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

C.M. Knudsen

A. Fritts

S.L. Schroder

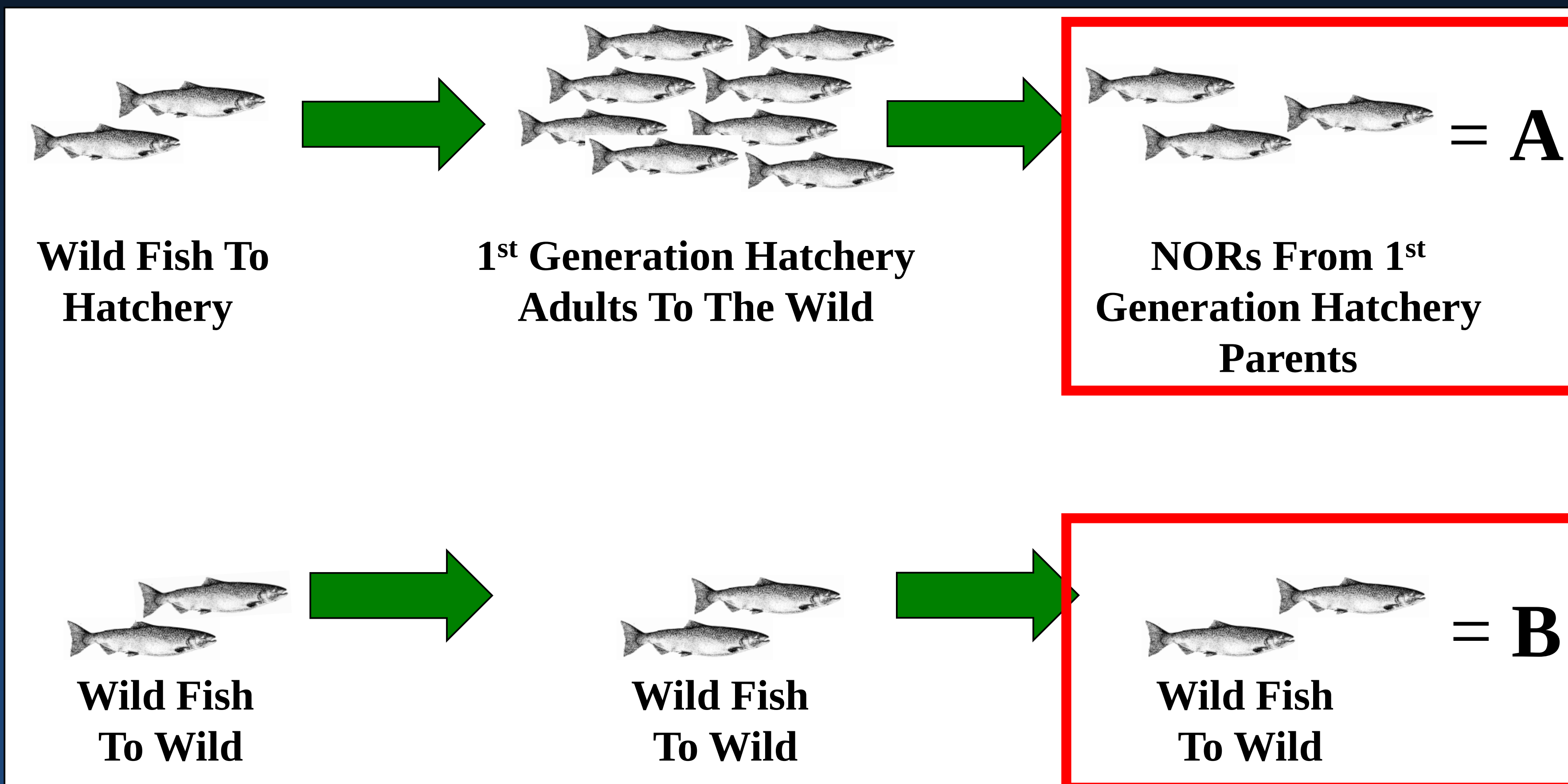
C.A. Stockton

T.W. Kassler

Key Assumption Of Supplementation:

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

Operational Definition Of Supplementation



Is A > B?

Wild and Hatchery Salmon Experience Profound Environmental Differences

Reproduction

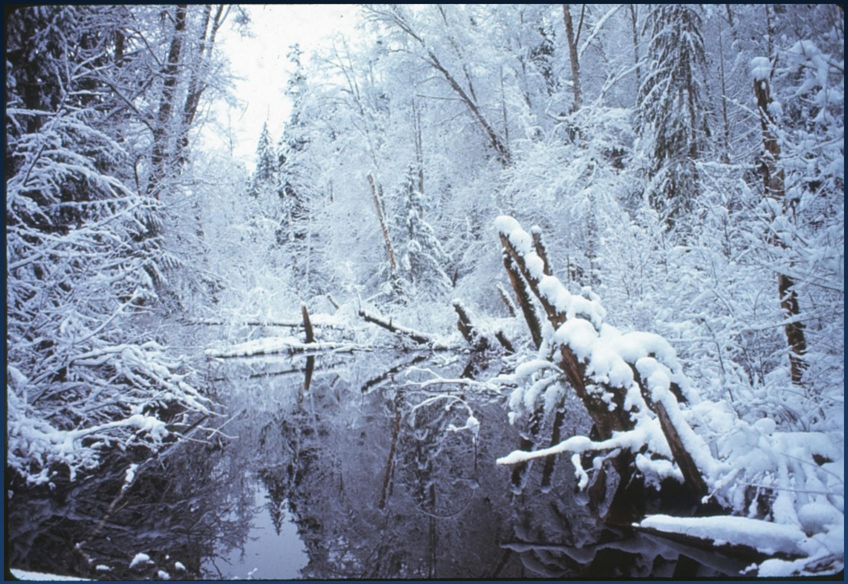
Natural Reproduction

Artificial Reproduction

Incubation

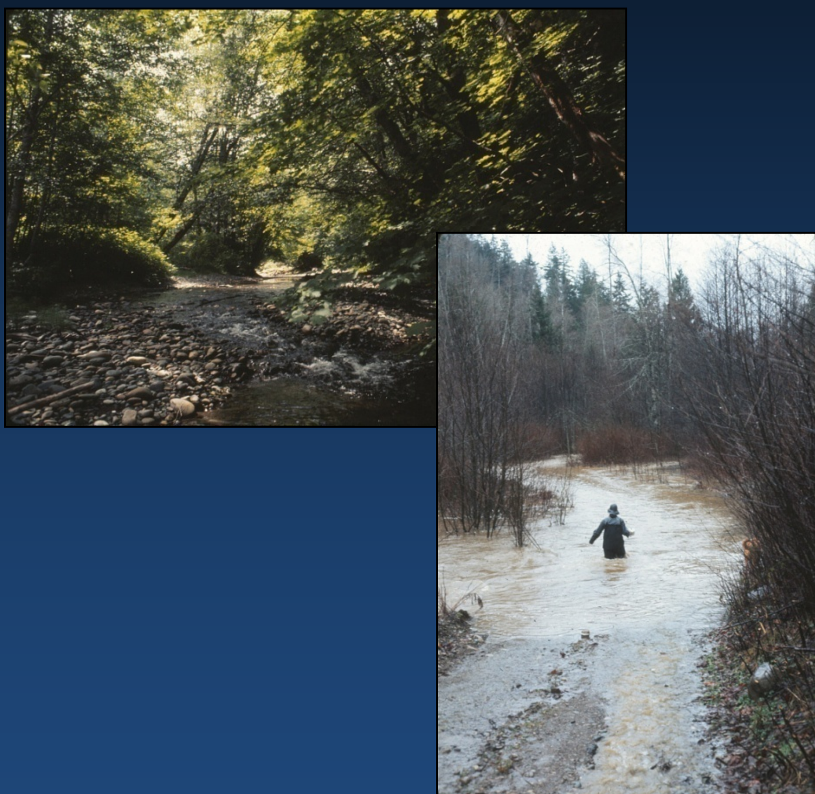
FACTOR	NATURAL	HATCHERY
Density	Low	High
Substrate	Gravel	Usually Plastic
Water Flow	Low	High
Light Level	None	Low to Moderate
Natural Foods	Present	Not Present
Temperature Regimes	Variable	Constant to Variable
Volitional Emergence	Yes	Usually No

Rearing Conditions



FACTOR	**NATURAL**	**HATCHERY**
Density:	**Low**	**High**
Habitat:	**Complex**	**Simple**
Food:	**Diverse**	**Uniform**
Predators:	**Present**	**Absent**
Flow:	**Variable**	**Low & Constant**
Movement:	**Volitional**	**Constrained**
Diseases/Parasites:	**Unmanaged**	**Managed/Treated**

Degree Of Variation



Natural environments are often quite variable both within and between years

Hatchery environments are relatively constant, particularly year-to-year

Potential Effect Of These Differences

❖**They may cause genetic change (domestication)**

Via: **Relaxation of selection for traits favored in the wild environment,**

Selection (intentional or unintentional) for traits favored in the hatchery environment,

& **Genetic drift**

❖**And non-genetic phenotypic changes**

such as time- and size-at-release

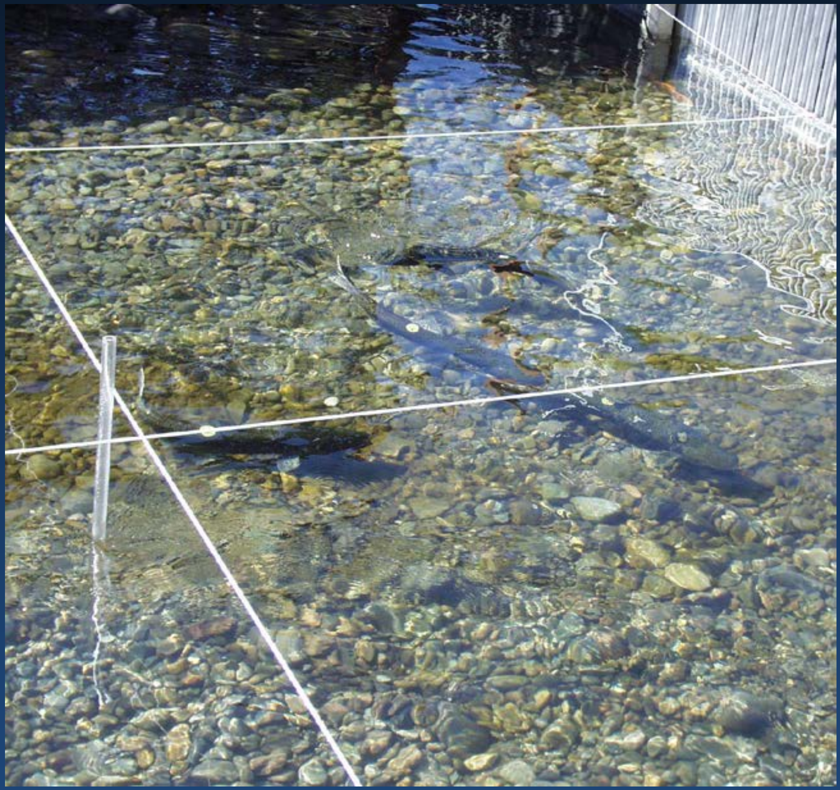
Initial Study Findings: Hatchery (SH) vs Wild

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

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

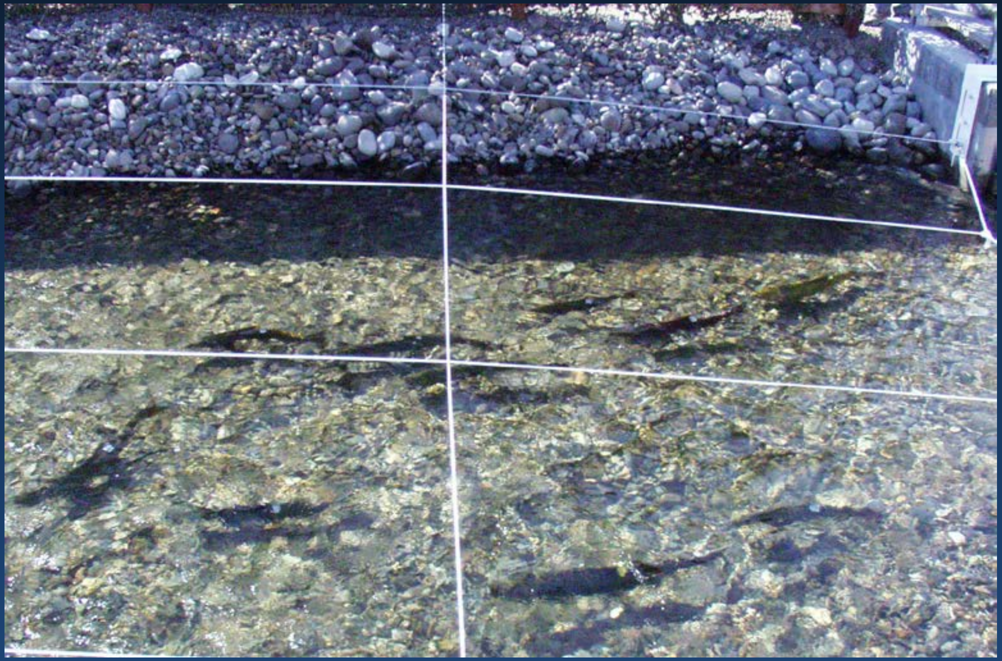
3) **Wild and Hatchery Males Had Similar Breeding Success Values**

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



Schroder et al. 2008. TAFS 137.
Schroder et al. 2010. TAFS 139.
Schroder et al. 2011. EBF 94.

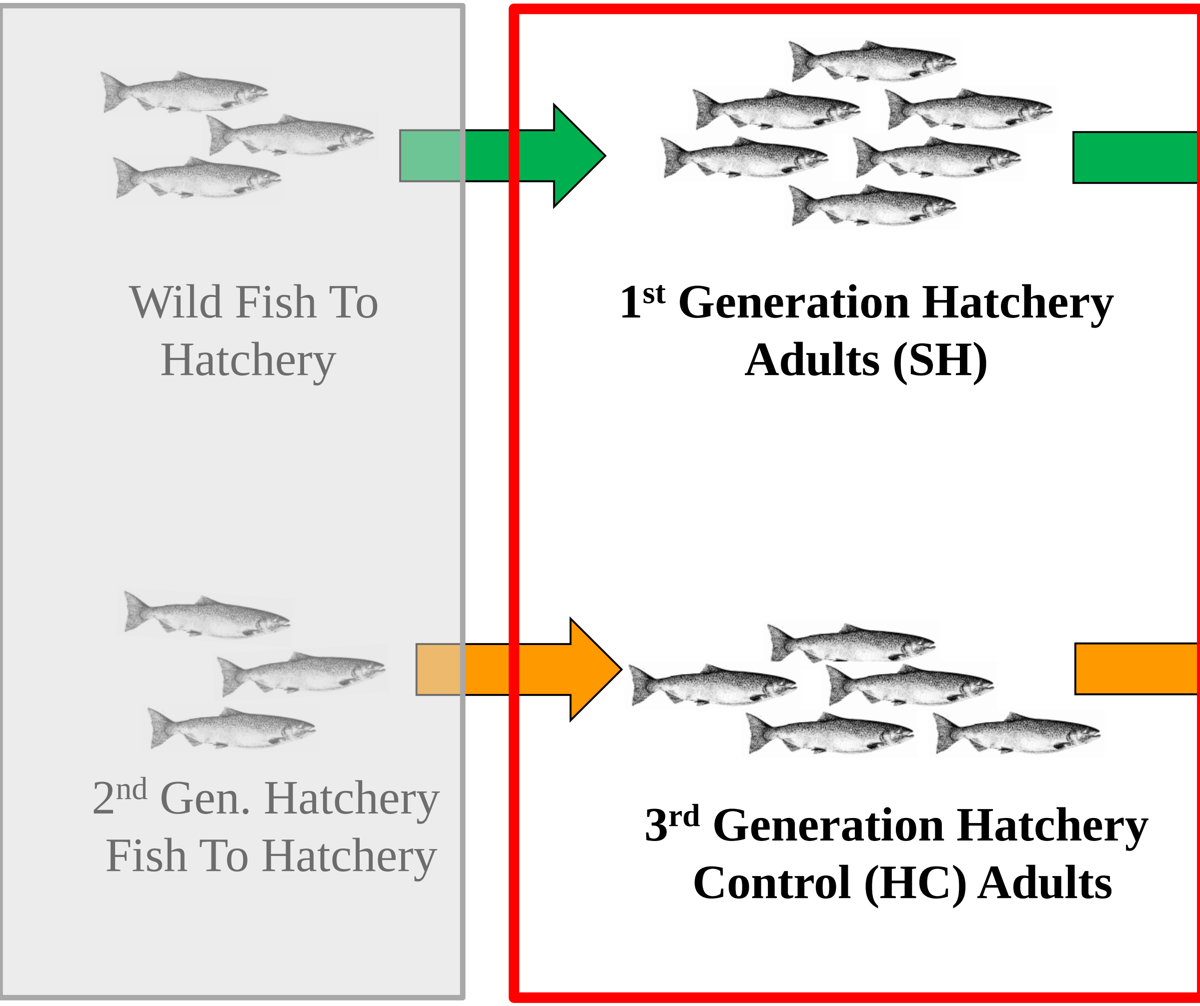
Why Test 1st Generation vs 3rd Generation Fish?

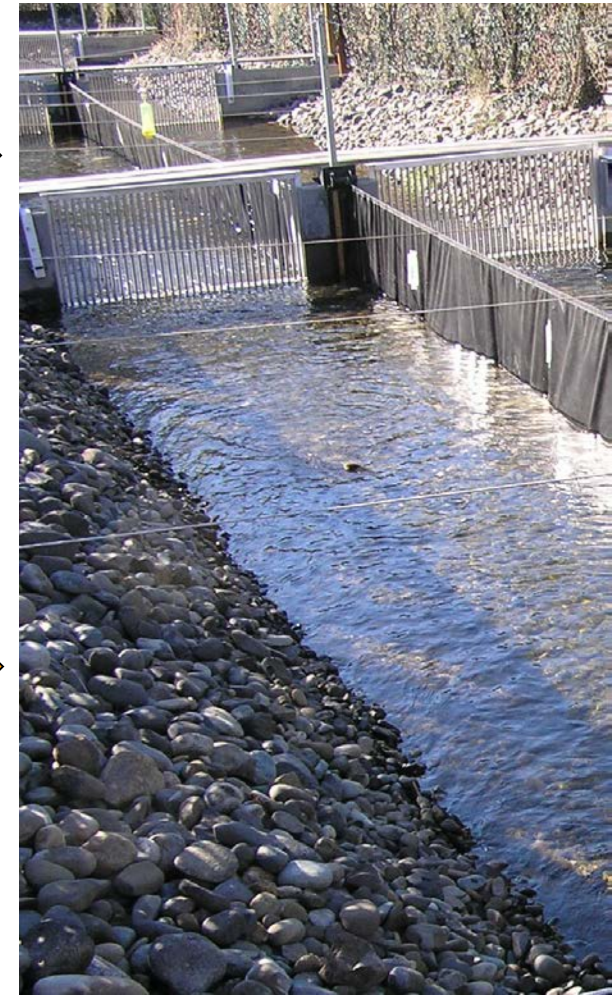


Wild & 1st Generation Hatchery Fish Experienced Different Early Environments

Therefore:

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



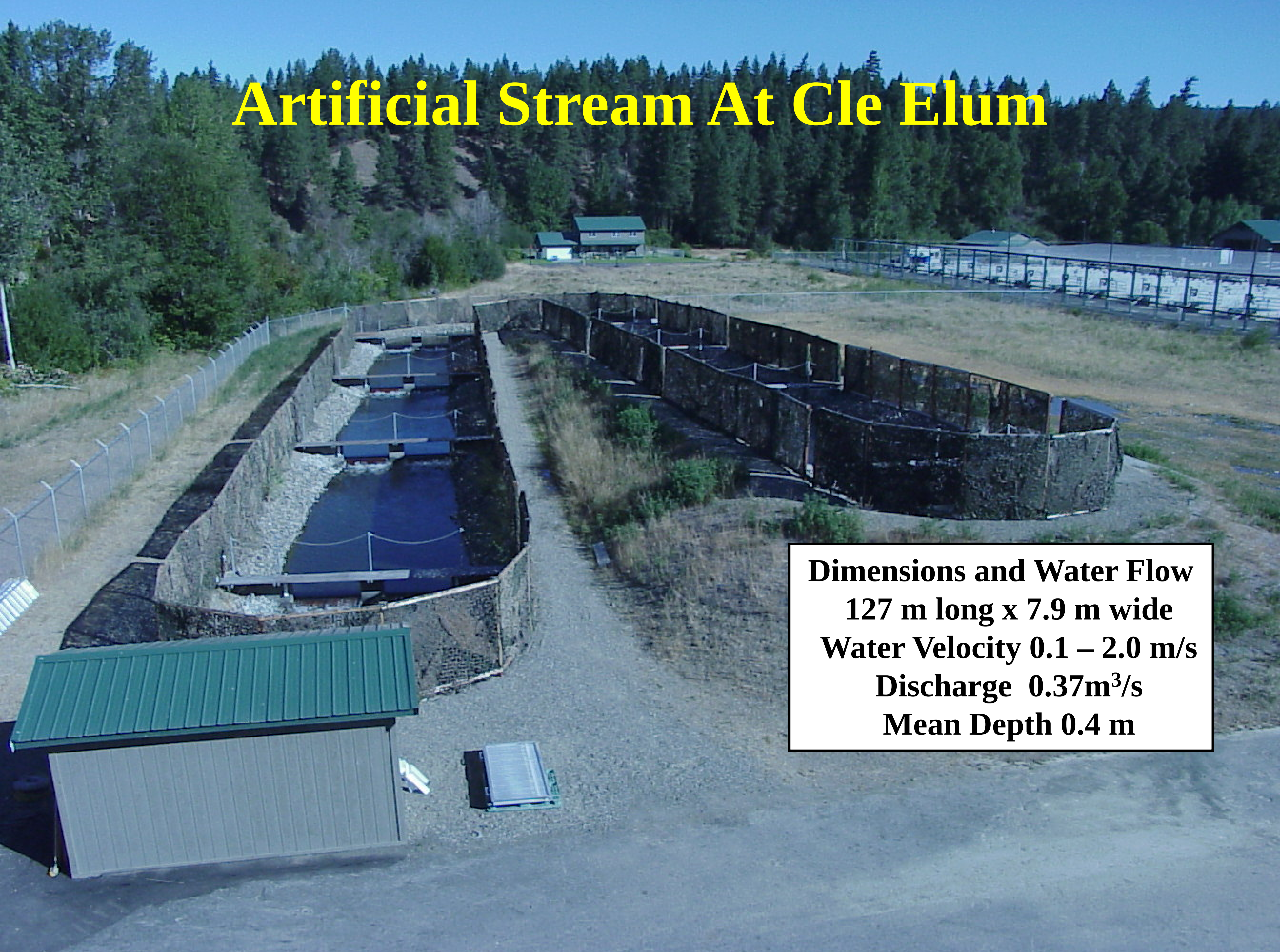


Fish Being Compared

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 – Pedigree Analysis

They Were Then Released Into The Channel...

...And Observations Made

- Study Design: 24 test replicates 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 replicates	6 replicates
2011	6 replicates	6 replicates
2012	6 replicates	6 replicates
2013	6 replicates	6 replicates
Total	24 replicates	24 replicates

2013

- Final year of 1st and 3rd generation comparisons
- Each replicate contained four males and four females
- 2 replicates per section
- 6 total sections

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

- **Spawning ground longevity**
- **Fecundity**
- **Reproductive behavior (observations)**
- **Fry production (pedigree analyses)**
- **Body size**

To Date

For 2011 spawners:

- 67,235 fry were produced
- 7,135 collected for use in pedigree assessments
- just under 3,000 fry were actually pedigreed
- pedigree analysis was just completed May 2013
- no analyses using pedigree data have occurred yet

To Date

For 2012 spawners:

- 26,415 fry were produced
- 11.3% were collected for use in pedigree assessments
- pedigree analysis will be completed in 2014

2012 fry production was 21.8% of 2010 and 39.3% of 2011. Why was fry productivity 2-5 times greater in 2010 and 2011?

BY 2012 Fry Trapping

- April 25th 2013 flow to the channel stopped due to pump failures
- The two upper sections were completely dewatered with very high mortality
- Fry were removed from within the gravel or standing water
- DNA samples were collected
- Shutdown of trapping occurred 2-3 weeks earlier than normal

Preliminary: Fry Count Data

Year	Data Type	Origin	N	Percent
2011	Raw fry counts by section[1]	HC	13,983	44.7
		SH	17,285	55.3
	Raw pedigree counts	HC	1,279	45.0
		SH	1,563	55.0
2012	Raw fry counts by section[1]	HC	9,119	34.5
		SH	17,296	65.5

[1]Raw counts, so leakage from one section to another could be a factor, pre-spawn mort, egg retention and fecundity.

Results To Date

- No sign. differences in the body size of SH and HC fish in 2010-2012.

- However, in 2010 and 2011 first generation females had greater average fecundities.

Results To Date

- 2010: No significant differences due to the number of generations of hatchery culture in either male or female:
  - aggression
  - courting or digging frequencies

2010-2011 Results

- SH and HC females did not significantly differ in:
  - absolute fry production.

Summary

- Three years (2010 - 2012) of fry production and behavioral data have been collected.
- Two years of spawner behavioral data analyzed (2010-2011).
- These results should be regarded as preliminary and subject to change.
- One final year of 1^{st} and 3^{rd} generation hatchery fish will be placed into the channel in 2013.

Acknowledgments

Charlie Strom, Vernon Bogar, DJ Brownlee, Greg Strom, Simon Goudy, and Quinn Jones (CESRF) helped process study fish and operated and maintained the artificial stream

Mark Johnston and his crew collected the study fish at Roza and transported them to the CESRF

WDFW staff making behavioral observations:
2011 - Jamie Schlump, Brian Johnson, and Matt Sizer
2012 - Danielle Rockey, Rebecca Powell, and Matt Sizer

Cheryl Dean, Cherril Bowman and other staff in the WDFW's Molecular Genetics Laboratory assisted us in the pedigree analyses

BPA for funding