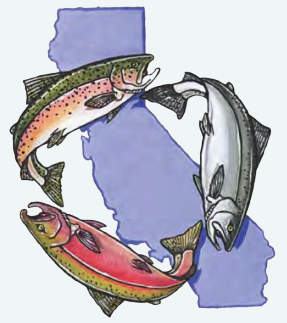


# Springing into Action: Spring-Run Chinook Reintroduction in the Klamath Basin Post Dam Removal



A Concurrent Session at the 43<sup>rd</sup> Annual Salmonid Restoration Conference  
Santa Cruz, California, April 29 - May 2, 2025

## **Session Coordinators:** Shari Anderson, Lazuli Ecological Services, and Craig Tucker, Suits and Signs Consulting



Following the largest dam removal project in U.S. history, Klamath Basin partners are preparing for the reintroduction of spring-run Chinook salmon, potentially the Basin's most historically abundant run. Achieving a resilient, self-sustaining population will require collaboration among Tribal nations, agencies, landowners, NGOs, and the scientific community. This session will bring together diverse perspectives to share knowledge, examine challenges, and explore pathways for successful reintroduction in the Upper Klamath Basin.

This session will convene State and Federal agency staff, scientists, and Tribal representatives to examine the implementation of active spring-run Chinook reintroduction in the Upper Klamath Basin. The discussion will begin with a review of reintroduction plans developed prior to dam removal, followed by presentations from leading researchers on habitat use and genetics. Topics will include the importance of preserving the unique genetics associated with early run timing, the role of habitat exclusivity in future restoration strategies, and considerations for identifying appropriate brood stock.

Tribal representatives will discuss how emerging science aligns with Traditional Ecological Knowledge, deepening our understanding of the diverse life history strategies expected as spring-run Chinook repopulate the Basin. The session will also highlight new monitoring data from recent experimental smolt releases, exploring how observed fish movements and habitat use can inform restoration priorities to support successful repopulation of the Upper Klamath Basin.

After hearing from the diverse set of speakers, we will facilitate dialogue in a panel discussion that allows open conversation with the audience. We expect the conversation to be energetic and informative given the developing nature of the reintroduction strategy.

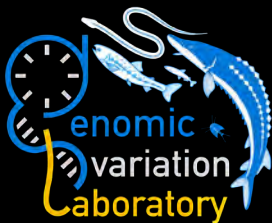
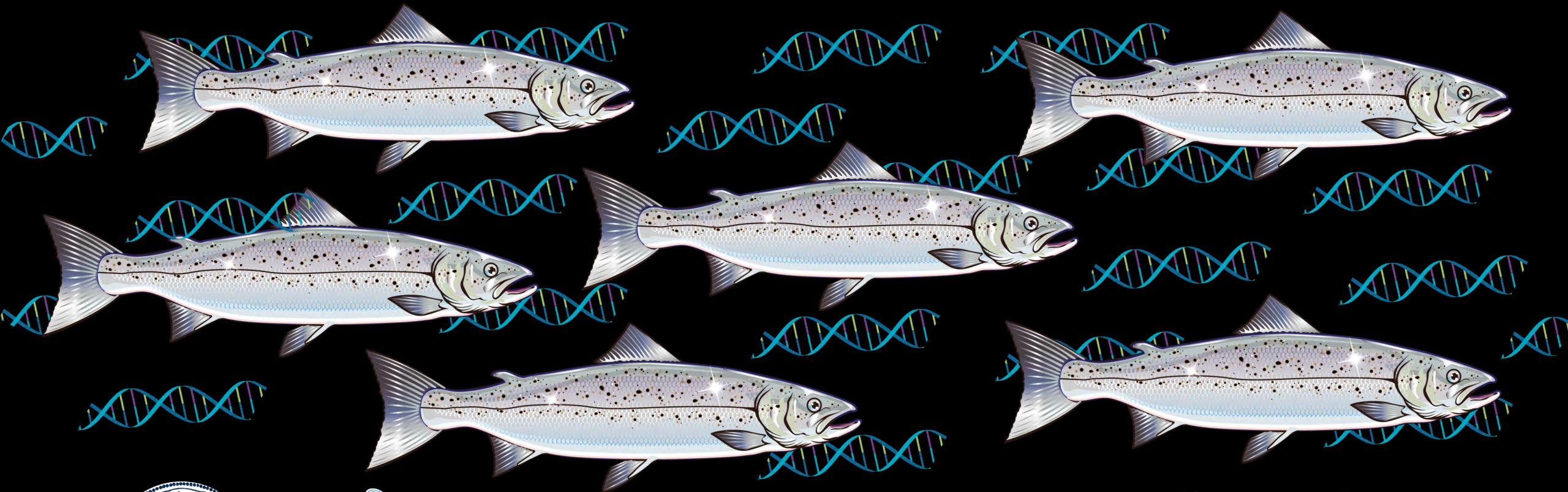
# Presentations



- **Runs in the Genes: Technologies for Rapid Genetic Identification of Chinook Salmon Runs**  
Sean Canfield, Ph.D., California Department of Water Resources..... Slide 4
- **Ecosystem Response to the Removal of the Elwha River Dams, Washington State, U.S.A.**  
George Pess, Ph.D., George Pess Consulting, LLC..... Slide 24
- **The Role of Natural and Man-Made Barriers on the Distribution of Summer and Winter-Run Steelhead in the Greater Klamath-Siskiyou Region**  
Samantha Kannry, TRIB Research..... Slide 81
- **Lessons Learned from the San Joaquin River Restoration Program**  
Phillip Street, Ph.D., Science Coordinator, USFWS..... Slide 125
- **Wild ishyâat (Oncorhynchus tshawytscha) in a Spring-Run Chinook Salmon Stronghold**  
Toz Soto, Karuk Tribe, and Sophie Price, SRRC..... Slide 171
- **Panel Discussion:** The session concluded with a panel of Tribal culture bearers discussing the cultural role of Spring Chinook and how TEK and western science can best be integrated to inform management and restoration priorities

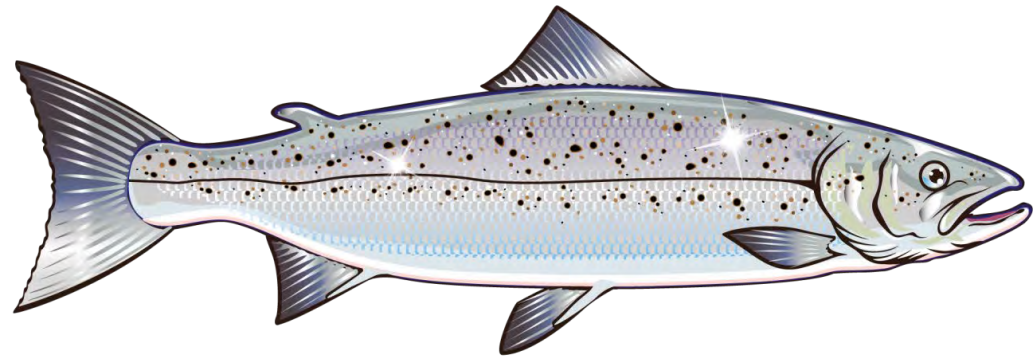
# Runs in the Genes:

Technologies for rapid genetic identification of Chinook salmon runs

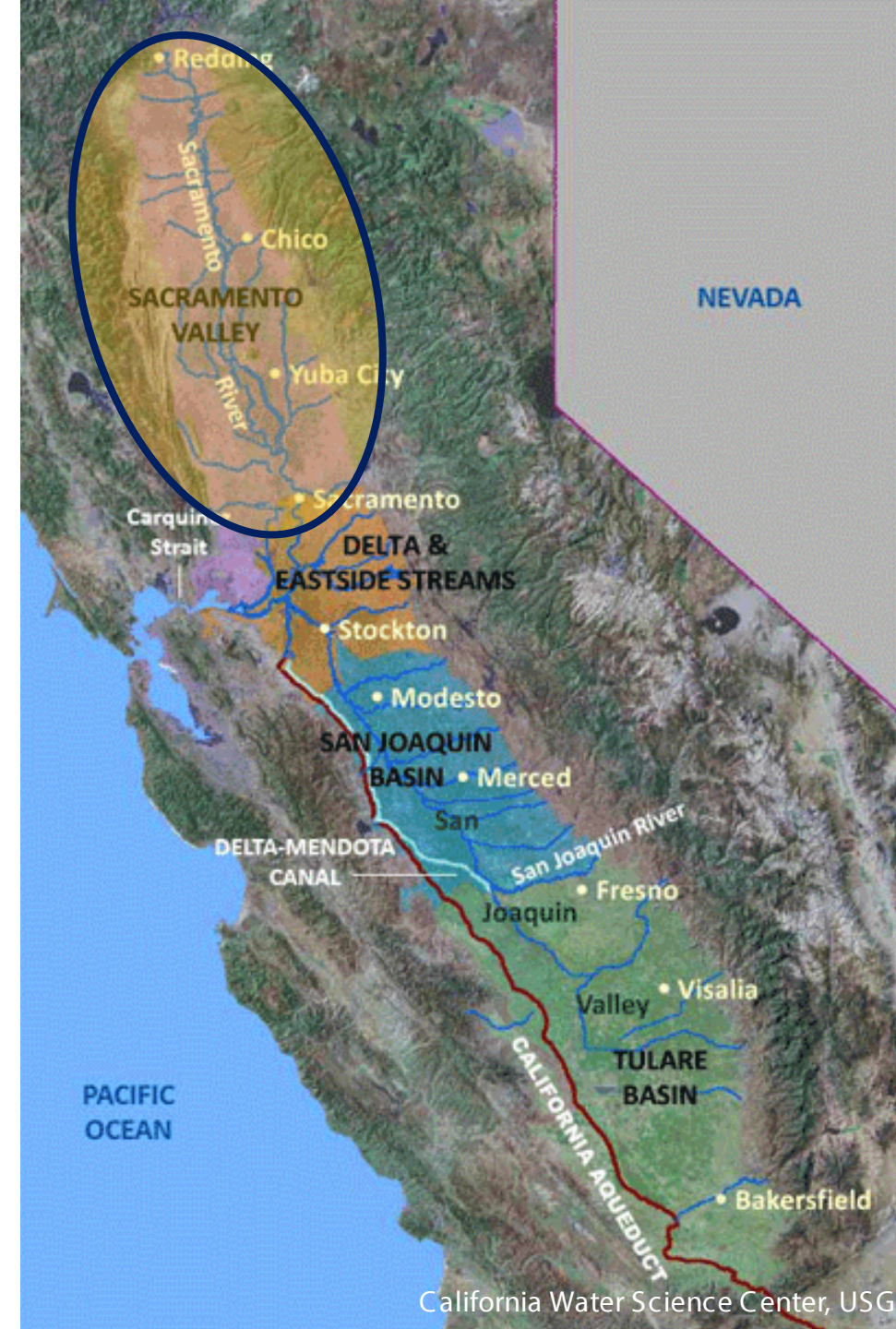


Sean Canfield, Melinda Baerwald  
Presented at SRF 2026





Chinook Salmon  
*Oncorhynchus tshawytscha*



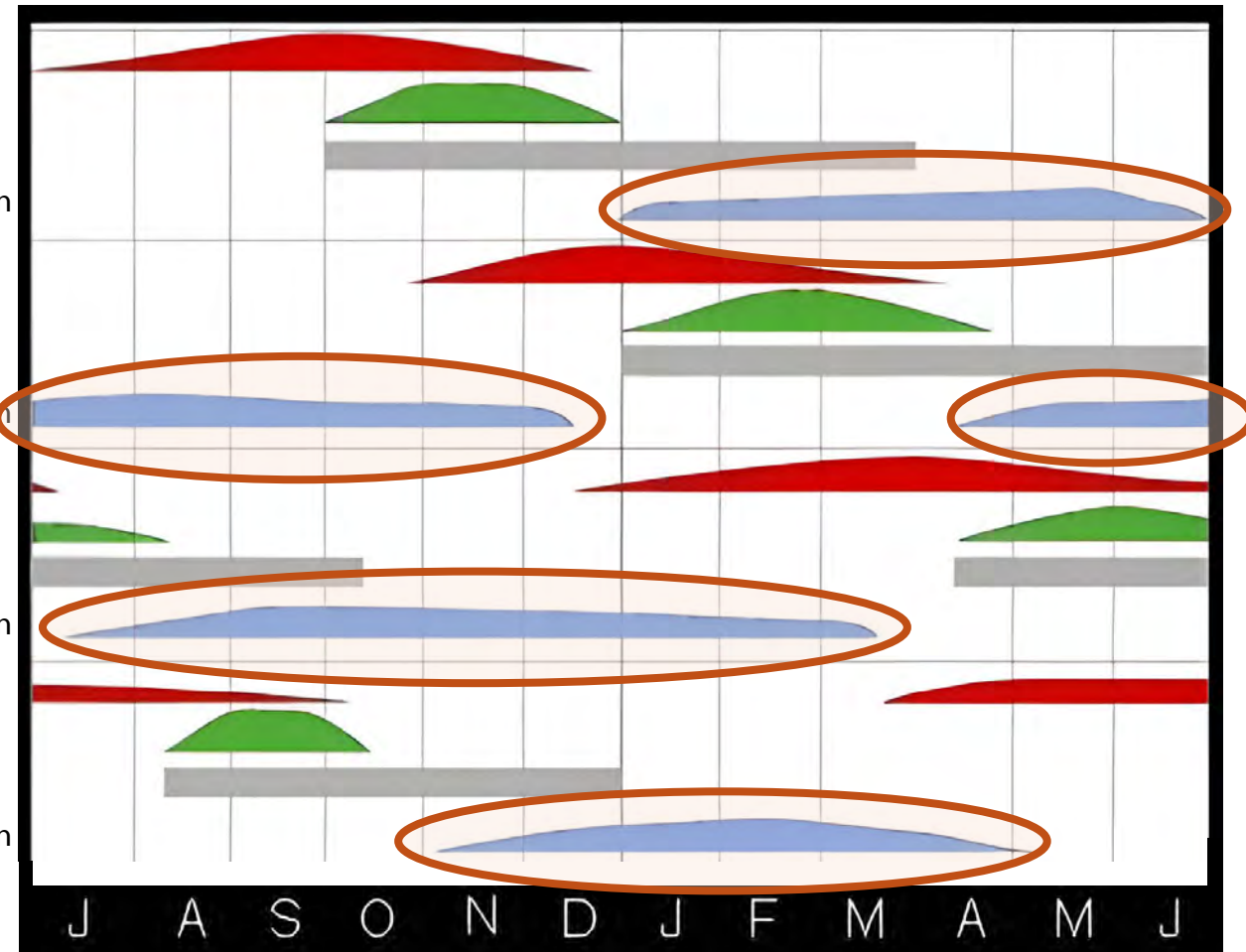
# 4 Distinct Central Valley Chinook Salmon Runs

“Late”  
Migrating

“Early”  
Migrating

{ Fall run  
 { Late Fall run  
 { Winter run  
 { Spring run

Adult Migration  
 Spawning  
 Incubation  
 Rearing & Migration  
 Adult Migration  
 Spawning  
 Incubation  
 Rearing & Migration  
 Adult Migration  
 Spawning  
 Incubation  
 Rearing & Migration  
 Adult Migration  
 Spawning  
 Incubation  
 Rearing & Migration

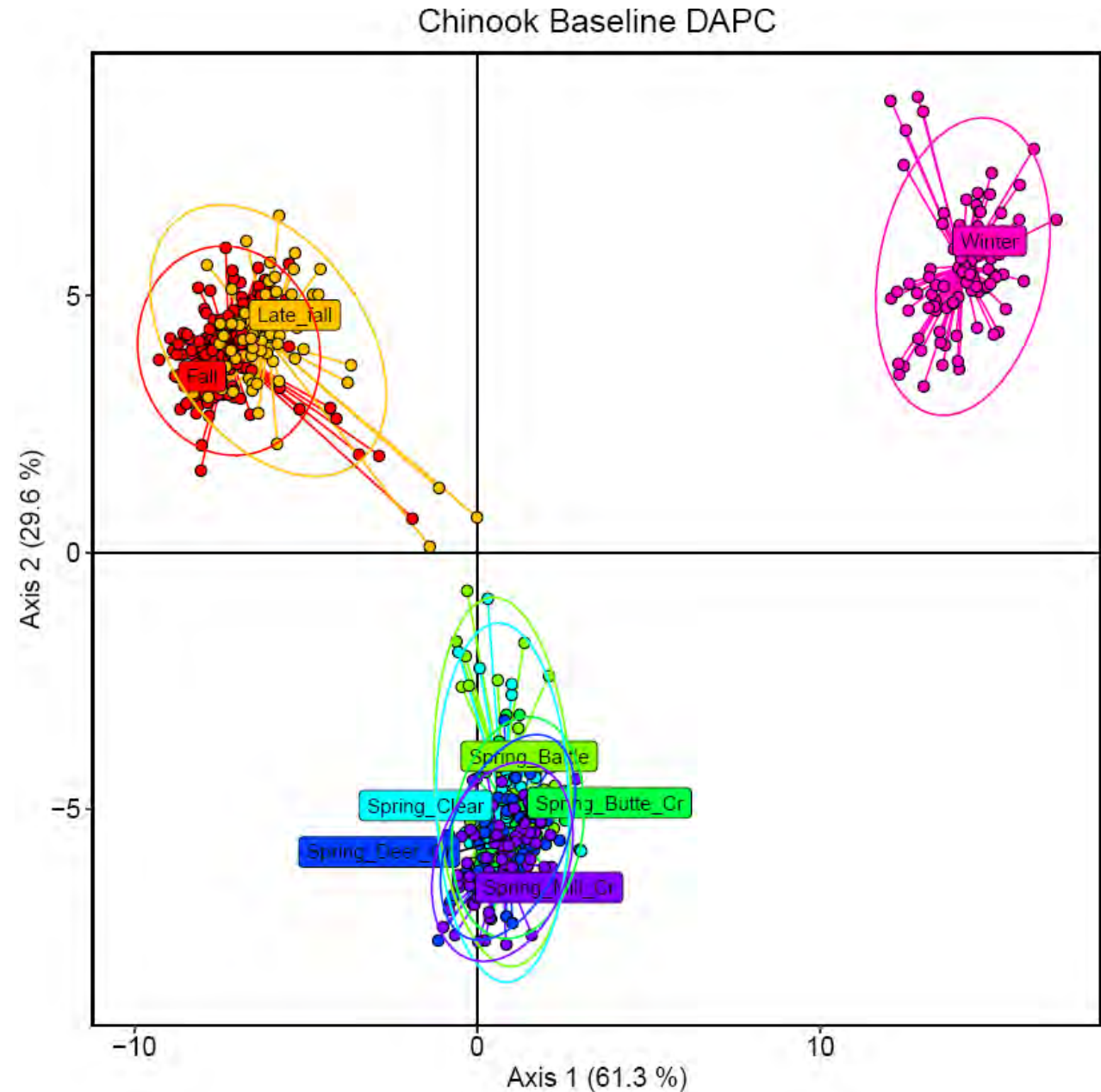


Adapted from figure by Rachel Johnson



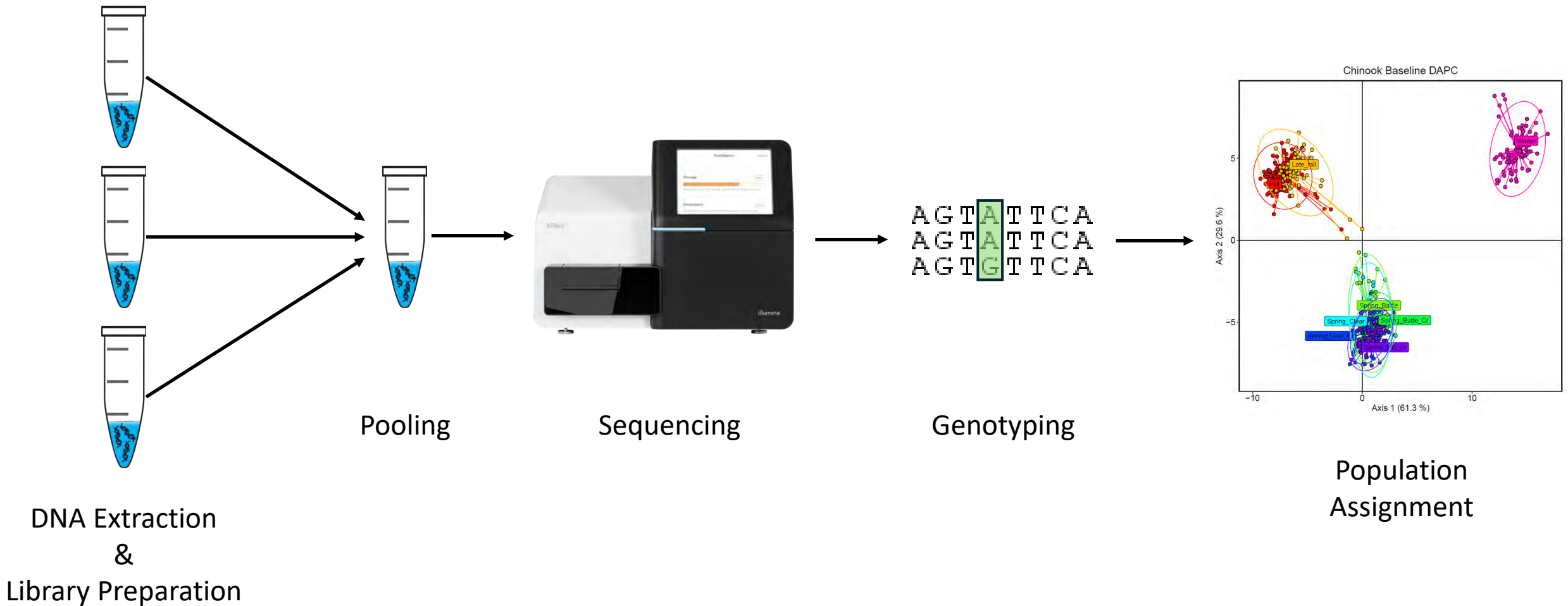
# Genetics for Run-Type Assignment

- Genetic markers can reliably identify the four Central Valley run types
- Can use hundreds of genetic markers per individual for run assignments (typically ~100-200+)
- A handful of markers on Chromosome 28 can distinguish between “early” and “late” run phenotypes (*GREB1L/ROCK1*)



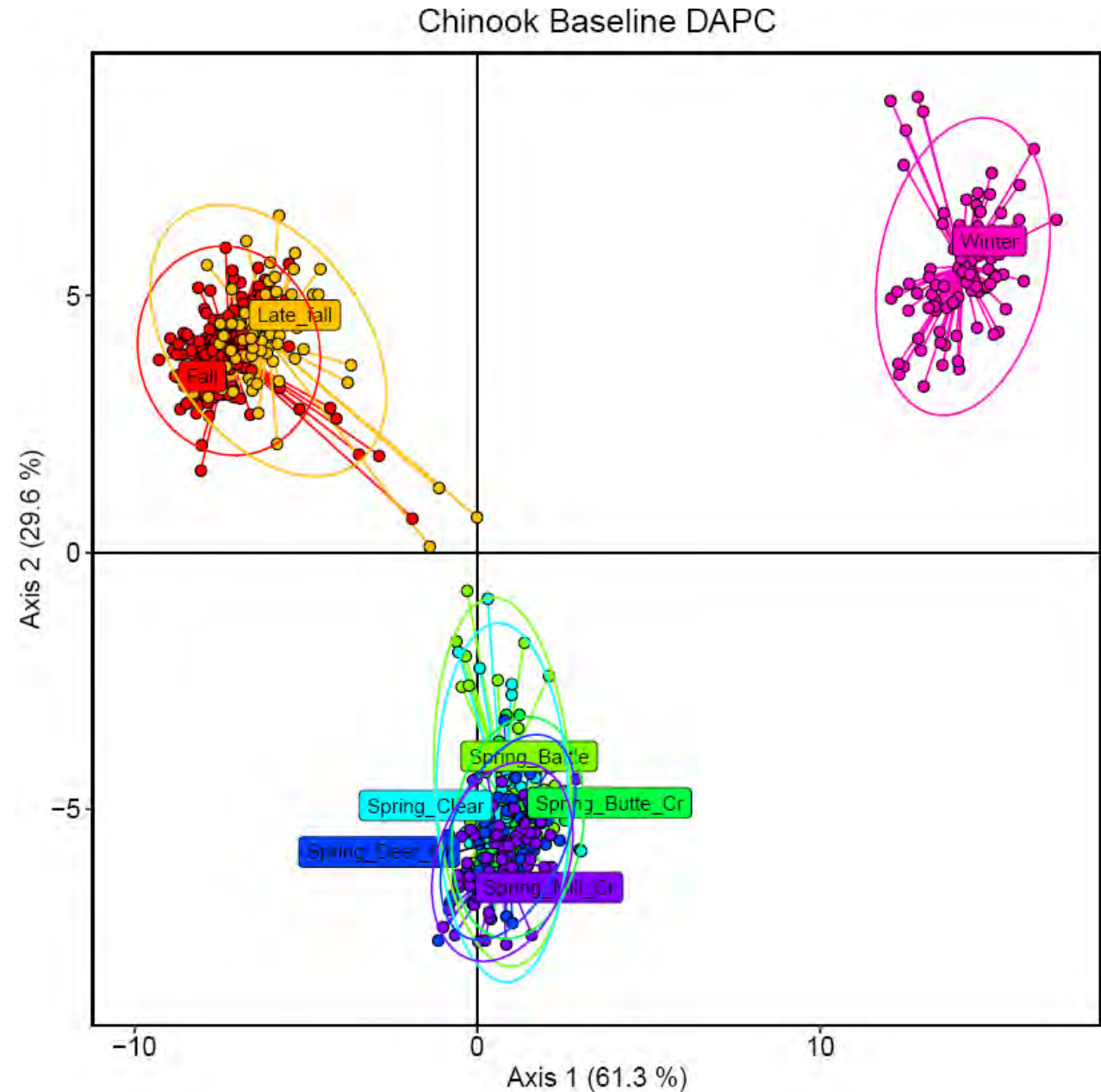
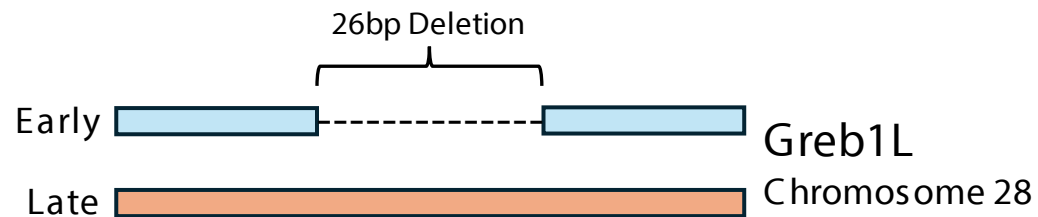
# Spring Run JPE Genetics Workflow

## GT-seq Genotyping

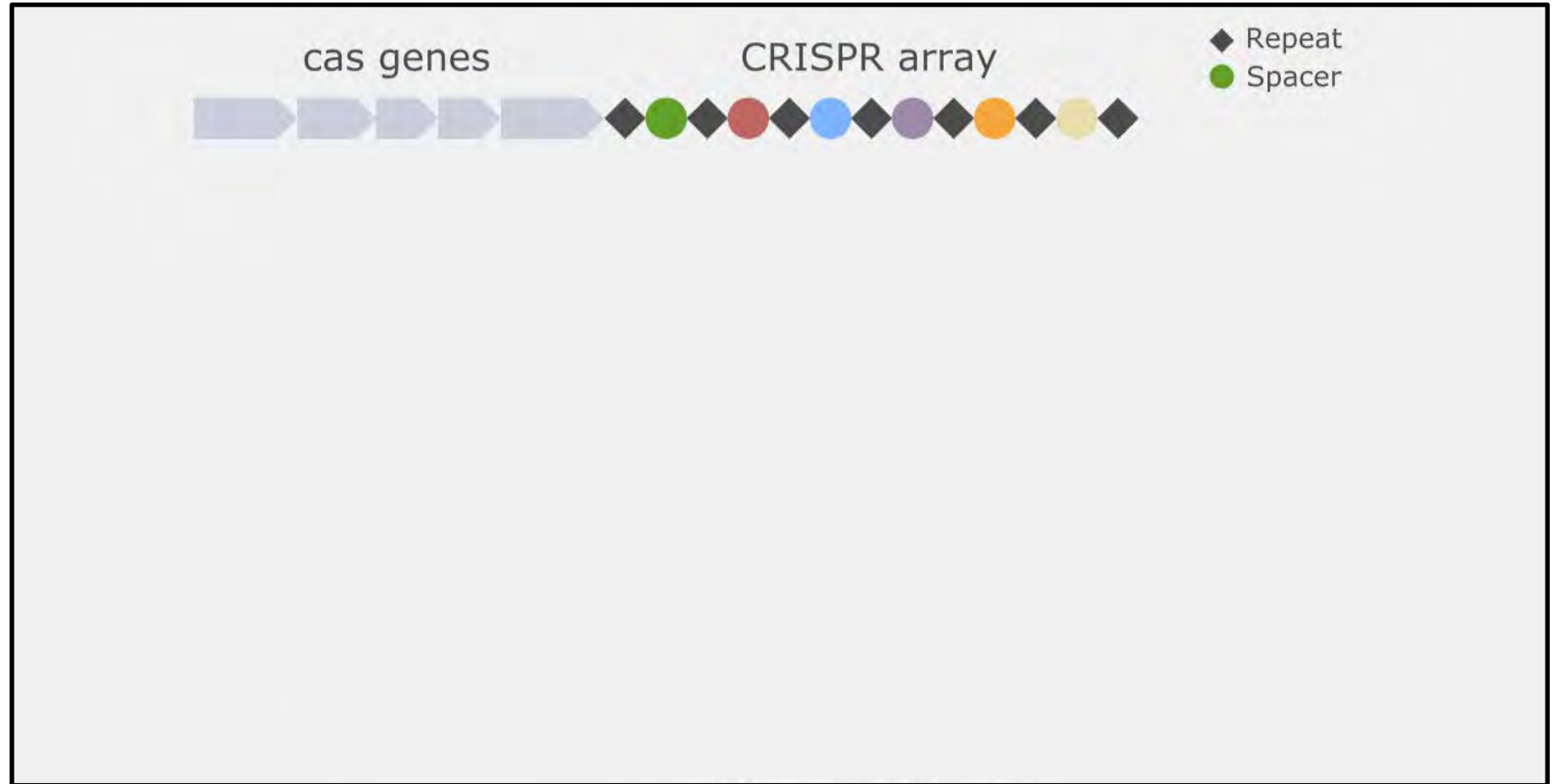


# Genetics for Run-Type Assignment

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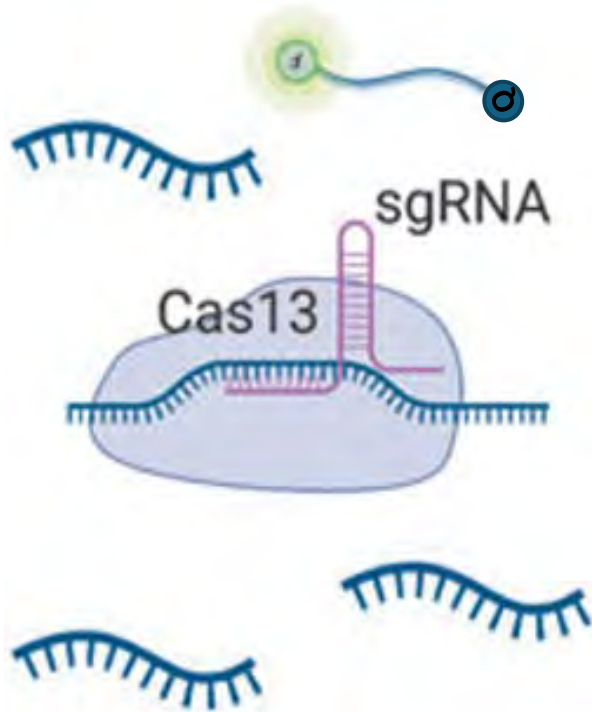


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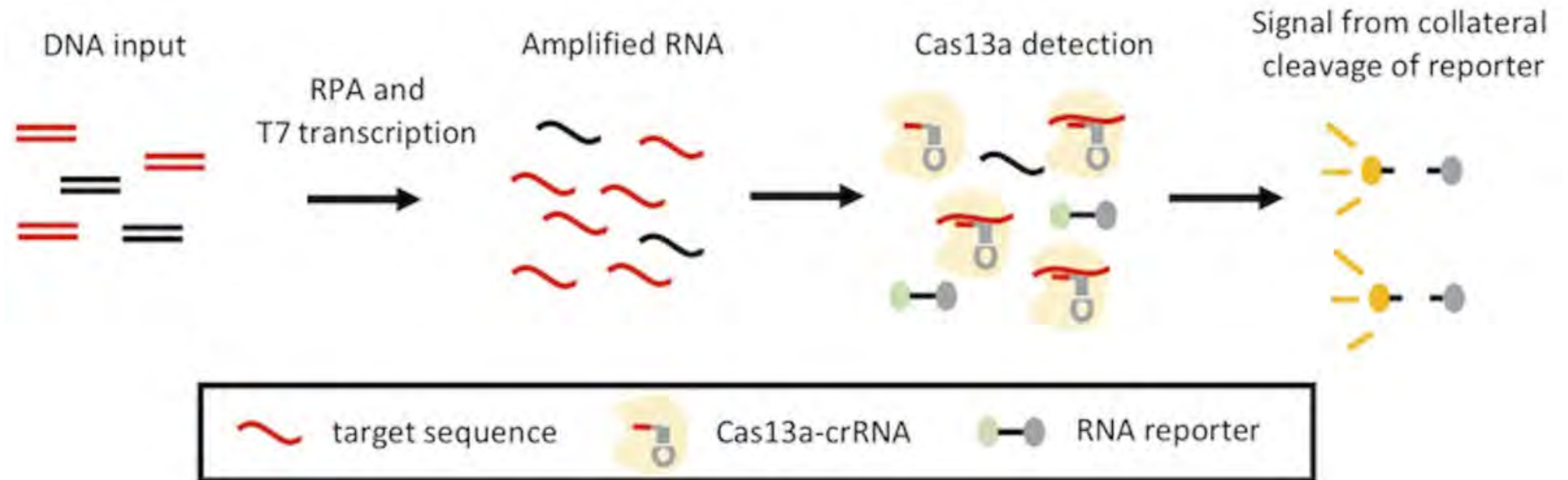


# Cas13a

“Collateral Activity”



# SHERLOCK: Specific High-Sensitivity Enzymatic Reporter UnLOCKIng



# SHERLOCK: Specific High-Sensitivity Enzymatic Reporter UnLOCKing

REPORT

Jonathan S. Gootenberg et al., Nucleic acid detection with CRISPR-Cas13a/C2c2. *Science* **356**, 438-442 (2017). DOI: [10.1126/science.aam9321](https://doi.org/10.1126/science.aam9321)

CRISPR TECHNOLOGY

## Nucleic acid detection with CRISPR-Cas13a/C2c2

Jonathan S. Gootenberg,<sup>1,2,3,4,5\*</sup> Omar O. Abudayyeh,<sup>1,2,3,4,6\*</sup> Jeong Wook Lee,<sup>7</sup>  
Patrick Essletzbichler,<sup>1,2,3,4</sup> Aaron J. Dy,<sup>1,4,8</sup> Julia Joung,<sup>1,2,3,4</sup> Vanessa Verdine,<sup>1,2,3,4</sup>  
Nina Donghia,<sup>7</sup> Nichole M. Daringer,<sup>8</sup> Catherine A. Freije,<sup>1,9</sup> Cameron Myhrvold,<sup>1,9</sup>  
Roby P. Bhattacharyya,<sup>1</sup> Jonathan Livny,<sup>1</sup> Aviv Regev,<sup>1,10</sup> Eugene V. Koonin,<sup>11</sup>  
Deborah T. Hung,<sup>1</sup> Pardis C. Sabeti,<sup>1,9,12,13</sup> James J. Collins,<sup>1,4,6,7,8,†</sup> Feng Zhang<sup>1,2,3,4,†</sup>

Received: 21 November 2022 | Revised: 22 February 2023 | Accepted: 24 February 2023

DOI: [10.1111/1755-0998.13777](https://doi.org/10.1111/1755-0998.13777)

MOLECULAR ECOLOGY  
RESOURCES WILEY

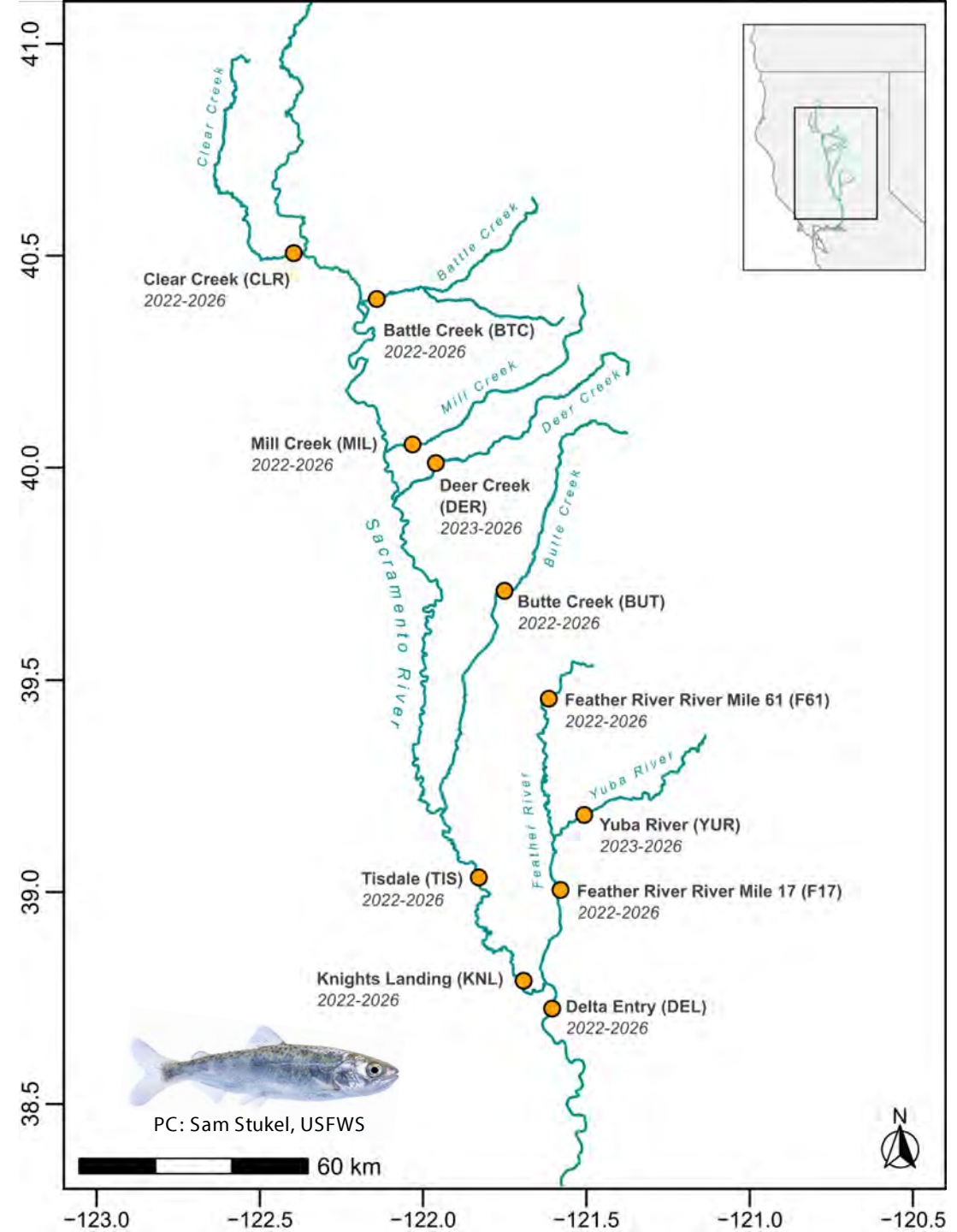
RESOURCE ARTICLE

## Rapid CRISPR-Cas13a genetic identification enables new opportunities for listed Chinook salmon management

Melinda R. Baerwald<sup>1</sup> | Emily C. Funk<sup>2</sup> | Alisha M. Goodbla<sup>2</sup> |  
Matthew A. Campbell<sup>2</sup> | Tasha Thompson<sup>3,4</sup> | Mariah H. Meek<sup>3</sup> | Andrea D. Schreier<sup>2</sup>

# California Central Valley Spring-Run Juvenile Production Estimate (SRJPE)

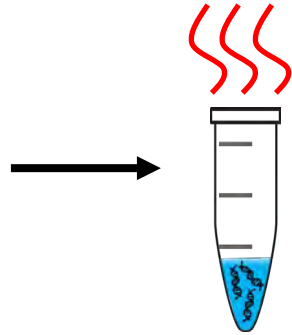
- 11 sites (RST) throughout Sacramento River Basin
- Sampled twice per month from Nov-May
- Genetic run identification of all samples
  - Up to ~800 fish per month



# SHERLOCK Workflow: Spring-Run Juvenile Production Estimate (SRJPE)



Genetic Sample Collection

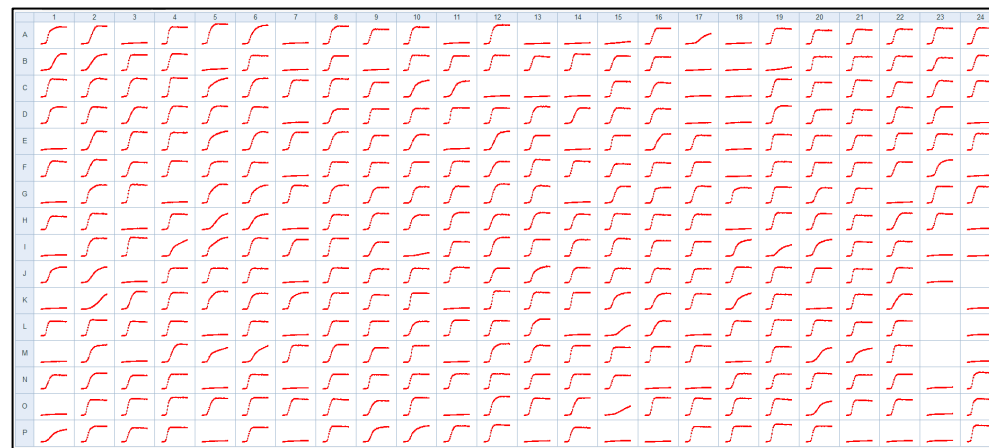


Rapid DNA Extraction



Plate SHERLOCK mix + Samples (DNA)

Incubate @ 37°C  
for 1 hour

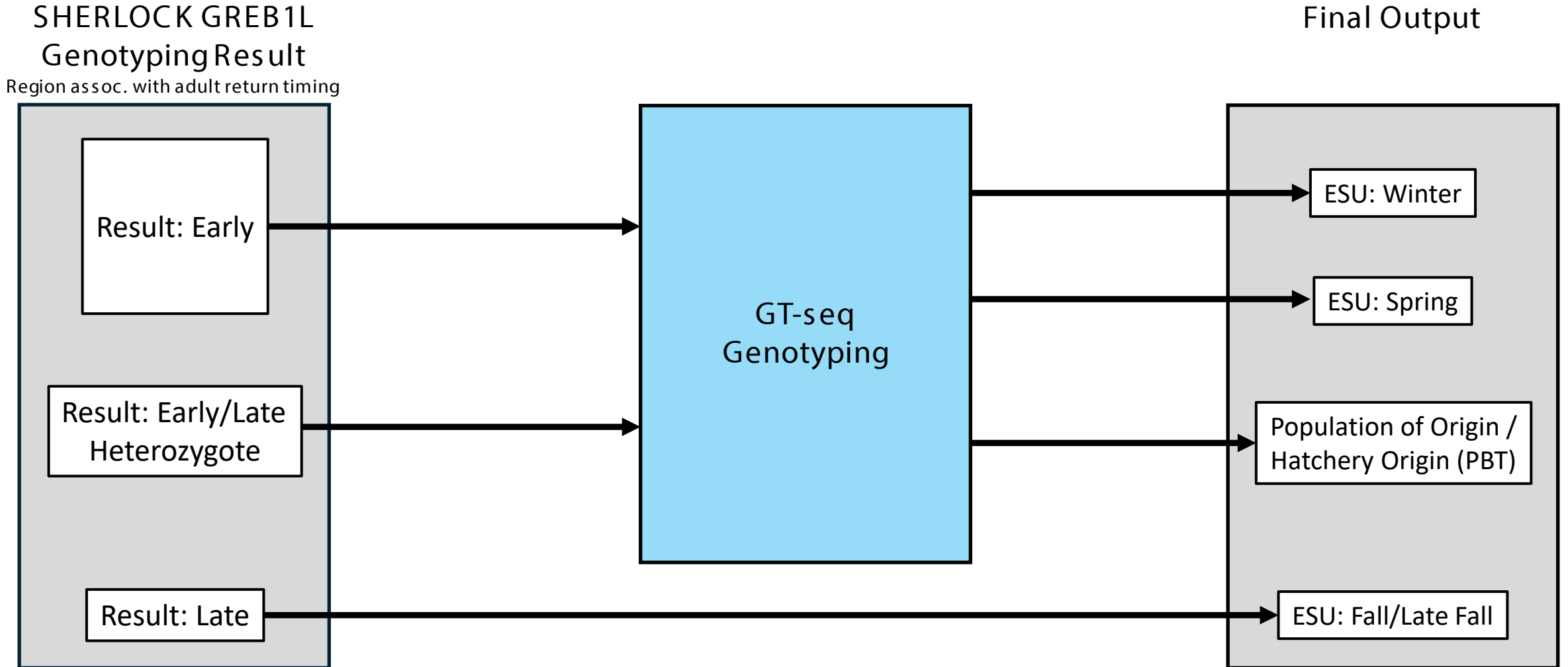


Data Analysis

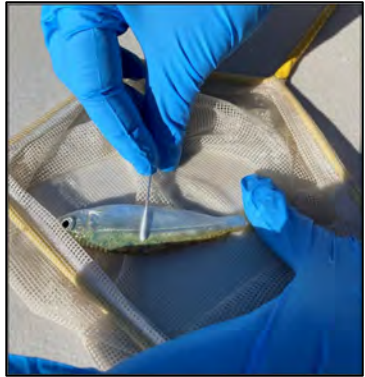


Read Fluorescence

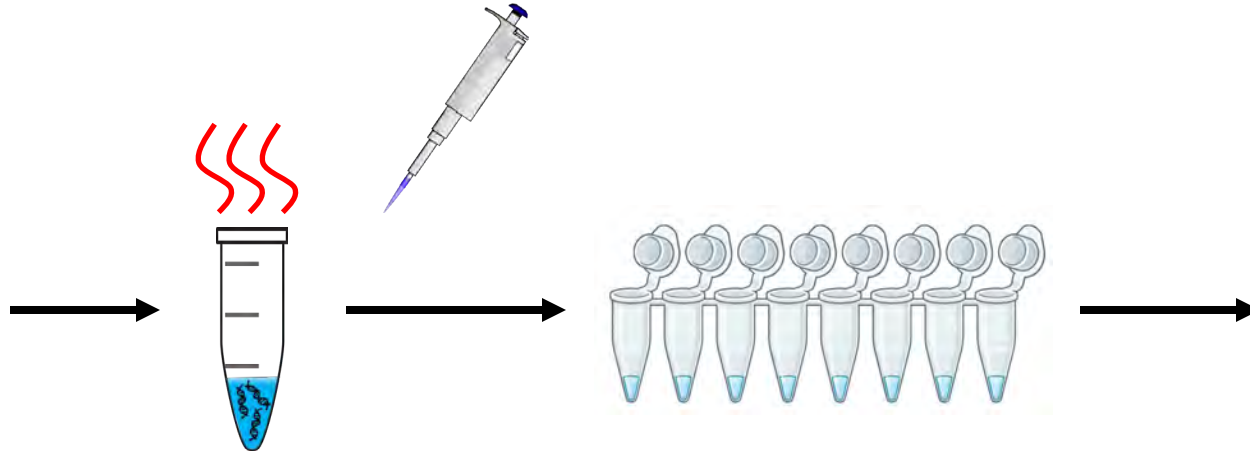
# 2026 JPE Genotyping Workflow



# SHERLOCK in the Field: The Axxin T16-ISO



Genetic Sample  
Collection



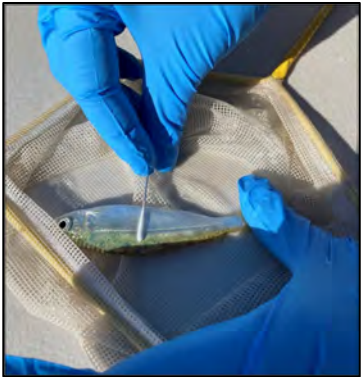
Sample Processing  
(Digestion/Heat-Kill)

Transfer to SHERLOCK  
Reaction Mixture  
(Pre-Frozen or Lyophilized)

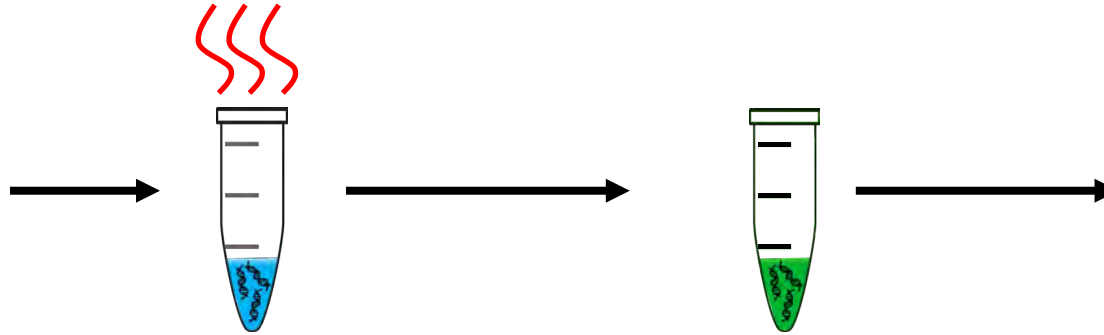


Incubate and Read Fluorescence  
with Axxin T16-ISO

# SHERLOCK in the Field: Lateral Flow Strips



Genetic Sample  
Collection



Sample Processing  
(Digestion/Heat-Kill)

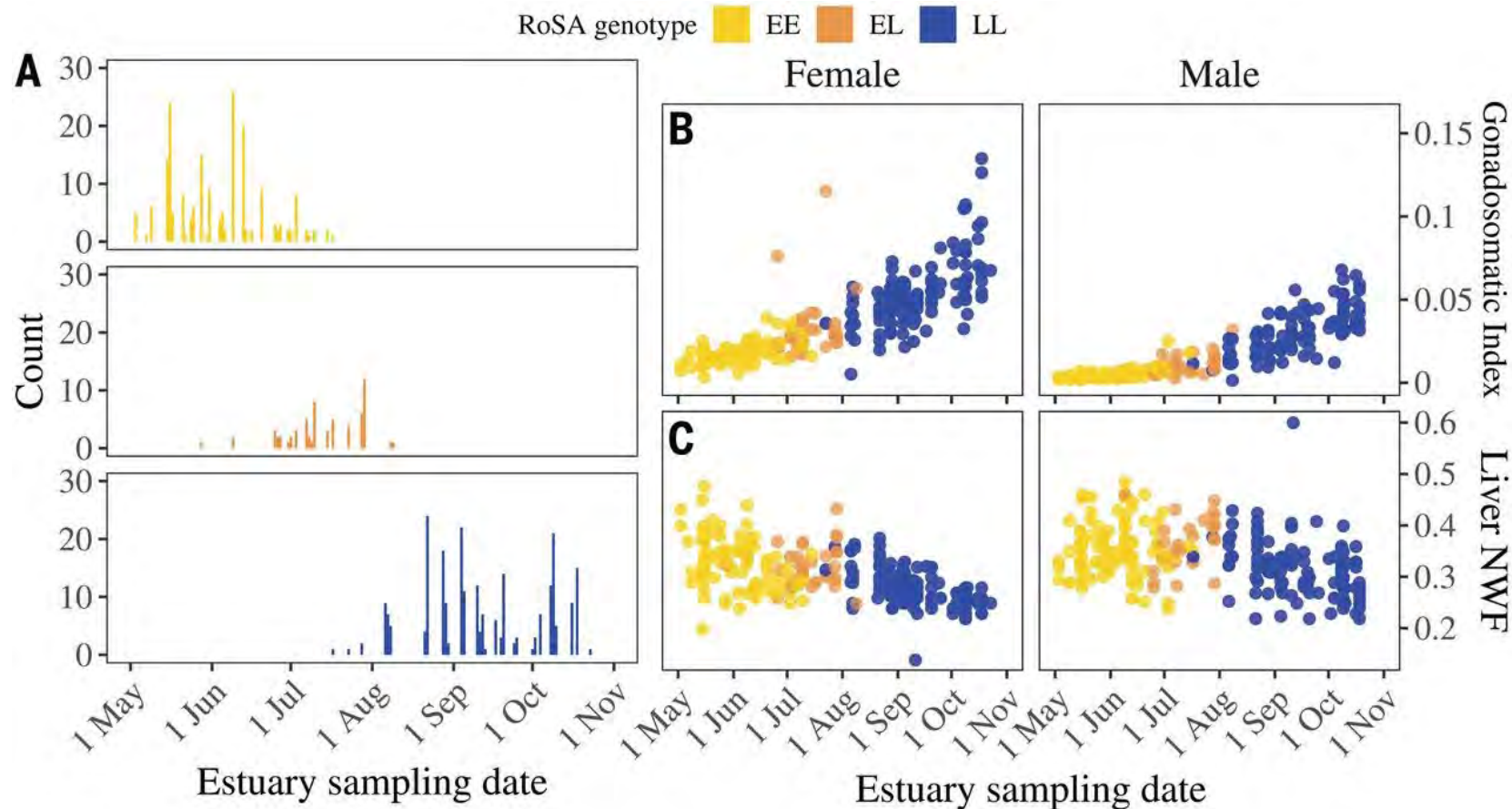
Combine SHERLOCK  
+ DNA/Sample,  
incubate @ 37°C

Soak Lateral Flow Strips,  
read results!

PC: Scott Meyer (DWR)

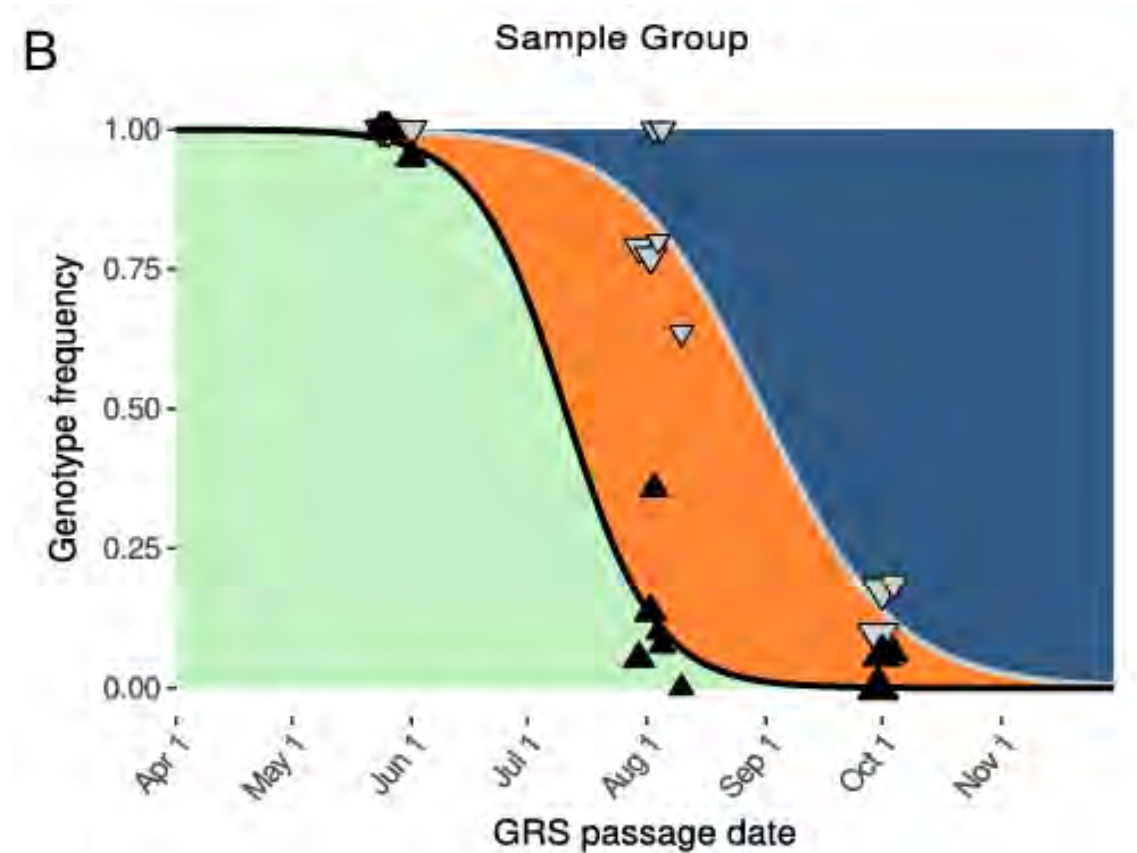
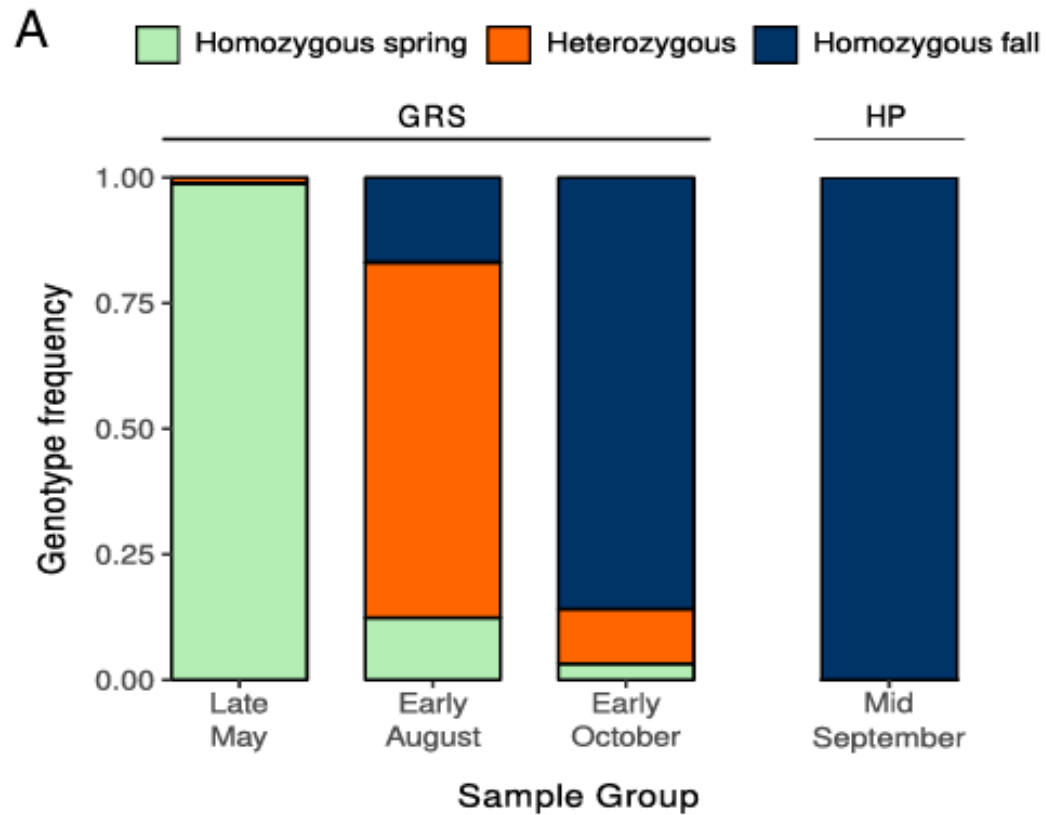
# Applying SHERLOCK in the Klamath River Basin

## Adult Return Migration Genotypes – Klamath River Estuary



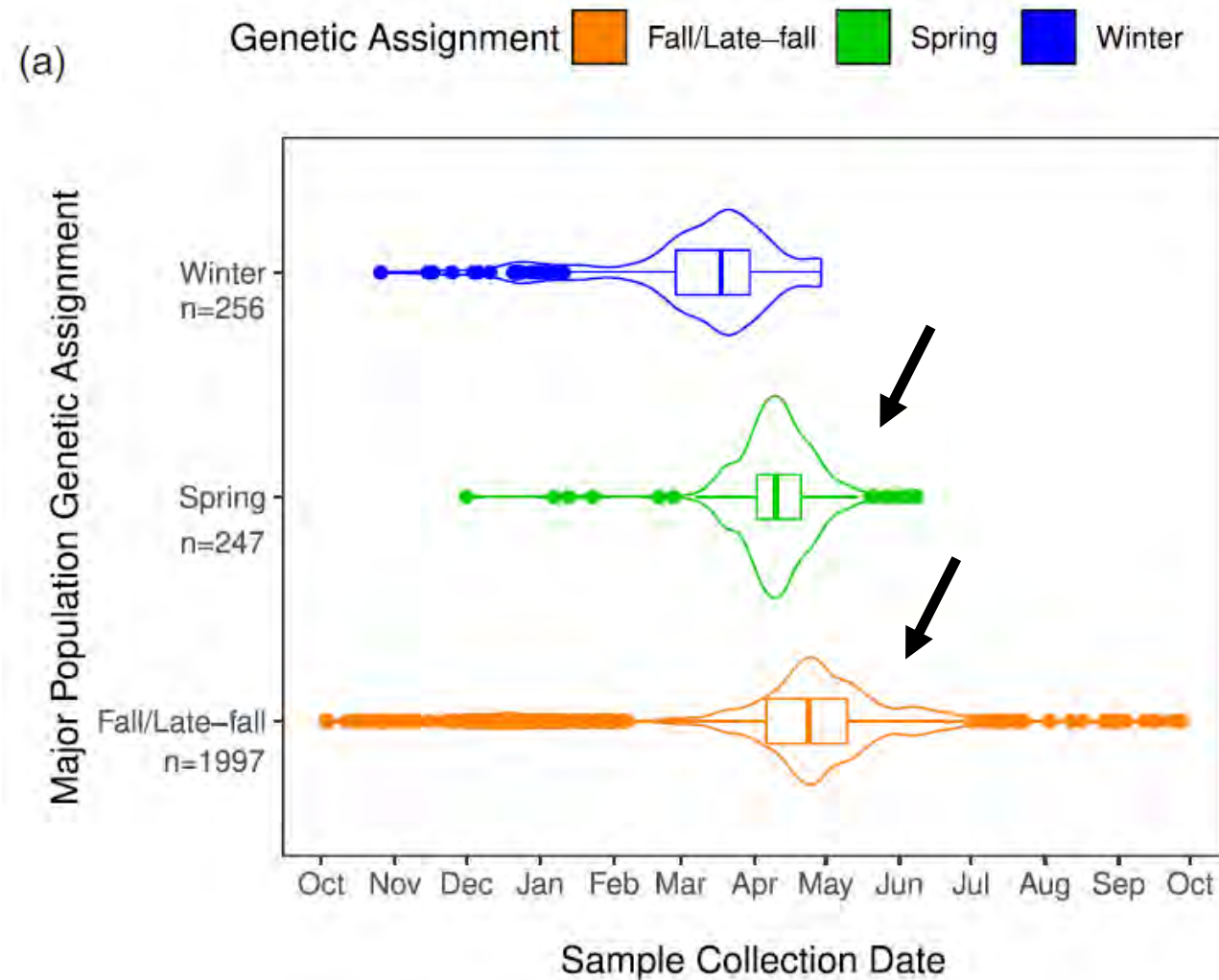
# Applying SHERLOCK in the Klamath River Basin

## Adult Return Migration Genotypes – Rogue River



# Applying SHERLOCK in the Klamath River Basin

## Juvenile Outmigration Genotypes – California Central Valley



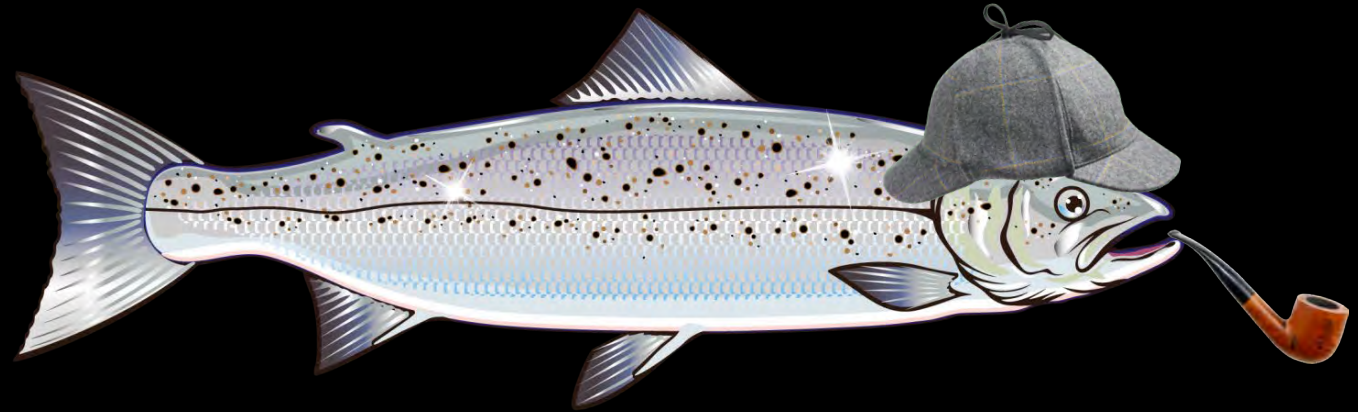
# Acknowledgements

## Assay Development

Alisha Goodbla  
Matthew Campbell  
Tasha Thompson  
Mariah Meek  
Emily Funk  
Andrea Schreier

## Lab Support

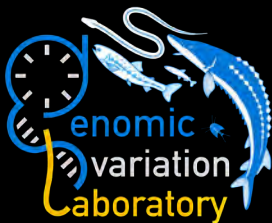
Sarah Stinson  
Scott Meyer  
Aviva Fiske  
Aviva Soll  
Pachia Lee  
Daphne Gille  
Emma Freedman  
Ross Harper  
Juan De La Torre



## Questions?

Reach out!

[Sean.Canfield@water.ca.gov](mailto:Sean.Canfield@water.ca.gov)



# Ecosystem response to the removal of two large dams in the Pacific Northwest



February 2026

# Today's talk

- Dams built and dam removal
- The Elwha River prior to dam removal
- The Elwha River Ecosystem & Fisheries Restoration Act
- How did dam removal happen?
- What has occurred with the removal of the Elwha River dams?
- Place, sediment, salmon, and the ecosystem
- Summary



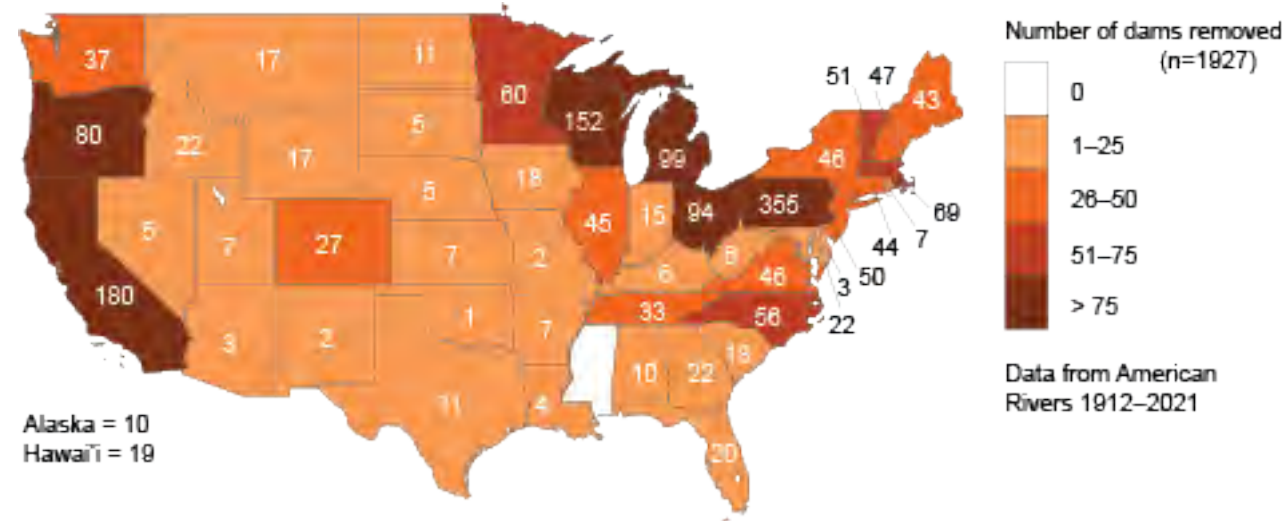
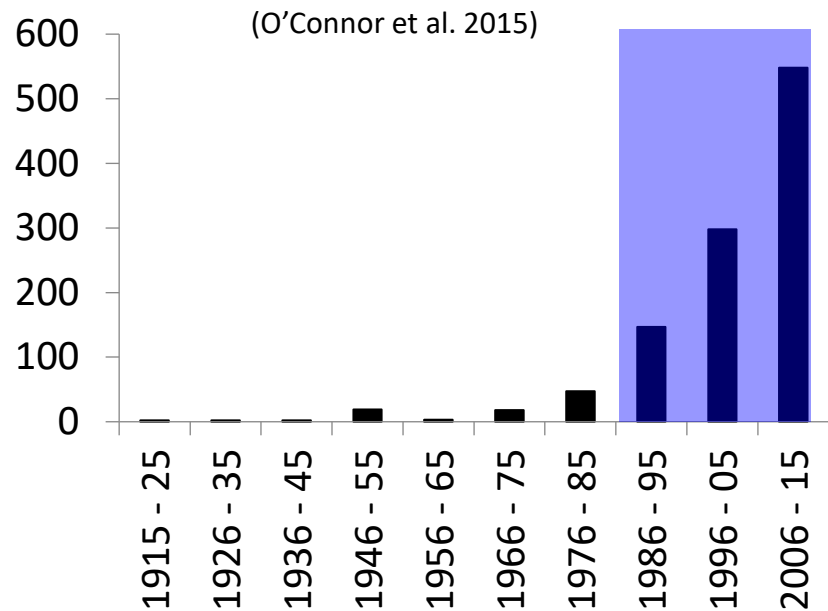
# Global distribution of dams & reservoirs



<http://globaldamwatch.org/our-research/>

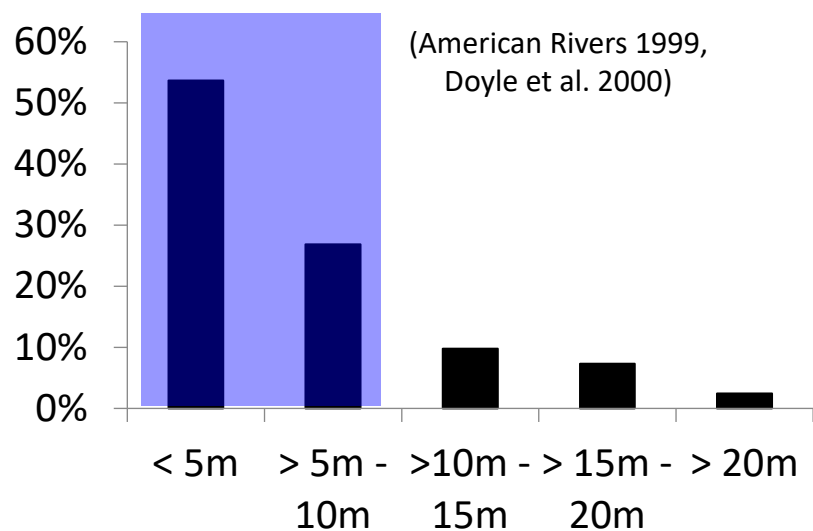
# Dam removal in the United States

## Number of dams removed



Increased removal over last 30 years

## Percent of total removed

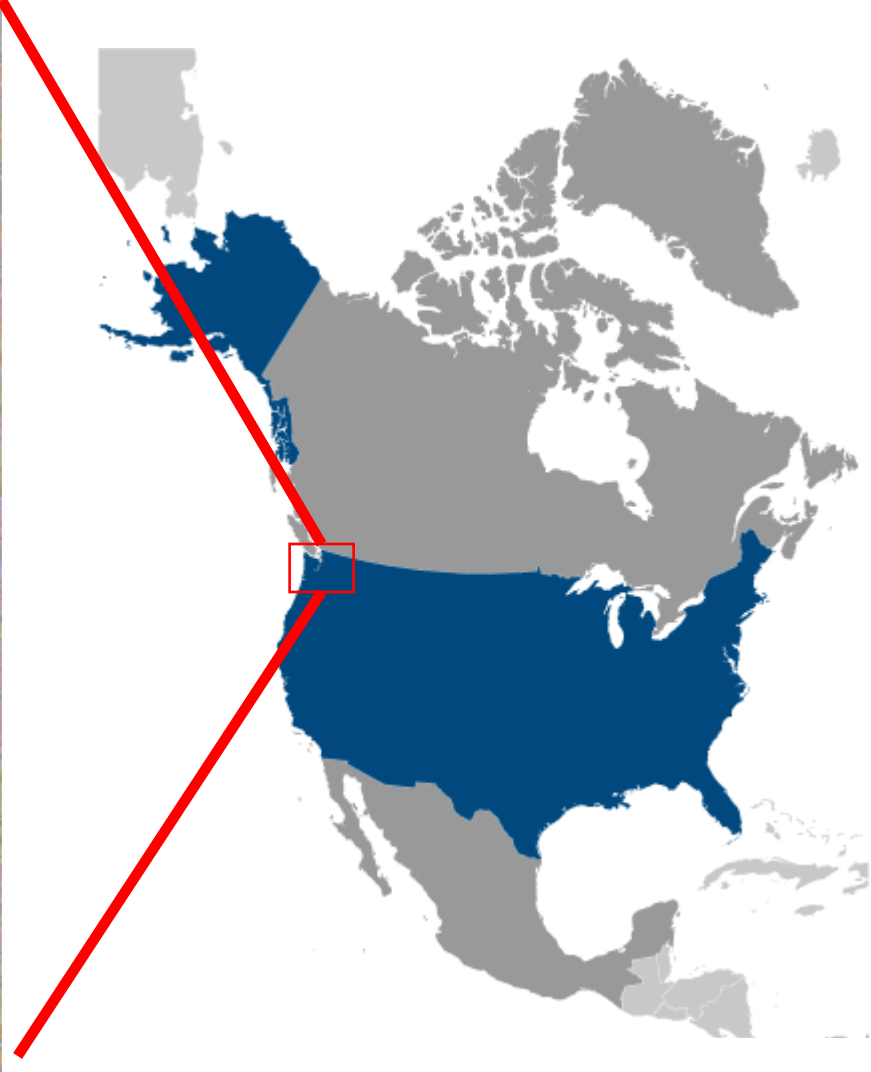


Most dams less than 10m in height

# Dam removal in the Pacific Northwest of the United States

Elwha River

- White Salmon River
- Sandy River
- Little Sandy River
  
- Rogue River
- Klamath River

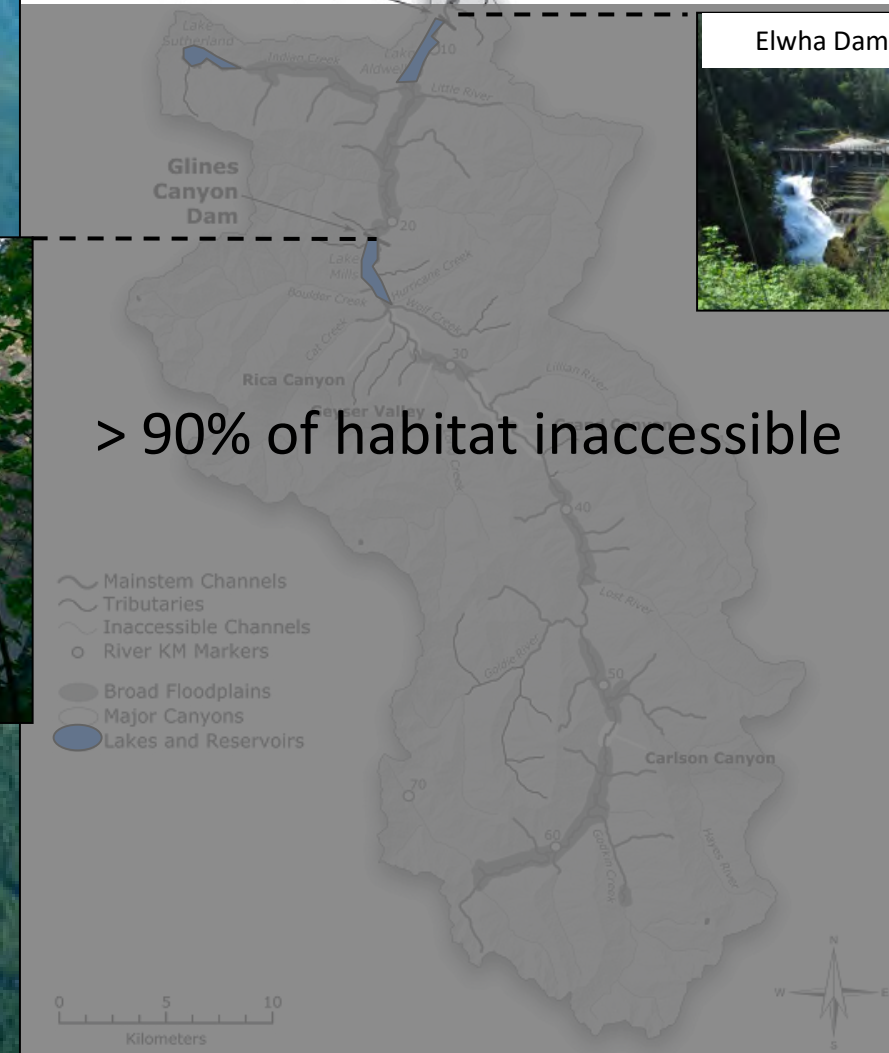
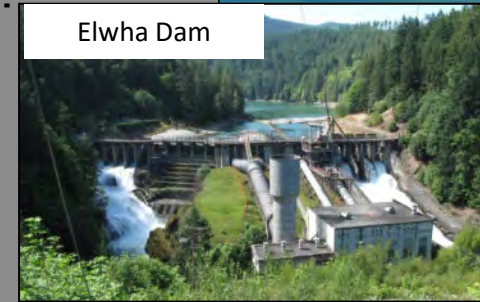
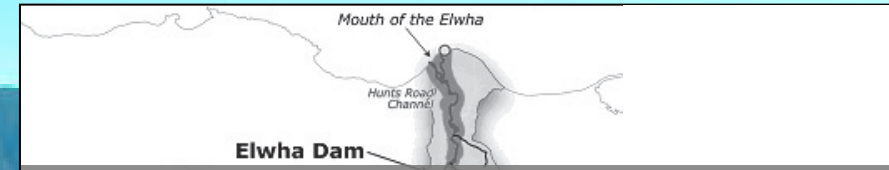


Average height ~30m

# Dam removal in the Pacific Northwest of the United States



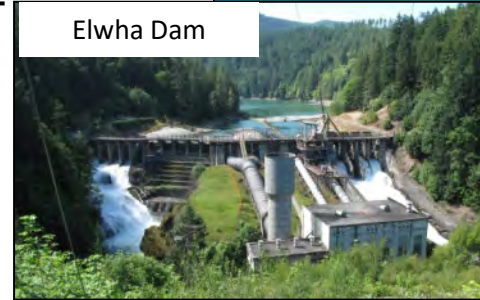
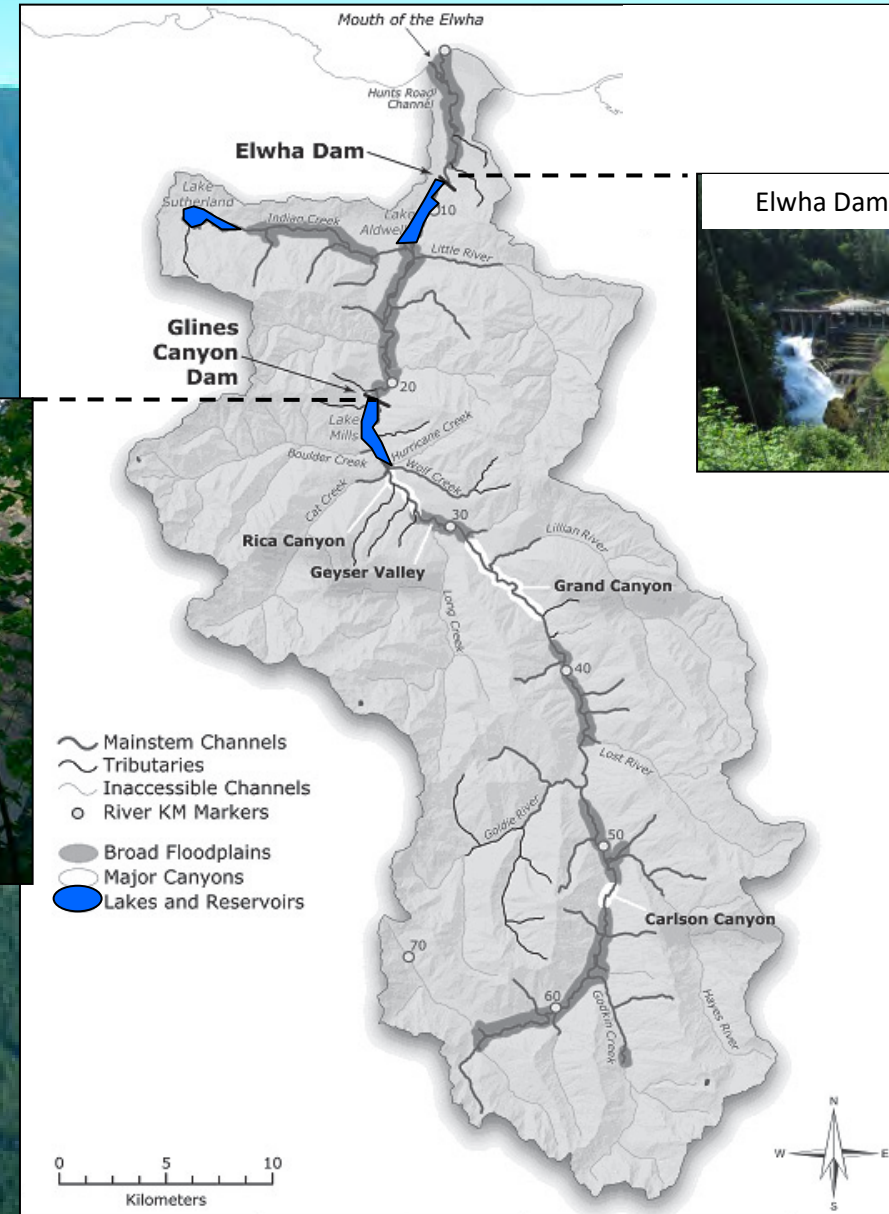
## The Elwha River Basin



# Dam removal in the Pacific Northwest of the United States

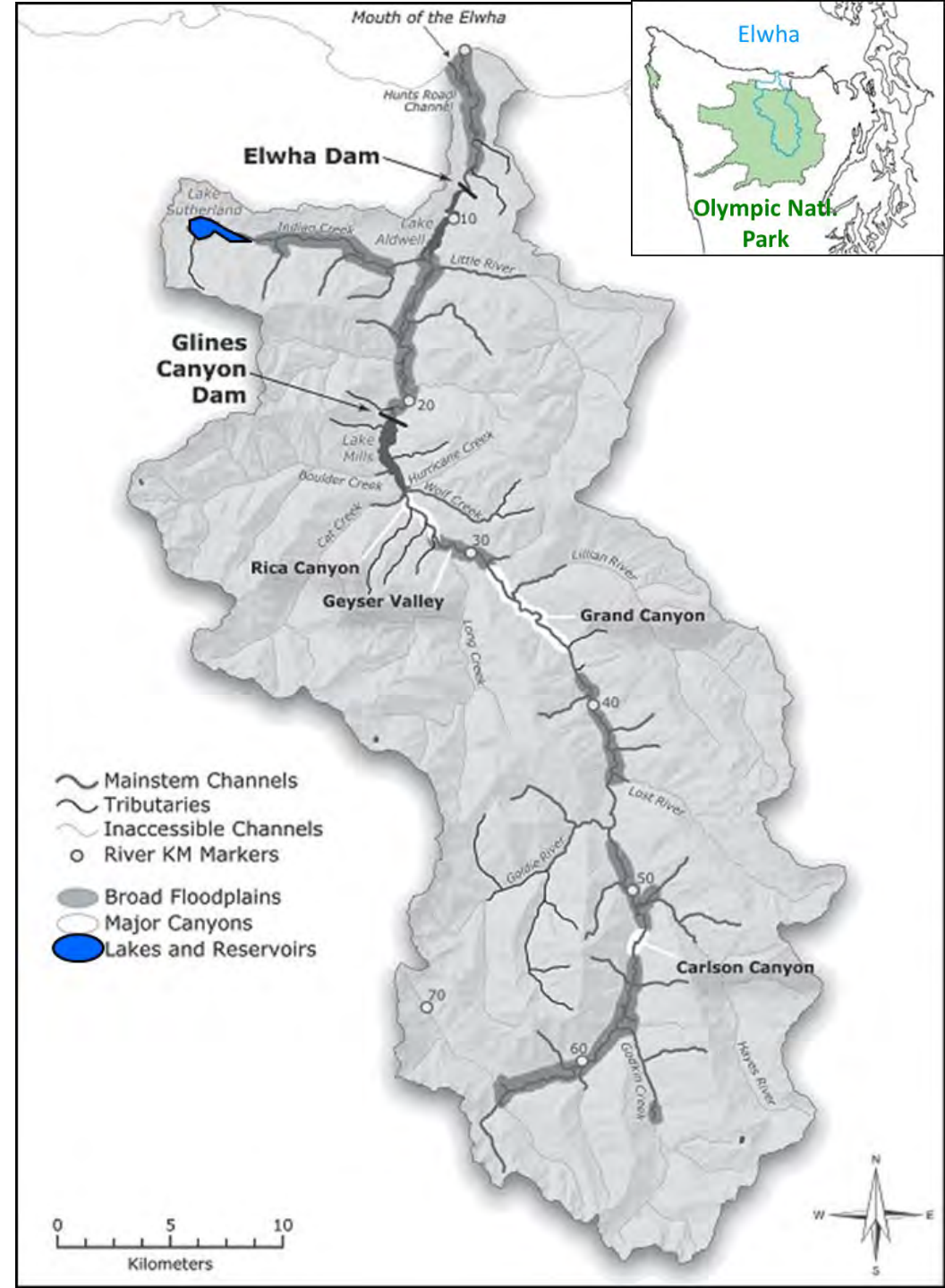


## The Elwha River Basin



# Elwha River

- 833 km<sup>2</sup>
- ~72 km of mainstem habitat
- 8 major tributaries
- 80% of watershed in Olympic National Park
- ~21 million m<sup>3</sup> of sediment released
- Initial salmon and steelhead population in low thousands and mostly hatchery



# Elwha River Fishes

Coho salmon



Pink salmon



Chinook salmon



Steelhead



Chum salmon



Sockeye salmon



Eulachon



Bull trout

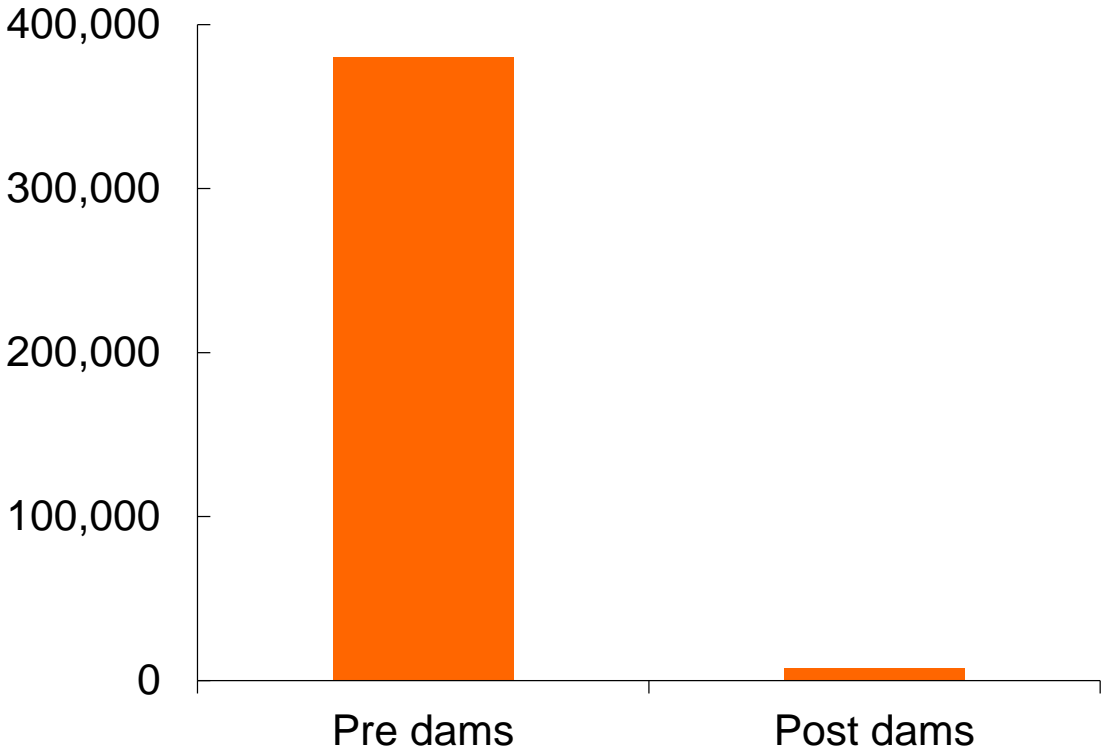


Pacific lamprey

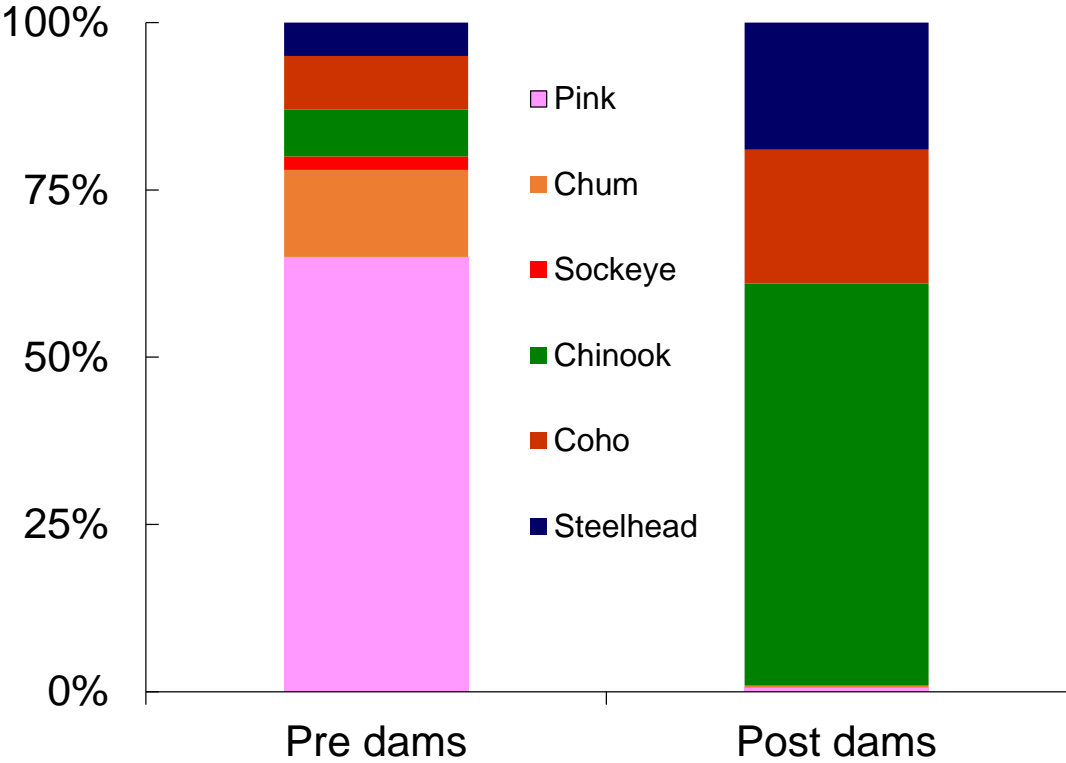


# Impacts to Elwha River salmon populations

## Total population decline



## Shift in species composition



Pess et al. 2008

All native populations were very low in abundance

# Elwha River Ecosystem and Fisheries Restoration Act

“...for the removal of the dams and full restoration of the Elwha River ecosystem and native anadromous fisheries.”

102<sup>nd</sup> Congress of the U.S.A. January 3, 1992



Photo by John McMillan

# What's going to happen to all the sediment?

~ 21 million m<sup>3</sup> of sediment accumulated in reservoirs

- ~ 54% fine, ~46% coarse
- ~40%-60% predicted to erode downstream

## Predictions

- suspended-sediment > 10,000 ppm
- temporary deposition of fines in pools
- more dynamic floodplain
- bed build up (aggradation) in lower river
- beach formation in estuary



N. Chism/Lighthawk

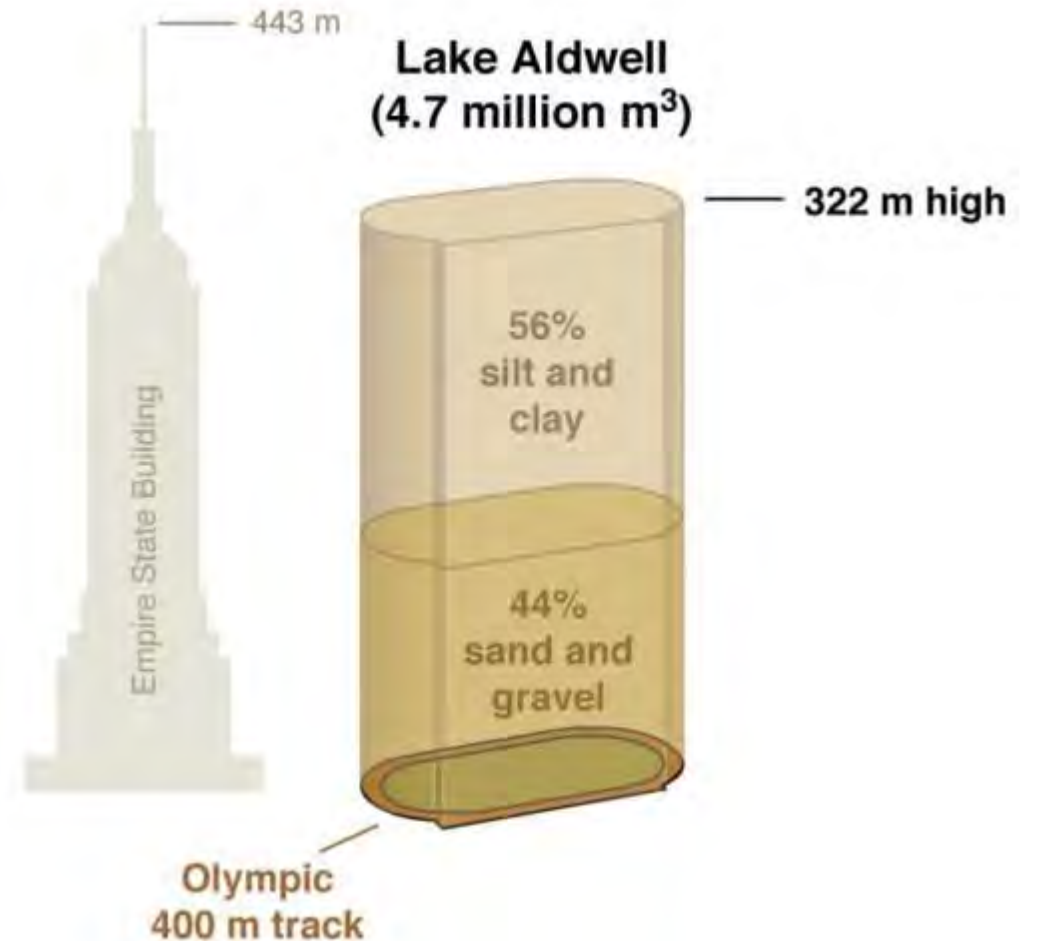
# Elwha Dam removal

Before Dam Removal: September, 2011



*Elwha Webcams courtesy NPS*

- Completed in 1912
- 33m concrete gravity dam





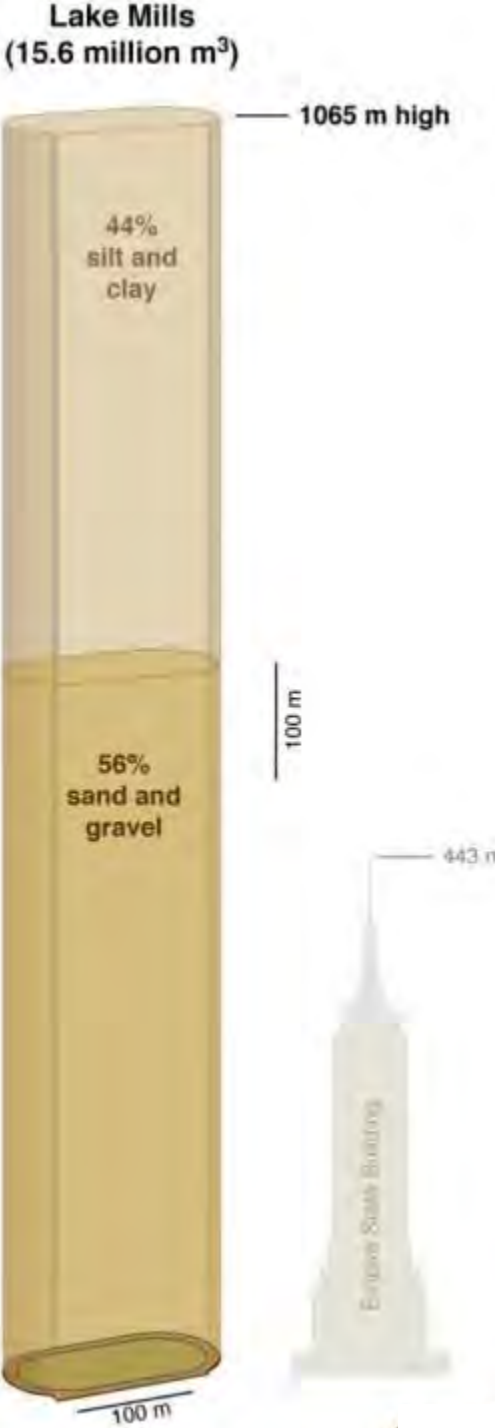
# Glines Canyon Dam removal

Before Dam Removal: September, 2011



Elwha Webcams courtesy NPS

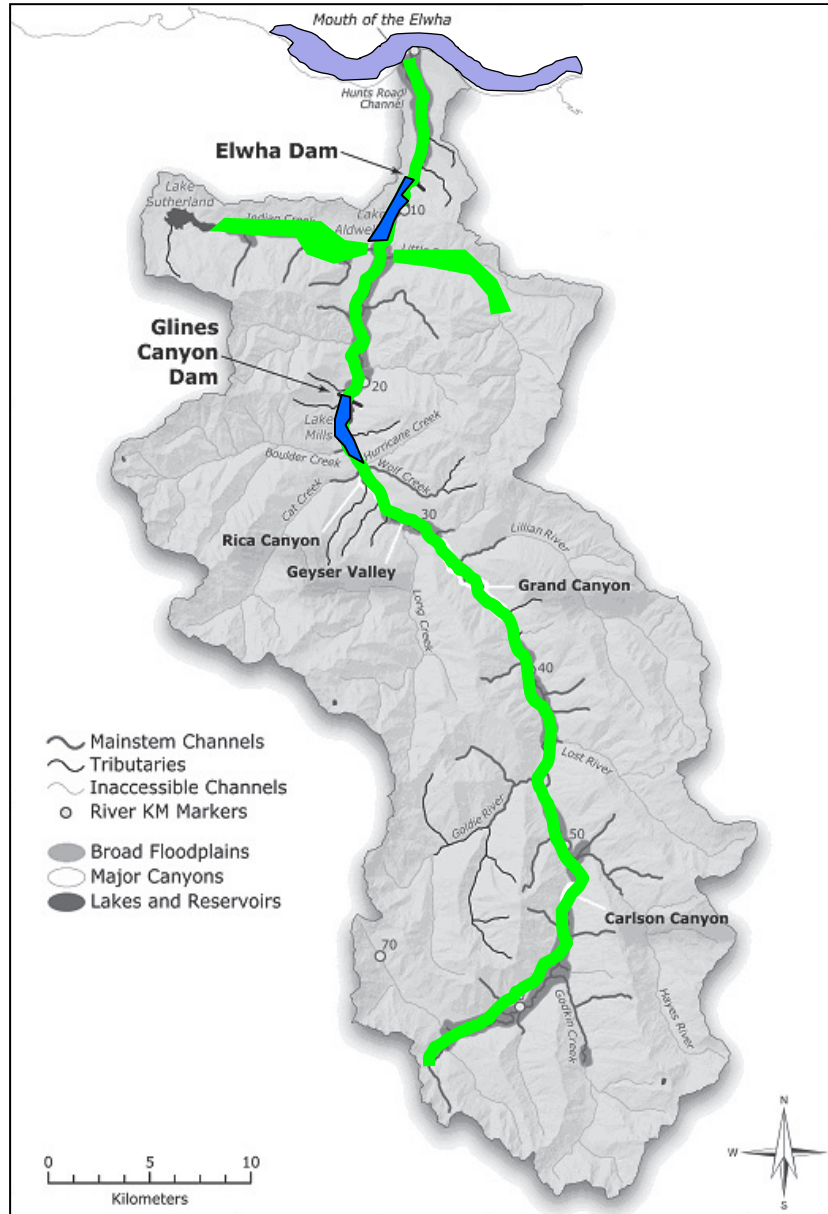
- Completed in 1927
- 64m concrete arch dam



May 12 14 08:32:59



# What has occurred with the removal of the Elwha River dams?



## Location

- Dams & former reservoirs
- Nearshore
- River ecosystem

## Processes

Sediment dynamics

Fish reintroduction



Riverine foodwebs

Terrestrial linkages

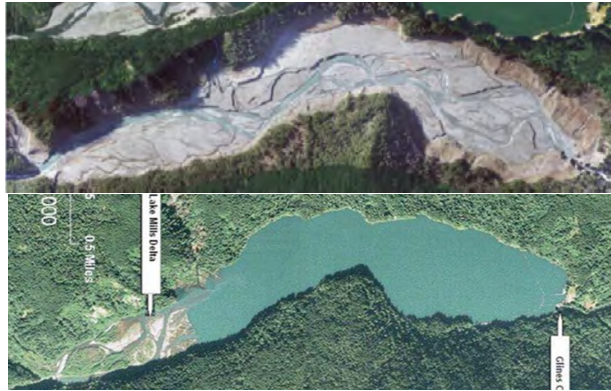
Revegetation

# Elwha River dam removal hypotheses

- Channel widening, aggradation, migration, development of river delta
- Initial decrease in primary & secondary productivity due to sediment
- Long term increase in marine derived nutrients & detrital input
- Salmonids will establish self-sustaining populations in the middle & upper Elwha from lower river, nearby watersheds, and resident populations
- “Reawake” salmon life history strategies
- Sediment impacts to immobile life stages
- Floodplain channels – sediment or refuge areas?



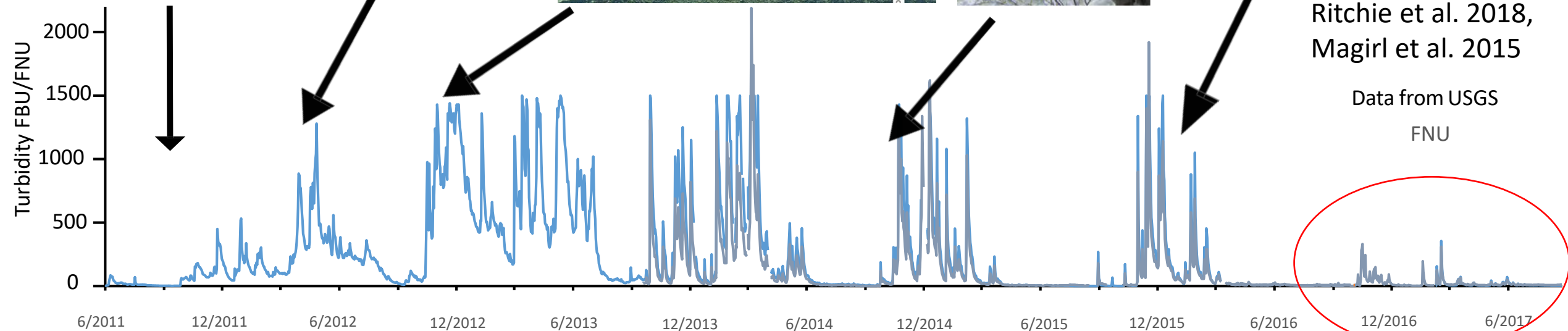
# How did sediment supply change due to the dam removal?



5 large flood events  
> 10,000 cubic feet/sec

Warrick 2020,  
Ritchie et al. 2018,  
Magirl et al. 2015

Data from USGS  
FNU



# Elwha River Estuary - Before and After

June 25, 2009 - ~ 2 years before dam removal

July 29, 2021 - ~ 7 years after dam removal





Photo courtesy of Andy Ritchie



Photo courtesy of Andy Ritchie

# Former Mills reservoir Mouth of Boulder Creek

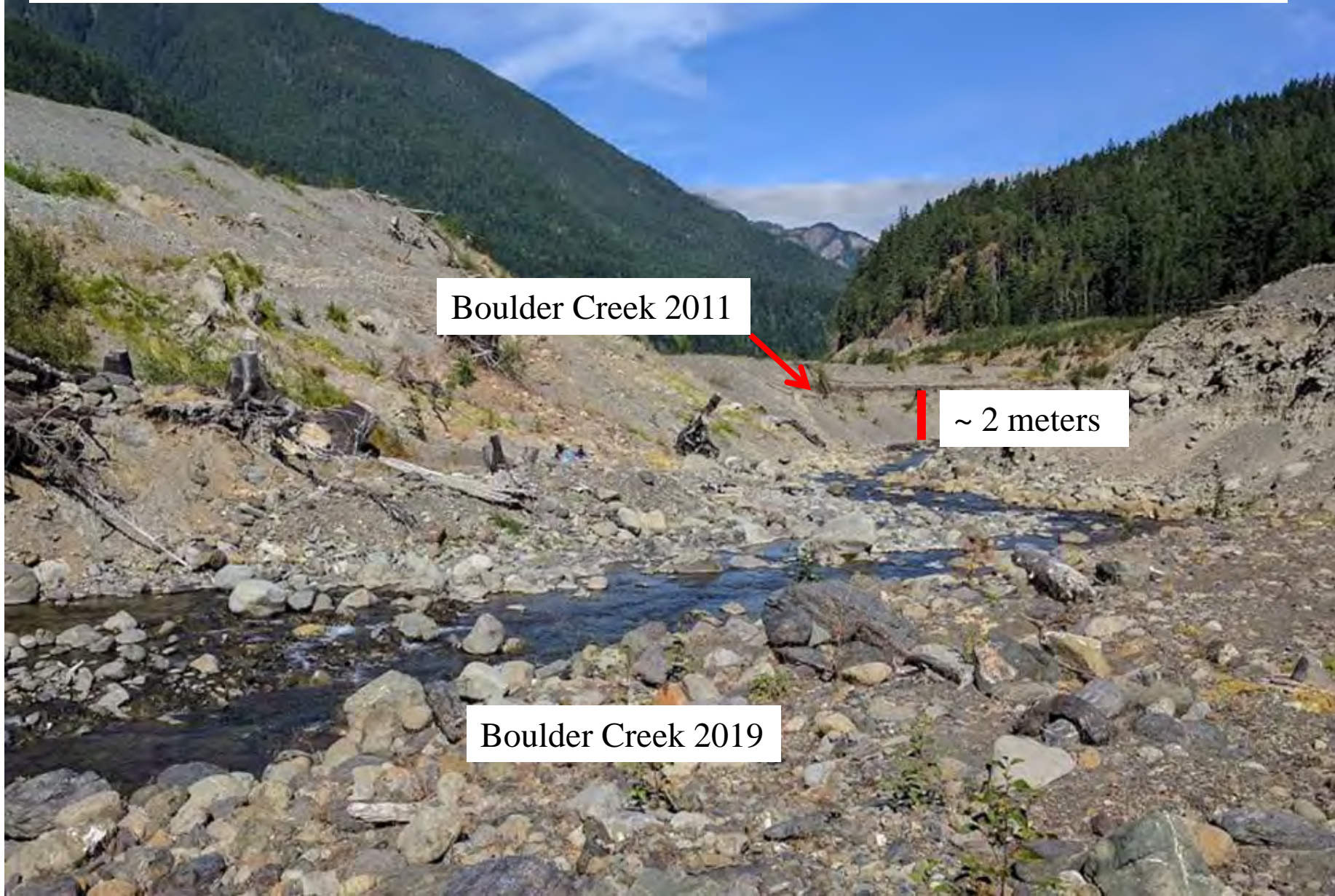


Boulder Creek

September 2011

Photo by John Gussman

# Former Mills reservoir Mouth of Boulder Creek

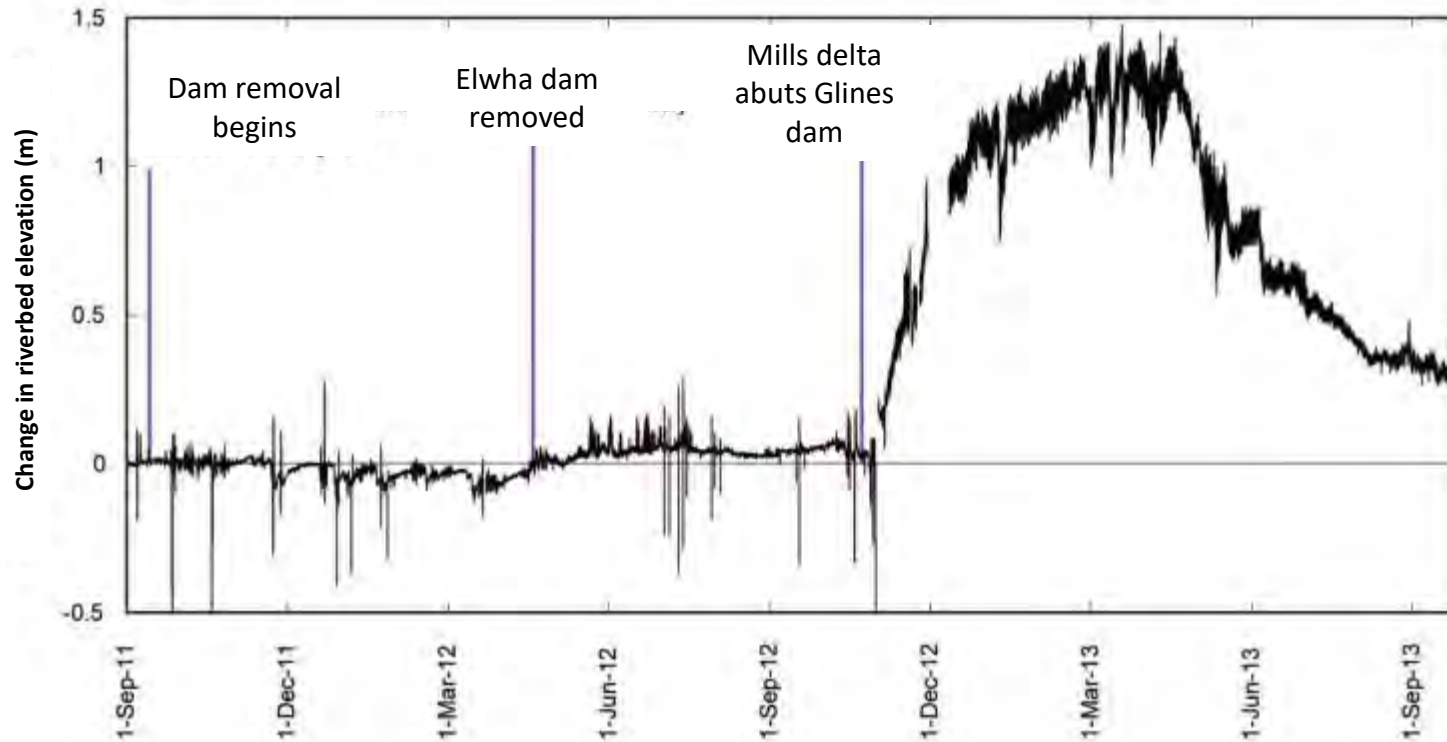


Boulder Creek 2011

~ 2 meters

Boulder Creek 2019

# How has freshwater habitat downstream of the dams changed with the increase in sediment supply?



Magirl, C. S., Hildale, R. C., Curran, C. A., Duda, J. J., Straub, T. D., Domanski, M., & Foreman, J. R. (2014). Large-scale dam removal on the Elwha River, Washington, USA: Fluvial sediment load. *Geomorphology*.

# Middle Elwha main stem & floodplain response



Gravel bar development,  
Wood accumulation

Bank erosion &  
channel avulsion

Pool filling

# Gravel bar development & wood accumulation in the Middle Elwha River

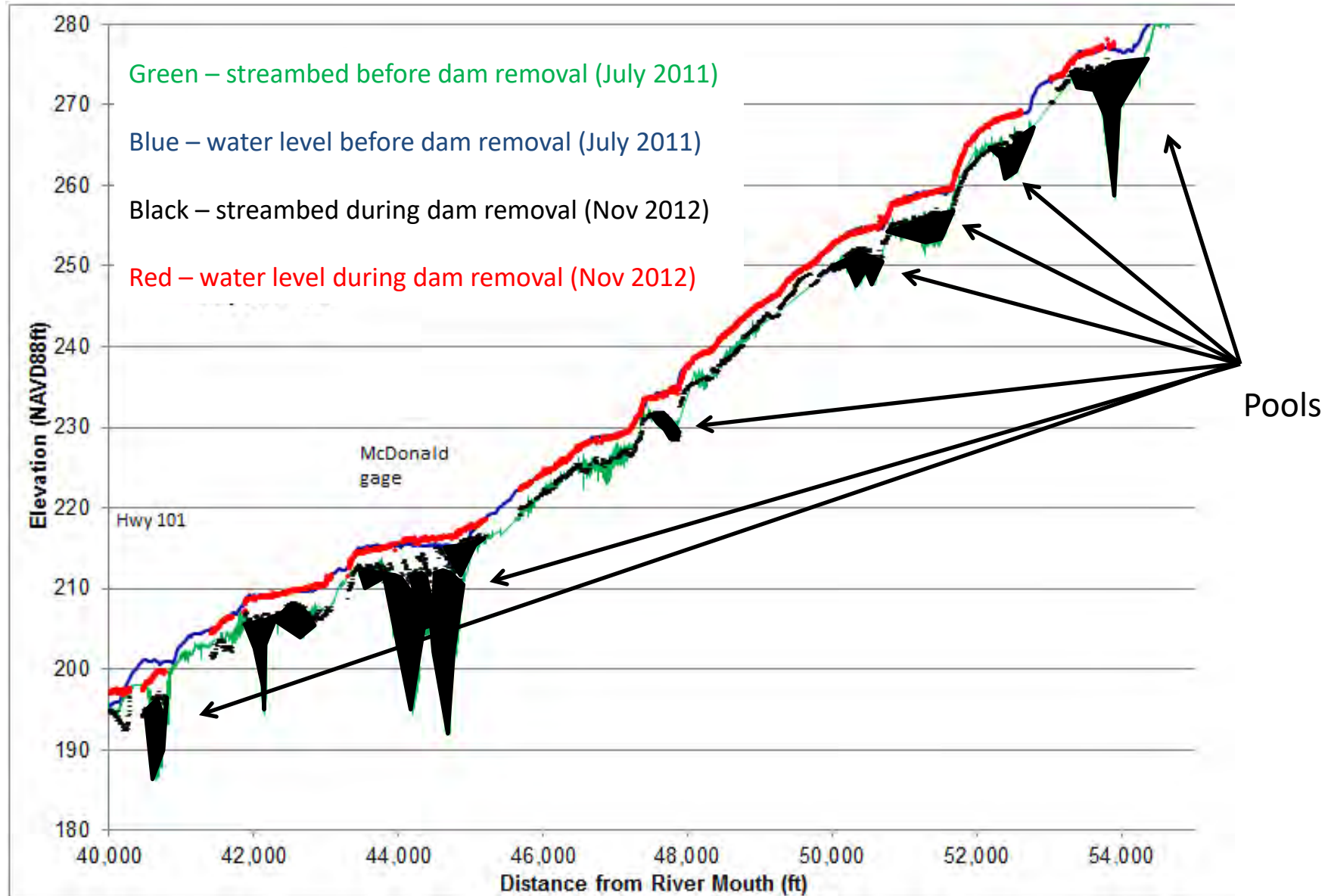


October 2012



March 2013

# Change in Middle Elwha mainstem depths during dam removal



- Slide courtesy of Jennifer Bountry and Tim Randle, Bureau of Reclamation

August 2011



November 2015



**Bank erosion &  
avulsion in the  
Middle Elwha**

# How much sediment and where did it go?

~7% stored in main stem

~60% of sediment transported to  
Strait of Juan de Fuca

~21 million m<sup>3</sup> released



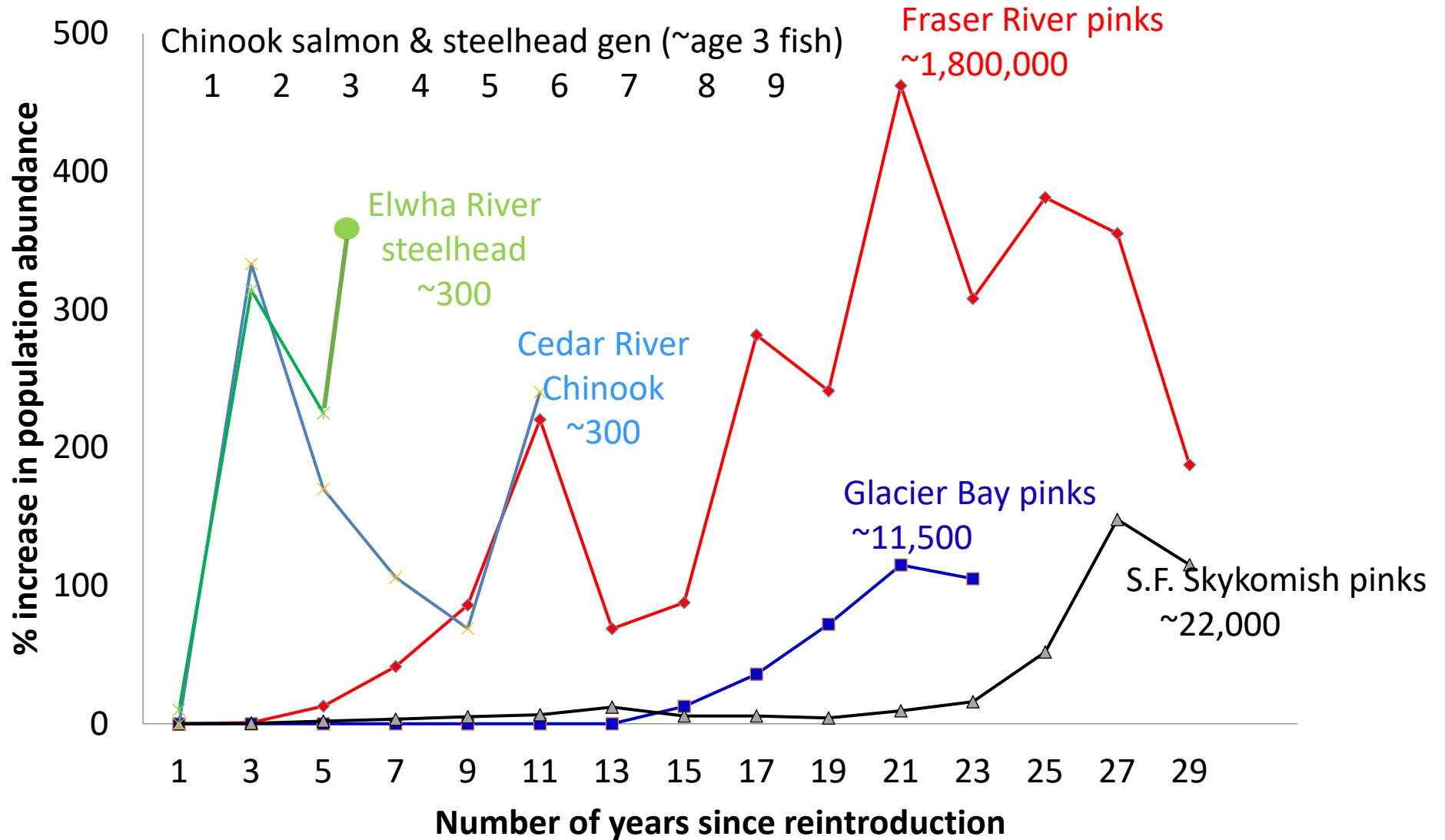
~29% deposited in nearshore

~4% stored in floodplain channels



Ritchie et al. 2018

# Salmon and steelhead can successfully reoccupy newly available habitats



# Elwha River salmon reintroduction above the former dams

- Assisted Relocation

- Hatchery & wild adult coho salmon
- Hatchery & wild steelhead



- Natural reintroduction

- Steelhead, Chinook salmon, Coho salmon, Pink salmon, Sockeye salmon, Bull Trout & Pacific Lamprey

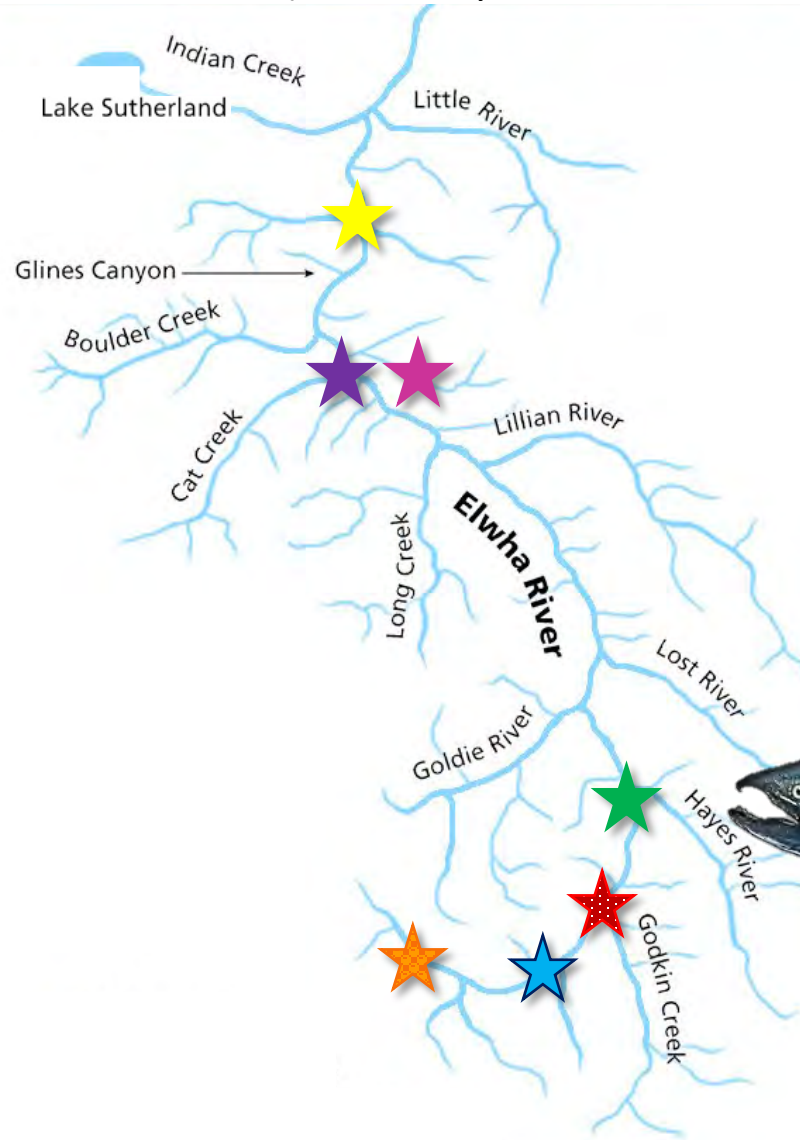


Liermann et al. 2017,  
Pess et al. 2024

Reintroduction is a combination of relocation & natural reintroduction by adult salmonids & other species

# Where and how long did it take to get above the former dams?

(Glines Canyon dam removed Aug 2014, Rockfall removed Oct 2015)



**Chum**-rkm 21 (Nov 2014)



**Pink**-rkm 26 (Aug 2019)



**Coho**-rkm 26 (Oct 2016)



**Sockeye**-rkm 58 (Aug 2015)



**Chinook**-rkm 58 (Sept 2014)



**Steelhead**-rkm 60 (Jul 2014)



**Bull Trout**-rkm 65 (Aug 2014)

# There are more Chinook salmon in the Elwha River after the removal of the dams Chinook salmon (majority hatchery Chinook salmon)

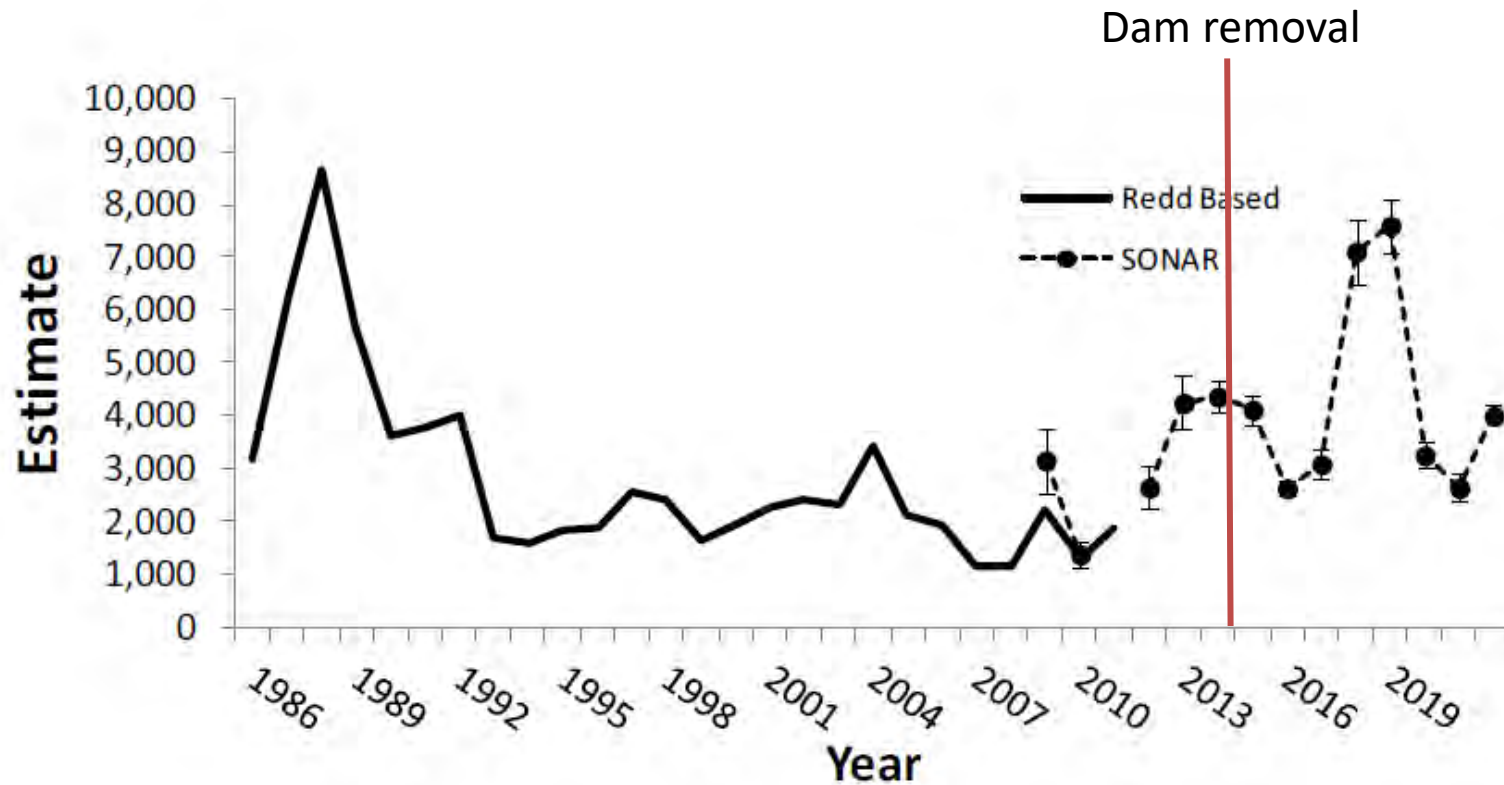


Photo by John McMillan

# There are more coho salmon in the Elwha River after the removal of the dams

Coho salmon (initially mostly hatchery coho salmon ~1,000)

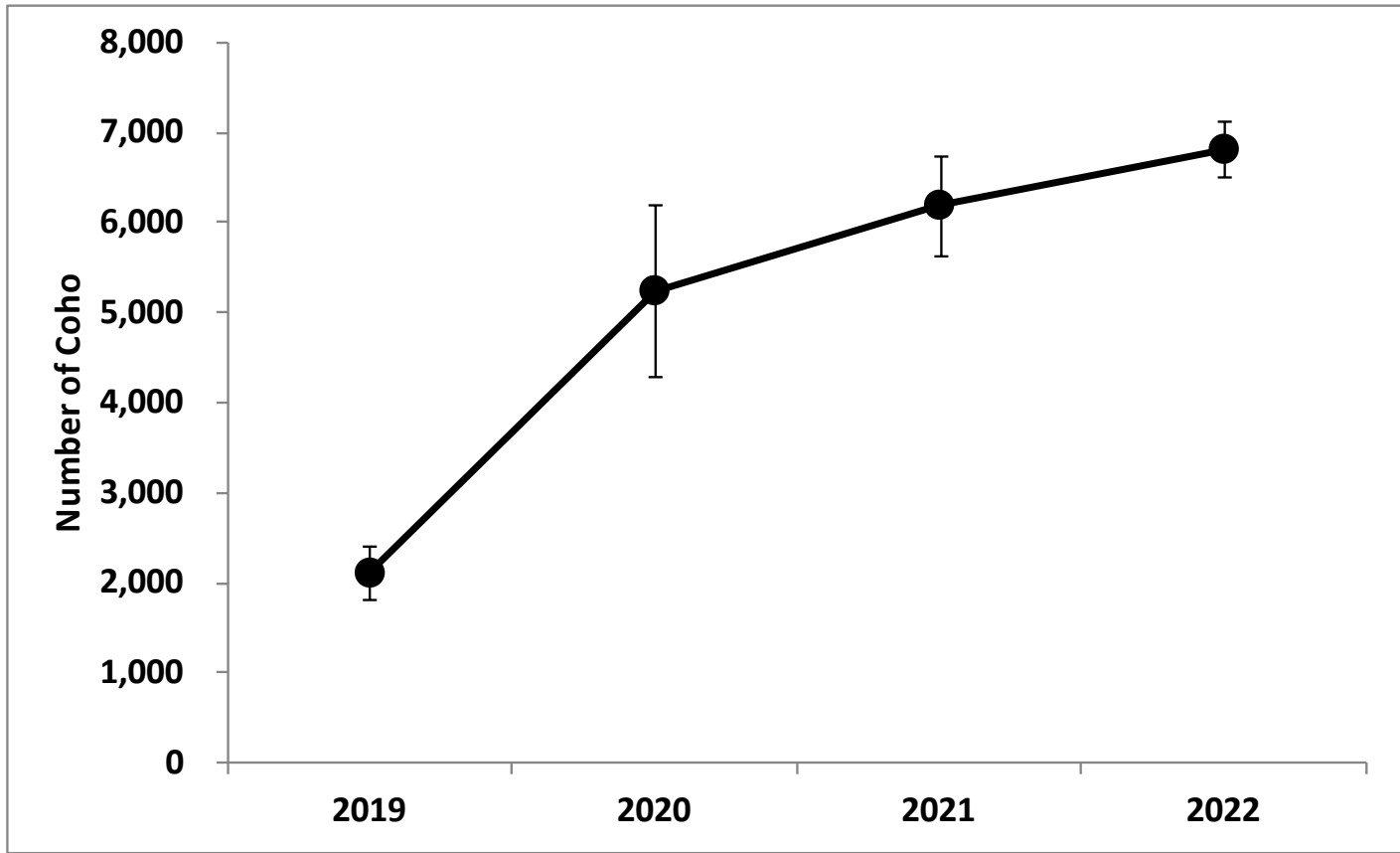
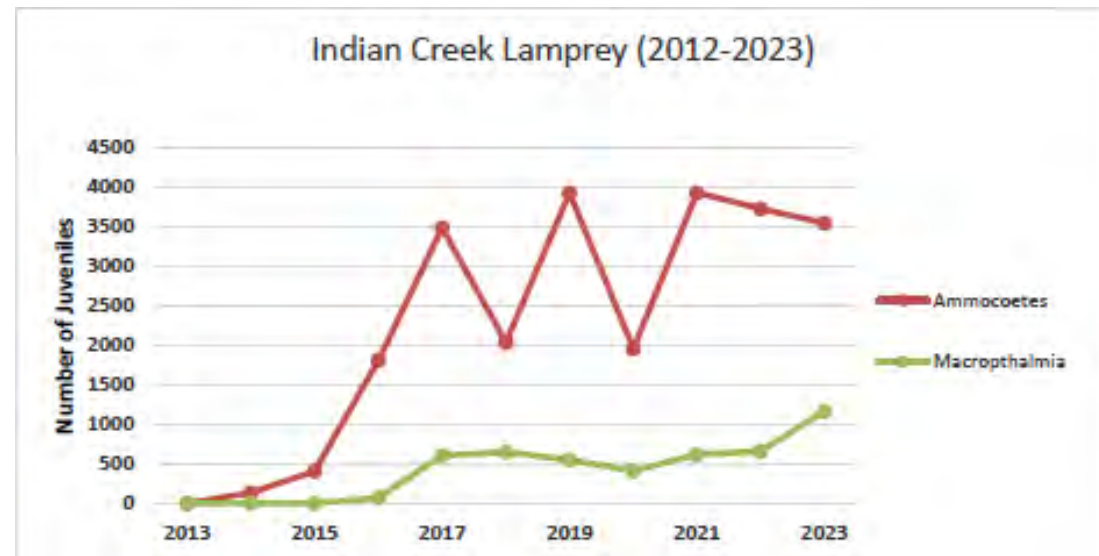


Photo by John McMillan

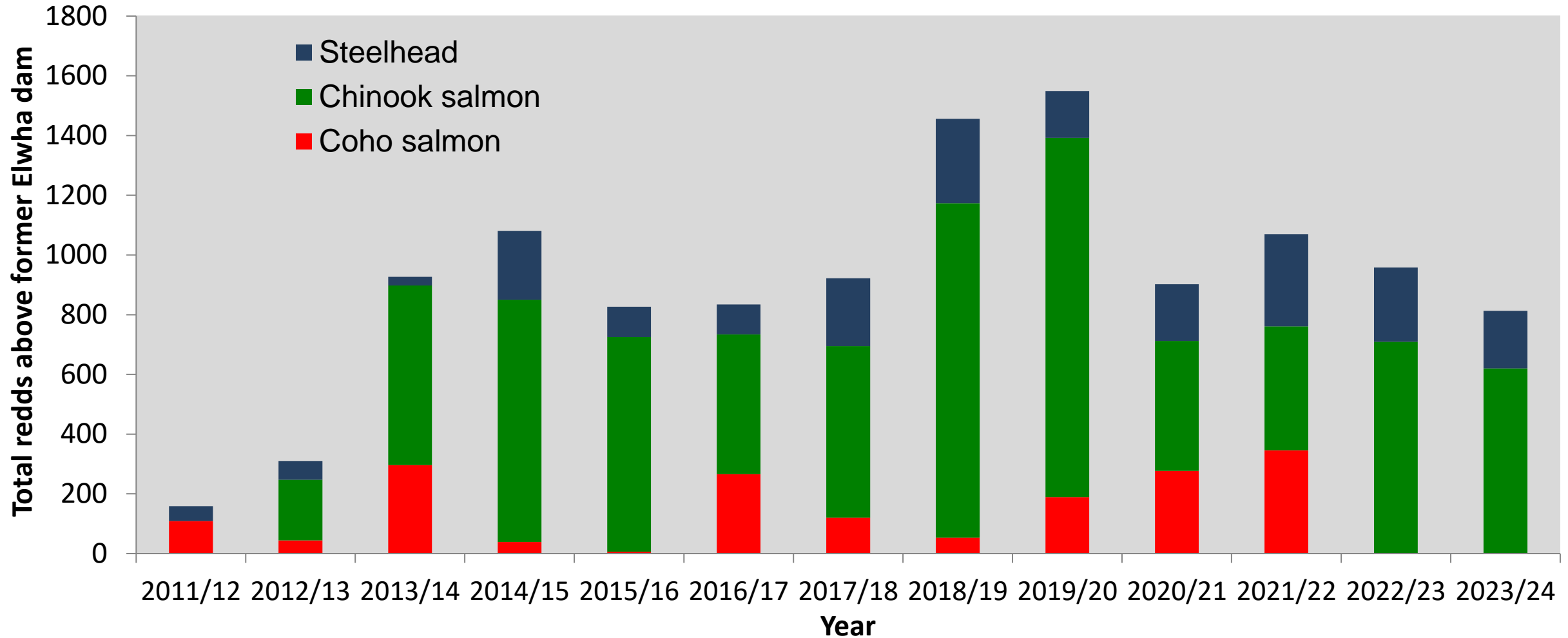
# Elwha River Pacific lamprey

- Elwha River Pacific lamprey - a 12-fold increase three years following dam removal (Hess et al, 2021).
- First documented above former Elwha dam 2013 and above former Glines Canyon dam 2016
- Increasing captured of juveniles at smolt traps



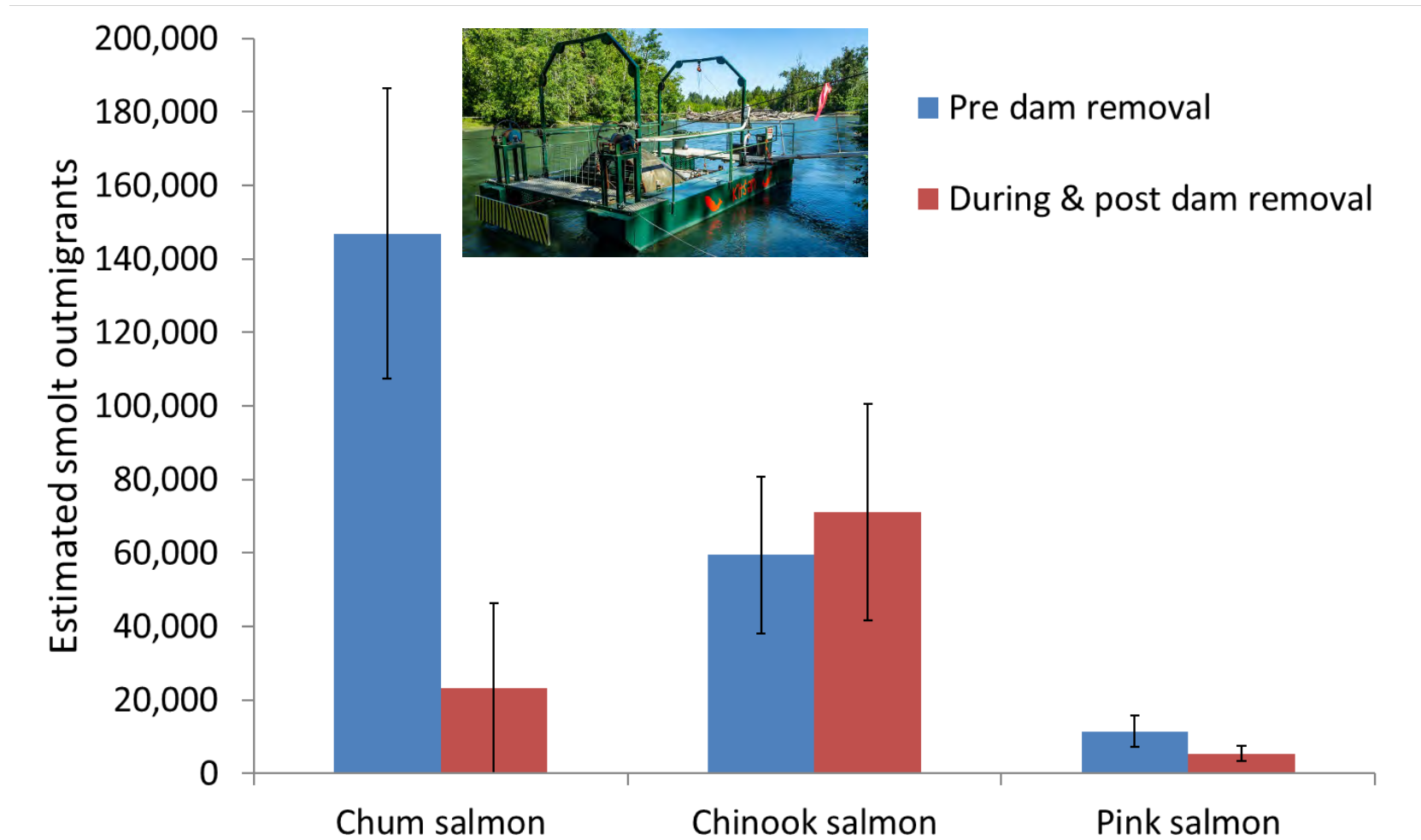
# Salmon recolonization above the former dams

## Chinook salmon, Steelhead, & Coho salmon

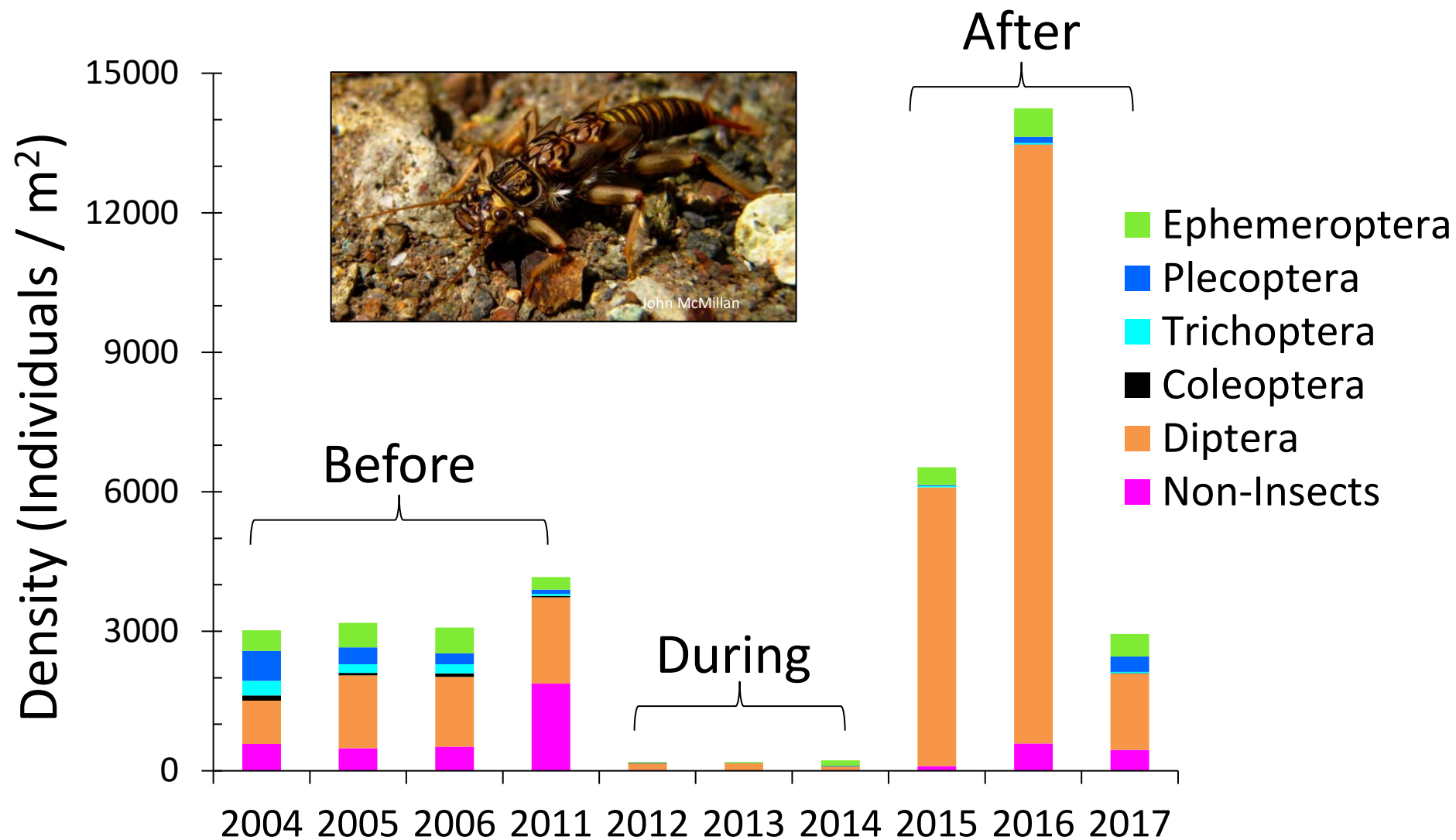


Note – no coho salmon redd data for 2022/23 and 2023/24. Coho salmon population has increased during those years.

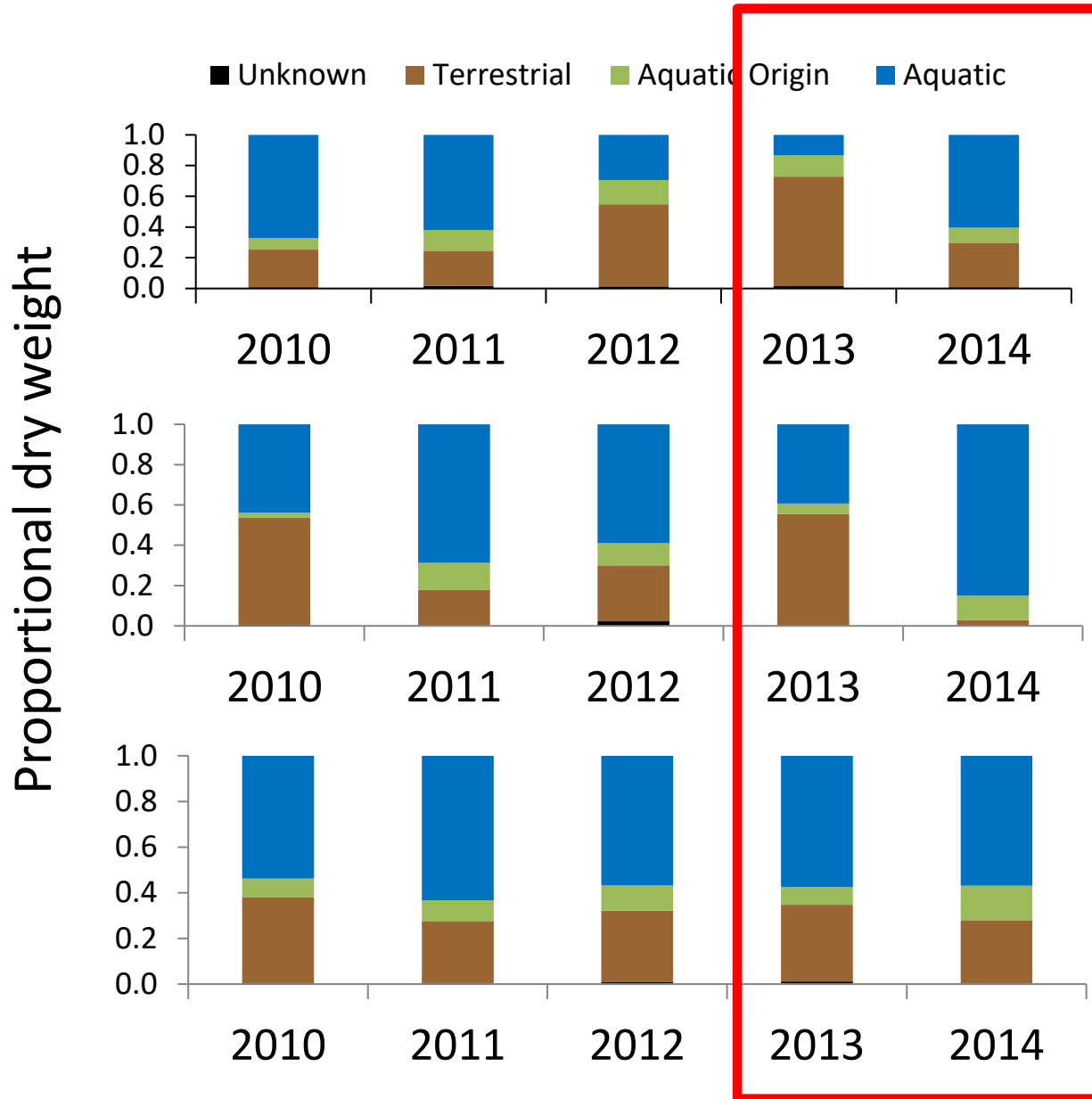
# Sediment had an impact on juvenile salmon, especially during dam removal



# Changes to benthic invertebrate density below the Elwha River dams



# Changes to Elwha River juvenile rainbow trout (*O. mykiss*) summer diet origin



Below  
Dams

Between  
Dams

Tributaries



# The American dipper has changed its behavior and benefited from spawning salmon

- Adult dippers **13 times more likely to be year-round residents** below obstructions
- Dippers below obstructions **20 times more likely to attempt multiple broods**
- **Higher survival** below obstructions due to salmon eggs

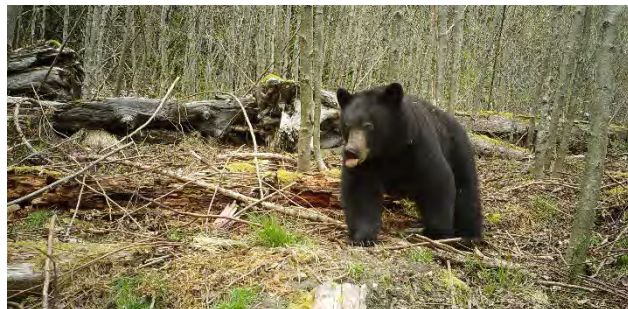
Tonra et al. 2015, 2016



# Wildlife reoccupation of former reservoirs



- There is a diverse array of species, including elk, cougars, bobcats, bears, weasels, and woodpeckers
- Small mammal abundance and diversity increased with increased vegetation development
- Beavers have successfully recolonized both former reservoirs
- Deer and elk are found on both former reservoirs
- Deer and elk browse pressure is high but it has not impeded revegetation processes
- Current efforts included monitoring wildlife presence and distribution using game cameras.



# Vegetation change due to dam removal sediment dynamics & new landforms



Expansion of delta created sites for pioneer vegetation

New intertidal water bodies = expansion of emergent marsh vegetation

New gravel bars = increased plant species diversity



Different vegetation trajectories on landforms - submerged valley walls, high terraces, & dynamic floodplains

Strait of Juan de Fuca

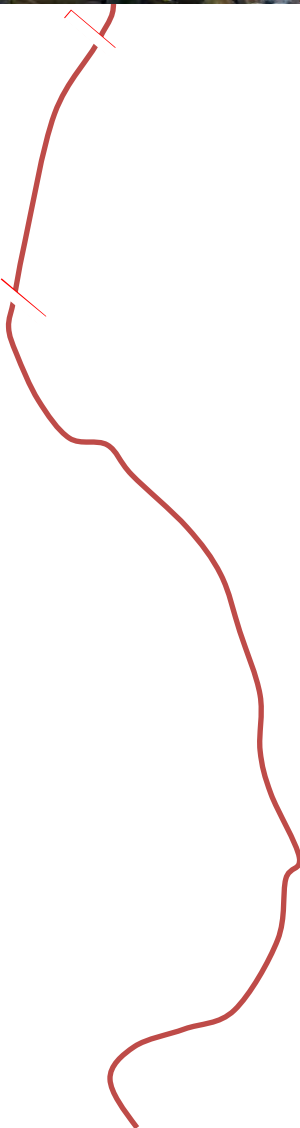
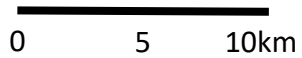


Elwha Dam

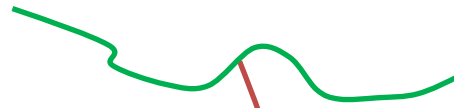
Glines Canyon Dam

**Chinook  
salmon**

All photos by John McMillan



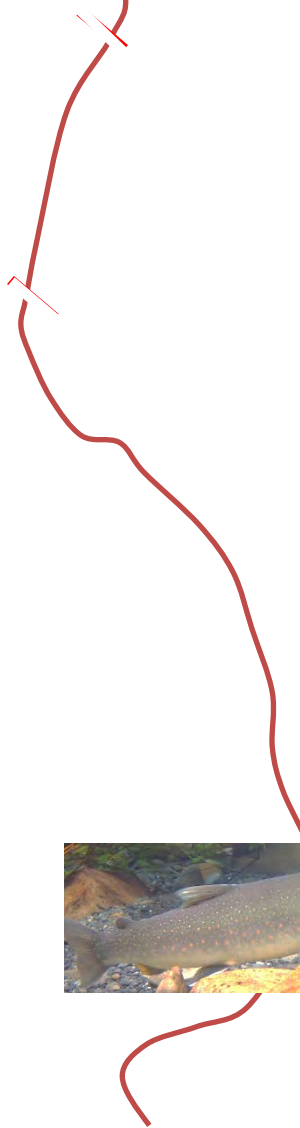
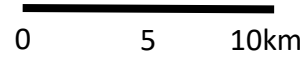
Strait of Juan de Fuca



Elwha Dam

Glines Canyon Dam

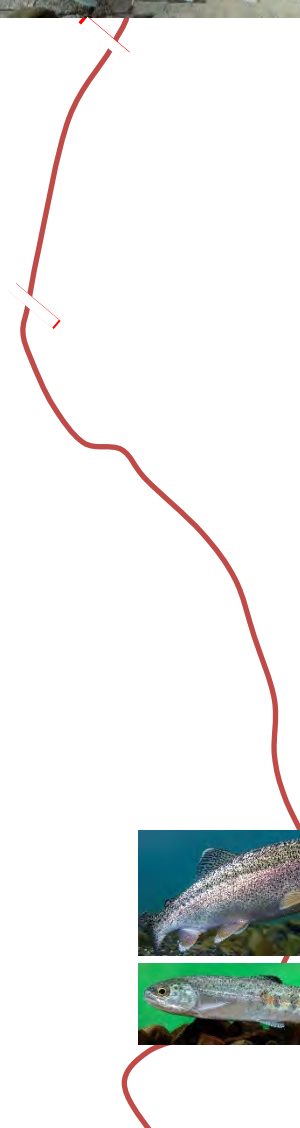
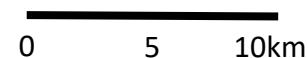
**Bull Trout**

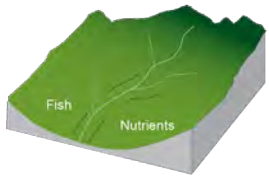


Elwha Dam

Glines Canyon Dam

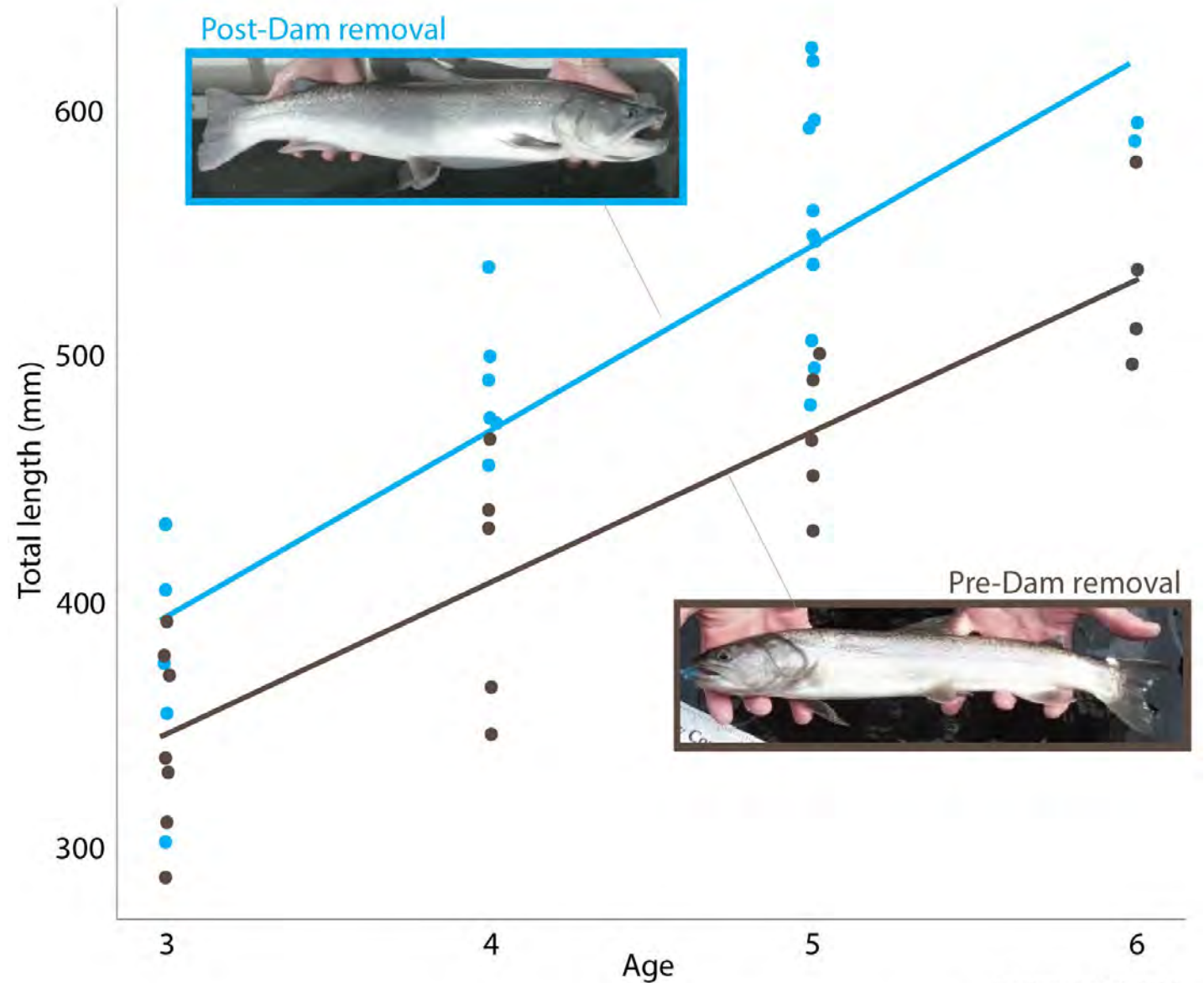
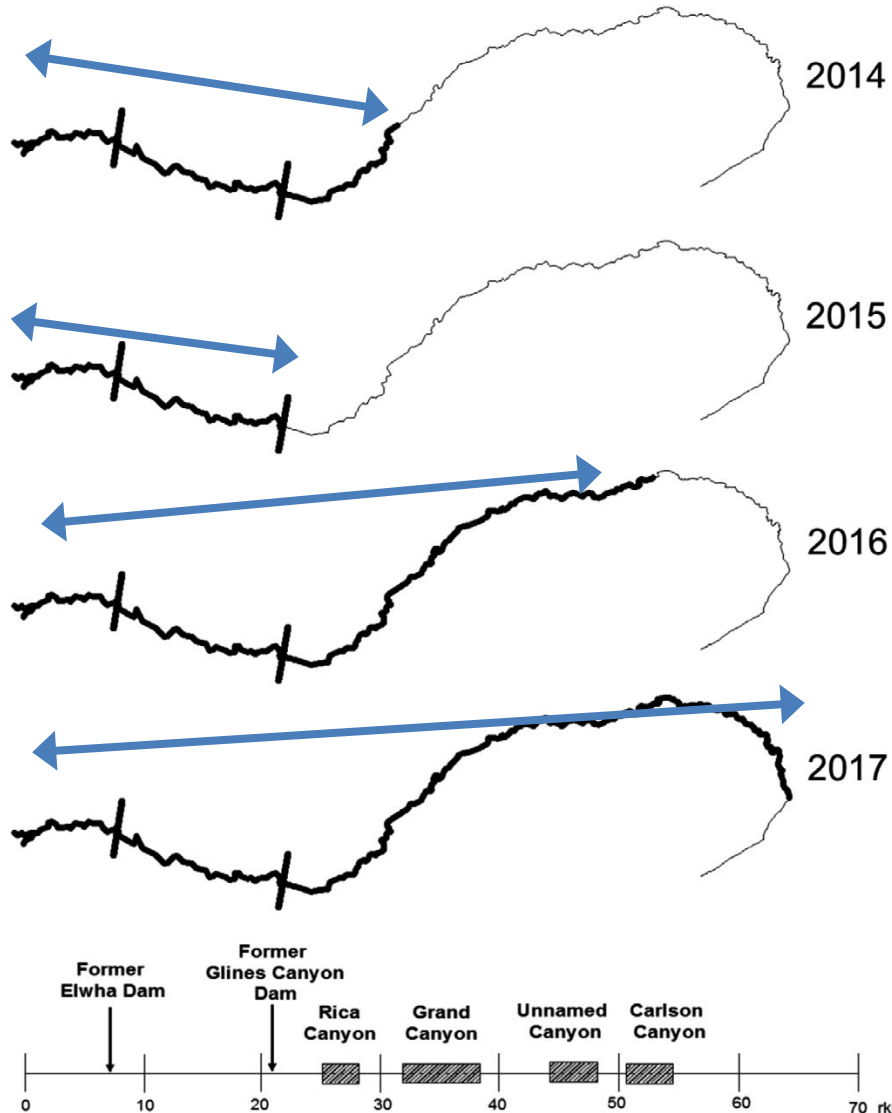
**Steelhead/  
Rainbow  
Trout**





# Bull trout & re-awakening whole-river migration

Upstream migration via radio-telemetry ↙



# There are more steelhead in the Elwha River after the removal of the dams

Winter Steelhead (2025 ~74% NOR)

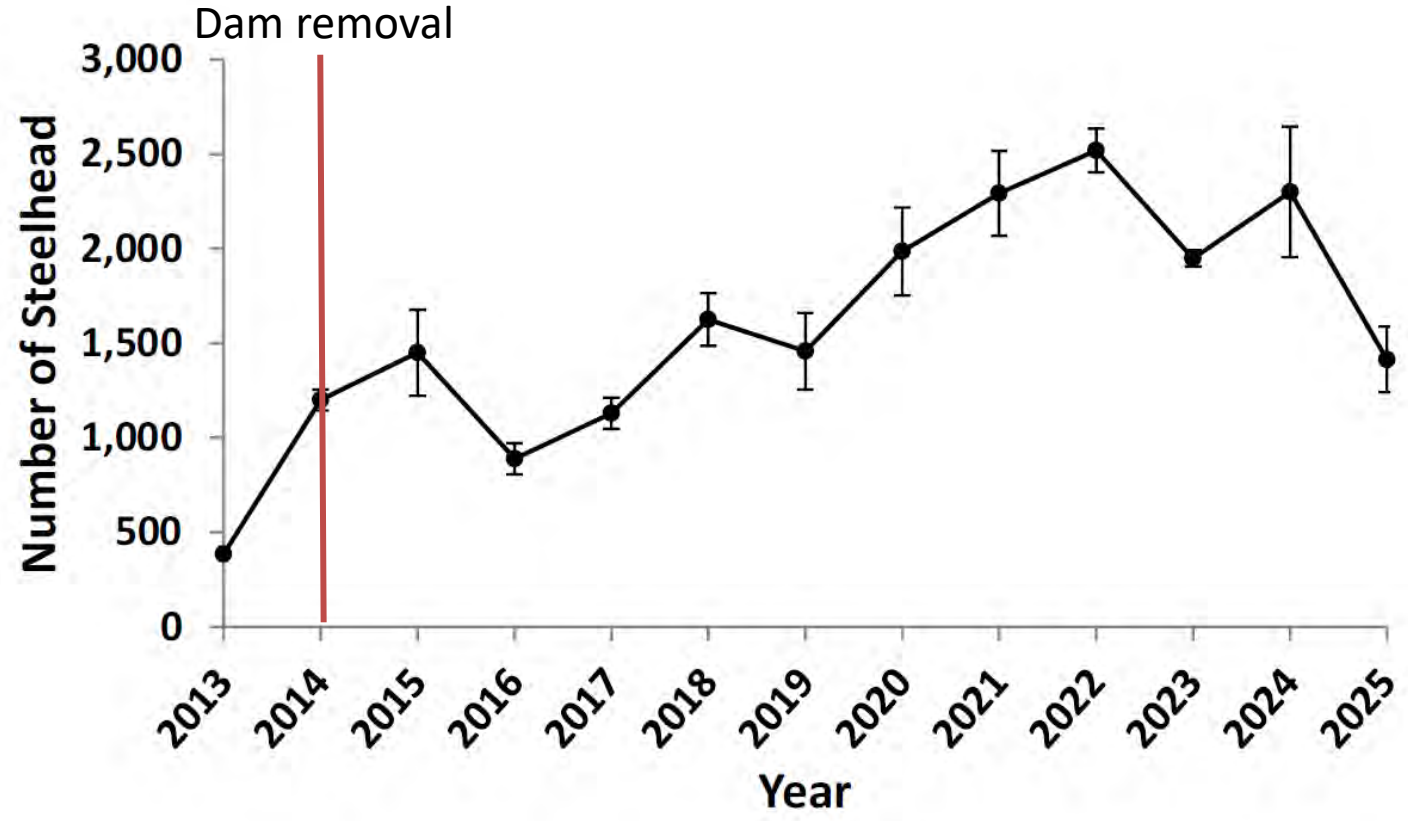
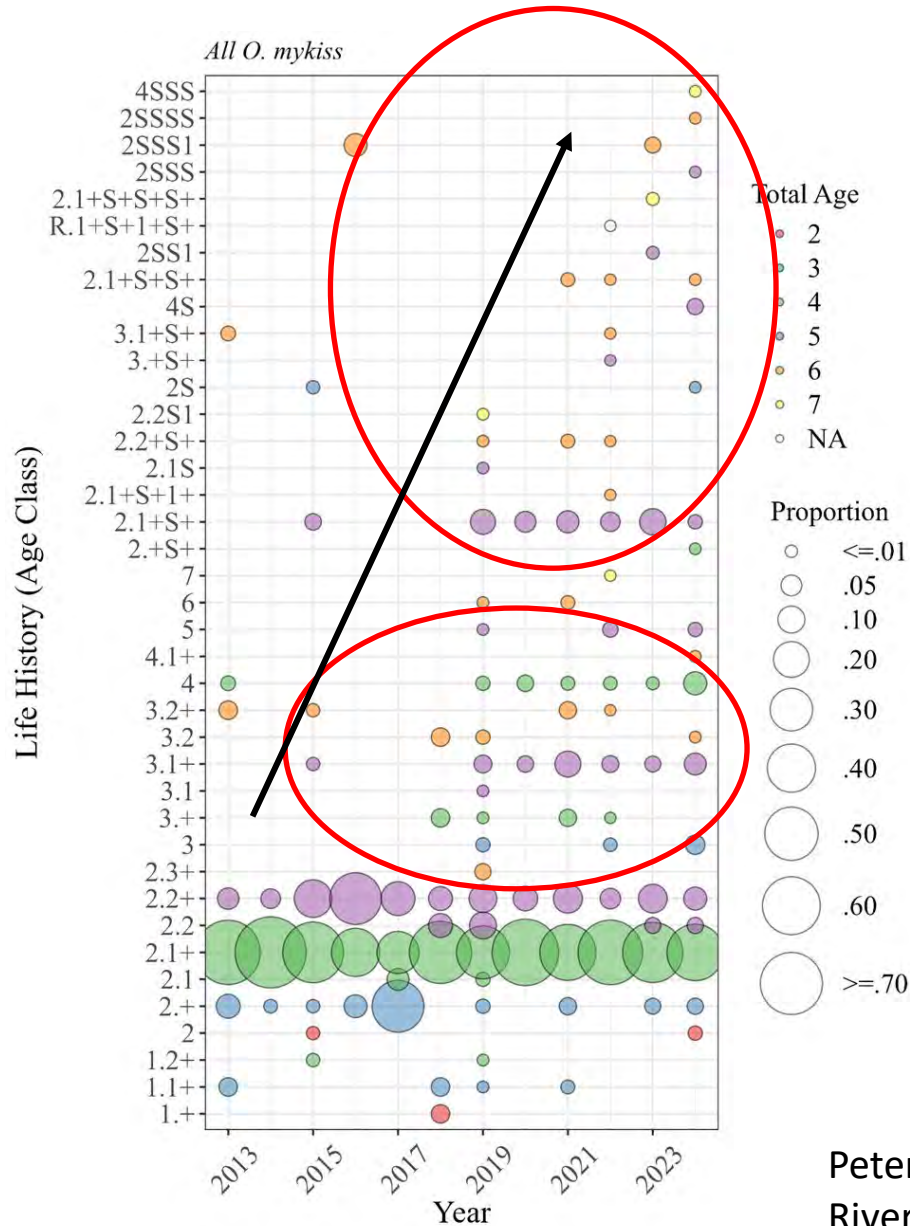


Photo by John McMillan

# *o. mykiss* life history expansion

I--Repeat spawners--I



2013 to 2018 – 1 to 3 life histories

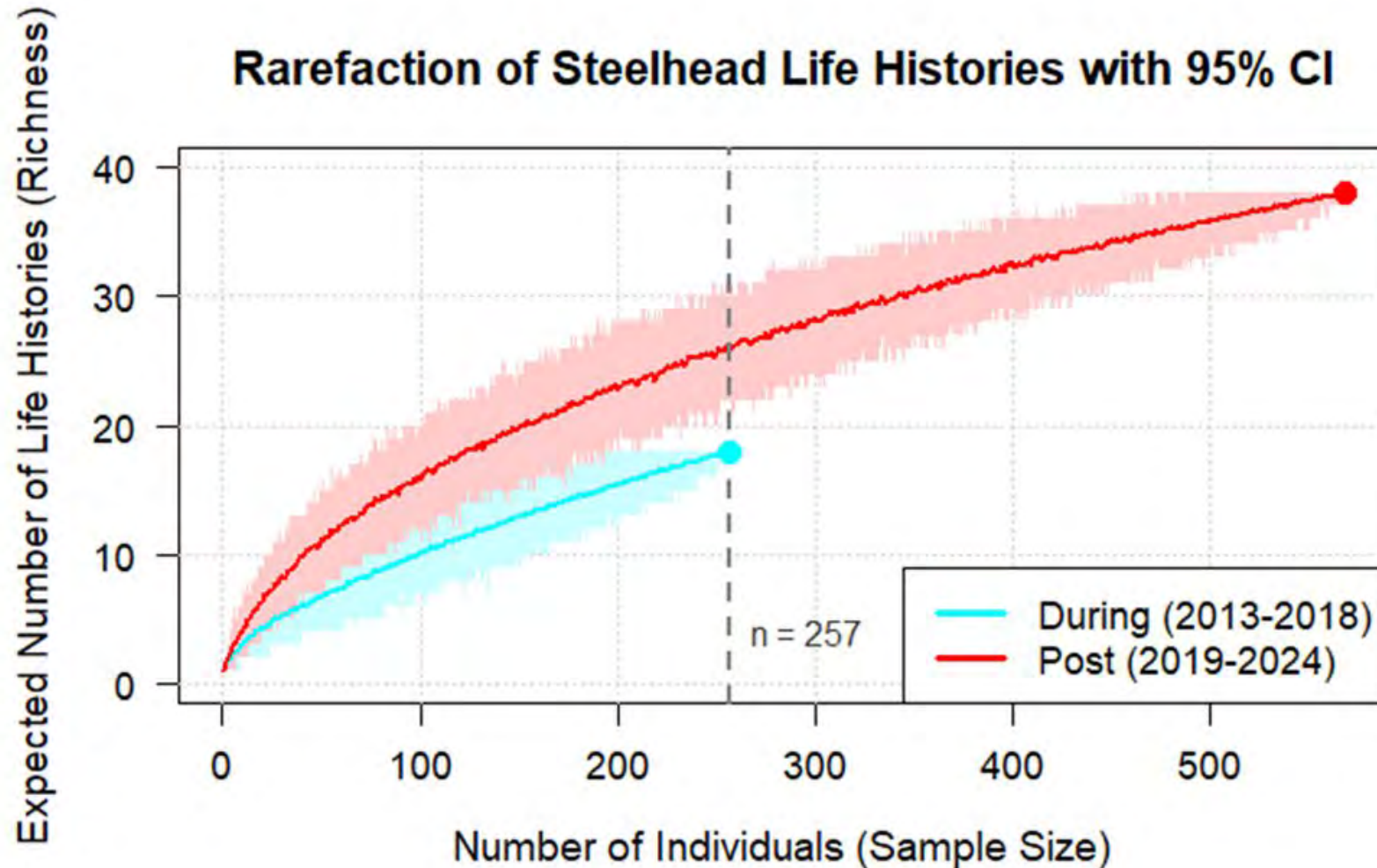
2018 to 2020 – up to 4 life histories

2021 to 2024 – 3 to 8 life histories per year

2018 to 2024 – More 3 plus fish

2018 to 2024 – More repeat spawners

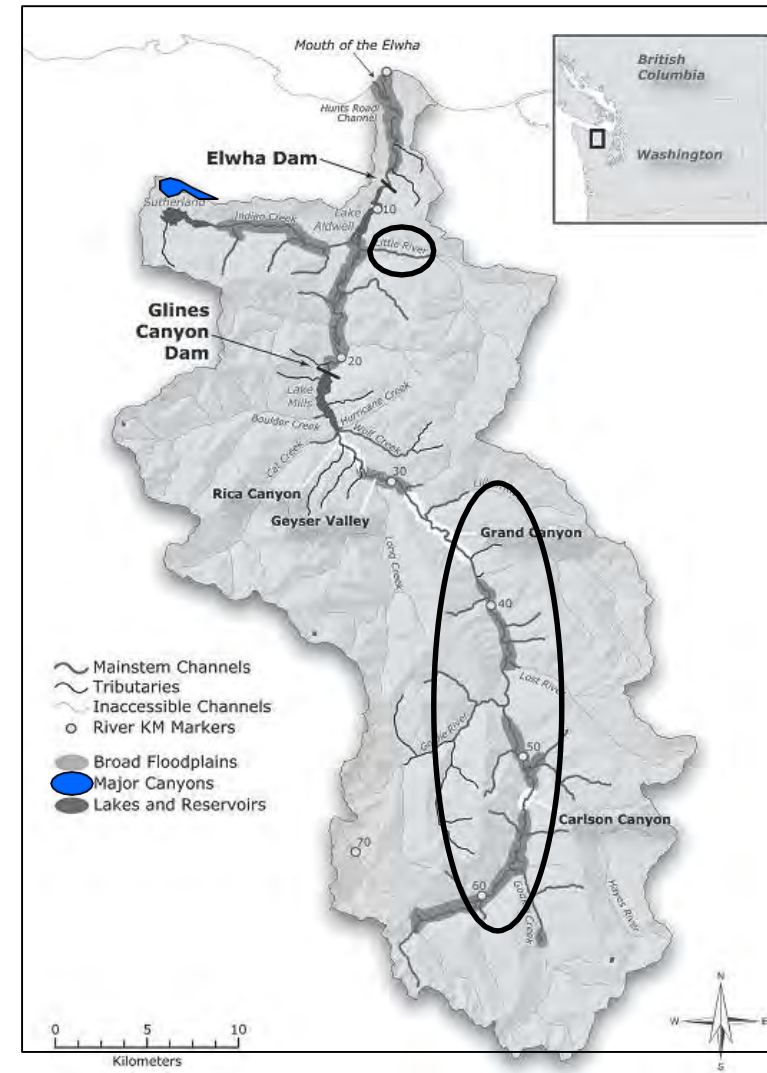
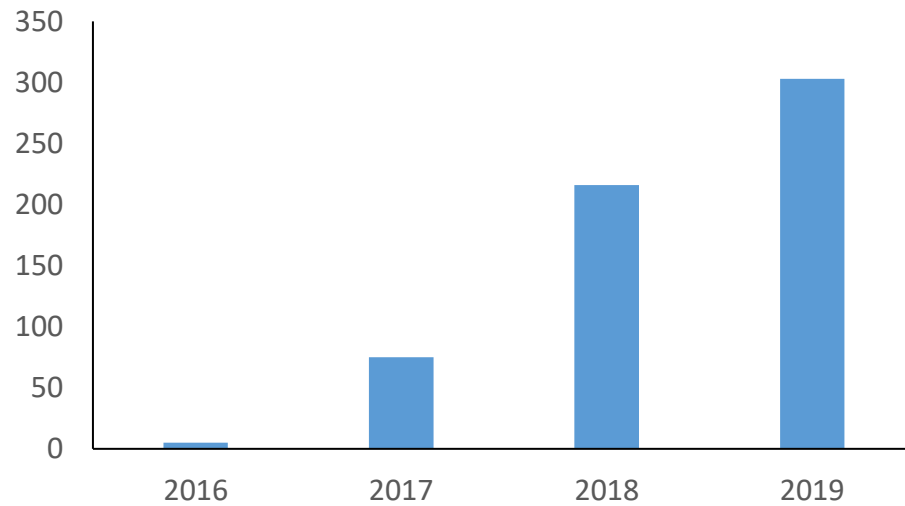
# *o. mykiss* life history expansion not a sampling phenomenon



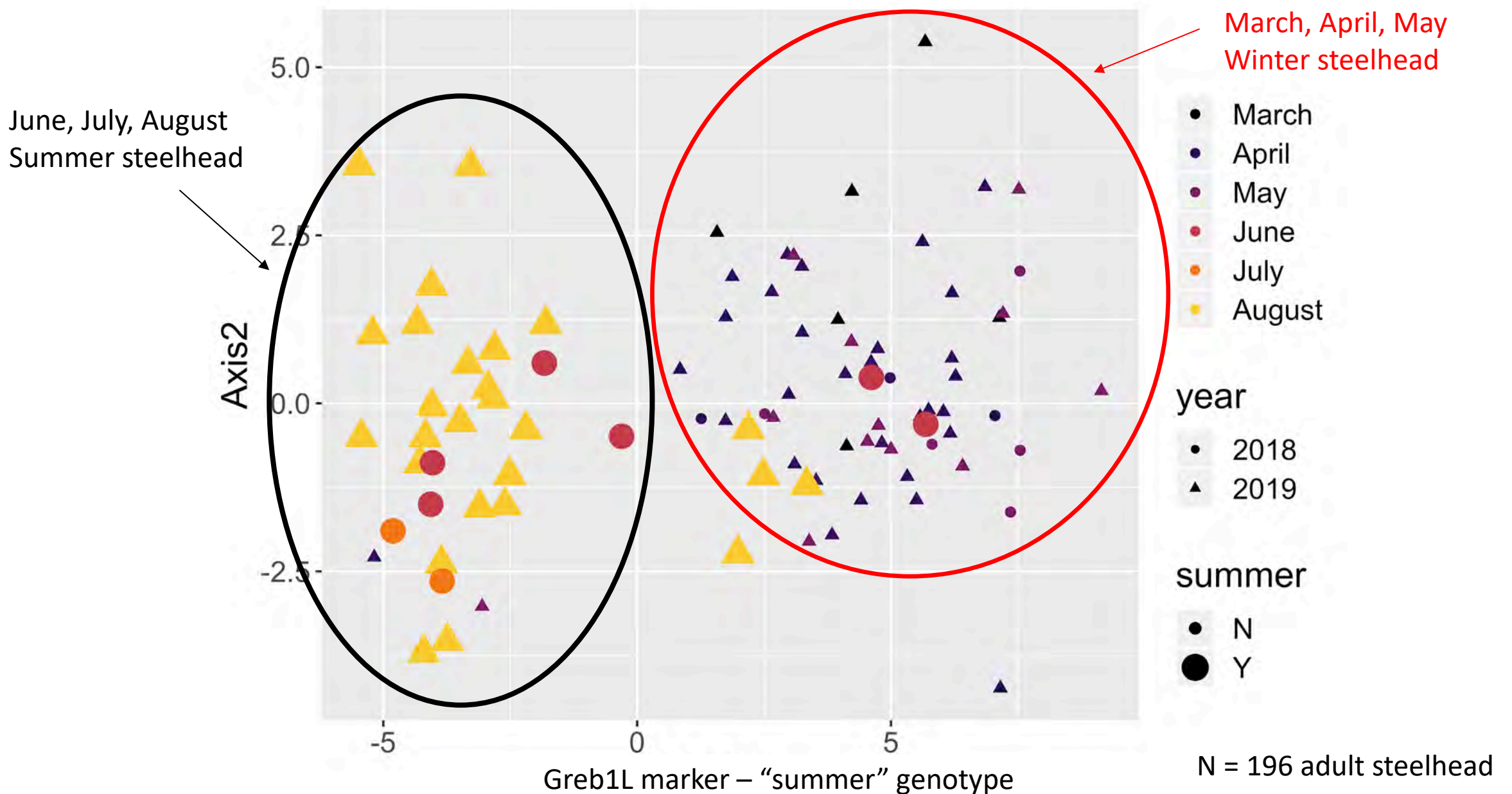
Peters et al. in review. Life history diversity of *oncorhynchus mykiss* in the Elwha River during and following dam removal. *Frontiers in Ecology and Evolution*

# The reawakening of summer steelhead in the Elwha River

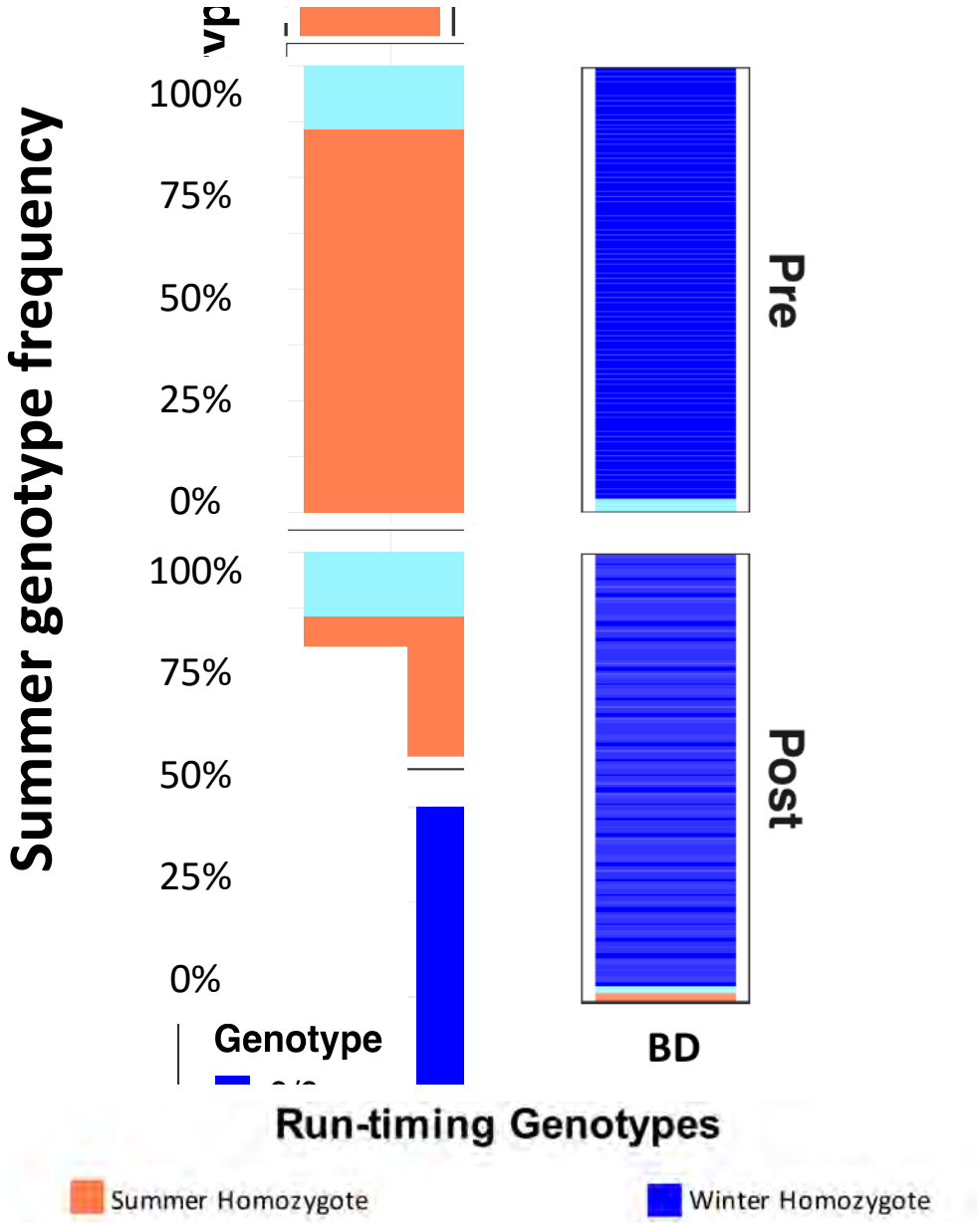
Number of summer steelhead observed



# 2018 & 2019 Returning Elwha River wild summer & winter steelhead



# A higher frequency of “summer” genotype above dams (AD) before & after dam removal



AD = above Glines Canyon dam

BD = below the dams

N = 2,608 juvenile, smolt, & adult steelhead

# Elwha River dams and former reservoirs

- Elwha and Glines Canyon dam removal complete



- > ~65% of total stored sediment has been released

Pre dam removal



2015

# Elwha River nearshore, delta and main stem

- ~90% of sediment transported to Strait of Juan de Fuca
- There is now a ~60 hectare delta at the Elwha river mouth
- ~10% of sediment stored in-river, supplying spawnable gravels and changing habitats



# Elwha River fish reintroduction

- Adult salmon making it above former dams and spawning in the hundreds to thousands
- Both hatchery and wild fish are contributing to the development of self-sustaining populations
- Pacific Lamprey growing in numbers
- Bull Trout anadromy allows for growth benefits
- ‘Re-awakening’ of summer steelhead



# Elwha River riverine foodwebs

- Benthic invertebrates reduced over 95% in lower Elwha, now making a comeback
- Juvenile salmon diet shift – aquatic to terrestrial back to aquatic
- American dippers have altered their migratory behavior and have productivity benefits from salmon



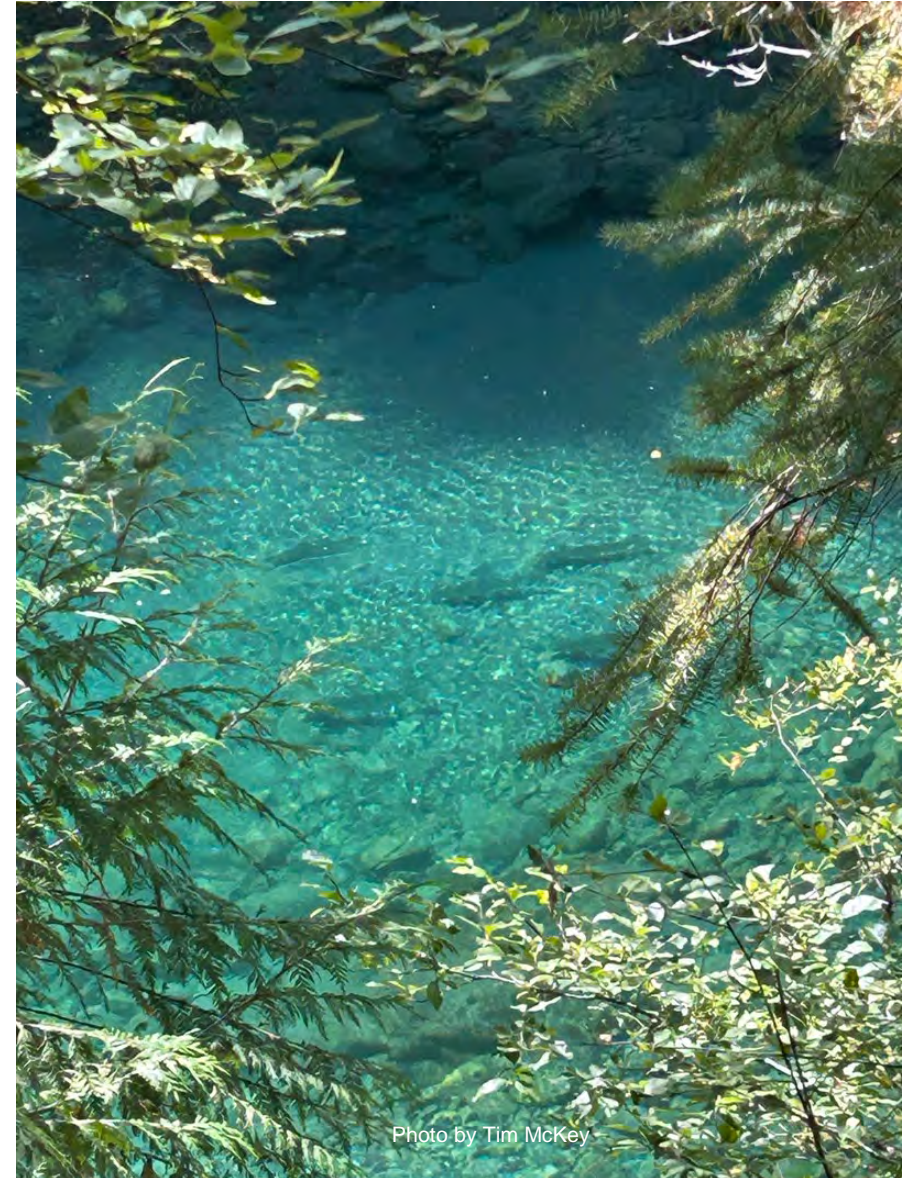
# Elwha River re-vegetation

- Vegetation change due to:
  - dam removal
  - sediment flux
- the creation of new landforms
  - delta,
  - river, and
  - former reservoirs



# Elwha River *O. mykiss*

- We have identified 39 different *O. mykiss* life history strategies in the Elwha River from 2013 to 2024
- Life history diversity has increased during that time
- Since 2018 there has been an increase in 3+ anadromous, older resident *O. mykiss*, and repeat spawners



Thank you



Photo by John McMillan



Photo by Tim McKey



# The role of natural and man-made barriers on the distribution of summer and winter-run steelhead in the greater Klamath-Siskiyou region

Samantha Kannry

# Steelhead Life-histories

- Anadromous, resident
- Winter-run, summer-run



# Why are summer-run steelhead special?



“Historically, summer steelhead returned to those West Coast rivers which consistently met any one of three general criteria:

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- 1) having at least one natural barrier posing difficult or impossible passage to other anadromous fish,
- 2) having considerable canyon water ensuring cold summer flows,
- 3) being a river which cut so far inland that no other race of steelhead would have either the time or necessary body fats to reach certain spawning/rearing areas.

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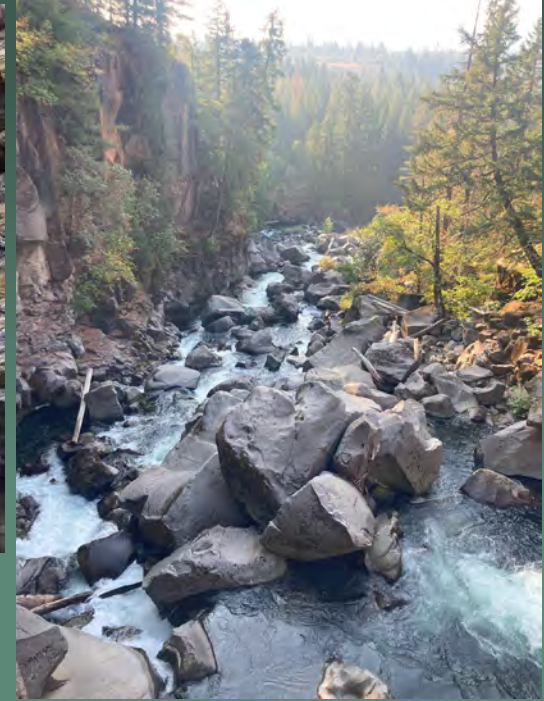
For much the same reasons, the summer steelhead streams were among the most imposing and strikingly beautiful rivers in the world.”

-Bill McMillan, from “Dry Line Steelhead and Other Subjects”

Summer-run  
steelhead have  
experienced a  
more  
precipitous  
decline



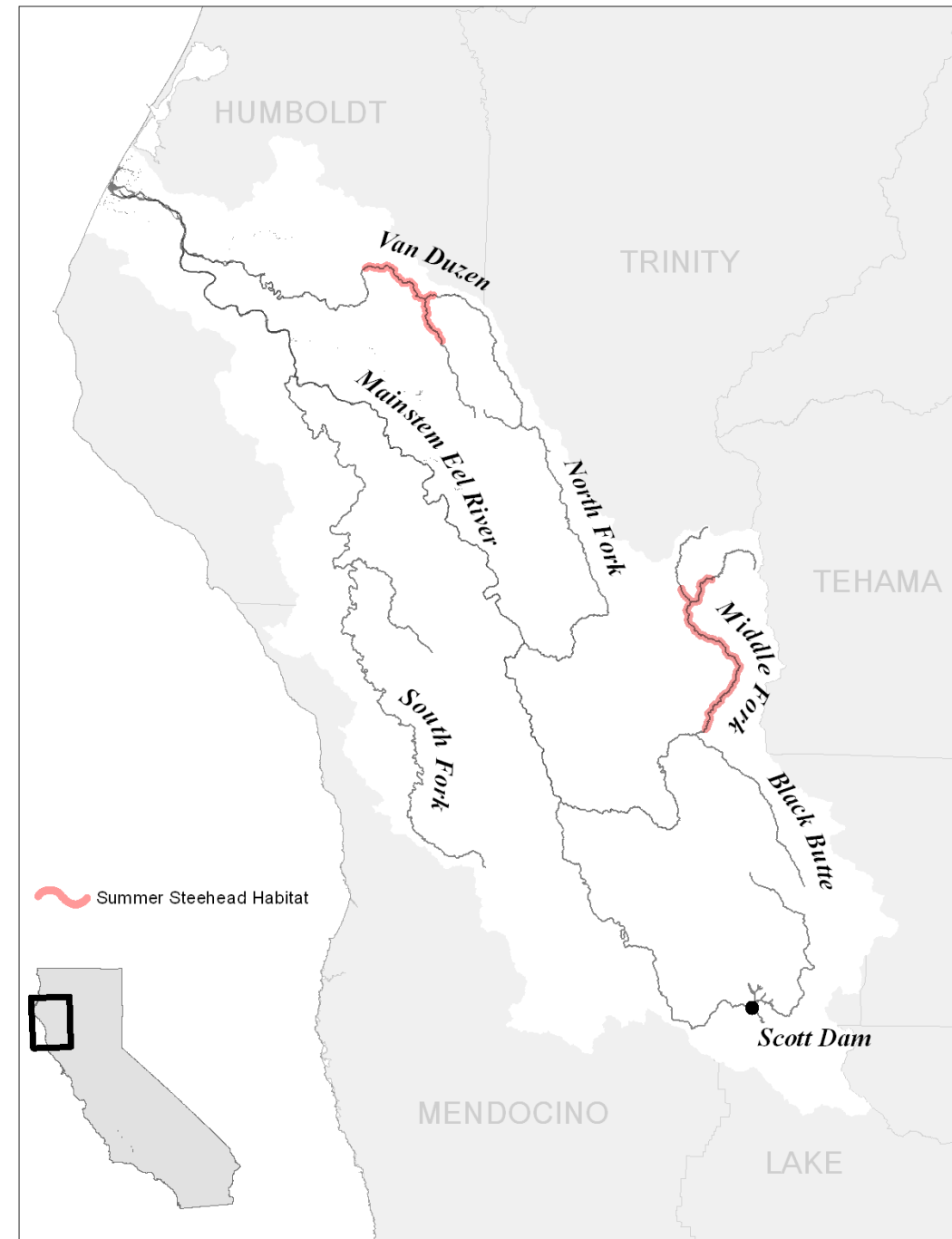
Summer-run steelhead in Middle Fork Eel



Barriers have differing forms, depending on the watershed



The Eel River is the southern end of the range of summer steelhead



# A number of questions existed regarding present and historical distribution of summer steelhead in the Eel

- Present state of genetic diversity above Scott Dam
- Do summer and winter-run fish spawn and rear in different locations in the Eel?
- Are summer-run genetics maintained in winter-run populations?



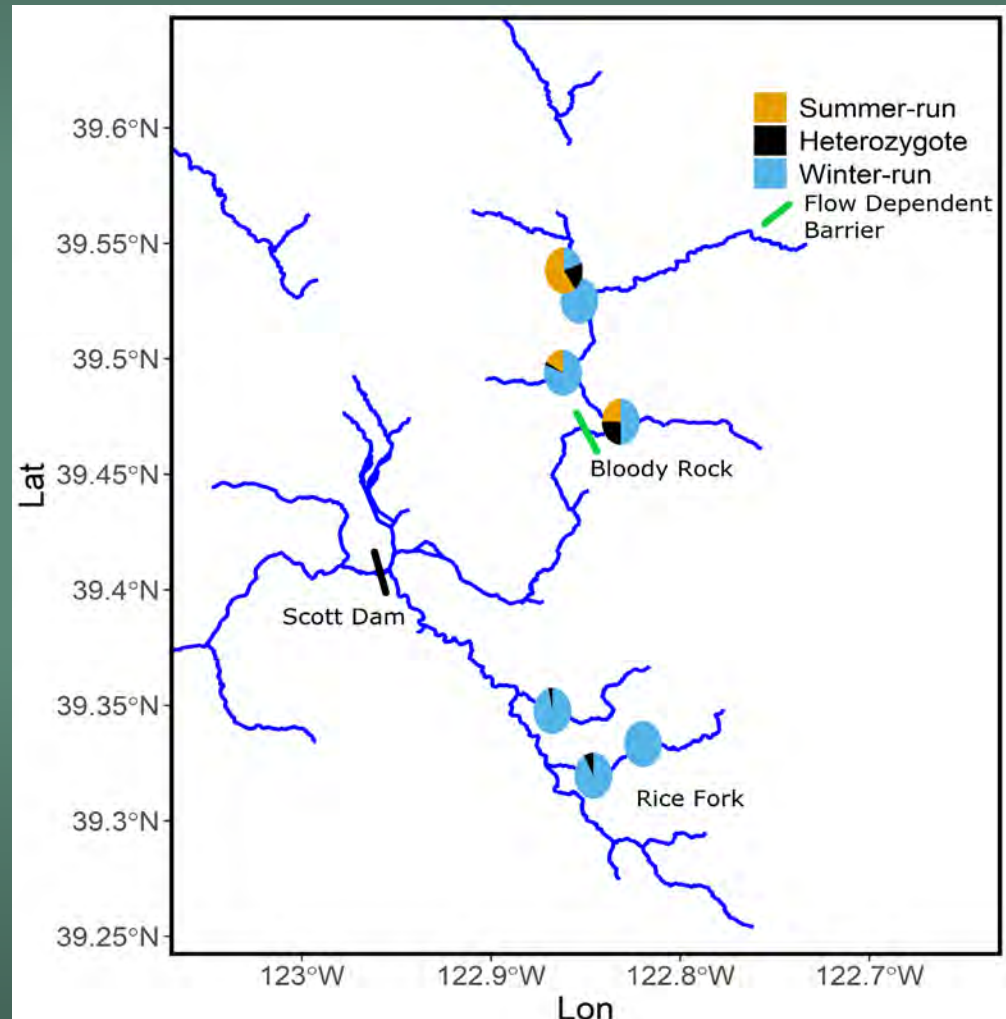
# What is the current state of genetic diversity of resident rainbow trout above Scott Dam?



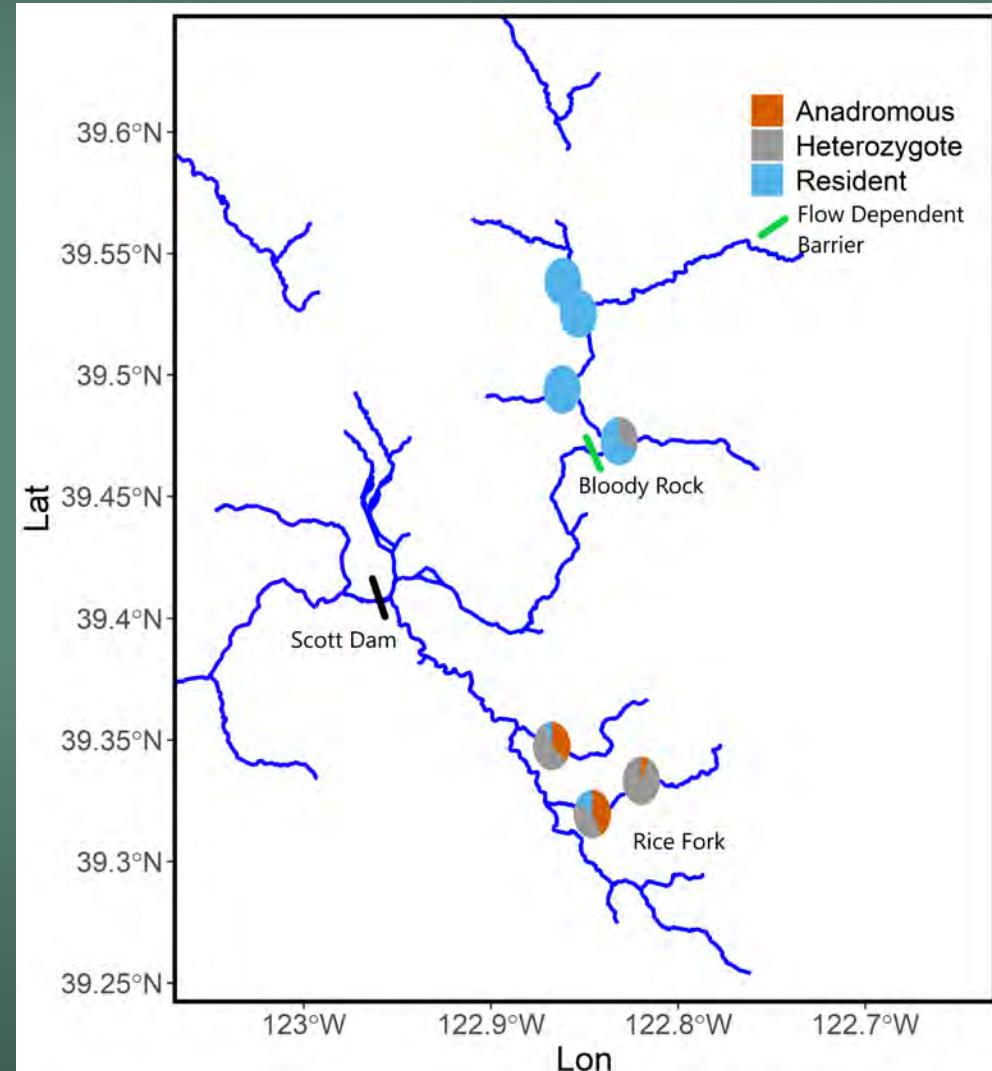
Photo Credit: Mikey Weir

*M. Weir*

# Summer-run alleles are present in resident trout population above Scott dam



Migratory potential is being maintained in the resident population above Scott dam



# Conclusions from the Eel

- Summer and winter-run steelhead are reproductively isolated by distinct geographic barriers



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- Loss of summer-run phenotype = loss of summer-run genotype



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# Conclusions from the Eel

- Summer and winter-run steelhead are reproductively isolated by distinct geographic barriers
- Loss of summer-run phenotype = loss of summer-run genotype
- Hatchery supplementation will not benefit fishes in the Eel River
- Minking heals the soul, we should see where else we can go



## Questions arose about summer-run steelhead in the greater region

---

- What is the distribution of summer and winter-run alleles around barriers in Redwood Creek, Baduwa't, Smith, Trinity and Klamath Rivers?



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- What are the run-timing genotypes of above dam resident trout populations
- Distribution of resident/anadromous type fish, overall genetic diversity

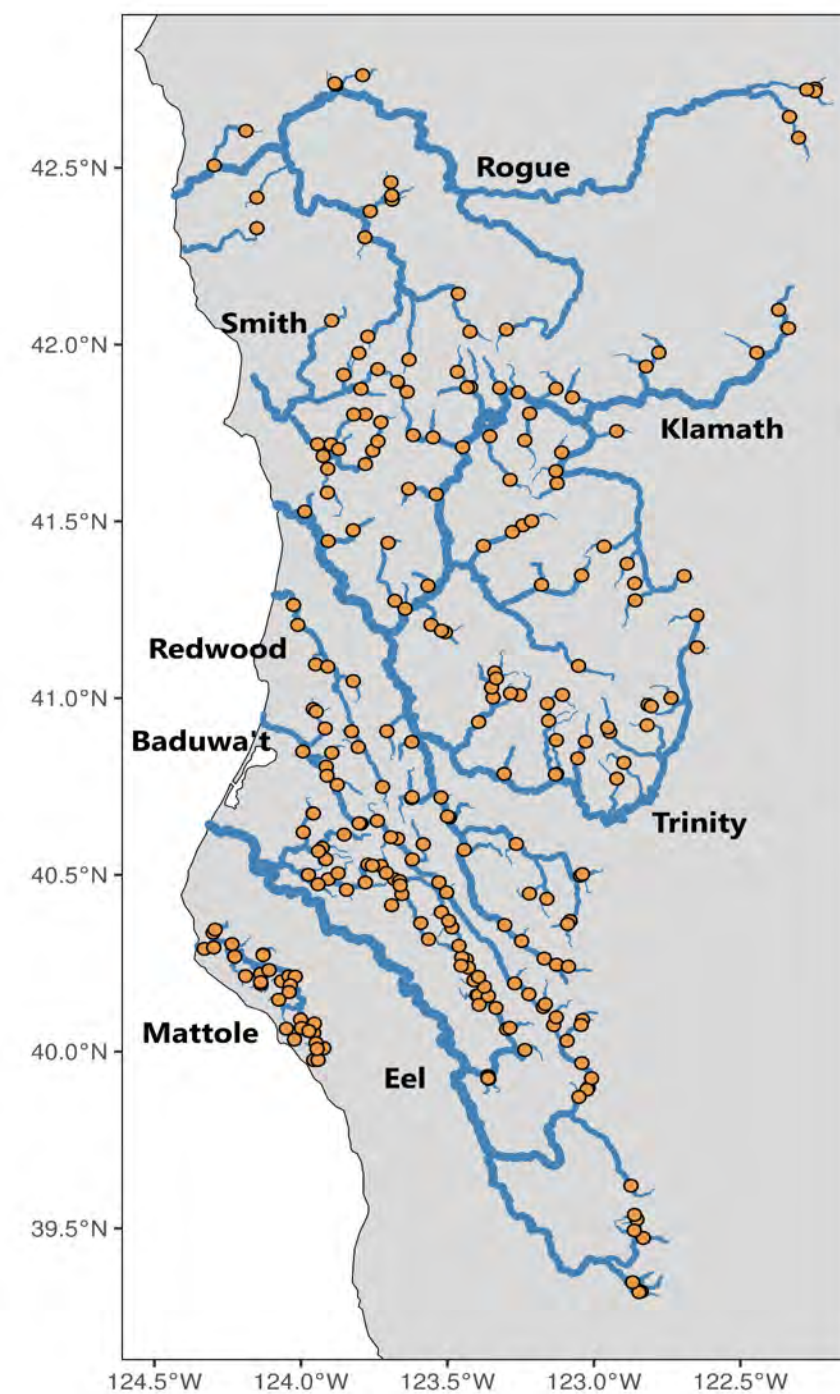




Minking (river backpacking),  
combined with nighttime  
dip-netting or seining are the  
most fruitful methods

- Spatial Distribution
- Young of the Year
- Lab work and analysis

Sampling locations are spread throughout the major north coast/southern Oregon summer-steelhead watersheds



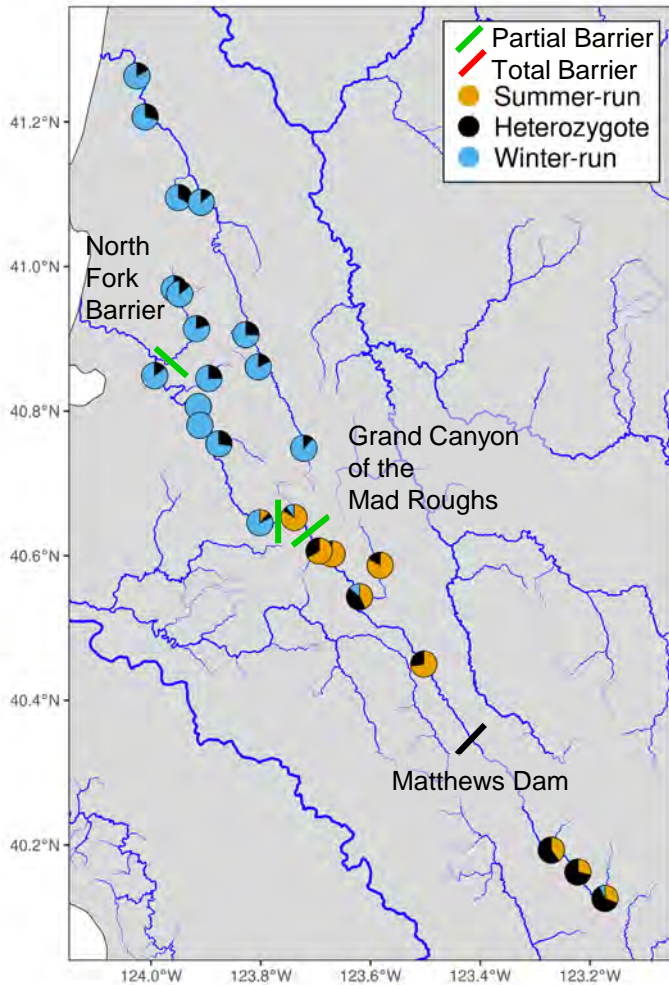
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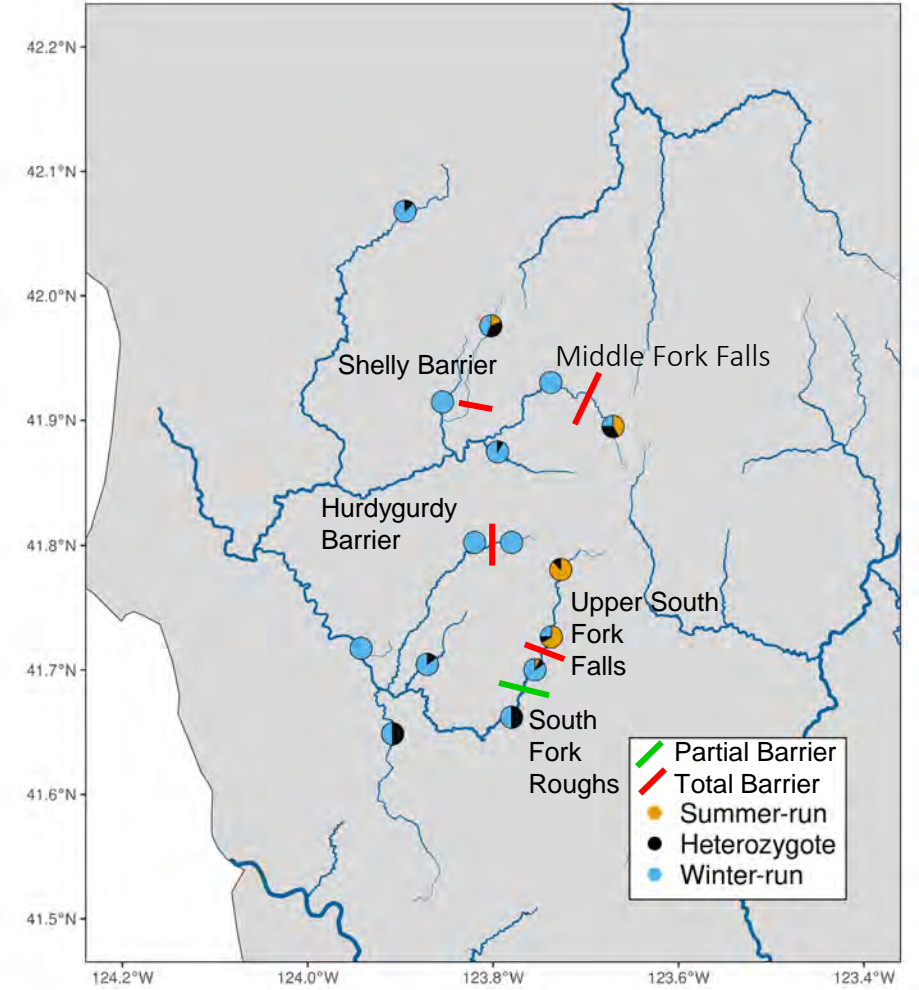
- What is the distribution of summer and winter-run alleles around barriers in Redwood Creek, Baduwa't, Smith, Trinity and Klamath Rivers?
- What are the run-timing genotypes of above dam resident trout populations



# Summer and winter-run steelhead are separated by barriers in the Baduwa't and Smith Rivers, but not in Redwood Creek

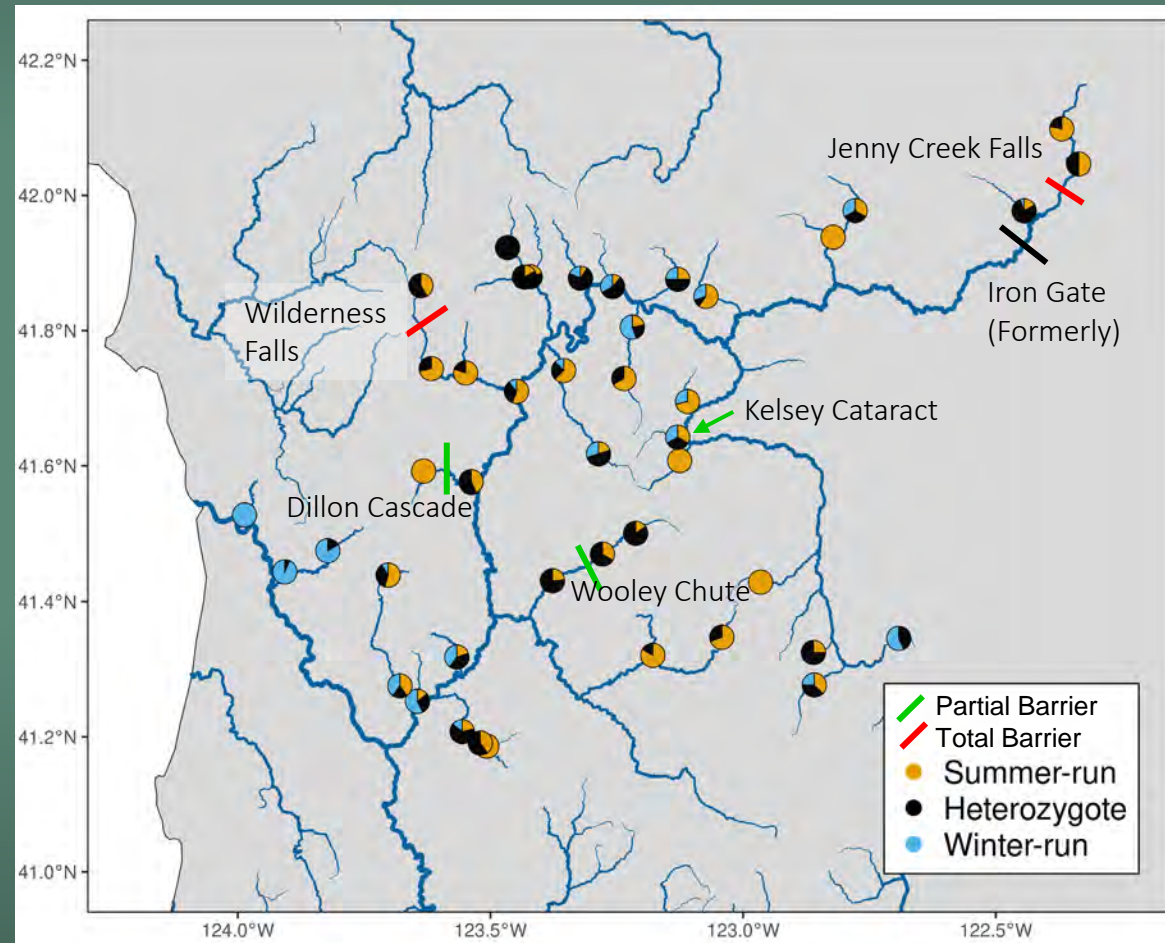


Baduwa't and Redwood

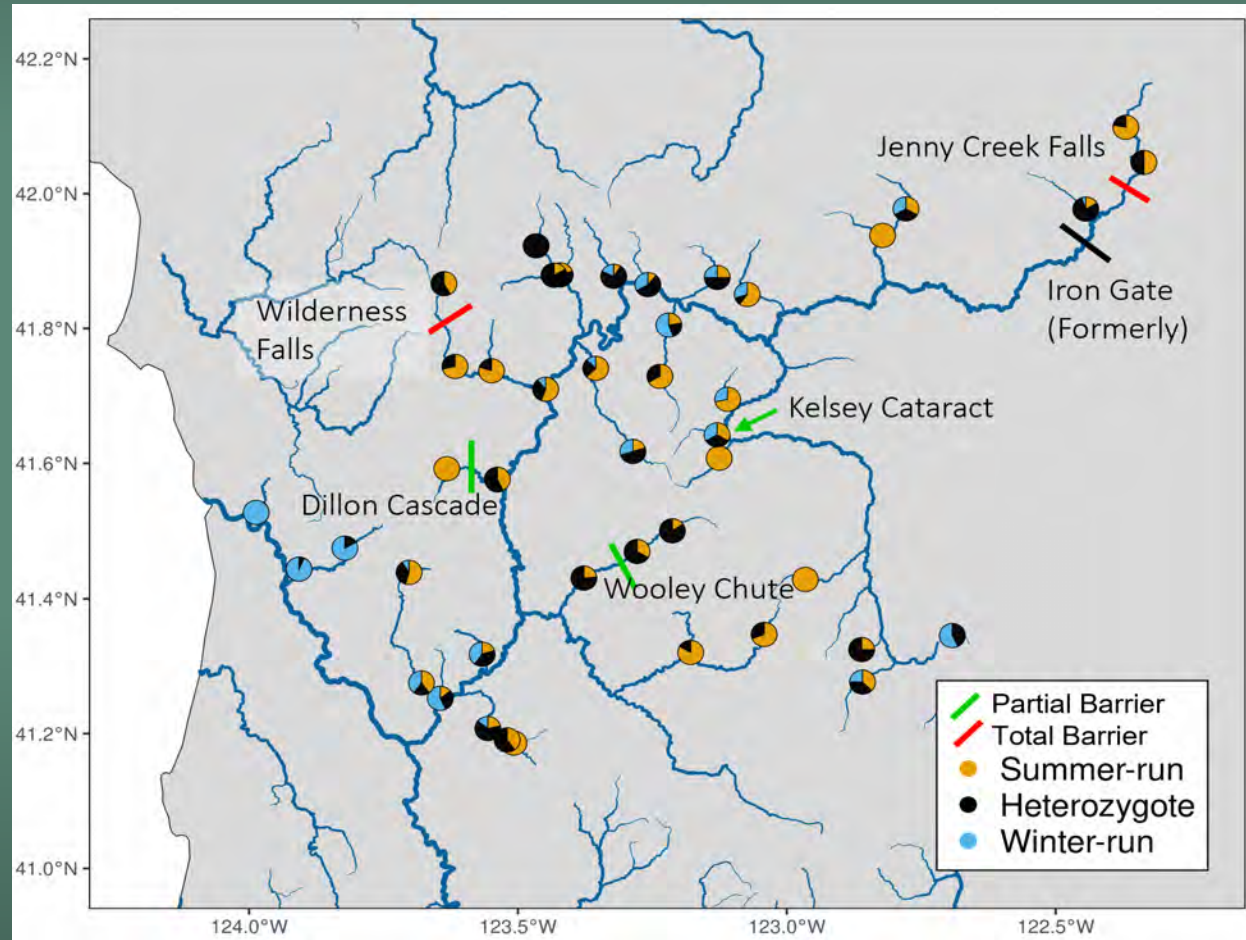


Smith

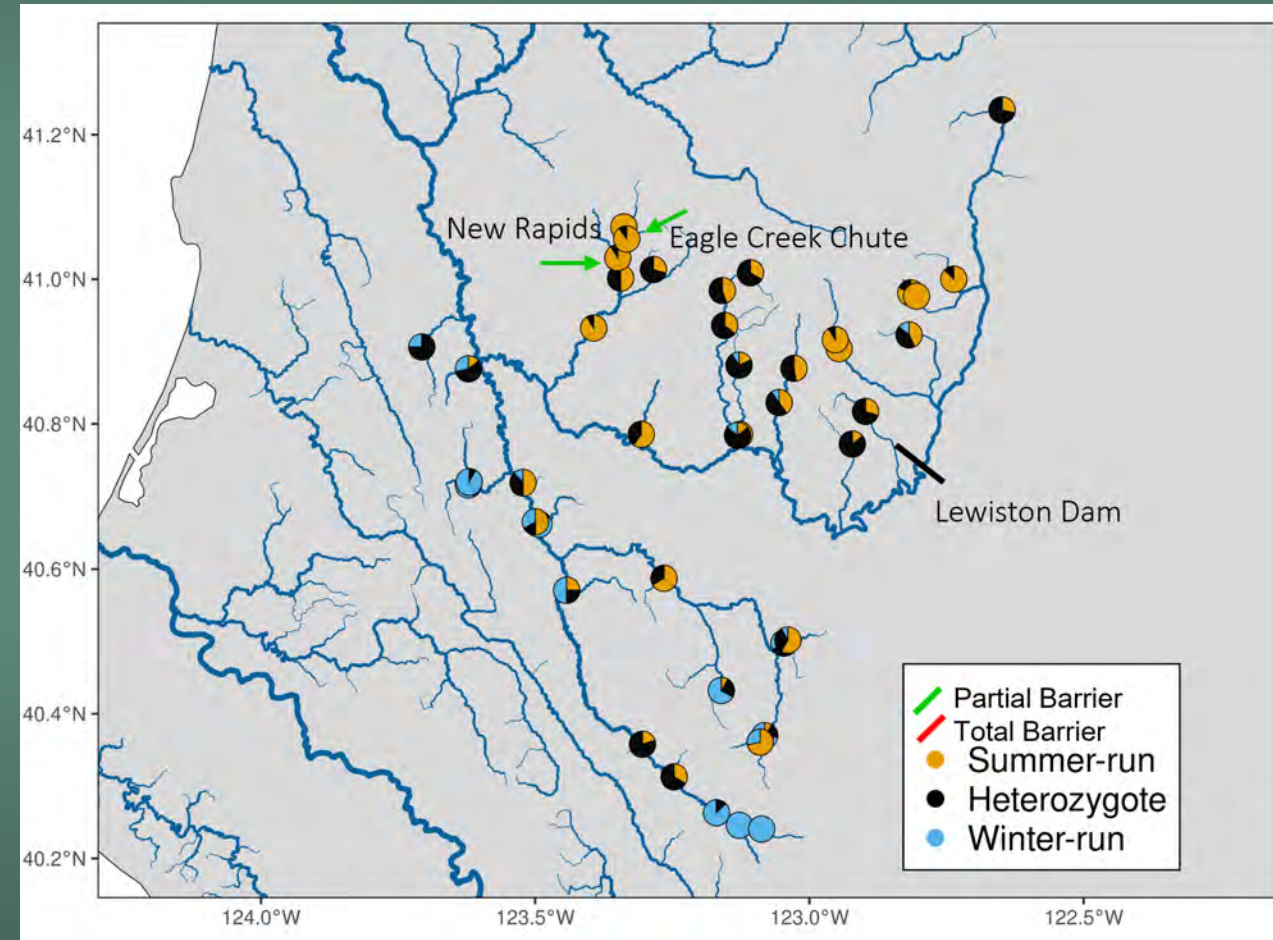
# Klamath/Trinity steelhead are more complicated and segregated by barriers and cold canyon water



# Klamath/Trinity steelhead are more complicated and segregated by barriers and cold canyon water



Klamath



Trinity

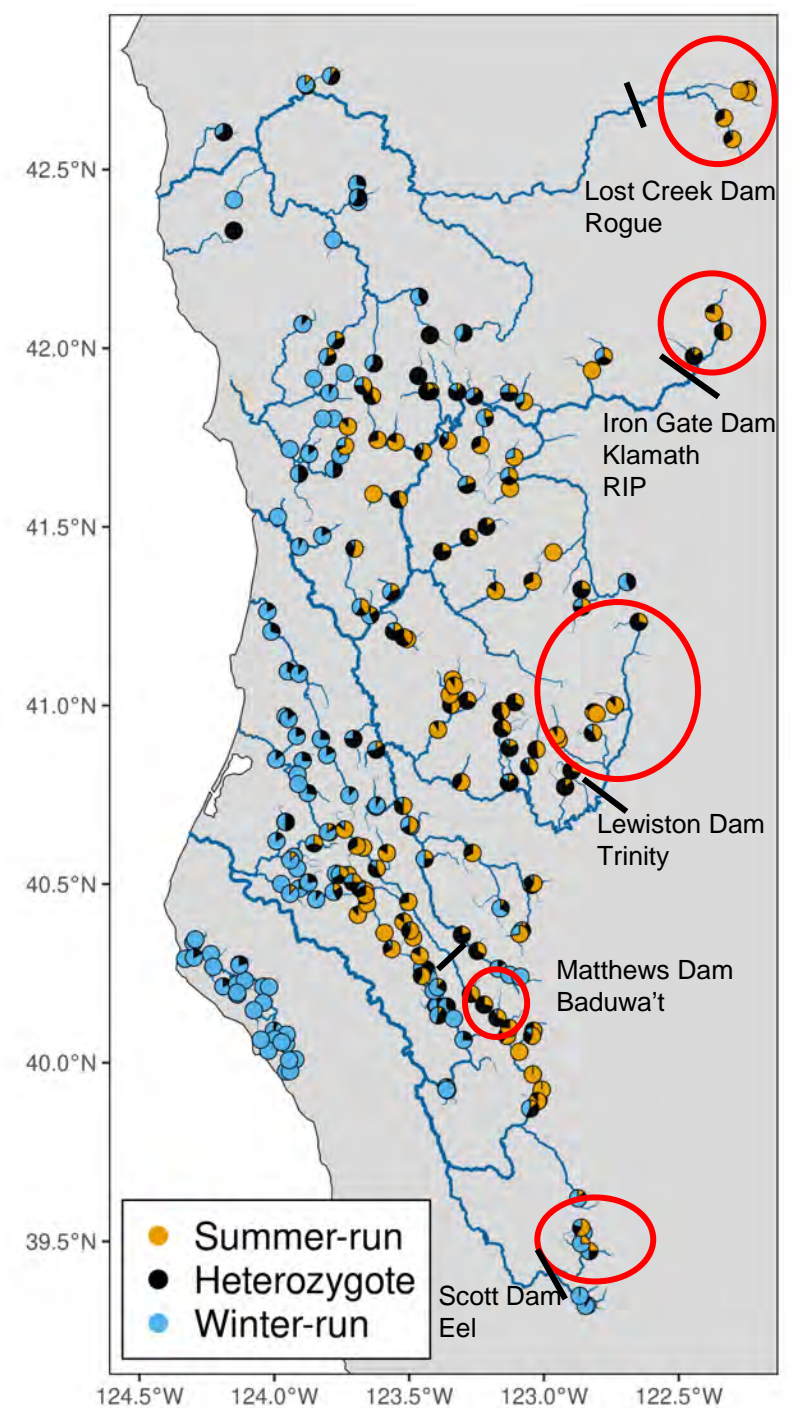
## Questions arose about summer-run steelhead in the greater region

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- What is the distribution of summer and winter-run alleles around barriers in Redwood Creek, Baduwa't, Smith, Trinity and Klamath Rivers?
- What are the run-timing genotypes of above dam resident trout populations



Resident trout populations  
above dams are reservoirs  
for summer-run alleles





## Conclusions

- Summer-run and winter-run steelhead are segregated by barriers in Baduwa't and Smith Rivers



## Conclusions

- Summer-run and winter-run steelhead are segregated by barriers in Baduwa't and Smith Rivers
- Genetic evidence of summer run in Scott River



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- Above-dam resident trout populations are maintaining summer-run alleles



## Conclusions

- Summer-run and winter-run steelhead are segregated by barriers in Baduwa't and Smith Rivers
- Genetic evidence of summer run in Scott River
- Barriers take on different forms
- Above-dam resident trout populations are maintaining summer-run alleles
- Further research of fall-run steelhead and half-pounders

# Suggestions to consider to improve heart, home and the world

- To heal our rivers, we must heal ourselves



# Suggestions to consider to improve heart, home and the world

- To heal our rivers, we must heal ourselves
- Treat your smartphone like a landline



# Suggestions to consider to improve heart, home and the world

- To heal our rivers, we must heal ourselves
- Treat your smartphone like a landline
- Find comfort in inconvenience



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- Reconsider purchases and investments
- Cultivate mystery



# Acknowledgments

Eel River Biologists: Shaun Thompson, Scott Harris

Amazing volunteers: Lindsey Holm, Seth Ricker, Ryan Thompson, Jeff Abrams, Natalie Okun, Corianna Flannery, Avi Kertesz, Emily Cooper-Hertel, Erin Phillips, Max Ramos, Zoe Ziegler, Cat Fong, Mary Clapp, Alisha Saley, Rose Dana, Ensieh Habibi, Nick Blixt, Brett Lovelace

Additional samples: Yurok Tribe, Bob Pagliuco, Keith Lackey, Suzanne Kelson, Emma Held, Nathan Queener

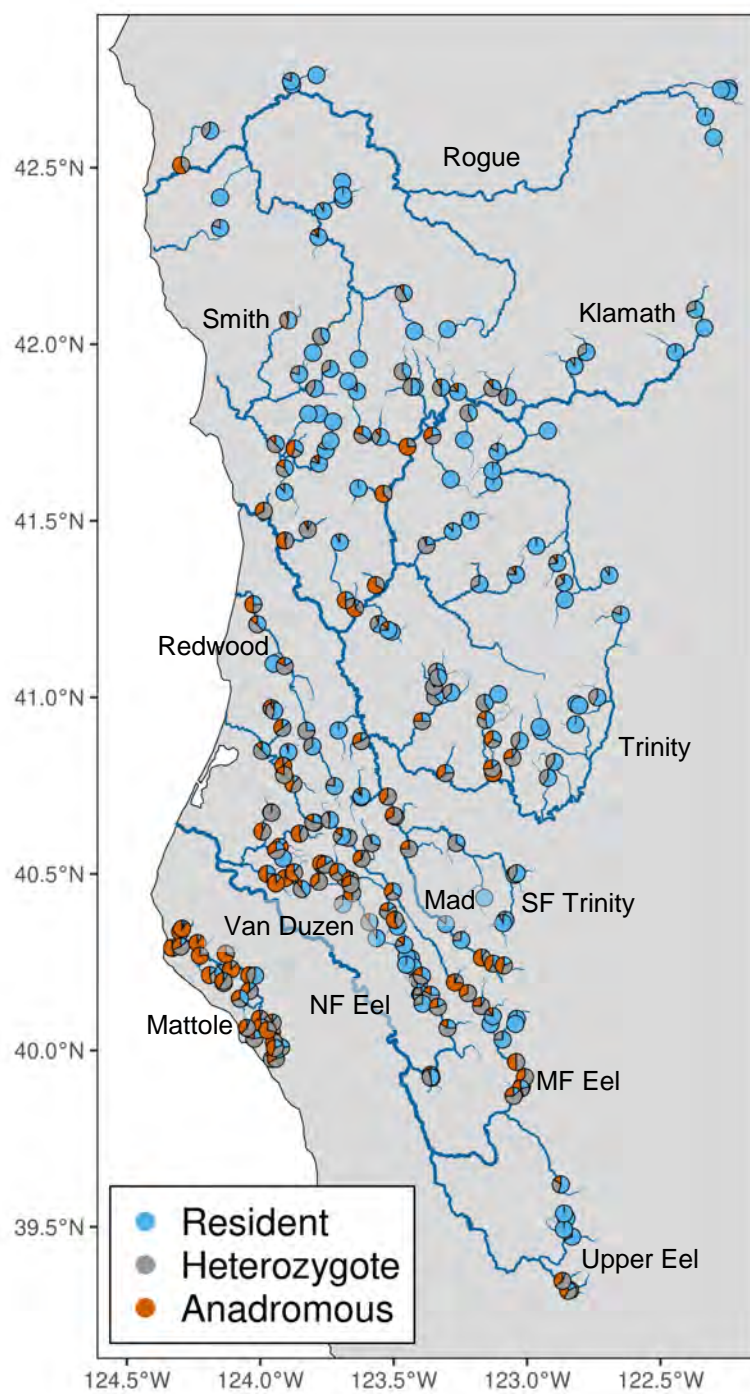
Funders/Collaborators: BLM, Native Fish Society, Friends of the Eel River, Mattole Salmon Group, Sequoia Park Zoo, UC Davis Ecology Graduate Group, Genomic Variation Laboratory UC Davis, Patagonia Inc.

Foundational concepts and essential assistance: Tasha Thompson, Mike Miller, Sean O'Rourke, Zane Ruddy, Sam Rizza



# Questions?





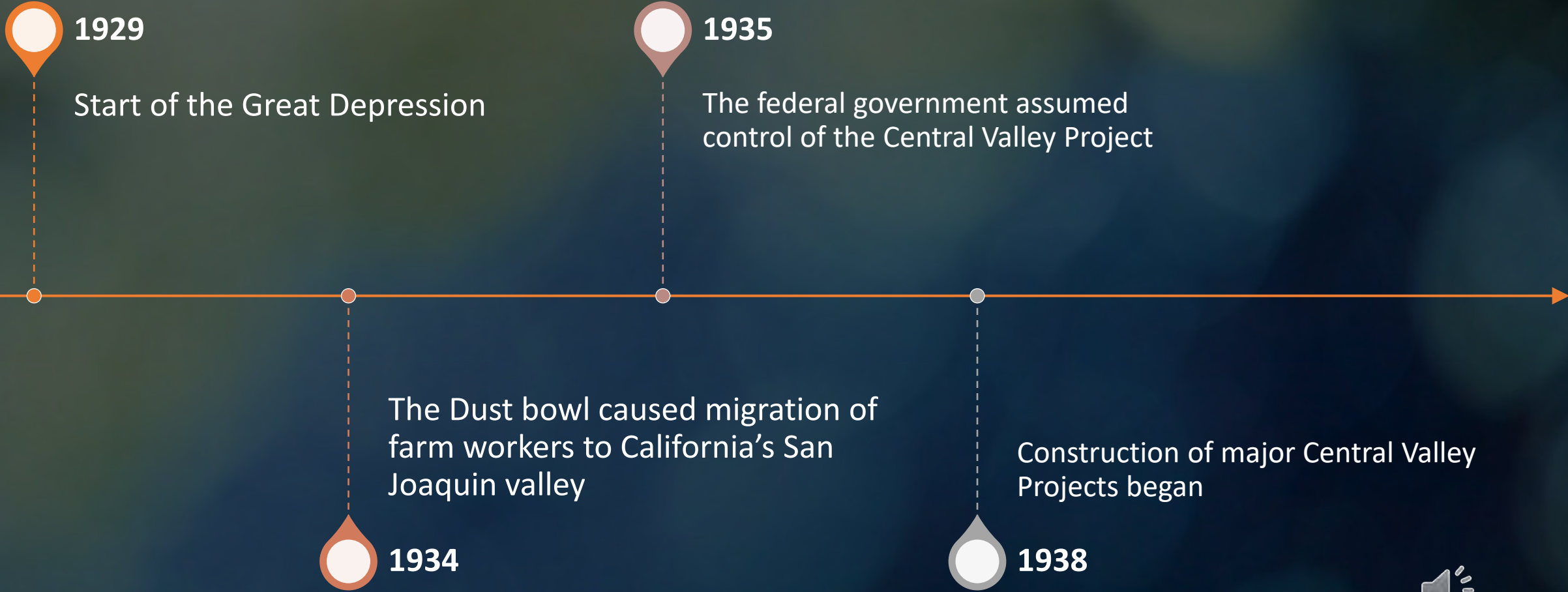
# Lessons Learned from the San Joaquin River Restoration Program



USFWS: Phillip Street

All the implementing agencies personnel past and present







*"Mother nature under controll"  
River coralled and  
punning bank high,  
as contractor moves muak  
from below water level*

17



*San Joaquin  
River throtbled.  
note Coffor Dam  
in foreground.*

26



*"Friant Dam" as seen from  
Friant Bridge Jun 3, 1942*



CAUTION  
DO NOT SWIM  
OR PLAY IN THE  
WATER

**1942**

Friant Dam constructed in 1942 causing habitat degradation and fragmentation

**2006**

In 2006, the SJRRP resulted from a lawsuit between Departments of Interior and Commerce, the Natural Resource Defense Counsel, and the Friant Water Users Authority

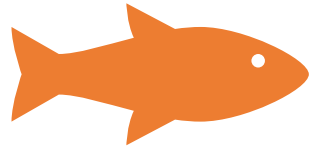
**1950**

By 1950 all Chinook salmon runs above the Merced River extirpated

**2009**

In 2009, the San Joaquin River Restoration Settlement Act was authorized

# Settlement goals



## Restoration Goal

To restore and maintain fish populations in “good condition” in the main stem of the San Joaquin River below Friant Dam to the confluence of the Merced River, including naturally reproducing and self-sustaining populations of Salmon and other Fish

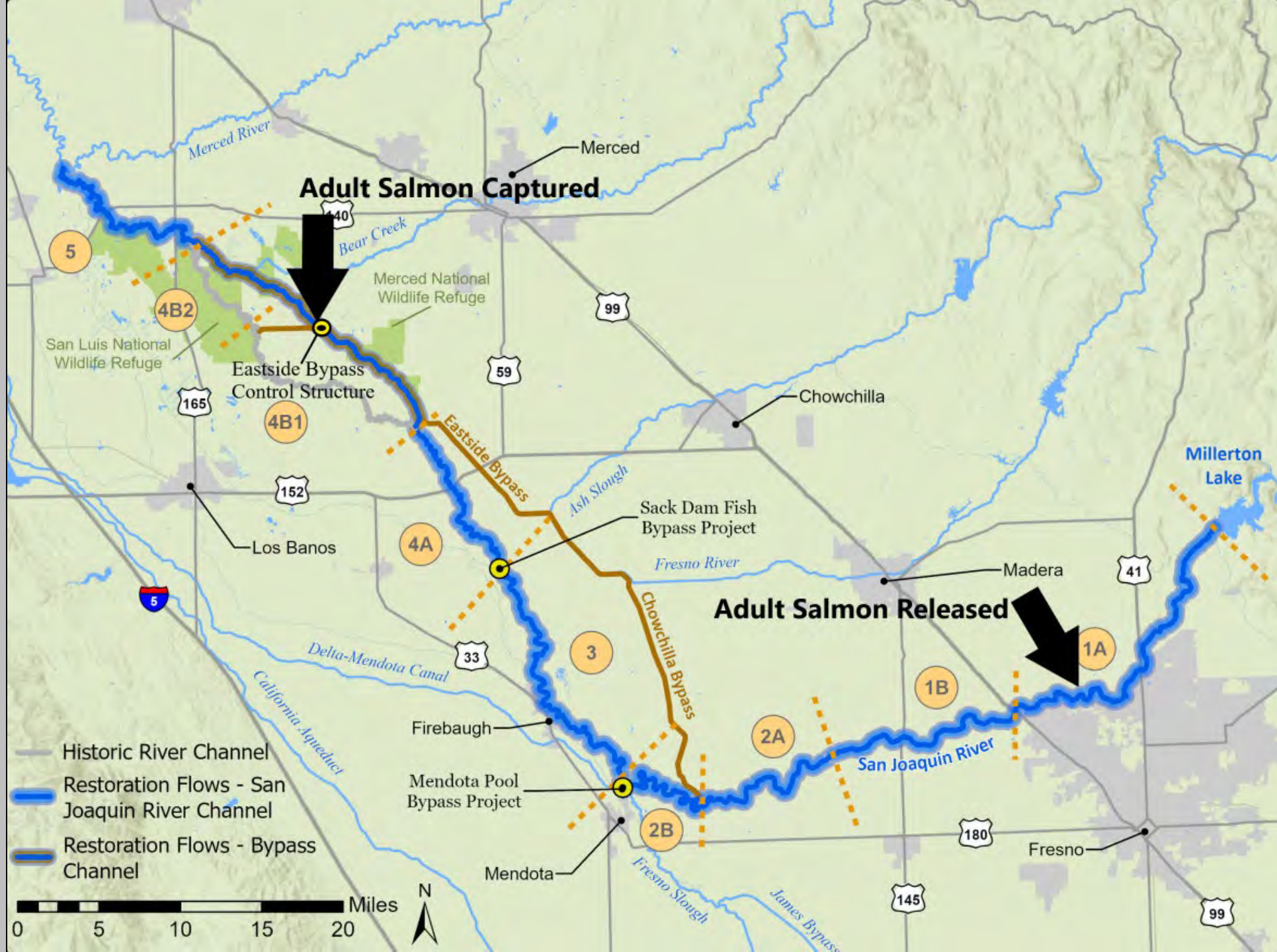


## Water Management Goal

To reduce or avoid adverse water supply impacts to all of the Friant Division long-term contractors that may result from the Interim Flows and Restoration Flows provided for in the Settlement.

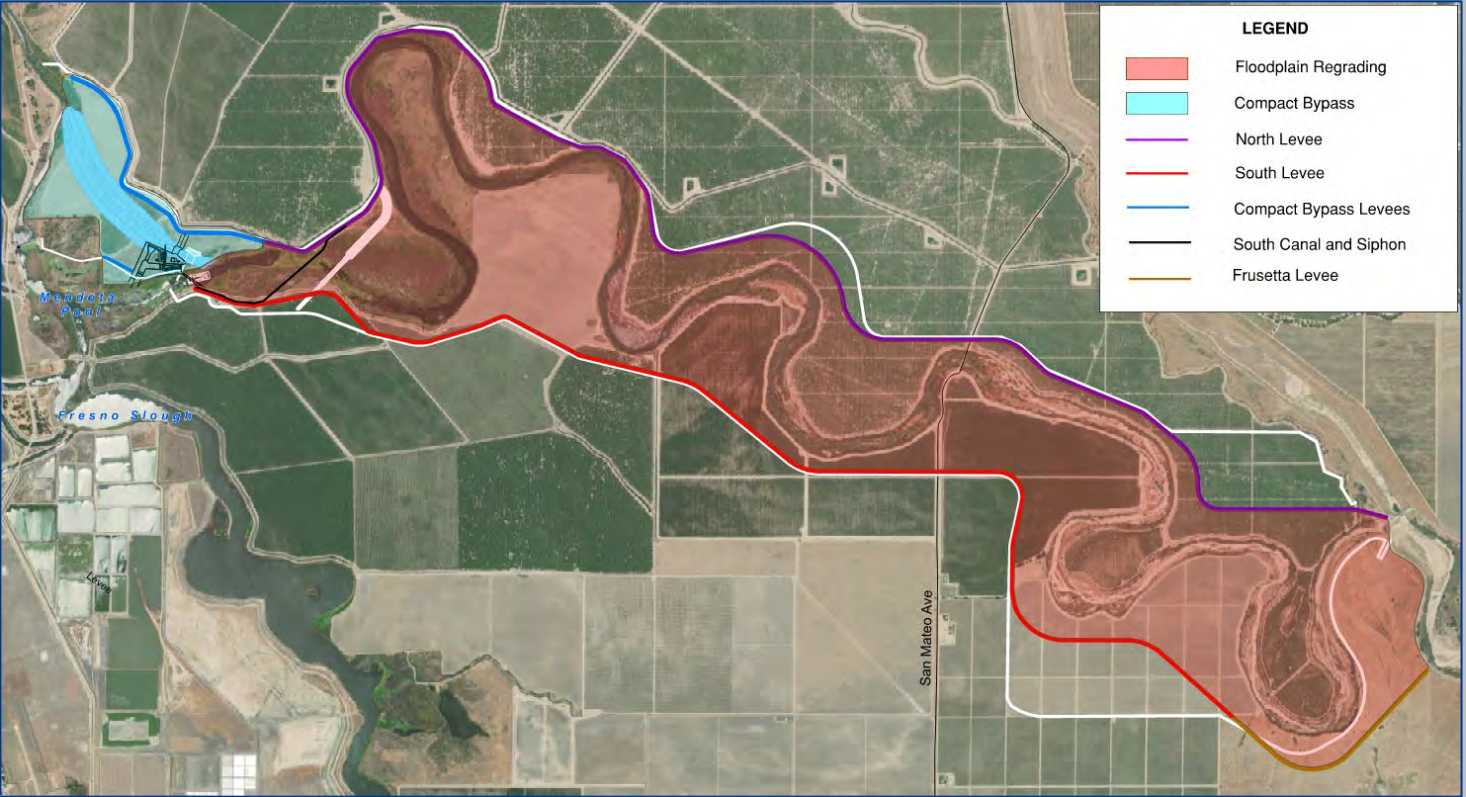






# Restoration Area

## Reach 2B

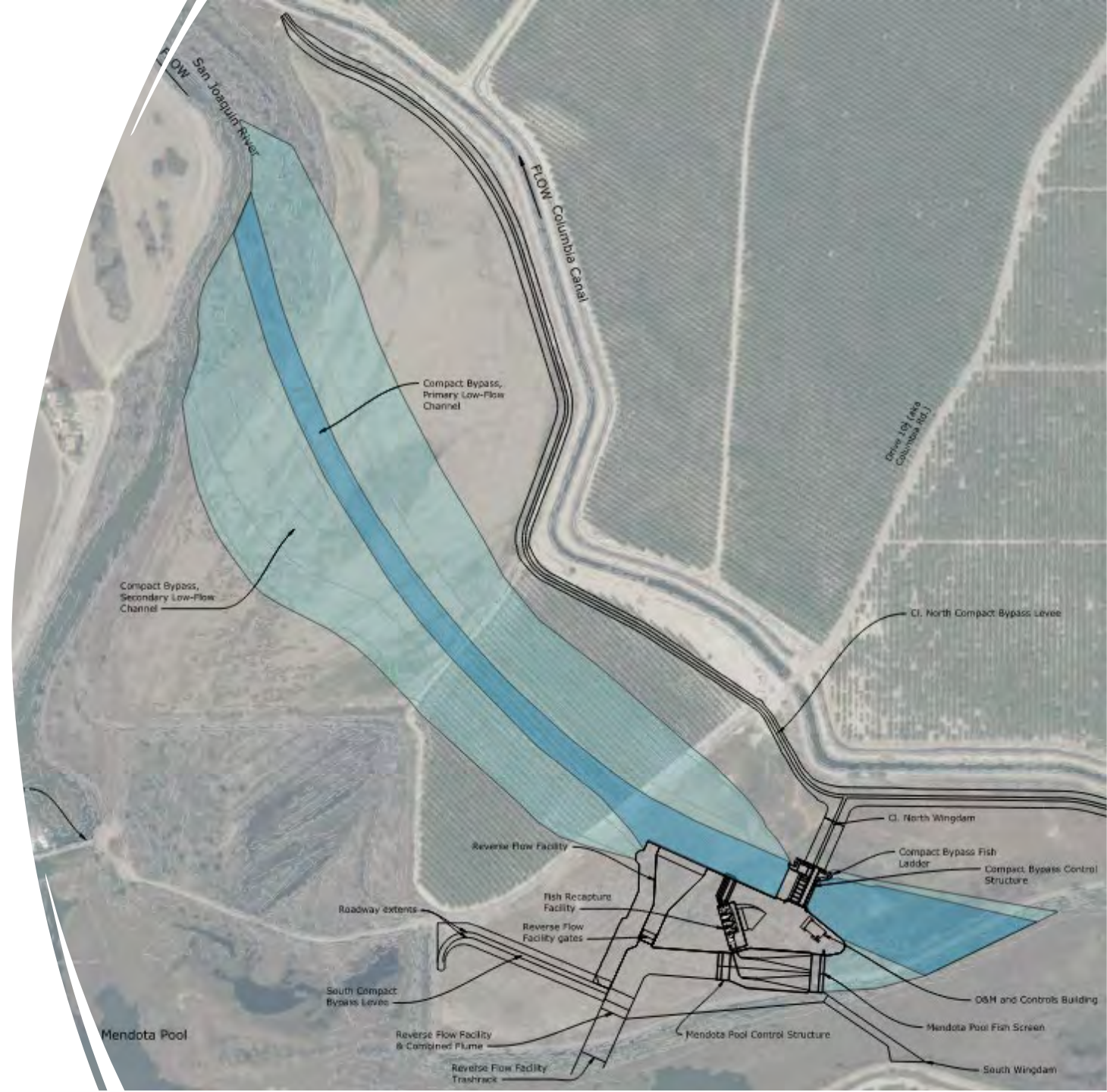






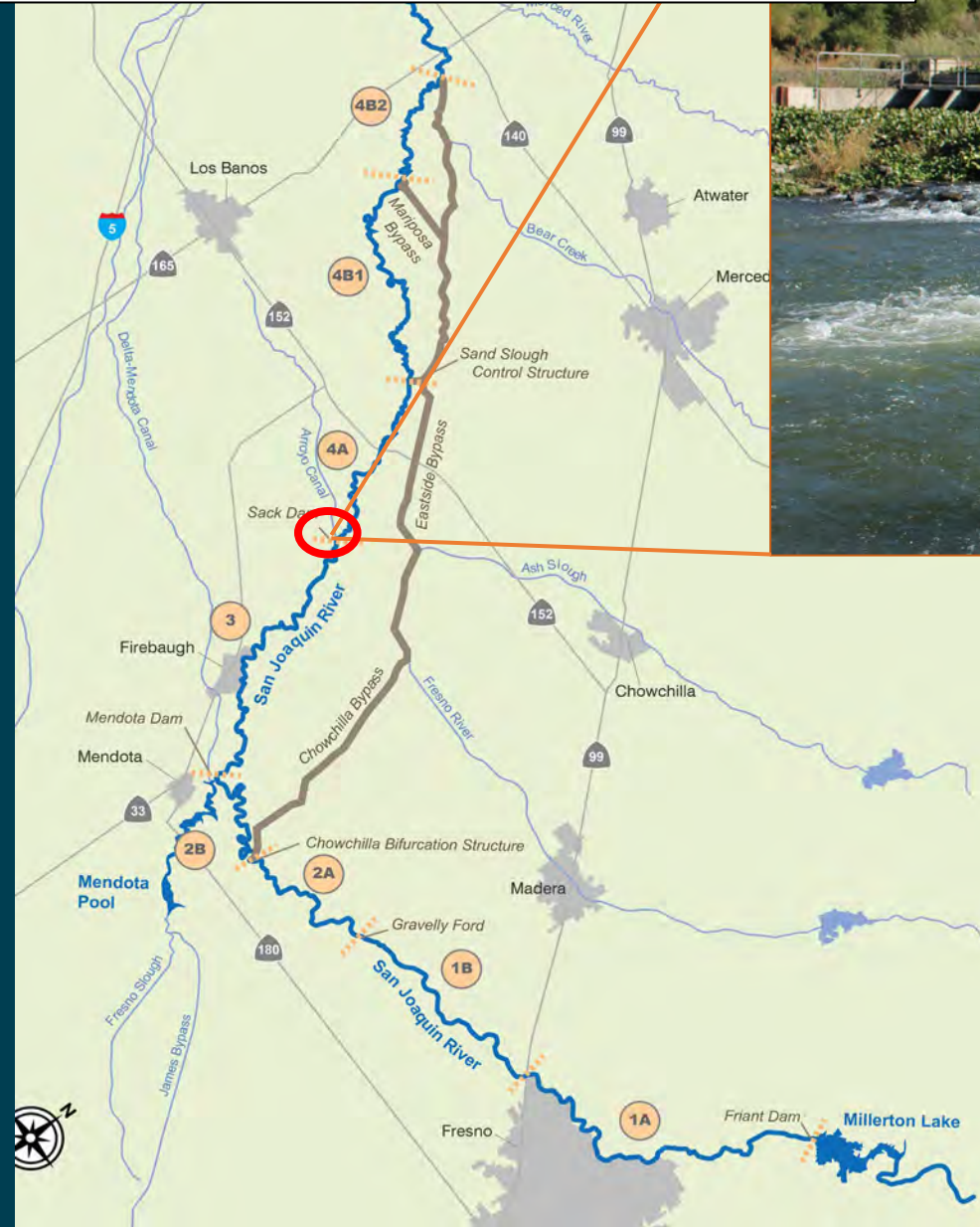
# Construction: Mendota Pool Bypass, Fish Screen, and Associated Features

- Expected start date 2027 - 2029
- Phase 1A 60% design
- Phase 1b 30% design



# Arroyo Canal and Sack Dam

- Arroyo Canal is approximately 23 river miles downstream of Mendota Dam Project Components
- Boundary between Reach 3 and Reach 4A Fish Screen









# Construction:

Arroyo Canal Fish Screen & Sack Dam Fish Passage Facility

BEFORE

# Construction: Arroyo Canal Fish Screen & Sack Dam Fish Passage Facility

AFTER (rendering)



\*Illustration by Stantec



# Eastside Bypass Control Structure



- 25 million in proposed California budget
- Permitting is nearly complete
- Construction expected to begin in 2027

# Chinook Salmon Reintroduction History

## 1992

- Hills Ferry Barrier

## 2009

- Flows entered the river for the first time in 60 years

## 2012-2016

- Fall-run trap and haul
- Juvenile trap and haul (2014-2016)

## 2014

- First juvenile spring-run

## 2016

- Ancillary adult spring-run broodstock

## 2019

- Adult Spring-run trap and haul operations

- First confirmed returning adult

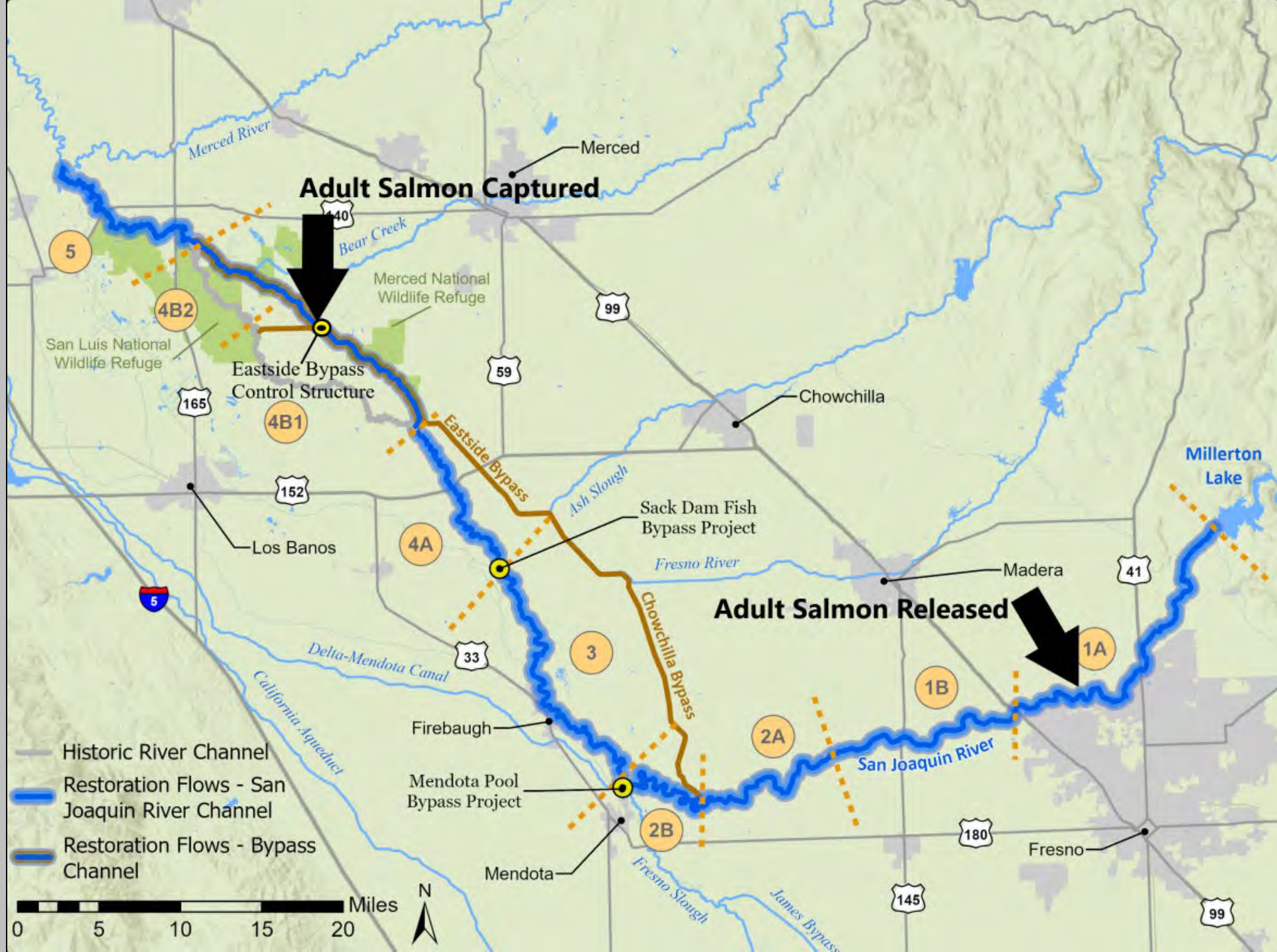
## 2025

- SCARF completed
- Largest adult return 448
- Collected brood stock from the river for the first time

## Future


- Fall-run to recolonize the Restoration Area

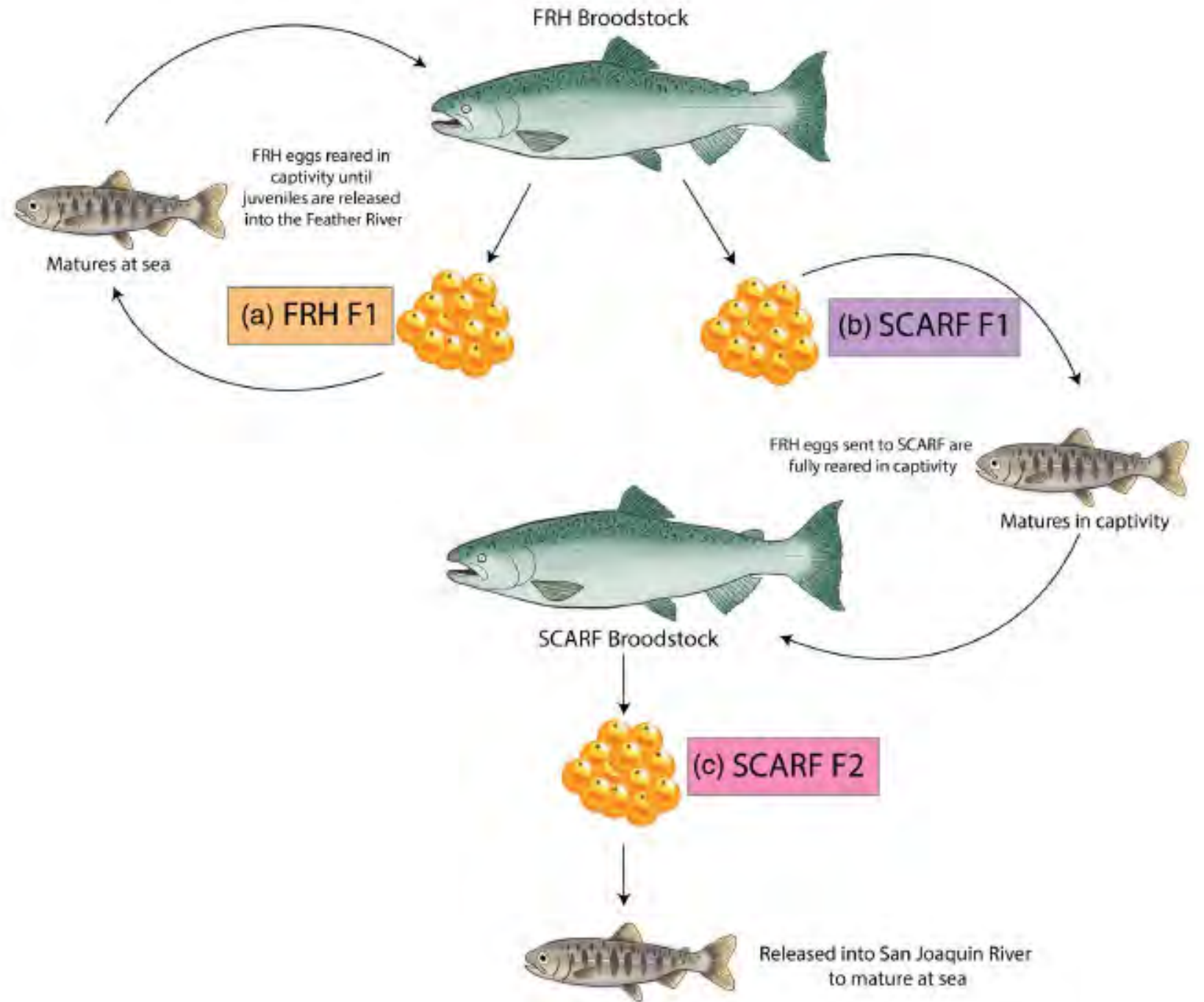




CONTRIBUTED PAPER

# Reintroduction of spring-run Joaquin River: Evaluating ge- captive breeding

Kasey C. Pregler<sup>1</sup>  | Anthony Clemente  
Stephanie M. Carlson<sup>1</sup>  | John Carlos G





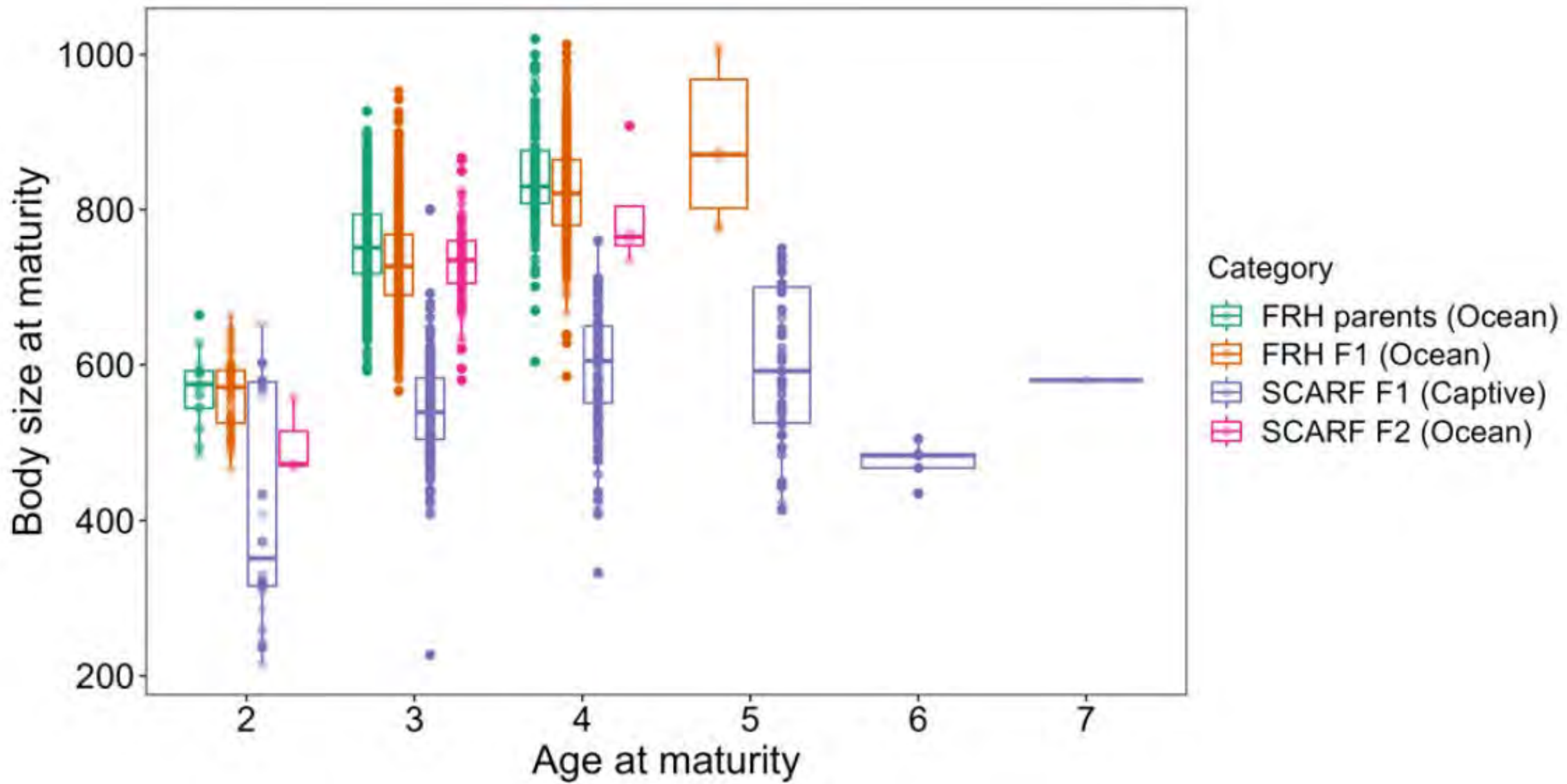






Silverado





# Reintroduction: Salmon Conservation & Research Facility









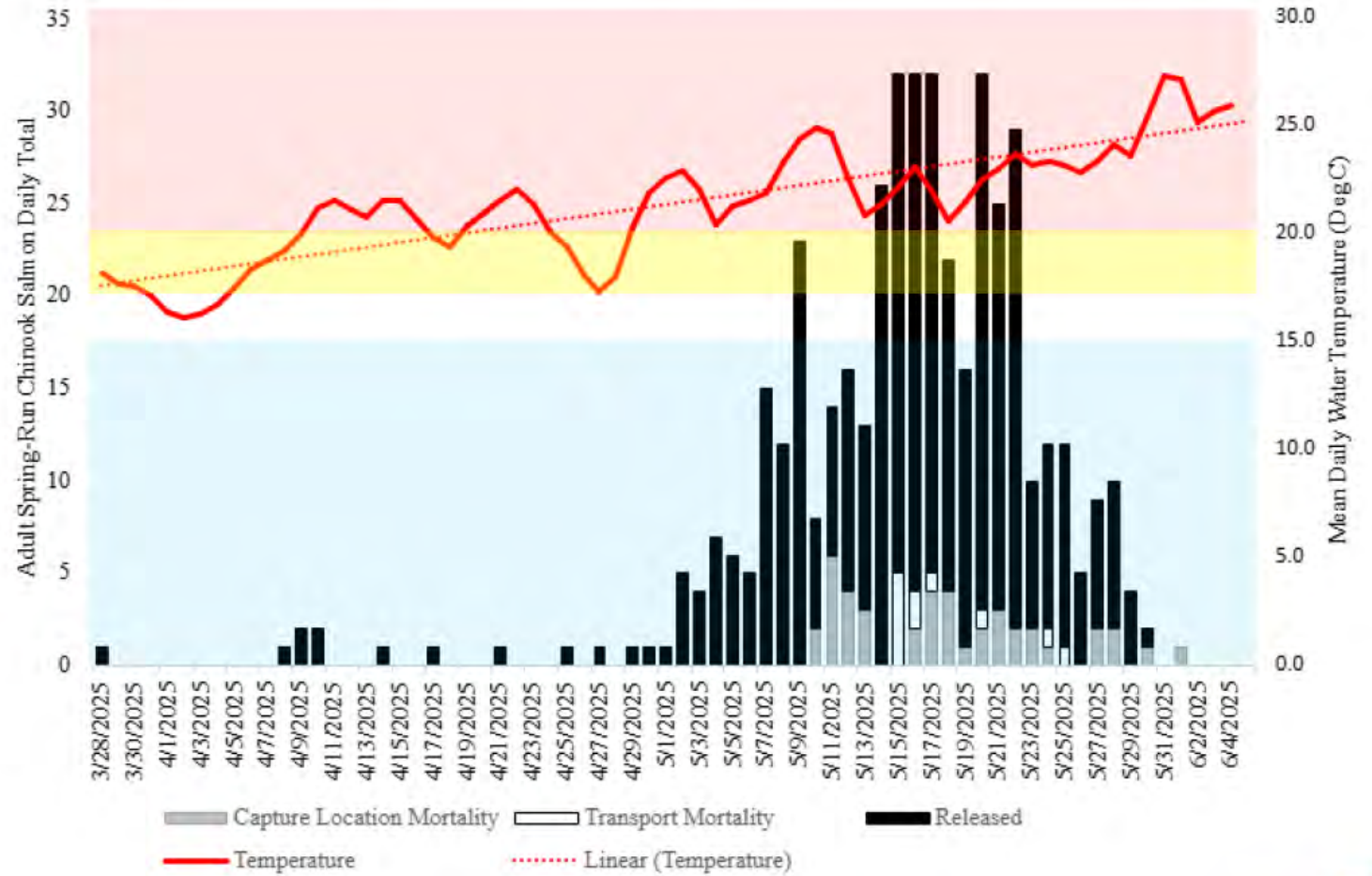
# Monitoring



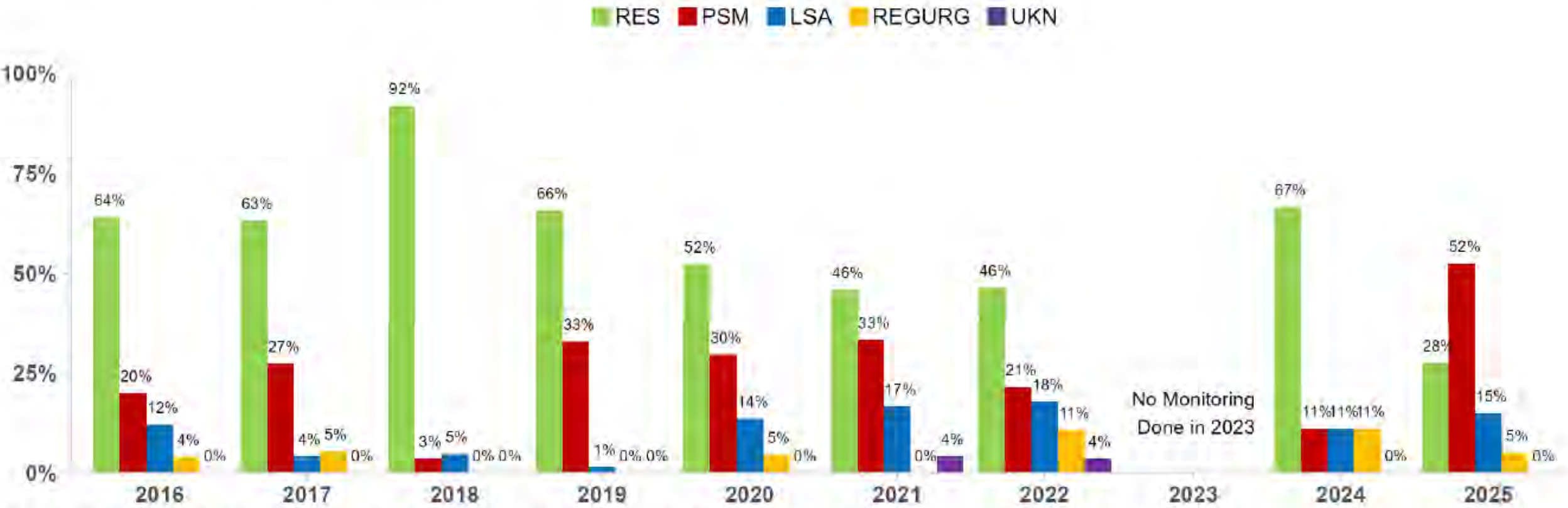


# 2025 Adult Spring-Run Chinook Salmon Monitoring and Trap and Haul

- 448 Adult Spring-Run Chinook Captured
- 394 Released
  - 265 Released in "Good" Condition
  - 99 Released in "Fair" Condition
  - 30 Released in "Poor" Condition
  - 39 Acoustically Tagged
- 42 Capture Location Mortalities
- 11 Transport Mortalities
- 1 Release Site Mortality



# Estimates of residency, prespawn mortality, fish leaving the study area, regurgitated tags, and unknown fate across study years (2016 - 2025)



RES = Residency, PSM = Prespawn Mortality, LSA = Fish Left Study Area, UKN = Unknown Fate







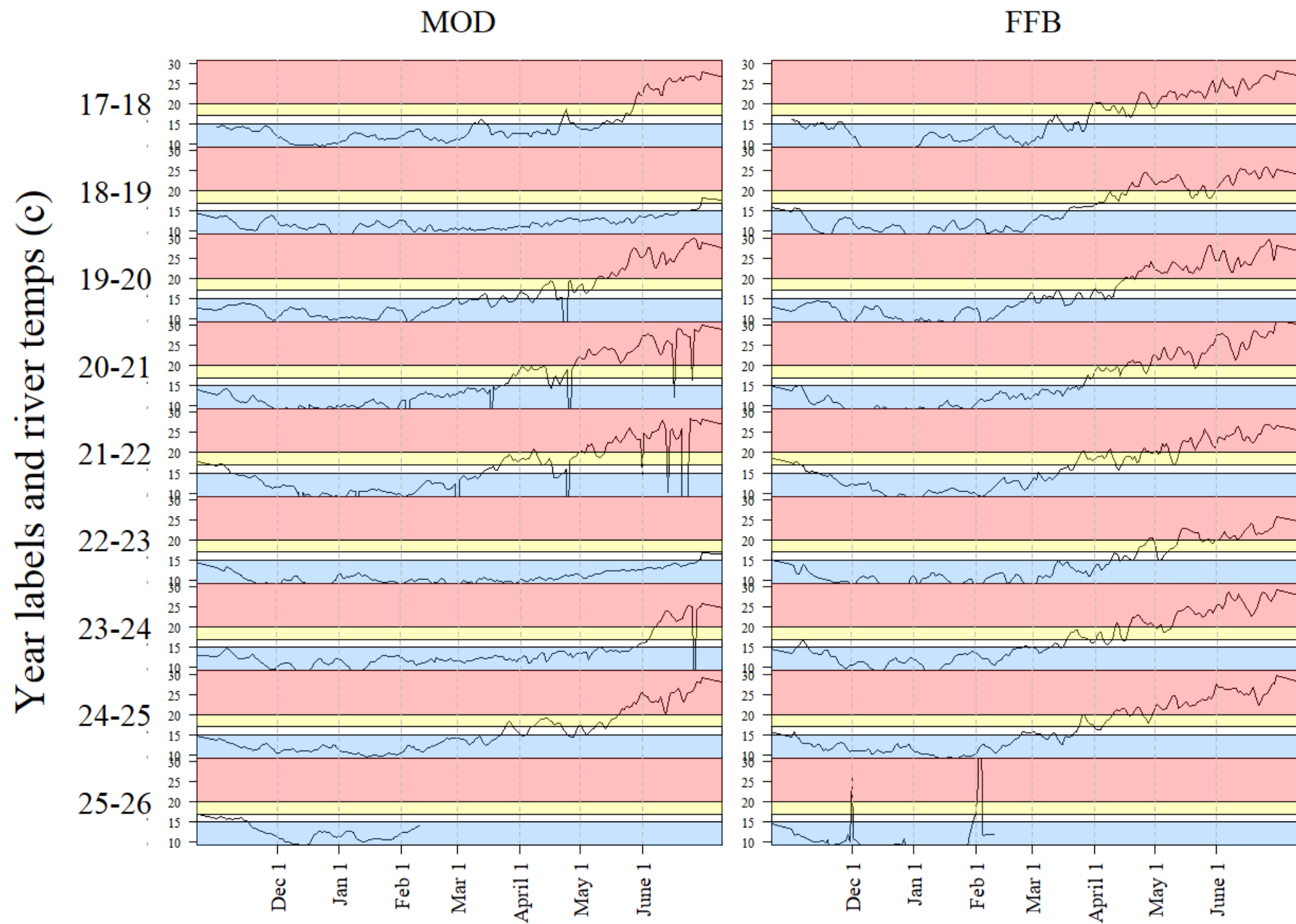




## Lessons learned and conclusions

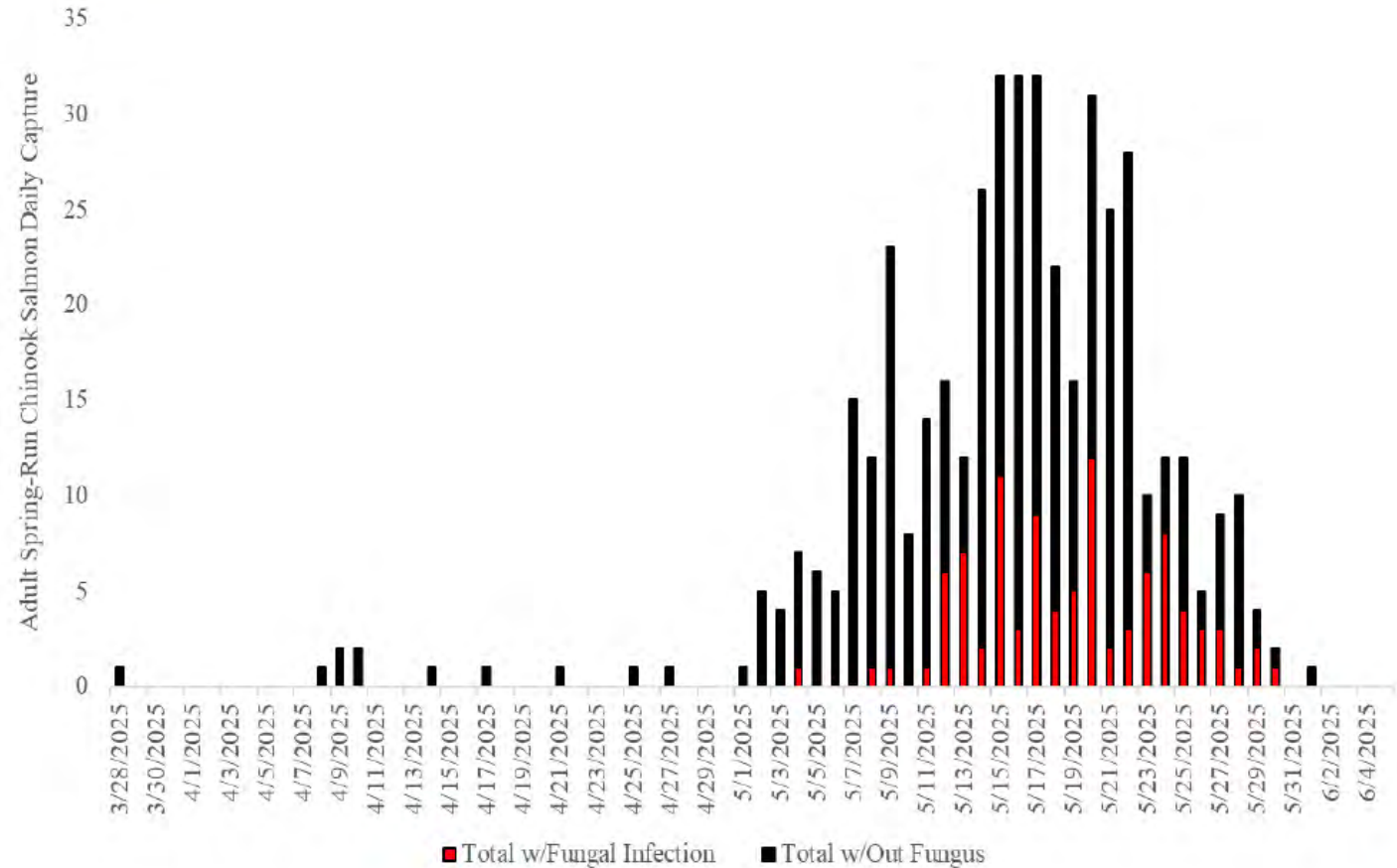
- Expect the unexpected
- Genetic composition matters
- Projects like this take time
- SJRRP still has some milestones to achieve
- Expect the unexpected

# San Joaquin vs. Tuolumne



# 2025 Adult Spring-Run Chinook Salmon Monitoring and Trap and Haul

- Fungal Infection noted on 96 Adult Salmon (21%)
- First recorded observance since inception of monitoring effort
- Common infections (Saprolegnia) ubiquitous, but impacts exacerbated w/stress
- Cause and impacts?
- Remedy?



UNIVERSITY OF  
CALIFORNIA

KARUK TRIBE

SALMON RIVER  
RESTORATION  
COUNCIL



Photo credit: Michael E

# Wild ishyâat (*Oncorhynchus tshawytscha*) in a spring-run Chinook salmon stronghold

By Toz Soto, Sophie Price, Amy Fingerle & Karuna Greenberg



# INTRODUCTION

## Ishyâat: Spring Chinook of the Klamath basin

- Historically managed as one population with fall runs<sup>3</sup>
- Karuk have always distinguished between runs<sup>5</sup>
- Tribal importance
- Now ESU is listed as threatened under CESA



# INTRODUCTION

## Ishyâat: Spring Chinook of the Klamath basin

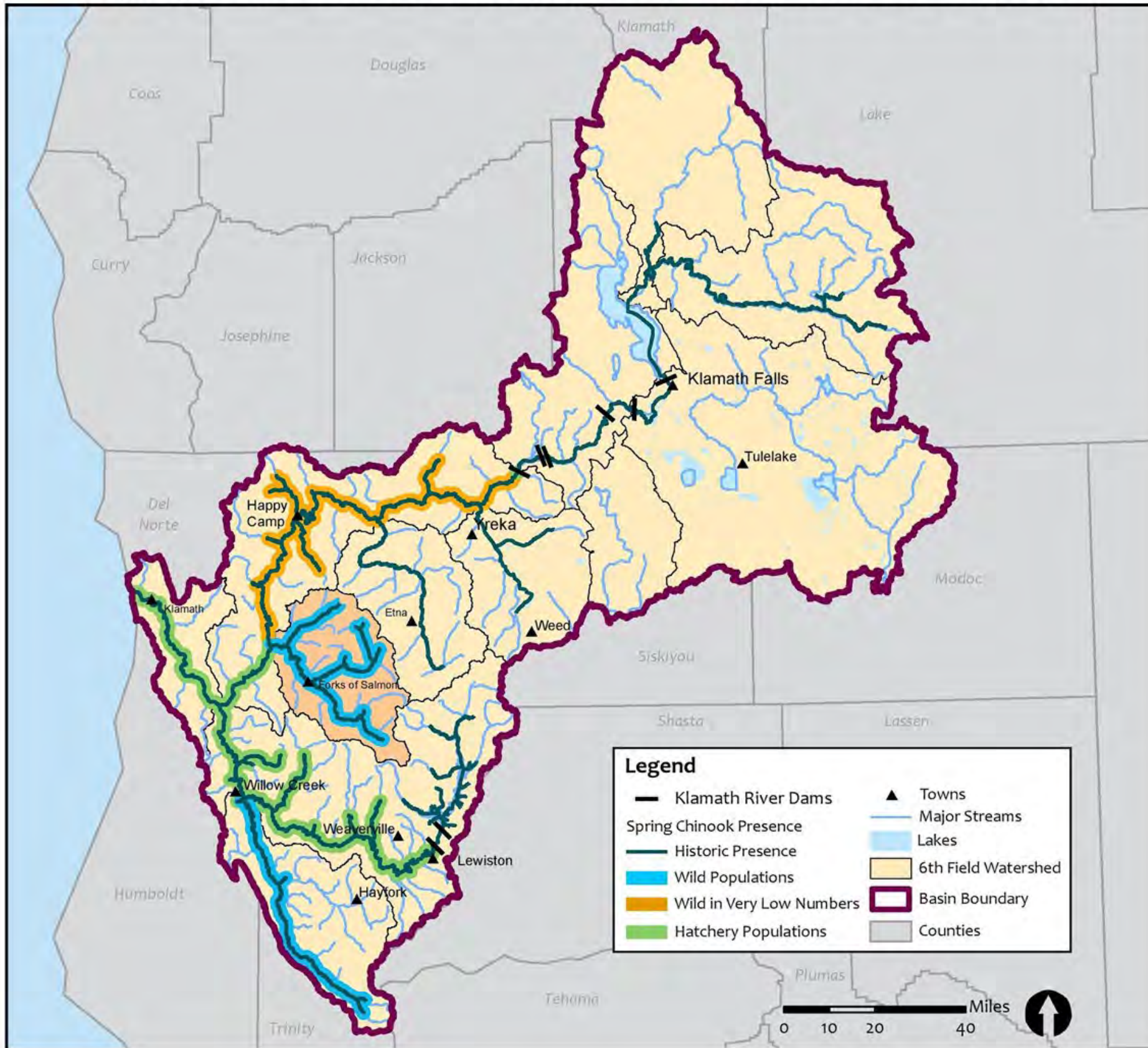
- Imminent danger of extirpation
- Historical population in Klamath >100,000 fish<sup>4</sup>
- Diminished by 1900s due to hydraulic mining and commercial fishing and dams<sup>6</sup>
- Salmon River population: ~90 -1600 individuals since 1990
- Population crash in 2015

<sup>4</sup> Moyle, 2002; Emmett et. al., 1986



Photo credit: Scott

Spring Chinook historical & current distribution in the Klamath basin



# SALMON RIVER

Last remaining stronghold for wild

Klamath spring Chinook

Sparsely populated<sup>10</sup> and 98.7% public lands<sup>9</sup>

No major agriculture or industry<sup>10</sup>

45% is designated Wilderness Area<sup>9</sup>

Not dammed

Legacy impacts from logging and gold mining

Mediterranean climate<sup>9</sup>

<sup>9</sup> SRRCKauffman & Garwood, 20



Photo credit: Scott

# SALMON RIVER

## A unique watershed

- High elevation coastal mountains
  - Glacier on Thompson peak
  - Confined, high gradient river channel
- Flow and temperature regimes driven by annual snowpack and runoff



# SALMON RIVER

A unique watershed

- Fall and spring Chinook populations spawn in close proximity
- Populations are separated by high gradient cascades and form seasonal barriers



Photo credit: Beau Quinn

# SALMON RIVER

A unique watershed

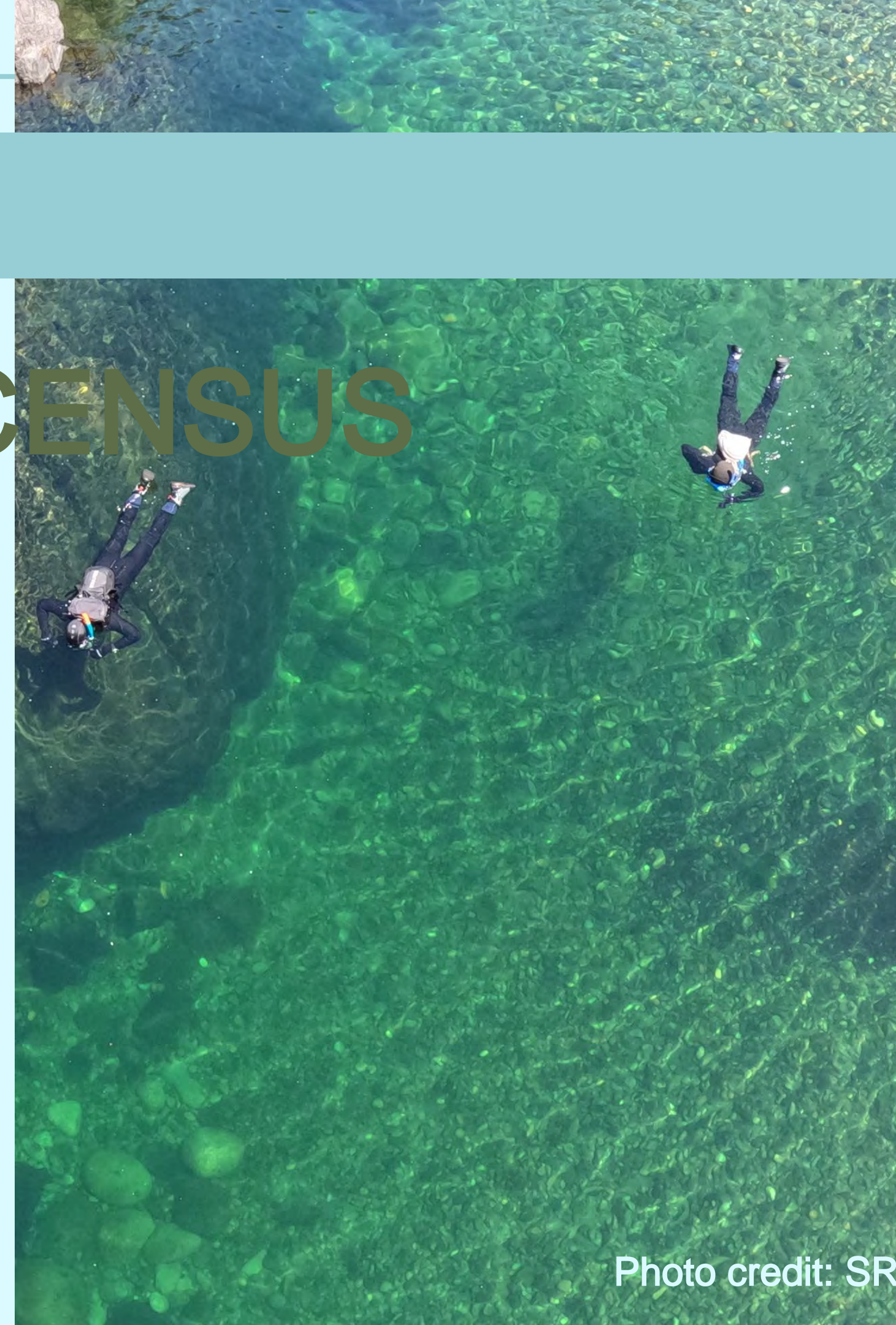
- Fall and spring Chinook populations spawn in close proximity
- Populations are separated by high gradient cascades and form seasonal barriers

# STATUS & TREND

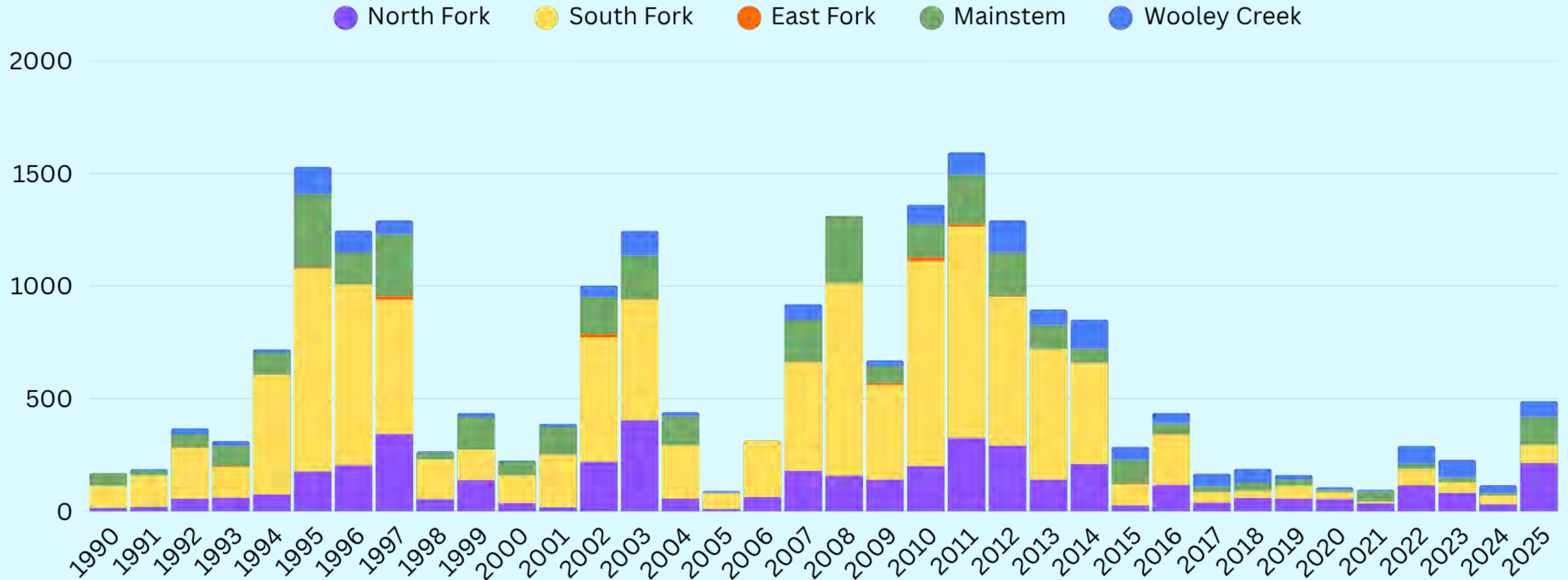
Photo credit: Peter Bohler

# ANNUAL POPULATION CENSUS

- Since 1990.
- Mainstem and forks surveyed in single day in July/August
- ~80 professional and volunteer surveyors
- Training day prior to the survey
- Live adult spring Chinook enumerated and documented on map

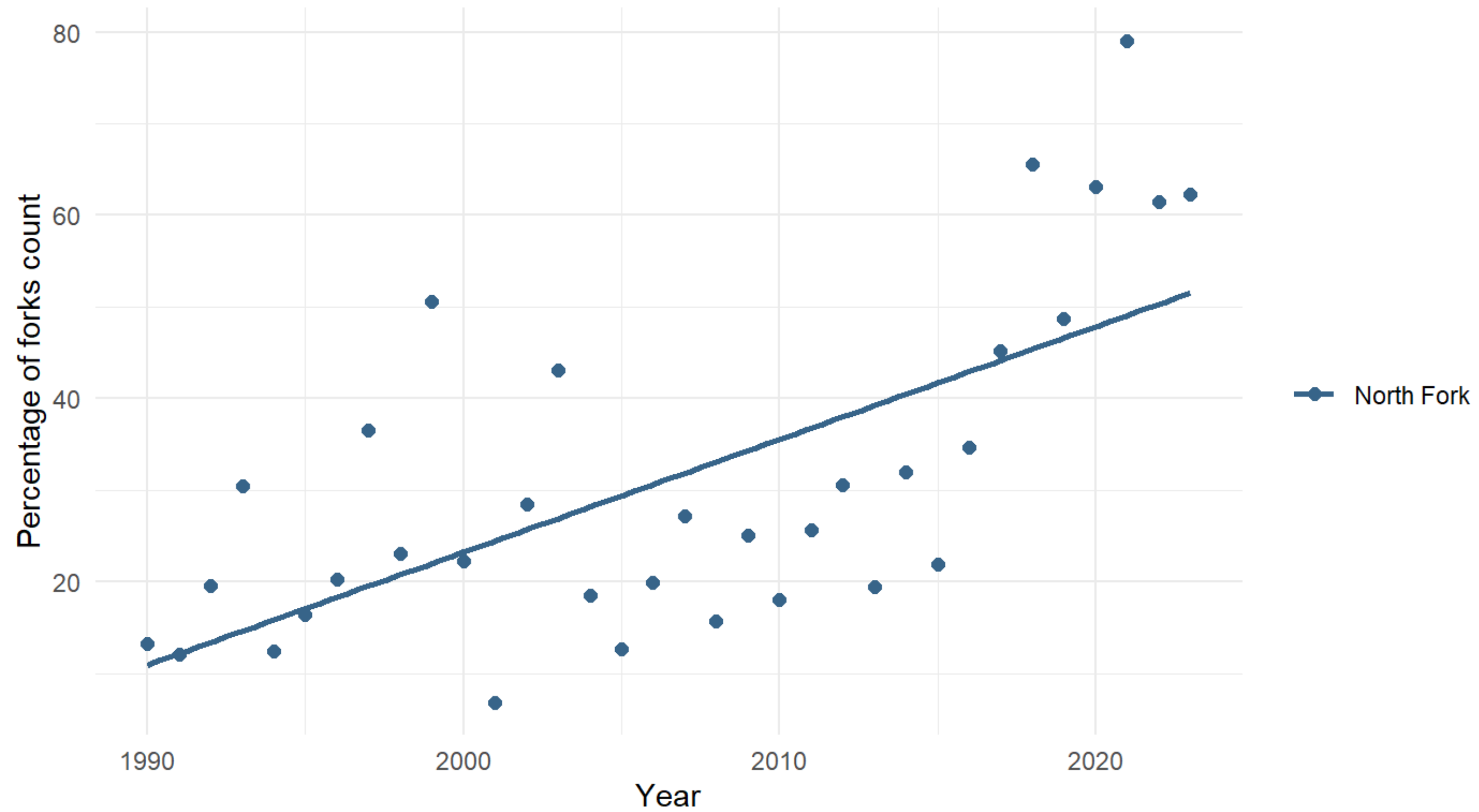


# Annual population census

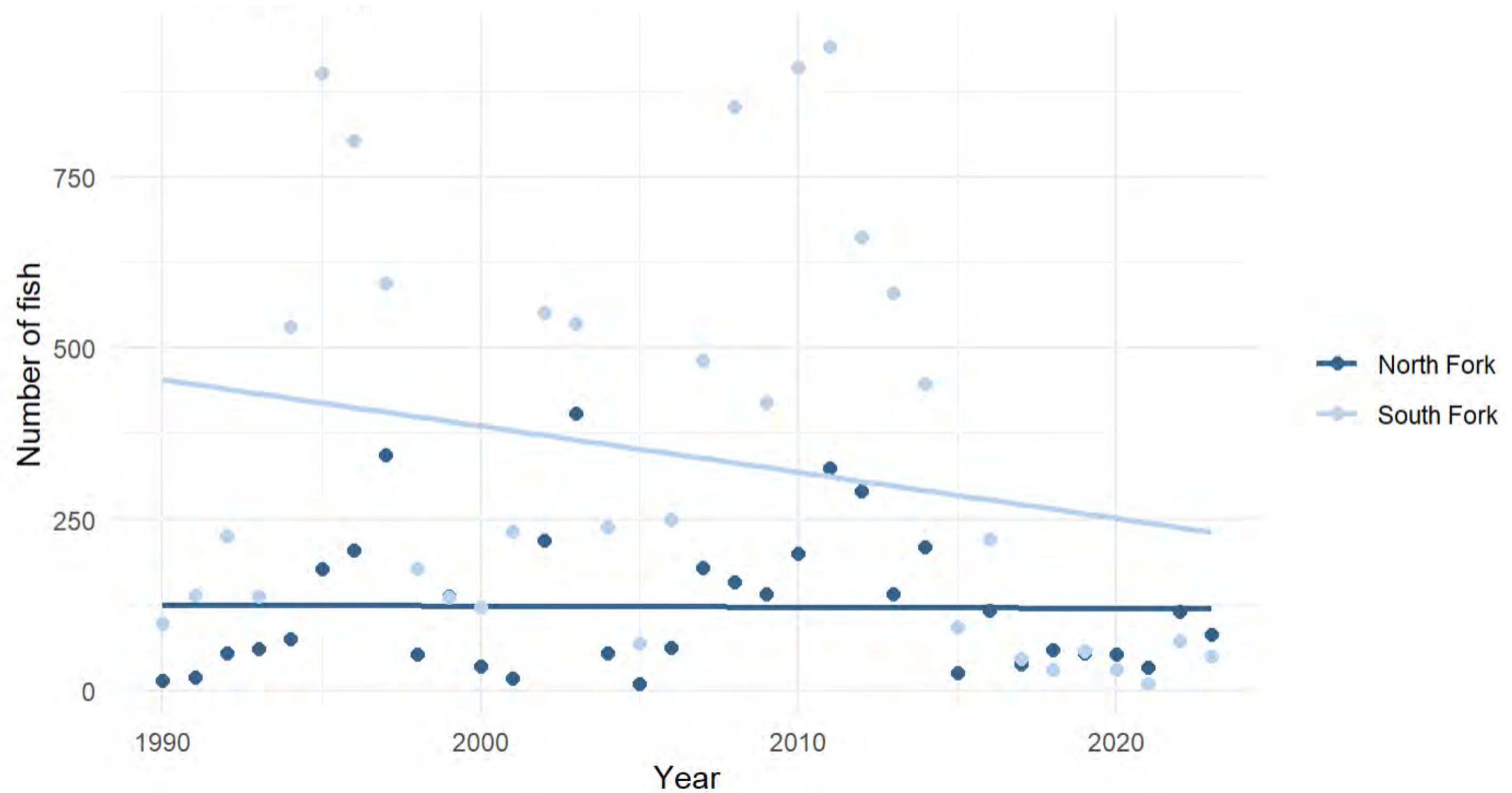


Source: SRRC

# Distribution North Fork



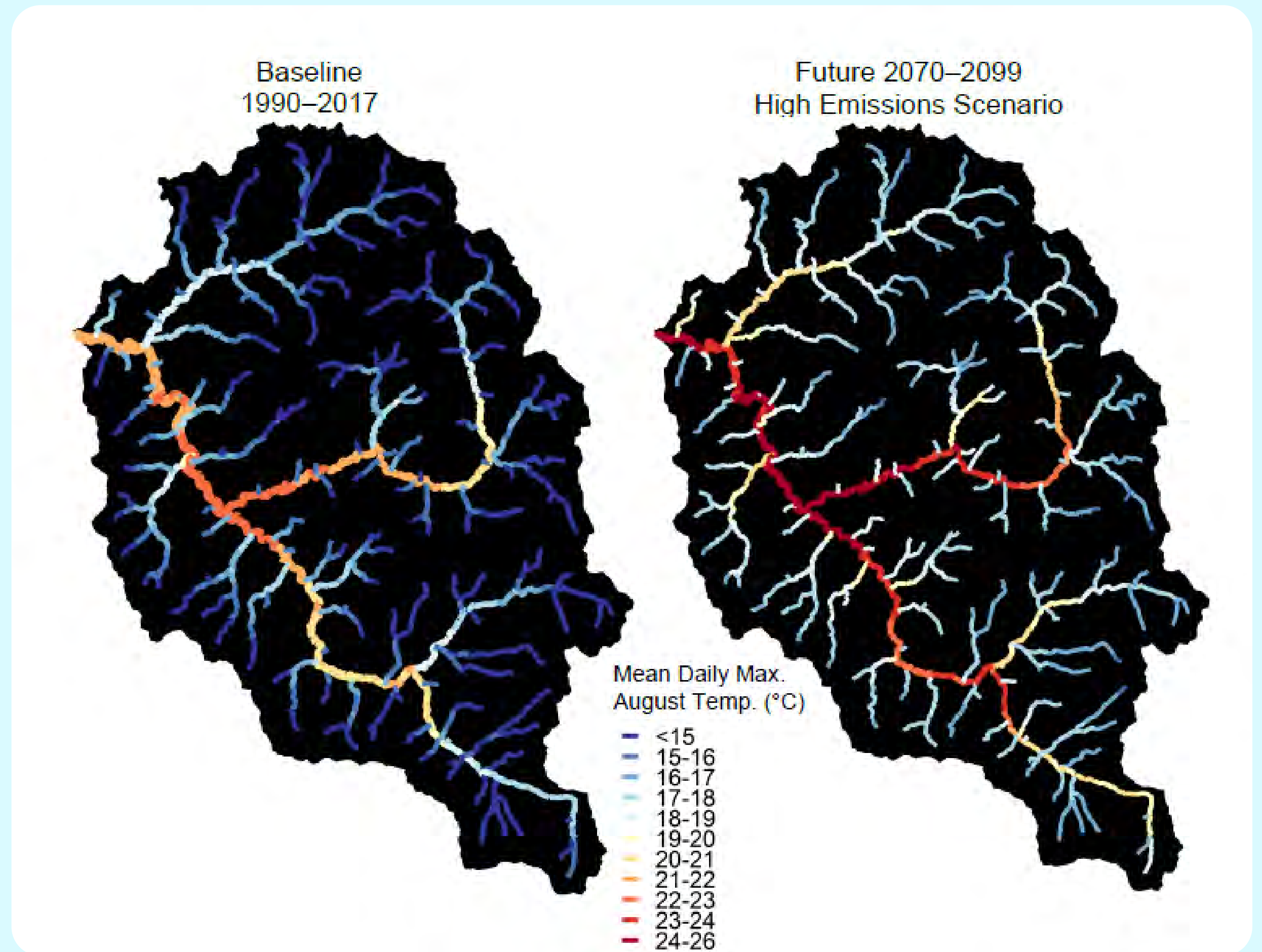
# Distribution North Fork vs. South Fork

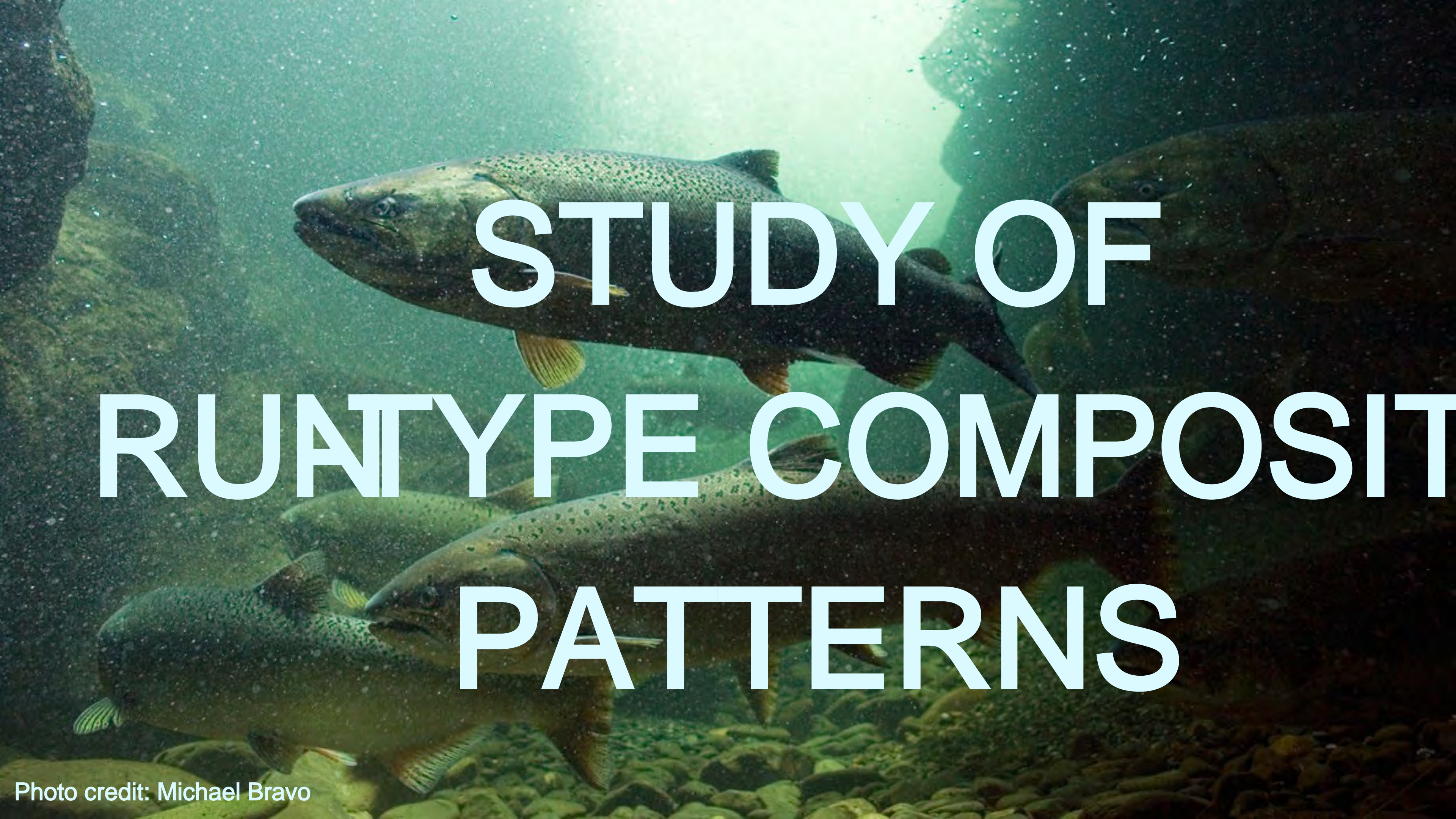


# CLIMATE CHANGE

Asarian et. al. 2019:

- Water temperatures are warming due to
  - increases in air temperature
  - decreases in snowpack
  - decreases in river flow
- Models predict South Fork will warm faster than the North Fork





# STUDY OF RUNTYPE COMPOSIT PATTERNS

# OBJECTIVES

- Compare run type proportions between years and subbasins (North Fork & South Fork)
- Evaluate run type proportions under different migration conditions → fall spawning migration flows



# METHODS

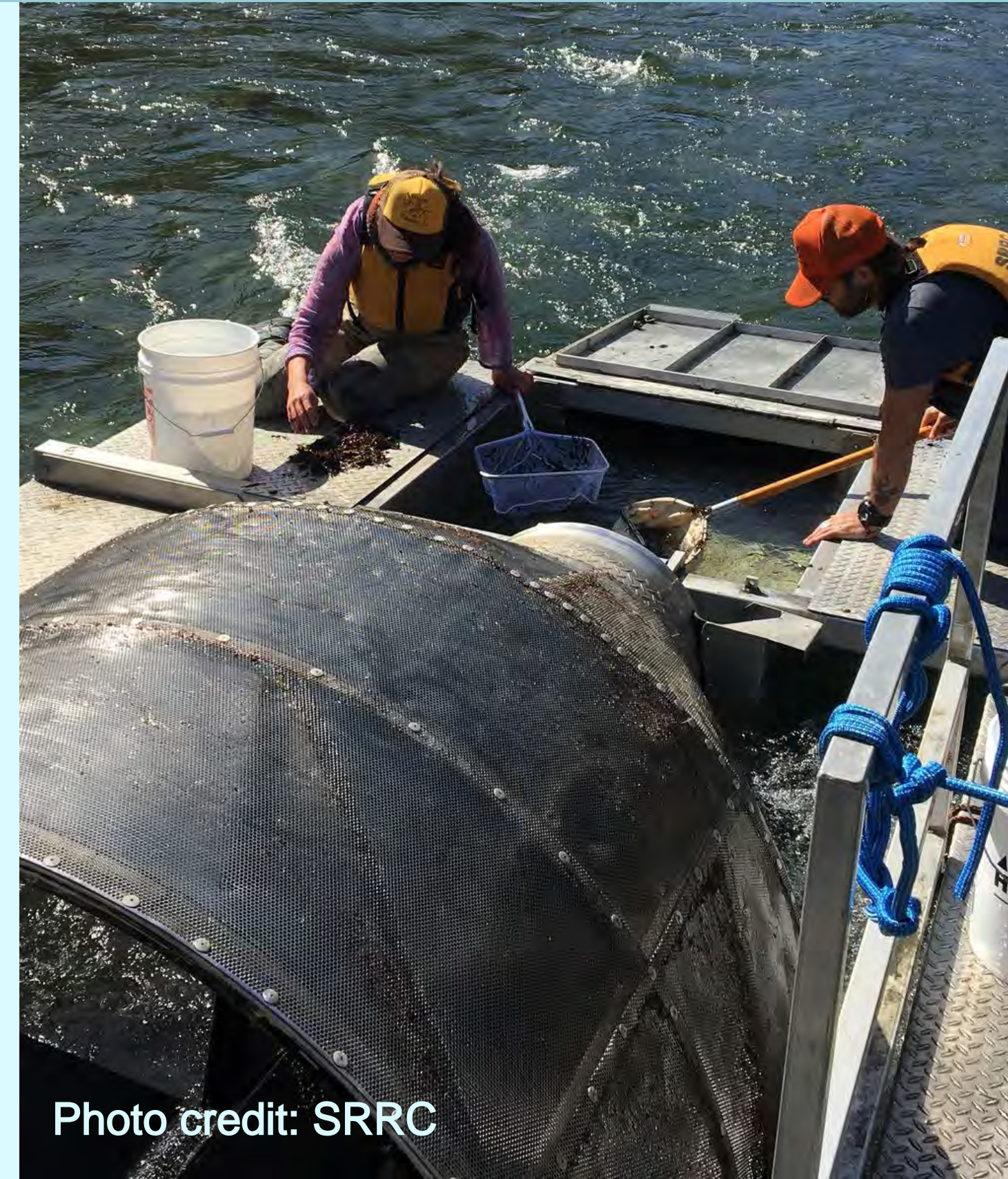
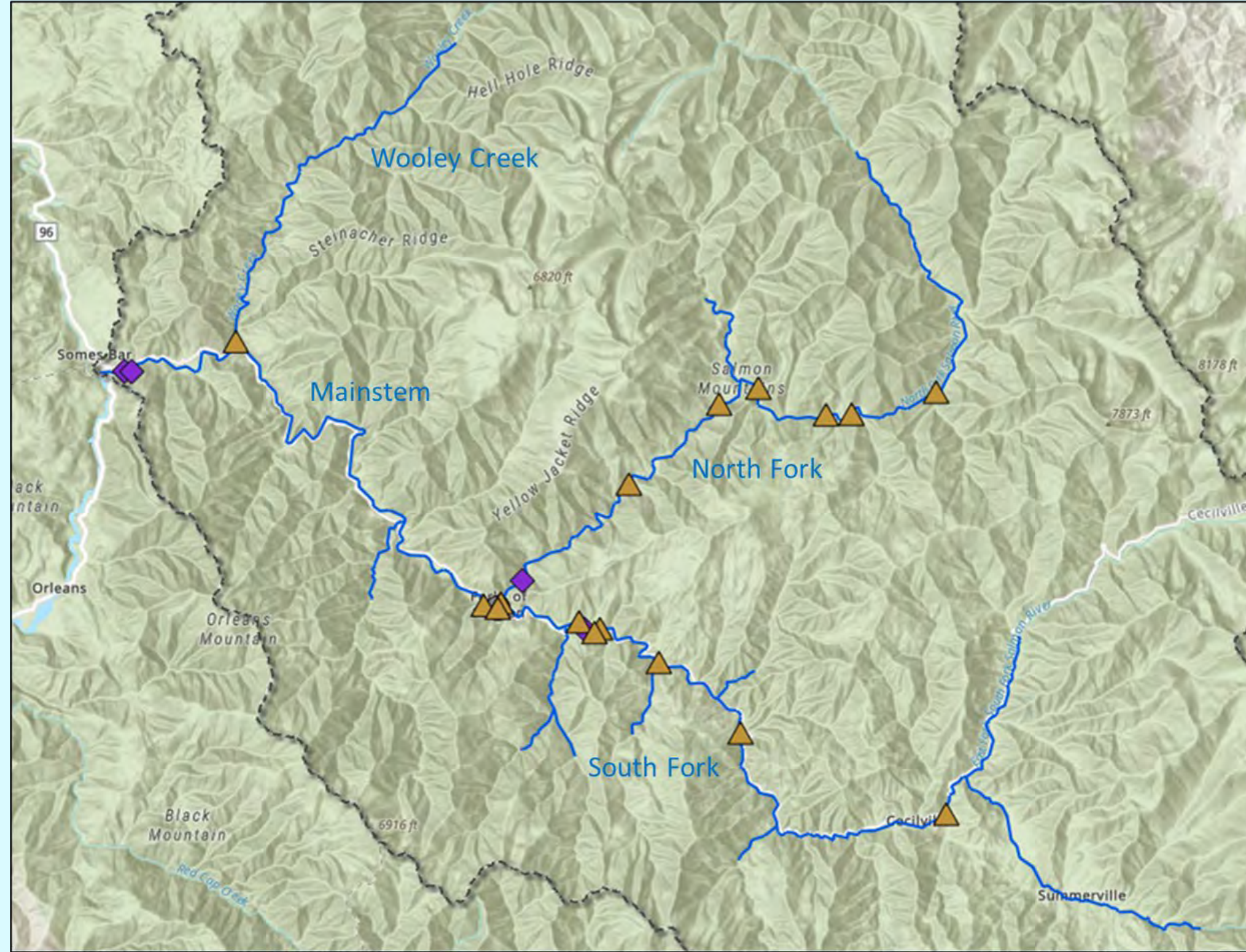


Photo credit: SRRC

# METHODS

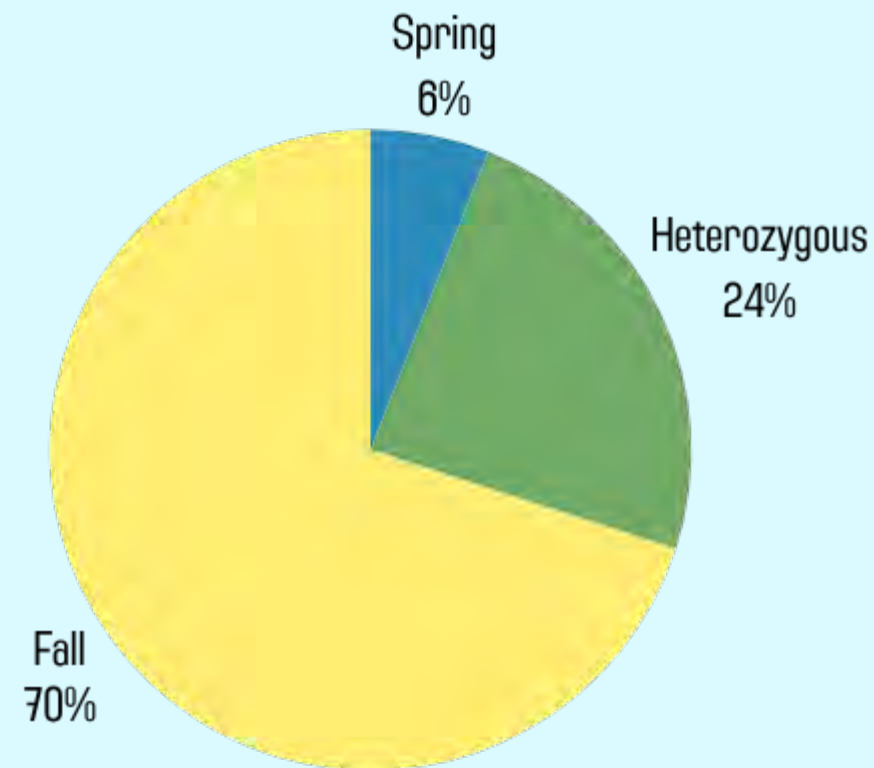


# SAMPLING LOCATIONS

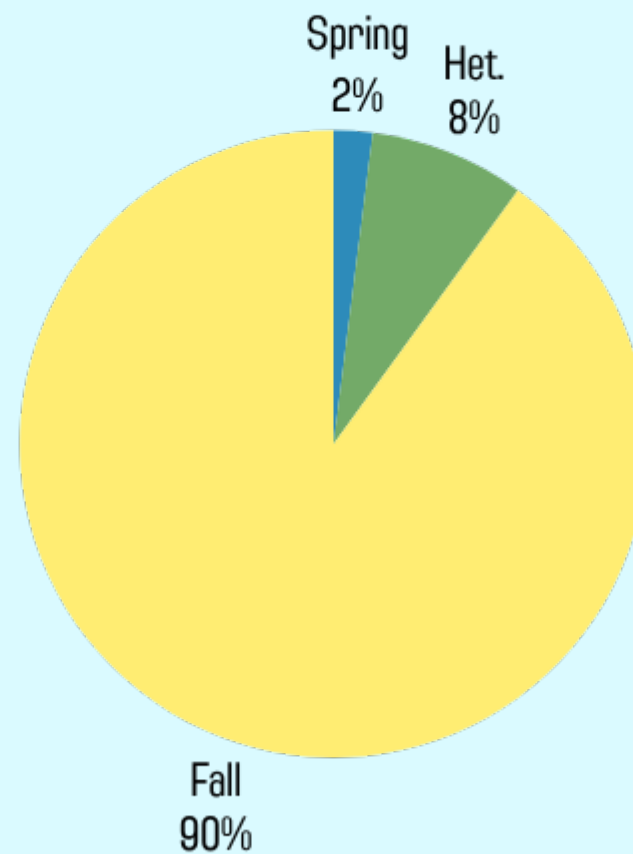


# RESULTS: Genotype frequencies from lower Salmon River t year (Spring, heterozygous & fall)

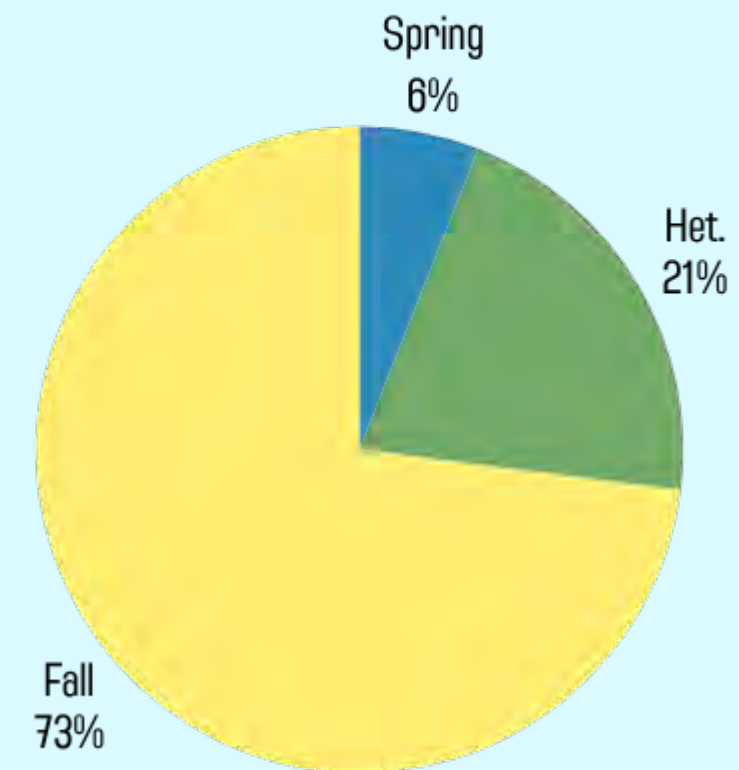
Brood Year 2022



Brood Year 2023

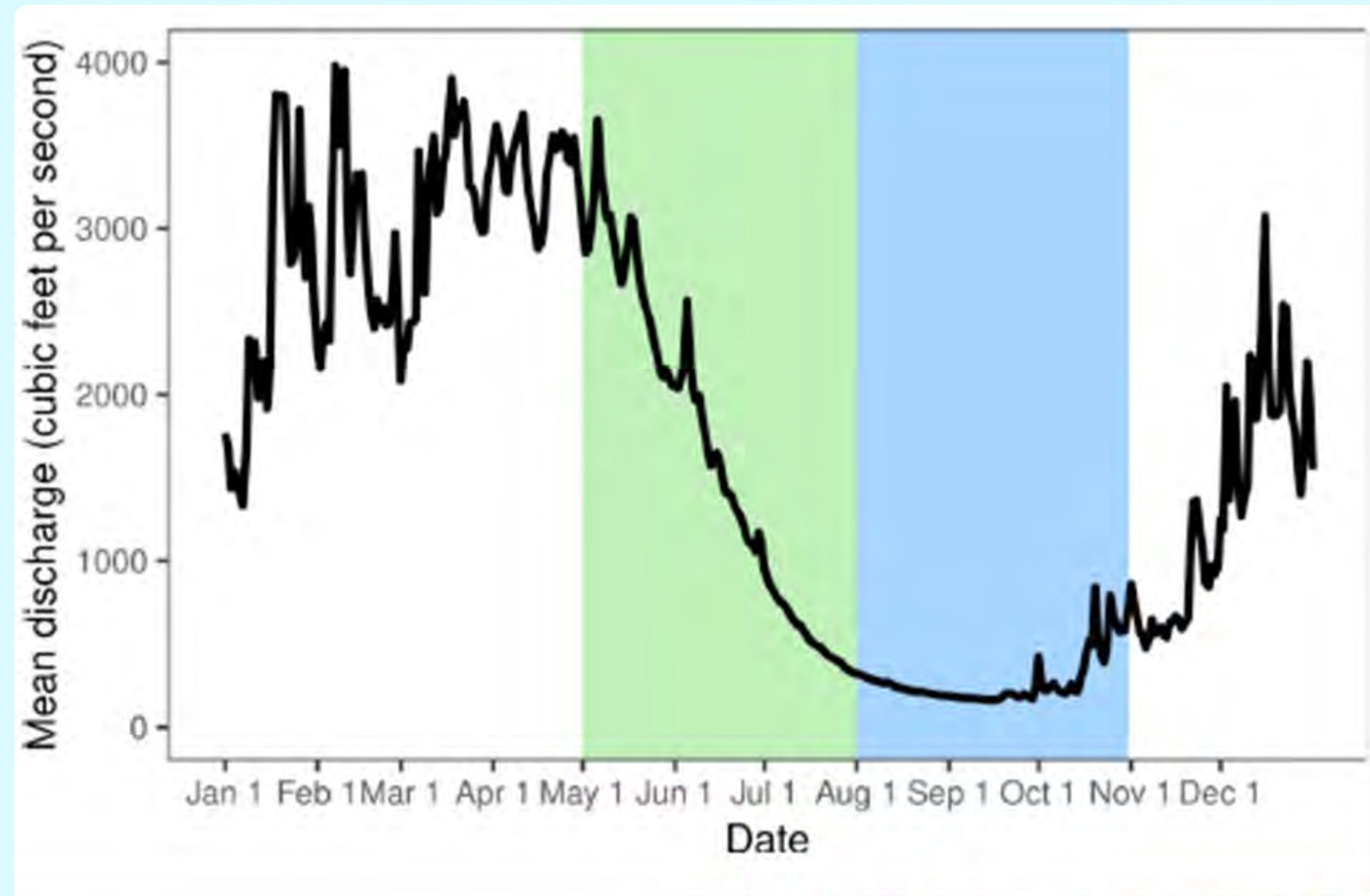


Brood Year 2024



# CONTEXT: MIGRATION TIMING

Spring vs.  
Fall Chinook  
migration  
timing



Approx. migration timing of **spring Chinook** and **fall Chinook**<sup>1</sup>

Figure from Neuner & Tucker  
(2022)

# CONTEXT: MIGRATION TIMING

**Seasonal  
barriers**

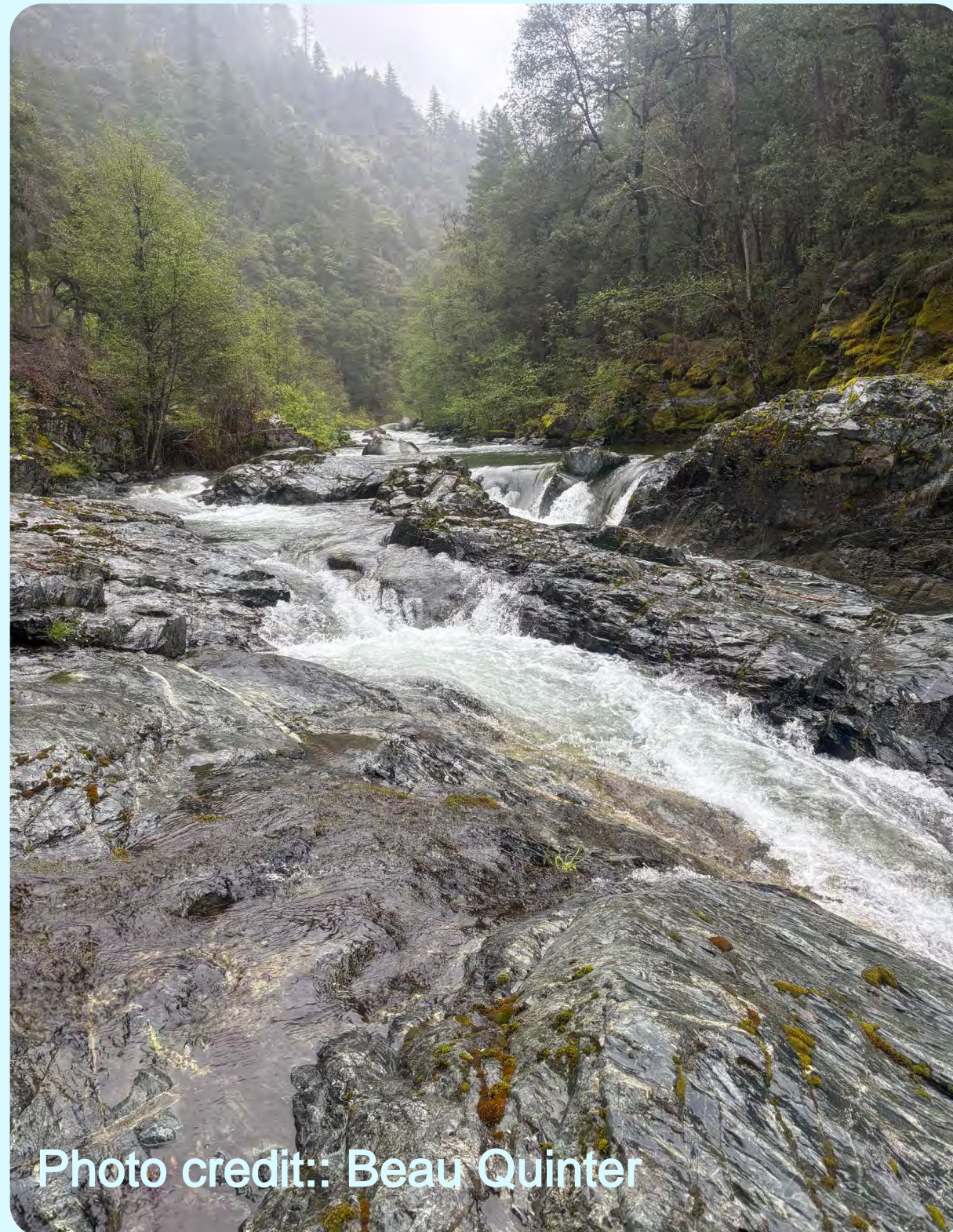
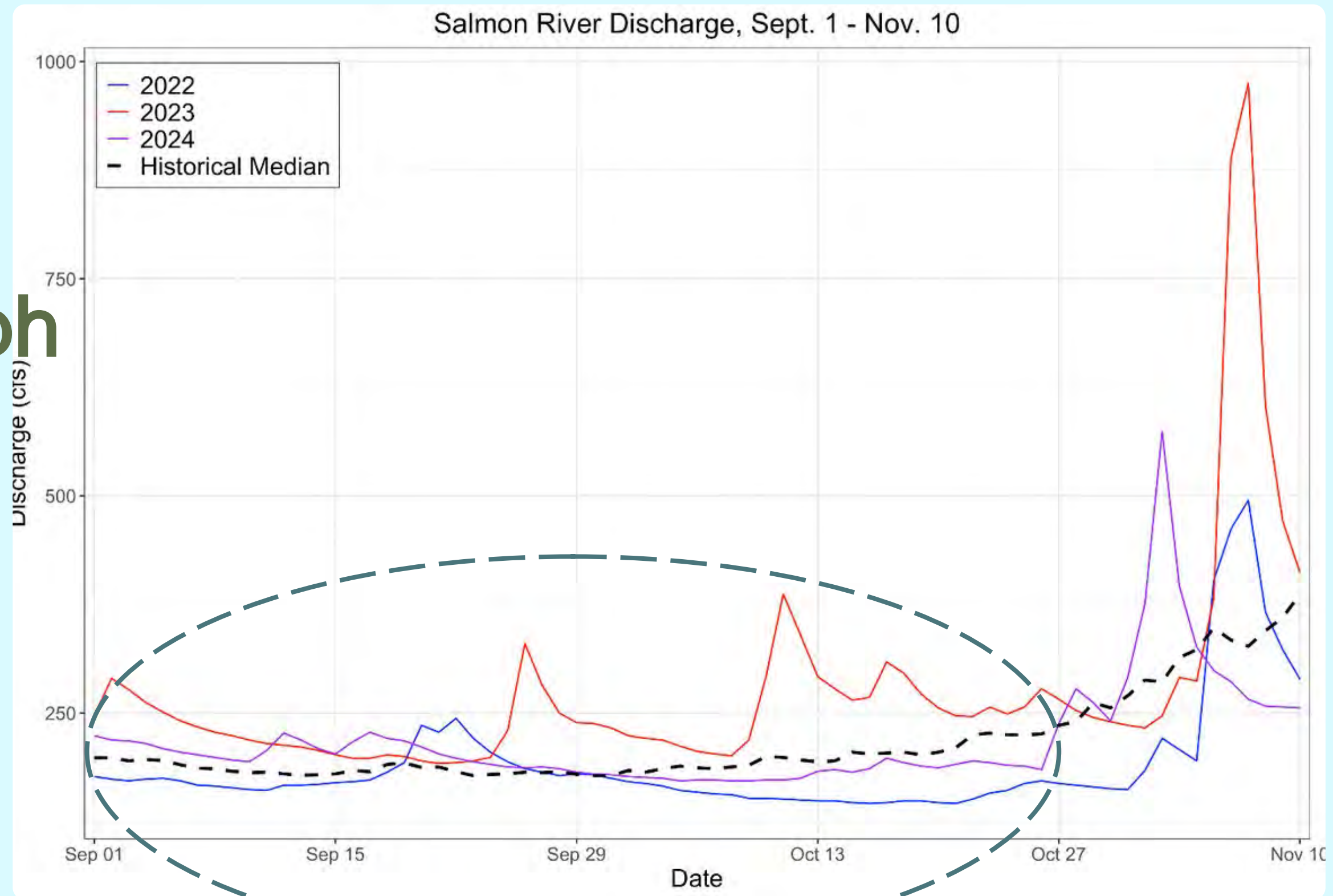


Photo credit: Beau Quinter



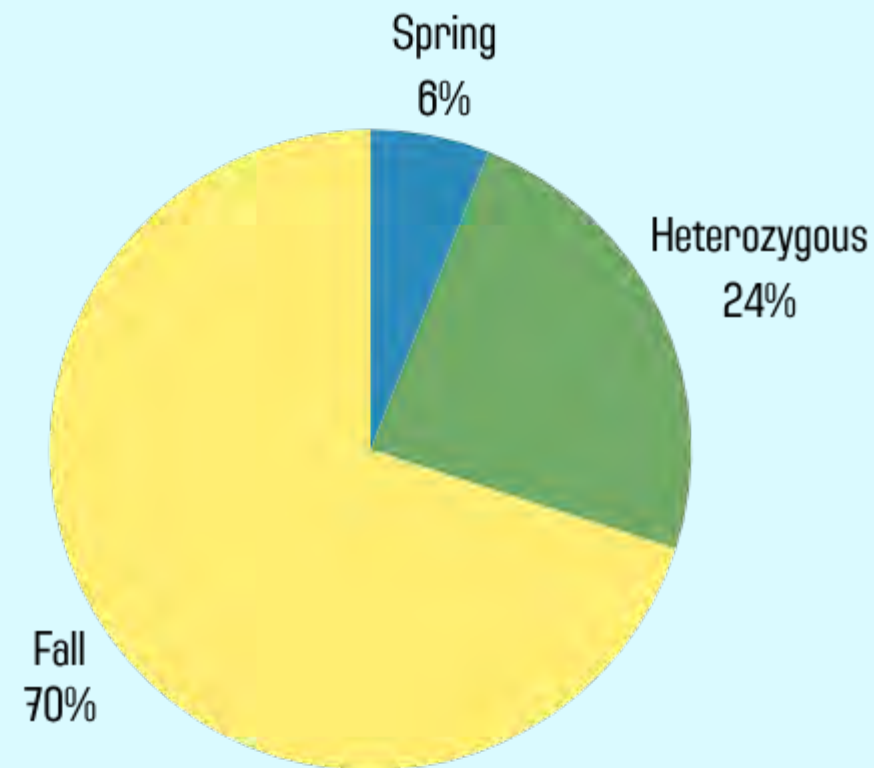
# CONTEXT: FALL CHINOOK MIGRATION

Fall hydrograph  
in 2022, 2023,  
& 2024

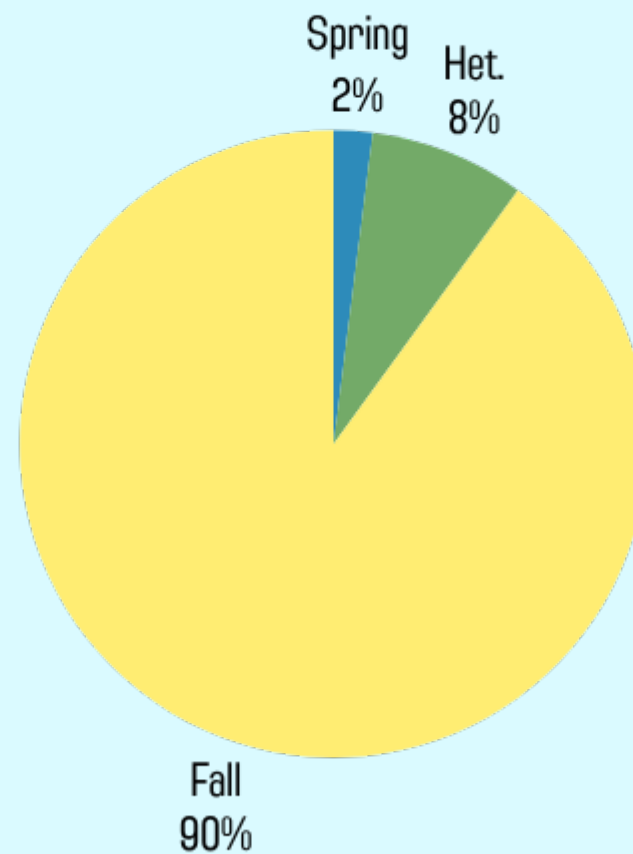


# Genotype frequencies from lower Salmon River trap by brood Spring, heterozygous & fall

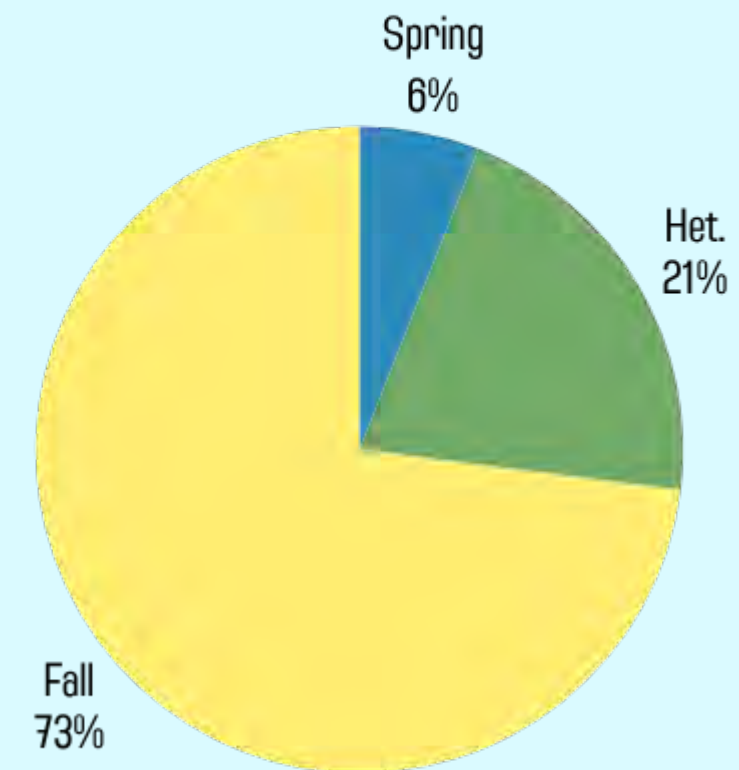
Brood Year 2022



Brood Year 2023

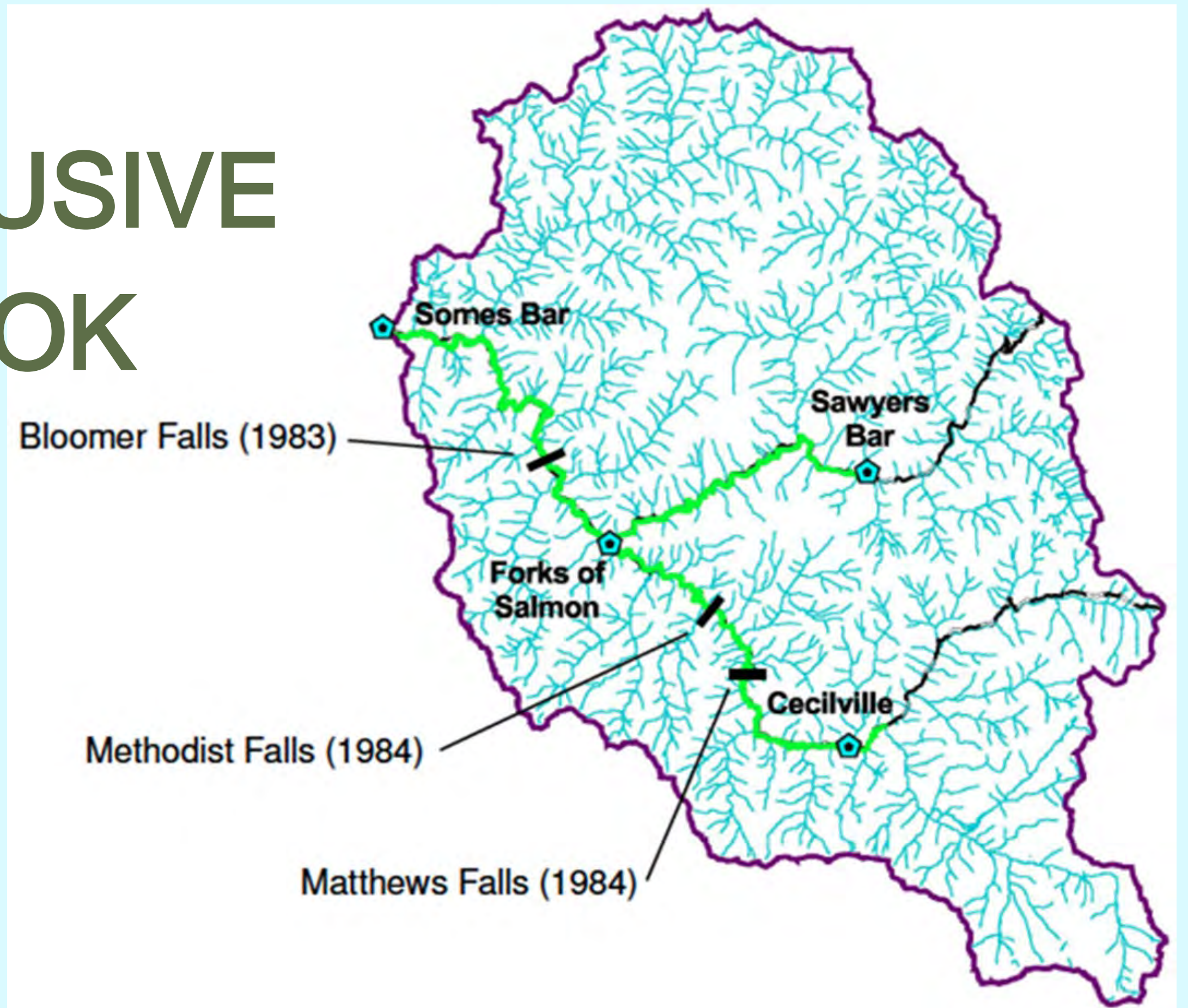


Brood Year 2024



# LOSS OF EXCLUSIVE SPRING CHINOOK HABITAT

- Two boulder cascades were blown out of the South Fork
- One in the mainstem

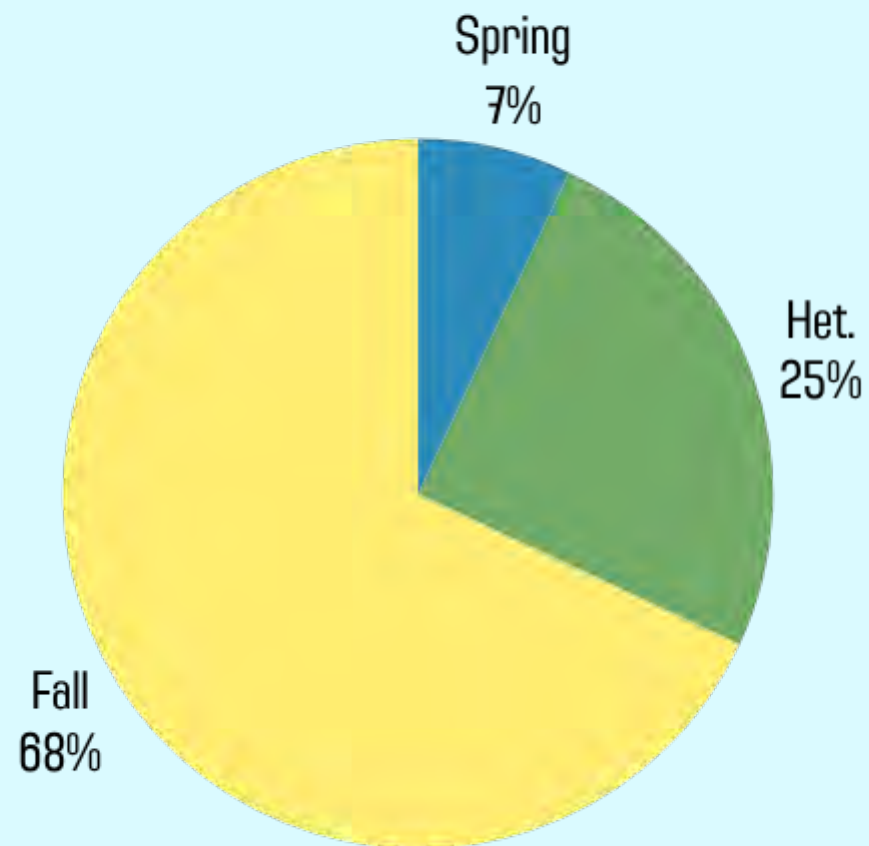


# WET year **2023**

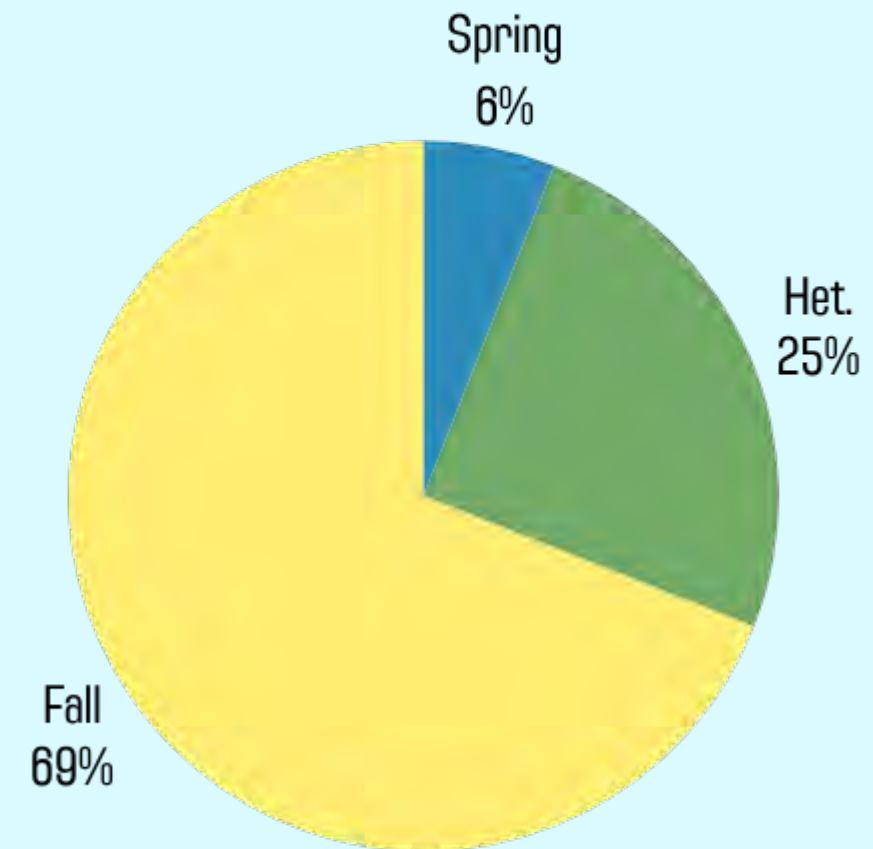
NORTH FORK

SOUTH FORK

**Brood Year 2023**

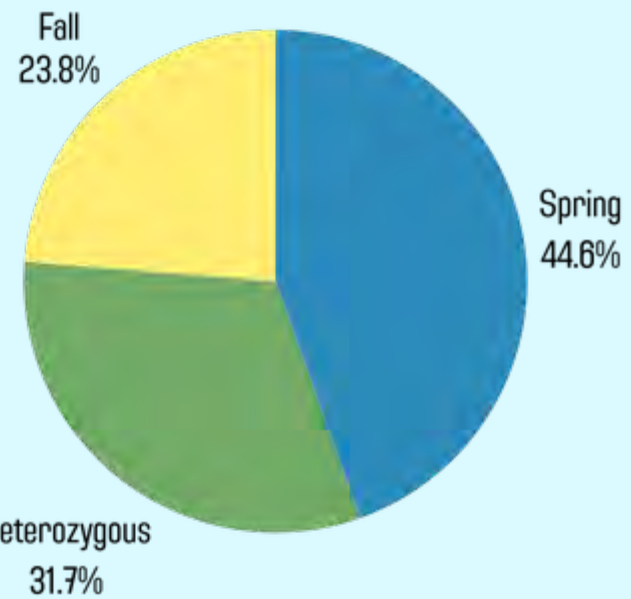


**Brood Year 2023**

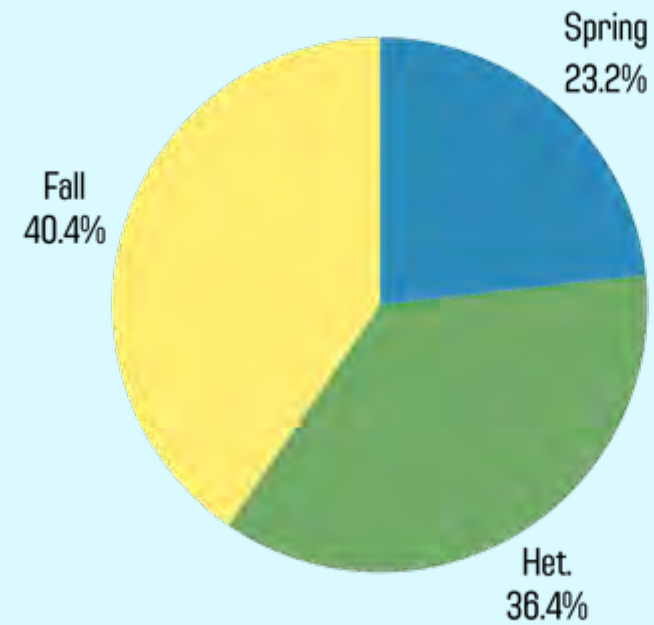


# The two DRY years (2022 & 2024)

## NORTH FORK

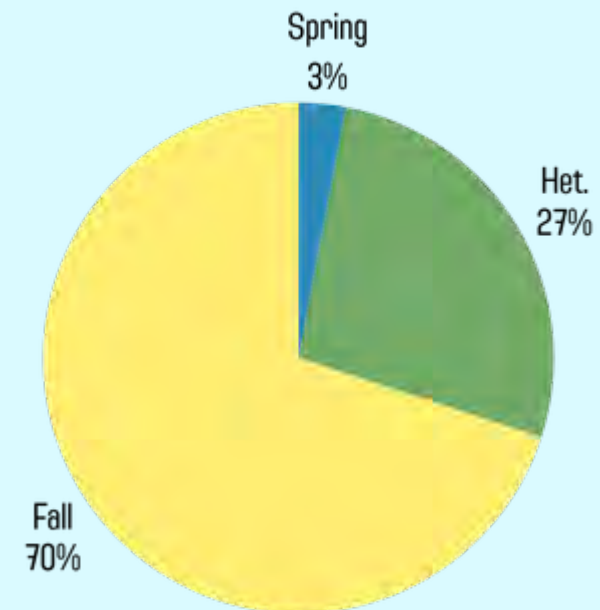
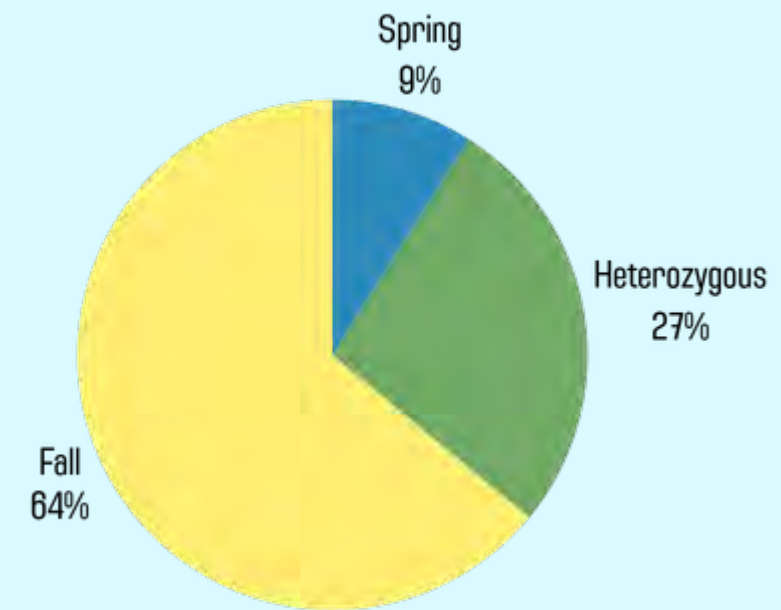


Brood Year 2022



Brood Year 2024

## SOUTH FORK



# EXCLUSIVE HABITAT IN NORTH FORK

- Existing boulder cascade on the lower North Fork which likely acts as a low flow barrier to fall Chinook



# CONSERVATION IMPLICATIONS

- Spring Chinook need access to exclusive habitat
- Taking steps towards installing a seasonal low-flow barrier on the South Fork
- Undamming the Klamath provides opportunities for highly productive exclusive habitat for spring Chinook



# Research team

## UC Berkeley:

Stephanie Carlson, Ted  
Grantham

**Karuk Tribe:** Beau  
Quinter, Harold  
Mitchell

**Salmon River**

**Restoration Council:**

Sam Stroich, Andrew  
Ayers

**Wild Salmon Center:**

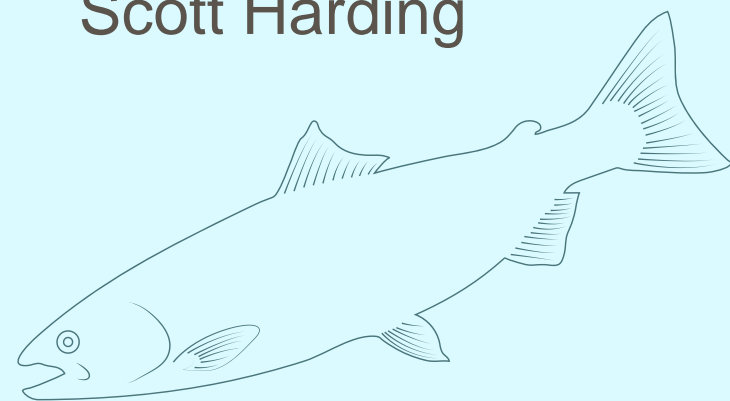
Matt Sloat, Tasha  
Thompson, Jon Hart

**UC Davis:** Mike Miller

# THANK YOU Funders

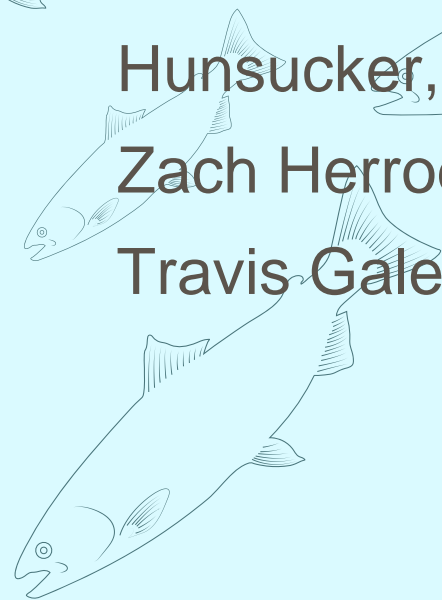
## Collaborators

Alma Nuñez Gutierrez, Ben  
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Ecology Group, Crystal  
Robinson, Judson Fisher &  
Karuk GIS Team, LeRoy Cyr  
& Six Rivers N.F., Lyra  
Cressey, Maija Meneks &  
Klamath N.F., Melaney  
Dunne, Rosemary Romero,  
Scott Harding



## Field support

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Harrison, Cassady Bowman,  
Clayton Tuttle, Eric Fieberg, Irie  
Swift, Jonathan Peaslee,  
Kenneth Brink, Miranda Velarde,  
Olyn Cole, Sam Robertson,  
Trevor Peterson, Tuekwe  
Hunsucker, Veronica Nelson,  
Zach Herrod, Chaas Hillman,  
Travis Gale, Luna Buchin



Oliver Lyman Fish & Wildlife Grant  
Colman Watershed Fellowship  
Department of ESPM at UC Berkeley