Northwest **Power** and **Conservation** Council

July 5, 2023

MEMORANDUM

TO: **Fish and Wildlife Committee Members**

FROM: **Maureen Hess**

SUBJECT: **Presentation on Improved productivity of naturalized spring Chinook salmon following reintroduction from a hatchery stock in Lookingglass Creek, Oregon**

BACKGROUND:

Presenter: Hayley Nuetzel – Fishery Scientist/Project Leader, Columbia River Inter-Tribal Fish Commission

Summary: Hayley will update the Committee on a recent publication, associated with Project #2009-009-00, which showed that fish reintroduced from a hatchery stock possess the adaptive capacity to positively contribute to natural productivity and recovery goals.

Relevance: The 2014 Columbia River Basin Fish and Wildlife Program and the 2020 Addendum outlines two strategies that are supported by the efforts of the Basinwide Supplementation Evaluation (BSE) Project (#2009-009-00): 1. The use of hatcheries for reintroduction, and 2. Fish propagation including hatchery programs. The BSE Project supports these strategies by implementing research, monitoring, and evaluation related to hatchery supplementation and reintroduction programs for Salmon and Steelhead. This additionally supports the Council's commitment to an adaptive management approach (Part Four of the 2014 Program).

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Workplan: Fish and Wildlife Division Workplan; Program Implementation and Performance

Background: The Basinwide Supplementation Evaluation (BSE) Project was initiated by the Columbia River Inter-Tribal Fish Commission in 2009 to lend research, monitoring and evaluation (RM&E) support to tribally managed hatchery supplementation and reintroduction programs for Salmon and Steelhead throughout the Columbia River Basin. While multiple studies are supported by the BSE project, the presentation update for the Committee will focus on one study that evaluated action effectiveness of a reintroduction program for Spring Chinook. Results from the BSE Project are published (as noted in the abstract below) and used in adaptive management decision processes that guide future analyses, recovery actions, and management decisions.

Abstract

Supplementation of depressed salmonid populations with hatchery production has been questioned due to domestication effects, which may reduce reproductive fitness. However, for extirpated populations, reintroduction typically requires use of hatchery stocks. We evaluated this strategy by monitoring the naturalization of spring Chinook salmon reintroduced to Lookingglass Creek, OR (Grande Ronde Basin), from a captive brood, hatchery stock. We compared the reproductive success (RS) of naturally spawning natural-origin relative (NOR) to hatchery-origin (HOR) adults across 9 brood years. Individual RS (the number of progeny produced) was estimated by pedigree reconstruction analyses, and then analyzed by generalized linear models to estimate the effect of parental origin, while controlling for potentially confounding covariates. When evaluating RS by juvenile progeny, NOR spawners were more likely to be reproductively successful, and when successful, produced more progeny on average than successful HOR counterparts. We found a similar advantage when evaluating RS by adult progeny, although the origin effect was not as important among successful spawners. Results suggest fish reintroduced from a hatchery stock possess the adaptive capacity to positively contribute to natural productivity and recovery goals.

More Info:

Journal Publication

Project #2009-009-00 Basinwide Supplementation Evaluation Project:

- 2021-2022 Anadromous Fish Habitat and Hatchery Review – Project proposal and Council Decision
- Initial review in 2009 – Council Decision
- CBFish.org – Additional project information

Presentation on Improved Productivity of Naturalized Spring Chinook in Lookingglass Creek, OR

Fish and Wildlife Committee Meeting

July 11, 2023

Northwest **Power** and
Conservation Council

Presentation background and relevance to the CRB F&W Program

- Implementation connected to Adaptive Management (Part 4 of the Program) and Strategies:
  - Fish propagation including hatchery programs
  - The use of hatcheries for reintroduction

- Project # 2009-009-00 Basinwide Supplementation Evaluation Project
  - Established in 2009, in recognition of a need for more widespread and advanced RM&E throughout the Basin (ISRP & ISAB, 2005), and guided by recommendations outlined by the Ad Hoc Supplementation Work Group (AHSWG 2008)

Presentation background and relevance to the CRB F&W Program

Management purpose of hatchery programs

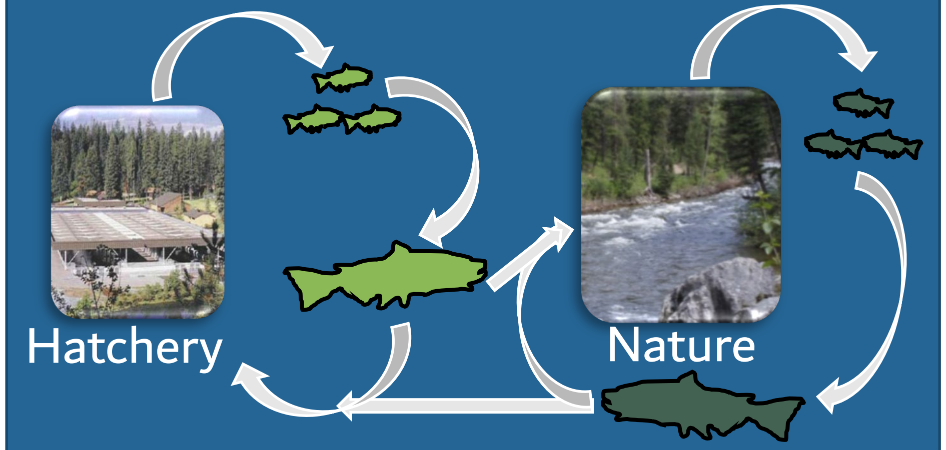
1.) Harvest Fishery – Fish for harvest

2.) Supplementation – Prevent extirpation, rebuild natural production

3.) Reintroduction – Restore extirpated populations

Two different management approaches

Supplementation & Reintroduction [Integrated management]



- Two environments, One population
- Support rebuilding natural production
- Prevent or restore extirpated populations

Harvest Fishery [Segregated management]

- Two environments, Two populations
- Promotes harvest of hatchery fish
- Managed to not impede recovery of natural populations

Presentation background and relevance to the CRB F&W Program

- Hayley Nuetzel, Fishery Scientist
  Columbia River Inter-Tribal Fish Commission

  - Overview of the Basinwide Supplementation Evaluation Project

  - Highlight recent publication

Canadian Journal of Fisheries and Aquatic Sciences

OPEN ACCESS | Article

Improved productivity of naturalized spring Chinook salmon following reintroduction from a hatchery stock in Lookingglass Creek, Oregon

Hayley M. Nuetzel[a], Peter F. Galbreath[a], Benjamin A. Staton[a], Carrie A. Crump[b], Leslie M. Naylor[b], and Gene E. Shippentower[c]

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Corresponding author: **Hayley M. Nuetzel** (email: hnuetzel@critfc.org)

Abstract

Supplementation of depressed salmonid populations with hatchery production has been questioned due to domestication effects, which may reduce reproductive fitness. However, for extirpated populations, reintroduction typically requires use of hatchery stocks. We evaluated this strategy by monitoring the naturalization of spring Chinook salmon reintroduced to Lookingglass Creek, OR (Grande Ronde Basin), from a captive brood, hatchery stock. We compared the reproductive success (RS) of naturally spawning natural-origin relative (NOR) to hatchery-origin (HOR) adults across 9 brood years. Individual RS (the number of progeny produced) was estimated by pedigree reconstruction analyses, and then analyzed by generalized linear models to estimate the effect of parental origin, while controlling for potentially confounding covariates. When evaluating RS by juvenile progeny, NOR spawners were more likely to be reproductively successful, and when successful, produced more progeny on average than successful HOR counterparts. We found a similar advantage when evaluating RS by adult progeny, although the origin effect was not as important among successful spawners. Results suggest fish reintroduced from a hatchery stock possess the adaptive capacity to positively contribute to natural productivity and recovery goals.

Key words: reintroduction, origin, Chinook, reproductive success

Improved Productivity of Naturalized Spring Chinook in Lookingglass Creek, OR

NPCC – Fish & Wildlife Committee Meeting

11 July 2023

Hayley Nuetzel – CRITFC Fishery Scientist

Presentation Outline

1) Overview of the **B**asinwide **S**upplementation **E**valuation (BSE) Project
   a) Goals & Purpose
   b) Structure
   c) Studies
   d) Takeaways

2) Lookingglass Creek Study
   a) Introduction
   b) Methods
   c) Results
   d) Conclusions

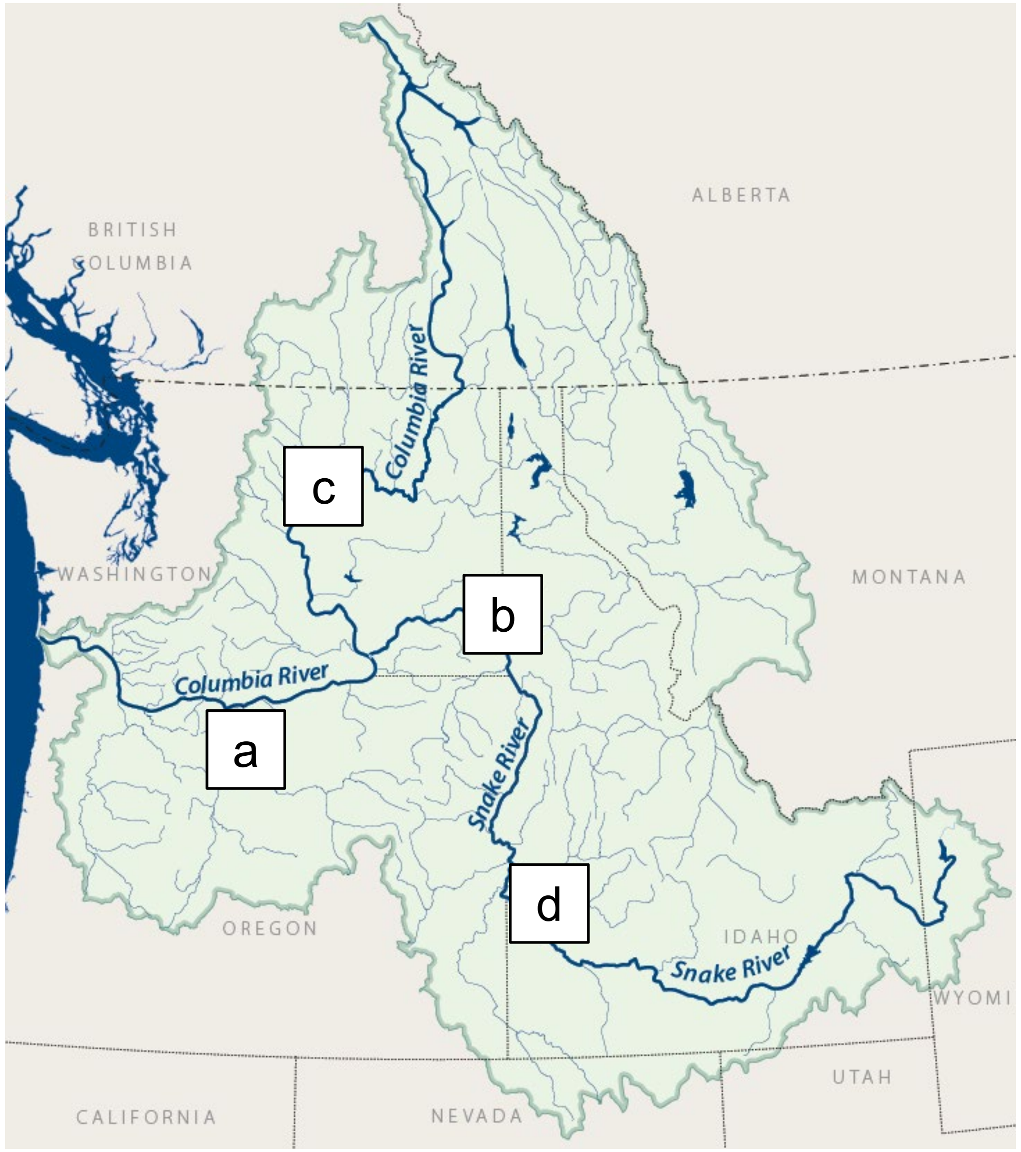
BSE Project – Goals & Purpose

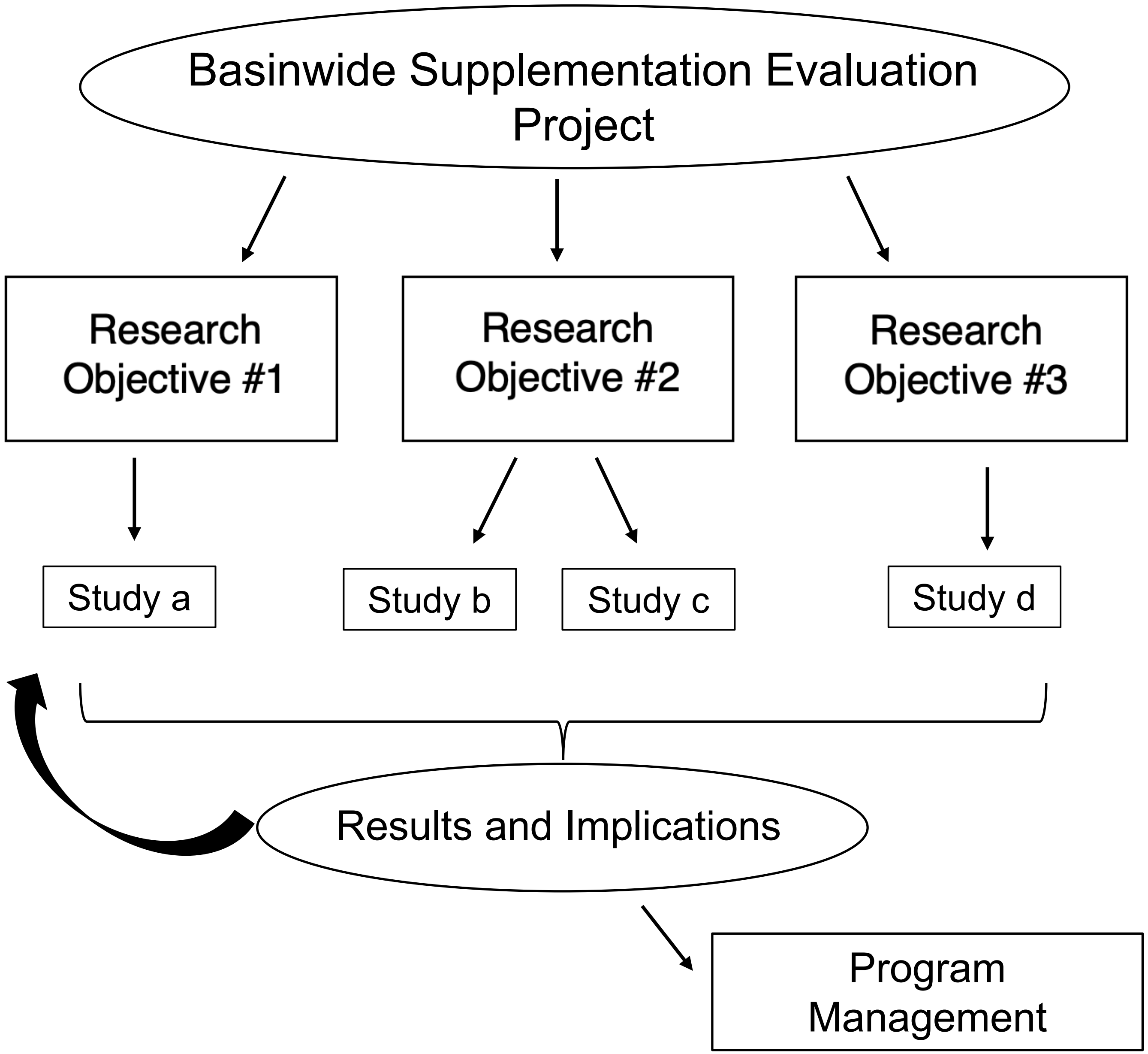
To lend research, monitoring and evaluation support to tribally-managed supplementation and reintroduction programs for salmon and steelhead throughout the Columbia River Basin*, so that programs may adaptively manage and thrive.*

"The plan's vision is to put fish back in the rivers and protect the watersheds where the fish live."

- Wy-Kan-Ush-Mi Wa-Kish-Wit, "Spirit of the Salmon," Plan

BSE Project - Structure





Research Objective #1

Question

How do hatchery supplementation programs impact natural populations?

Goal

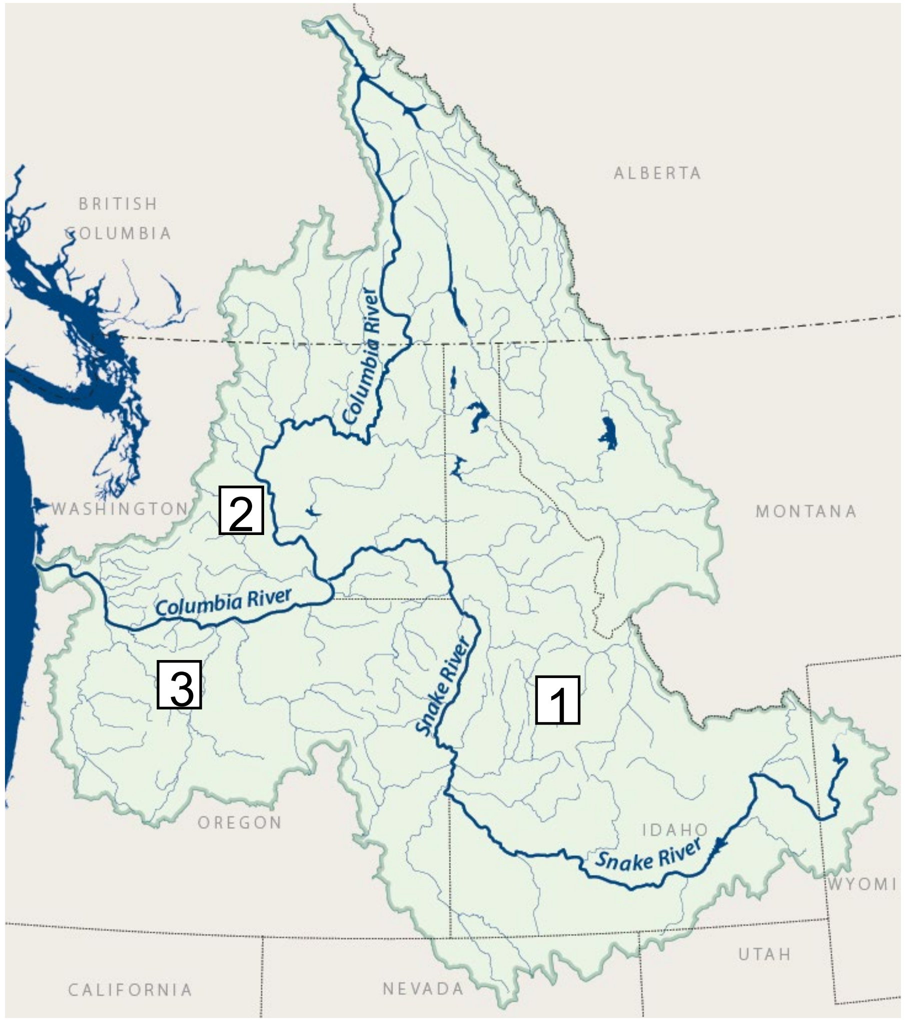
Provide hatchery managers with data that directly evaluates success in meeting programmatic goals.

Research Objective #1
Studies

1. Johnson Creek (Salmon River Basin) – spring/summer Chinook Relative Reproductive Success (RRS) by origin

2. Upper Yakima River - spring Chinook RRS by origin (*ongoing*)

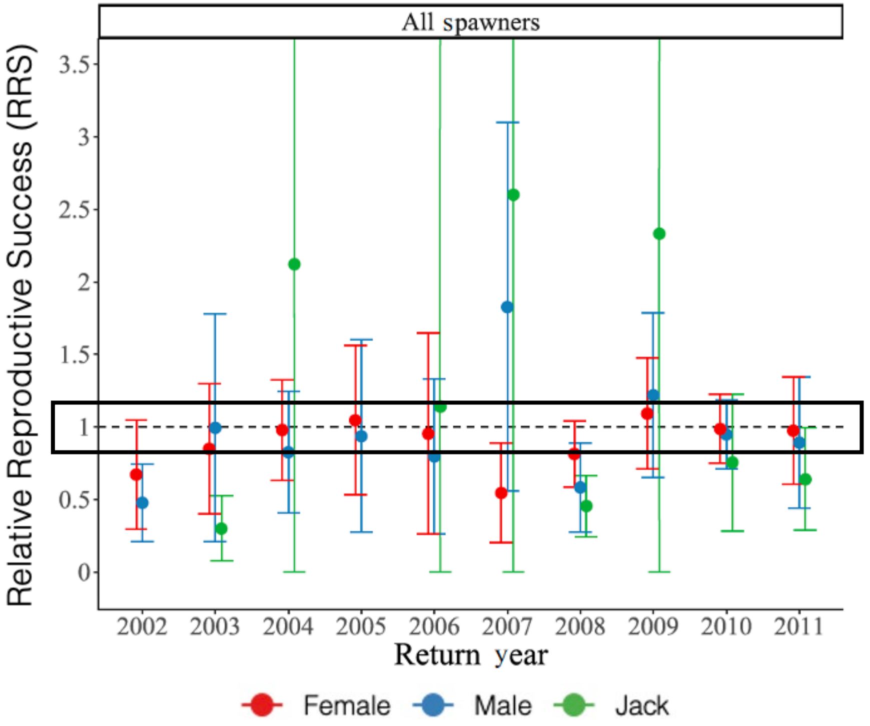
3. Upper Warm Springs River (Deschutes River basin) – comparing reproductive success between spring Chinook and coho salmon



Research Objective #1
Findings & Implications

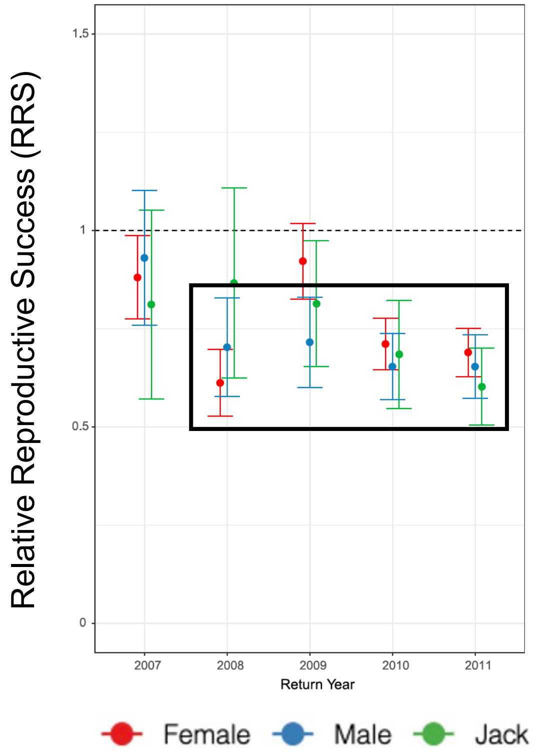
- Context – similar programs in different systems may produce different findings

Johnson Creek spring/summer Chinook RRS



From Janowitz-Koch *et al.*, 2019

Upper Yakima spring Chinook RRS

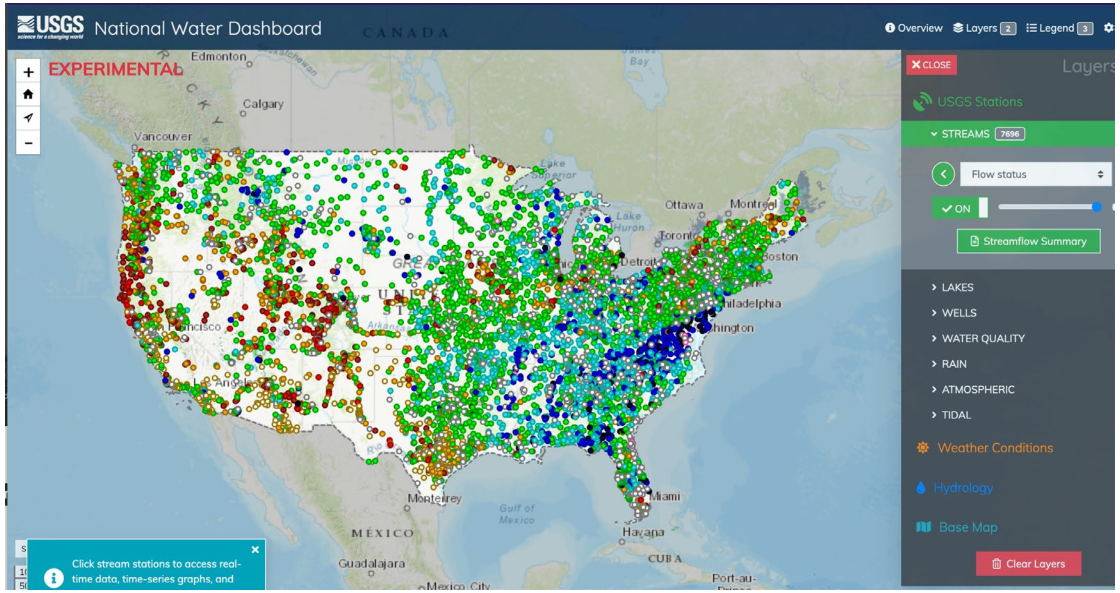


From Koch *et al.*, 2022

Research Objective #1
Findings & Implications

- Consider and integrate environmental data

- Recognize interacting demographic and phenotypic factors



Research Objective #2

Question

How can we successfully reintroduce salmon and steelhead to habitat that may have once supported sustainable populations?

Goal

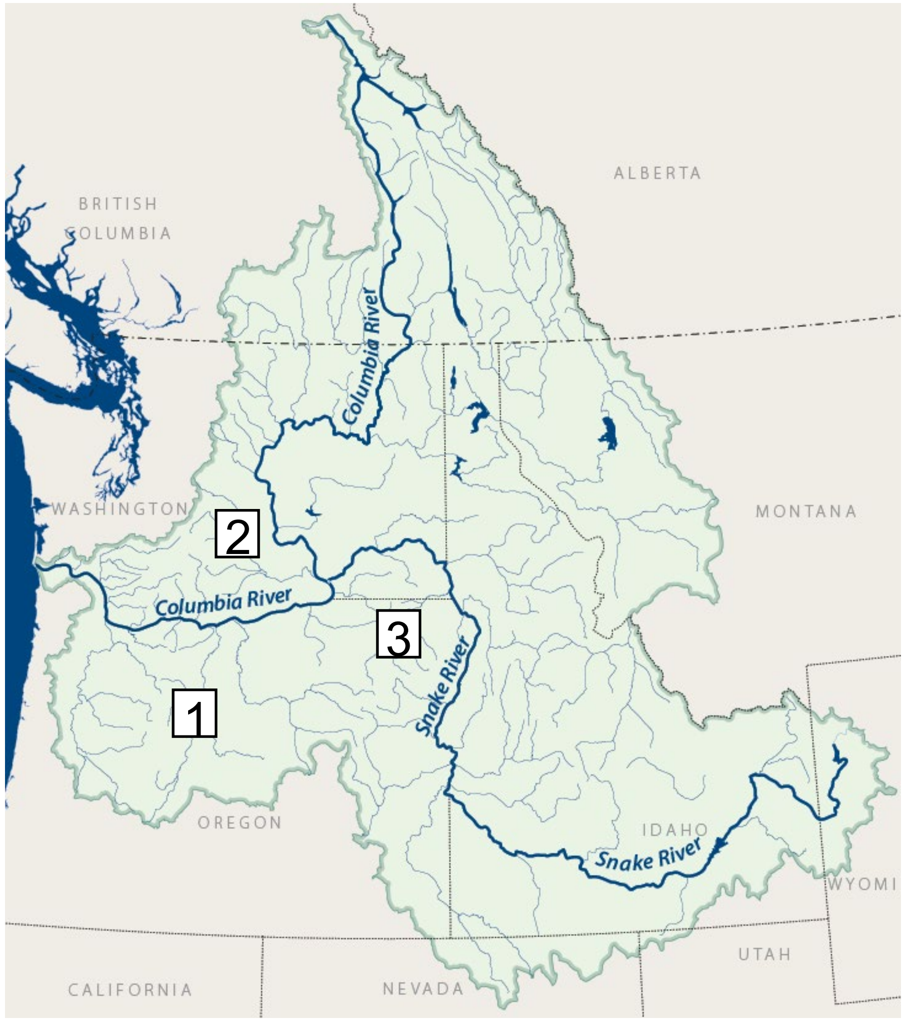
Provide program managers with data that qualifies the success of a reintroduction effort and isolate actions that facilitate long-term goals.

Research Objective #2
Studies

1. Deschutes River Basin – Genetic Stock Identification (GSI) for reintroduced sockeye salmon

2. Yakima River Basin – GSI and reproductive success of reintroduced sockeye salmon (*ongoing*)

3. Lookingglass Creek (Grande Ronde River Basin) – reproductive success of naturalized spring Chinook relative to hatchery-origin fish

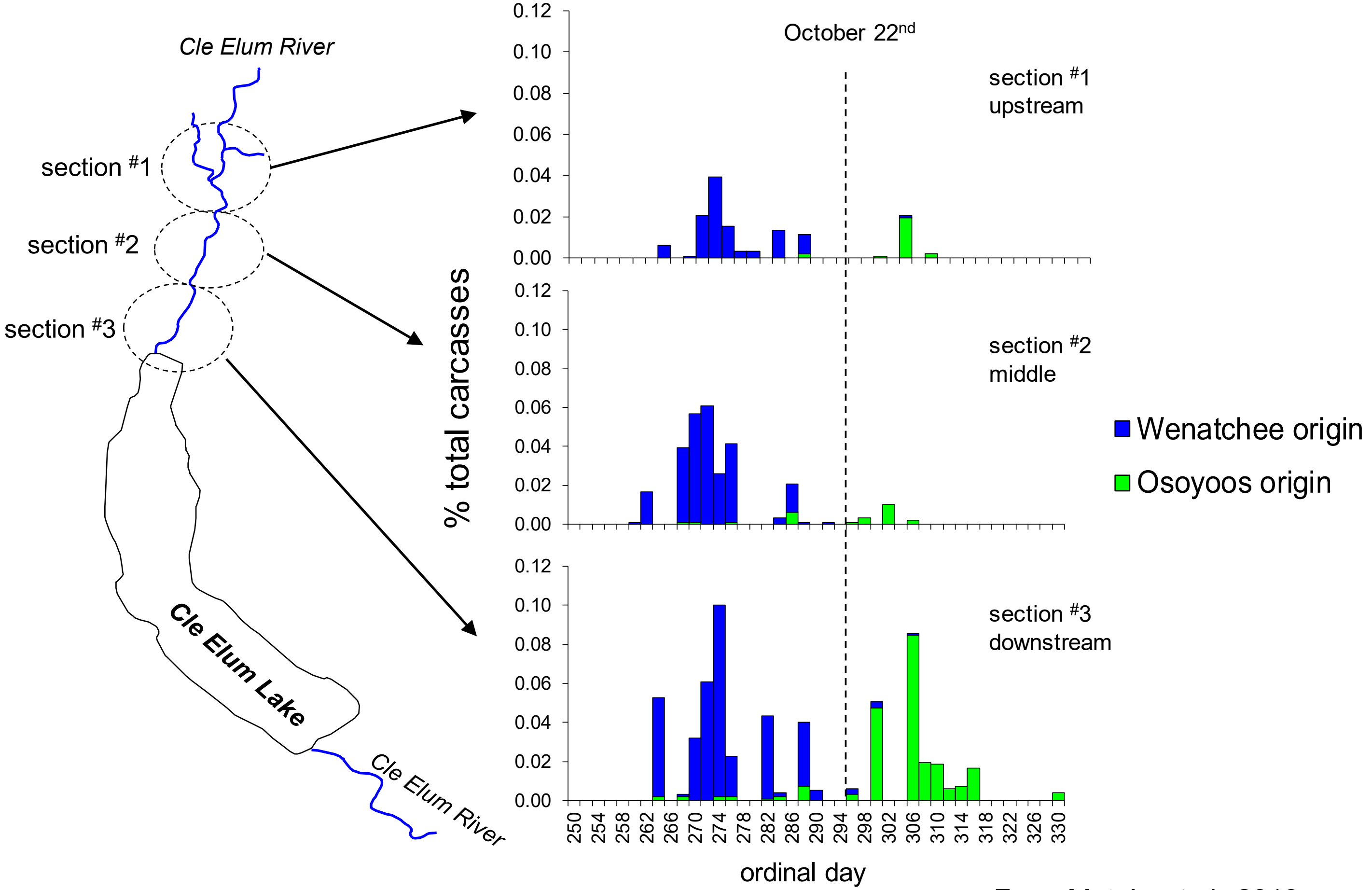


Research Objective #2

Findings & Implications

- Stock-specific life history may persist in non-natal (i.e., introduced) environment
- Progress of naturalization in different systems

Sockeye Carcass Recoveries – Cle Elum Lake



From Matala *et al.*, 2019

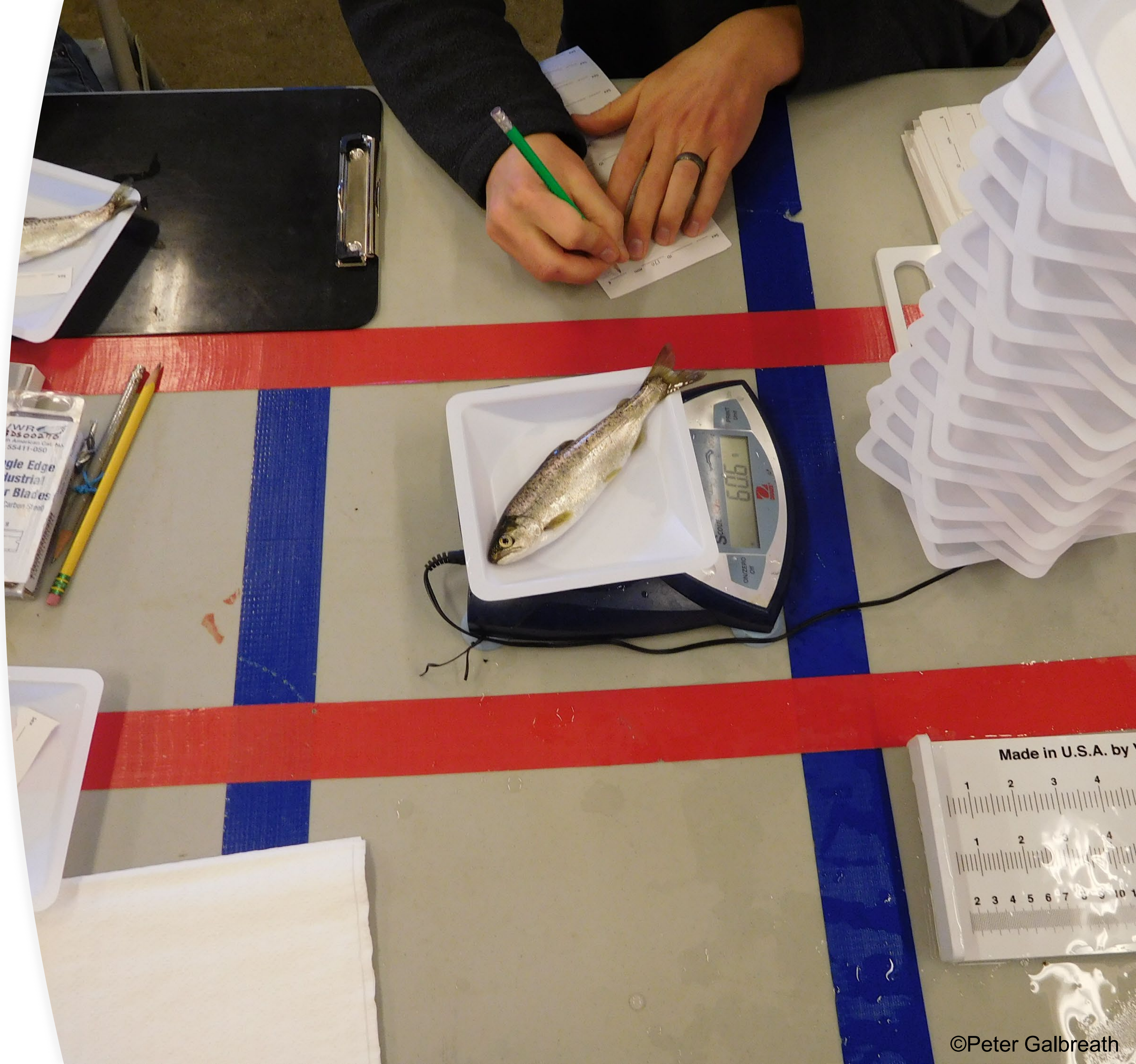
Research Objective #3

Question

How does hatchery rearing affect growth and fitness of fish? How do these physiological processes differ from their naturally-reared counterparts?

Goal

Provide hatchery managers with technical modifications that can be implemented within their production framework, and which help achieve conservation hatchery goals.



Research Objective #3
Studies

1. Effect of sire age on precocious maturation rates among male spring Chinook salmon

2. Effect of targeted feed deprivation on precocious maturation rates among male spring Chinook salmon

3. Effect of photoperiod manipulation on precocious maturation rates and smoltification among male spring Chinook salmon (*ongoing* – CESRF)

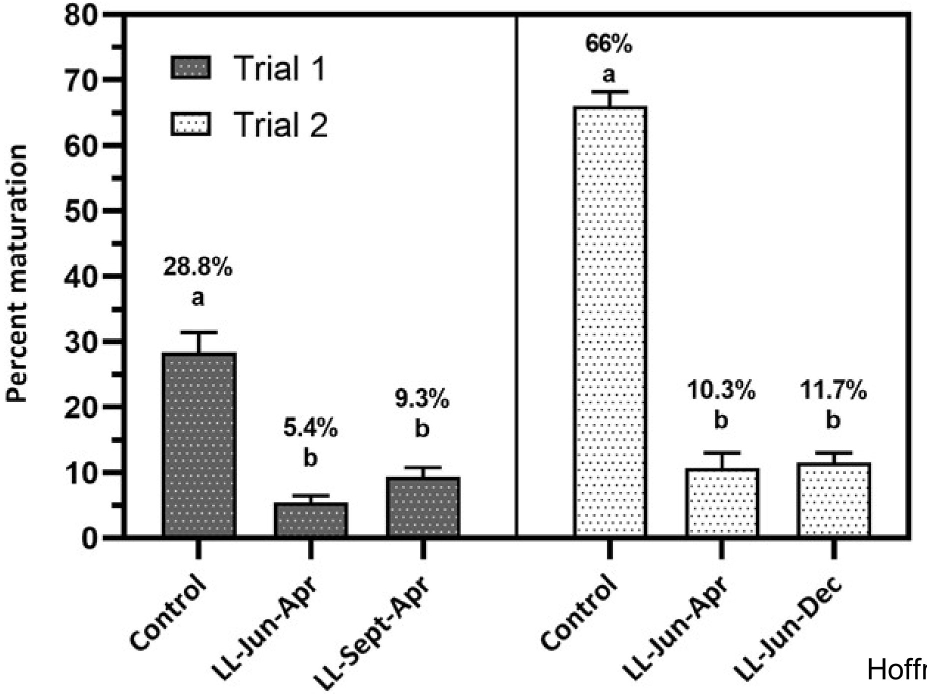
Cle Elum Supplementation & Research Facility – jointly operated by YN & WDFW

Aquaculture Research Institute – operated by the University of Idaho

Research Objective #3
Findings & Implications

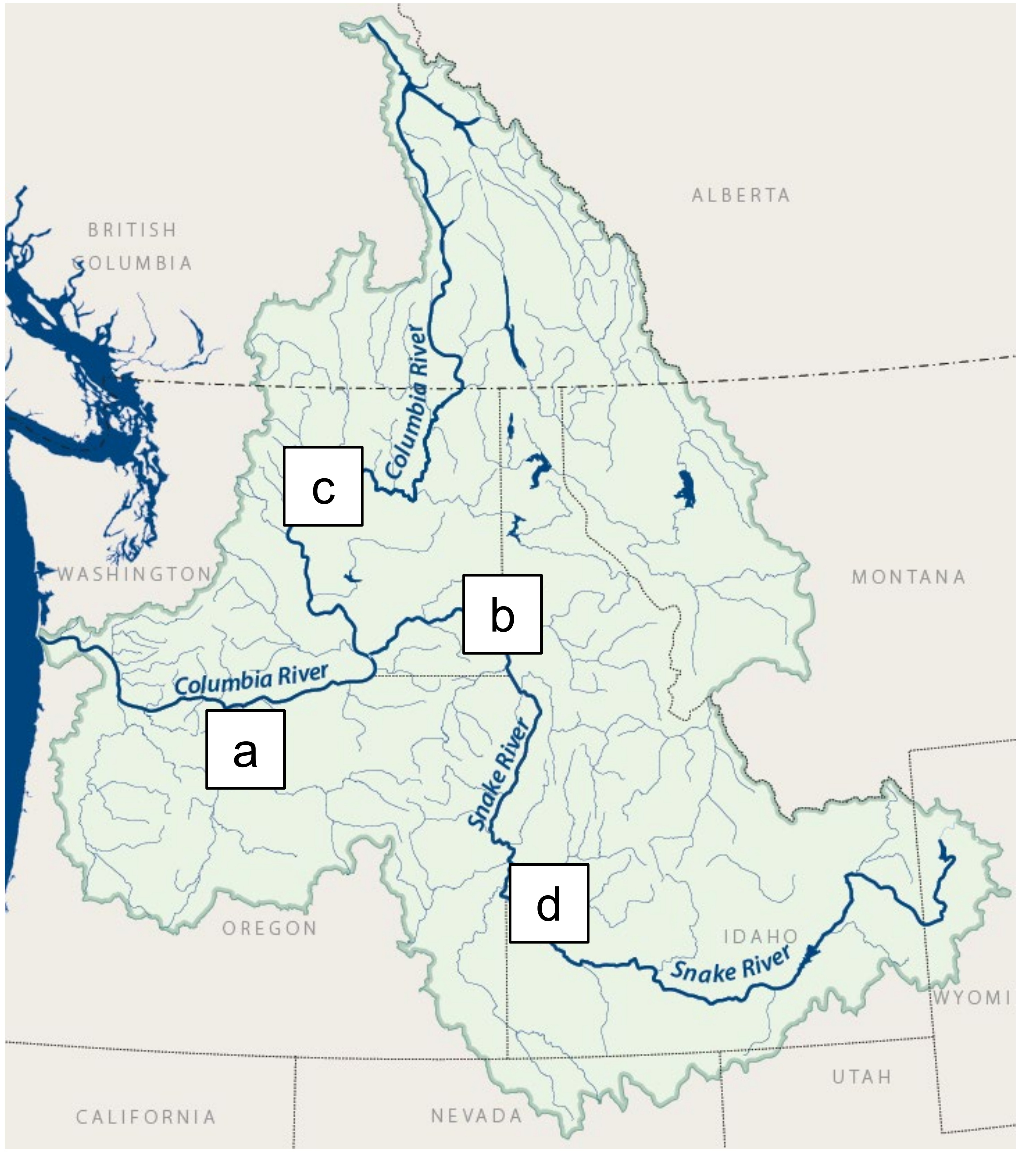
- Targeted periods of feed deprivation and photoperiod manipulation appear effective in reducing minijack rate

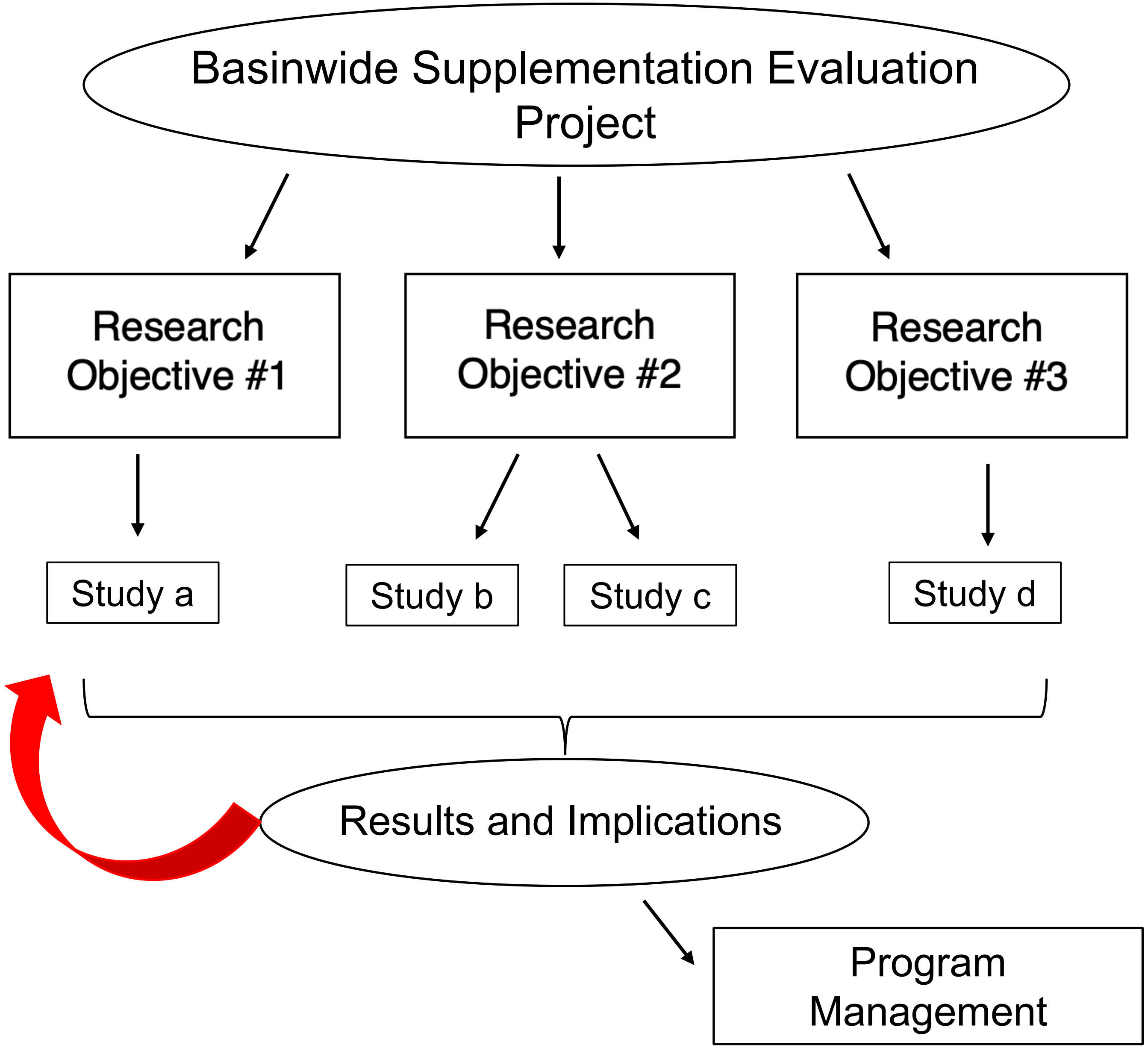
- Family effect but cannot be simply distilled to sire age



Hoffman *et al., 2023*

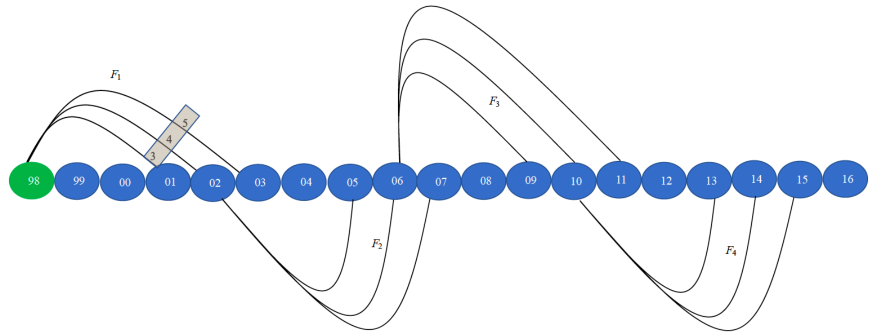
BSE Project - Structure



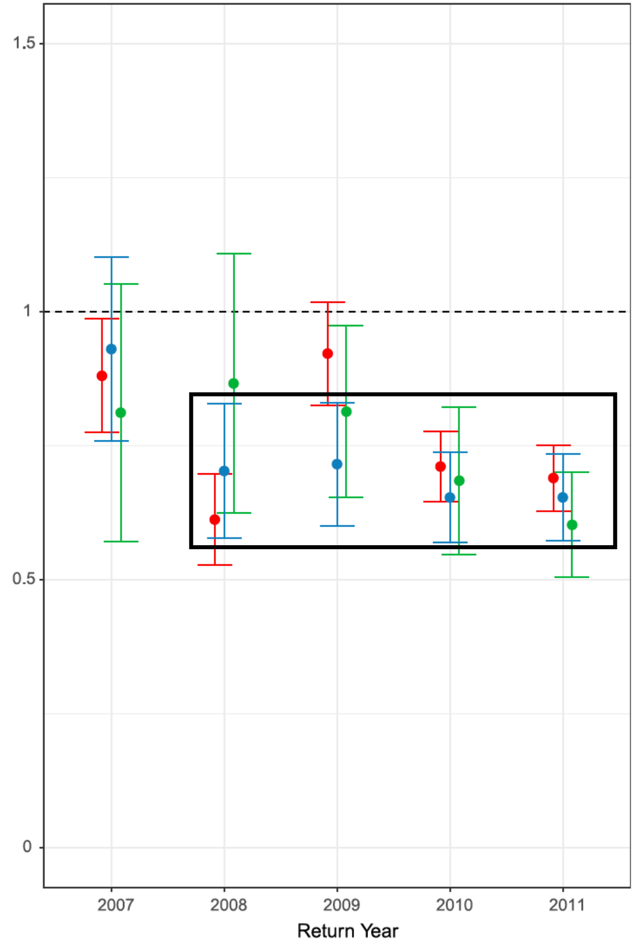


BSE Project – Lessons Learned

- Context is important
- Studies ideally progress over several generations
- Science informs management



Upper Yakima spring Chinook RRS



Questions?

The Progression of Naturalization: Using Parentage-Based Tagging to monitor the reintroduction of spring Chinook salmon to Lookingglass Creek, OR

H.M. Nuetzel[1], P. Galbreath[1], B. Staton[1], C.A. Crump[2], L. Naylor[2], G.E. Shippentower[2]

[1]Columbia River Inter-Tribal Fish Commission

[2]Confederated Tribes of the Umatilla Indian Reservation

DEFINITIONS

Reproductive Success (RS): The number of progeny attributed to any one individual; a proxy for fitness. A successful spawner is one that is attributed >0 progeny

Relative Reproductive Success (RRS): A comparison of reproductive success (RS) conditioned upon a demographic/phenotypic characteristic (i.e., origin, age).

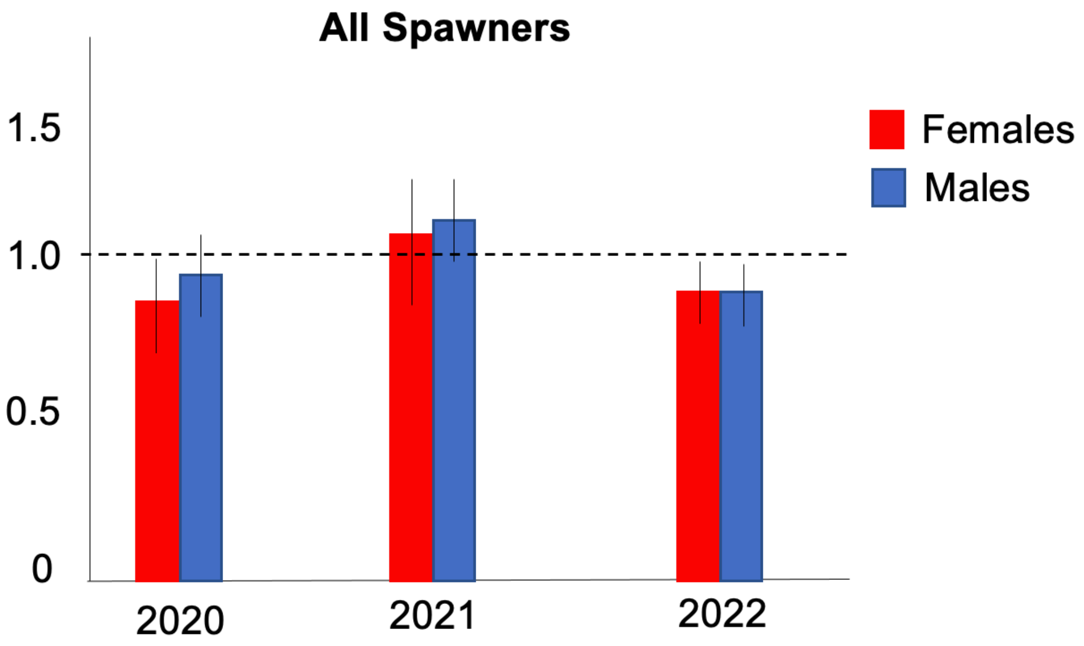
Hatchery-origin (HOR): An individual hatched in a hatchery

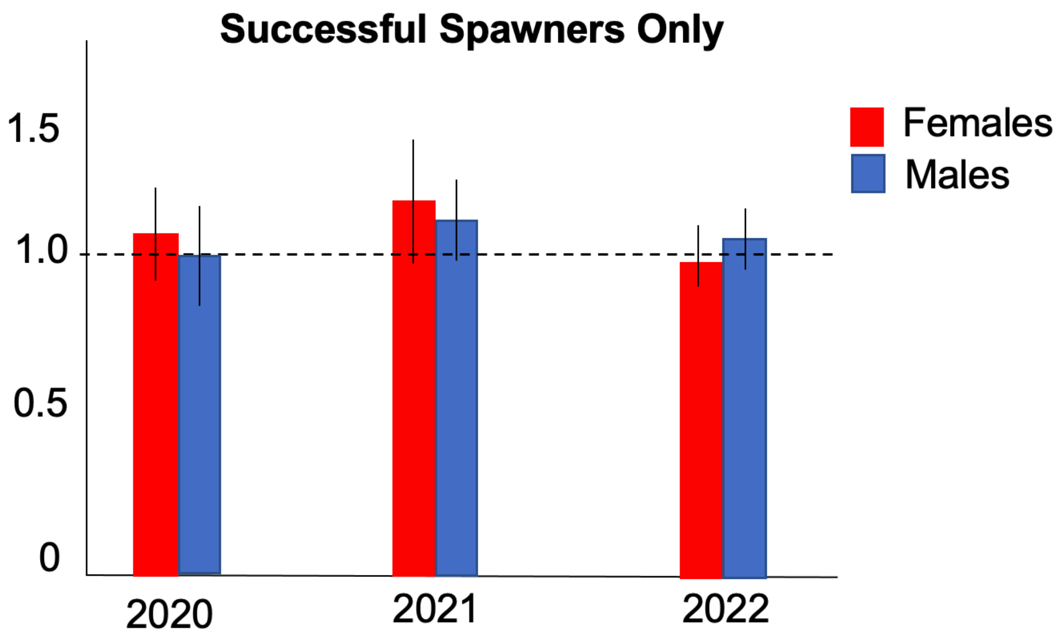
Natural-origin (NOR): An individual hatched in nature

Definitions

Calculating RRS

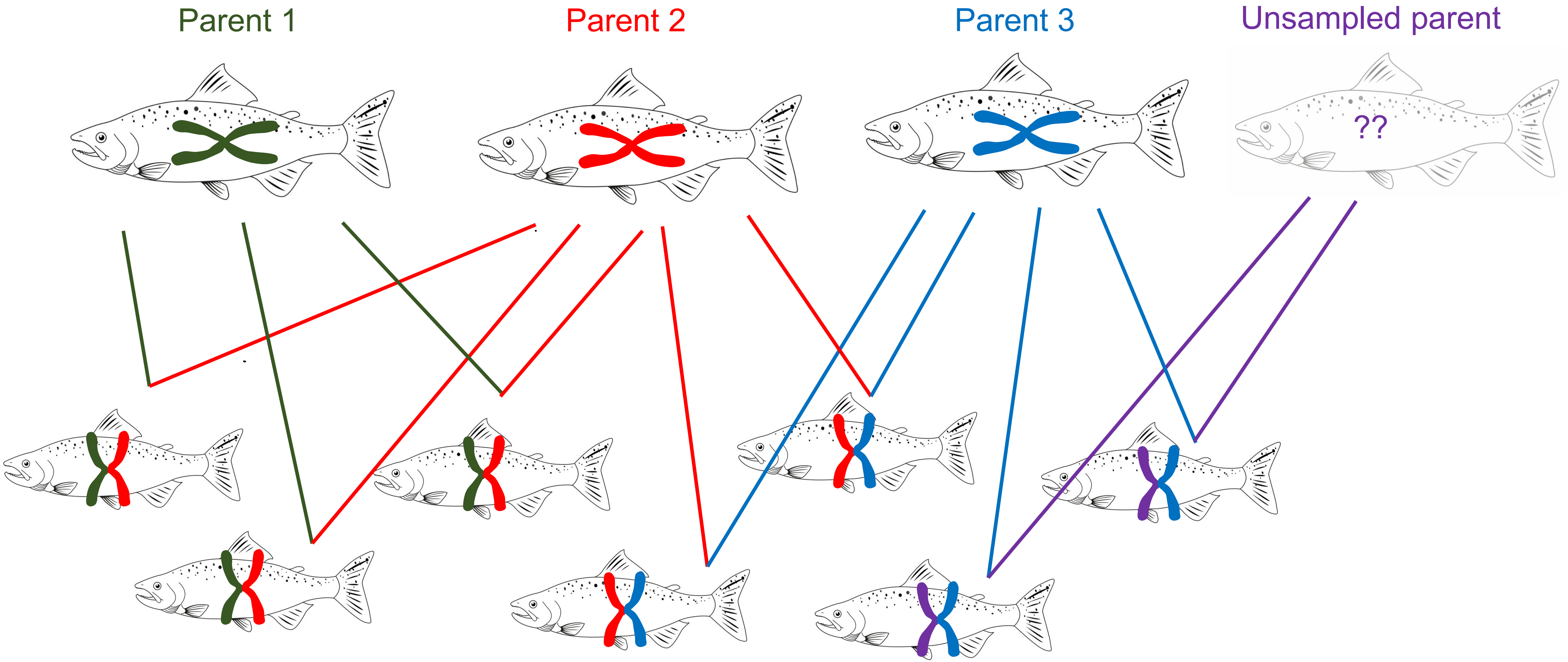
$$RRS = \frac{Avg\ RS\ of\ HOR\ fish}{Avg\ RS\ of\ NOR\ fish}$$

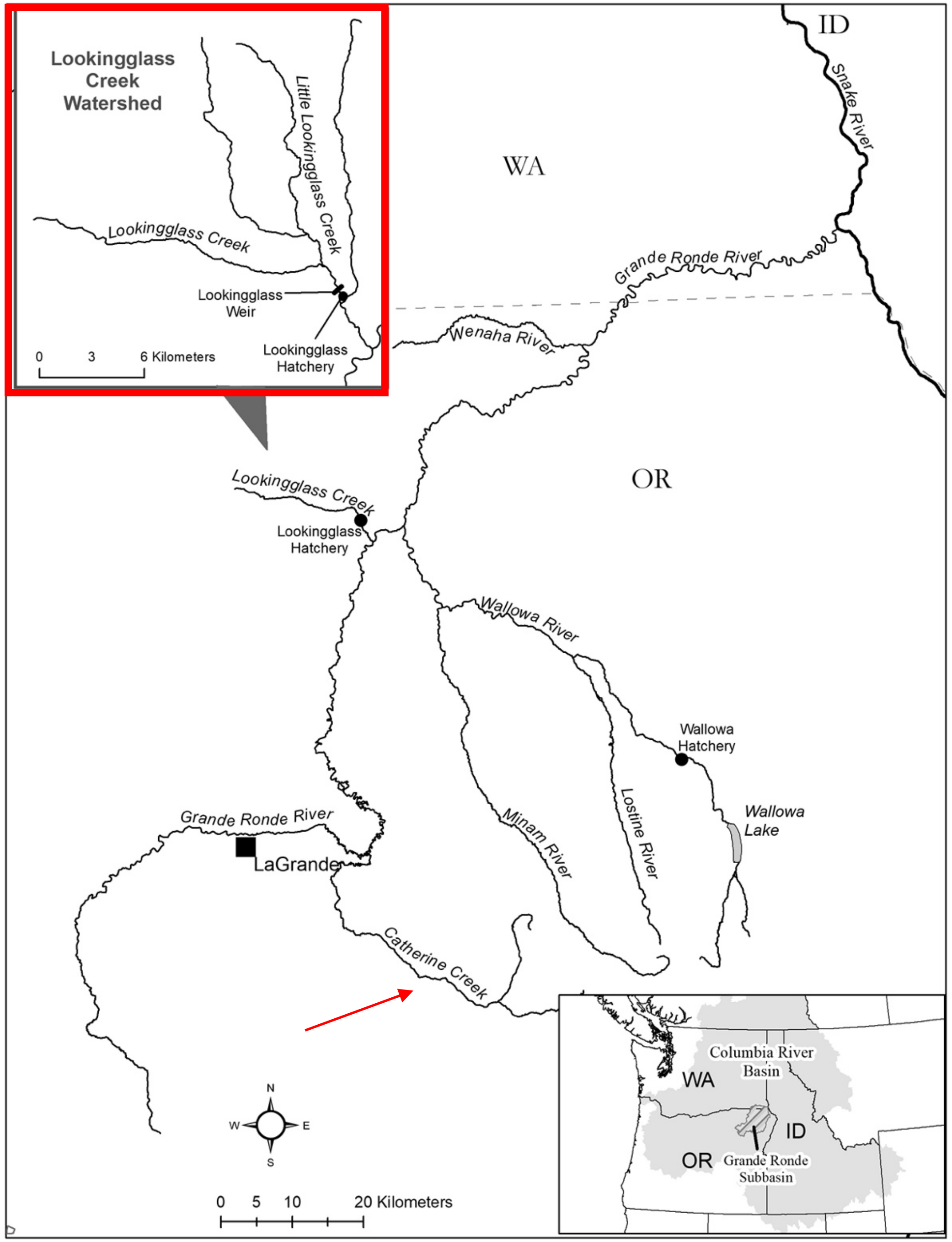




Definitions

Parentage-Based Tagging (PBT): a non-lethal tagging method that uses genetic data to infer familial relationships. These inferred parent-offspring relationships may indicate stock-of-origin, inform survival trends, estimate reproductive success, etc.



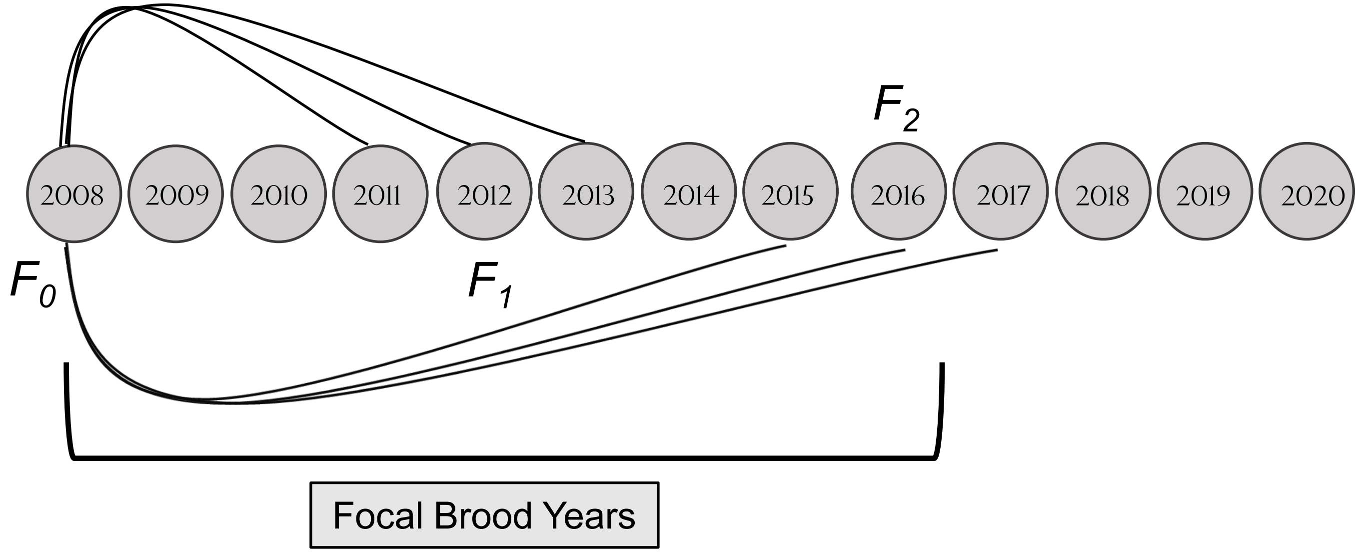


History

- 1956–1975: Construction of Lower Snake River Dams
- 1976: Lower Snake River Compensation Plan
- 1982: Lookingglass Hatchery
- 1992: ESA – Snake River spring/summer Chinook salmon
- 2001: First Catherine Creek (CC) captive brood released
- 2004: CC adults return
- 2008: First natural origin adults return since BY2000
- 2022: Relative Reproductive Success (RRS) study

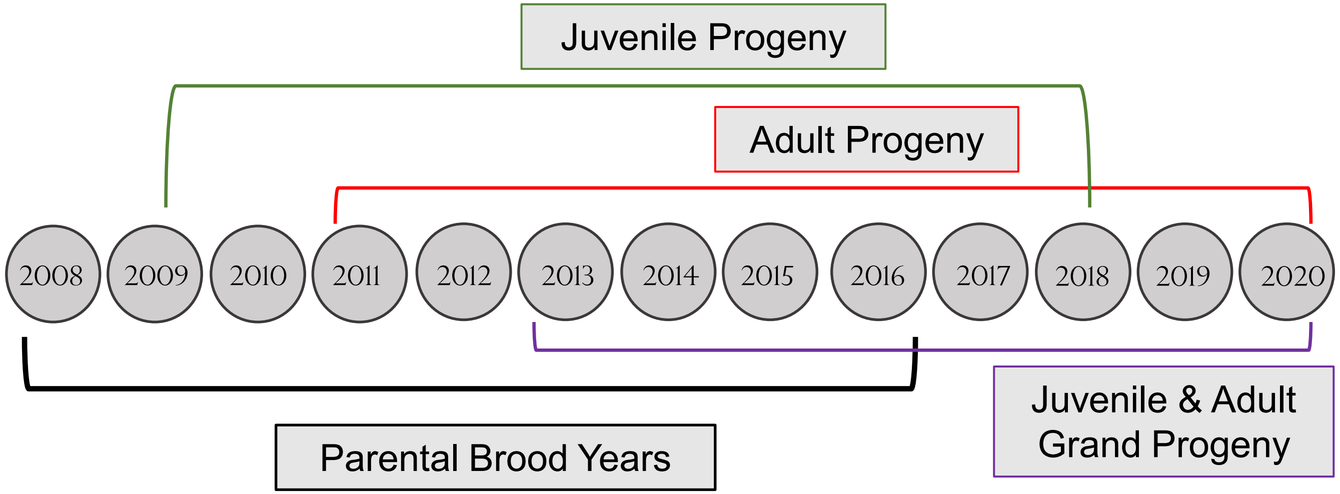
Study Design

Question: Do natural-origin (NOR) spring Chinook salmon experience greater reproductive success than their hatchery-origin (HOR) counterparts when spawning naturally in Lookingglass Creek?



Study Design

Question: Do natural-origin (NOR) spring Chinook salmon experience greater reproductive success than their hatchery-origin (HOR) counterparts when spawning naturally in Lookingglass Creek?

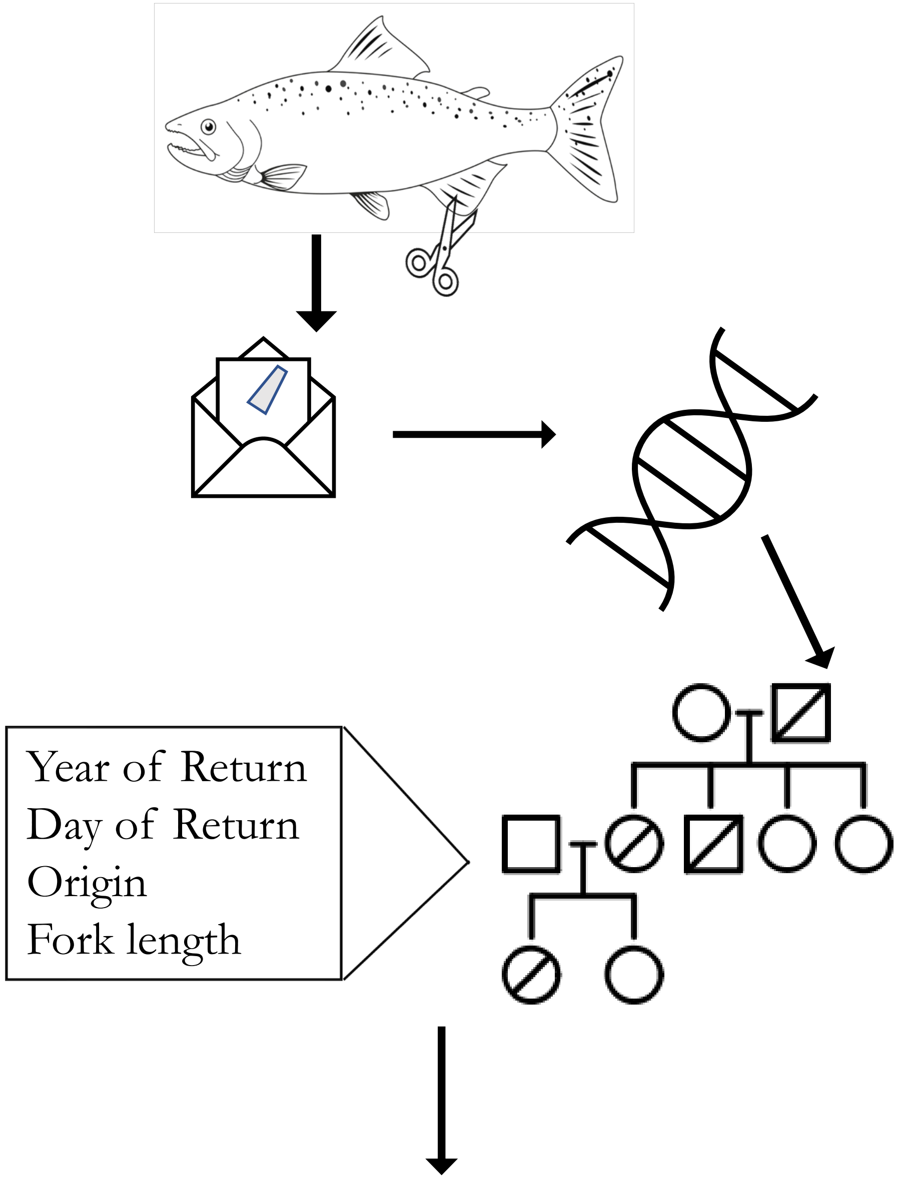


Methods

1. **Generate genotype data**
   a) DNA extraction by Qiagen & Chelex
   b) Amplification of 93 SNP markers by Gtseq

2. **Pedigree reconstruction**
   a) Reconstruct parent-offspring trios & single parent-offspring pairs

3. **Generalized Linear Modelling**
   a) Use parentage assignments & phenotypic data to predict reproductive success



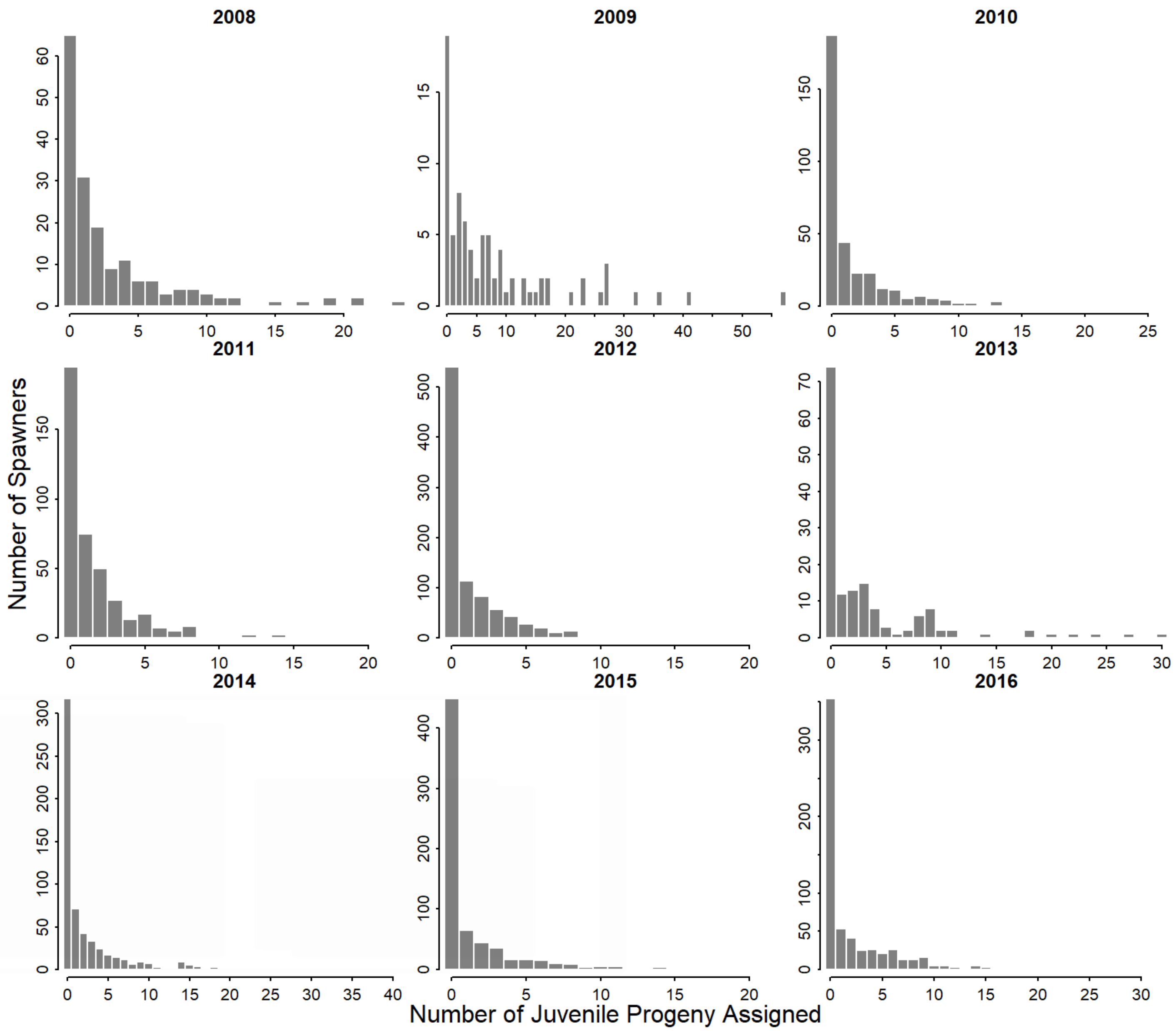
$RS \sim origin * sex * year + day * origin + length * origin + I(day^2)$

Results

- Individual Reproductive Success

Avg. Proportion Natural Spawners Assigned ≥ 1 progeny

	HOR	NOR
Male	54.37%	64.05%
Female	56.58%	64.21%

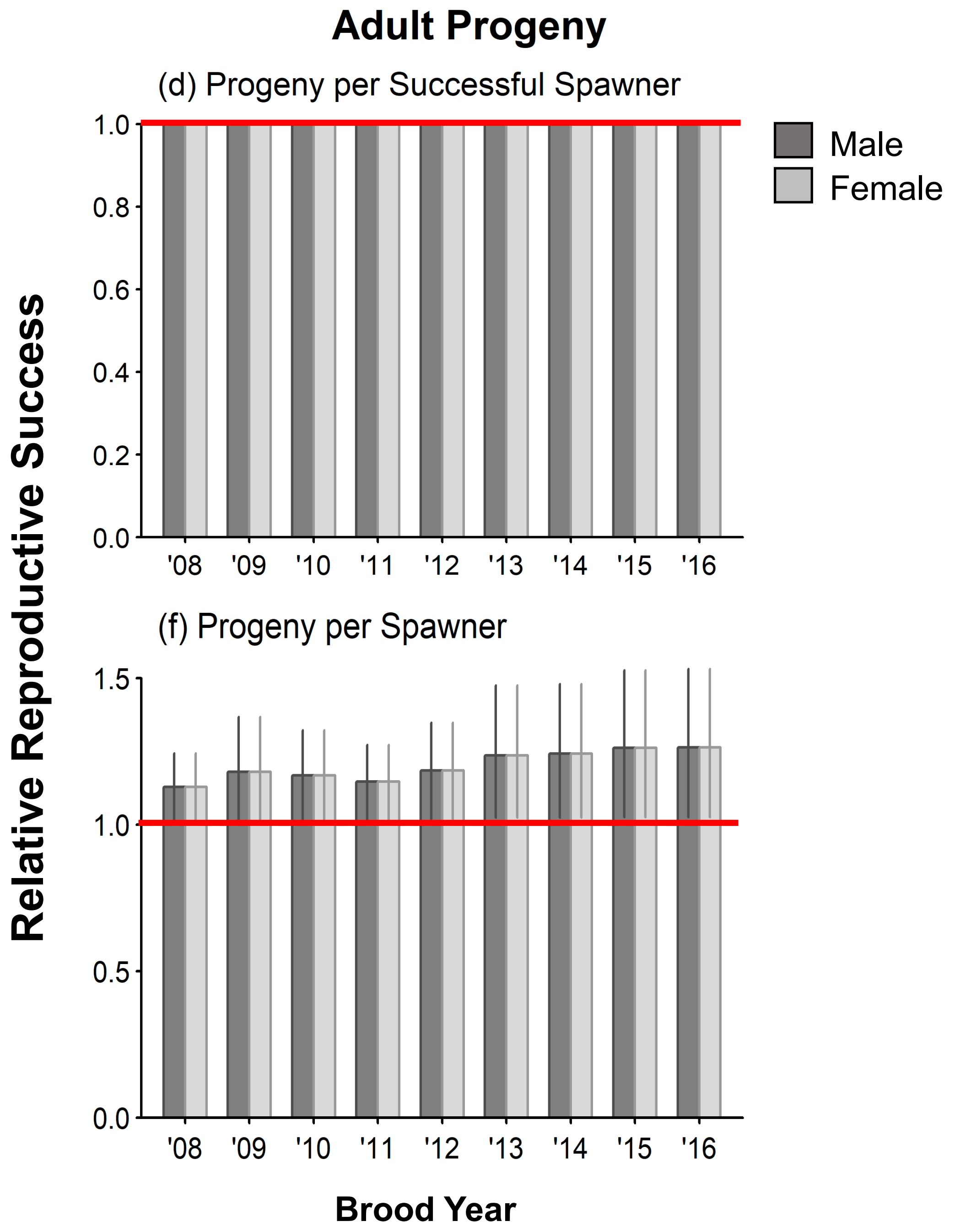


Results

- RRS by Individual Origin
  - Relative Reproductive Success (RRS) expectations by origin given **adult progeny**

$$RRS = \frac{NOR\ RS}{HOR\ RS}$$

  - Top Model identified following covariates as important to predictions:
    - Origin
    - Sex
    - Year

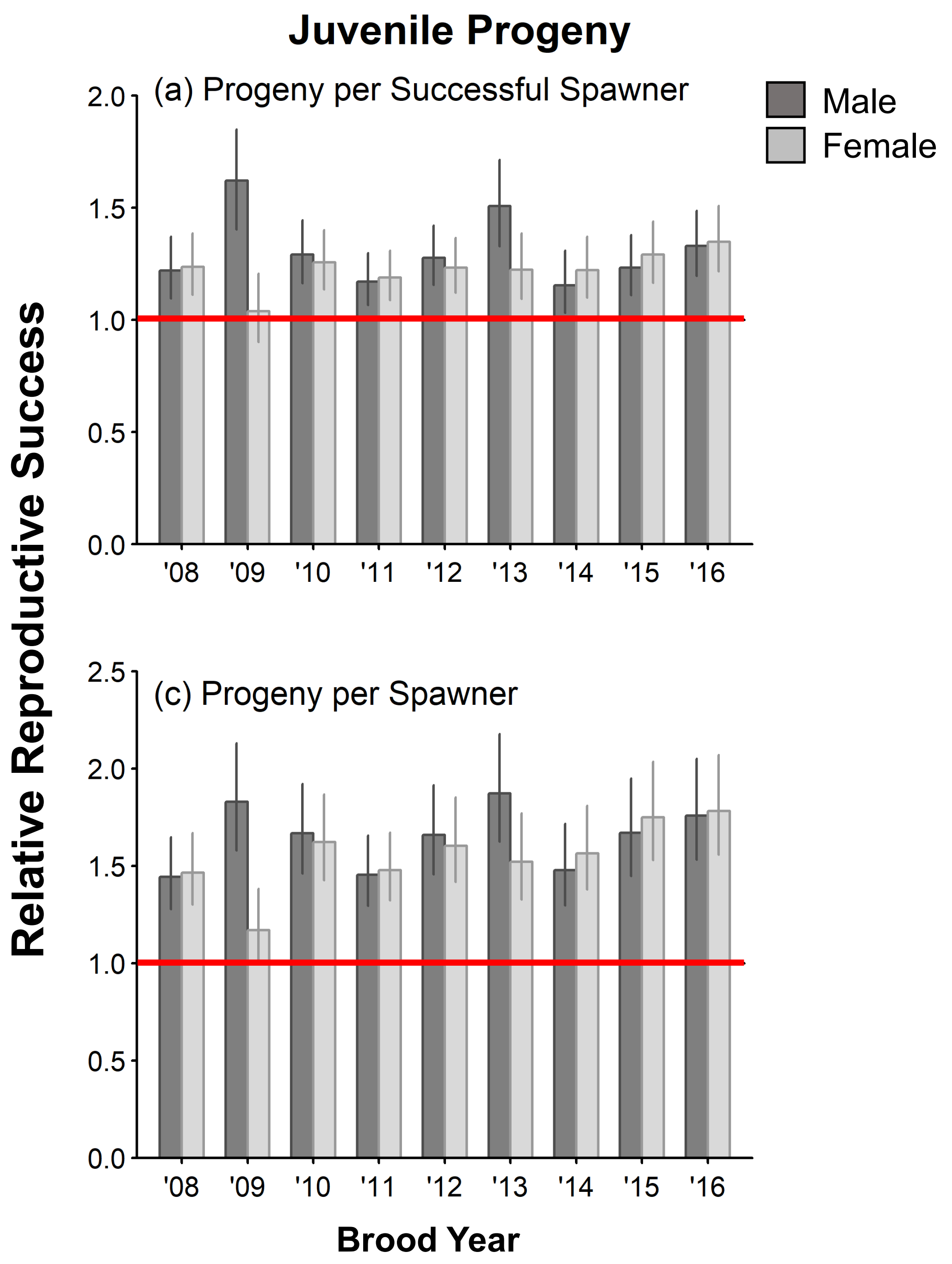


Results

- RRS by Individual Origin
  - Relative Reproductive Success (RRS) expectations by origin given **juvenile progeny**

$$RRS = \frac{\text{NOR RS}}{\text{HOR RS}}$$

  - Top Model identified following covariates as important to predictions:
    - Day
    - Length
    - Origin
    - Sex
    - Year

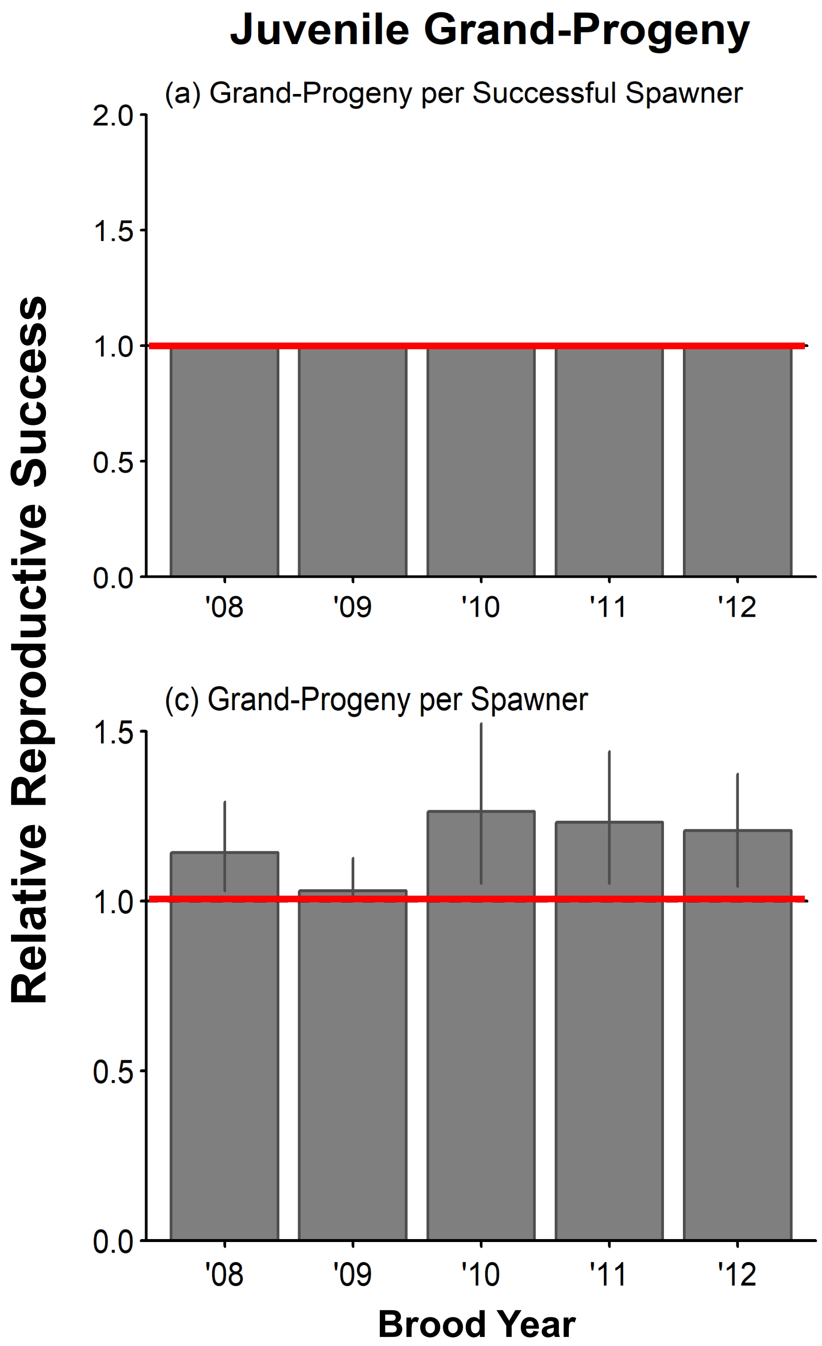


Results

- RRS by Individual Origin
  - Relative Reproductive Success (RRS) expectations by origin given **grand-progeny**

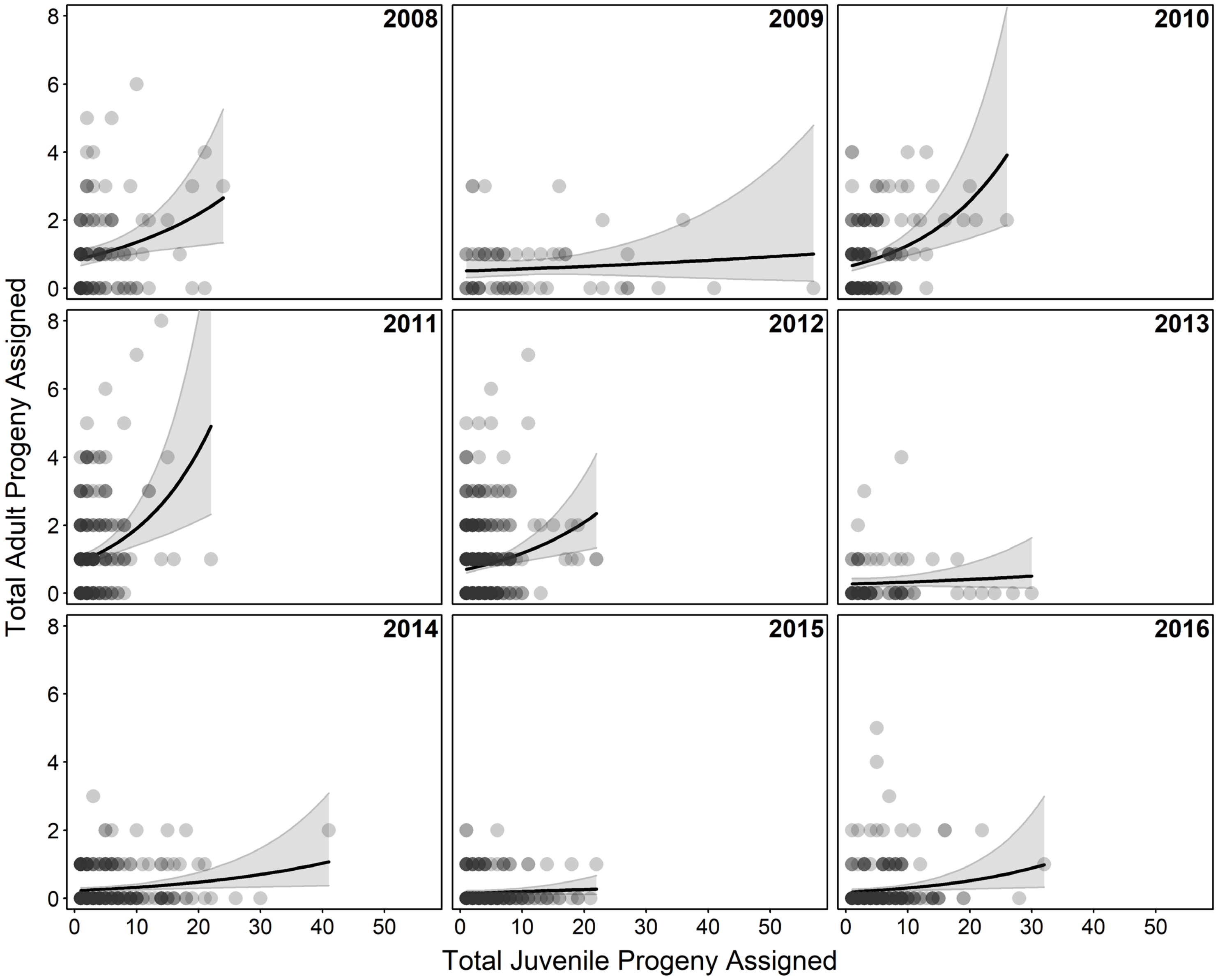
$$RRS = \frac{NOR\ RS}{HOR\ RS}$$

  - Top Model identified following covariates as important to predictions:
    - Origin
    - Year



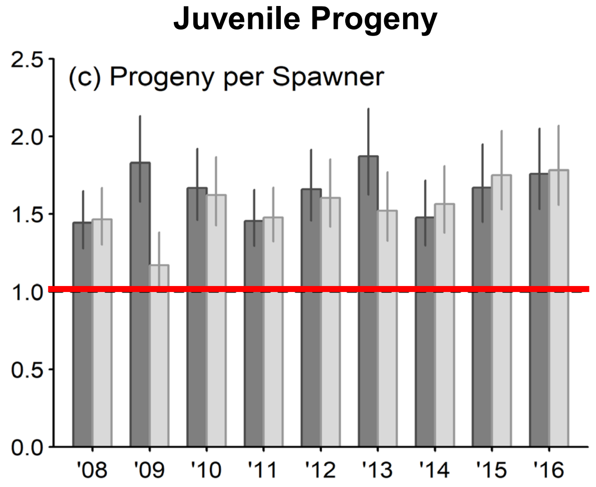
Results

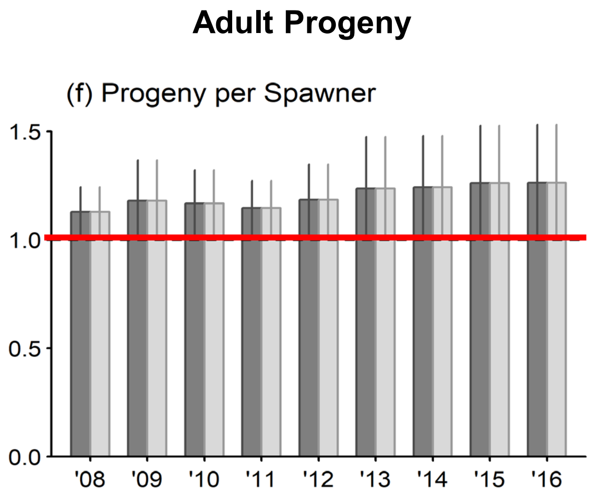
- Juvenile to Adult Progeny
  - Is individual RS given juvenile progeny relational to RS given adult progeny?
  - Some relationship but significant variability

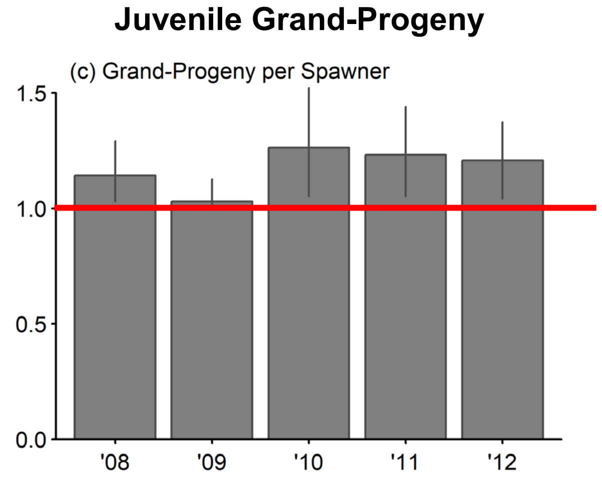


Synthesis & Interpretation

- Individual NOR fish demonstrate higher RS than HOR
  - Less pronounced across two generations



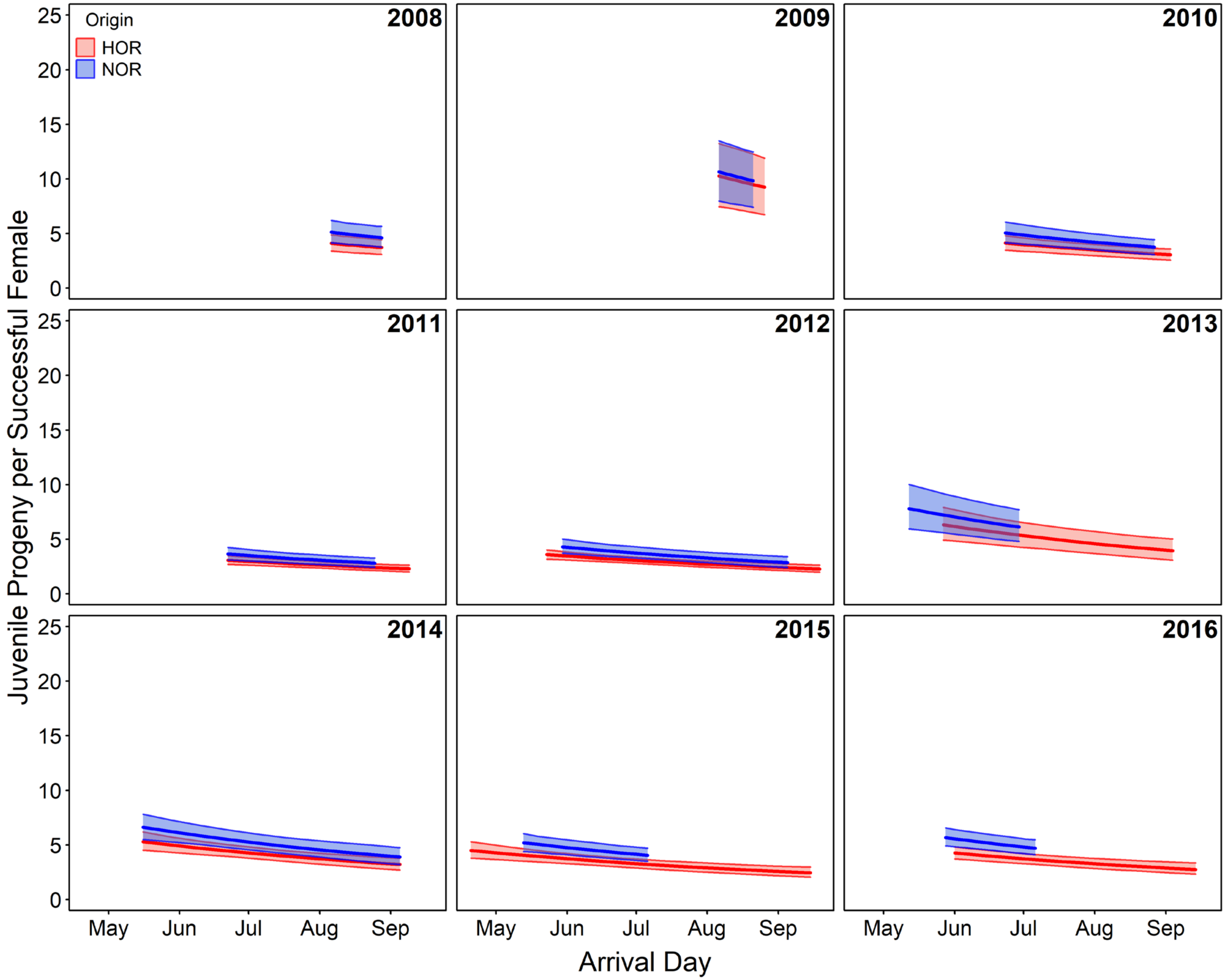




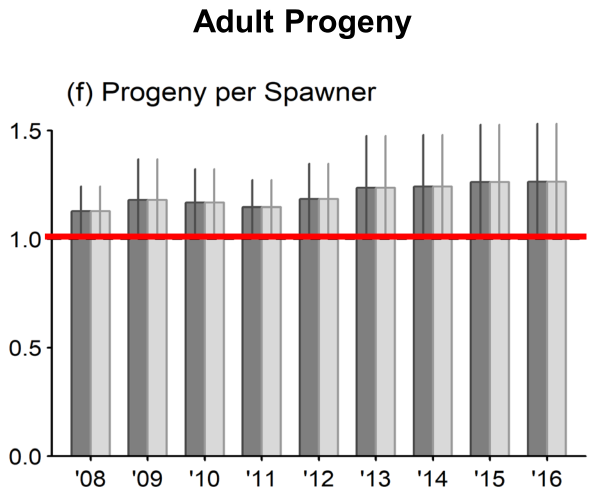
Synthesis & Interpretation

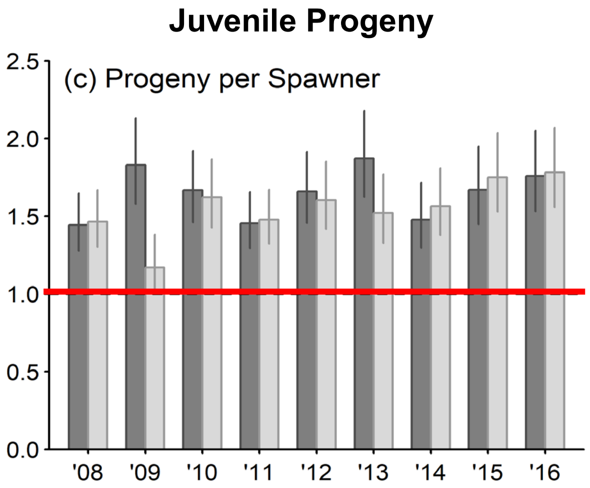
- Juvenile progeny produced is not necessarily predictive of adult progeny produced
  - RRS inference was the same

- RRS comparisons given adult v. juvenile progeny may provide unique insights



Conclusions





Acknowledgements

The Bonneville Power Administration for providing funding under agreements reached within the Columbia Basin Fish Accords (Project 2009-009-00).

The Lower Snake River Compensation Plan for providing funding for work associated with the evaluation of the reintroduction of spring Chinook to Lookingglass Creek.

Bureau of Reclamation Internship program for supporting summer field technicians over the last five years.

Columbia River Inter-Tribal Fish Commission

Zachary Penney, Doug Hatch and Shawn Narum for administrative and scientific support. All the lab technicians at the Hagerman Fish Culture Experiment Station for generating genetic data.

Confederated Tribes of the Umatilla Indian Reservation

Mike McClean (Project Biologist) for his assistance reviewing and interpreting years of metadata logs. All the field technicians that have collected innumerable tissue samples throughout the years.

Oregon Department of Fish & Wildlife

Diane Deal (Lookingglass Hatchery Manager), Andrew Gibbs (East Region Hatchery Coordinator) & Joseph Feldhaus (RME Project Lead)

Contact: hnuetzel@critfc.org

QUESTIONS?

GLM Output Given Juvenile and Adult Progeny

Progeny Type	Hurdle Model Component		AIC$_c$ Output		
	Conditional	Zero	K	ΔAIC$_c$	Weight
Juvenile	day + length + origin + sex + year	origin + sex + year + sex:year	33	0.00	0.13
	day + length + origin + sex + year + length:origin	origin + sex + year + sex:year	34	0.68	0.10
	day + length + origin + sex + year + sex:year	origin + sex + year + sex:year	41	0.78	0.09
	day + length + origin + year	origin + sex + year + sex:year	32	1.07	0.08
	day + length + origin + sex + year	**origin + year**	**24**	**1.23**	**0.07**
	day + length + origin + sex + year + length:origin + sex:year	origin + sex + year + sex:year	42	1.34	0.07
	day + length + origin + sex + year + day:origin	origin + sex + year + sex:year	34	1.36	0.07
	day + length + origin + sex + year	origin + sex + year + origin:year + sex:year	41	1.53	0.06
	day + length + origin + year + length:origin	origin + sex + year + sex:year	33	1.61	0.06
	day + length + origin + sex + year	origin + sex + year	25	1.71	0.06
	day + length + origin + sex + year + day:origin + length:origin	origin + sex + year + sex:year	35	1.76	0.06
	day + length + origin + sex + year + length:origin	origin + year	25	1.90	0.05
	day + length + origin + sex + year + sex:year	origin + year	32	1.94	0.05
	day + length + origin + sex + year	origin + sex + year + origin:sex + sex:year	34	1.98	0.05
Adult	length + sex + year + sex:year	origin + year	30	0.00	0.25
	sex + year + sex:year	**origin + year**	**29**	**0.50**	**0.20**
	day + length + sex + year + sex:year	origin + year	31	0.76	0.17
	day + sex + year + sex:year	origin + year	30	1.10	0.15
	length + sex + year + sex:year	origin + sex + year	31	1.34	0.13
	sex + year + sex:year	origin + sex + year	30	1.84	0.10

GLM Output Given Juvenile and Adult Grand-Progeny

Progeny Type	Hurdle Model Component		AIC$_c$ Output		
	Conditional	Zero	K	ΔAIC$_c$	Weight
Juvenile	**Intercept only**	**origin + year**	**8**	**0.00**	**0.62**
	origin	origin + year	9	0.99	0.38
Adult	**year**	**origin + year**	**11**	**0.00**	**0.50**
	origin + year + origin:year	origin + year	16	0.90	0.32
	origin + year	origin + year	12	1.99	0.18

RESULTS

- RRS by Cross Type
  - RRS expectations by Parental Cross Type

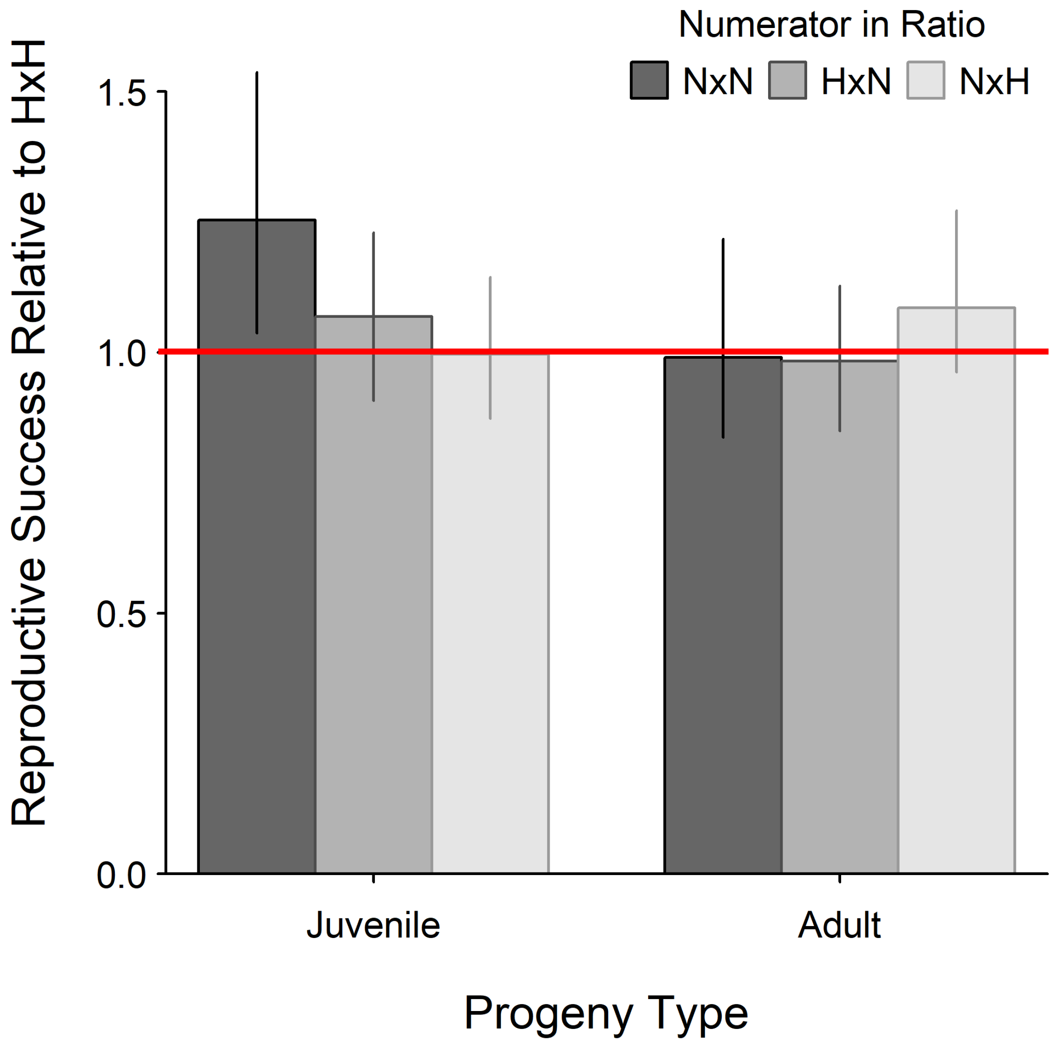
NxN = NOR male x NOR female

HxN = HOR male x NOR female

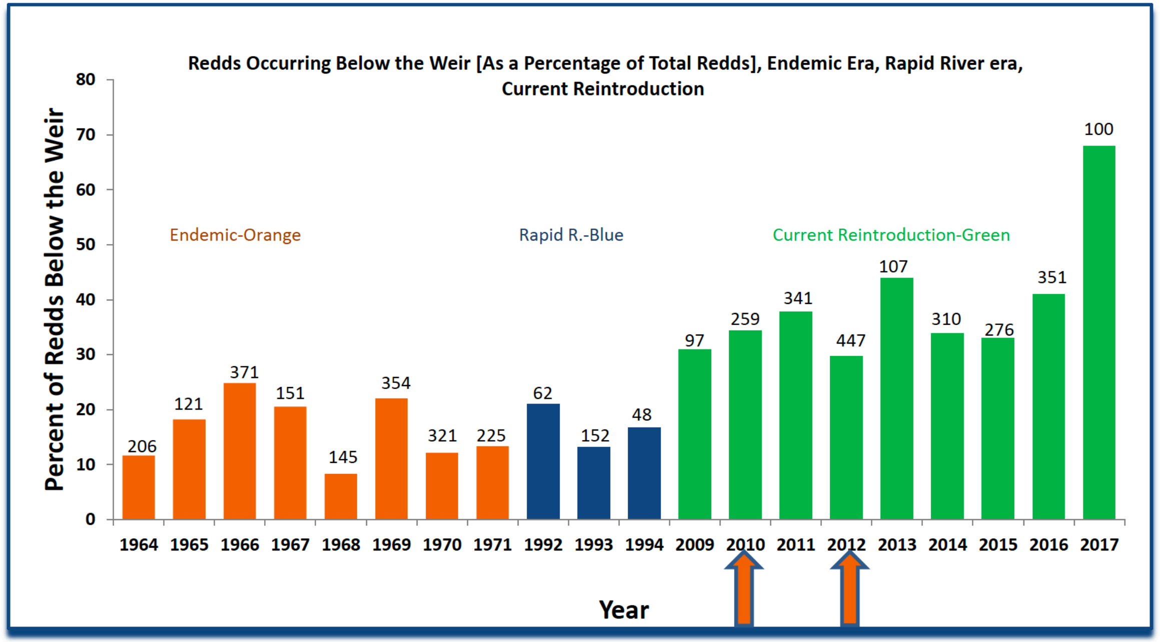
NxH = NOR male x HOR female

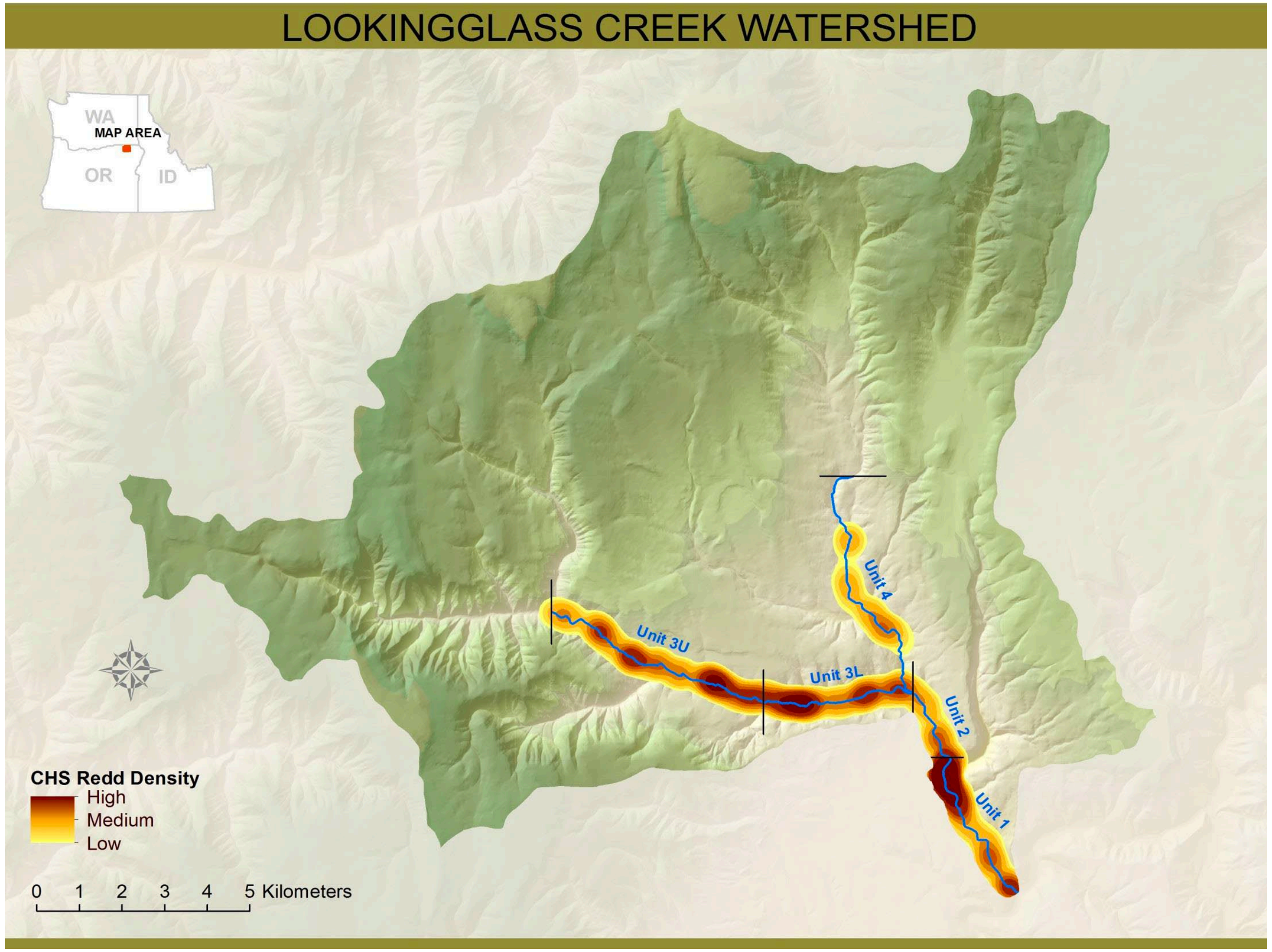
HxH = HOR male x HOR female

$$\textbf{RRS} = \frac{NxN\ RS}{HxH\ RS} \text{ or } \frac{HxN\ RS}{HxH\ RS} \text{ or } \frac{NxH\ RS}{HxH\ RS}$$

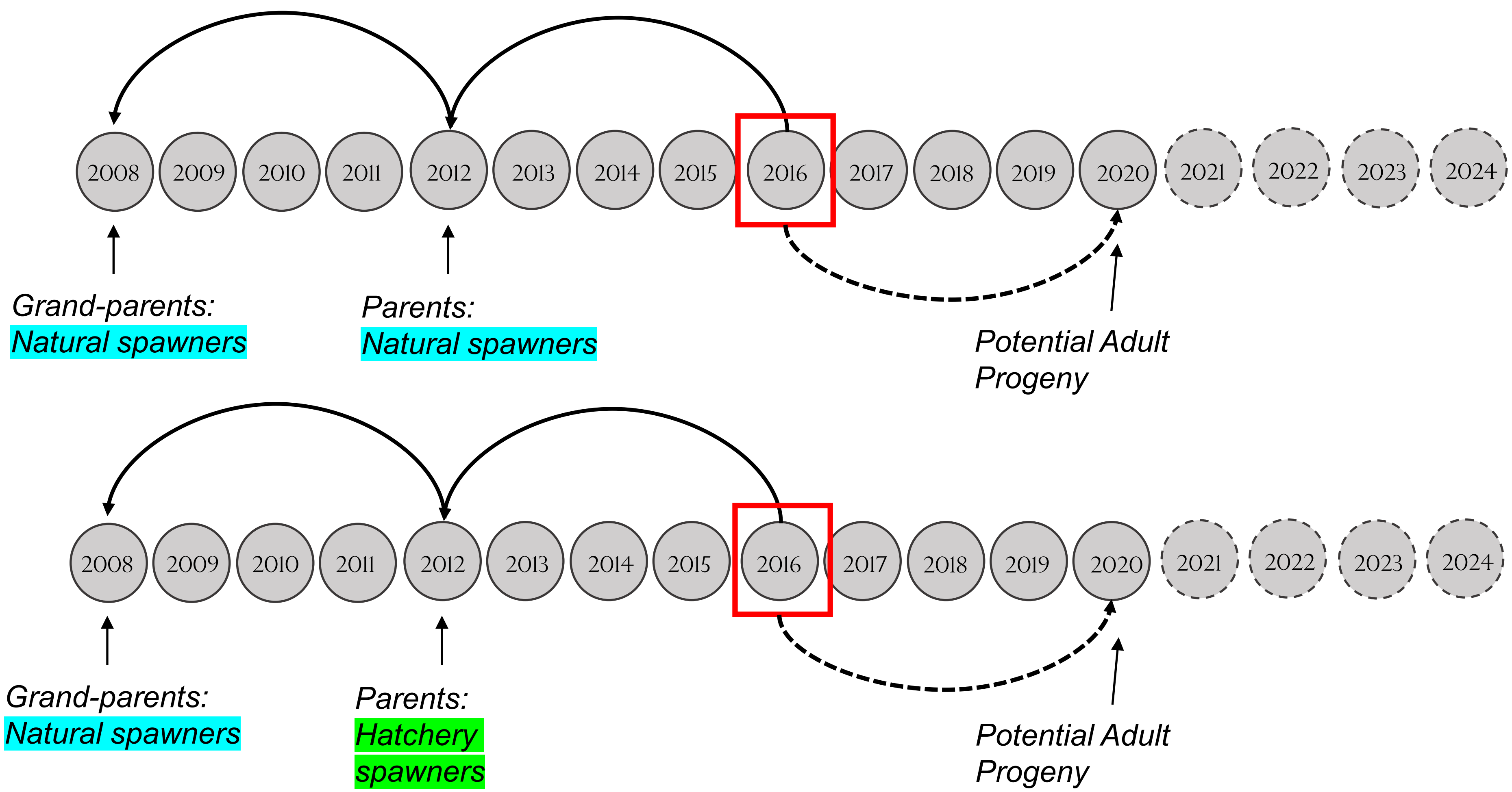


SPAWNING DISTRIBUTION PATTERNS



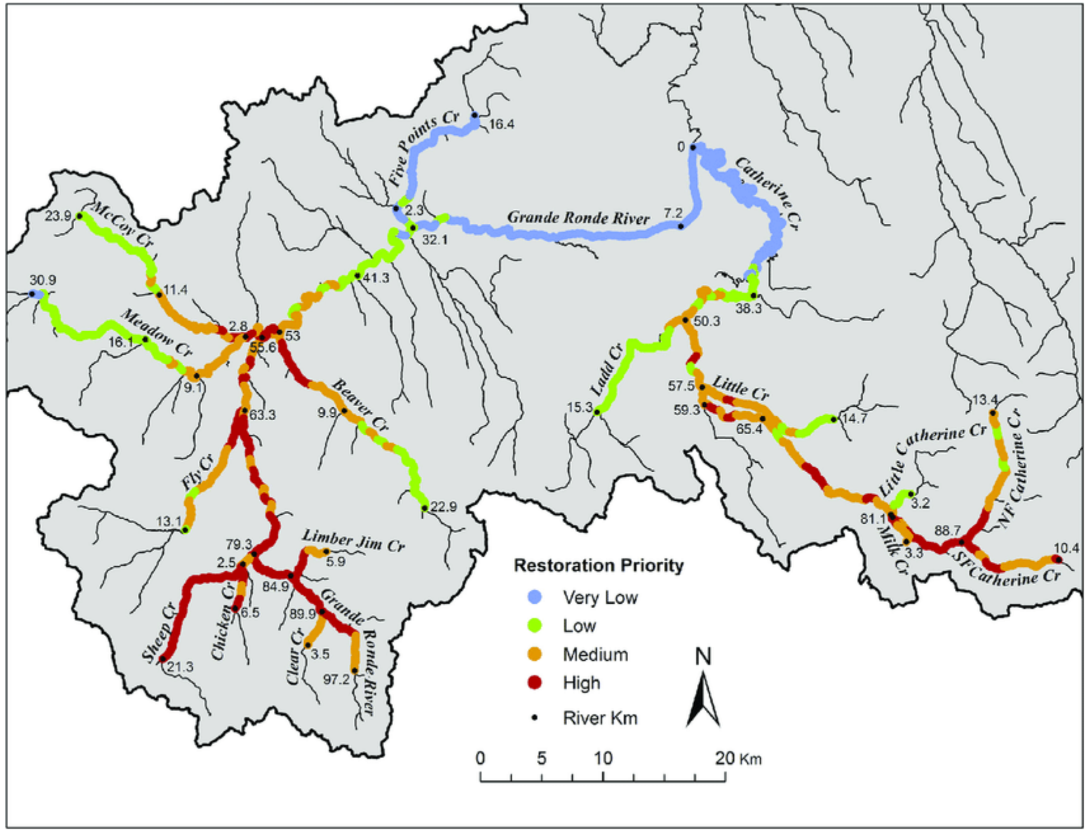


FUTURE DIRECTIONS



FUTURE DIRECTIONS

- Basinwide population structure
  - Endemic populations
  - Straying between populations



From Justice et al., 2016