | No. | Type Of Population |
|---|---|---|
| 3 | 14 | 1st - Generation Hatchery Fish |
| | 14 | 2nd - Generation Hatchery Fish |

| Year | Females | Males | No. Pops | Number In Each Population |
|---|---|---|---|---|
| 2006 | 36 | 36 | 6 | 6 Females & 6 Males |
| 2008 | 40 | 40 | 10 | 4 Females & 4 Males |
| 2009 | 48 | 48 | 12 | 4 Females & 4 Males |
| Totals | 124 | 124 | 28 | |

| Minutes Of Fish Observations | 25,424 |
|---|---|

| Yr | No. Of Fry | Fry Assigned To Parents | % Of Population |
|---|---|---|---|
| 2006 | 74,333 | 2,791 | 3.8% |
| 2008 | 16,161 | 2,459 | 15.2% |
| 2009 | 66,935 | 2,874 | 4.3% |

# Attack Frequency Males

| MALE ATTACKS/MIN | | |
|---|---|---|
| Year | Hatchery Generation | |
| | First | Second |
| 2006 | 1.1 | 1.2 |
| 2008 | 0.5 | 0.6 |
| 2009 | 0.4 | 0.3 |

| Source | *P* value | % Of Variation |
|---|---|---|
| Male Type | 0.902 | 0.0 |
| Year | <0.001 | 17.7 |
| Location | 1.000 | 0.0 |
| Within | | 82.3 |

# Attack Frequency Females

| FEMALE ATTACKS/MIN | | |
|---|---|---|
| | Hatchery Generation | |
| Year | First | Second |
| 2006 | 0.51 | 0.50 |
| 2008 | 0.25 | 0.27 |
| 2009 | 0.20 | 0.14 |

| Source | *P* value | % Of Variation |
|---|---|---|
| Female Type | 0.887 | 0.0 |
| Year | <0.001 | 27.4 |
| Location | 0.675 | 0.0 |
| Within | | 72.6 |

# Male Courting Frequency

| MALE COURTING FREQUENCY | | |
|---|---|---|
| Year | Hatchery Generation | |
| | First | Second |
| 2006 | 0.19 | 0.10 |
| 2008 | 0.19 | 0.13 |
| 2009 | 0.16 | 0.11 |

| Source | *P* value | % Of Variation |
|---|---|---|
| Male Type | 0.070 | 2.6 |
| Year | 0.492 | 0.0 |
| Location | 0.994 | 0.0 |
| Within | | 97.4 |

# Digging Frequency

| FEMALE DIGGING FREQUENCY | | |
|---|---|---|
| Year | Hatchery Generation | |
| | First | Second |
| 2006 | 0.63 | 0.45 |
| 2008 | 0.58 | 0.38 |
| 2009 | 0.41 | 0.39 |

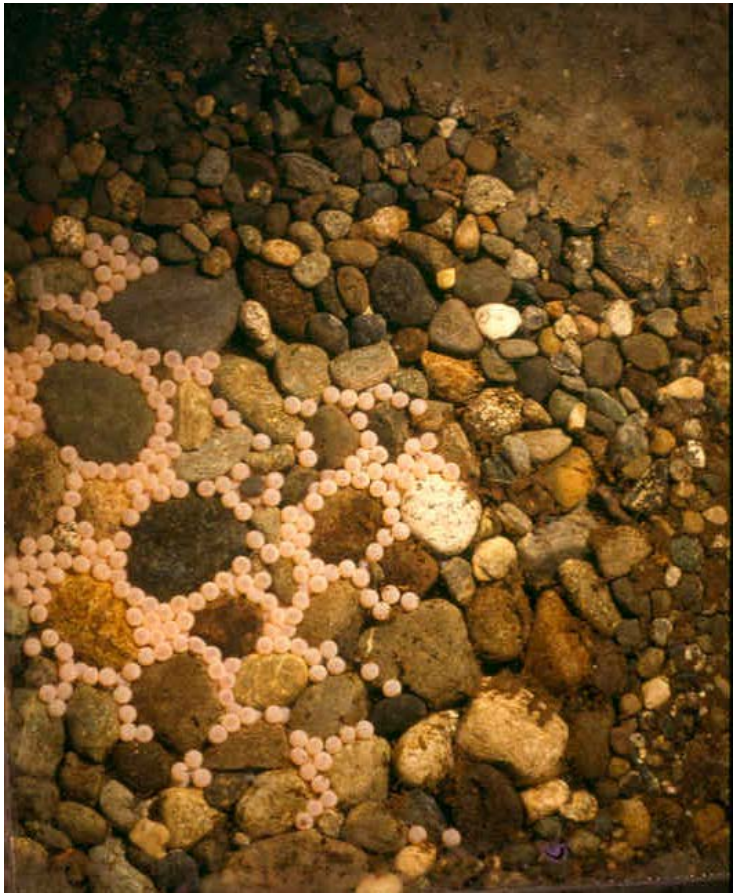
| Source | *P* value | % Of Variation |
|---|---|---|
| Female Type | 0.192 | 2.3 |
| Year | 0.394 | 0.4 |
| Location | 0.623 | |
| Within | | |

# % Spawned

| % SPAWNED | | |
|---|---|---|
| Year | Hatchery Generation | |
| | First | Second |
| 2006 | 86.8 | 84.8 |
| 2008 | 60.6 | 64.6 |
| 2009 | 73.5 | 77.6 |

| Source | *P* value | % Of Variation |
|---|---|---|
| Female Type | 0.880 | 0.0 |
| Year | 0.168 | 3.3 |
| Location | 0.710 | 0.0 |
| Within | | 96.7 |

# Fecundity To Fry



| FECUNDITY TO FRY | | |
|---|---|---|
| Year | Hatchery Generation | |
| | First | Second |
| 2006 | 77.7 | 87.2 |
| 2008 | 6.3 | 9.7 |
| 2009 | 49.1 | 47.7 |

| Source | *P* value | % Of Variation |
|---|---|---|
| Female Type | 0.917 | 0.0 |
| Year | <0.001 | 53.3 |
| Location | 0.868 | 0.0 |
| Within | | 46.7 |

# Fry Per Female

| FRY PER FEMALE | | |
|---|---|---|
| Year | Hatchery Generation | |
| | First | Second |
| 2006 | 1835 | 2582 |
| 2008 | 346 | 462 |
| 2009 | 1709 | 1553 |

| Source | *P* value | % Of Variation |
|---|---|---|
| Female Type | 0.901 | 0.0 |
| Year | <0.001 | 48.3 |
| Location | 0.664 | 0.0 |
| Within | | 51.7 |

# Conclusions

- When Time and Breeding Location Were Controlled No Significant Genetic Differences Were Detected Between 1st & 2nd Generation Hatchery Spring Chinook

- Currently Comparing Similar Traits Between 1st & 3rd Generation Hatchery Spring Chinook