
The distribution of neutral and adaptive genetic variation in California steelhead: Impacts of and on Central Valley water projects



Devon Pearse

Lead Scientist, Friends of the River

Research Geneticist, NOAA Fisheries (Ret.)

Adjunct Professor

Department of Ecology & Evolutionary Biology
University of California, Santa Cruz



**Pacific States Marine Fisheries Commission Steelhead Meeting
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— BUREAU OF —
RECLAMATION

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Daniel Martinez,
Jonathan Nelson,
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CDFW Tissue Archive

Outline

- >Project 1: Delta water export impacts on CV steelhead
- >Project 2: Genetic variation for run-timing in CV steelhead

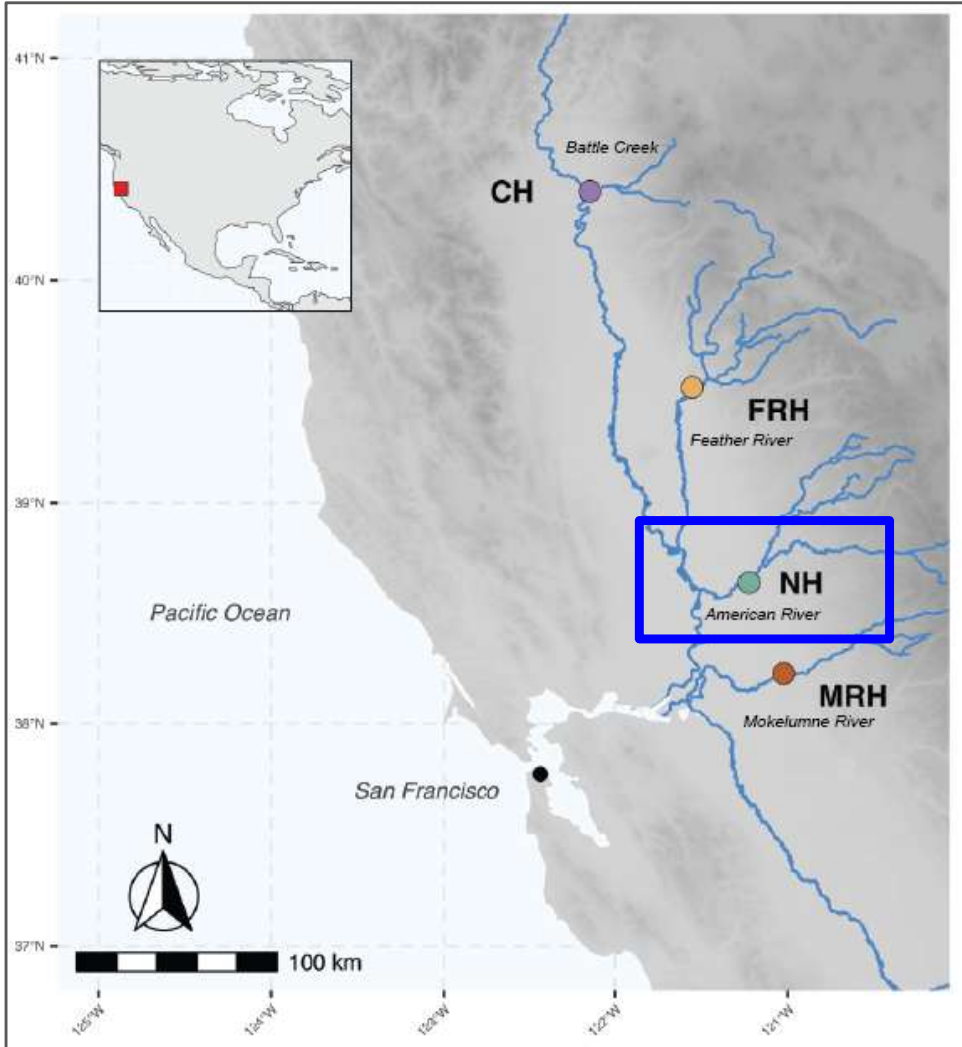


Dr. Laura C. Goetz

<https://www.lauracgoetz.com/>



California Central Valley Steelhead: Four hatchery programs

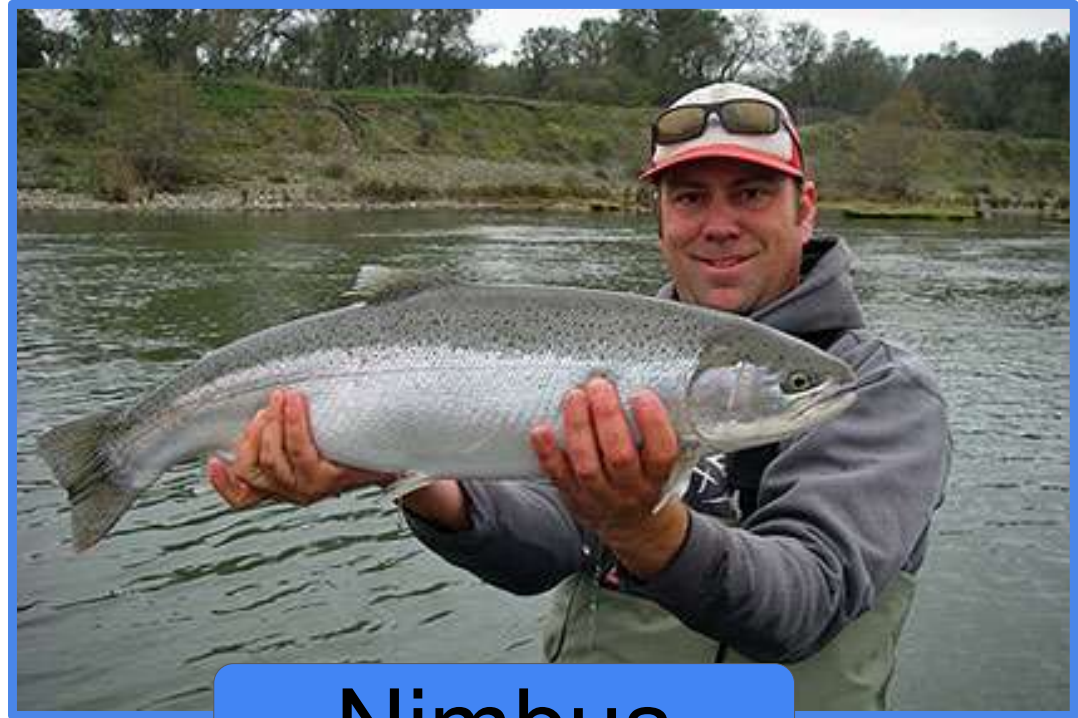


Coleman Hatchery	CH
Feather River Hatchery	FRH
Mokelumne River Hatchery	MRH
Nimbus Hatchery	NH

Nimbus steelhead are different from CV *O. mykiss*



Central Valley

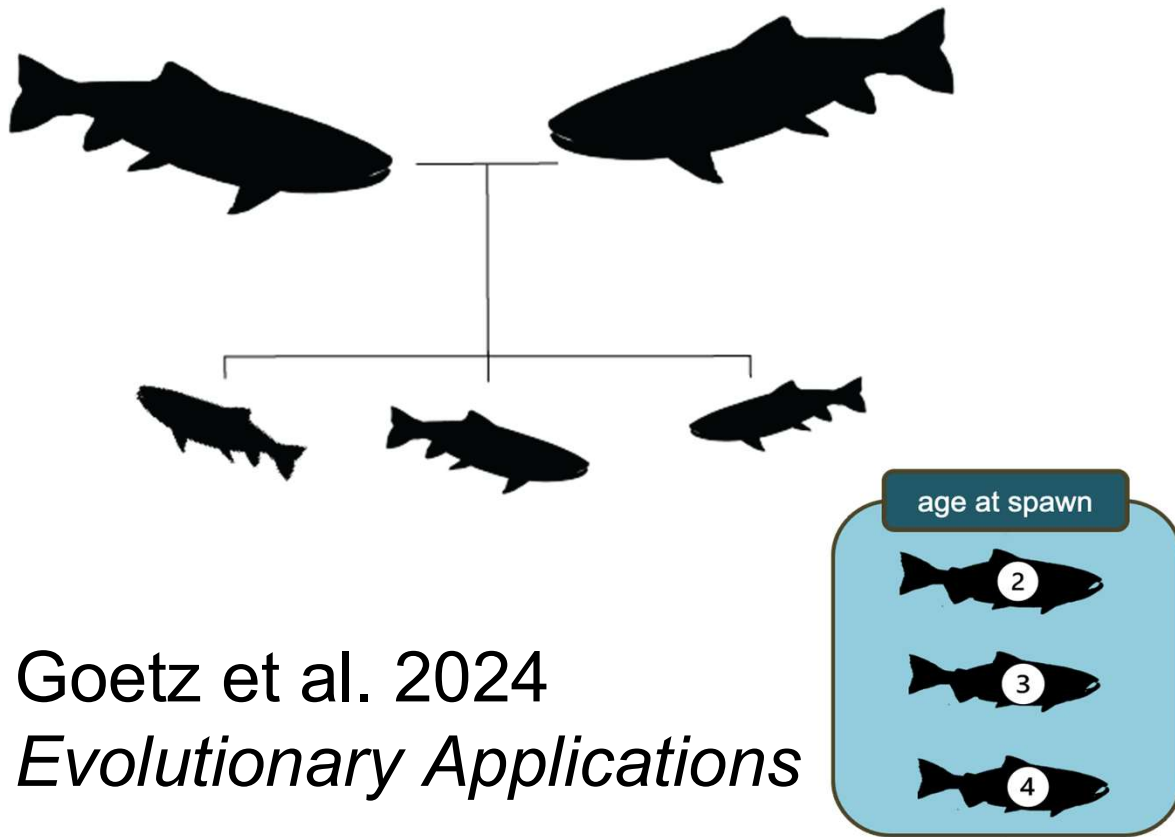


Nimbus

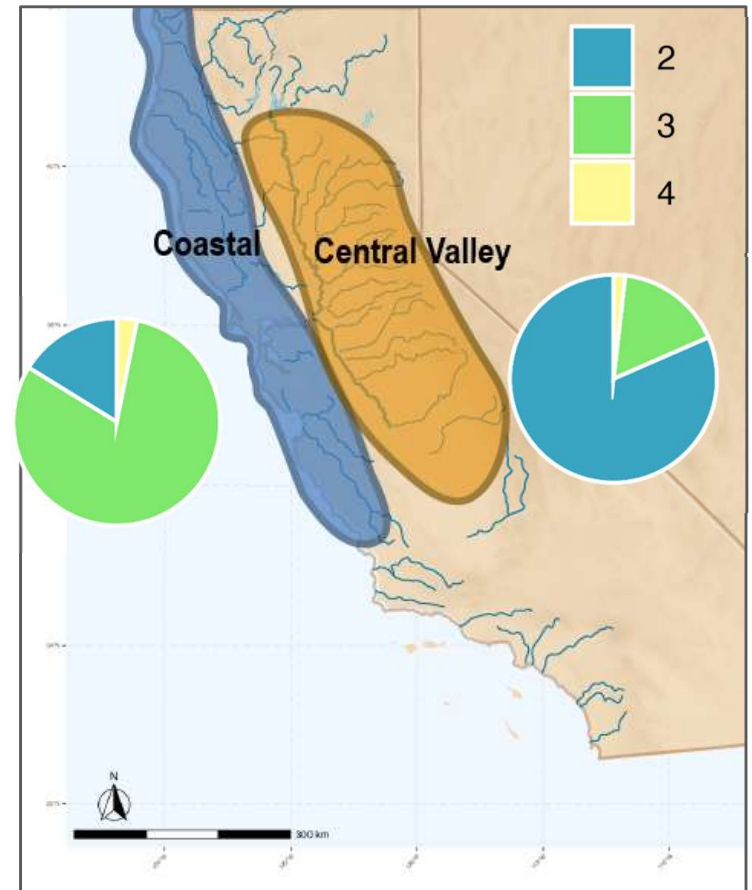
Credit: J. D. Richey

- Steelhead from Nimbus Hatchery coastal origin, not part of the CV DPS.
(Pearse & Garza 2015; NMFS 2020; Goetz et al. 2024)

NMFS SWFSC genetics lab genotyped 23,670 steelhead spawned at the four CCV hatcheries from 2011–2019 for parentage-based tagging



Goetz et al. 2024
Evolutionary Applications



>Project 1: Delta water export impacts on CV steelhead

Biological & Pre-2025 Regulatory Background

- Water export pumping practices at the federal Central Valley Project (CVP) and California State Water Project (SWP) impact migrating juvenile steelhead, with ongoing efforts to reduce 'loss'.
 - Both Hatchery and Wild *O. mykiss* juveniles migrating through the delta.
 - >Hatchery fish are 100% adipose (AD) fin-clipped (in theory).
 - >Hatchery fish are not counted as 'loss'.
 - Loss limits of natural origin Central Valley Steelhead are separated into two time periods (before/after April 1st).
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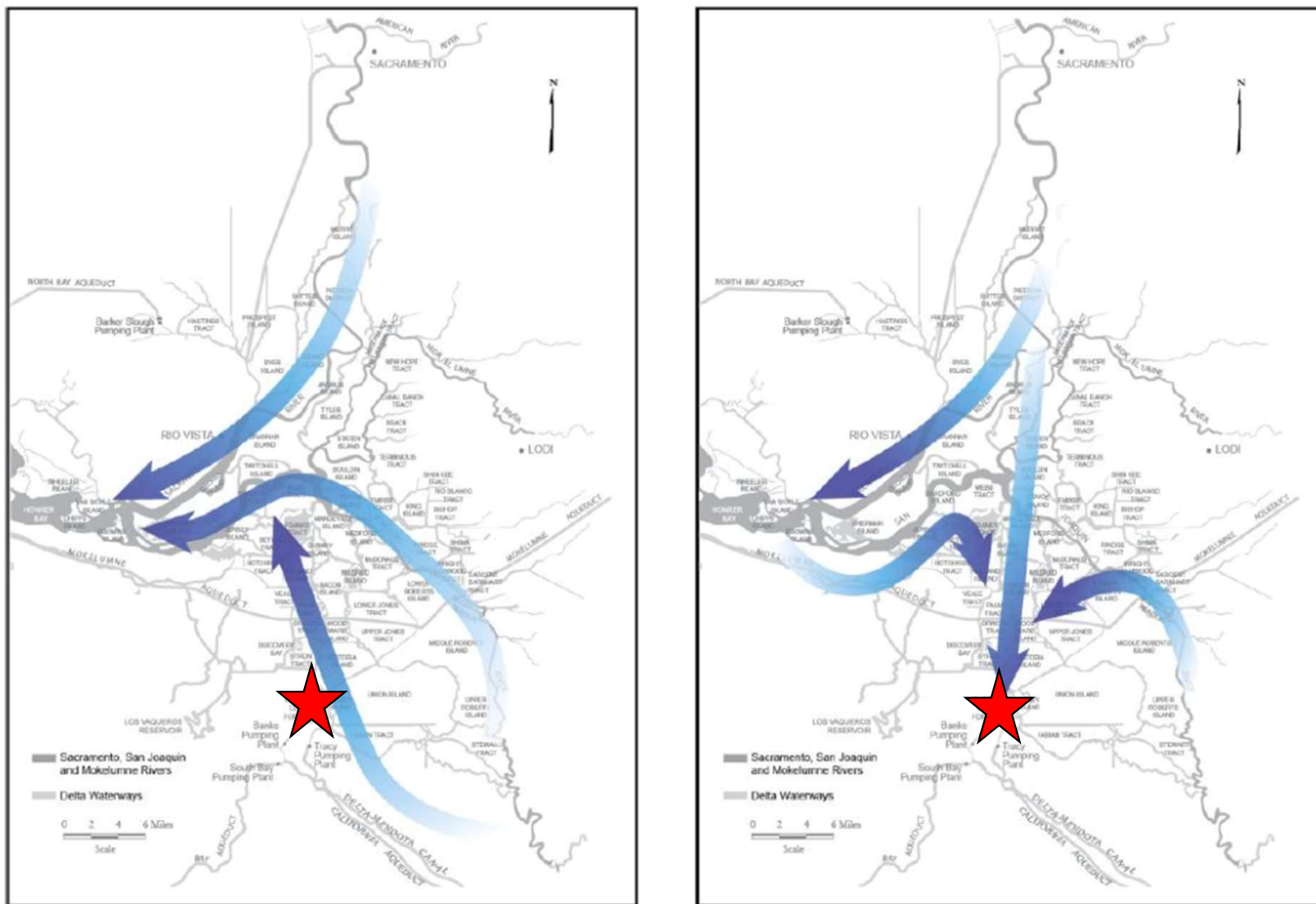


Figure 36. Generalized flow directions in the South Delta. The left panel depicts the tidally averaged flow direction in the absence of export pumping. The right panel depicts reversal of tidally averaged flows that occurs during times of high export pumping.

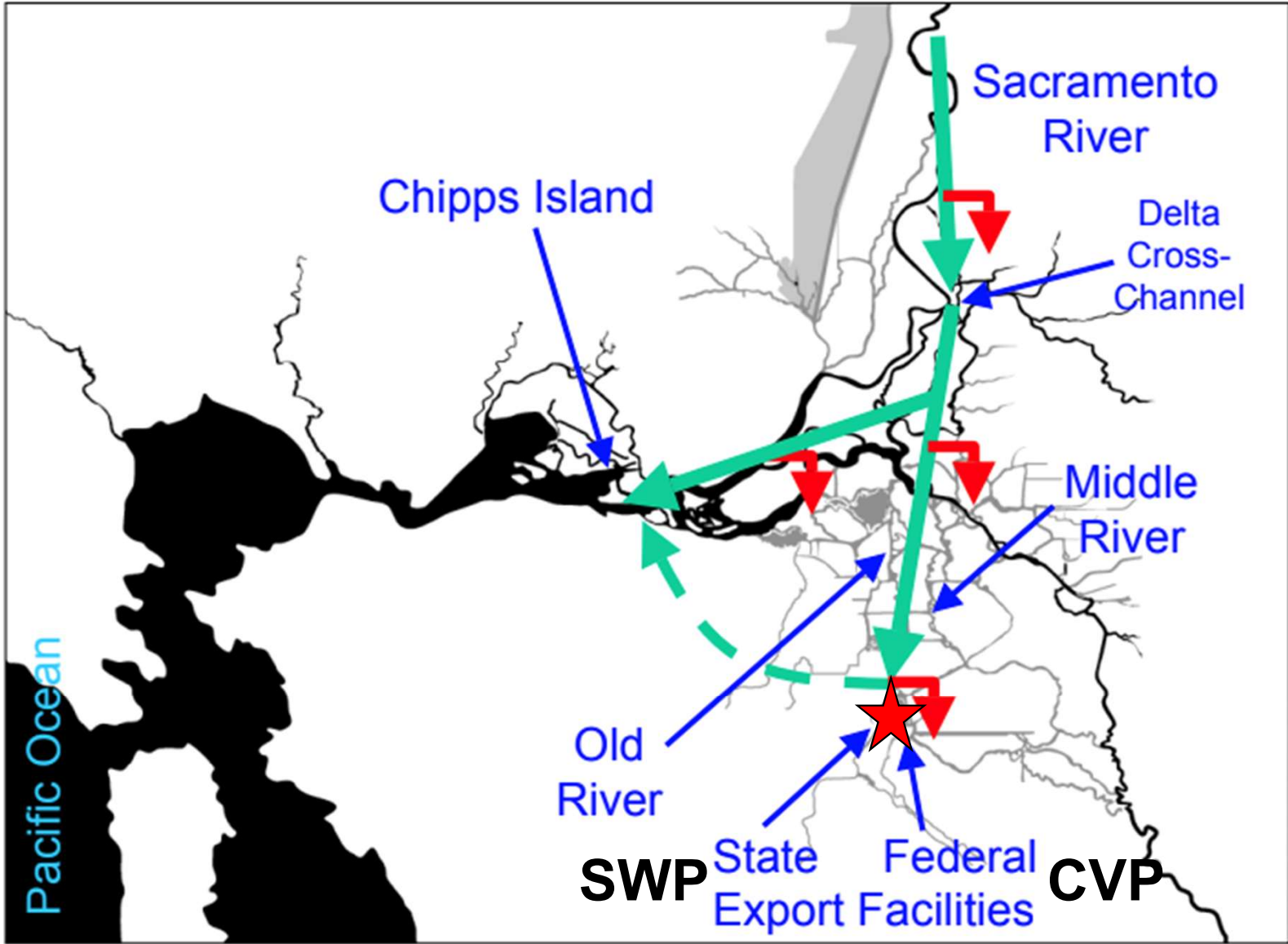
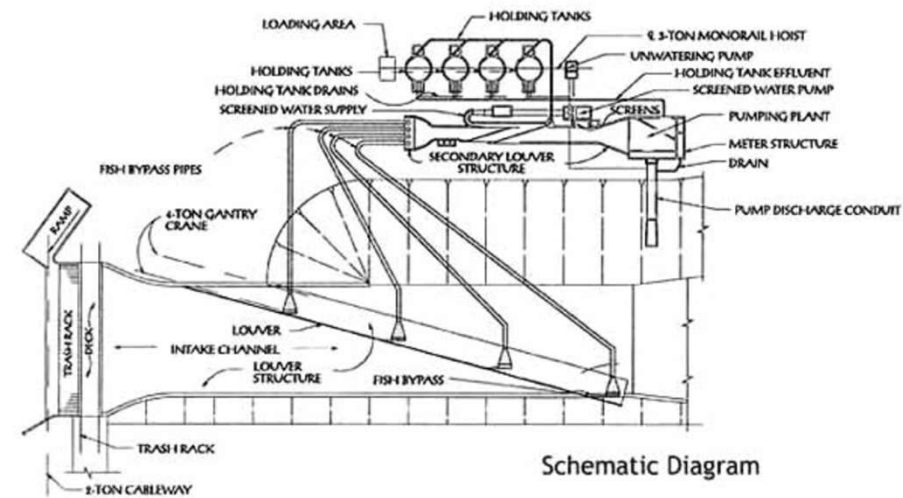


Figure 1. Map of the San Francisco Estuary showing locations mentioned in the text. Green arrows indicate general movement pathways for winter Chinook salmon; the dashed arrow represents movement of salvaged fish by truck. Red arrows indicate mortality losses; only those occurring at the export facilities are accounted for here.

Infrastructure: Predation and Louvers and Pumps, oh my!

- **CVP:** Tracy Fish Collection Facility, Old River - Delta-Mendota Canal
- **SWP;** Skinner Delta Fish Protective Facility, Clifton Court Forebay
- **“Salvaged”** fish counted, fin clipped, and released. ‘Loss’ extrapolated.



>Project 1: Delta water export impacts on CV steelhead

>Two groups of samples:

-Archival salvage samples, 2014-2020.

-2024 salvage samples + BY23 parents.



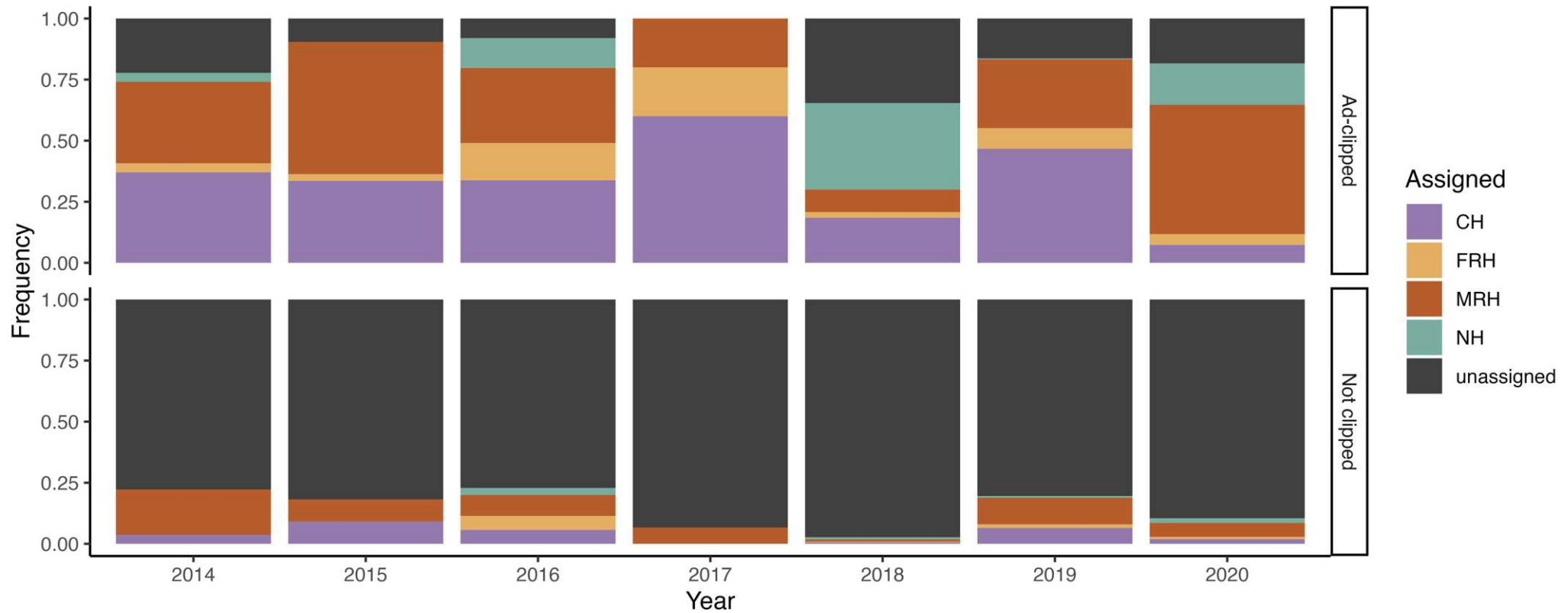
PBT: Archival Samples

- Archived samples collected at the CVP/SWP facilities, 2014-2020:
 - >Total of N=2,073 salvaged individuals over all years.
 - >Hatchery parents from 2011-2019 (Goetz et al. 2024 *Evol. Apps.*)
 - >SNP genotypes, identify hatchery parent pairs.

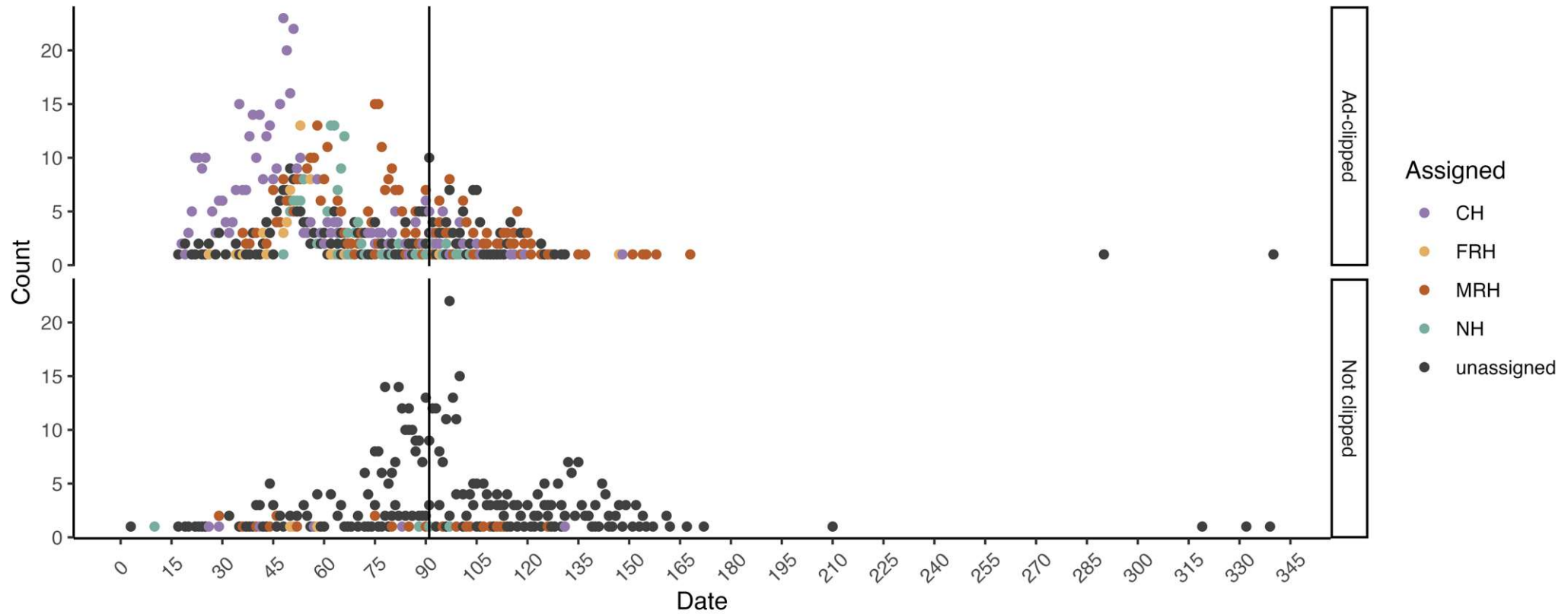
	2014	2015	2016	2017	2018	2019	2020
AD	27	146	361	10	260	557	136
N	27	11	35	15	332	138	105
	54	157	396	25	592	695	241

>High variability across years in numbers and proportion AD vs N.

PBT Results: Archival Samples



PBT Results: Archival Samples



2024 water year.

- Very high steelhead 'salvage'. N=1,219
- Majority unclipped=natural origin?
- Water curtailments.



May 23, 2024 | NCGASA Staff

DELTA PUMPS LIKELY KILLED OVER HALF A MILLION FISH IN TWO DECADES

This year was extra deadly for smolts

[Ari Plachta/Sacramento Bee/ May 23, 2024](#)

CBS News

Are California water pumps putting endangered fish species at risk of extinction? Experts say so.

Environmental activists say it is a well-documented problem in the Sacramento-San Joaquin River Delta that is now out of control.

Apr 10, 2024

Los Angeles Times

How a 'death trap' for fish in California's water system is limiting the pumping of supplies

Giant pumps hum inside a warehouse-like building, pushing water from the Sacramento-San Joaquin River Delta into the California Aqueduct,...

May 2, 2024

Los Angeles Times

As fish deaths increase at pumps, critics urge California agencies to improve protections

Environmental groups are urging water managers to scale back pumping until juvenile salmon and steelhead have finished migrating through the...

Apr 8, 2024

Sacramento Bee

California water agencies broke own rules, possibly killing thousands of endangered fish

Pumping plants in the Sacramento-San Joaquin River Delta severely harmed or killed almost double the legal amount of Chinook salmon and Steelhead trout in...

Apr 8, 2024



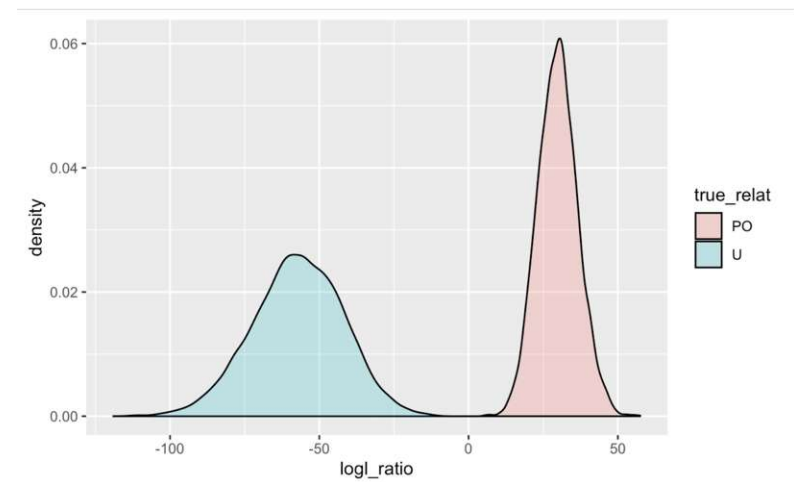
NOAA Fisheries

National Marine Fisheries Service



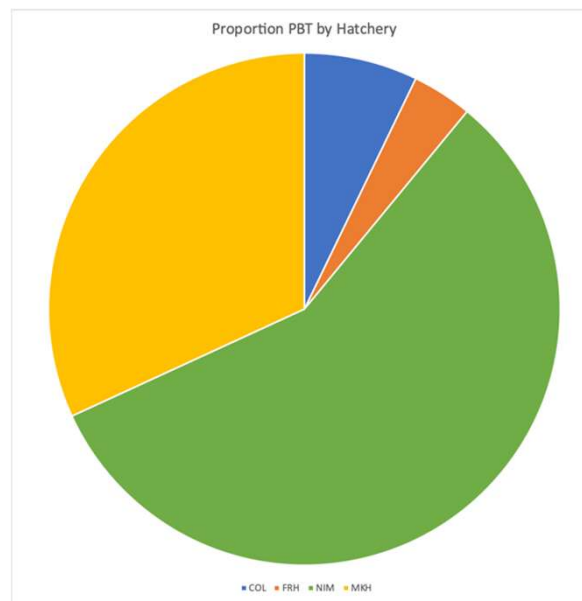
PBT: 2024 water year

- Large number of 2024 CVP/SWP salvage samples (Total N=1,219)
 - >Roughly equal between CVP (N=559) and SWP (N=660) facilities.
 - >AD = 453, N = 729, NA = 37 (excluded).
- Hatchery broodstock parents from BY2023 (N=2,066) All hatcheries release one year old smolts. >COL 499, FRH 621, NIM 696, MKH 250
- Microhaplotype panel (Le Gall et al. 2024)
 - >High power for both PBT and GSI, providing complementary results.
 - >Single-parent assignments increase hatchery assignments.



PBT: 2024 water year.

	<u>Unassigned</u>	<u>Assigned</u>
	<u>(745)</u>	<u>Hatchery Parents</u> <u>(474)</u>
AD-Clipped= 453 (38%)	33 (7.3%)	420 (92.7%)
Unclipped = 729 (62%)	687 (94.2%)	42 (5.8%)

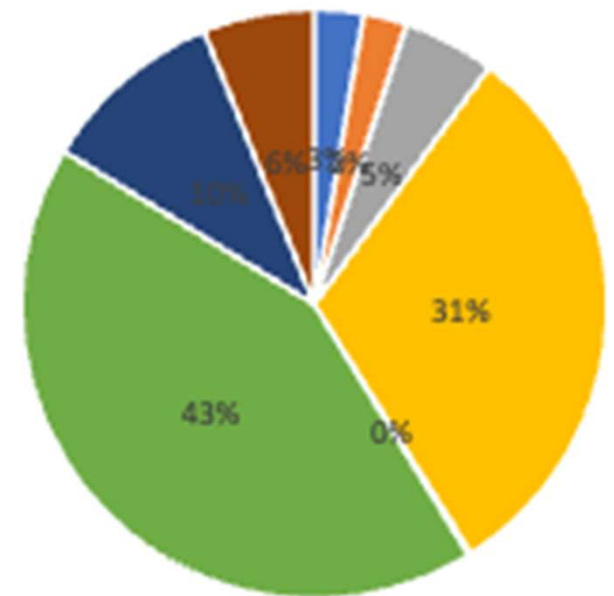


2024 Combined PBT + GSI results:

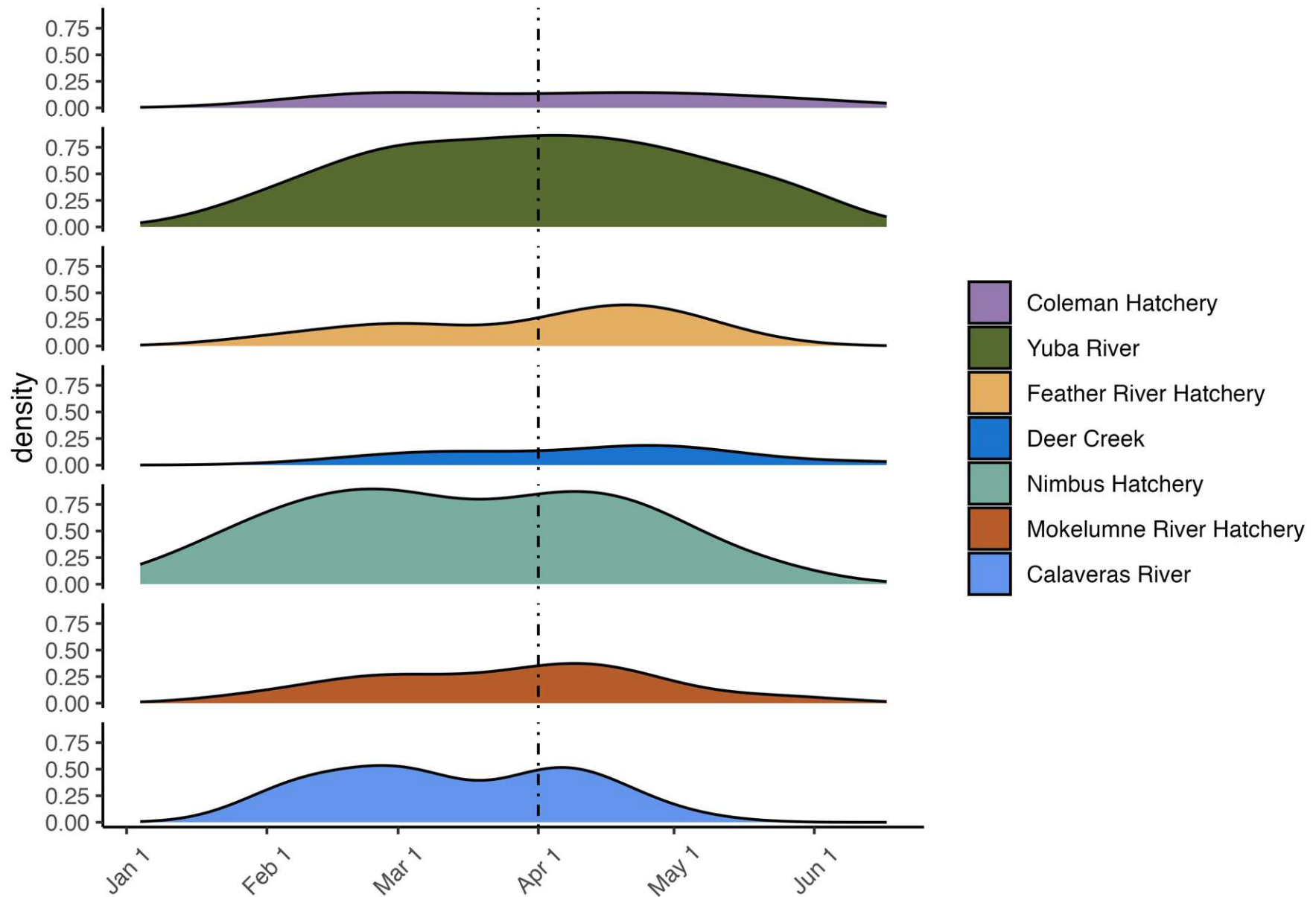
~97% PBT/GSI concordance for hatchery-origin AD samples.

668 unclipped fish that were not assigned to hatchery parents (natural-origin) assigned with GSI as follows:

18	Battle Ck (Coleman Hatchery)
206	Yuba River
34	Feather River (Hatchery)
16	Deer Creek
1	Putah Creek
284	American River (Nimbus)
41	Mokelumne River (Hatchery)
68	Calaveras River



Origins of unclipped, non-PBT fish by date:

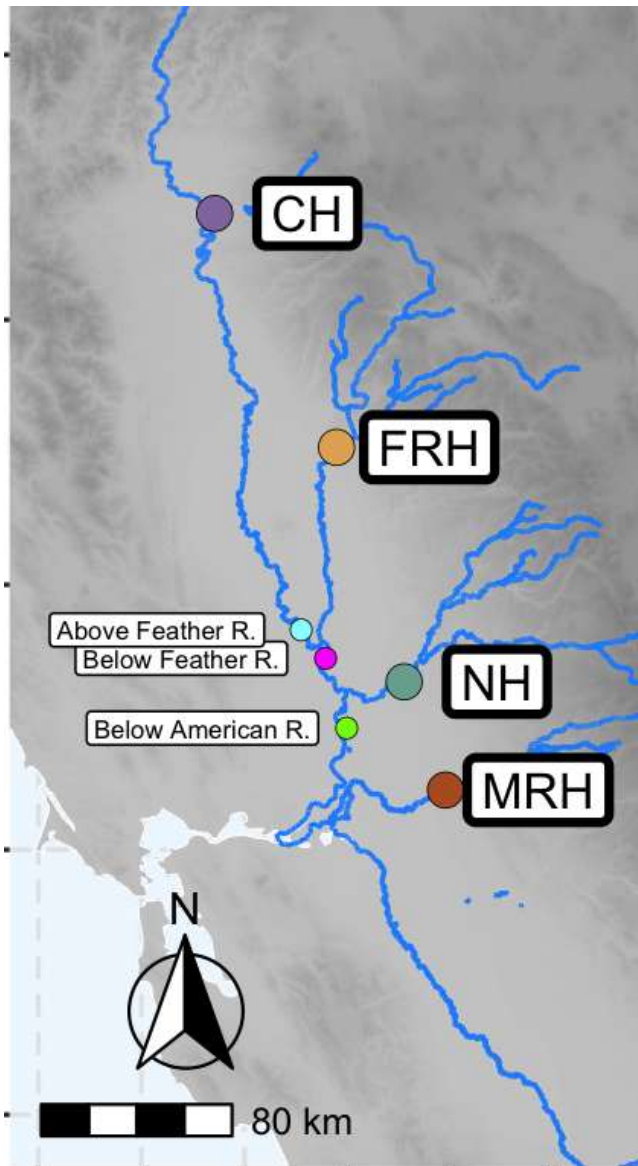


Outline

- >Project 1: Delta water export impacts on CV steelhead
 - >Project 2: Genetic variation in run-timing in CV steelhead
 - >Adult steelhead returning to rivers.
 - >Fyke trap samples over multiple years.
 - >Variation in the Greb1L-Rock1 genes.
-

CDFW Fyke trapping: 2015-2021

- 4+ traps: 12 ft diameter x 20 ft long
- Monitor *O. mykiss*



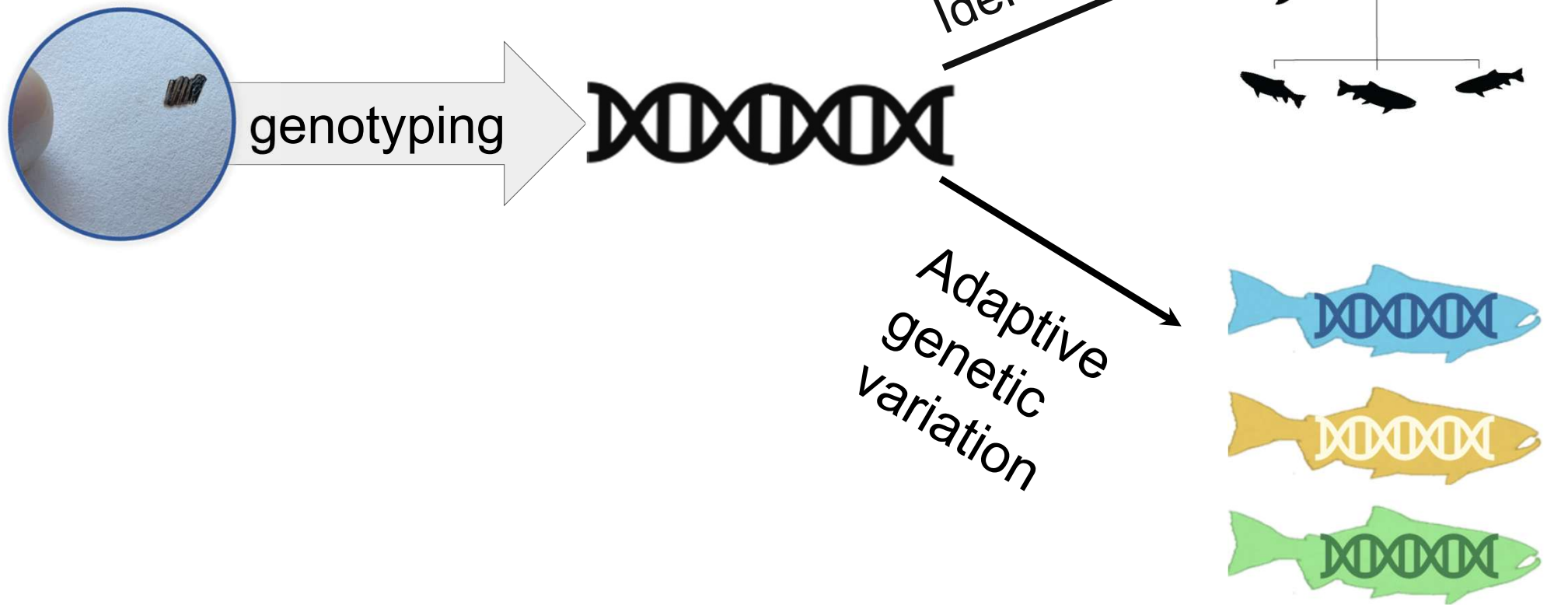
CDFW photo

Methods

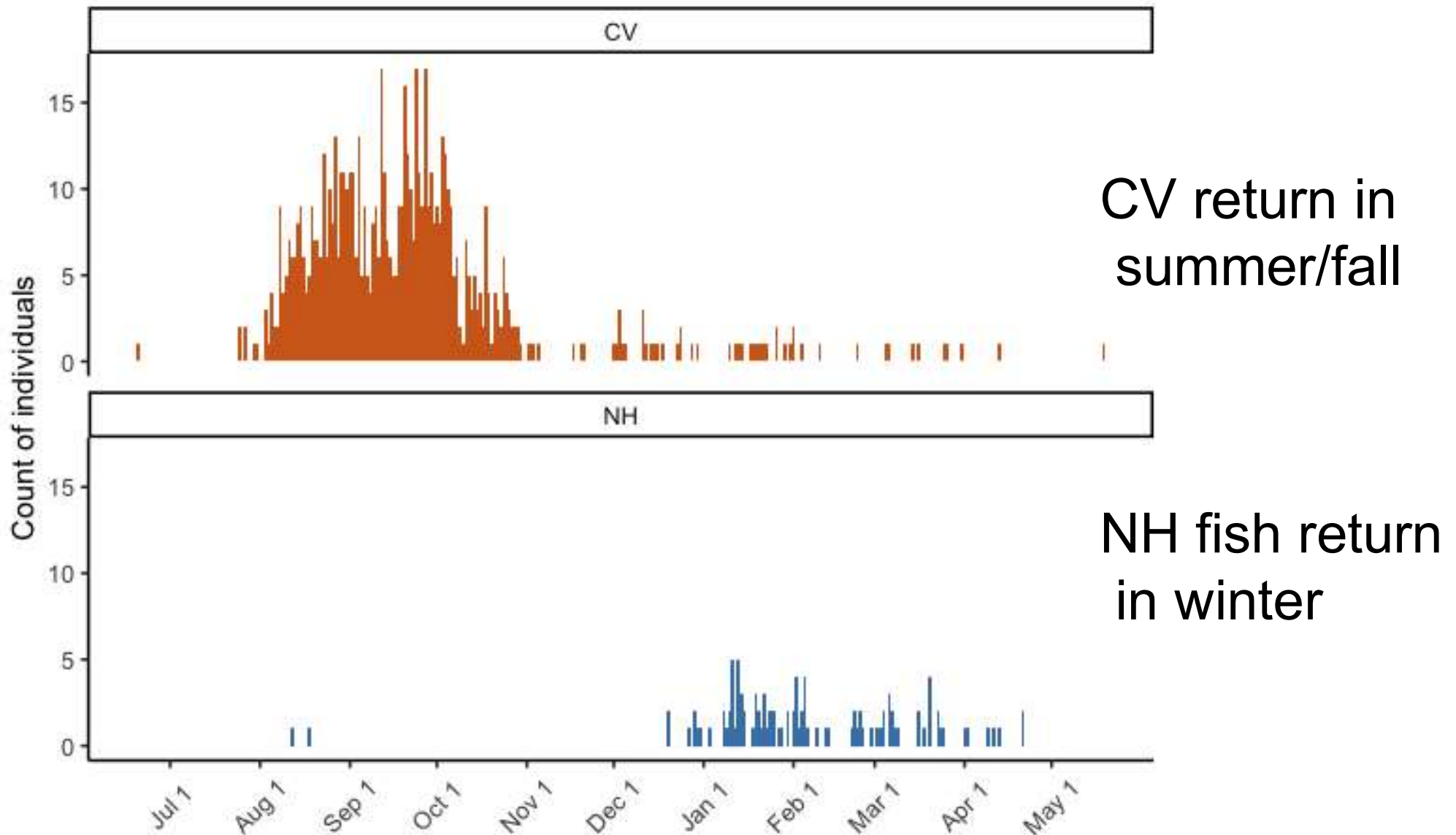
N = 790 samples

Genotypes for population genetics

Genotypes for ~25 targeted SNPs



Again: Nimbus genetically and phenotypically distinct



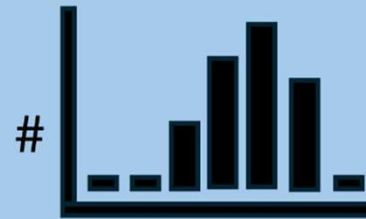
GREB1L



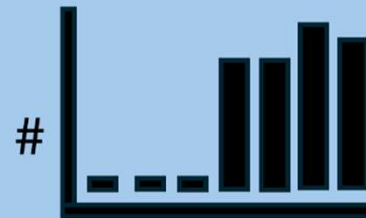
early



mid

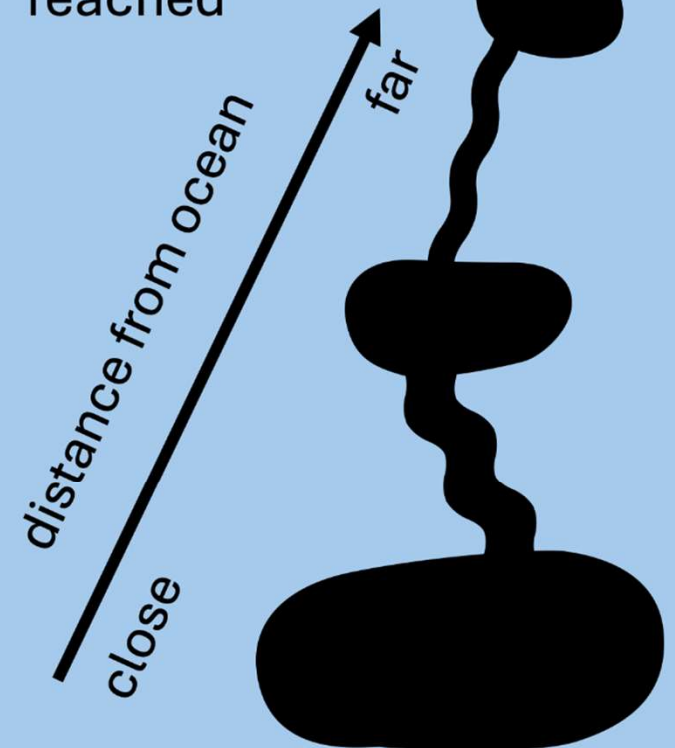


late



return period

spawning grounds reached

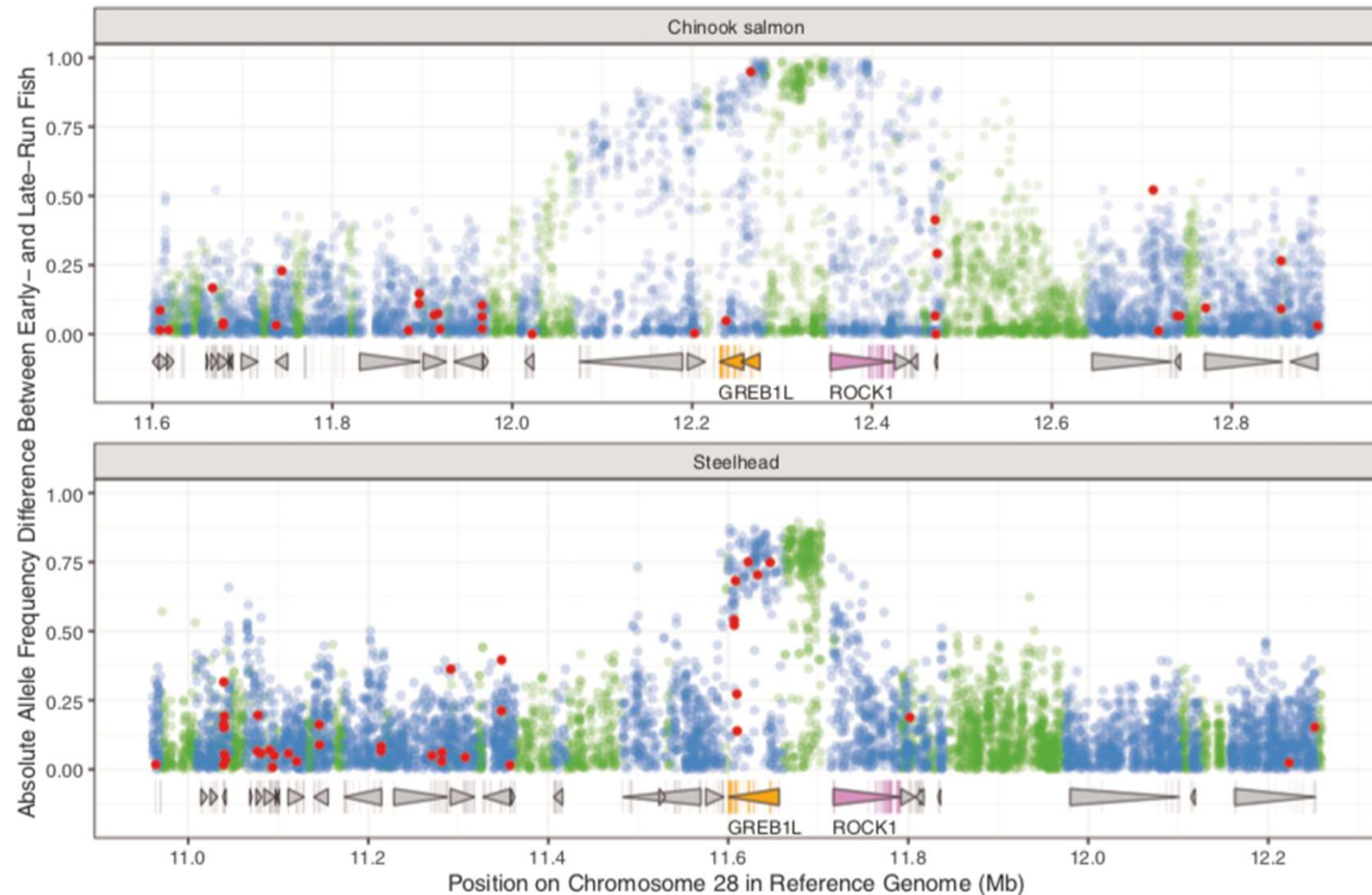


A few key SNPs have been used in many studies

Run timing: variation in the Greb1L/Rock1 region

California
Spring/Fall
Chinook
salmon

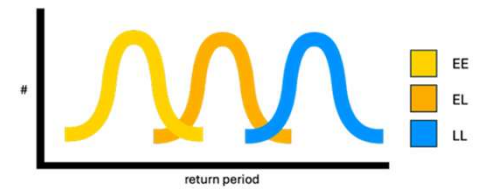
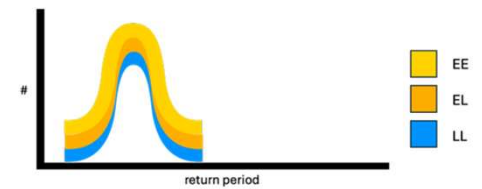
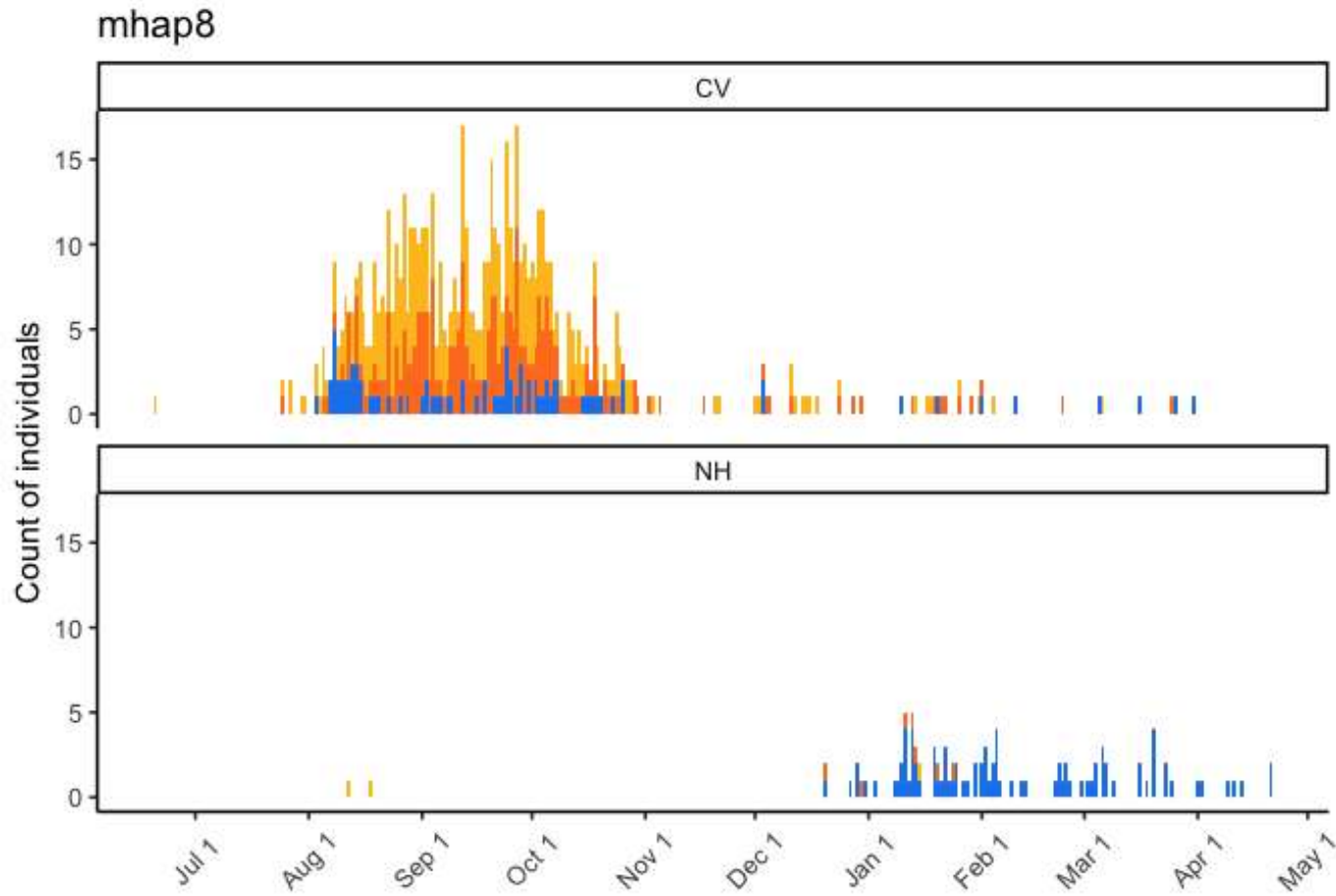
Summer/Winter
Steelhead
Kalama and
Klickitat Rivers,
Columbia River,
Washington



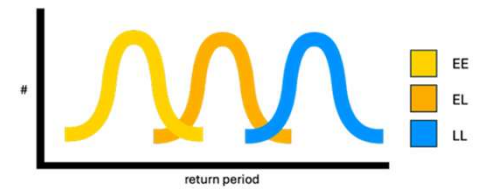
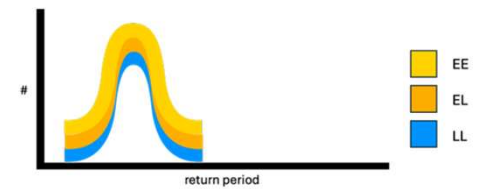
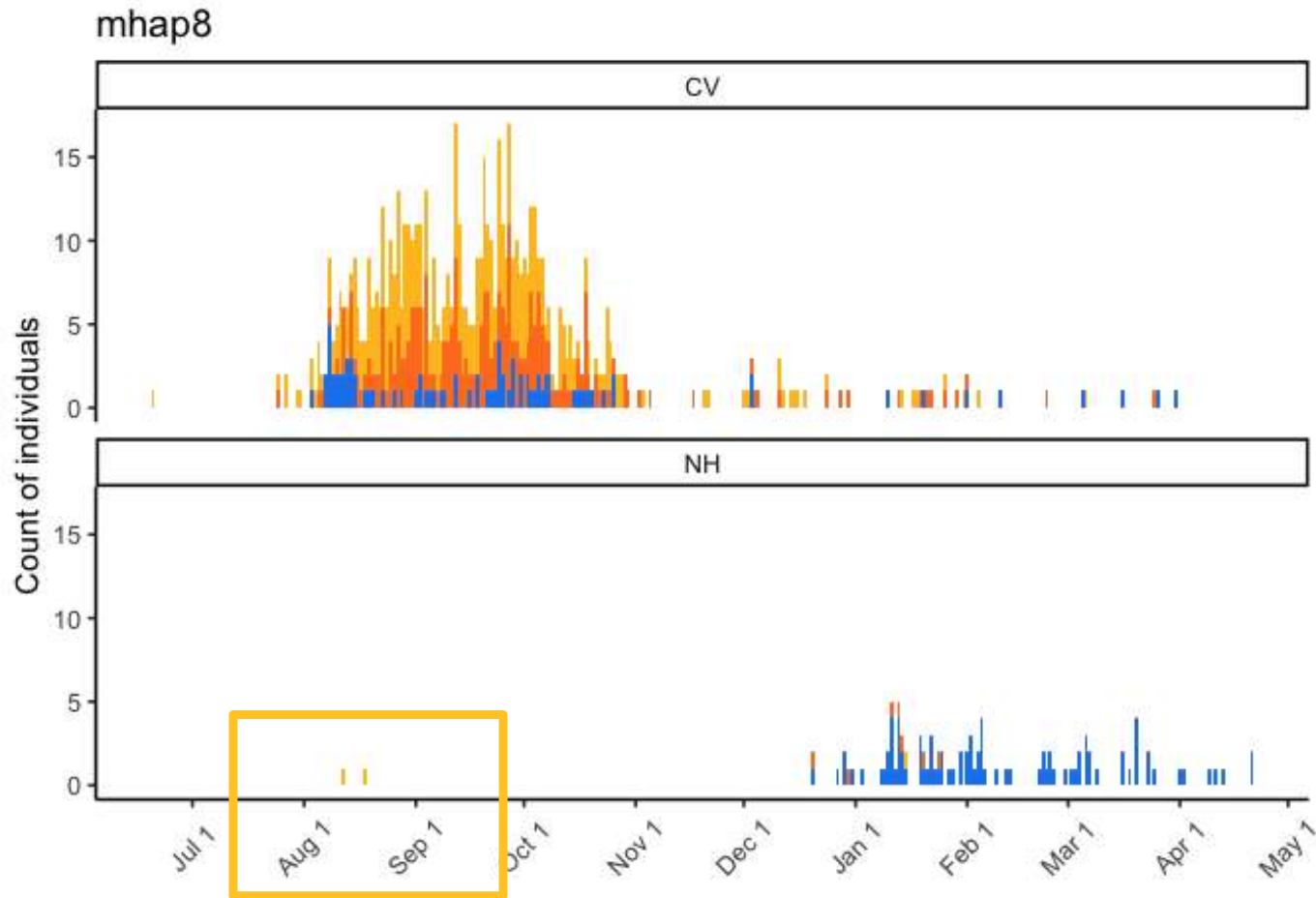
From **Waples et al. 2022 Journal of Heredity.**

Chinook data from Thompson et al. 2020, steelhead data from Micheletti et al. 2018

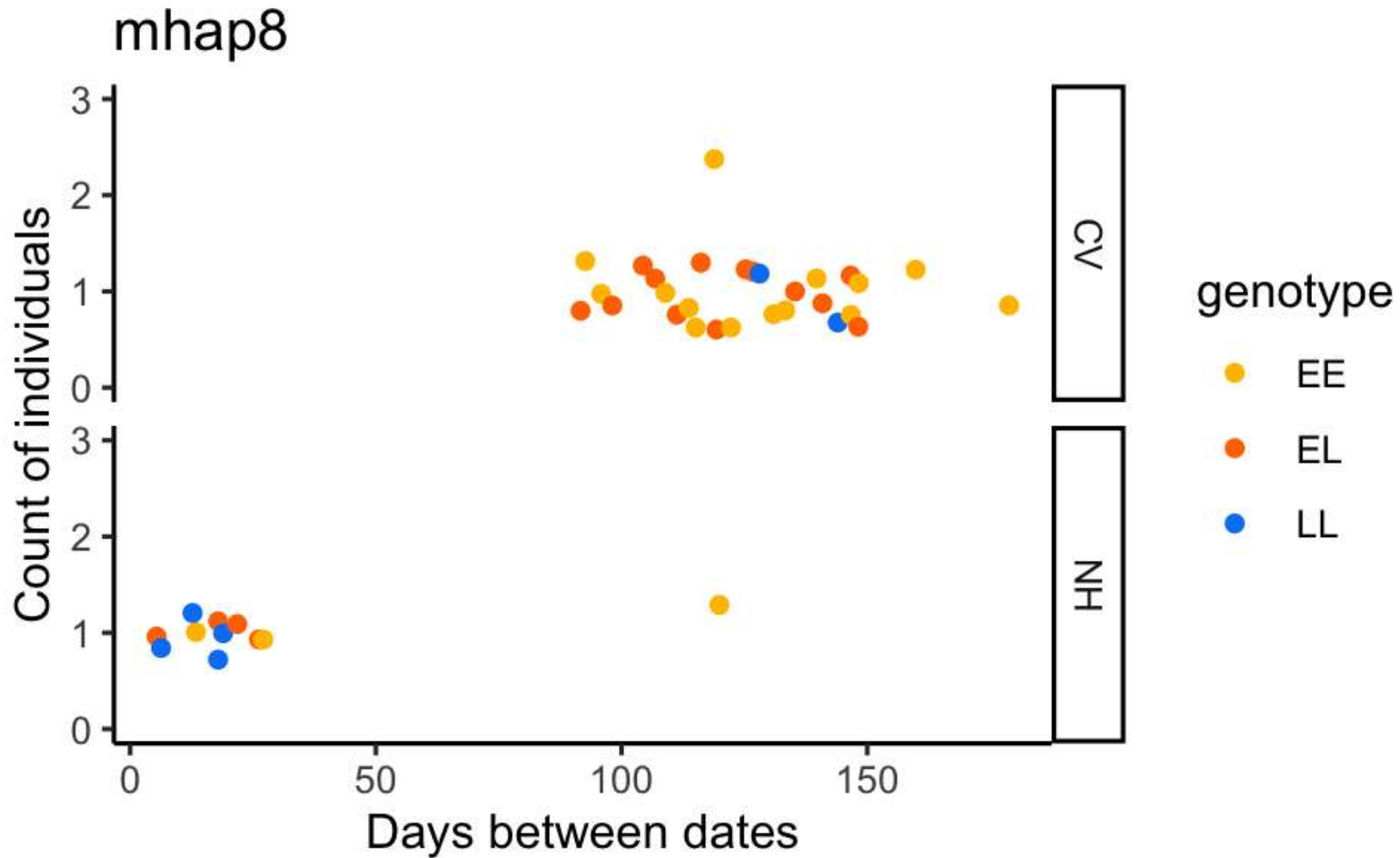
Association with key GREB1L/ROCK1 marker



Association with key GREB1L/ROCK1 marker



Last Thing! — Time in freshwater



Conclusions

- >Project 1: Delta water export impacts on CV steelhead
 - Fish need more flow in the river
and through the Delta***

- >Project 2: Genetic variation in run-timing in CV steelhead
 - Genetic diversity is complex and important***



Thanks!



<https://www.friendsoftheriver.org/>

>>Guide Activist Training, April 11-20, 2026<<
South Fork American River, Camp Lotus, CA

