Lower American River Science Share

June 9, 2026

Purpose of the LAR Science Share

Erica Bishop, Water Forum

Presentations

Each presentation will be followed by time for questions and discussion.

12:10	**A Modern Ghost Story: Using Chemical Tracers to Reconstruct the Migration Behaviours and Relative Survival of Juvenile Salmon from the American River** *Dr. Anna Sturrock, Associate Professor, School of Life Sciences, University of Essex, UK*
12:55	**Emigrating Salmon Habitat Estimation (ESHE) Model: Predicting Rearing Habitat Needs to Meet Population and Restoration Goals** *Kirsten Sellheim, M.S., Senior Scientist, Cramer Fish Sciences*
1:35	***10-minute Break***
1:45	**Parentage-based Tagging: Using Genetics to Monitor Central Valley Chinook Salmon** *Elyse Freitas, Senior Environmental Scientist, Fisheries Branch, California Department of Fish and Wildlife*
2:25	**Fine-scale Vegetation Mapping of the American River Parkway** *Sarah Norris, Consulting Arborist, Wild Rye Consulting, LLC*
3:10	**2-minute Teasers on Other Topics of Interest** **Announcements & Suggestions for Future Science Shares**
3:30	**Adjourn**

Introduction to Zoom Controls

Phone Users:
Press *9
to "Raise Hand"

When we call on you,
Press *6
to unmute/mute

Orient yourself to Zoom meeting controls:

Unmute/Mute | Start Video | Zoom Chat | Raise Hand

How you can participate today:

- **Verbal:** Get into the queue w/ Raise Hand function
- **Written:** Submit questions in Chat Box

Please remember to mute yourself when not speaking

Participatory Guidelines

- Ask questions! Share ideas! This is meant to be a science deep dive!
- Take space for your interests & curiosities…
- … And make space for others’ interests & curiosities!
- Be patient and open with the hybrid meeting format

University of Essex

A Modern Ghost Story:

Using Chemical Tracers to Reconstruct the Migration Behaviors and Relative Survival of Juvenile Salmon from the American River

Anna M. Sturrock, Kirsten Sellheim, Joseph Merz, Jamie Sweeney, Miranda Bell-Tilcock, George Whitman, Kohma Arai, Malte Willmes, Carson Jeffres, Rachel C. Johnson

anna.sturrock@essex.ac.uk | @otolithgirl.bsky.social | www.anna-sturrock.com

WATER FORUM

CALIFORNIA DEPARTMENT OF FISH & WILDLIFE

UC DAVIS UNIVERSITY OF CALIFORNIA

NOAA

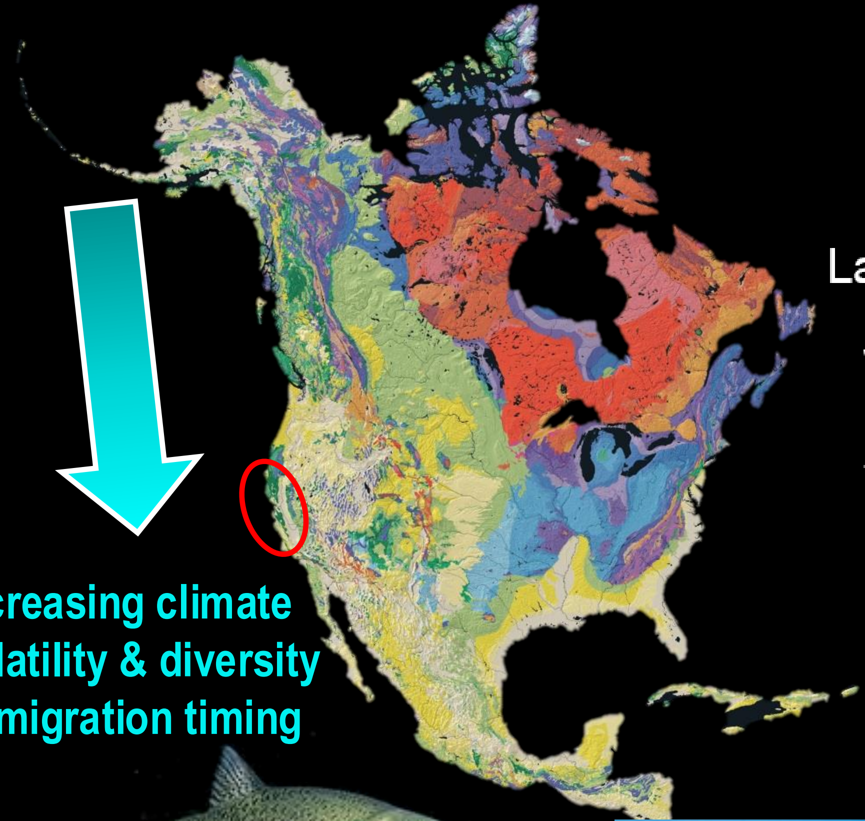
CRAMER FISH SCIENCES® Oregon • California • Washington • Idaho • Alaska

UK Research and Innovation

“The rapid loss of intraspecific variation is a hidden biodiversity crisis.”

Des Roches *et al.* 2021 Nature Ecology & Evolution

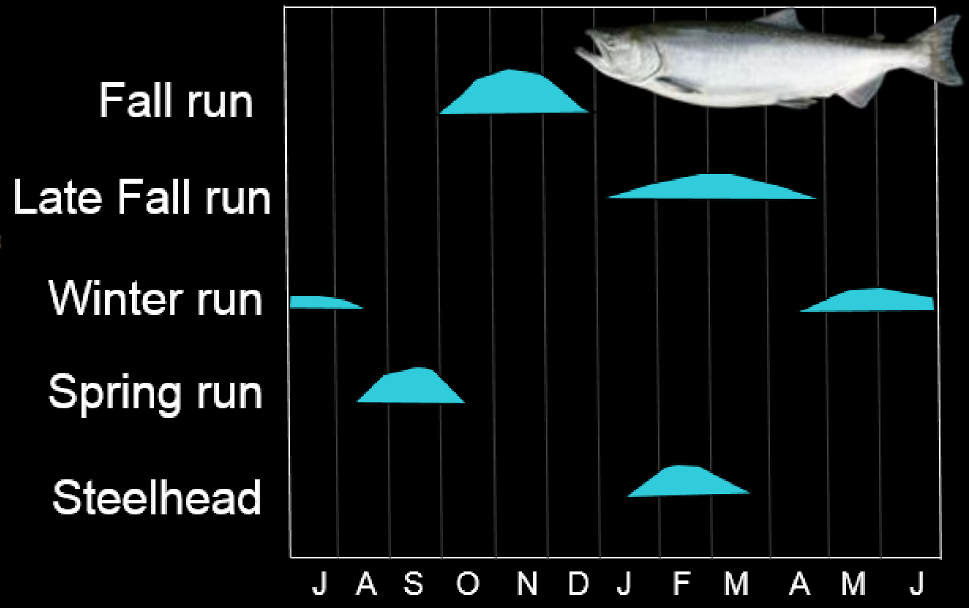
Chinook salmon in California



https://pubs.usgs.gov/imap/i2781/

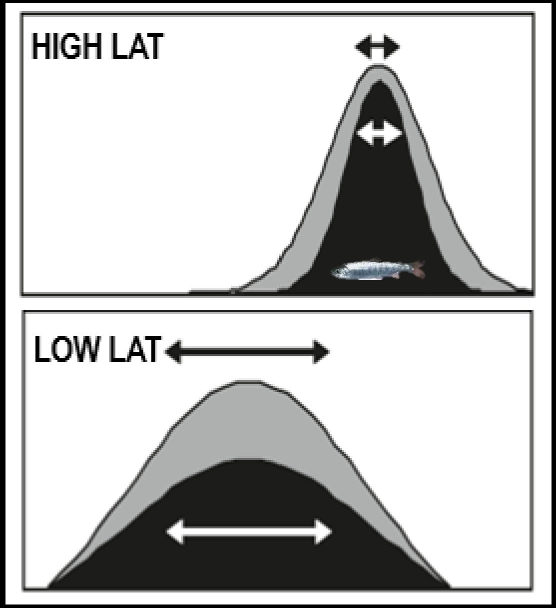
Increasing climate volatility & diversity in migration timing

ADULT RETURN TIMING

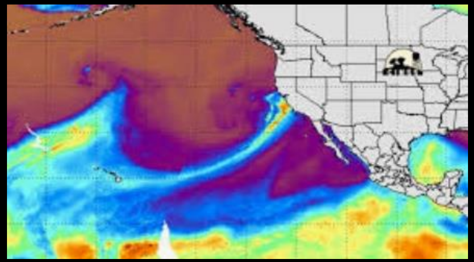


Data sources: Vogel and Marine, 1991; Hallock, 1983; CDFG, 1993

JUVENILE EMIGRATION TIMING

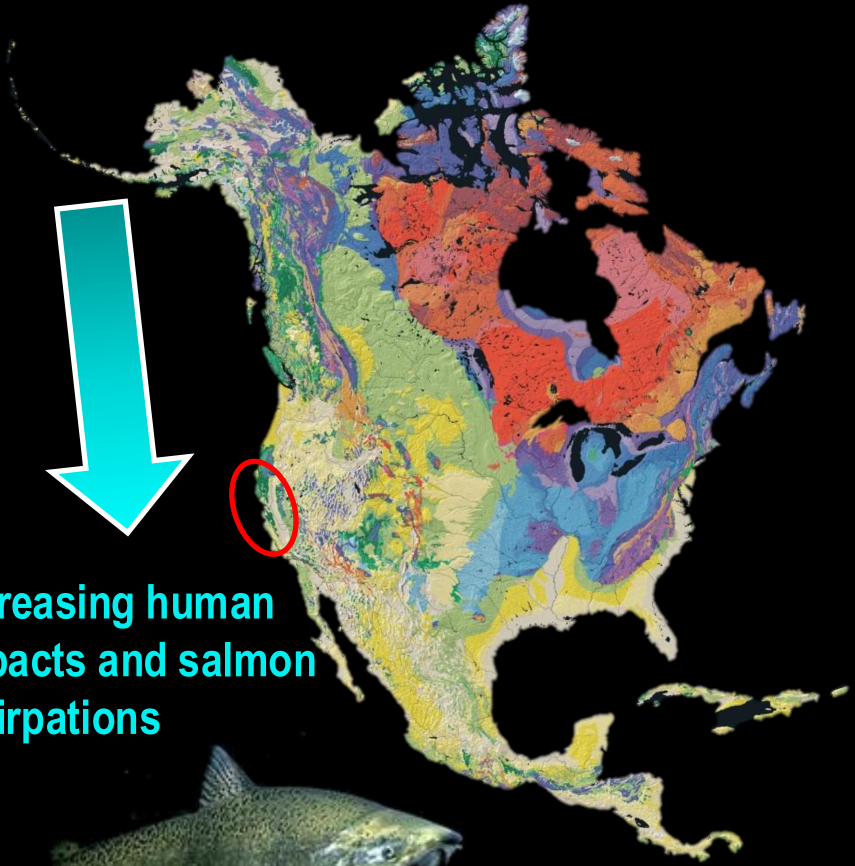


Spence & Hall (2010). CJFAS 67: 1316-1334

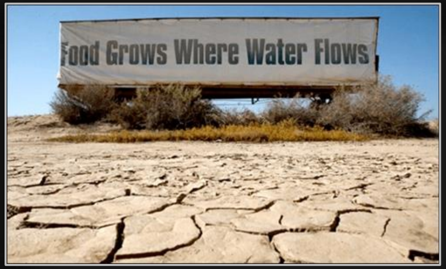


Multiple stressors

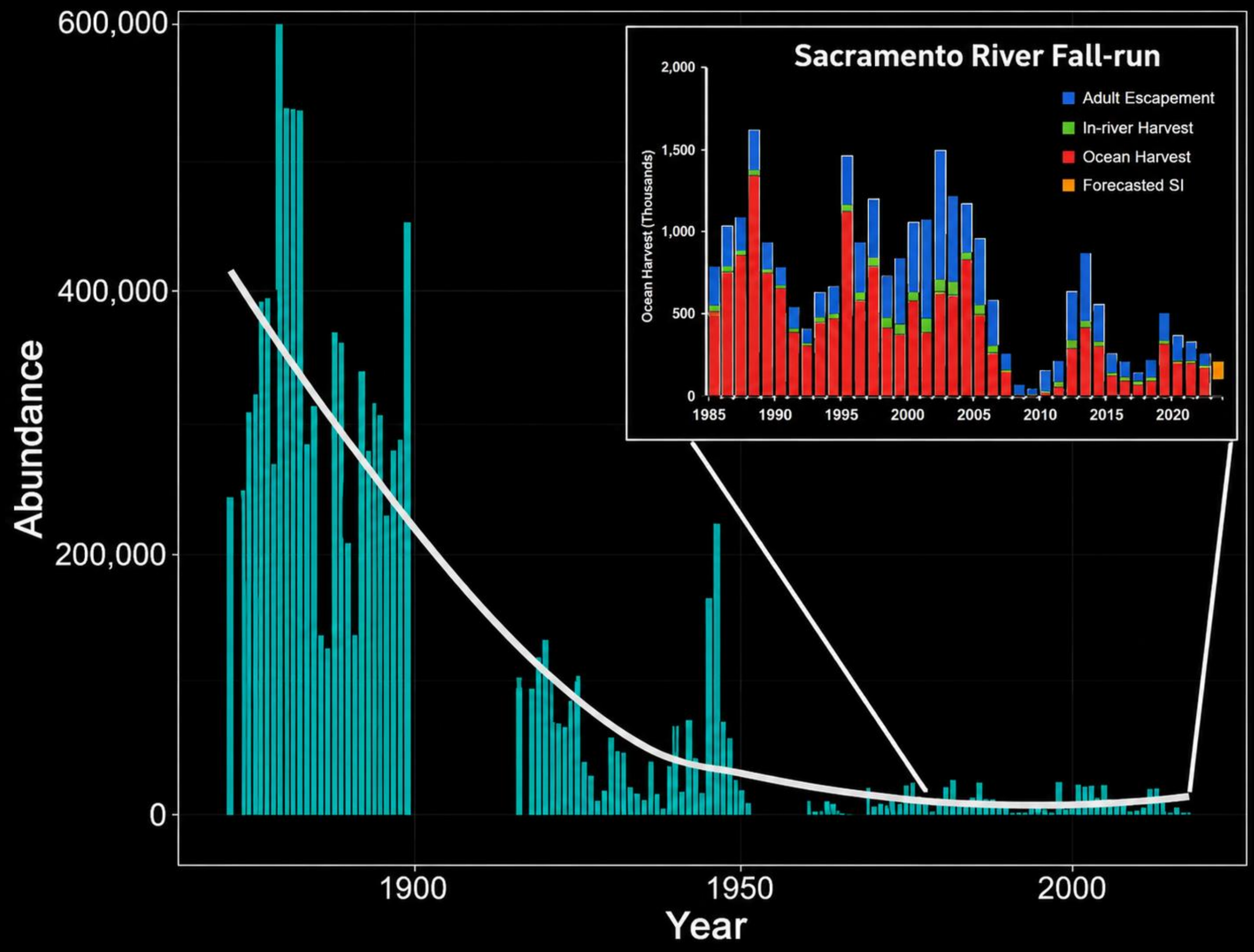
https://pubs.usgs.gov/imap/i2781/

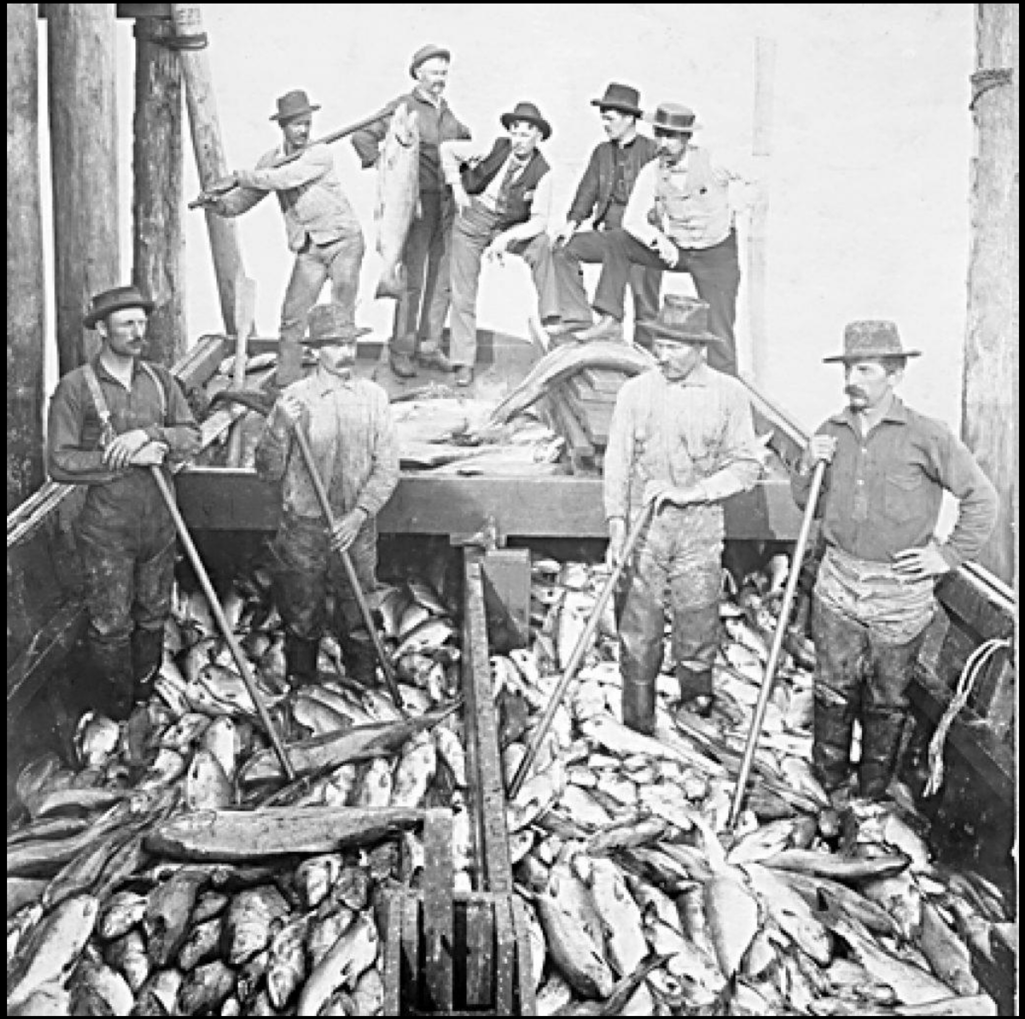


Increasing human impacts and salmon extirpations



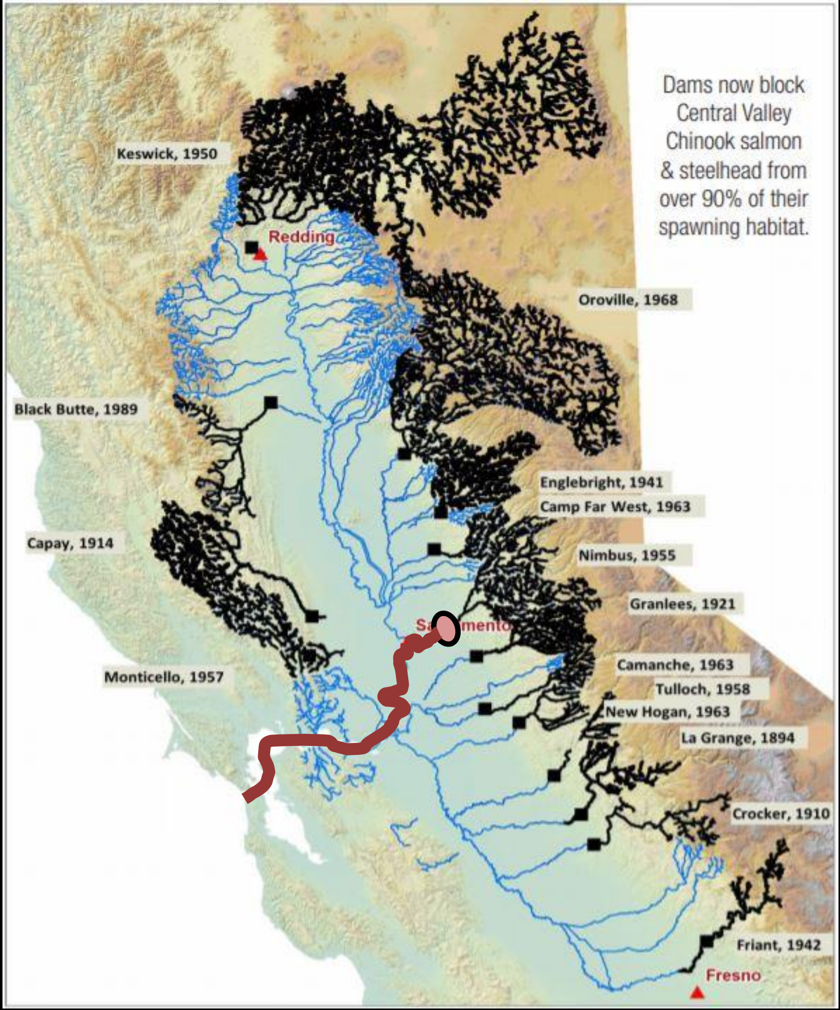
SHIFTING BASELINES





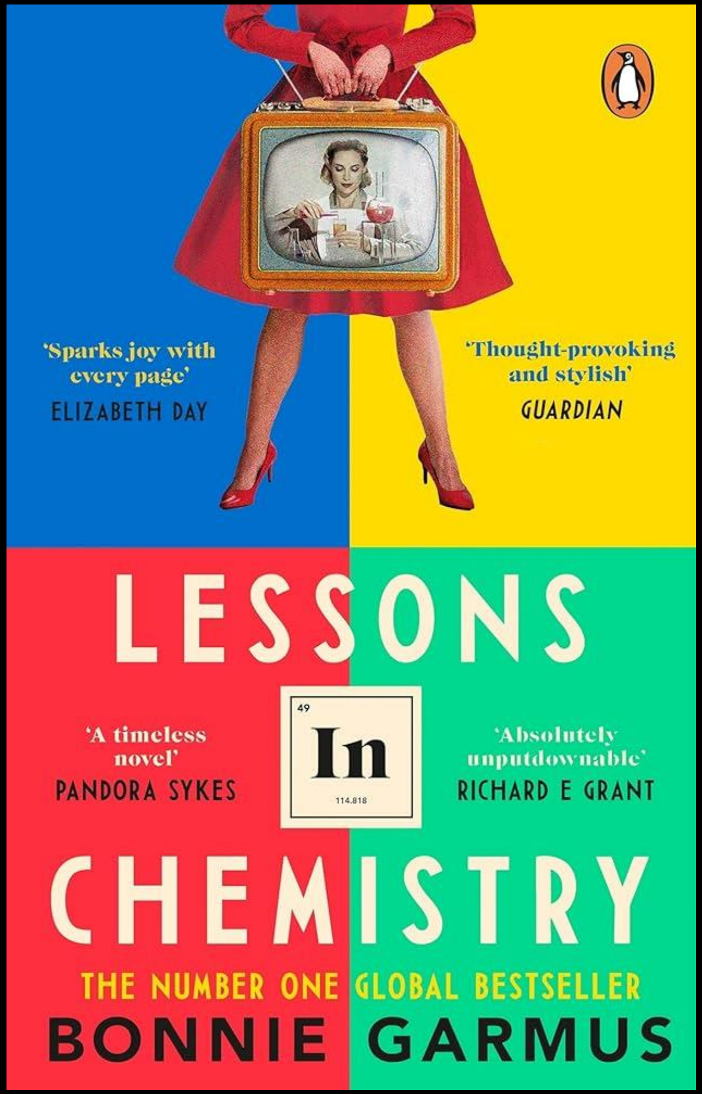
Data are from CDFW Status Report (1998) and Grandtab (Azat 2019).
Historical (pre-1900) abundance estimates are based on extrapolations from cannery records (slide courtesy of Dr Rachel Johnson).

Aim: To estimate the relative success of different juvenile outmigration strategies under contrasting flow conditions

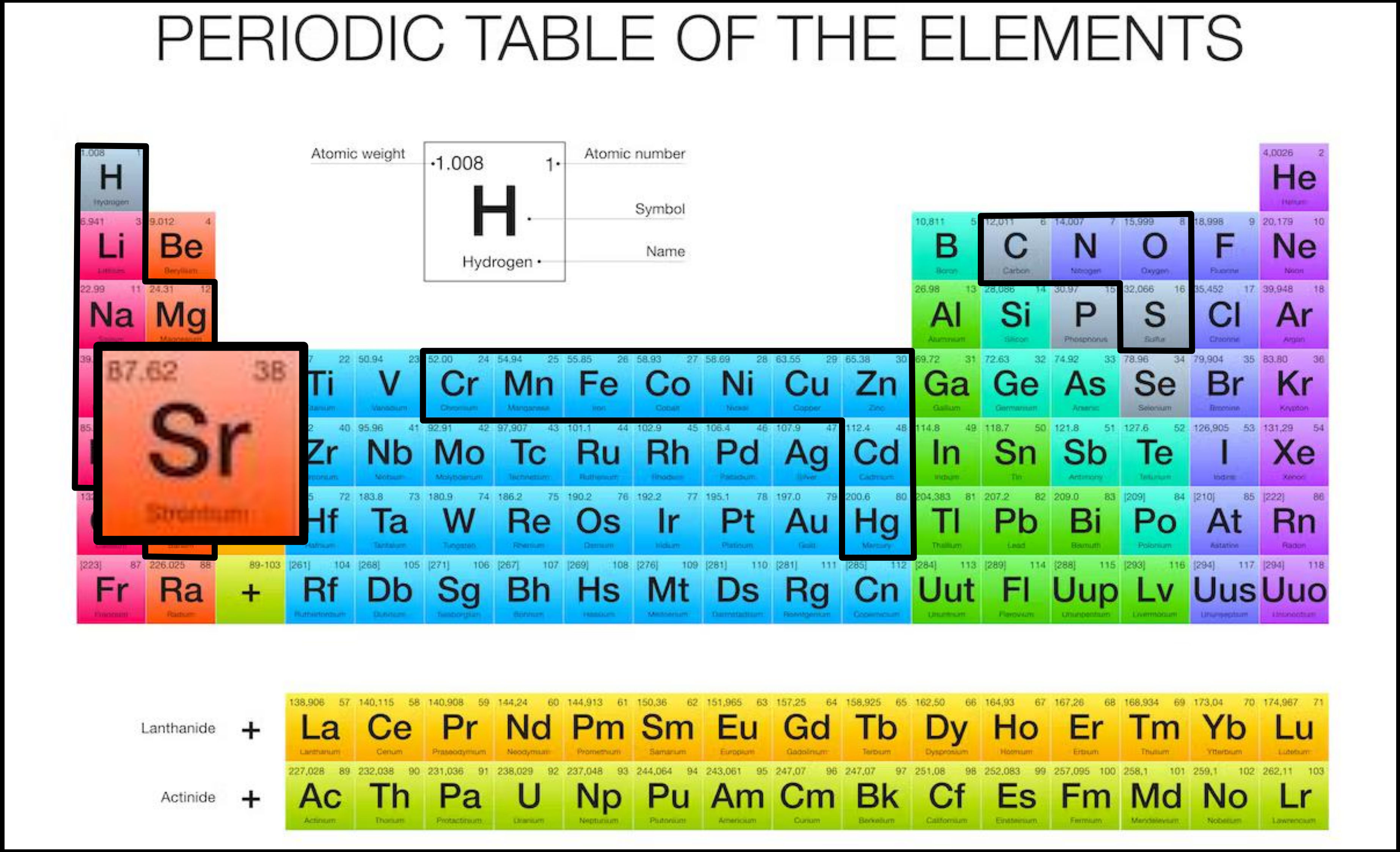


… but how can you track fry?

Tracking animals 101- Chemical markers or 'natural tags'

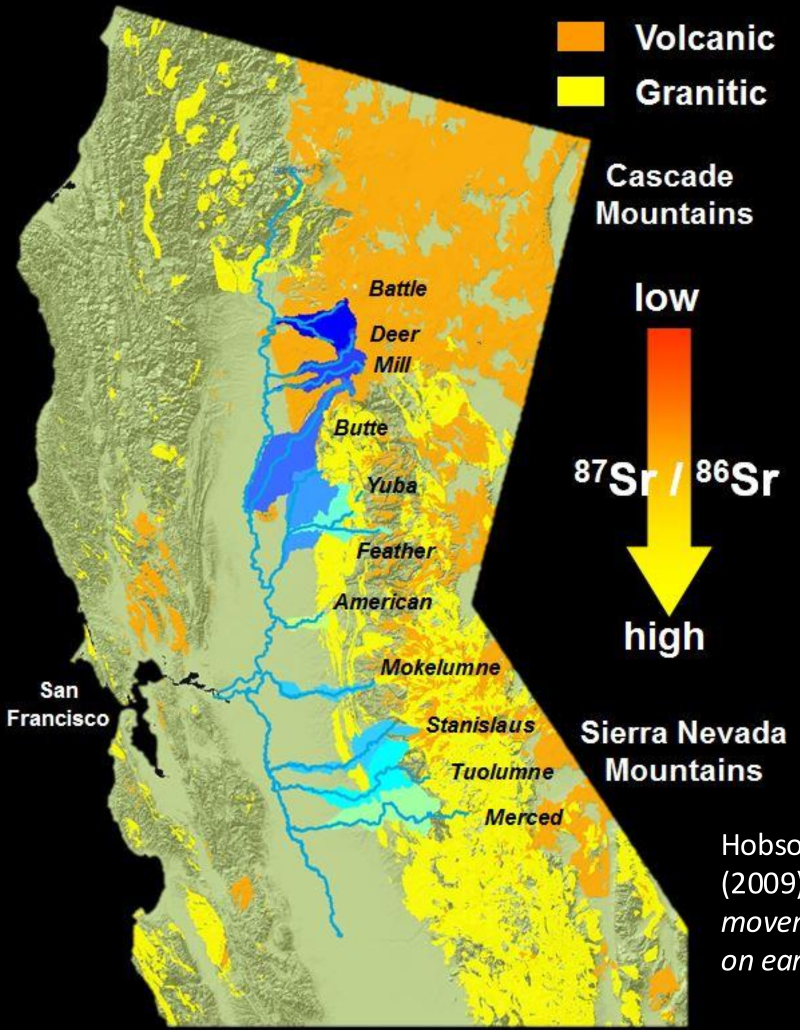


Tracking animals 101- Chemical markers or ‘natural tags’

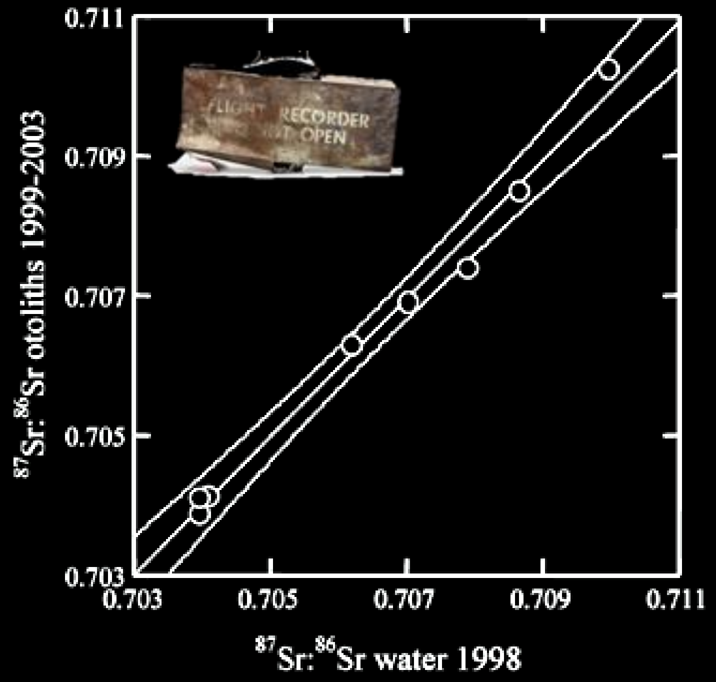


Tracking animals 101- Chemical markers or 'natural tags'

$^{87}Sr/^{86}Sr$ ISOSCAPE



Hobson, **Barnett-Johnson,** Cerling (2009). *Isoscapes: Understanding movement patterns and processes on earth through isotope mapping.*



Barnett-Johnson et al. (2008)
Limnology & Oceanography 53: 1633-42



Tracking animals 101- Archival structures

Chronological chemical and microstructural records in archival structures allow us to reconstruct lifetime movements and health histories.

THE CONVERSATION

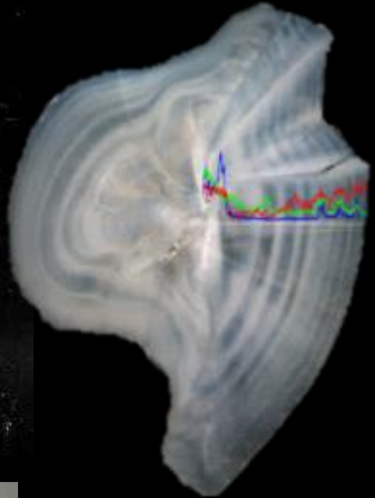
Academic rigour, journalistic flair

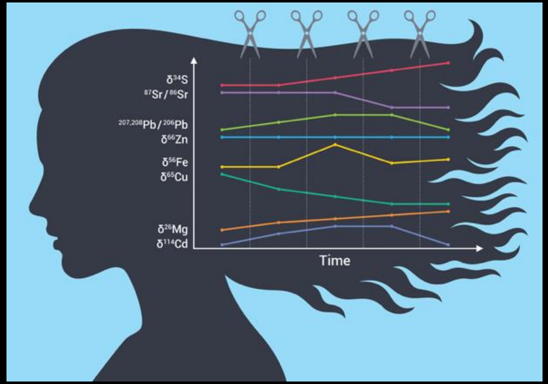
Most animals have their own version of tree rings – here's how we biologists use them to help species thrive

Published: February 11, 2025 5.26pm GMT

Anna Sturrock

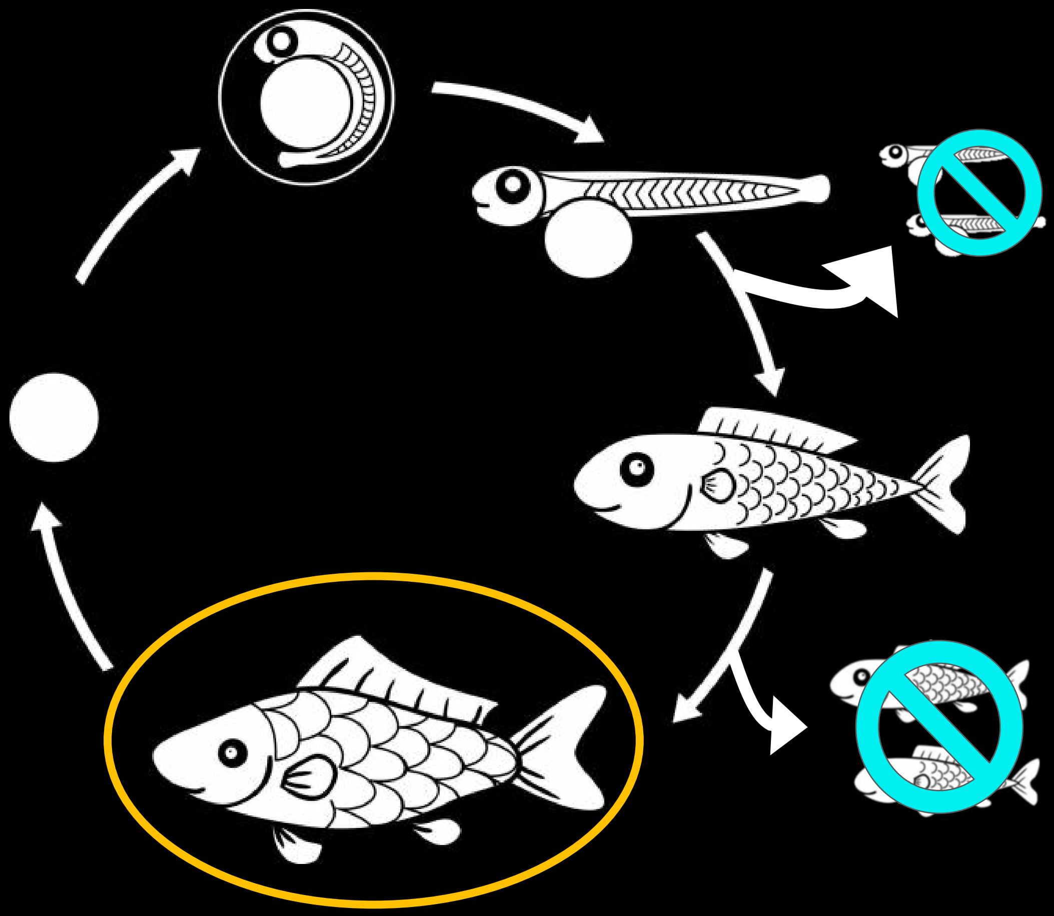
Senior Lecturer, School of Life Sciences, University of Essex



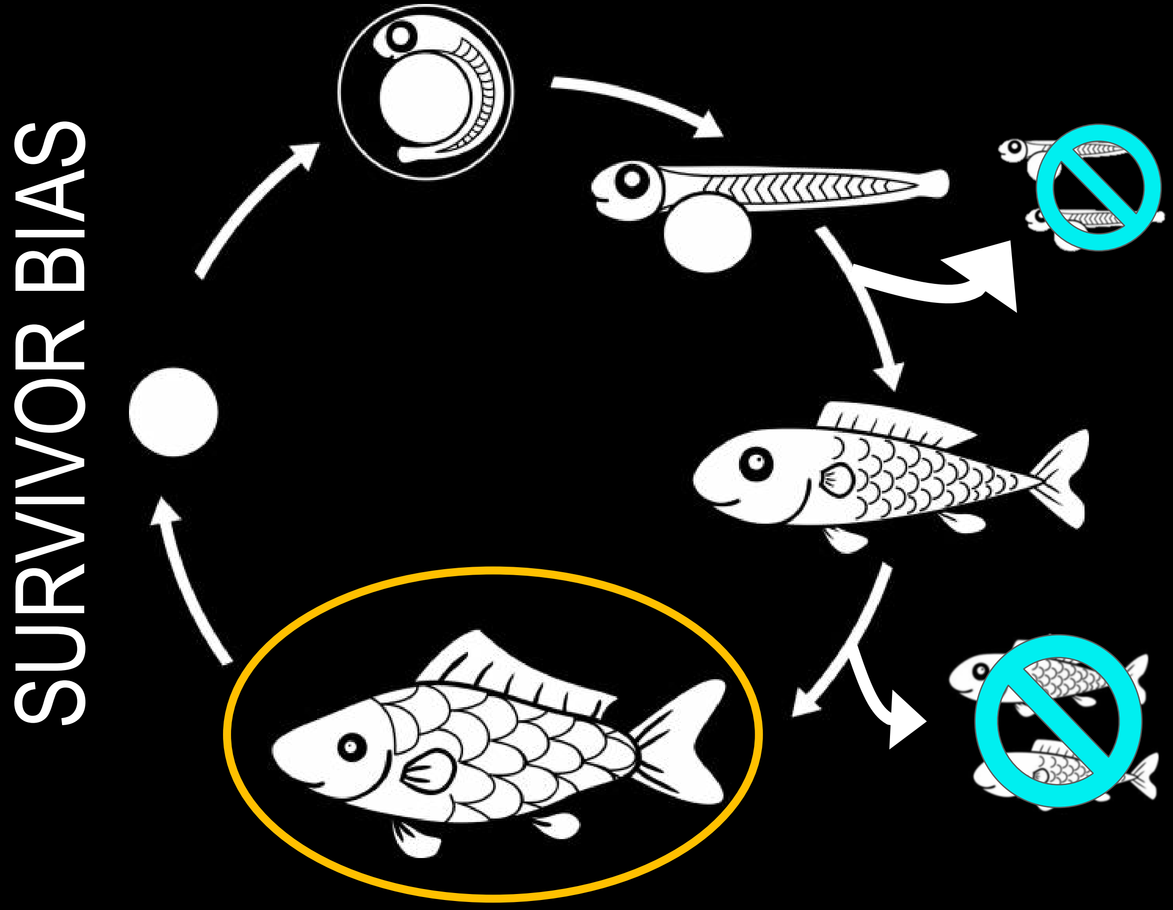


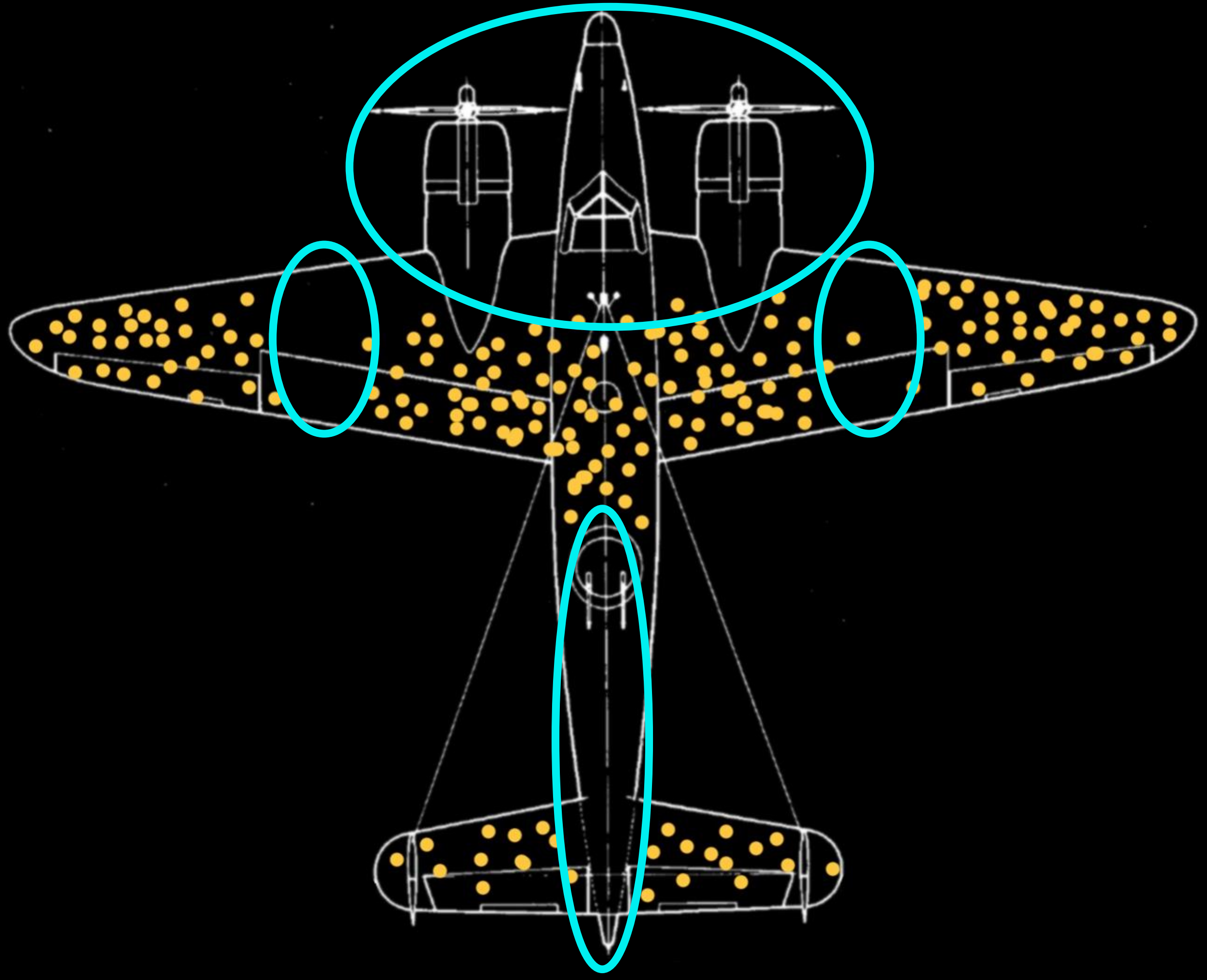
Ghost hunting

SURVIVOR BIAS

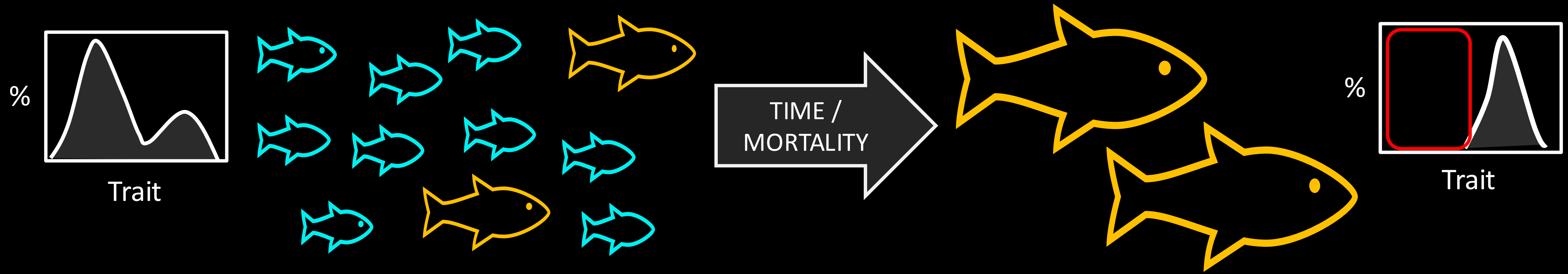


Ghost hunting

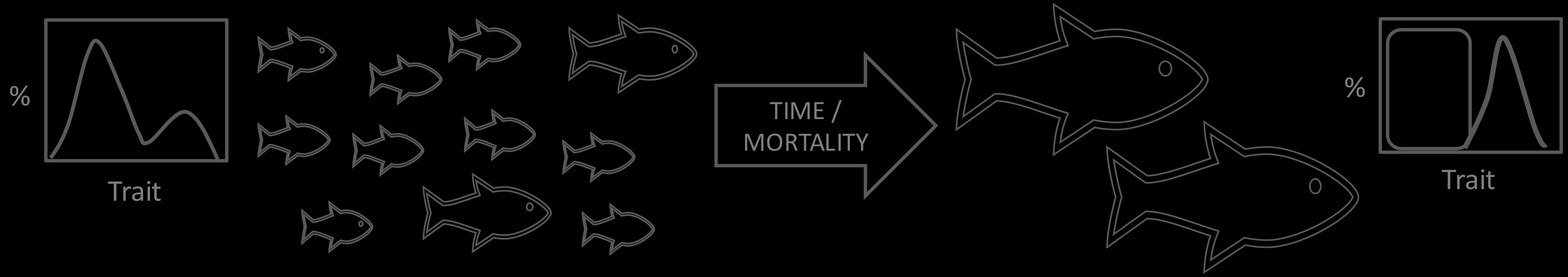




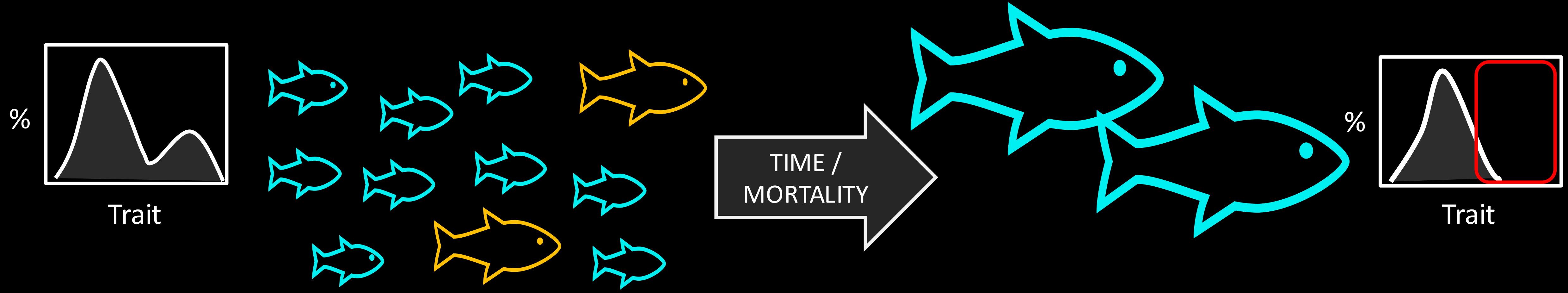
Ghost hunting



Ghost hunting



But in a different year or set of environmental conditions…

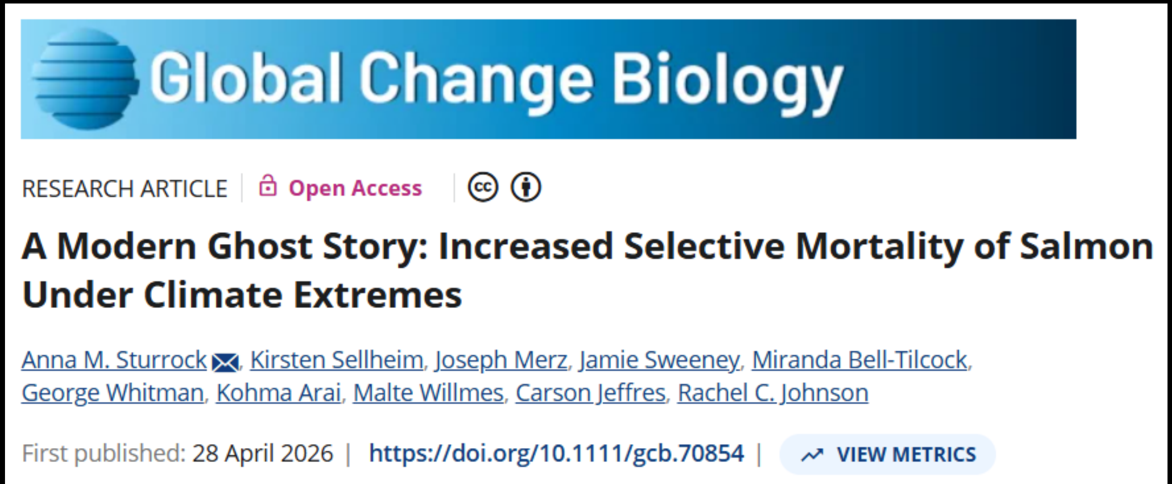


Aim: To estimate the relative success of different juvenile outmigration strategies under contrasting flow conditions

I. *What are the dominant strategies and what is their contribution to the surviving adults?*

II. *What fraction of their freshwater growth do juveniles assimilate in-river vs. in the Delta?*

III. *Where are we losing early migrants, and does this vary among years and flow conditions? (i.e., "ghost hunting")*


Global Change Biology

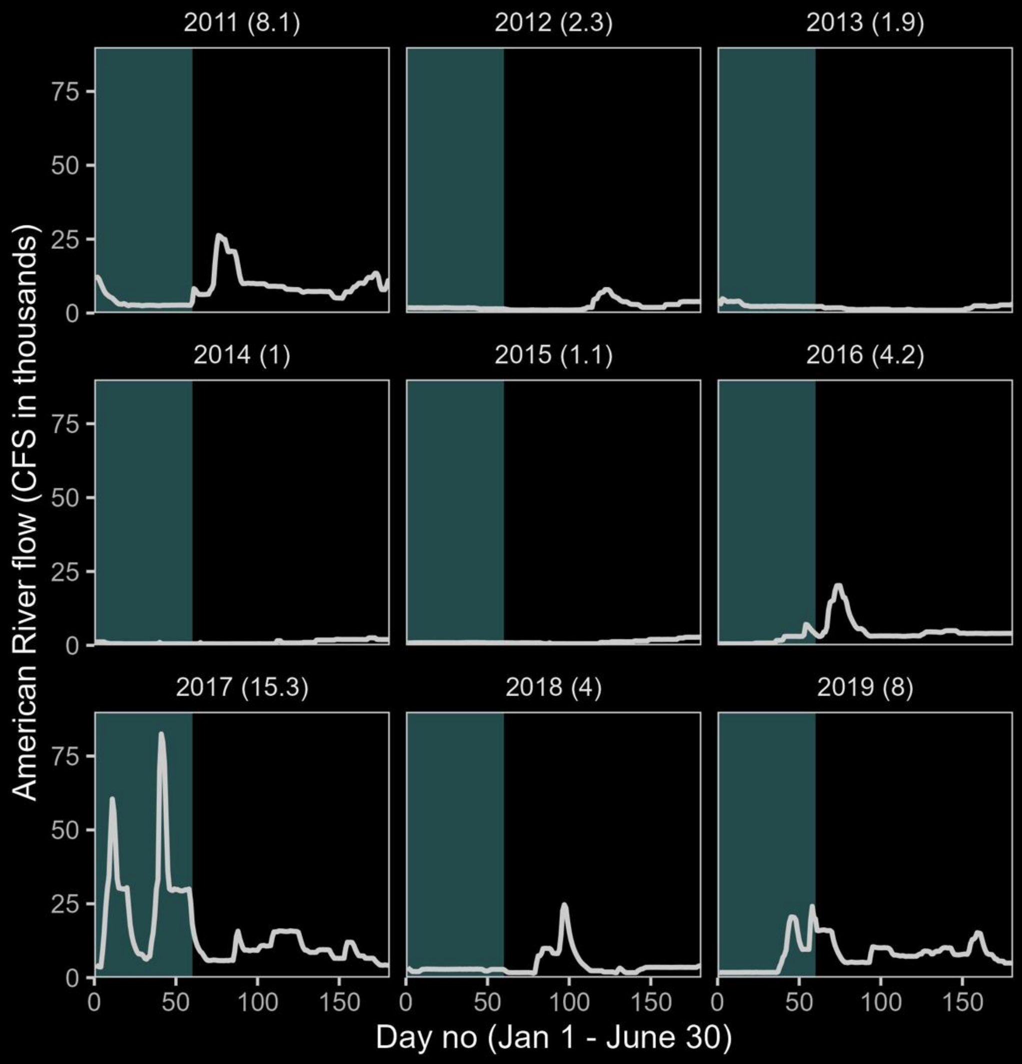
RESEARCH ARTICLE | Open Access

A Modern Ghost Story: Increased Selective Mortality of Salmon Under Climate Extremes

Anna M. Sturrock, Kirsten Sellheim, Joseph Merz, Jamie Sweeney, Miranda Bell-Tilcock, George Whitman, Kohma Arai, Malte Willmes, Carson Jeffres, Rachel C. Johnson

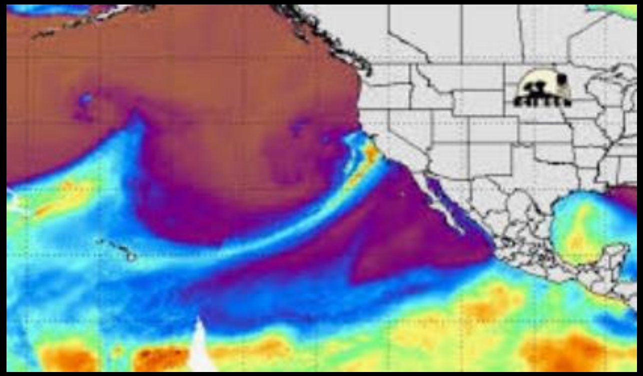
First published: 28 April 2026 | https://doi.org/10.1111/gcb.70854 | VIEW METRICS

Methods | Time series



2014-15

2017



Methods | Juvenile fish and carcass sampling

Methods | Tissue sampling

Carcass sampling

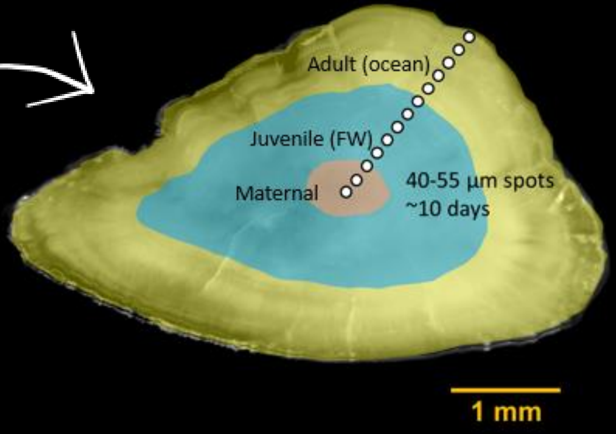
Scales
(age, cohort)

Otoliths
(habitat use, growth)

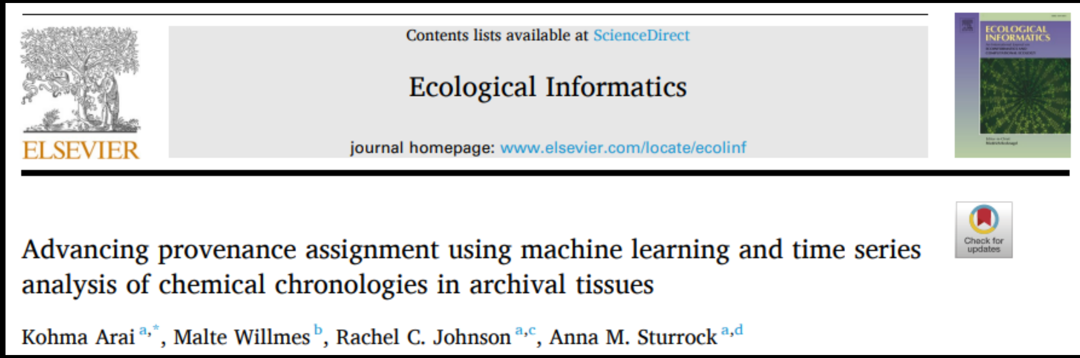
Mark-recapture
(abundance)

Eyes too!
(habitat use, diet)

Methods | Tissue analyses



UC Davis Interdisciplinary Center for Inductively-Coupled Plasma Mass Spectrometry



Contents lists available at ScienceDirect

Ecological Informatics

journal homepage: www.elsevier.com/locate/ecolinf

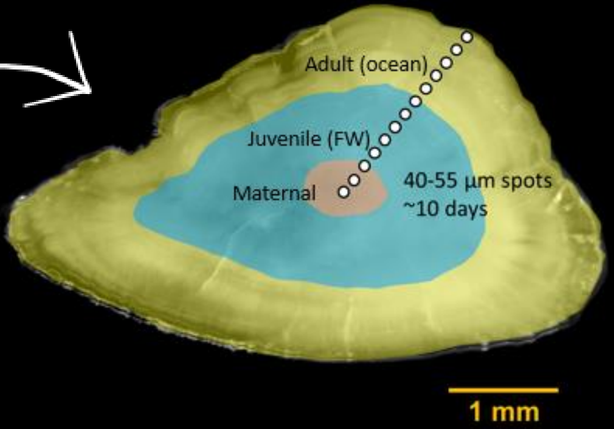
ELSEVIER

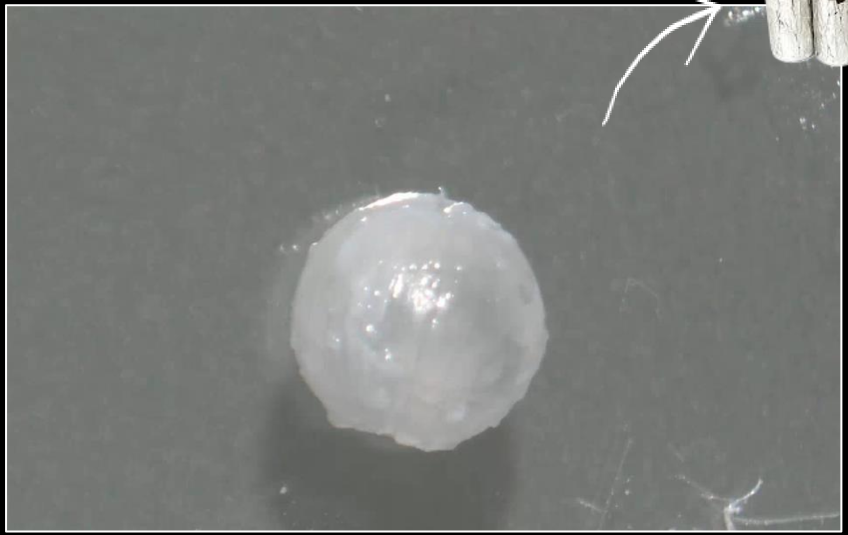
Advancing provenance assignment using machine learning and time series analysis of chemical chronologies in archival tissues

Kohma Arai [a,*], Malte Willmes [b], Rachel C. Johnson [a,c], Anna M. Sturrock [a,d]

LASER ABLATION MULTI-COLLECTOR INDUCTIVELY COUPLED PLASMA MASS SPECTROMETER (LA-MC-ICPMS) → OTOLITH $^{87}Sr/^{86}Sr$ → NATAL ORIGIN & MIGRATION HISTORY

Methods | Tissue analyses



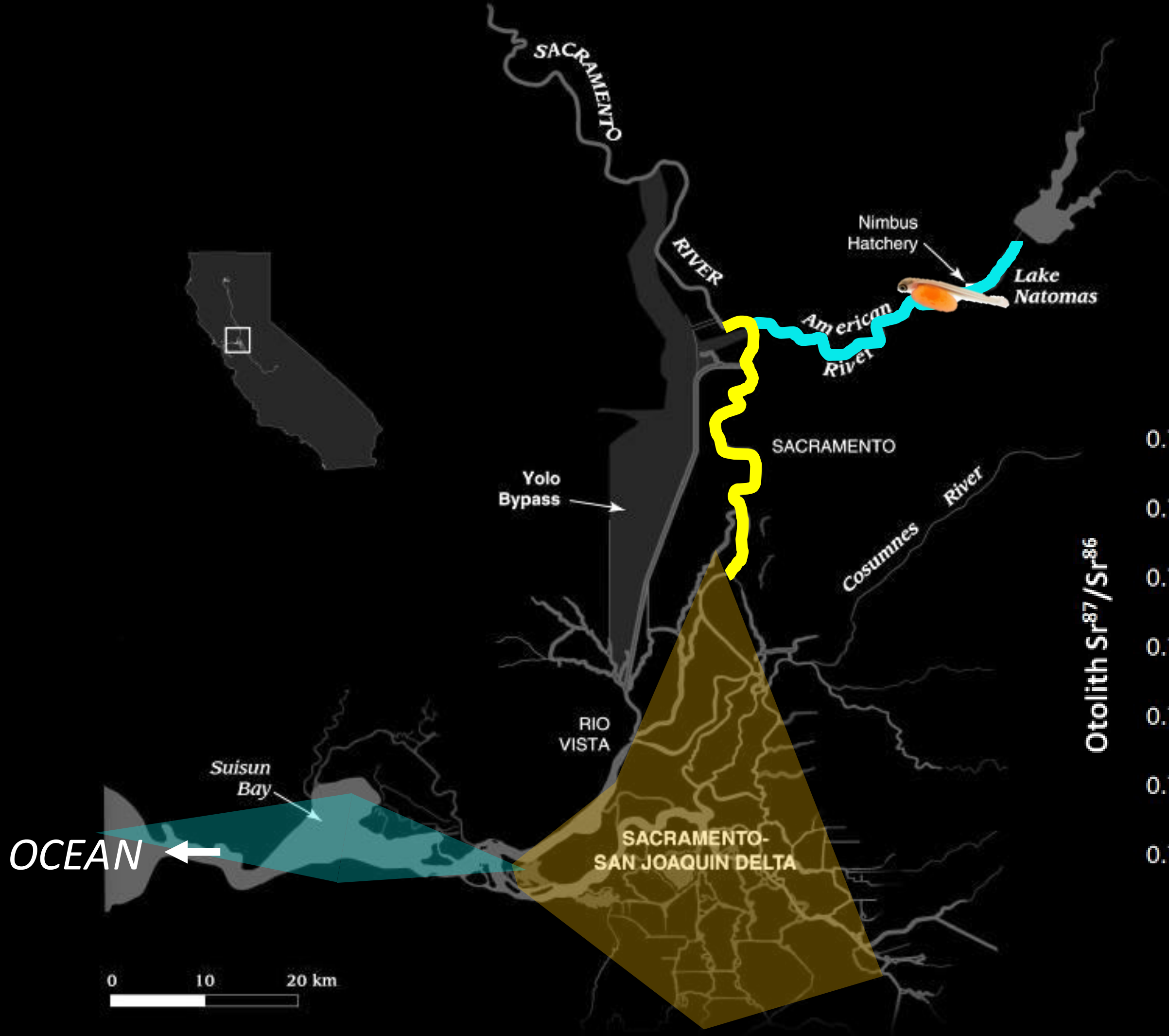


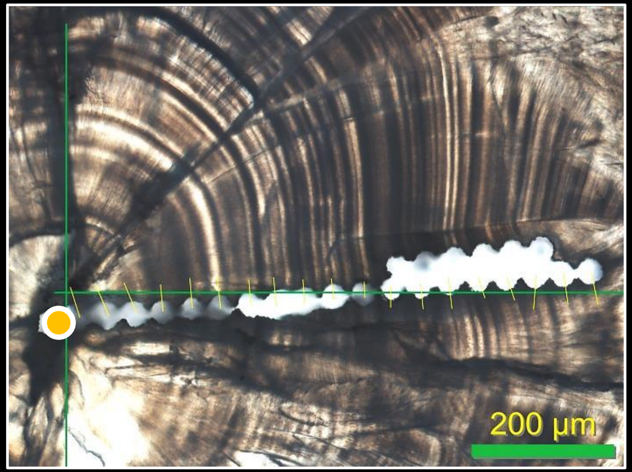
LASER ABLATION MULTI-COLLECTOR INDUCTIVELY COUPLED PLASMA MASS SPECTROMETER (LA-MC-ICPMS) → OTOLITH $^{87}Sr/^{86}Sr$ → NATAL ORIGIN & MIGRATION HISTORY

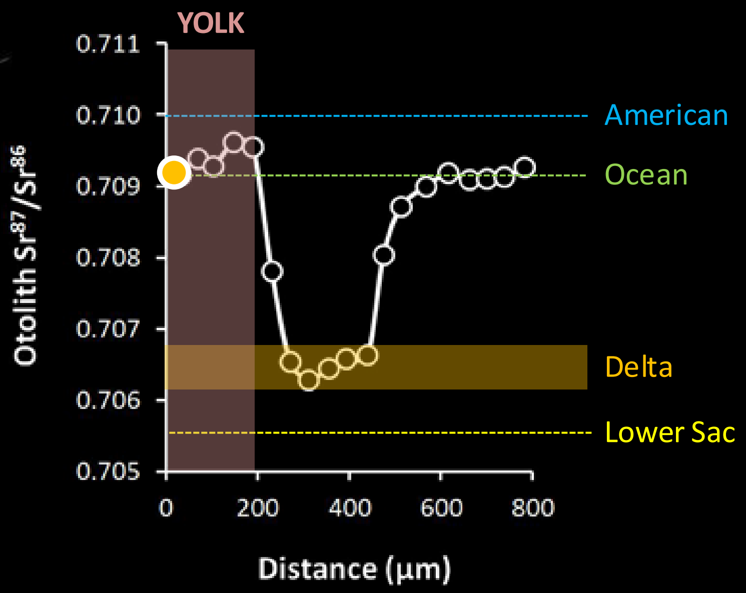
Felix Astejada, University of Essex

ION RATIO MASS SPECTROMETER (IRMS) → EYE LENS $\delta^{34}S$ → HW ORIGIN

Methods | Migration reconstruction

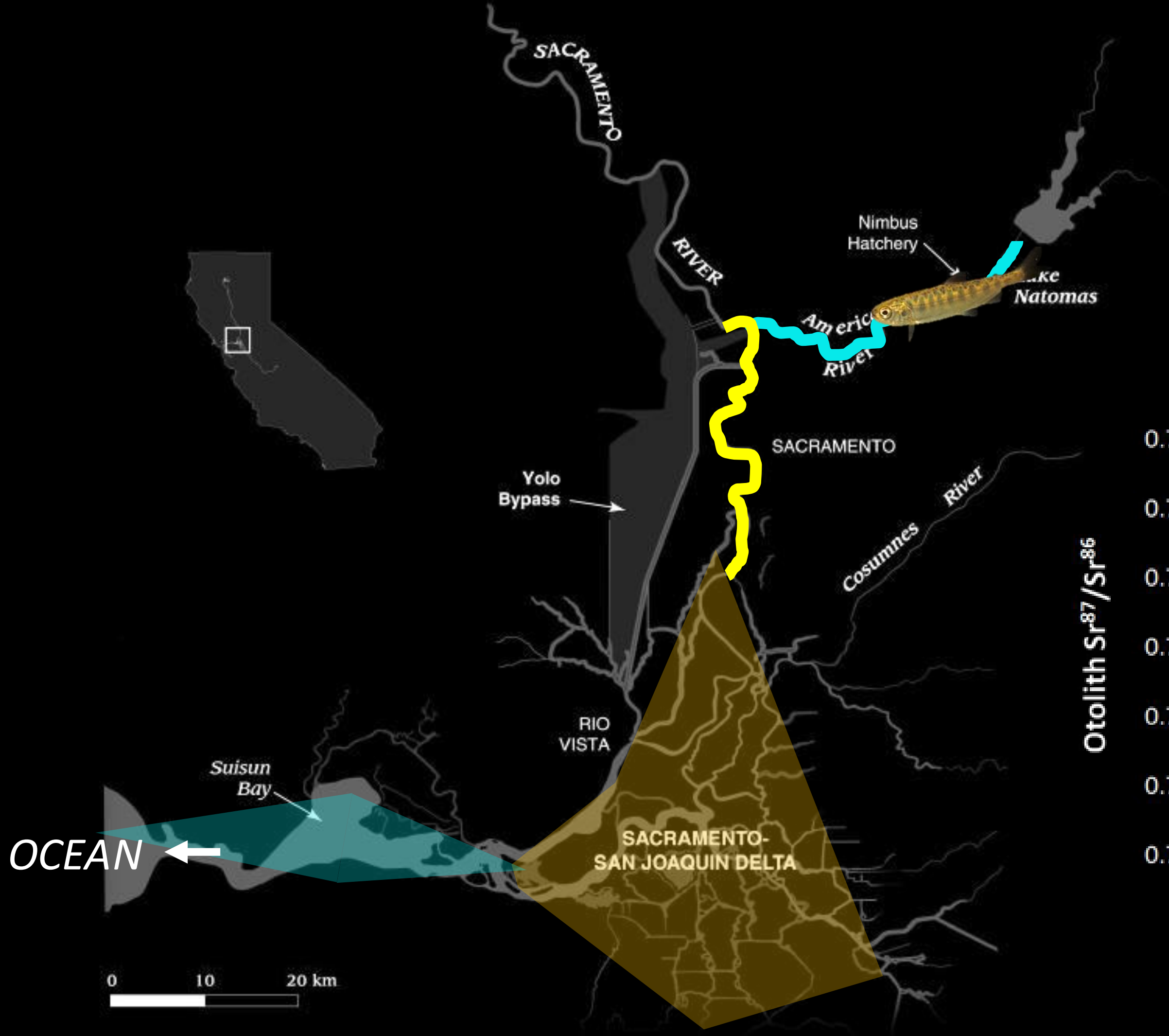


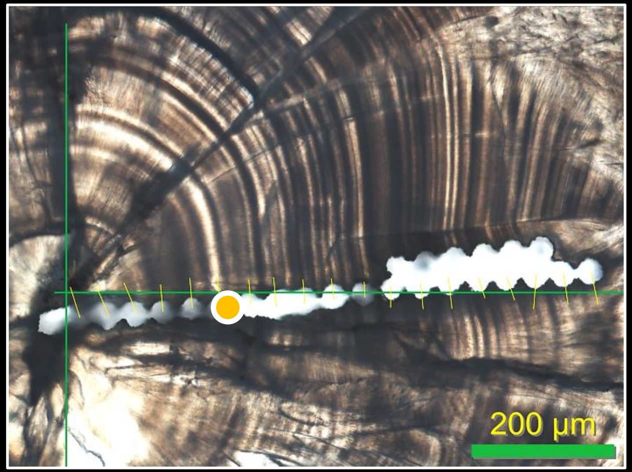


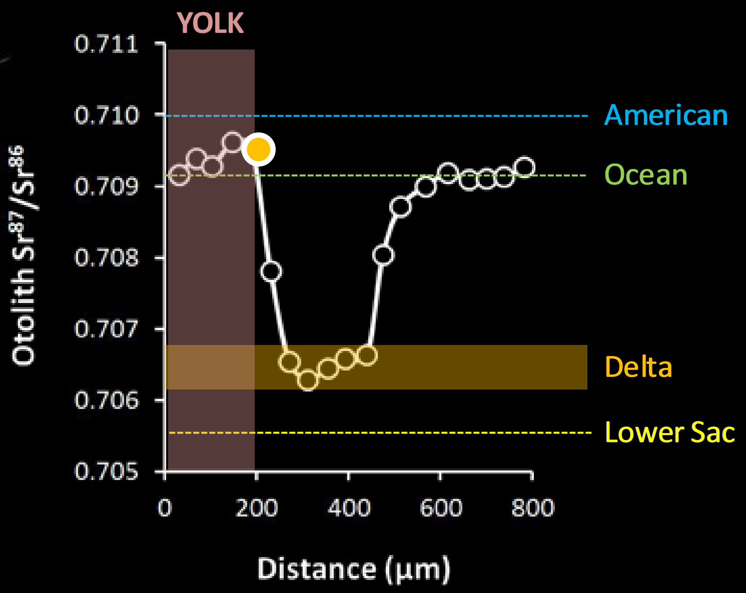


[NOT TO SCALE!]

Methods | Migration reconstruction







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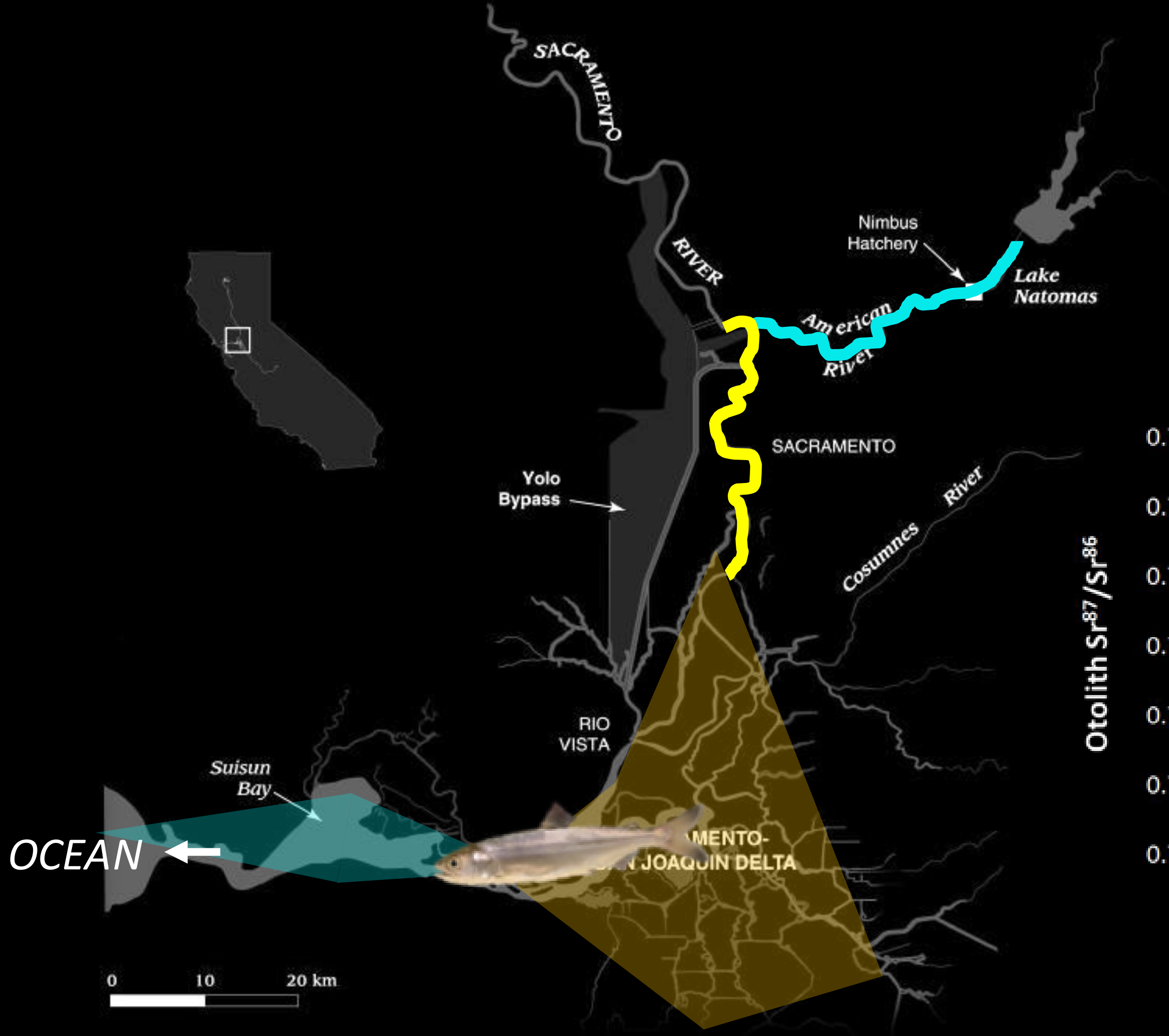
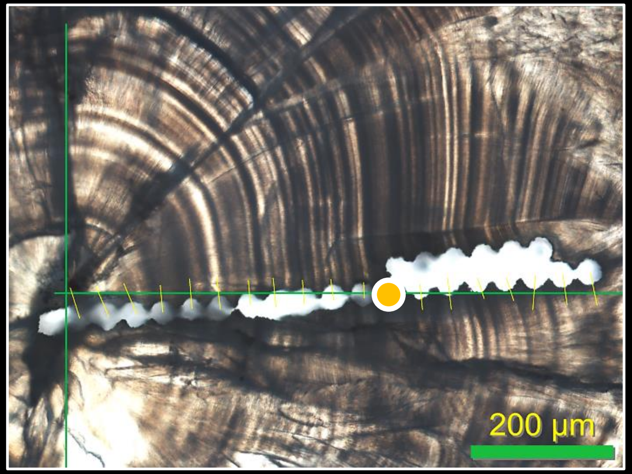
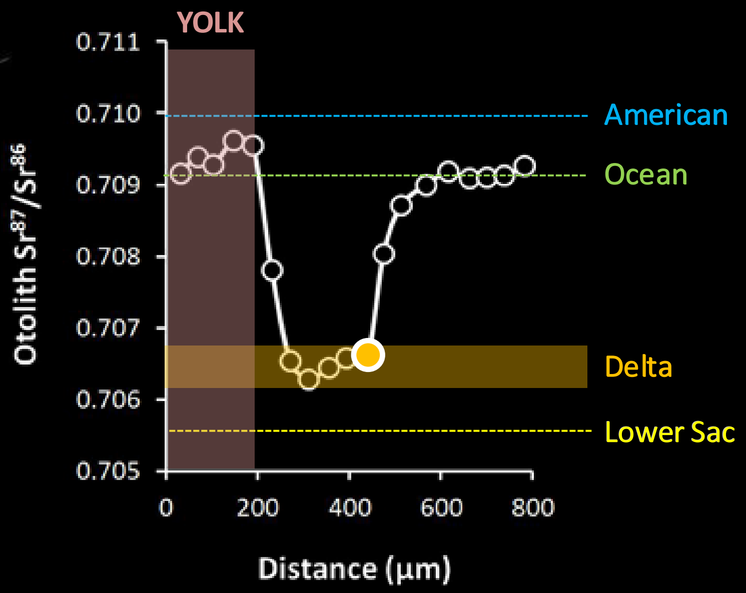
Methods | Migration reconstruction







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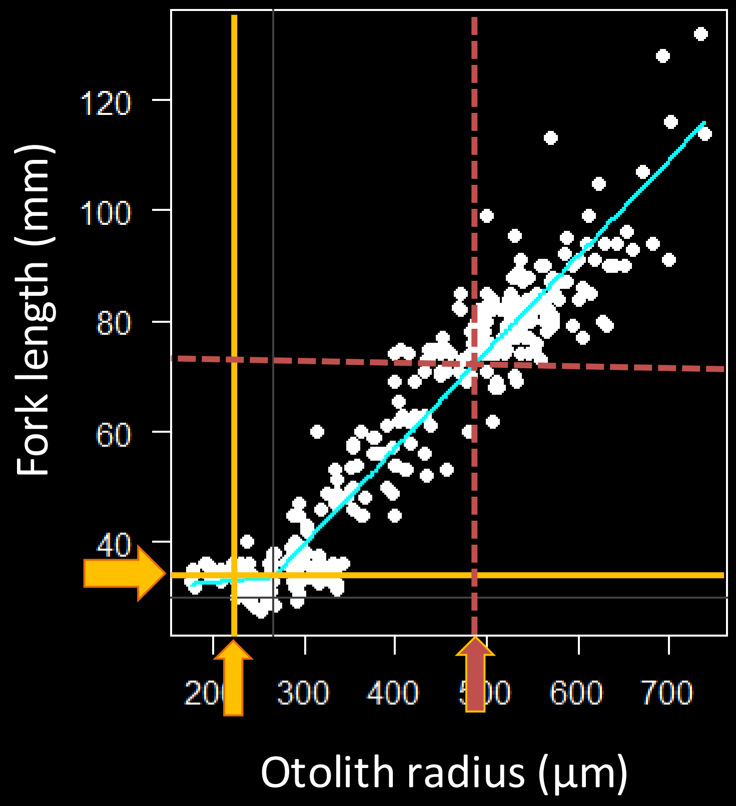
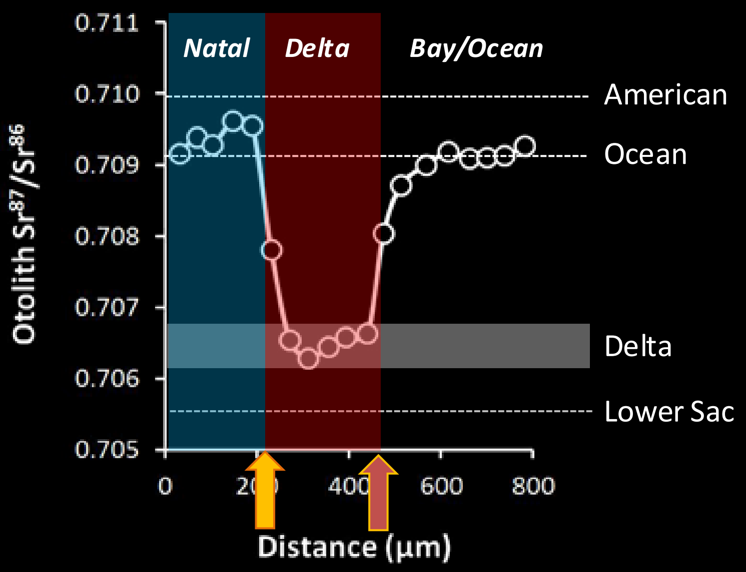
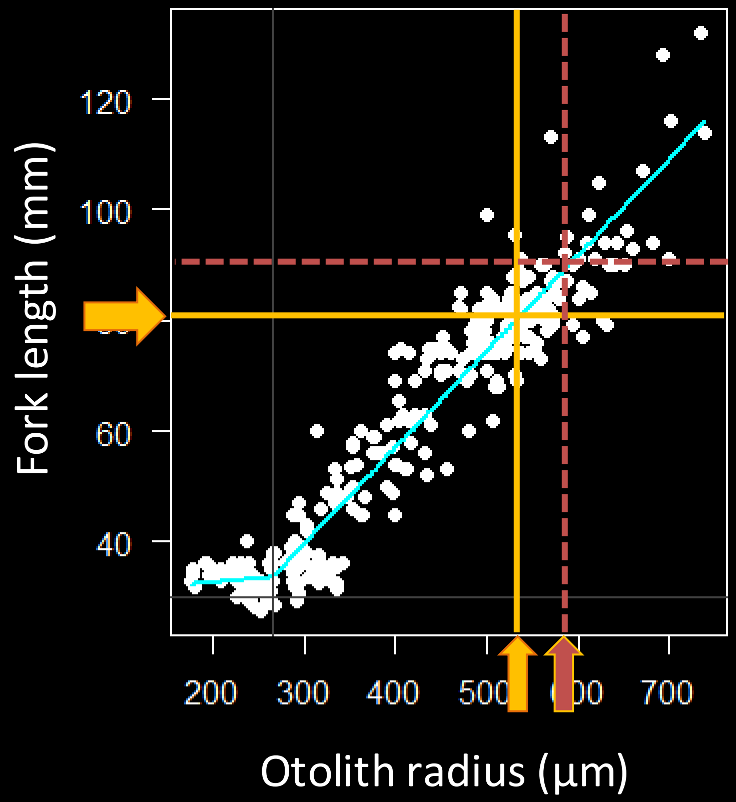
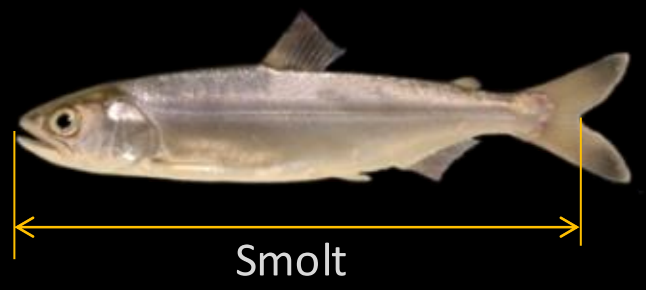
Methods | Migration reconstruction

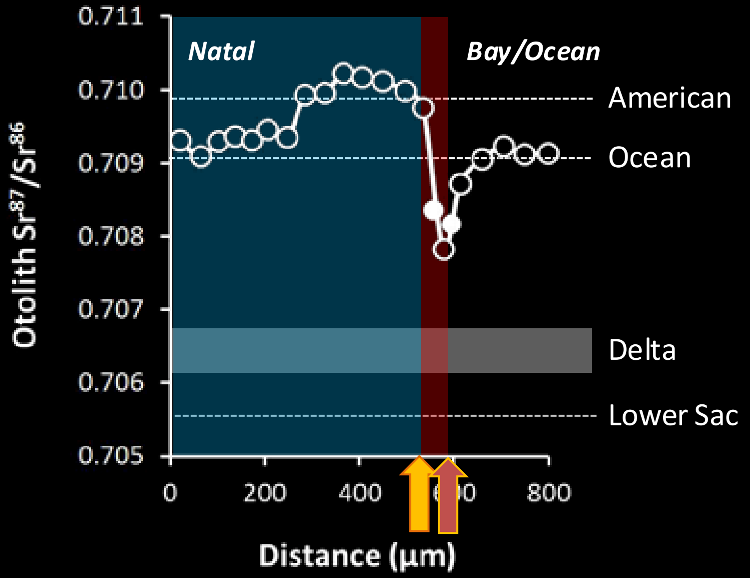




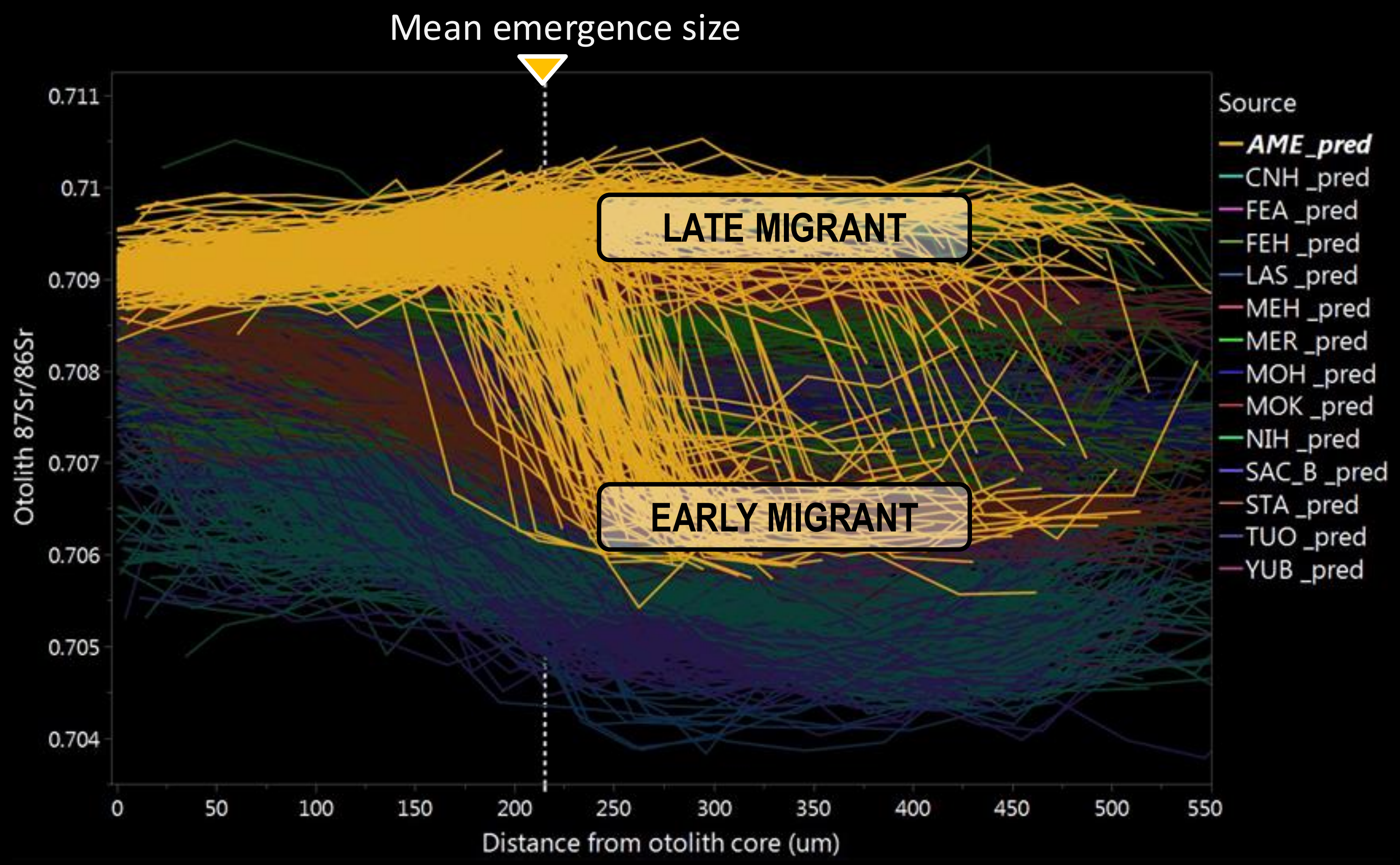
Methods | Migration reconstruction



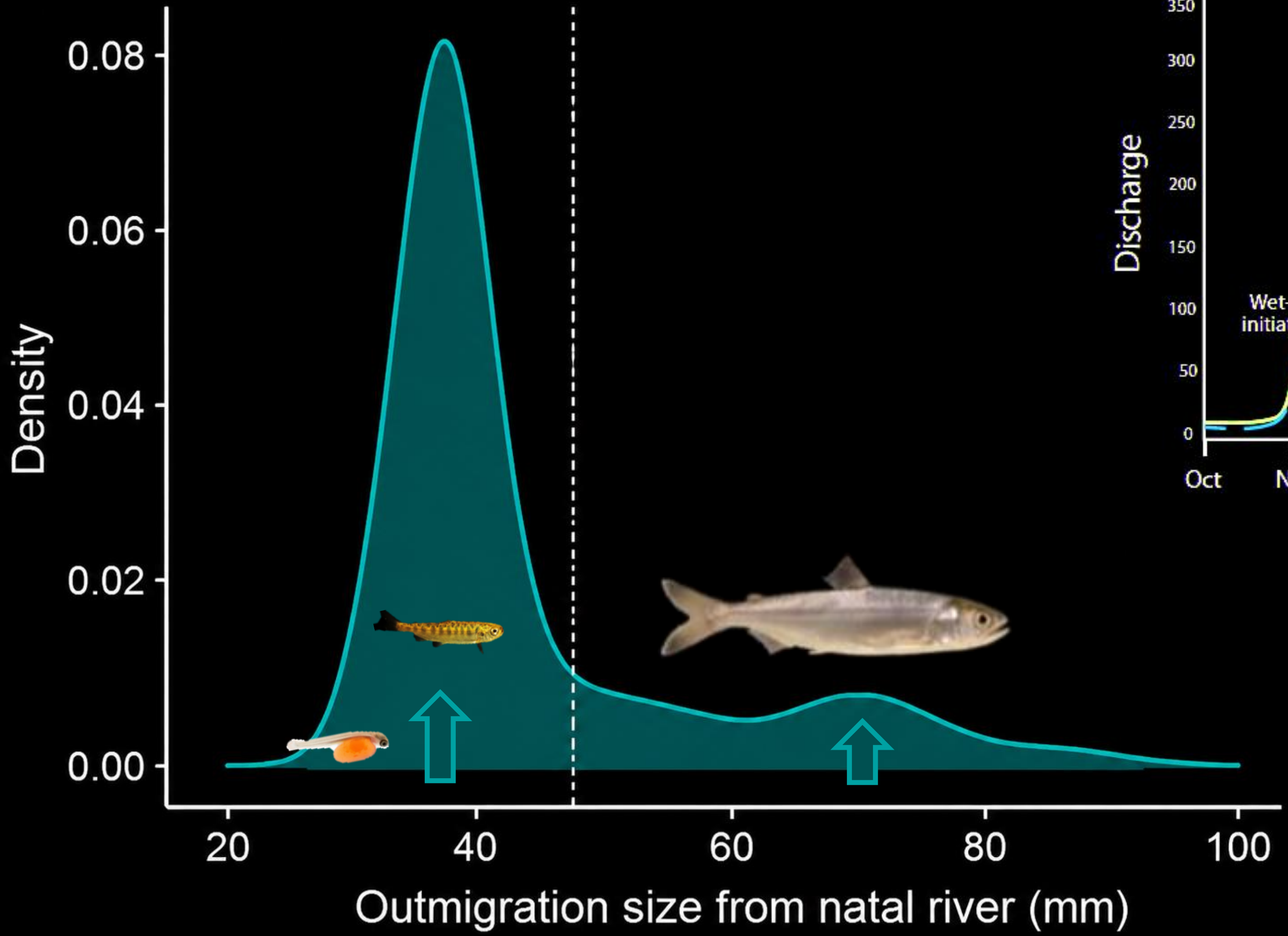


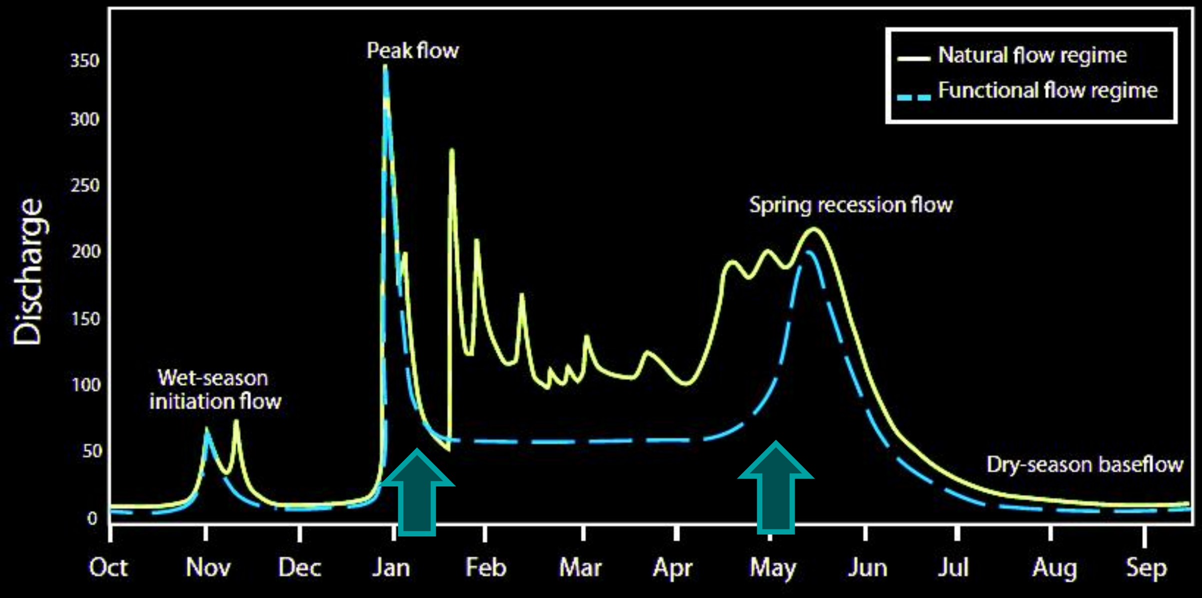


RESULTS I | TWO MIGRATION PULSES



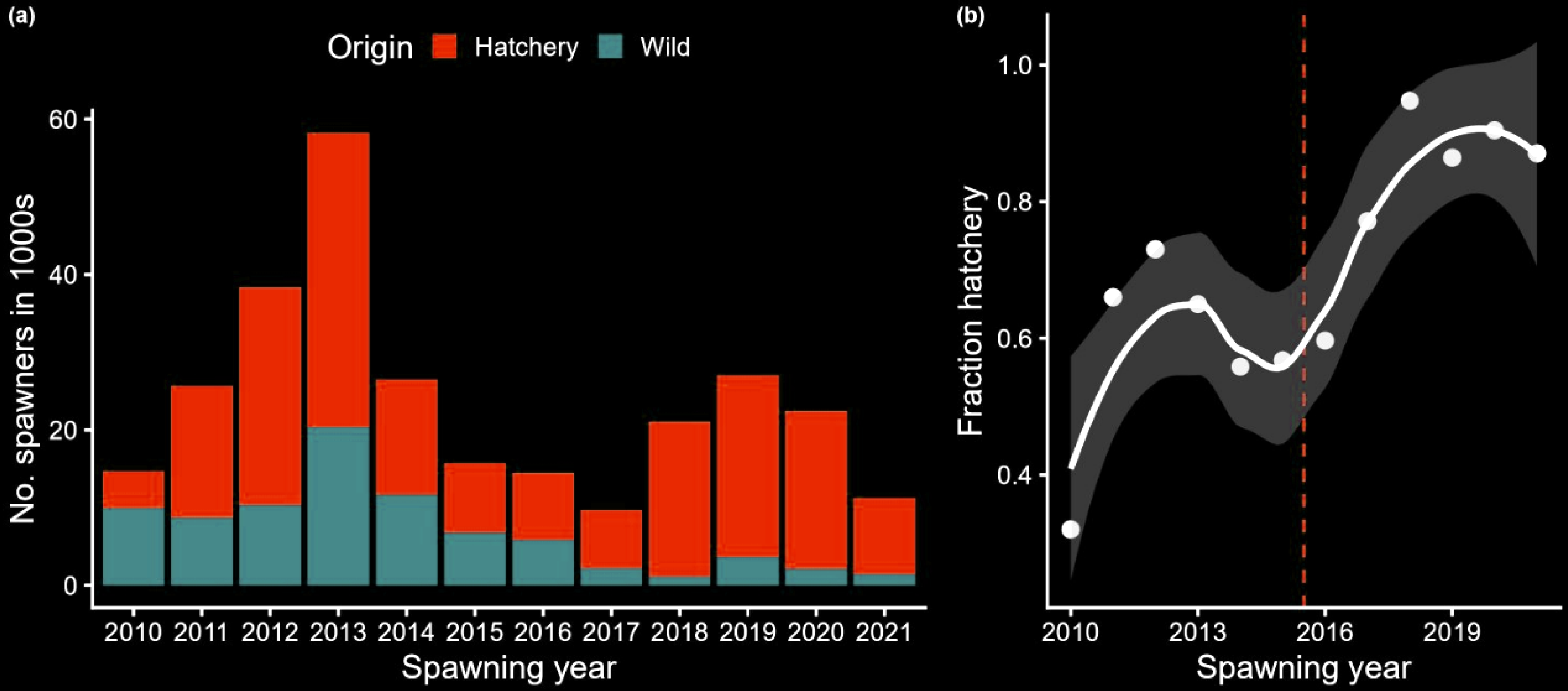
Results I | Two migration pulses



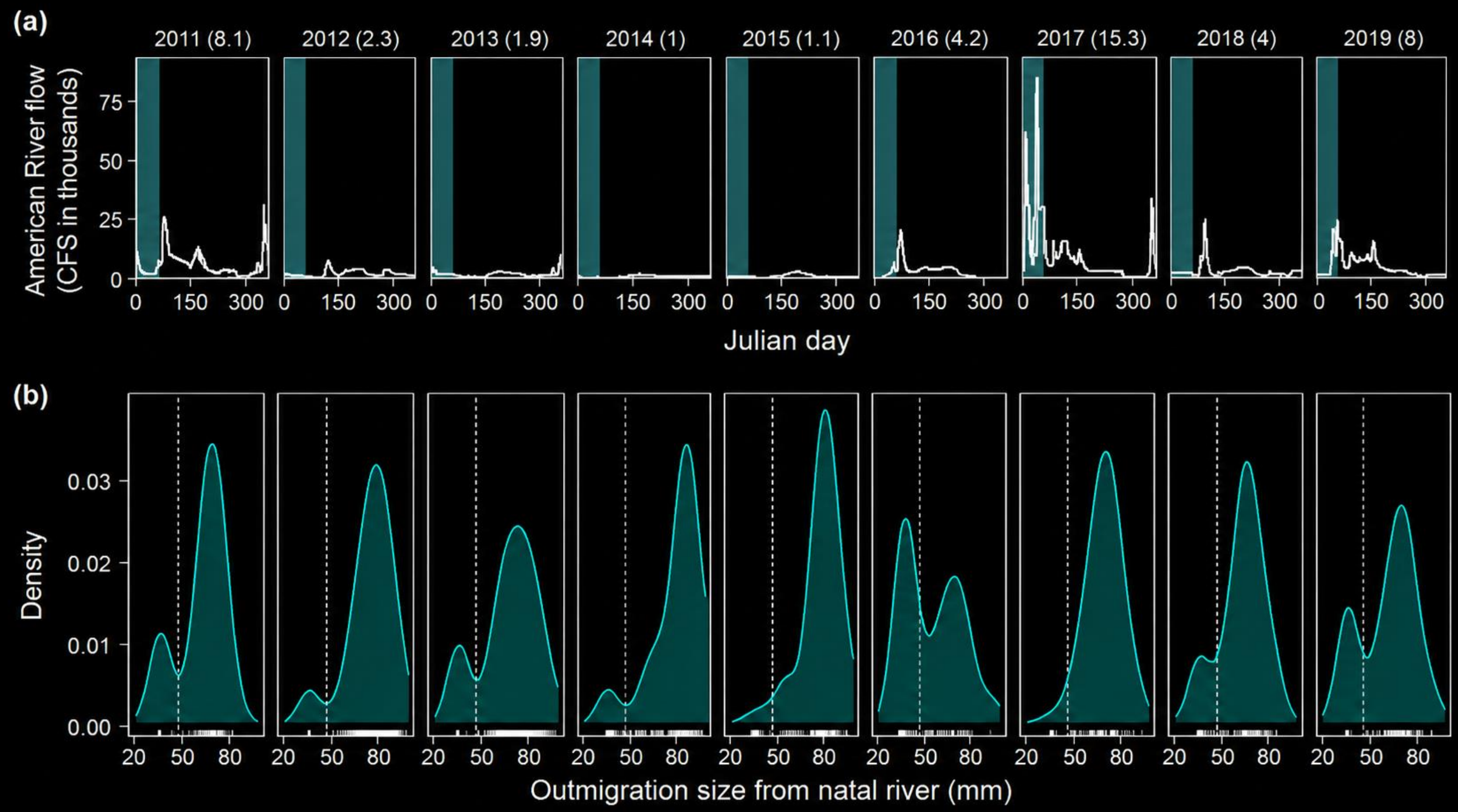


American R outmigrants sampled at Sherwood Harbour Kodiak and lower American River RST

Results I | Do early migrants survive to adulthood?



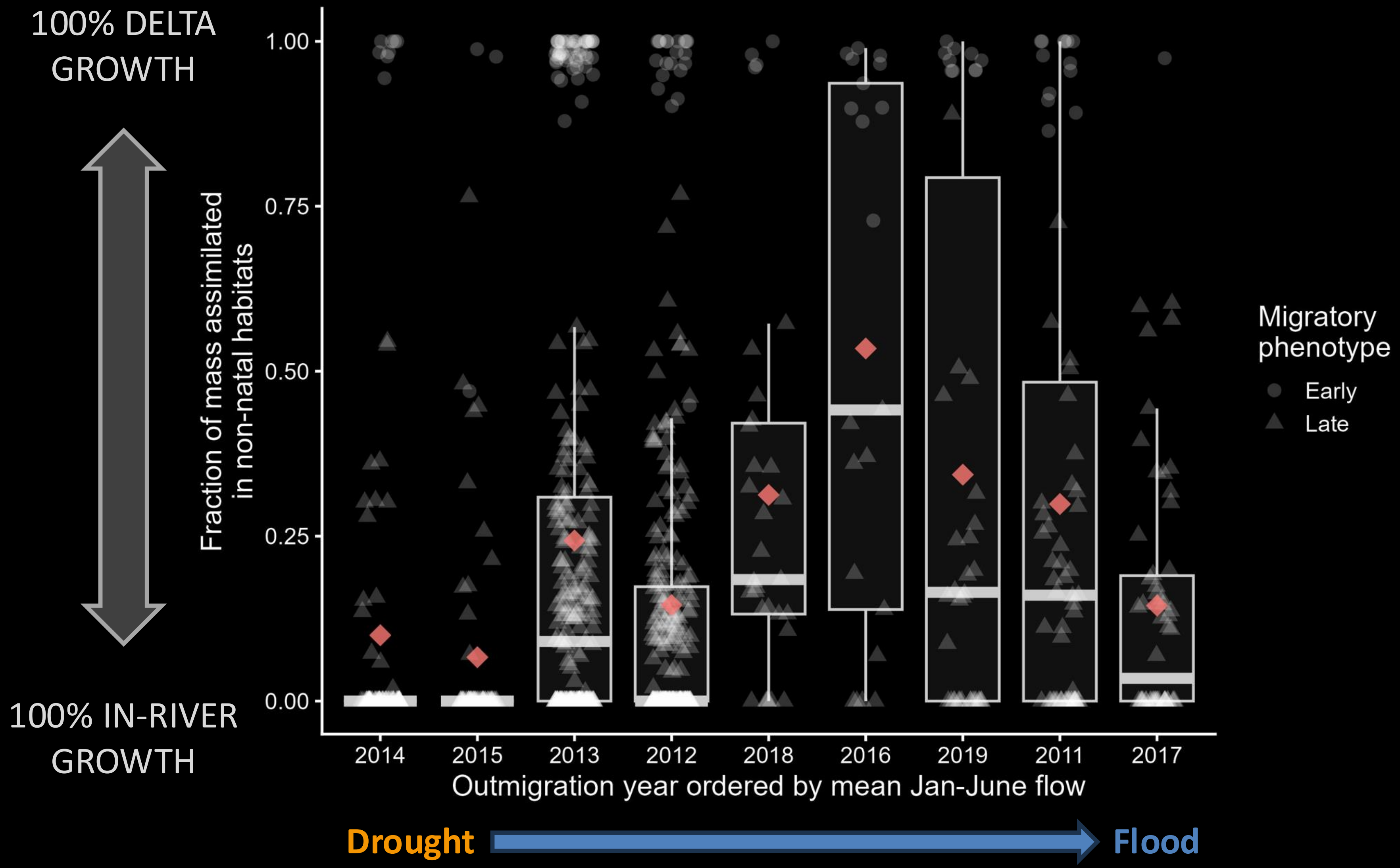
RESULTS I | DO EARLY MIGRANTS SURVIVE TO ADULTHOOD?



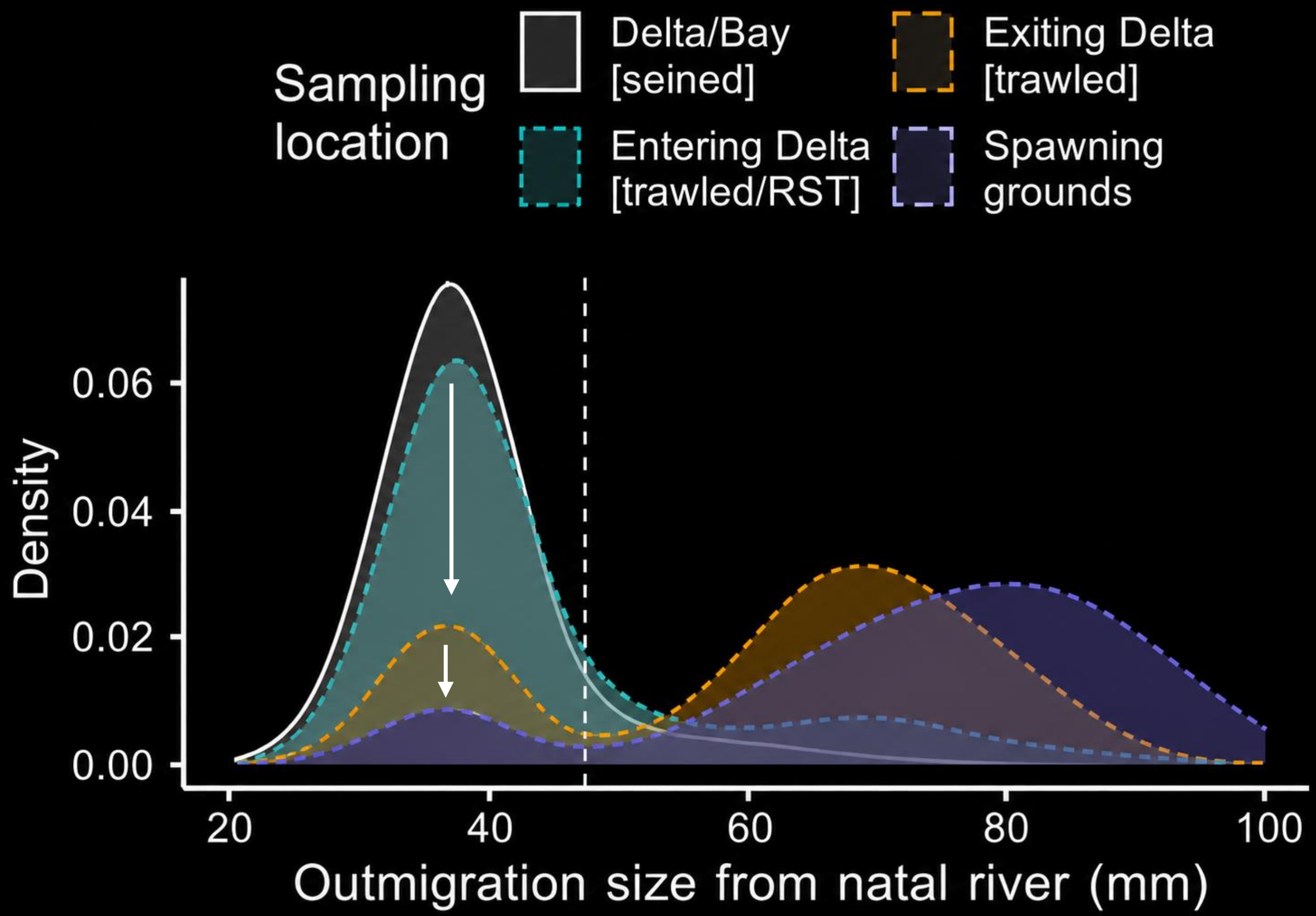
Contribution of early migrants (<55mm) to natural origin spawners

River	Range	Source
American	10-52%	Sturrock et al. (2026)
Yuba	33-89%	Willmes et al. (2024)
Stanislaus	5-23%	Sturrock et al. (2020)

Results II | Natal vs. Delta growth



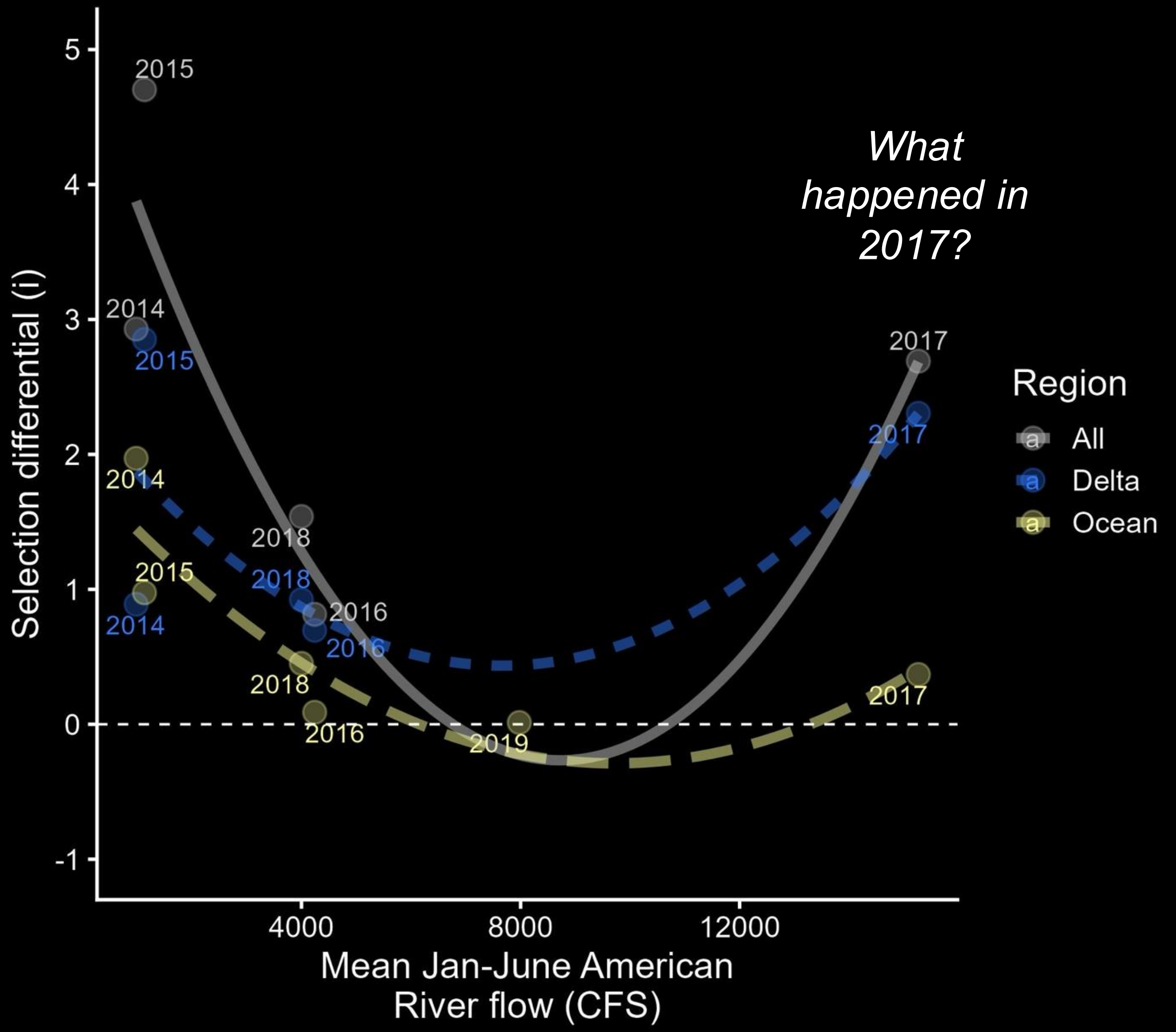
Results III | Where are we losing the early migrants?



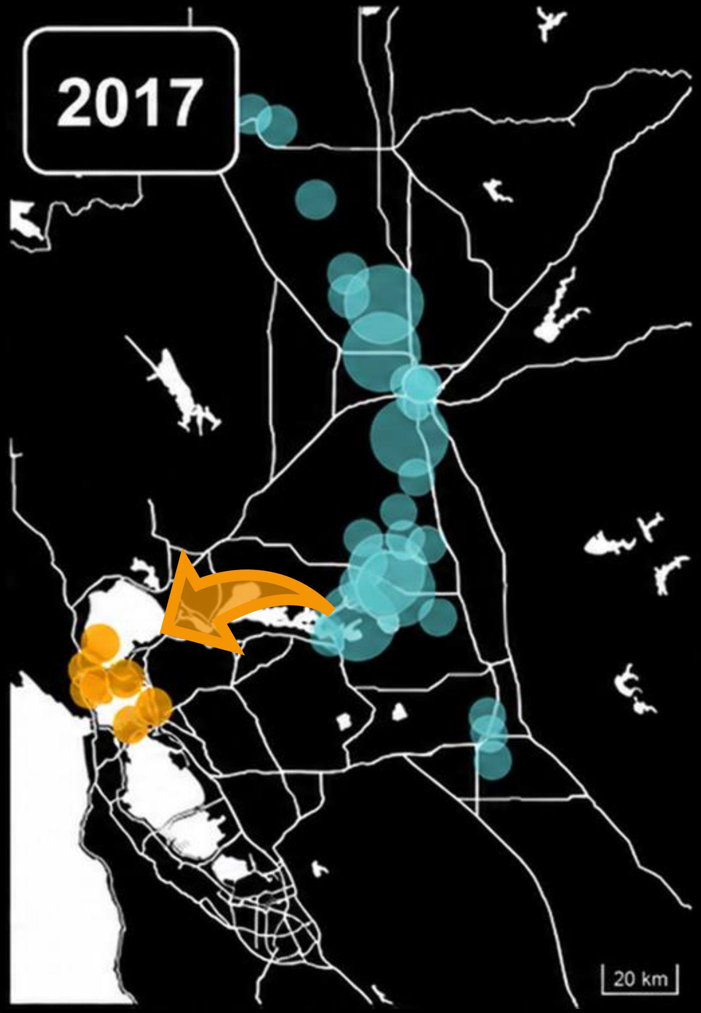
RESULTS III | WHERE ARE WE LOSING THE EARLY MIGRANTS?

BAD FOR FRY

GOOD FOR FRY

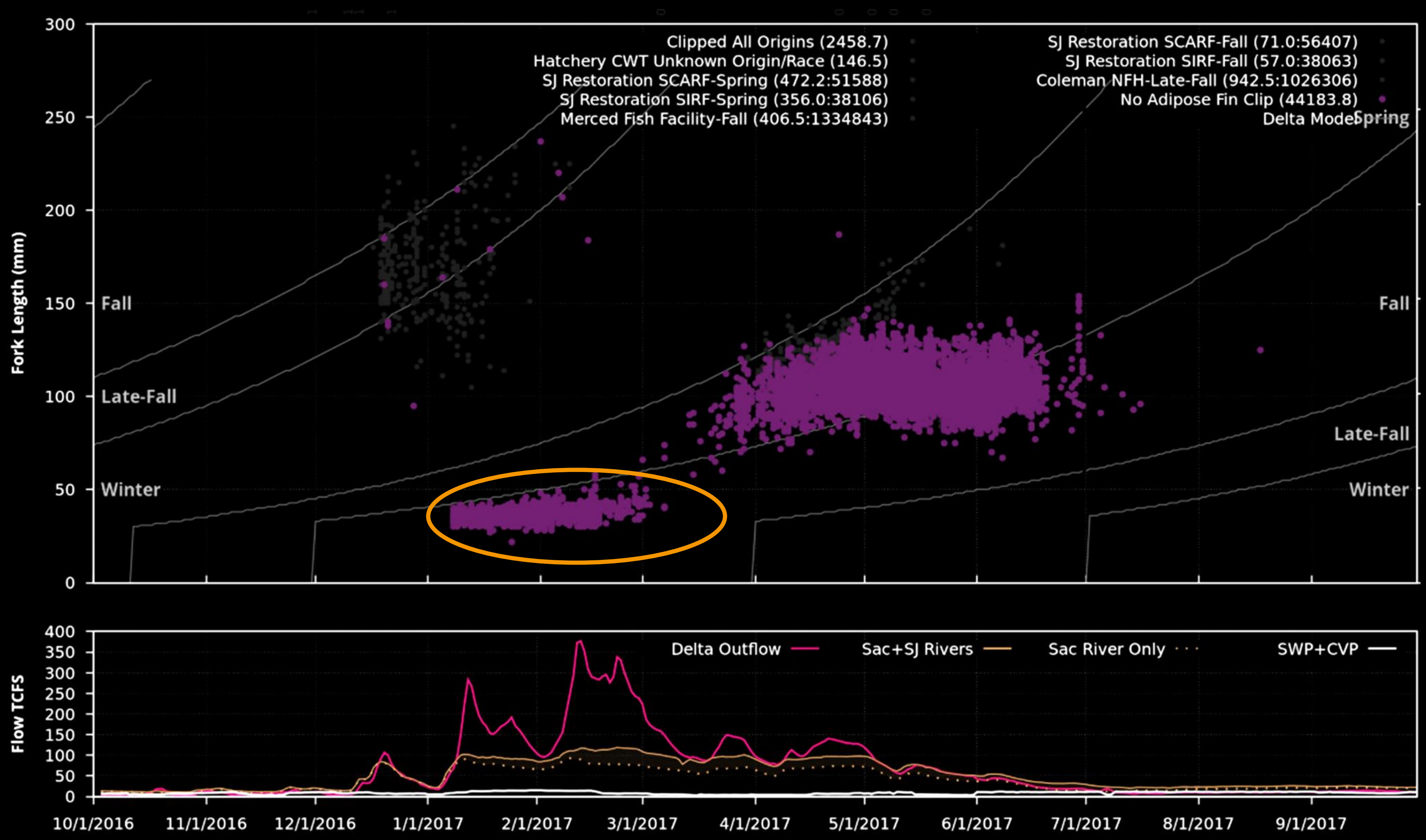


What happened in 2017?



Advected to the SF Estuary (→ salinity shock)

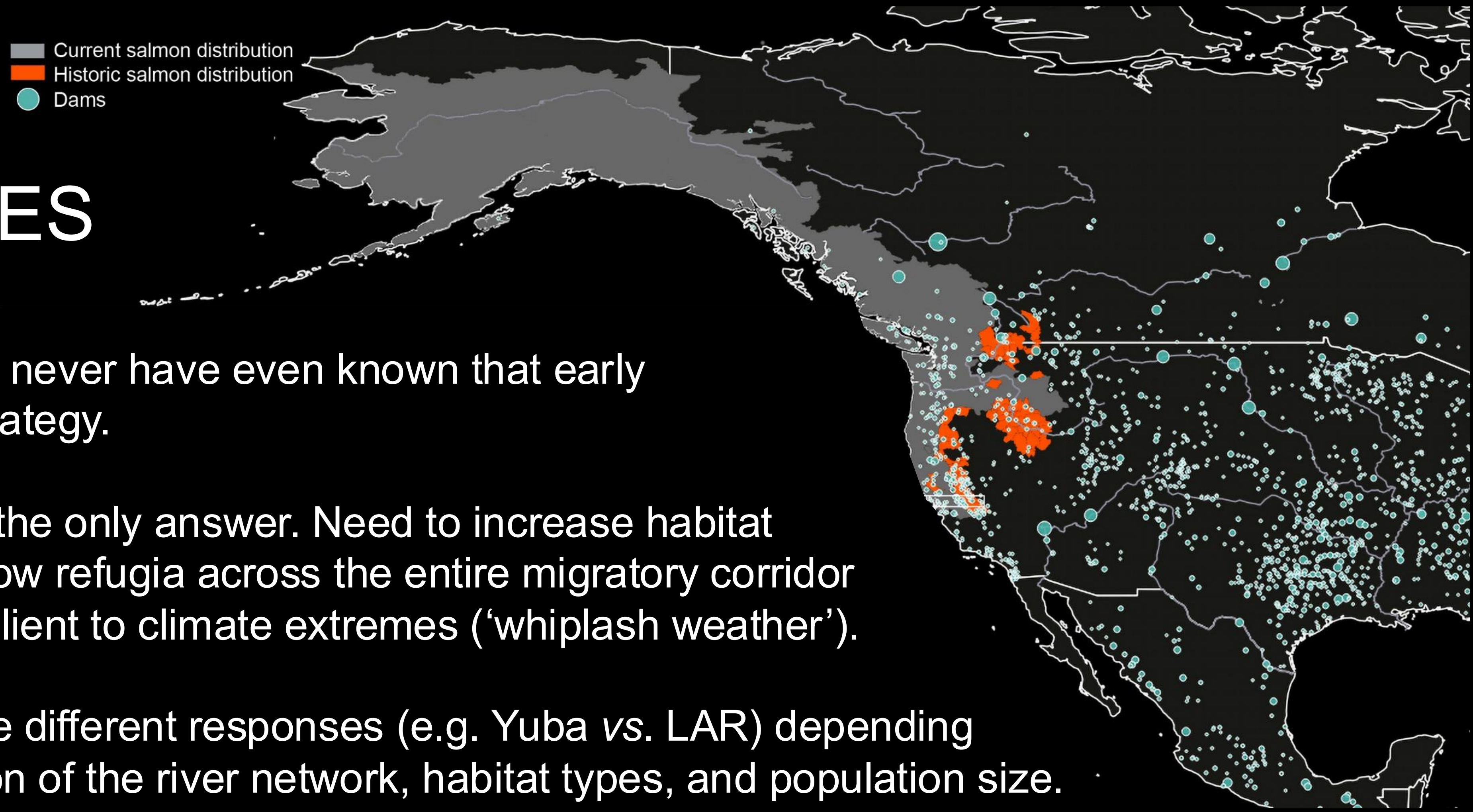
RESULTS III | WHERE ARE WE LOSING THE EARLY MIGRANTS?



Estimated loss of Chinook salmon at the SWP and CVP water export facilities in 2017. Pink dots = Chinook salmon with adipose fin intact.

Source: SacPas https://www.cbr.washington.edu/sacramento/data/delta_salvage.html

TAKE HOMES



- Without otoliths we would never have even known that early migration was a viable strategy.

- ‘Adding more water’ isn’t the only answer. Need to increase habitat complexity and thermal/flow refugia across the entire migratory corridor and to design actions resilient to climate extremes (‘whiplash weather’).

- Different populations have different responses (e.g. Yuba *vs*. LAR) depending on the spatial configuration of the river network, habitat types, and population size.

- While size selective mortality against fry was consistently highest in the Delta, life history diversity is more important than ever, as it spreads risk in an increasingly volatile and unpredictable climate.

Acknowledgements

Sacramento Water Forum for funding, and the support and advice of Lily Allen and Erica Bishop
Logan Day, Eric Bradbury and Kassie Hickey at PSFMC for their provision of the RST data,
the CDFW carcass survey crews (including Jeanine Phillips, Tracy Grimes and Jenny O'Brien),
IEP and the USFWS DJFMP crews (including Jack Ingram, Cory Graham and Denise Bernard),
Cramer Fish Sciences field and laboratory teams, Justin Glessner for ICP-MS support,
Mike Miller, Cathryn Lawrence, Keiko Mertz, Krista Schmidt, Laura Coleman, Bradyn O'Connor,
Kelly Neal and Mollie Ogaz (UC Davis), John Hannon (USBR), Fred Feyrer (USGS), and
George Pess (NOAA Northwest Fisheries Science Center) for his reviews of the manuscript.

THANK YOU FOR LISTENING

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A Modern Ghost Story

Questions & Discussion

We’ll be right back!

12:10	**A Modern Ghost Story: Using Chemical Tracers to Reconstruct the Migration Behaviours and Relative Survival of Juvenile Salmon from the American River** *Dr. Anna Sturrock, Associate Professor, School of Life Sciences, University of Essex, UK*
12:55	**Emigrating Salmon Habitat Estimation (ESHE) Model: Predicting Rearing Habitat Needs to Meet Population and Restoration Goals** *Kirsten Sellheim, M.S., Senior Scientist, Cramer Fish Sciences*
1:35	***10-minute Break***
1:45	**Parentage-based Tagging: Using Genetics to Monitor Central Valley Chinook Salmon** *Elyse Freitas, Senior Environmental Scientist, Fisheries Branch, California Department of Fish and Wildlife*
2:25	**Fine-scale Vegetation Mapping of the American River Parkway** *Sarah Norris, Consulting Arborist, Wild Rye Consulting, LLC*
3:10	**2-minute Teasers on Other Topics of Interest** **Announcements & Suggestions for Future Science Shares**

Emigrating Salmon Habitat Estimation (ESHE)

A model to predict habitat needs to meet population and restoration goals

CRAMER FISH SCIENCES®
An Employee Owned Consulting Company

verdantas

WATER FORUM

U.S. FISH & WILDLIFE SERVICE

BUREAU OF RECLAMATION

American River juvenile salmonid rearing habitat restoration

- +70% of historic habitat blocked by Nimbus Dam
- Remaining habitat degraded due to levees, mining, and urban expansion

Fundamental question: **How much** Chinook Salmon rearing habitat is needed and **where**?

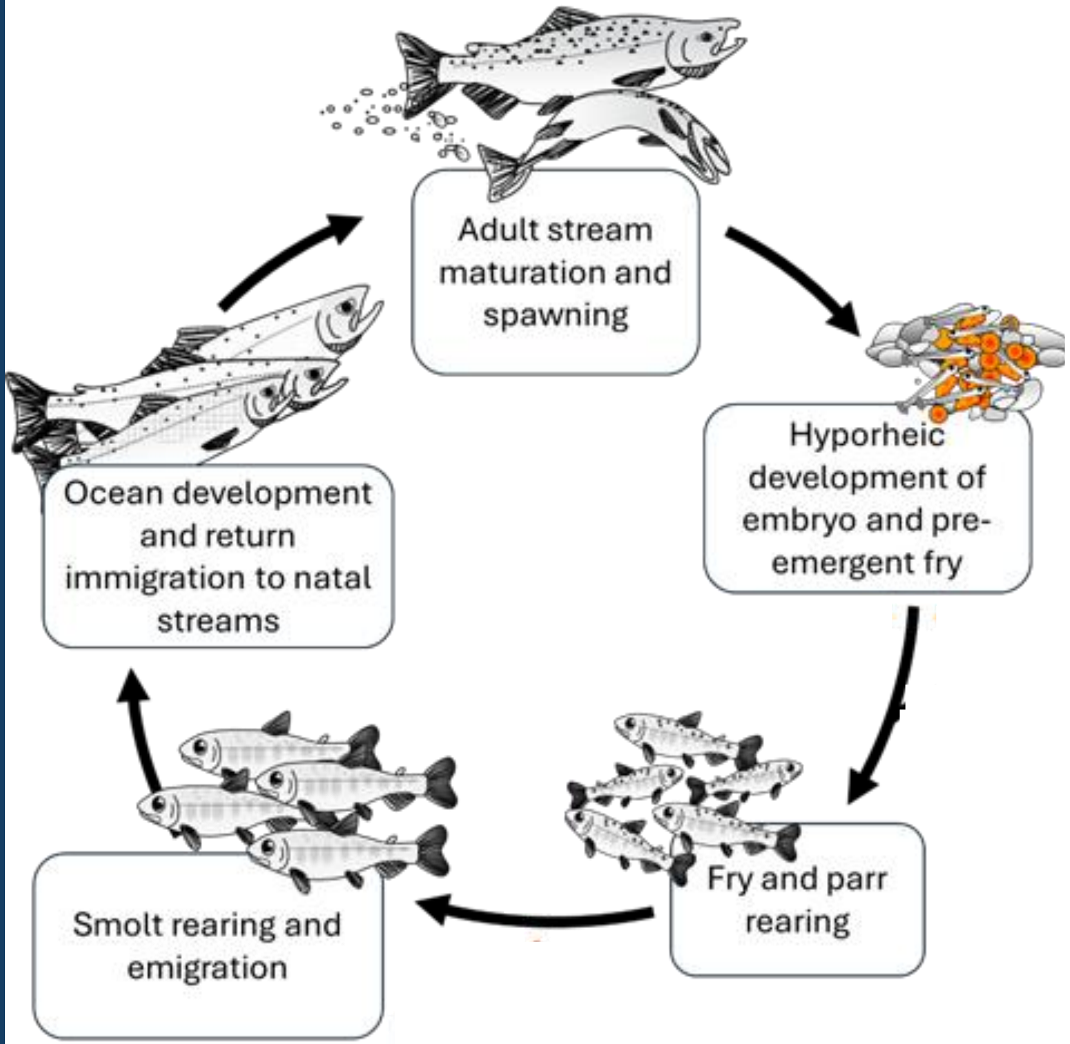
- Previously, restoration prioritization based on
  - expert opinion
  - areas of heavy utilization
  - logistically “easiest” sites
- Developed tool to assess river-wide habitat needs now and to support recovery goals
- Prioritize specific reaches by habitat deficit
- Assess population response to “what if” restoration scenarios

Fundamental question: **How much** Chinook Salmon rearing habitat is needed and **where?**

- Approach: **temporally** and **spatially** explicit individual-based rearing model using river specific metrics to predict:
  - **Existing rearing habitat**
  - **Most limited rearing reaches**
  - **Additional habitat** required to meet CVPIA population **doubling goal**
  - **How do these answers vary by flow?**
  - **How do these answers vary by rearing period?**

Models help us depict how habitat conditions affect organisms throughout their life cycles depending on needs.

Life Cycle Model



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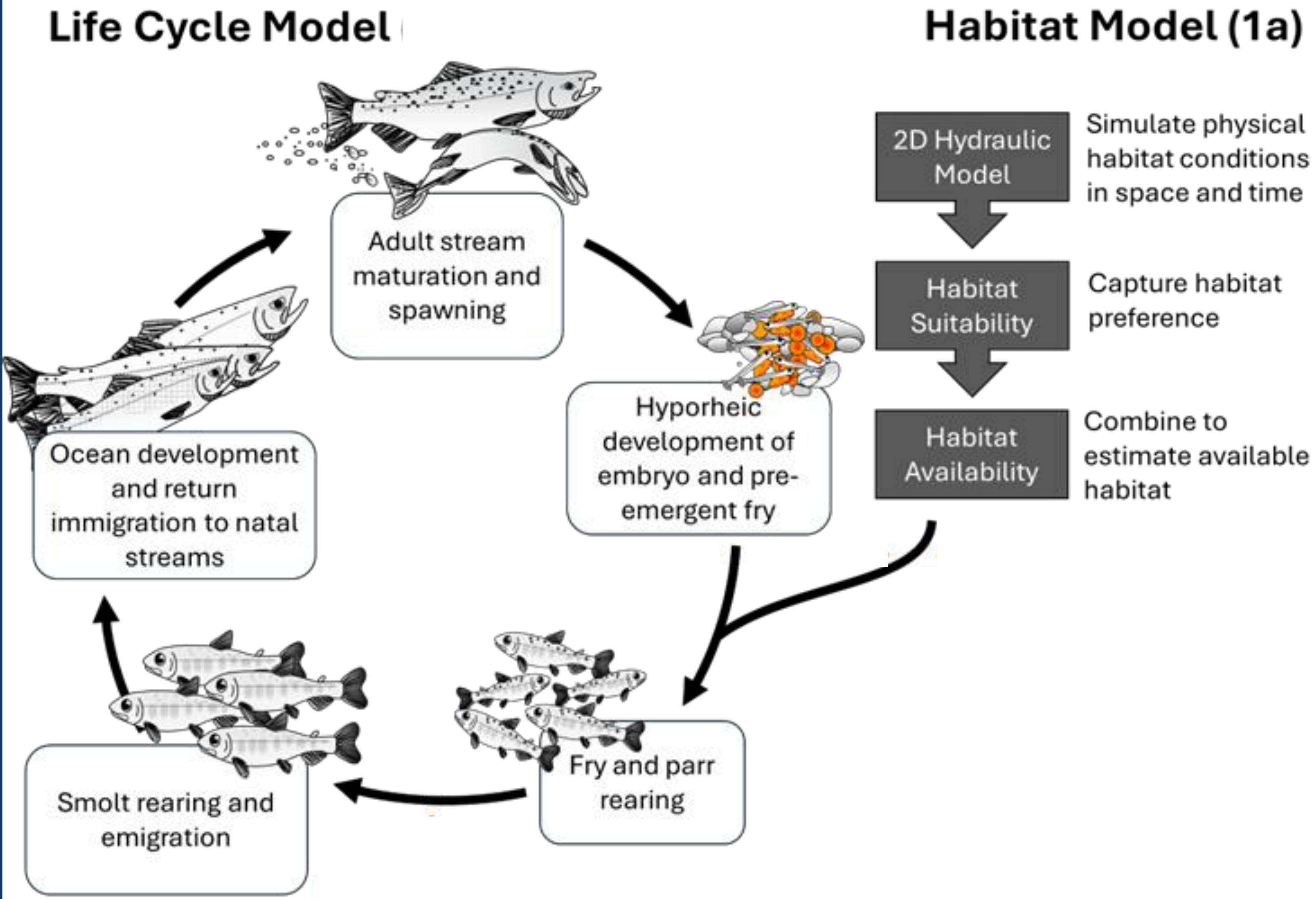
Habitat model (1a): Maps how flow over terrain creates available living space.



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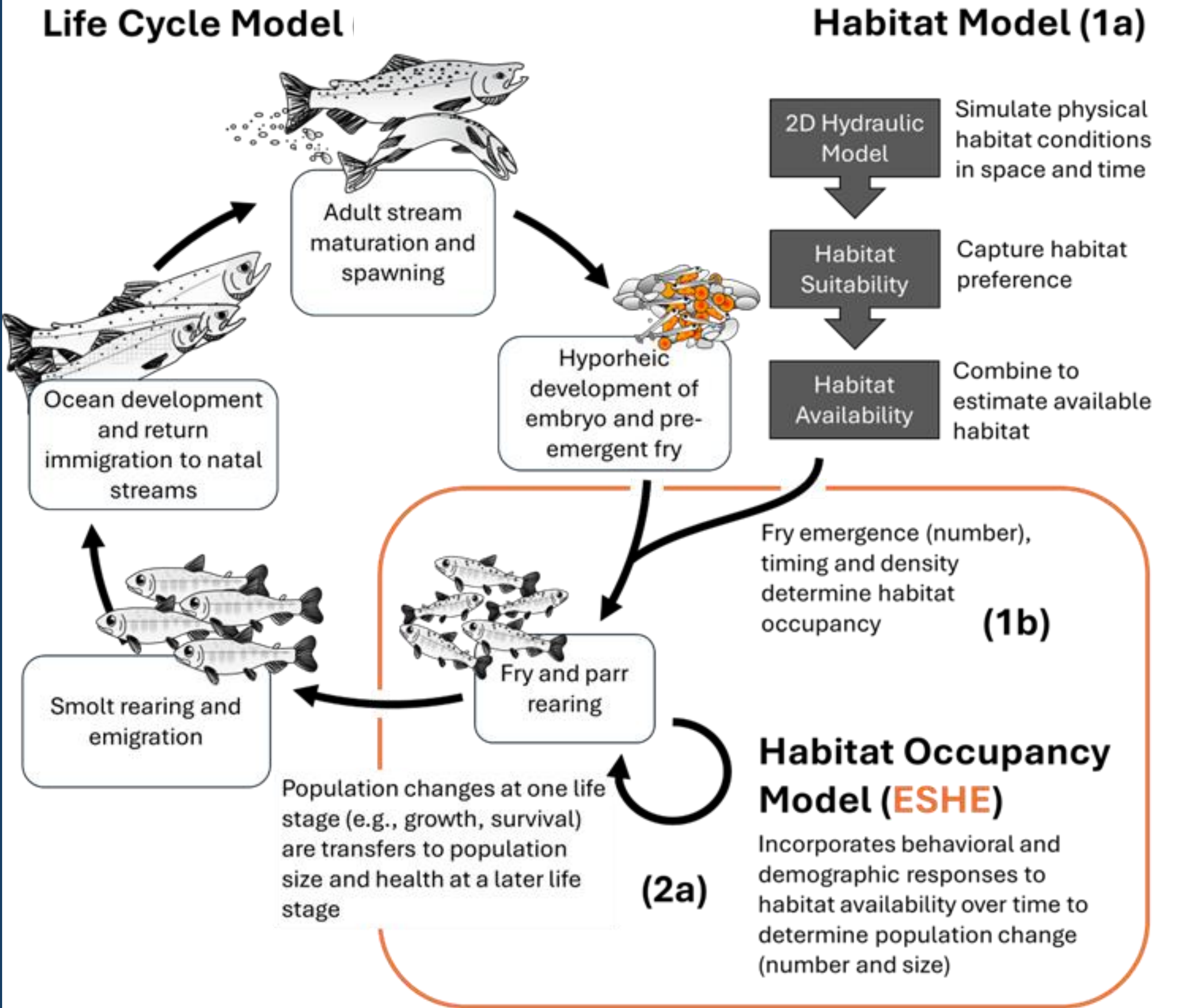
Habitat model (1a): Maps how flow over terrain creates available living space.

Habitat occupancy (ESHE)(1b): tracks how salmon use those areas over time.



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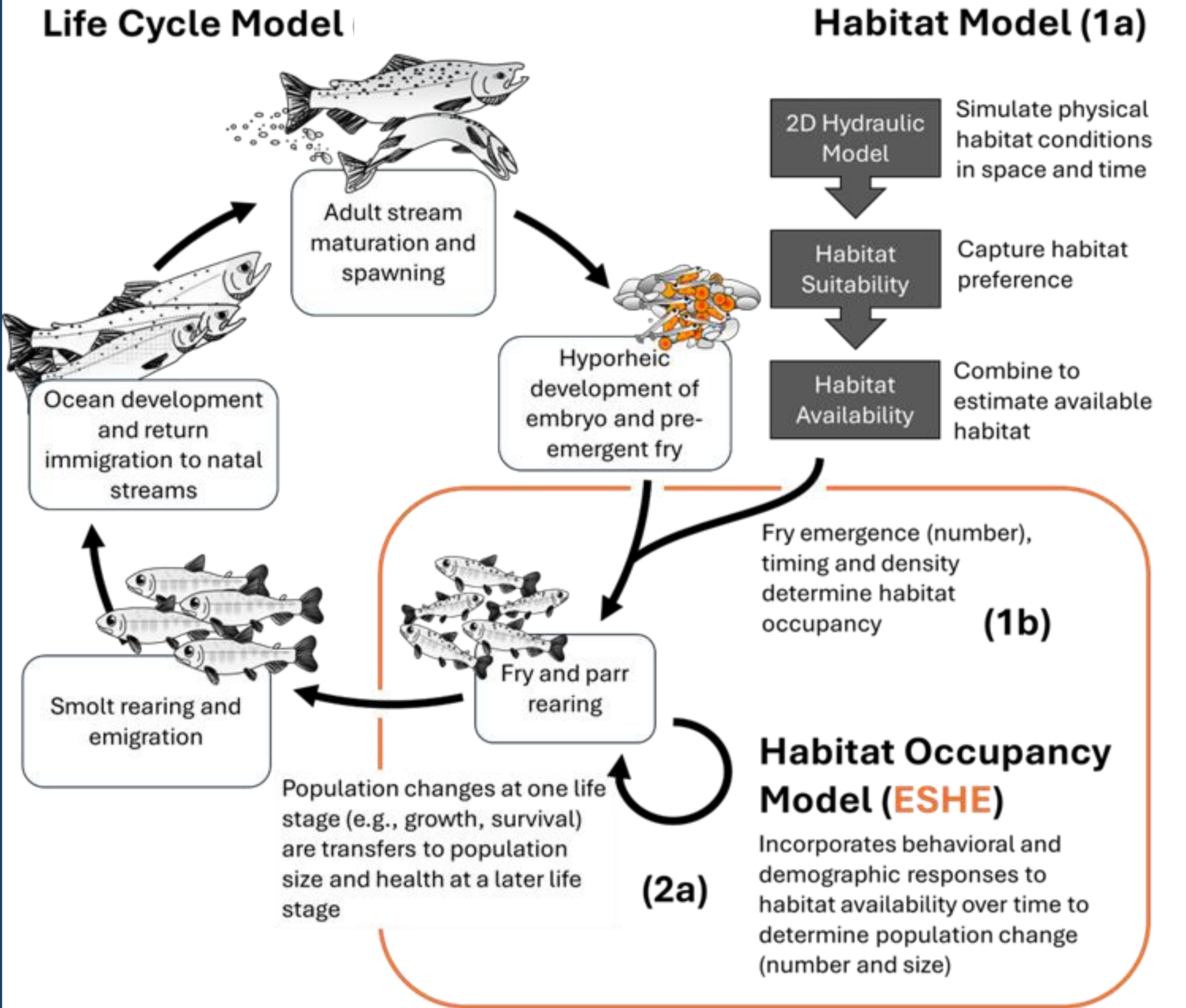
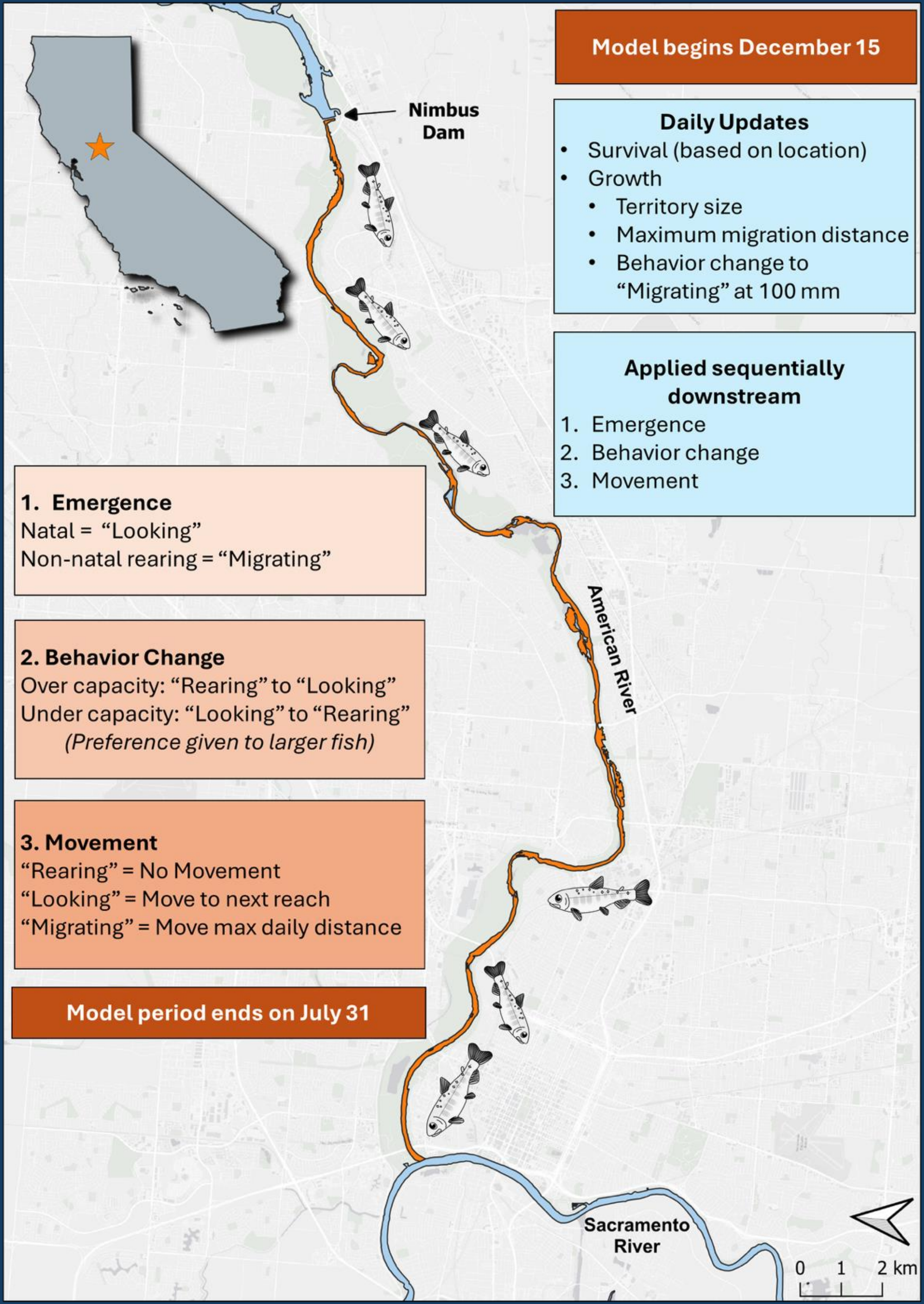
Habitat model (1a): Maps how flow over terrain creates available living space.

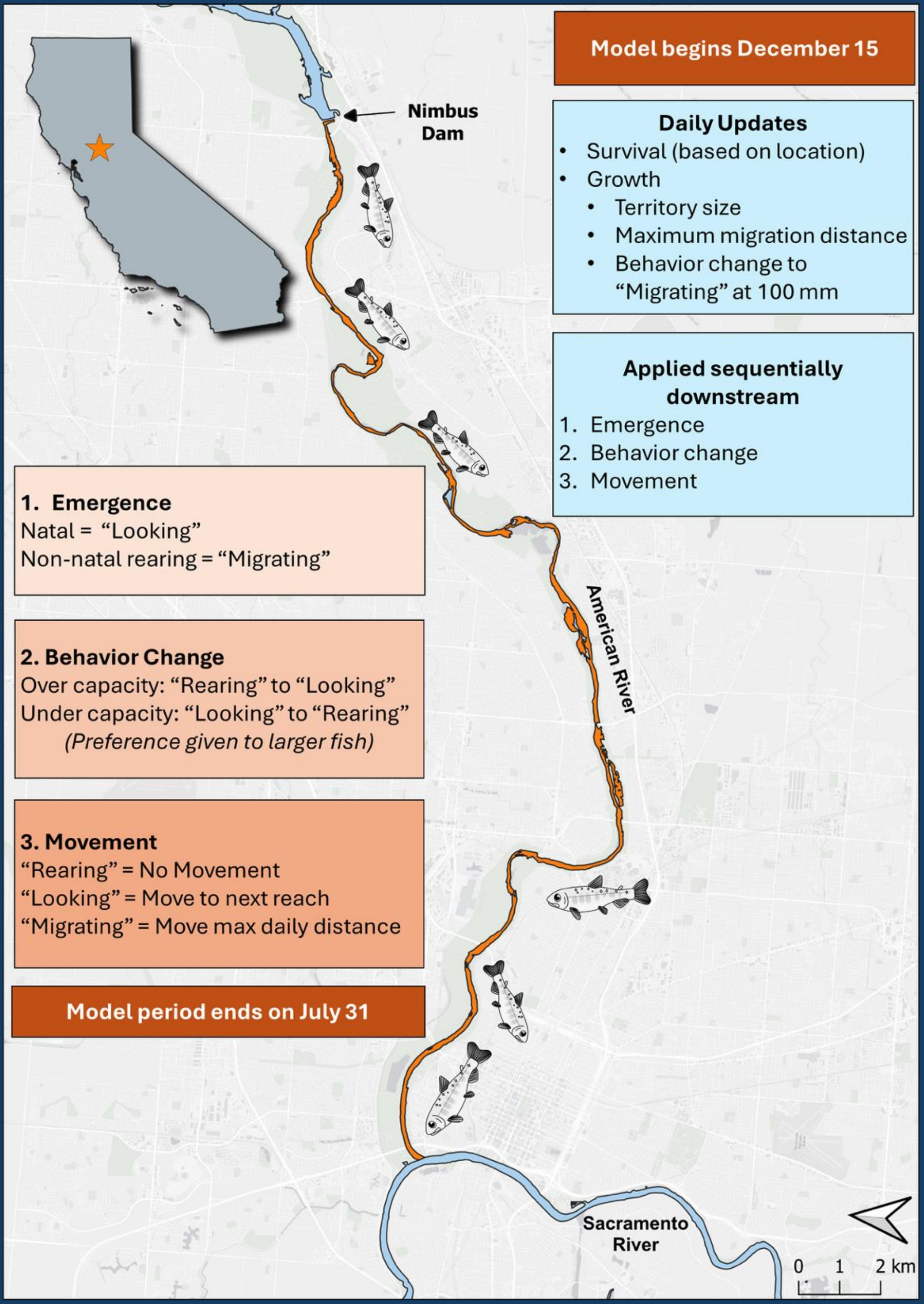
Habitat occupancy (ESHE)(1b): tracks how salmon use those areas over time.

Life Cycle (2b): tracks salmon as they grow/transform from eggs to emigrants and eventually return as spawning adults.

The Link: By combining models, we can predict how river changes impact growth and survival at every life stage.

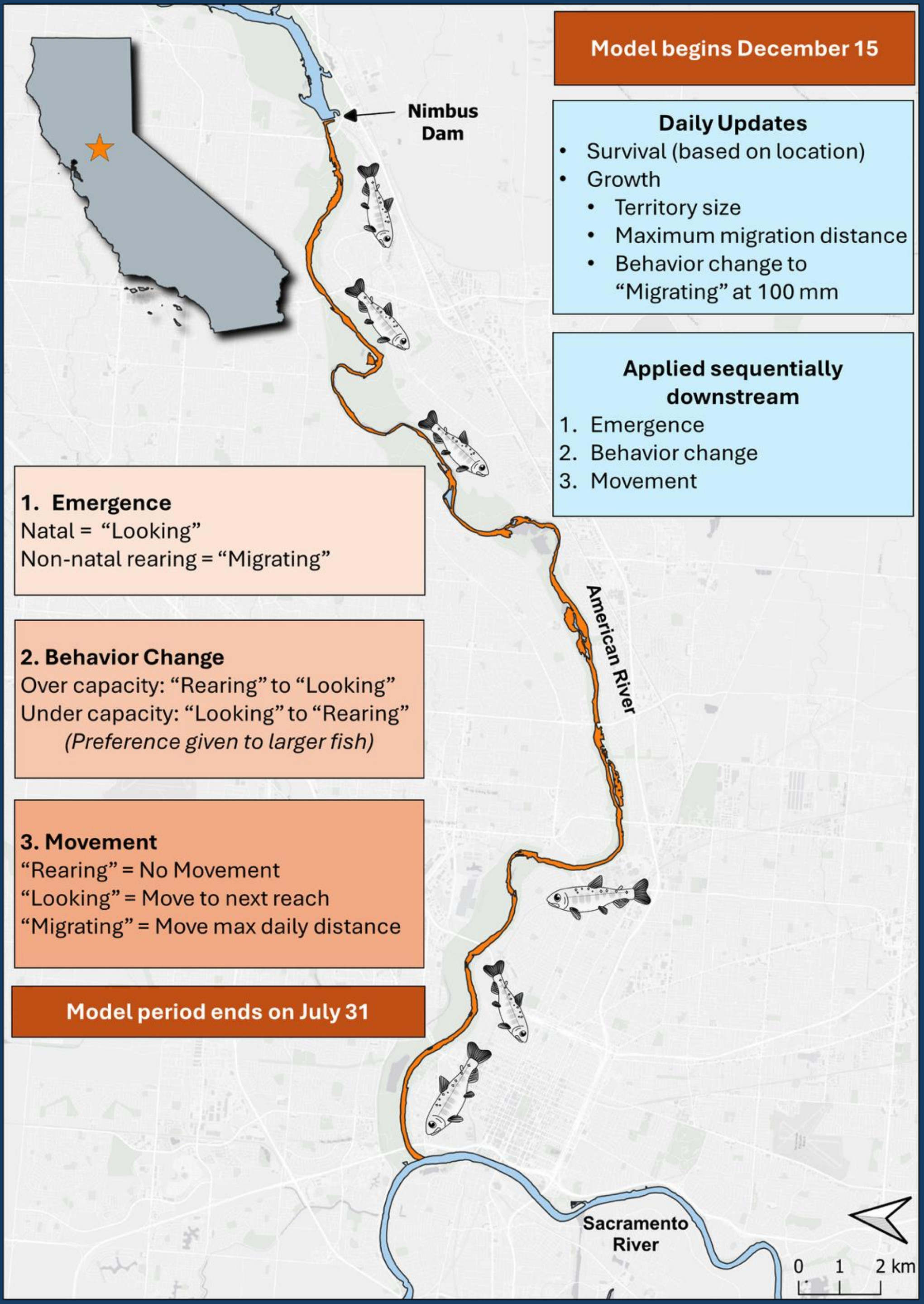



Model begins December 15
Nimbus Dam
Daily Updates
• Survival (based on location)
• Growth
• Territory size
• Maximum migration distance
• Behavior change to "Migrating" at 100 mm
Applied sequentially downstream
1. Emergence
2. Behavior change
3. Movement
1. Emergence
Natal = "Looking"
Non-natal rearing = "Migrating"
2. Behavior Change
Over capacity: "Rearing" to "Looking"
Under capacity: "Looking" to "Rearing"
(Preference given to larger fish)
3. Movement
"Rearing" = No Movement
"Looking" = Move to next reach
"Migrating" = Move max daily distance
Model period ends on July 31
American River
Sacramento River
0 1 2 km



ESHE Model Parameters and general data sources

	Parameter	Data Source
Input Data	Acre per RKM	2D Hec-RAS Model for juvenile salmon.
	Returning Adults	15-year average of adult returns in the LAR[1]. Assumes a 1:1 sex ratio, fecundity of 6,001 eggs[8] and an egg-to-fry survival of 0.67[9].
	Spawning Location	Percent of redds per river kilometer from aerial redd surveys[10].
	Emergence Timing	LAR spawning ground data from 2023 paired with 750-degree days to predict emergence date[10].
	Emergence Size	This is the initial size of fish at emergence[5].
Daily Update Data	Survival	Daily survival rate[3].
	Growth	Daily growth rates[4].
	Migration Rate	Migration rate is a function of size, determinizing the maximum distance a fish can migrate per day[2].
	Territory Size	Relationship between fish territory size fork length[6].



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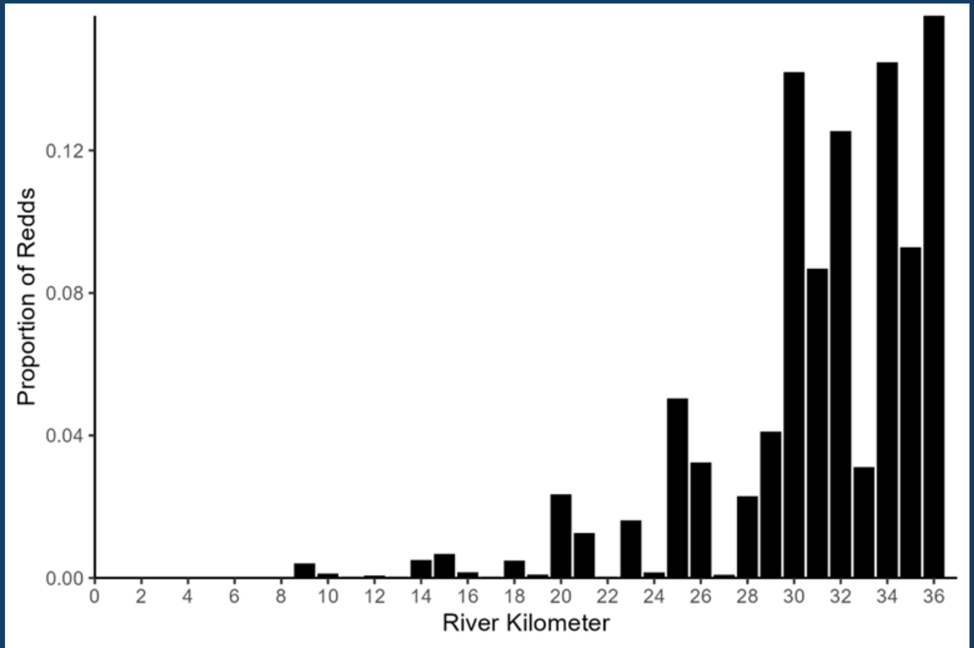
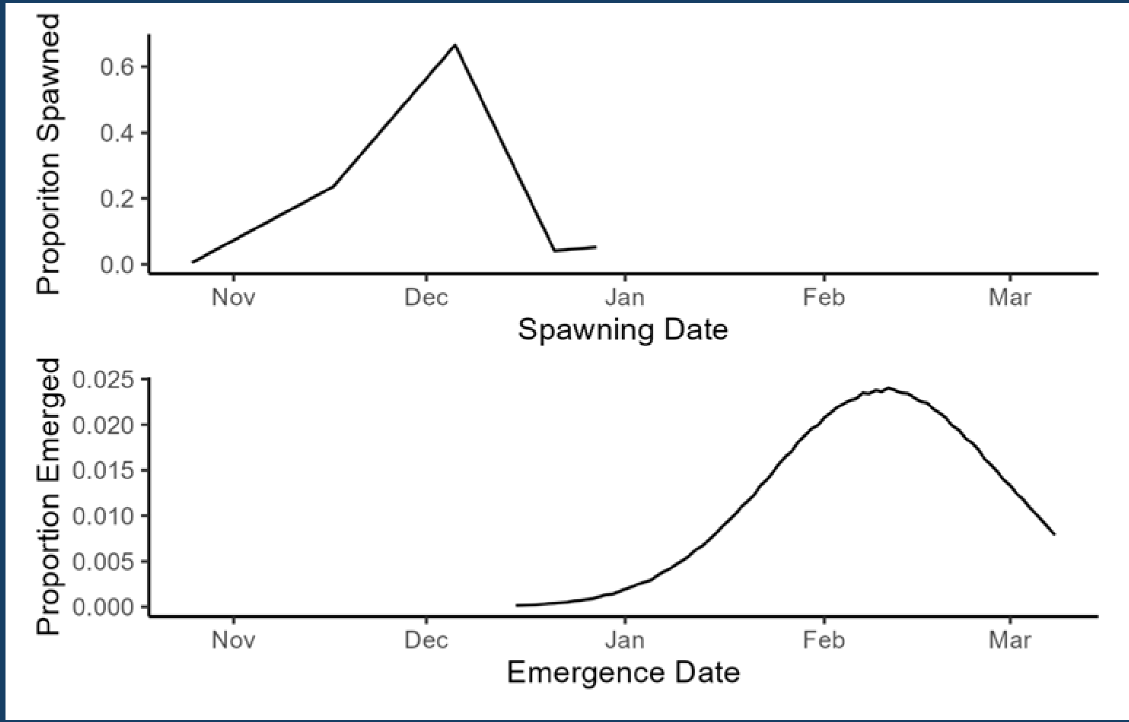
Fish cycle through the model with dynamic growth, survival and migration.

Dynamic growth depends on location (LAR growth data)
Survival based on behavior (LAR telemetry data)
Migration distance, behavior (migration), and territory are functions of size.

“Seeding” the model

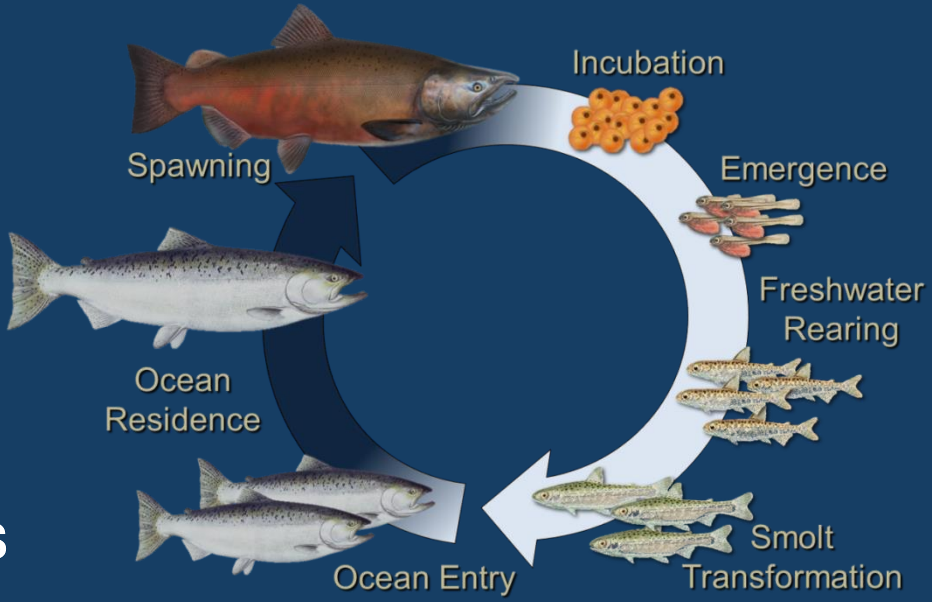
- Initial abundance of emerging fry
- Spatial distribution of emerging fry
- Timing of emergence

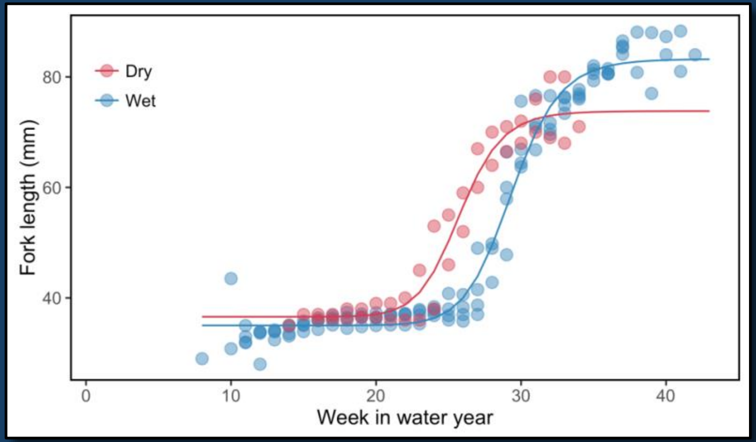


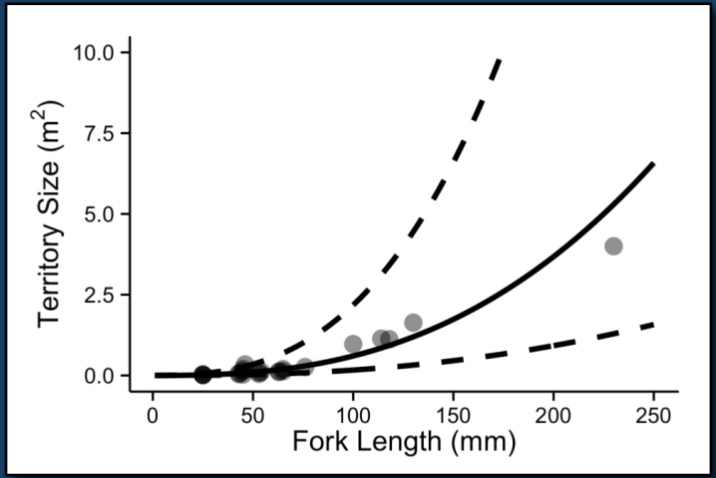


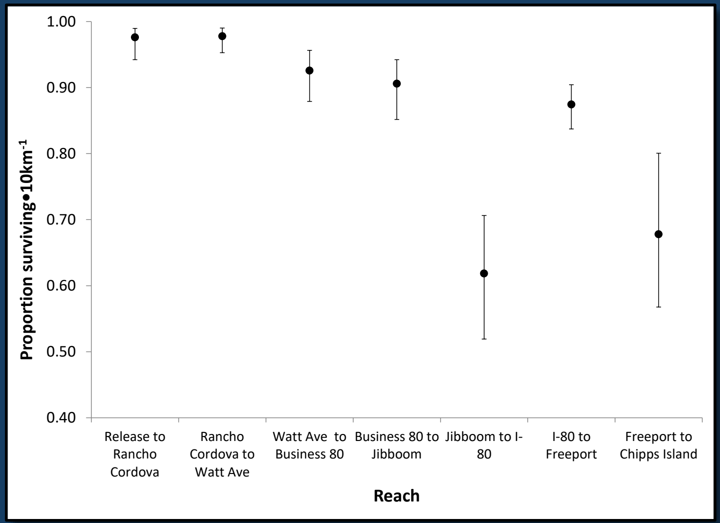
Data Are Leveraged To Inform Life-Cycle Models

- Daily growth rate (mark/recapture study)
- Daily survival rates (migrating/rearing)
- Proportion non-natal rearing fish
- Maximum rearing fish size







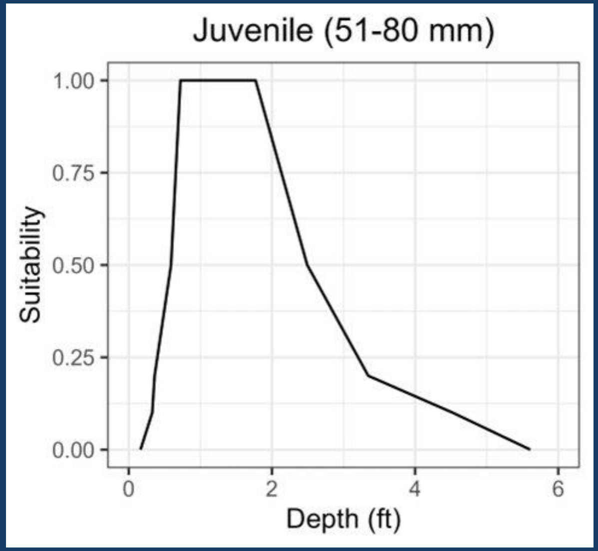


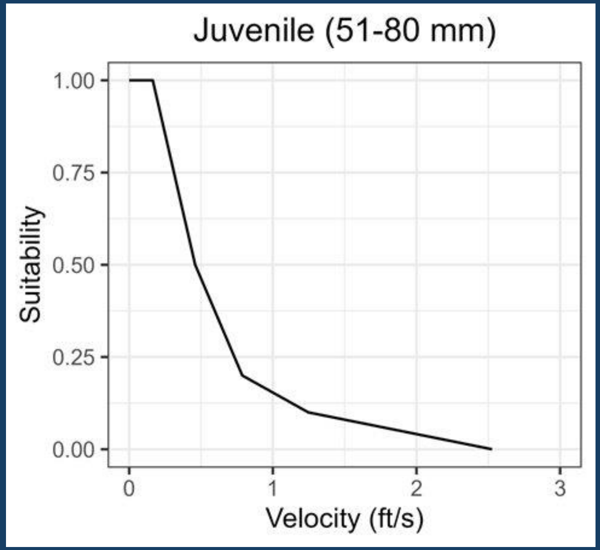
Reach-specific habitat acreage

- Habitat data developed by Verdantas with support from Water Forum and Reclamation and USFWS grant funds
- Long-term snorkel datasets used to develop river-specific suitability curves for depth, velocity, and cover
- Curves applied to a 2D hydraulic model to estimate habitat suitability
- Results collapsed into river-kilometer reaches

Depth and velocity habitat suitability

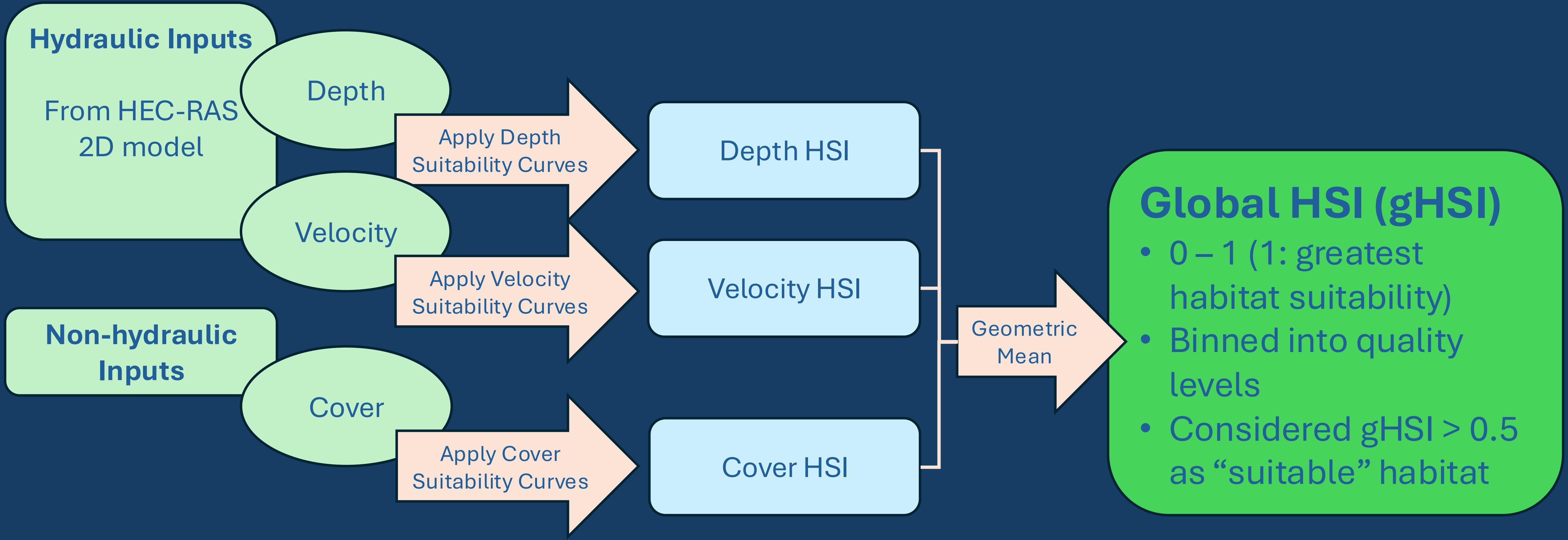
- Snorkel data from 2022 to 2024
- Depth and velocity
    - Non-parametric tolerance limits
- Cover
    - Woody/herbaceous veg, woody material, boulder/cobble, "other"



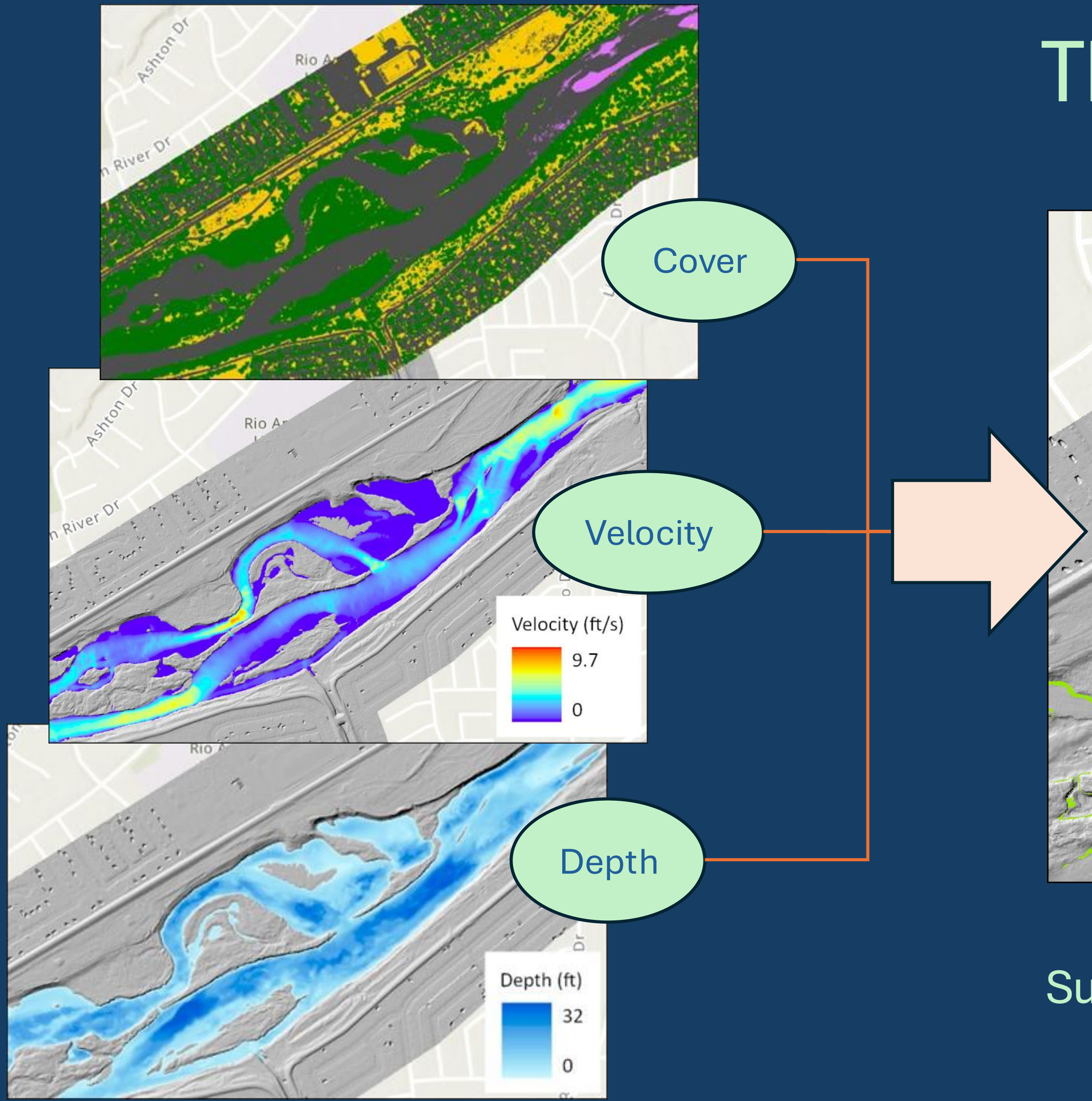


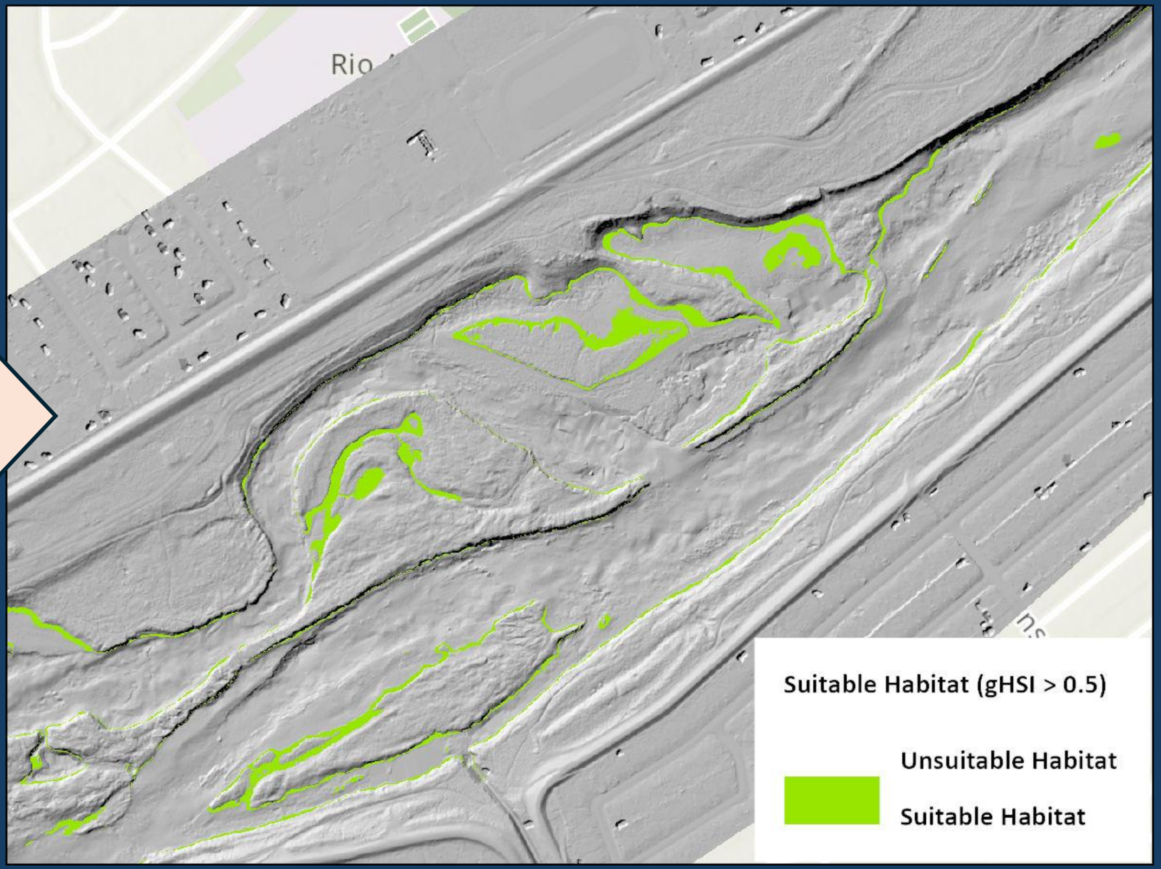
Cover Type	Juvenile
Woody/Herbaceous vegetation	1.0
Woody material	0.8
Boulder/cobble	0.3
None of the above	0.2

Habitat Suitability Index Workflow



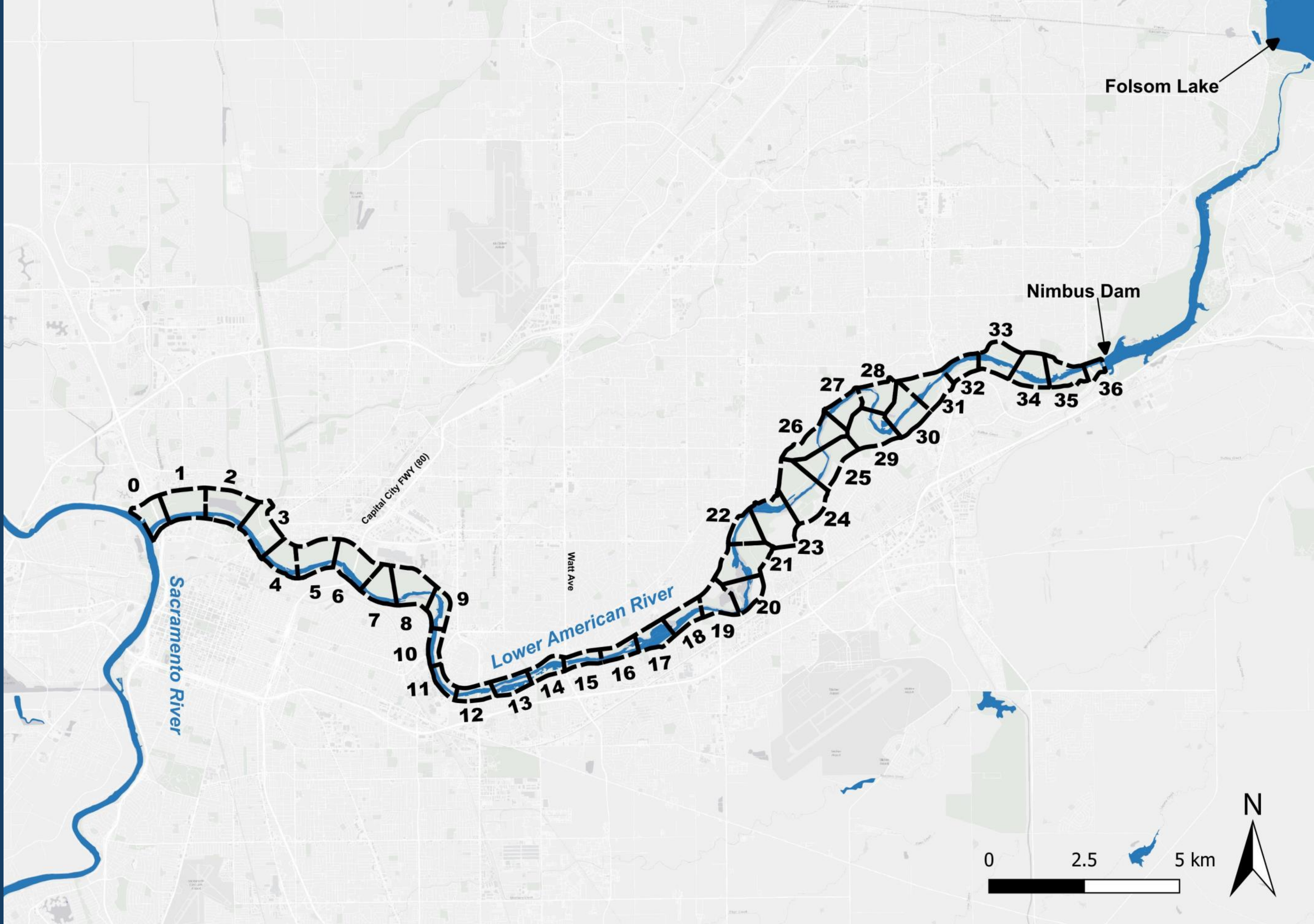
Threshold gHSI



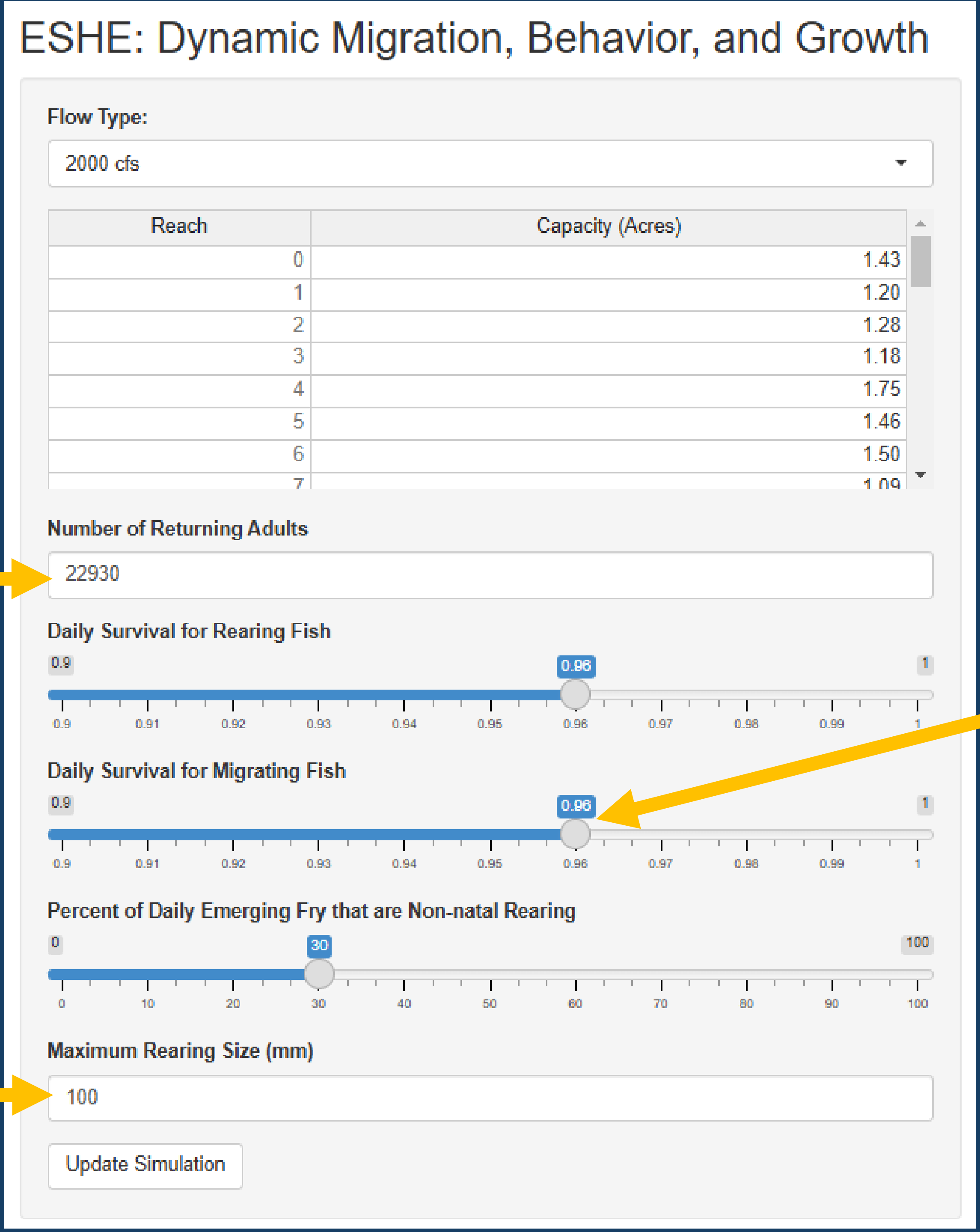


Suitable Habitat = gHSI > 0.5

River reaches



User interface

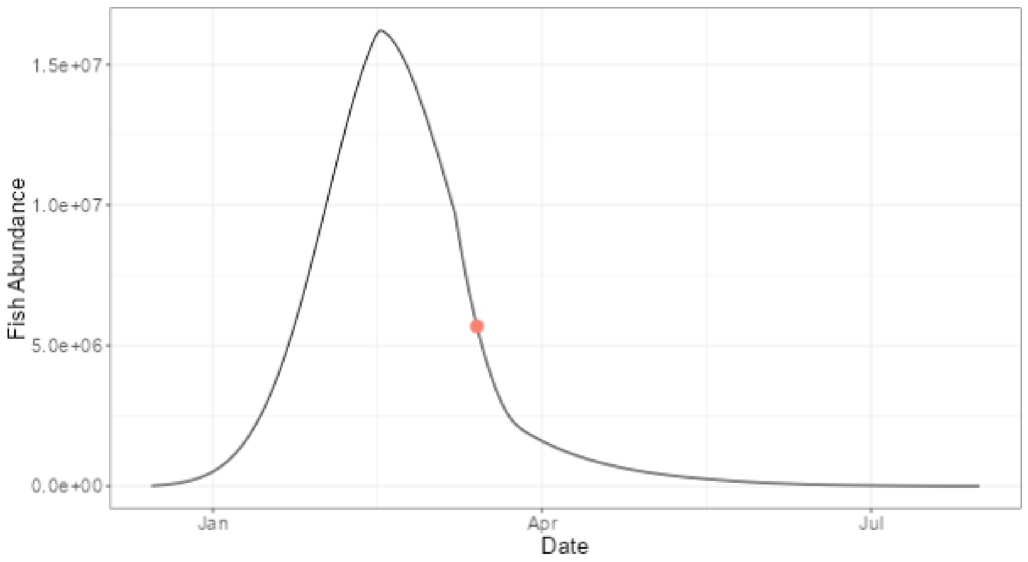


Average escapement (2009-2024)

2016 telemetry study

LAR rotary screw trap data (2013-2024)

Output

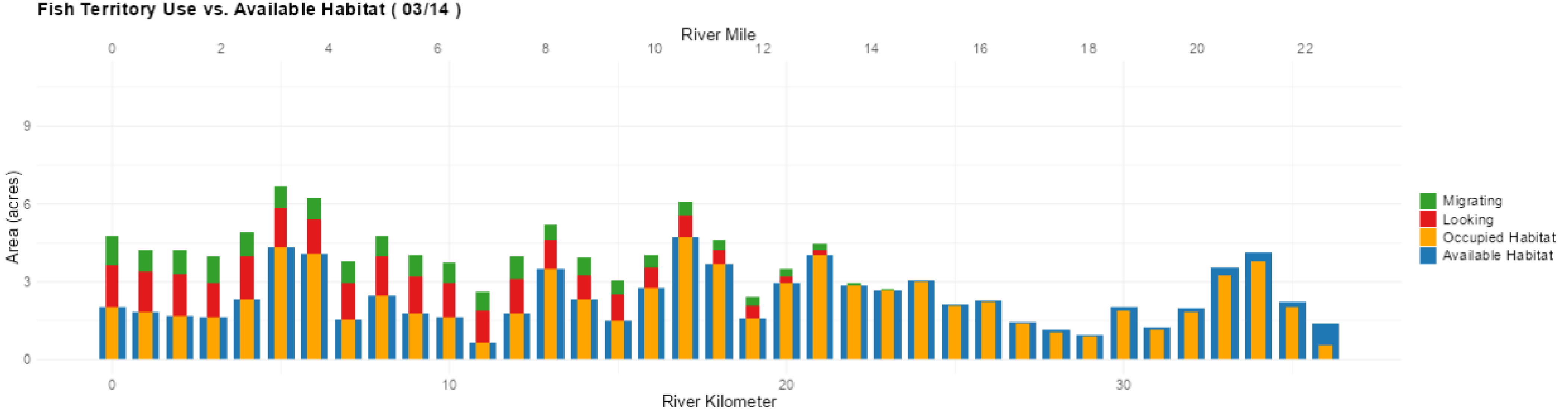


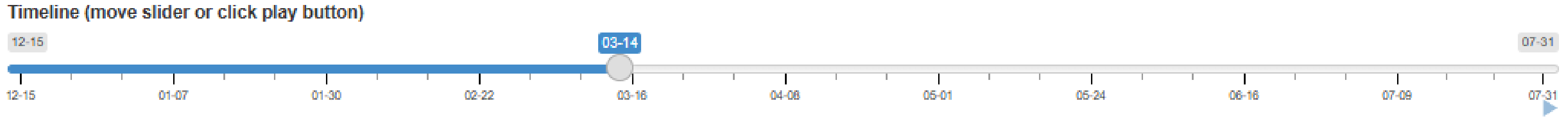
Output From Current Simulation	
Average Outmigrating Size (mm)	63.82
Average Duration in System (days)	57.00

Day with the greatest overcapacity: 02/17

Top 5 Reaches Over Capacity

Reach	Amount Over Capacity (Acres)
21	4.14
20	4.09
19	3.96
16	3.94
13	3.93





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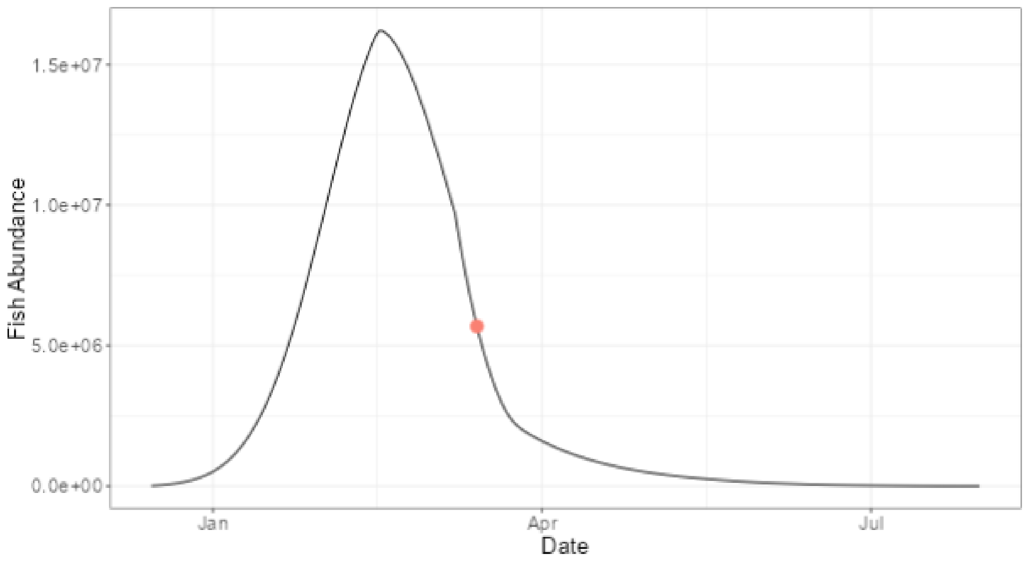

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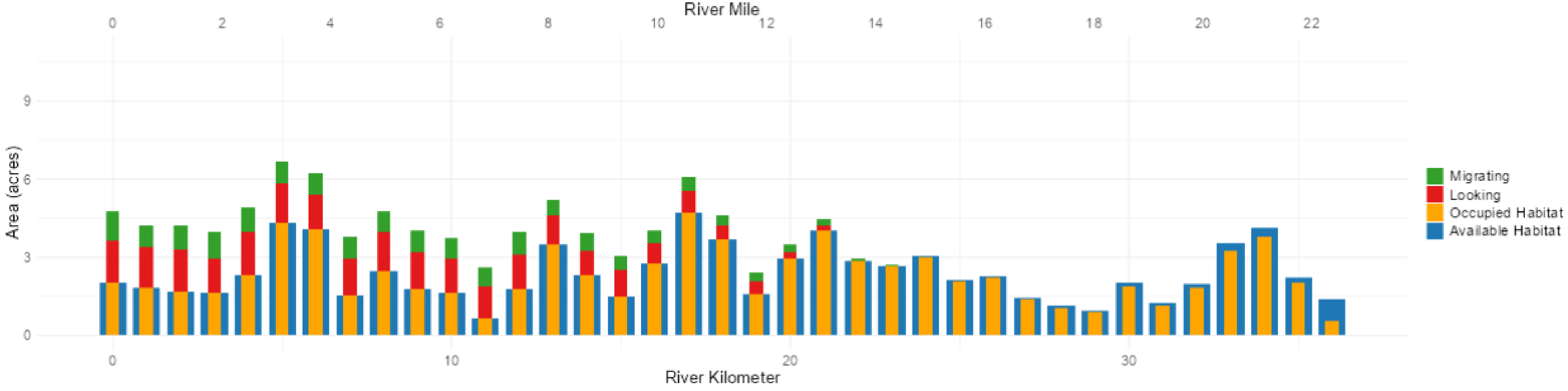
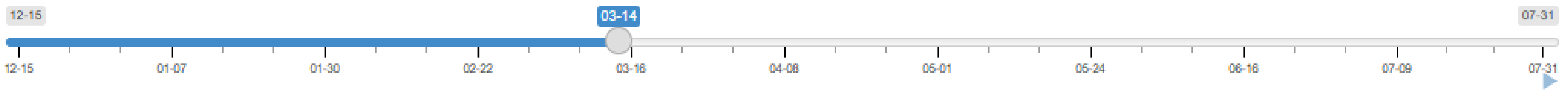
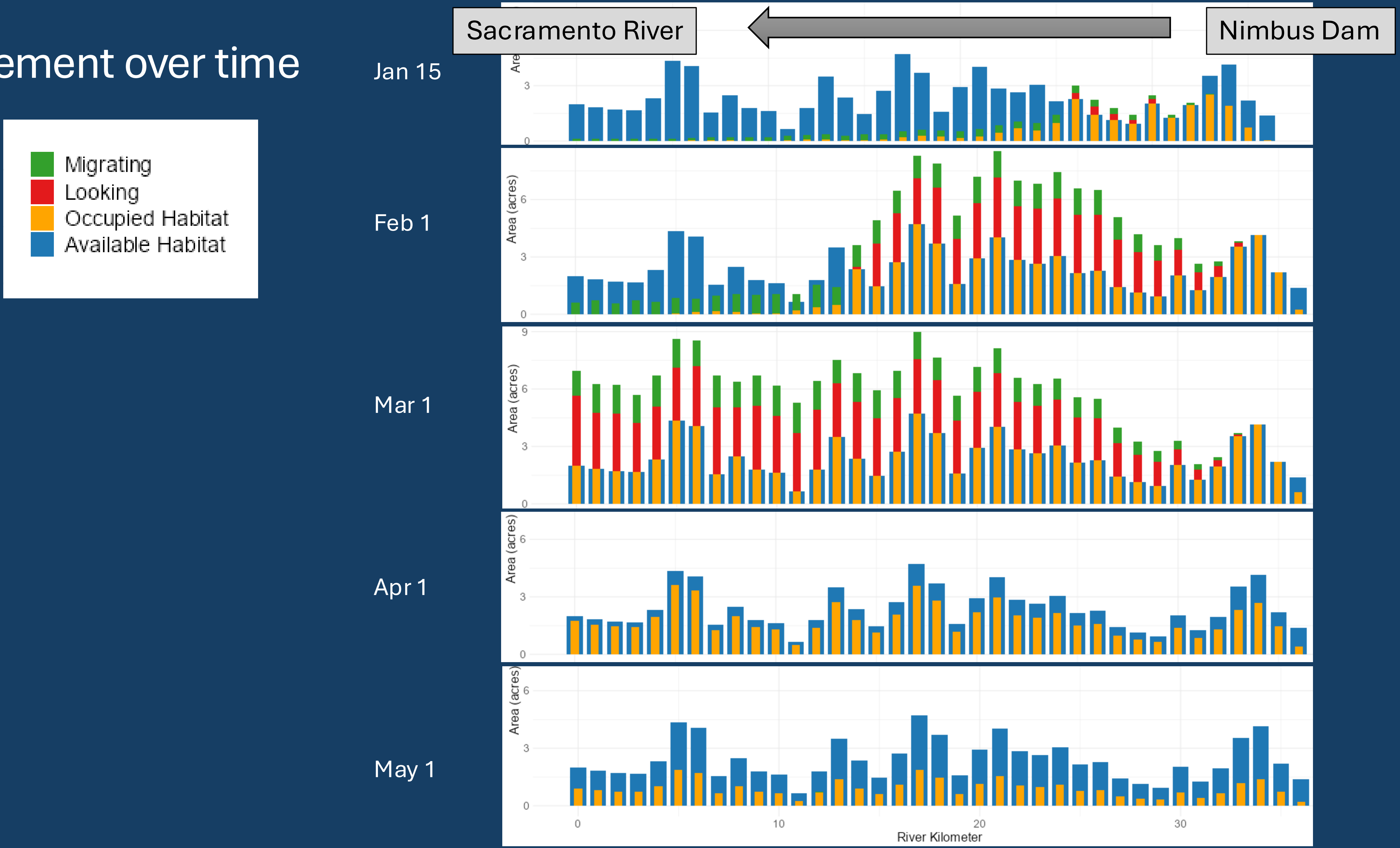
Fish Territory Use vs. Available Habitat (03/14)



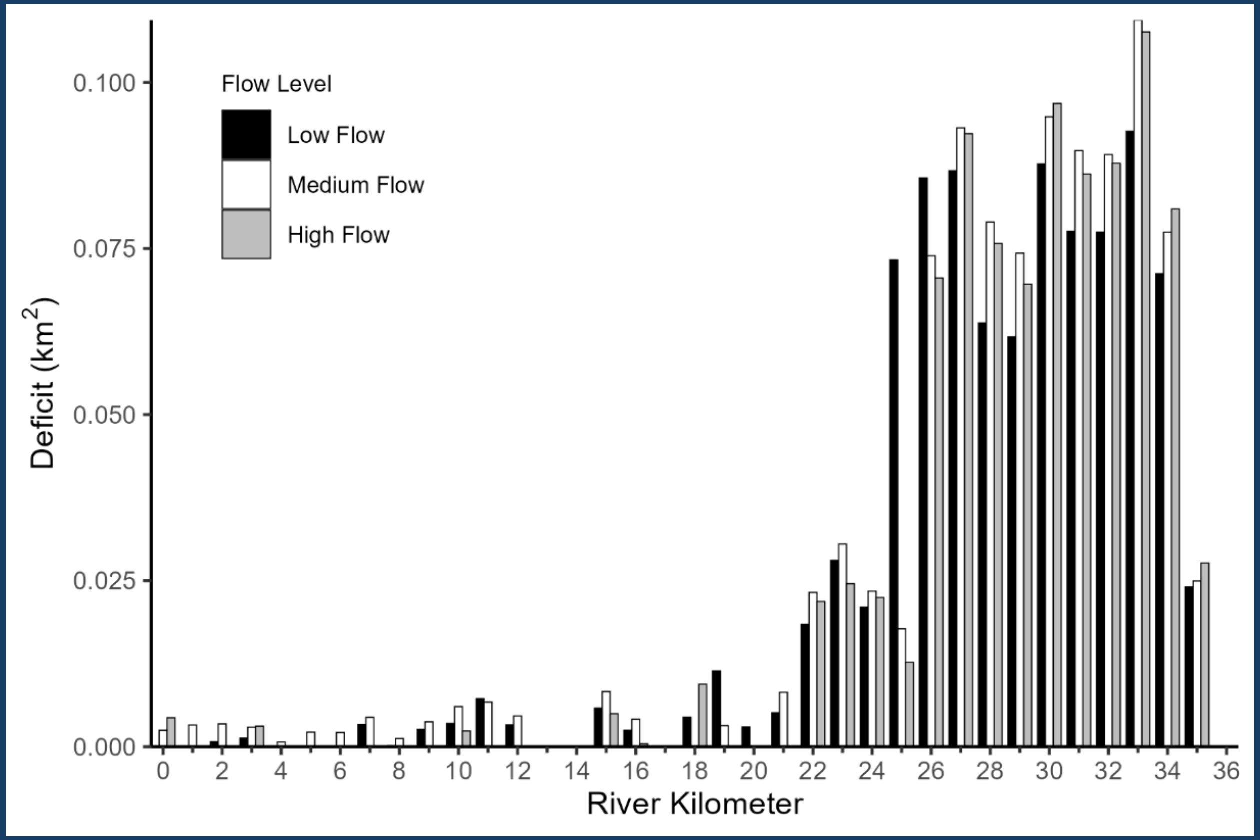
Timeline (move slider or click play button)



Movement over time

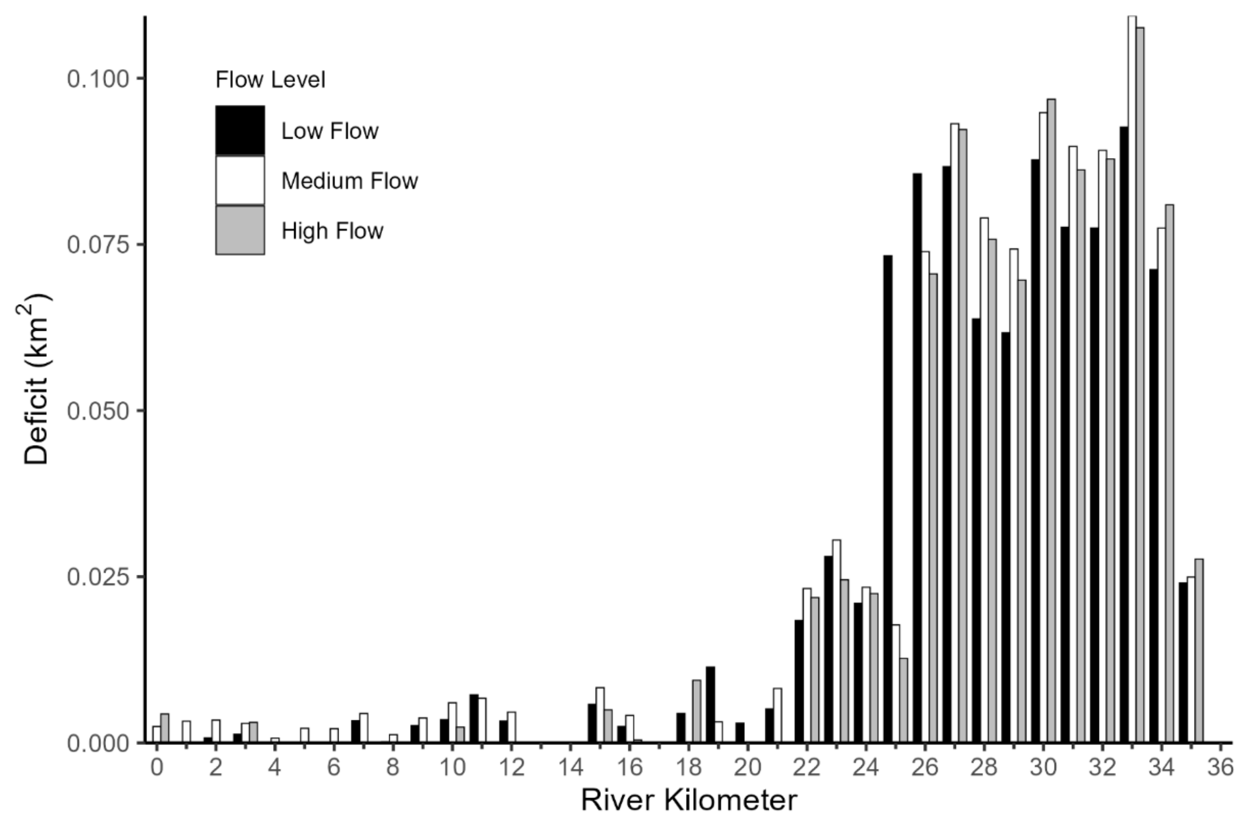


Habitat deficits for various flows and population levels



Current Population

Habitat deficits for various flows and population levels



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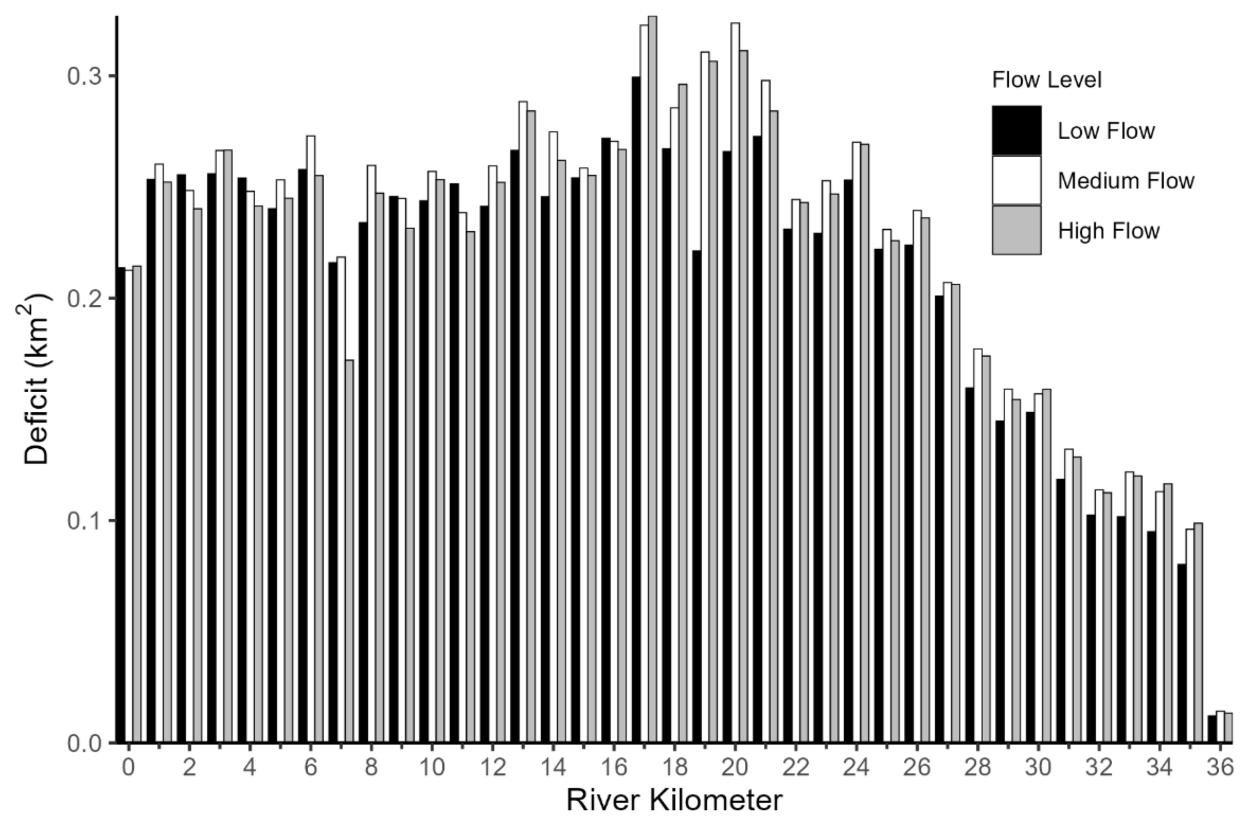
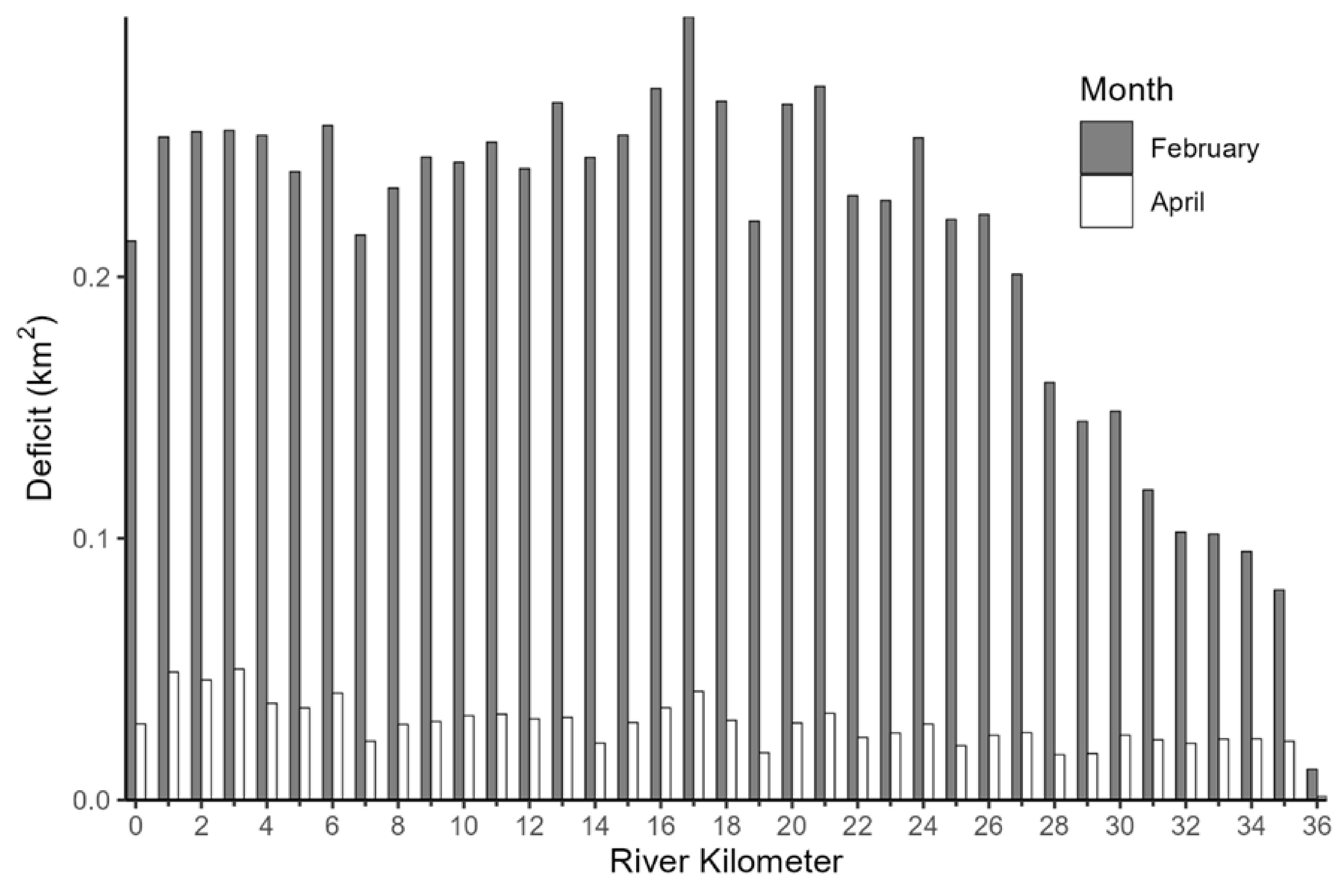


Goal Population

Seasonal habitat deficits



What are the reaches of greatest habitat deficit?

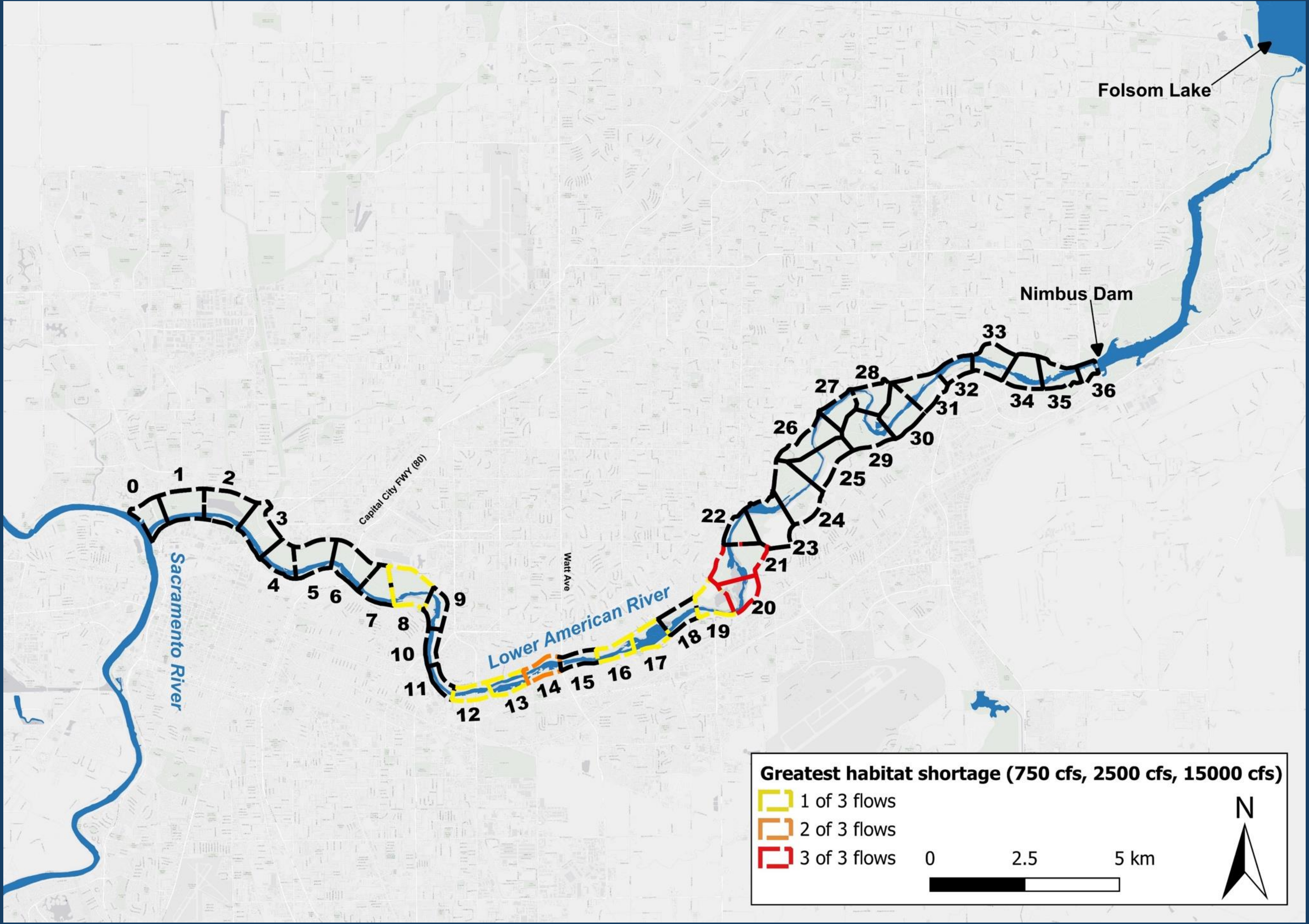
Output From Current Simulation	
Average Outmigrating Size (mm)	63.29
Average Duration in System (days)	56.00

Day with the greatest overcapacity: 02/18

Top 5 Reaches Over Capacity

Reach	Amount Over Capacity (Acres)
21	4.18
20	4.14
17	3.99
16	3.97
13	3.96

Habitat deficit for all flows typically occurs February 18 through February 22



Current work and future directions

- Integrate ESHE into restoration planning with other tools
- Adjust rearing habitat by reach to explore “what-if” scenarios
- Continue to refine model as additional data becomes available
- Peer reviewed publication
  - In review with Ecological Modeling journal

Thank you!

Contact:

Kirsten Sellheim

Cramer Fish Sciences

kirsten.sellheim@fishsciences.net

ESHE

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BREAK

PARENTAGE-BASED TAGGING

Using Genetics to Monitor Central Valley Chinook Salmon

Elyse Freitas, Senior Environmental Scientist, Fisheries Branch, California Department of Fish and Wildlife

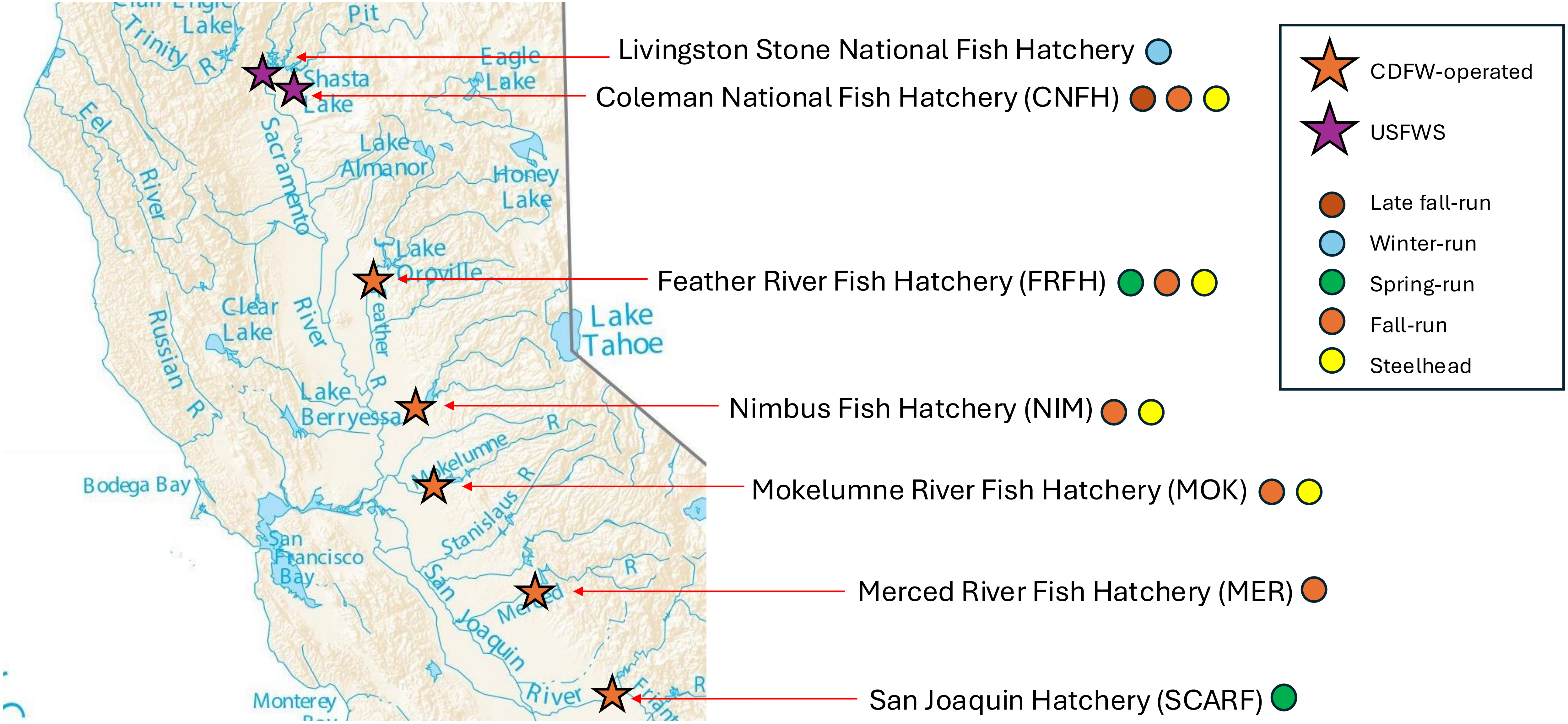
Outline

- Hatchery Production
- Constant Fractional Marking Program
- Parentage-Based Tagging
- Recoveries of PBT Fish (Results)
- Implementation Challenges

Central Valley Chinook Salmon Production

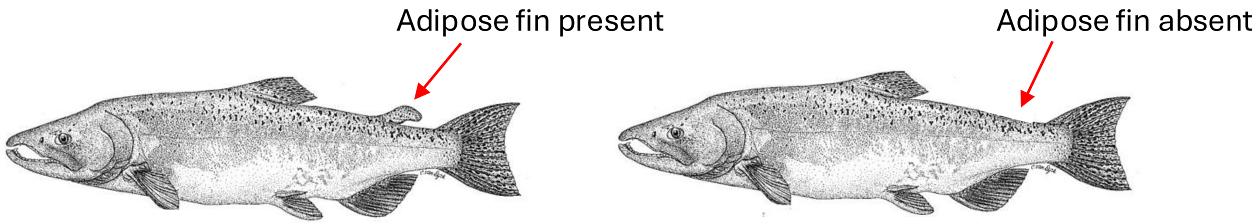
- Each year, the seven Central Valley hatcheries release up to 36 million Central Valley Chinook Salmon smolts
  - Mitigation
  - Ocean Enhancement
  - Conservation
- Hatchery-origin fish contribute to:
  - Ocean commercial & recreational fisheries
  - Inland recreational fishery
  - Escapement
- Monitoring is critical to management

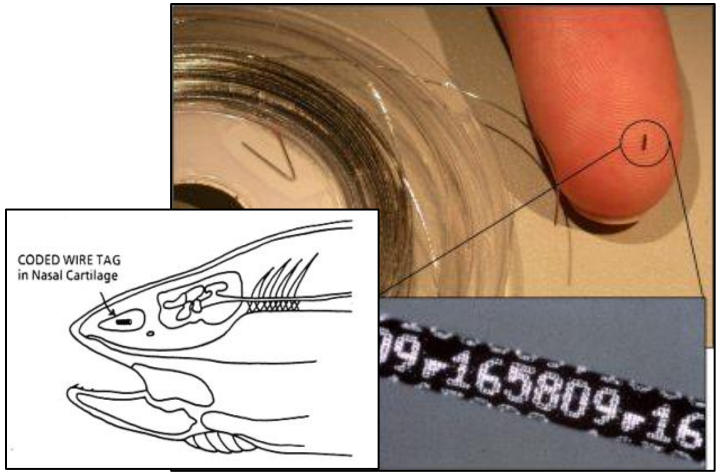
Central Valley Chinook Salmon Hatcheries



Marking/Tagging Hatchery Chinook Salmon

- Smolts mark/tagged with an adipose fin-clip and coded wire tag (CWT) prior to release:
  - Central Valley fall-run: minimum 25%
  - Central Valley spring-run: 100%
  - Sacramento River winter-run: 100%





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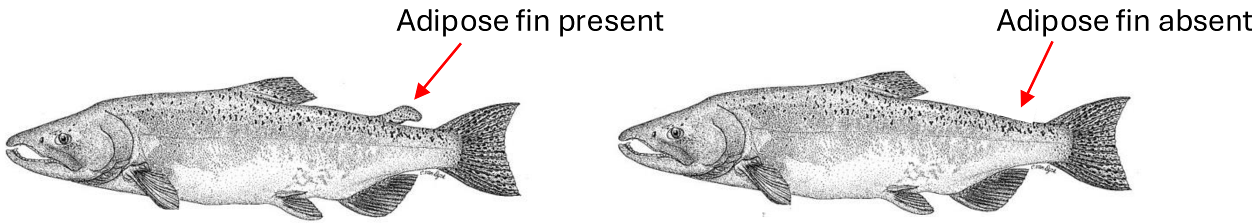
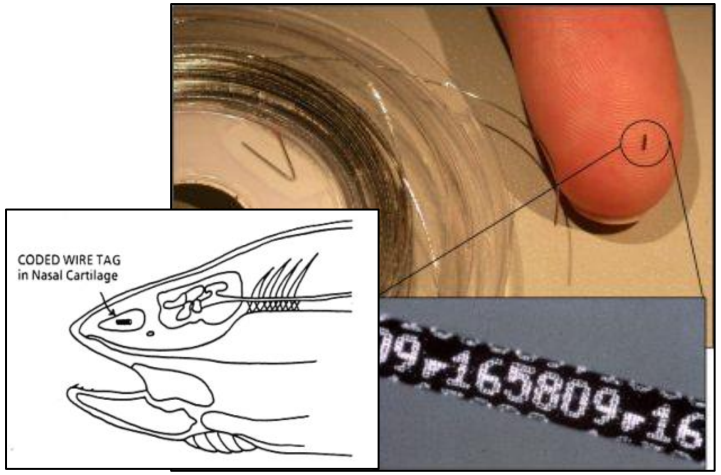


- CWT = 1.1 mm metal tag inserted into the snout of a juvenile salmon
  - Method introduced in the 1970s, use was standardized in CA in 2007
  - CWTs recovered by dissection of the salmon head & read under a microscope



Constant Fractional Marking Program (CFM)

- Valley-wide program to mark/tag hatchery production for management, began in spring 2007 (BY 2006 smolts):
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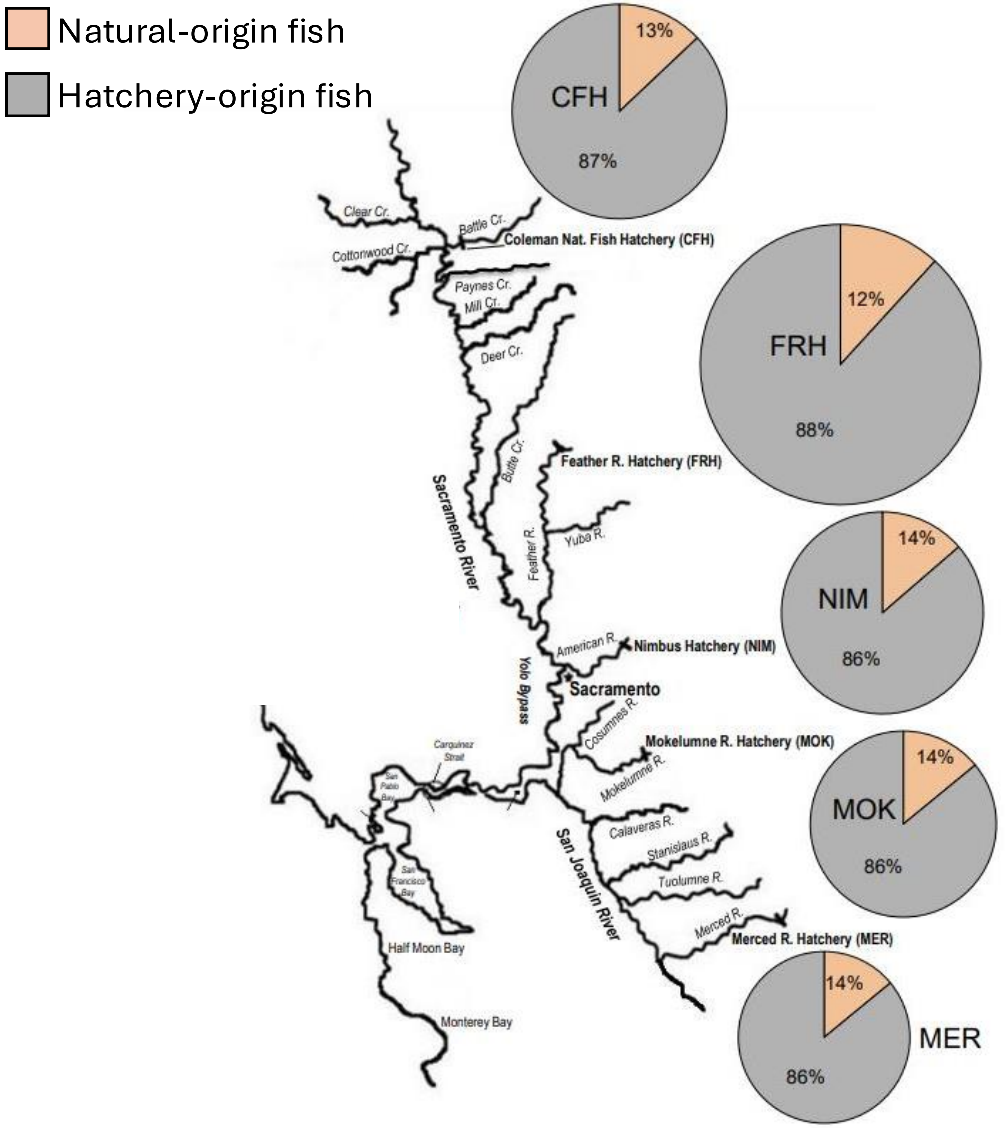
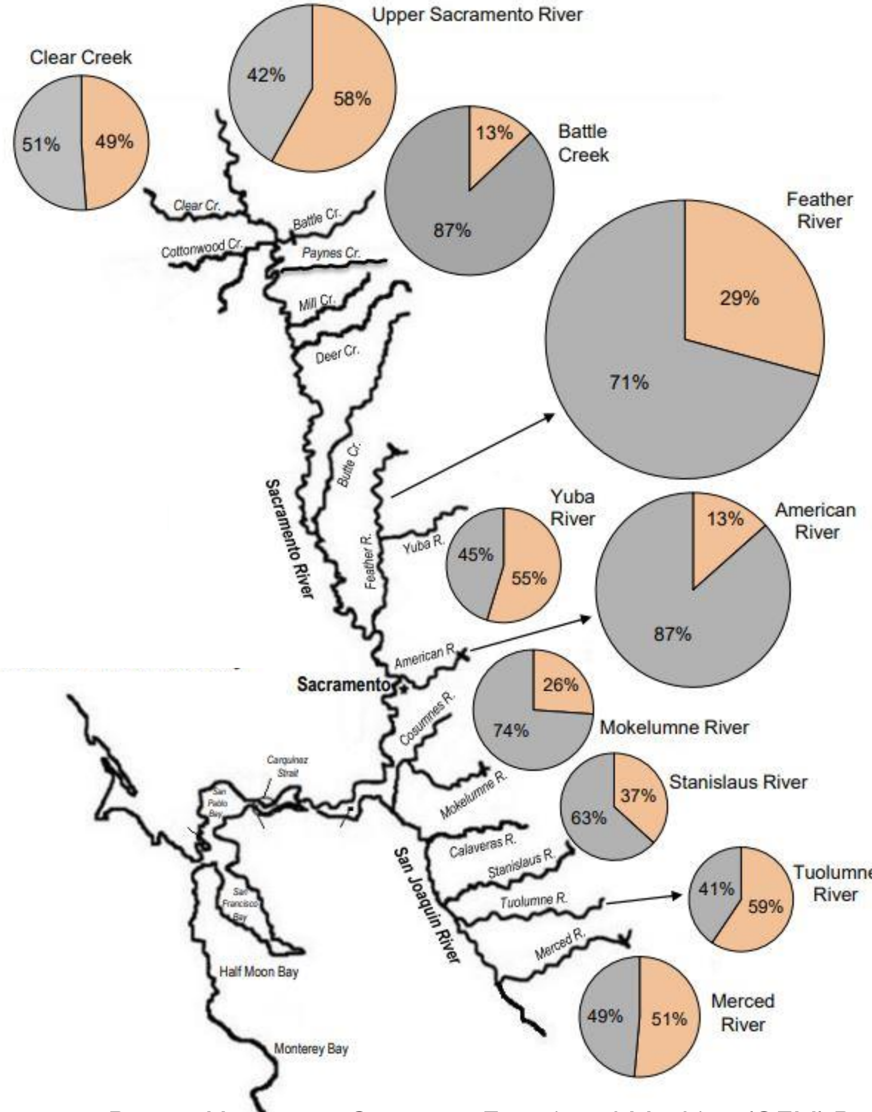
- Recovery programs methodologies were standardized to ensure adequate CWT recoveries for analyses
  - Heads collected from marked fish at targeted rates, sent to a lab for dissection & reading of the CWT
- Raw data available on the Regional Mark Information System (RMIS) operated by Pacific States Marine Fisheries Commission
- Data are analyzed and results are published, available at CalFish.com

Constant Fractional Marking Program (CFM)

- Analyses are used to:
  - Estimate the relative contributions of hatchery-origin and natural-origin fish to escapement
  - Evaluate stray rates of hatchery-origin fish
  - Determine relative success of different release strategies
  - Estimate stock composition of fisheries take
  - Assess fisheries' impacts on listed natural-origin stocks
  - Inform fisheries' harvest control guidelines and season developments

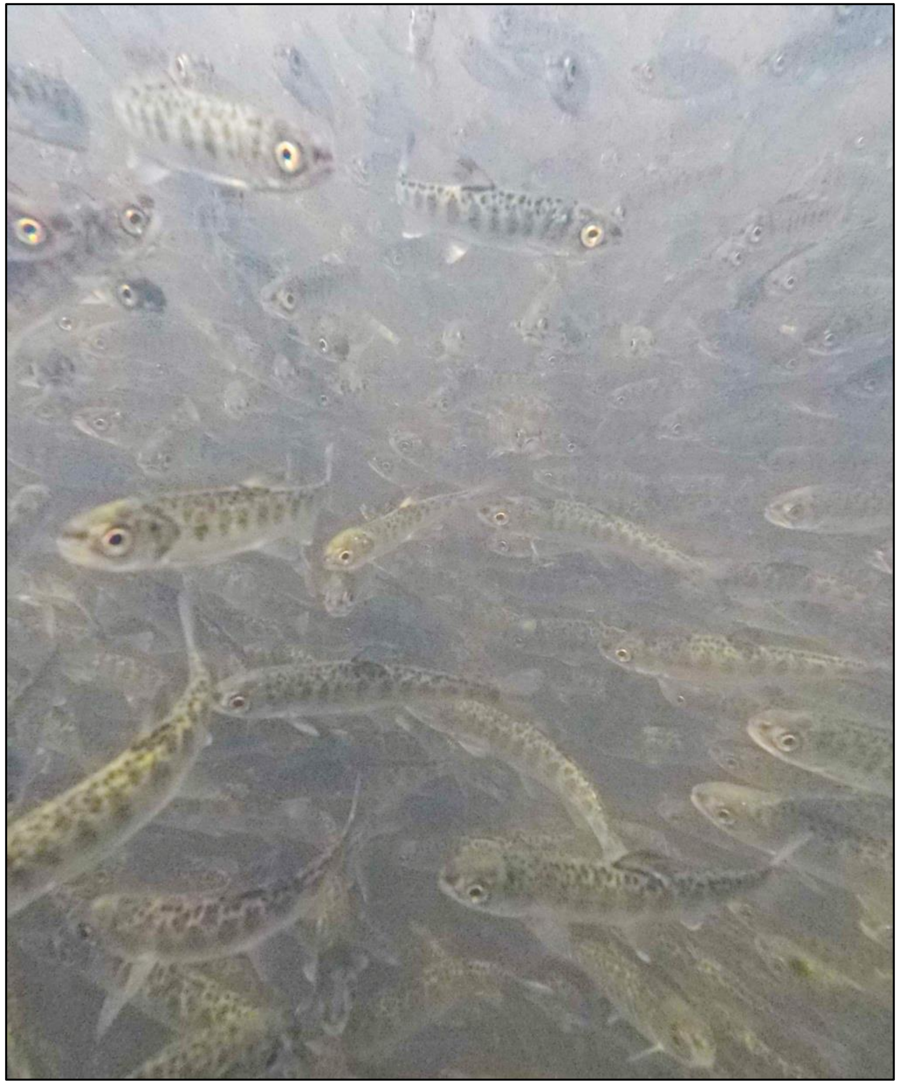
Constant Fractional Marking Program (CFM)





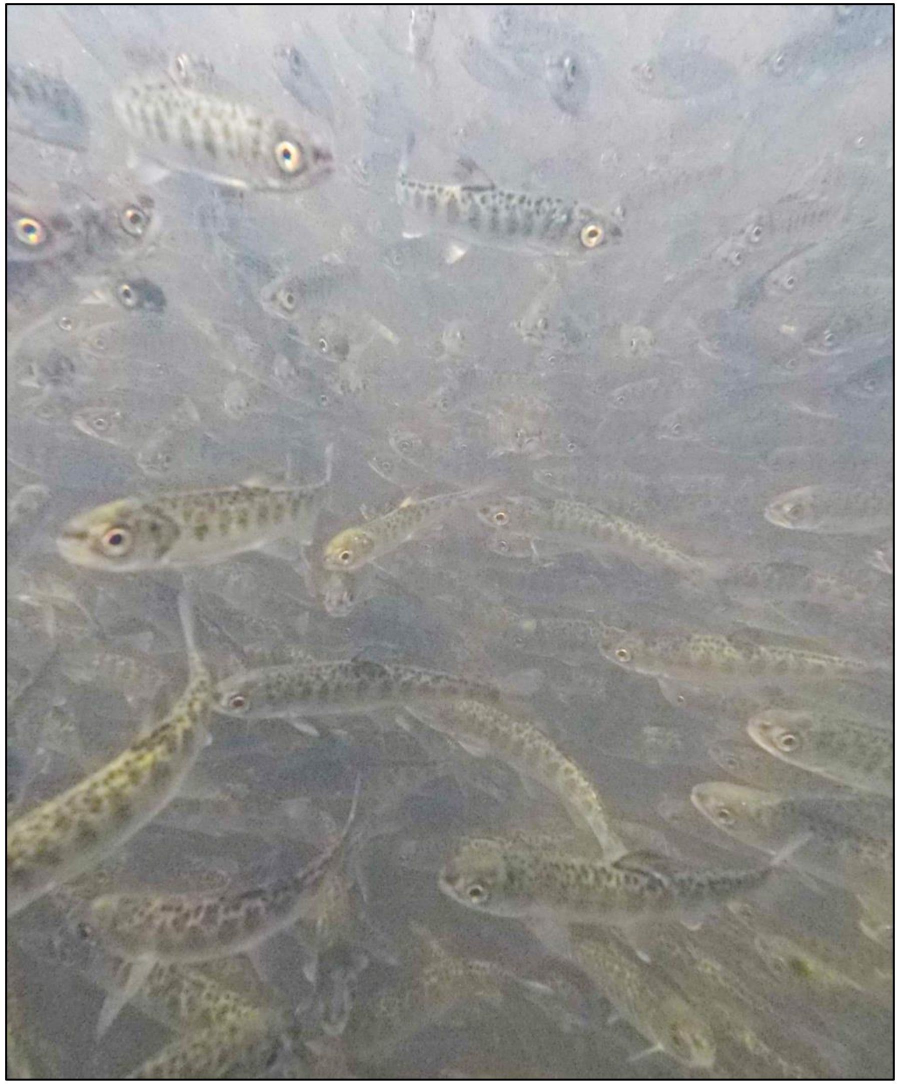
Return Year 2020 Constant Fractional Marking (CFM) Report, 2023

Limitations to the CFM



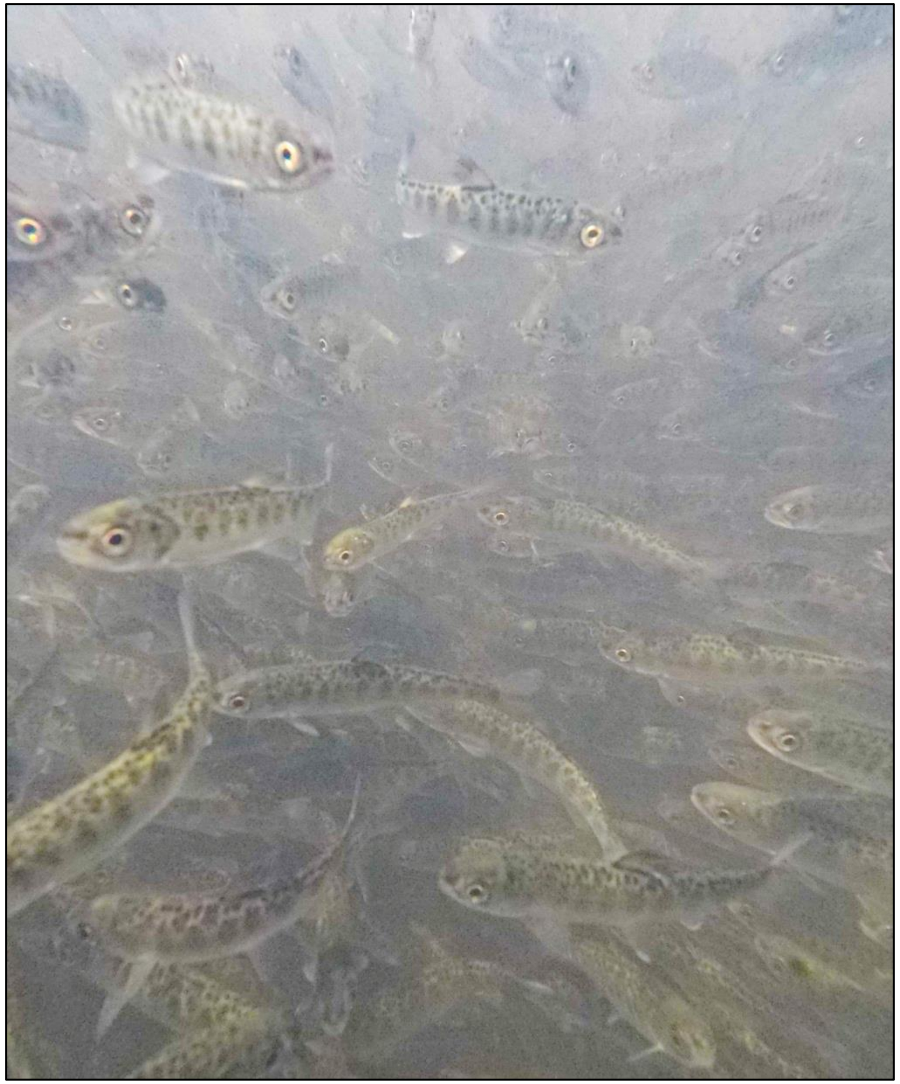
- Fish must be grown to a size of at least 57 mm before they can be marked/tagged
  - Tagging generally occurs ~150 days post-spawn, depending on water temperature, health, logistics

Limitations to the CFM



- Fish must be grown to a size of at least 57 mm before they can be marked/tagged
  - Tagging generally occurs ~150 days post-spawn, depending on water temperature, health, logistics
- Marking/tagging results in handling stress

Limitations to the CFM



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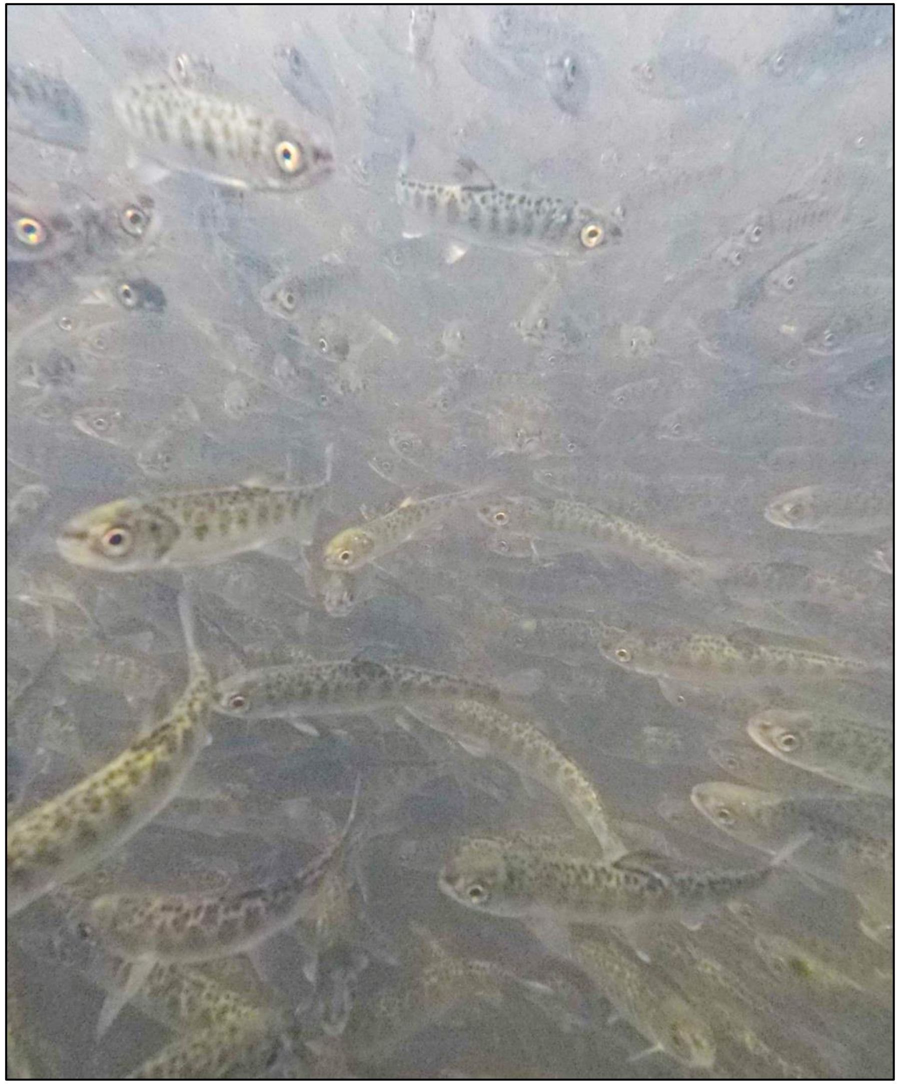
- Marking/tagging results in handling stress
- Complicated logistics & staffing shortages

Limitations to the CFM



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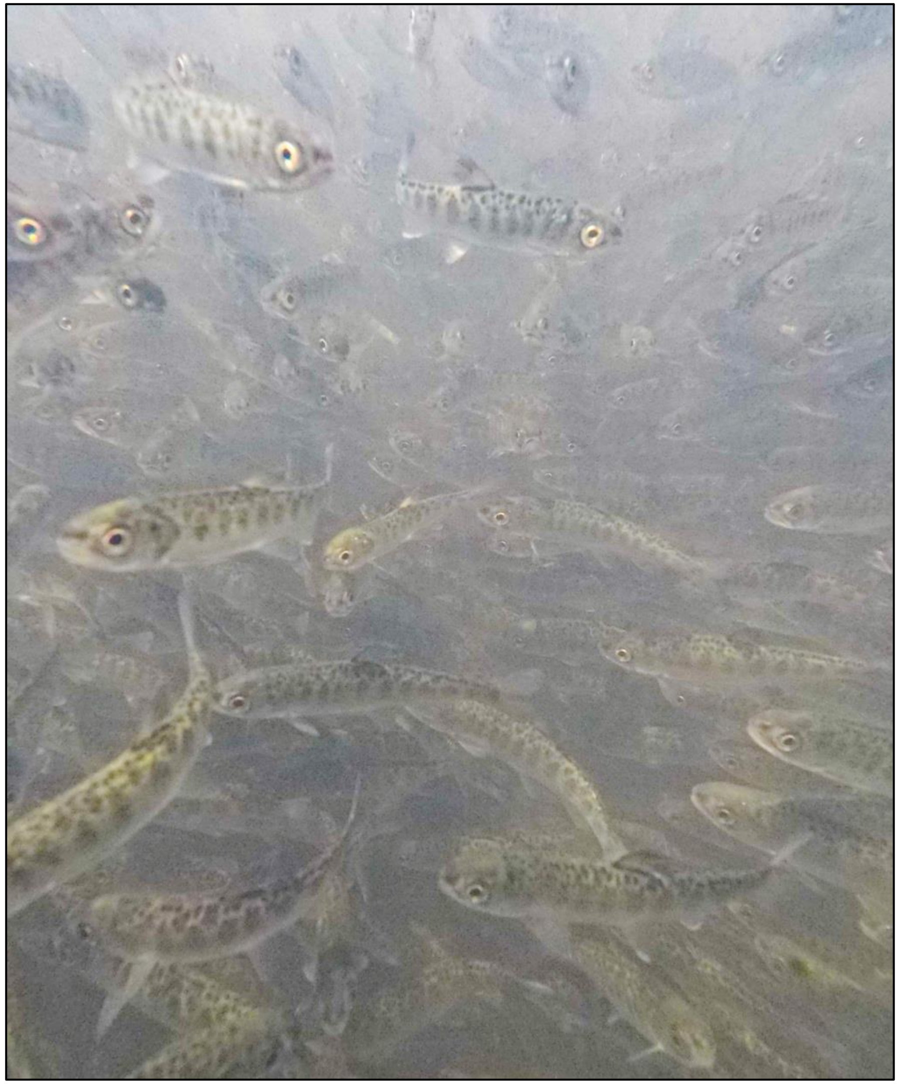

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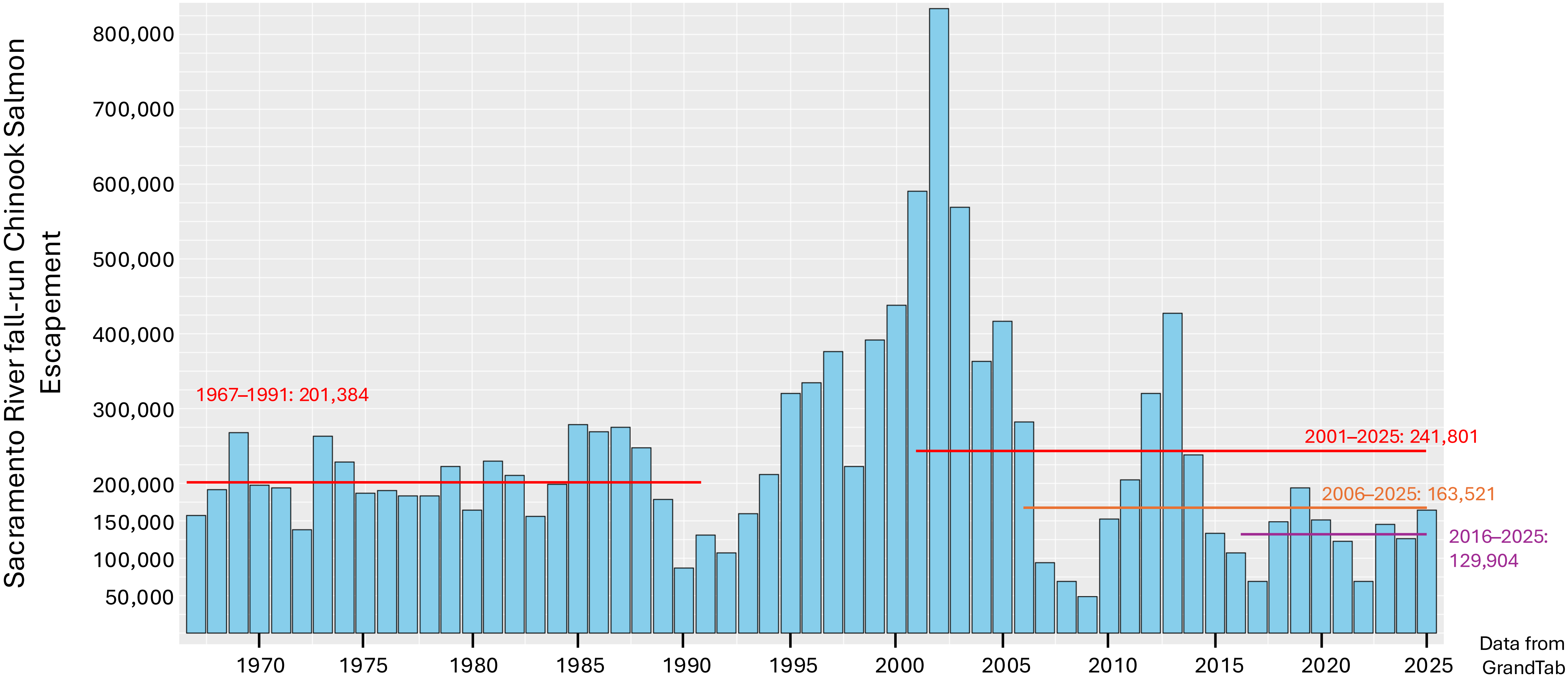
- Tags can only be recovered lethally

Population Decline



Data from GrandTab

Fry Releases

- Hatchery smolt production is limited by rearing space
  - The number of eggs that can be incubated exceeds the number of juveniles that can be reared

Eiko Jones Photography

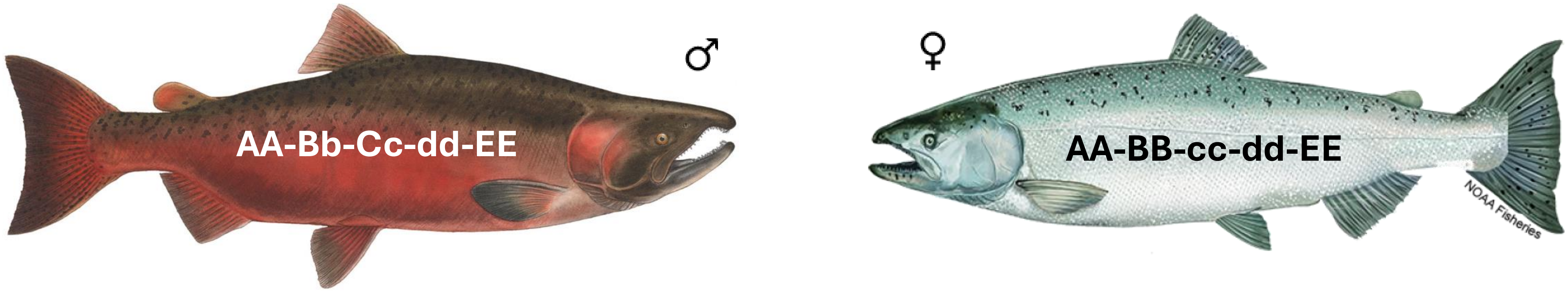
Fry Releases

- Hatchery smolt production is limited by rearing space
  - The number of eggs that can be incubated exceeds the number of juveniles that can be reared
- Fry releases bypass hatchery space limitations BUT fry cannot be physically marked or tagged
- Release of unmarked/untagged fish impacts CFM analyses

Eiko Jones Photography

Parentage-based Tagging (PBT)

- Genetic tagging method: genotypes of the parents are used to tag their offspring



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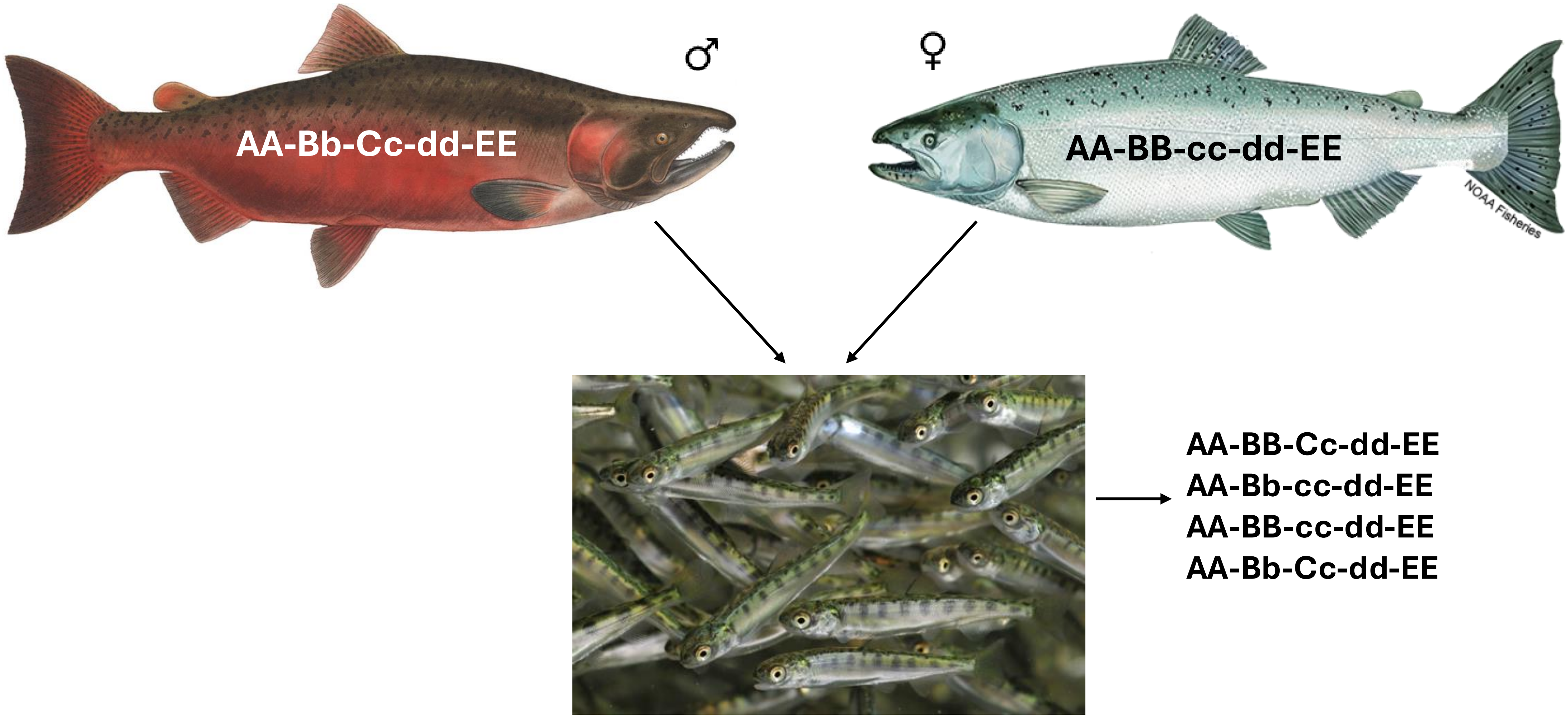

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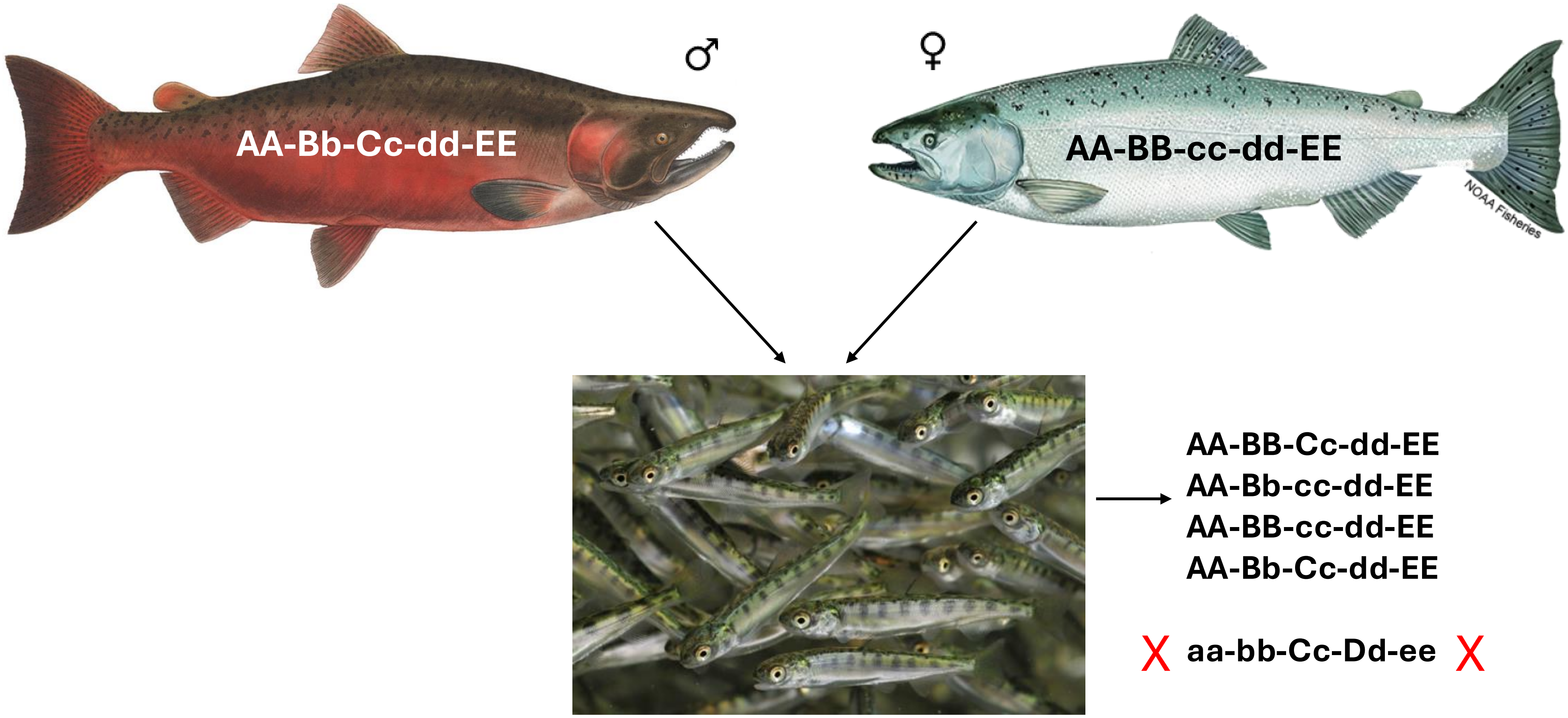

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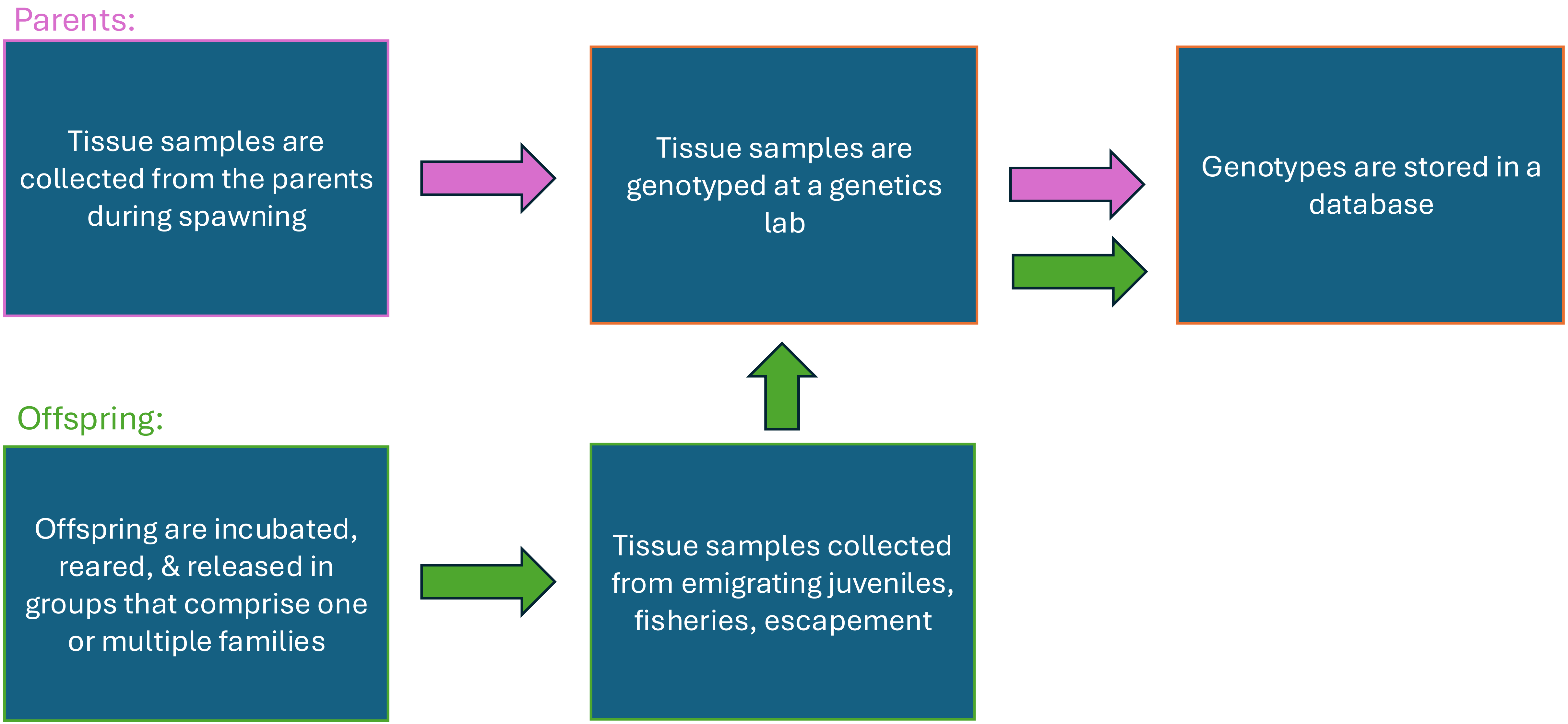
  - No handling stress
- Tag recovery is a tissue sample and is non-lethal
- PBT fish can be released at any time to take advantage of optimal water conditions
- PBT can provide the same data as CWTs for management
  - Additional application for genetic-based broodstock management, population genetic diversity analyses, & heritability studies

PBT Flow Chart

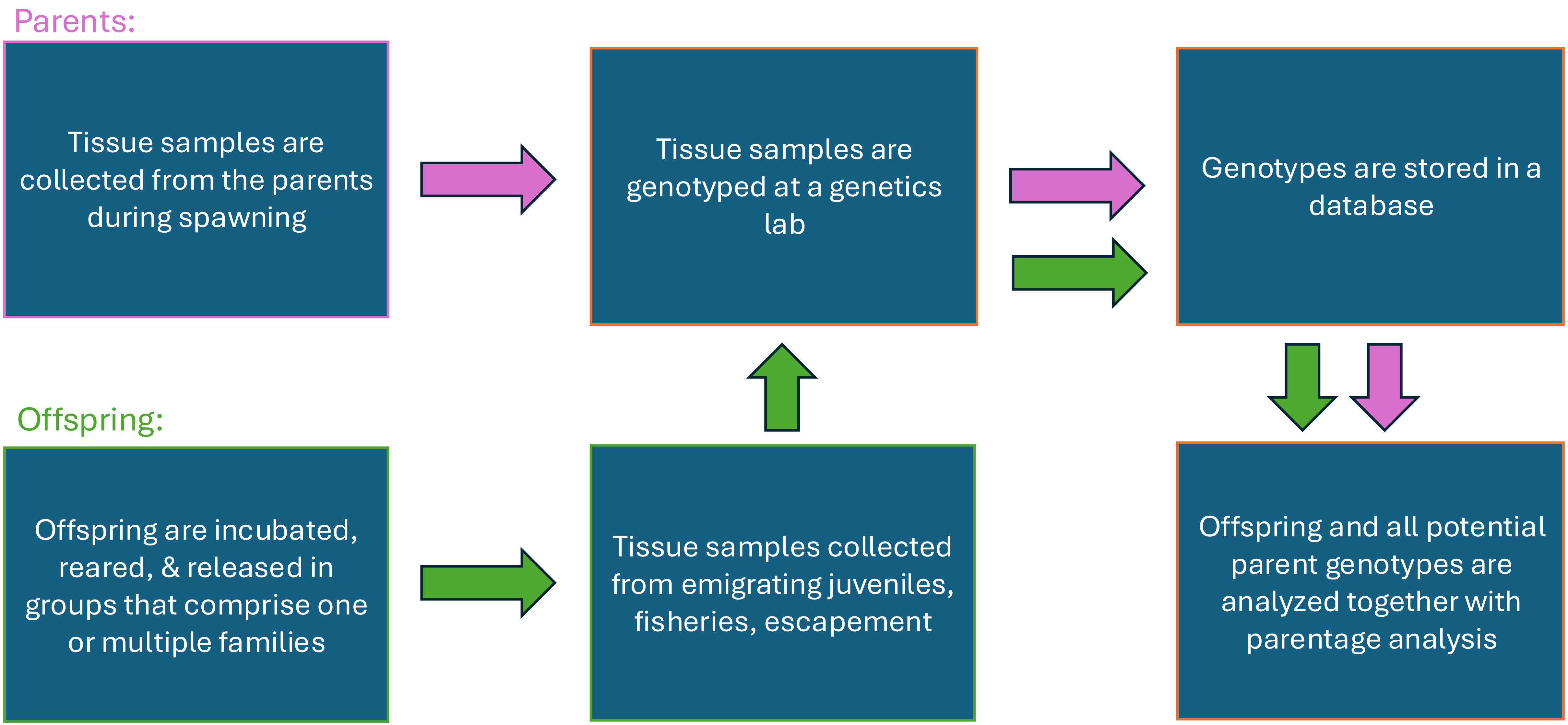
Parents:

1. Tissue samples are collected from the parents during spawning
2. Tissue samples are genotyped at a genetics lab
3. Genotypes are stored in a database

PBT Flow Chart



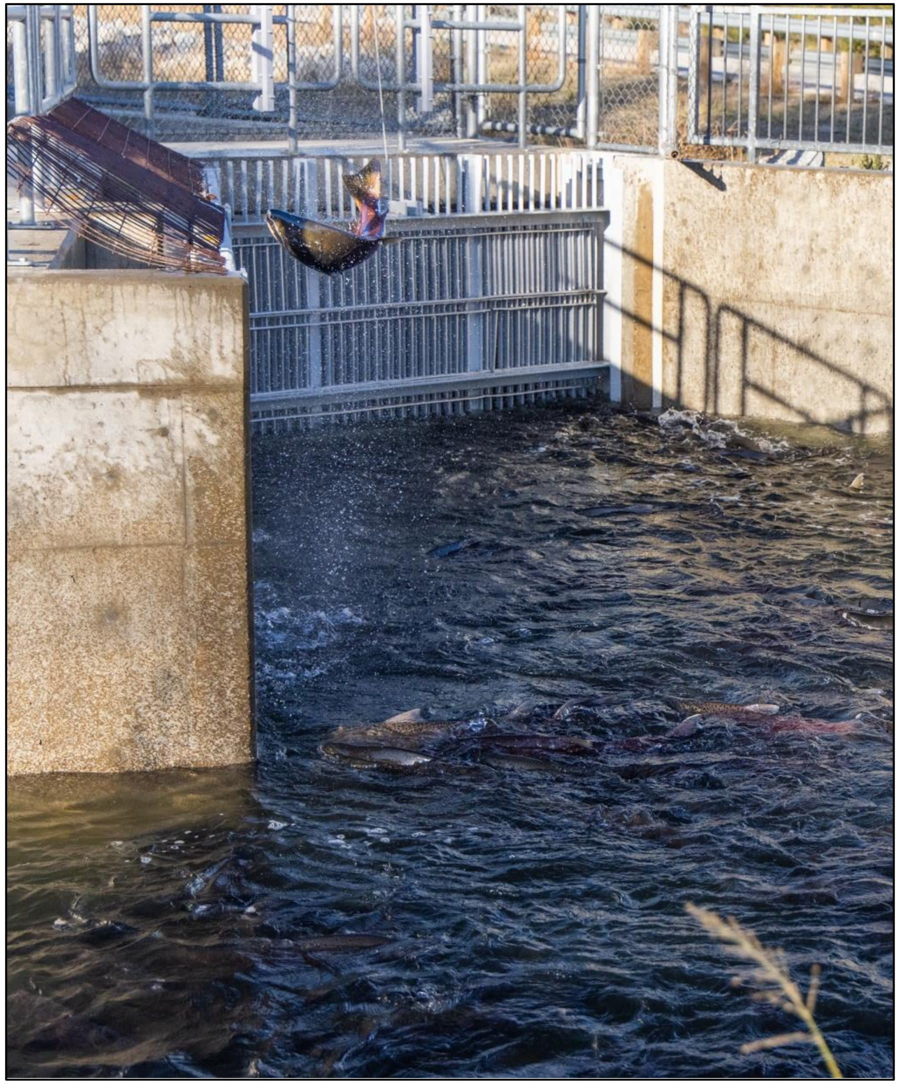
PBT Flow Chart



Central Valley PBT Fry

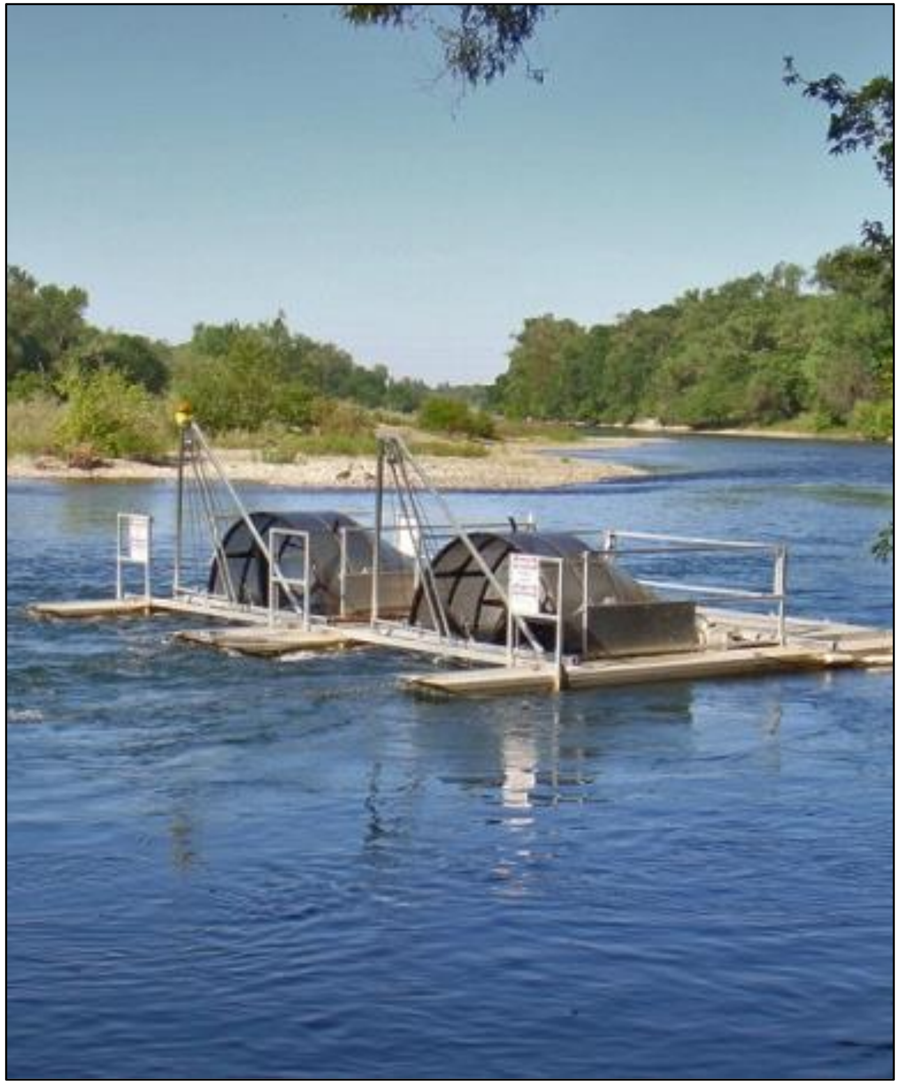
Brood Year	Hatchery	Est. Total Released
2021	CNFH	1,859,029
2022	CNFH	2,766,360
2022	NIM	1,153,036
2023	NIM	2,388,240
2024	FRFH	2,416,214
2024	NIM	2,247,805
2025	CNFH	7,197,359
2025	FRFH	1,886,603
2025	NIM	1,633,319
TOTAL	**---**	**23,547,965**

PBT Recoveries: Hatchery Escapement



- 2024 NIM Grilse Escapement: **3/468**
  - BY 2022 NIM fry release

PBT Recoveries: Juvenile Emigration

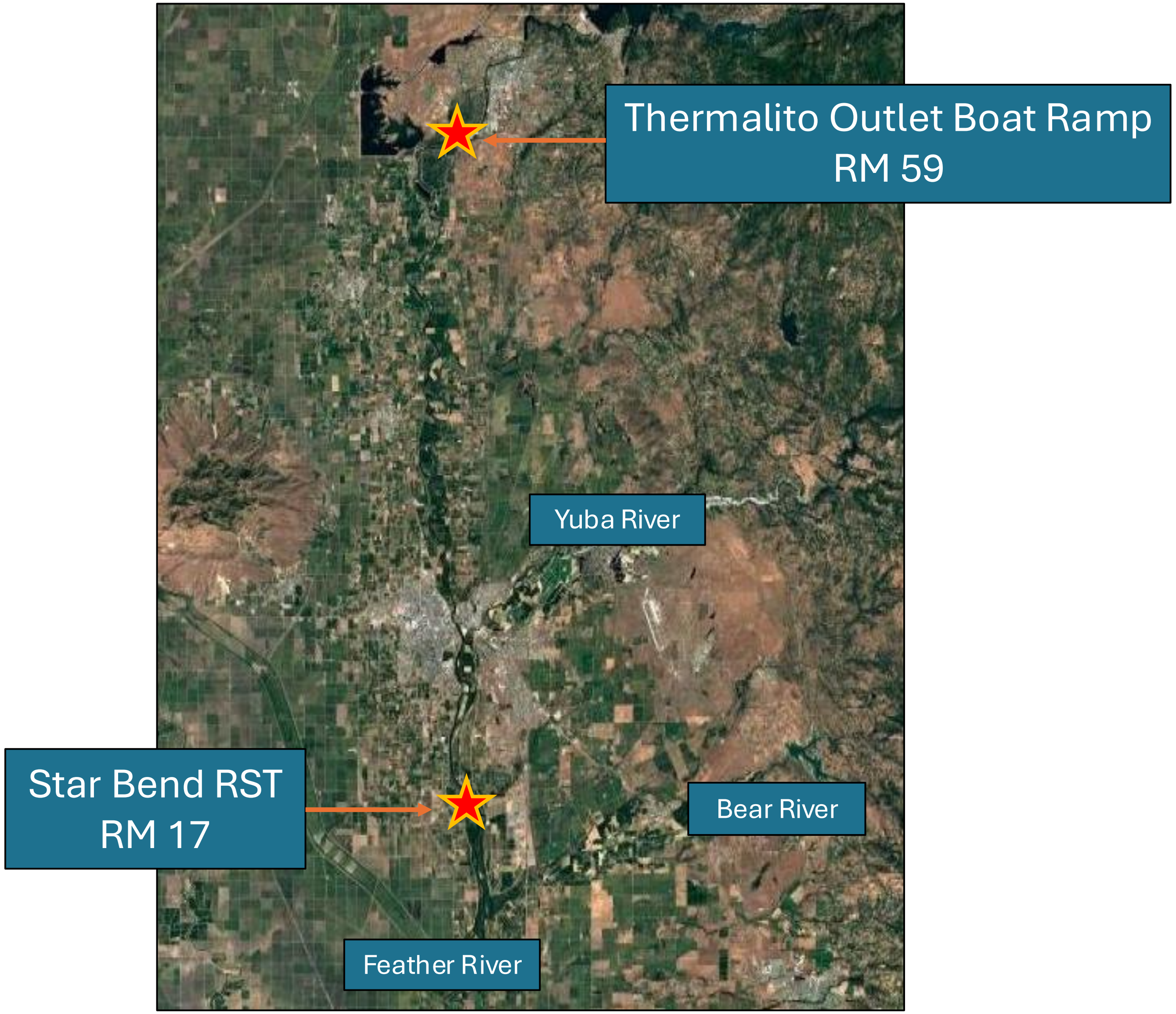


- 2025 Lower Feather River Emigration Monitoring (Star Bend RST): **34/730**
  - BY 2024 FRFH fry release
- 2025 Lower Sacramento River Emigration Monitoring (Lower Sac RST): **13/362**
  - BY 2024 FRFH fry release
- 2025 Lower American River Emigration Monitoring (Watt Ave. RST): **16/997**
  - BY 2024 NIM fry release

PBT Recoveries: Fisheries

- 2025 Ocean Recreational Fishery: **1/395**
  - BY 2022 NIM fry release; 3-year-old
- 2025 Inland Fishery: **1/333**
  - BY 2023 FRFH fry release; 670 mm female grilse caught on the Feather River

Lower Feather River Emigration Recoveries



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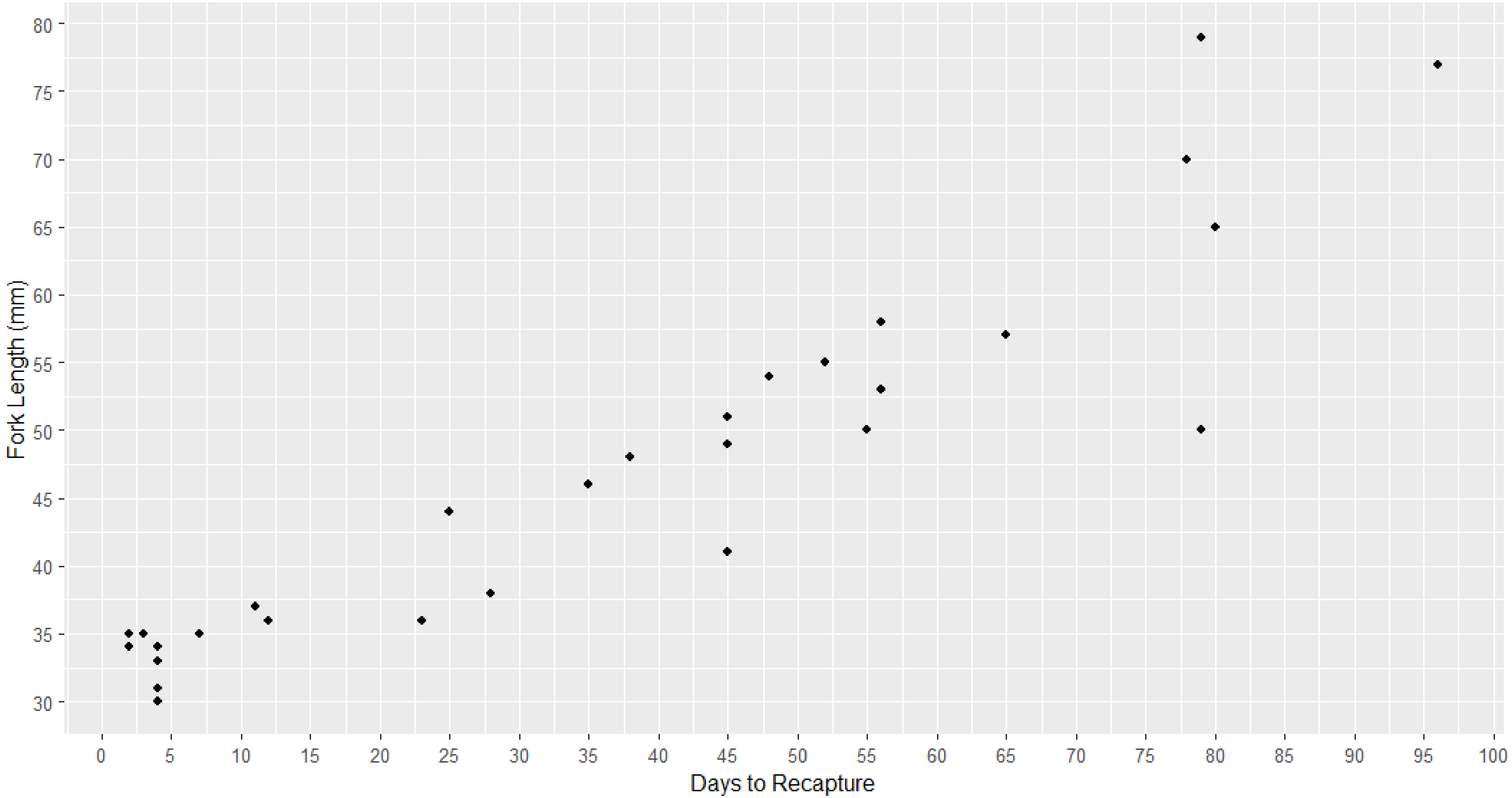

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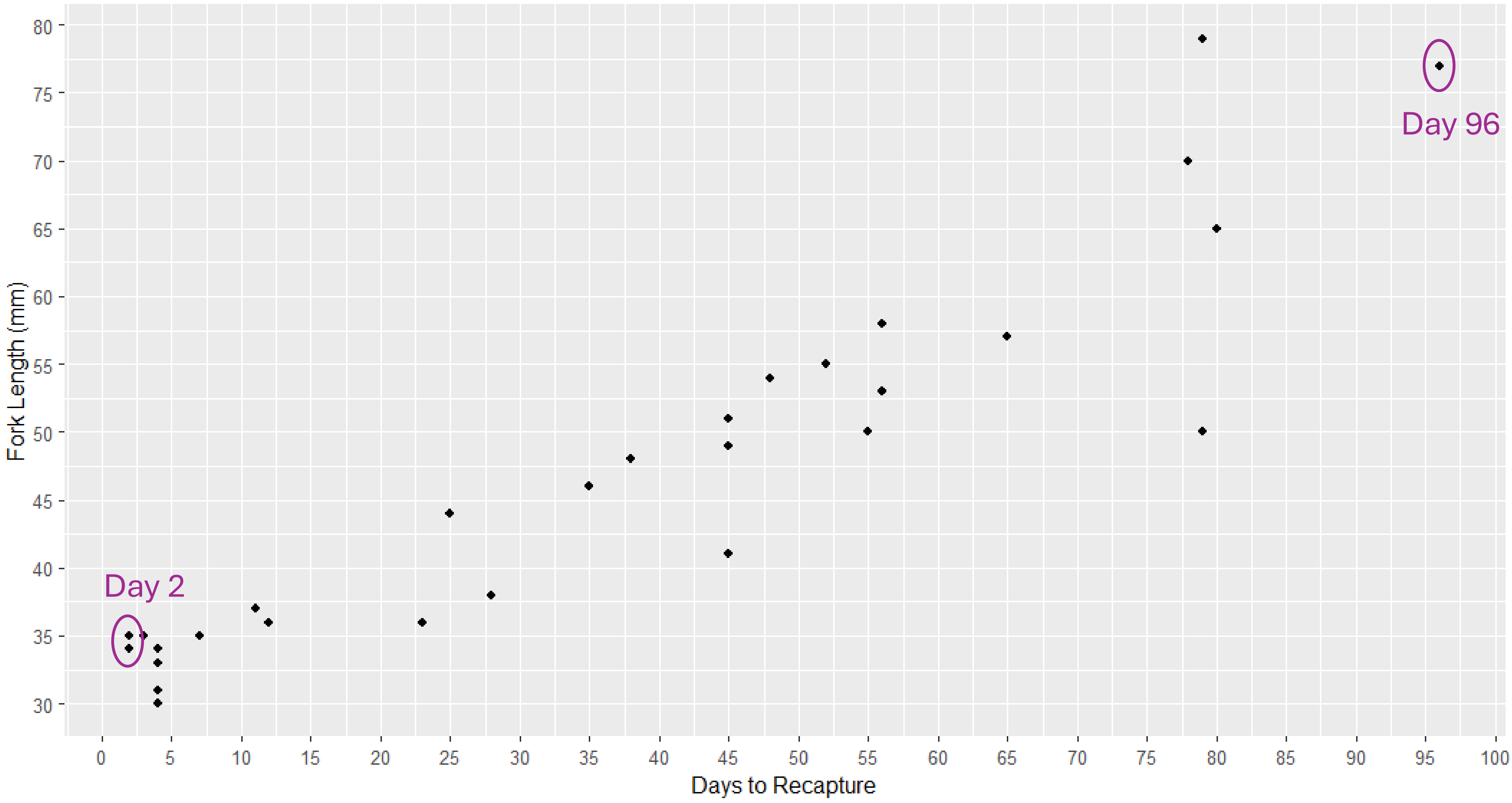

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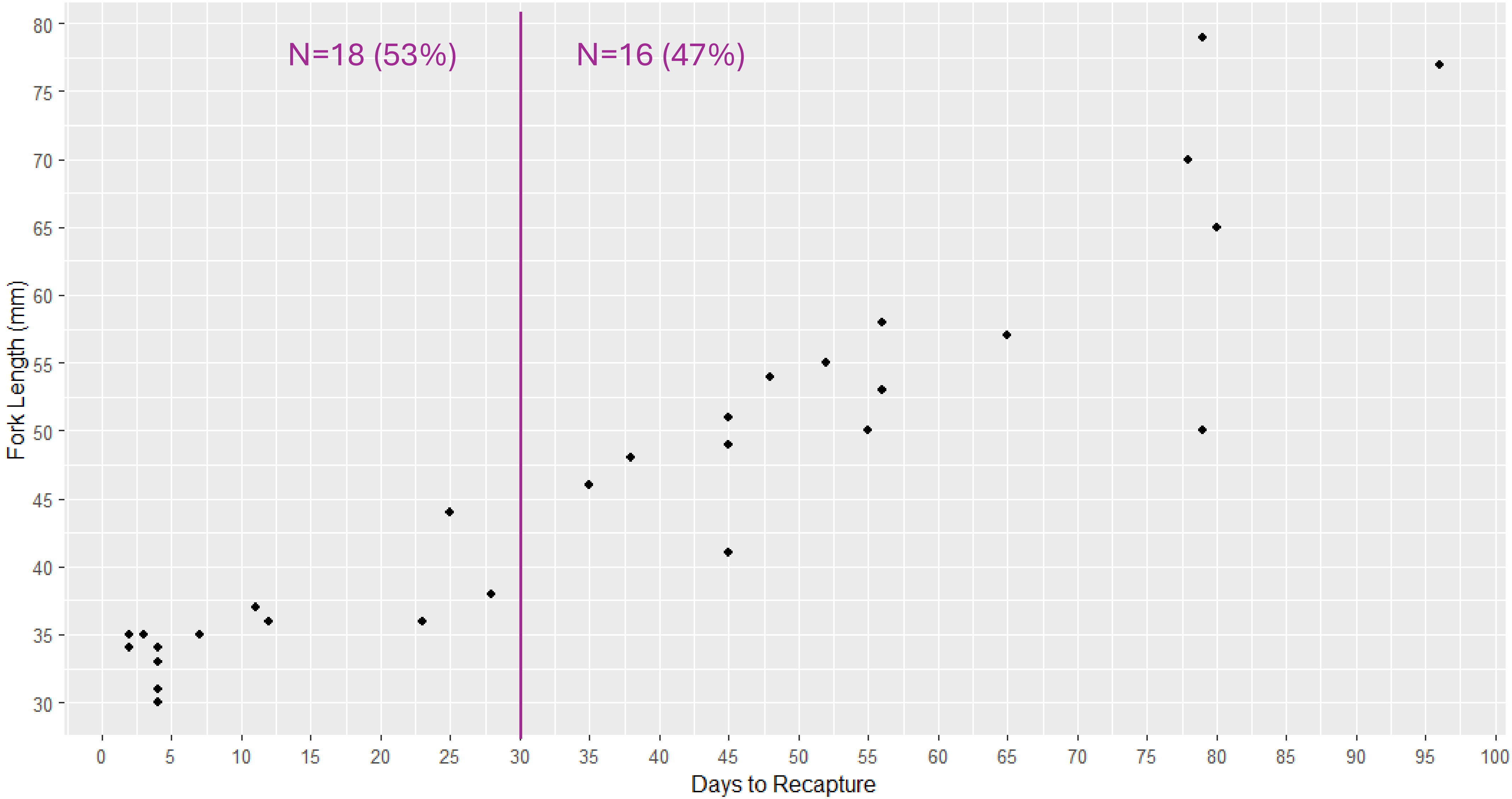

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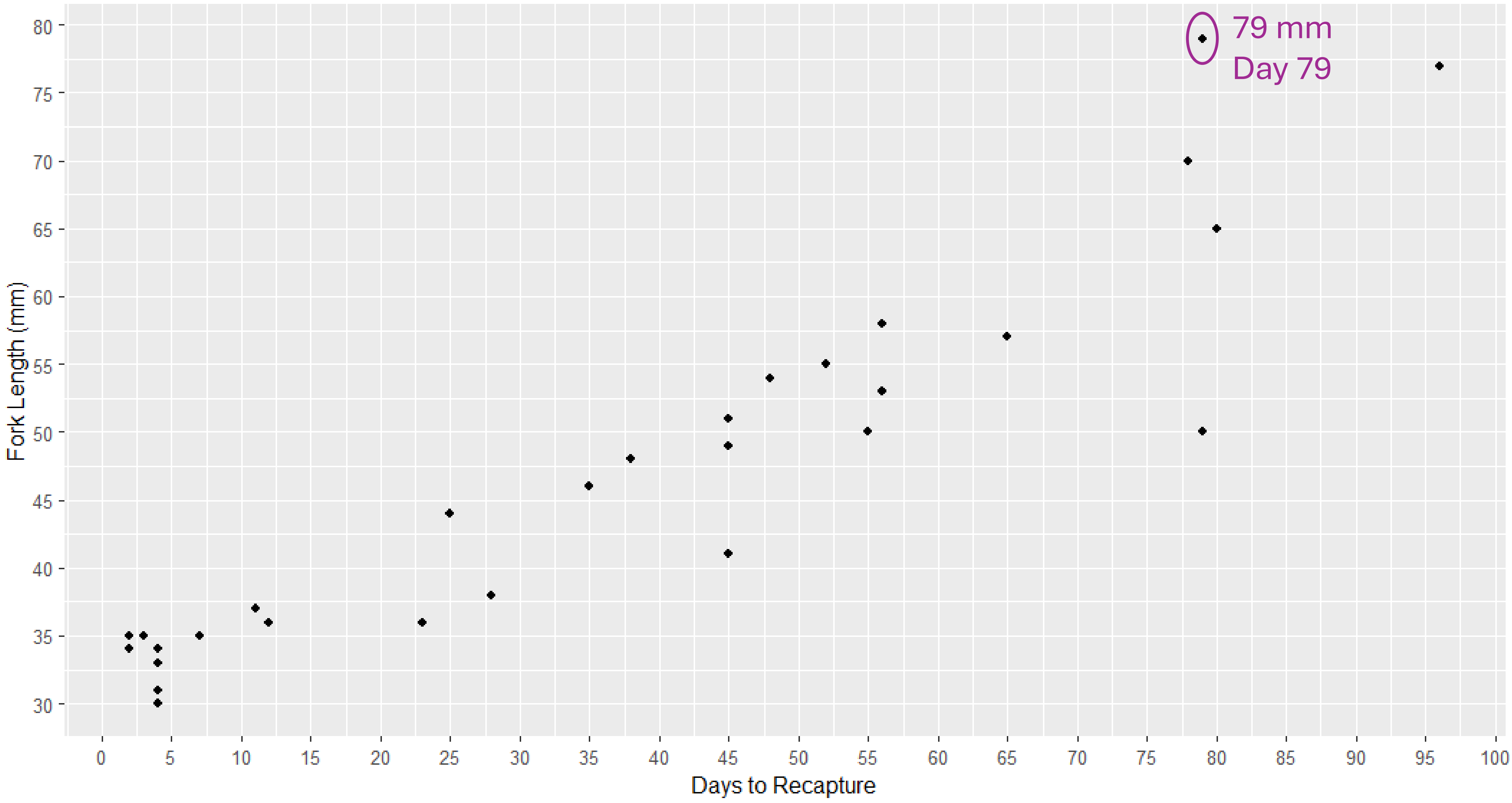

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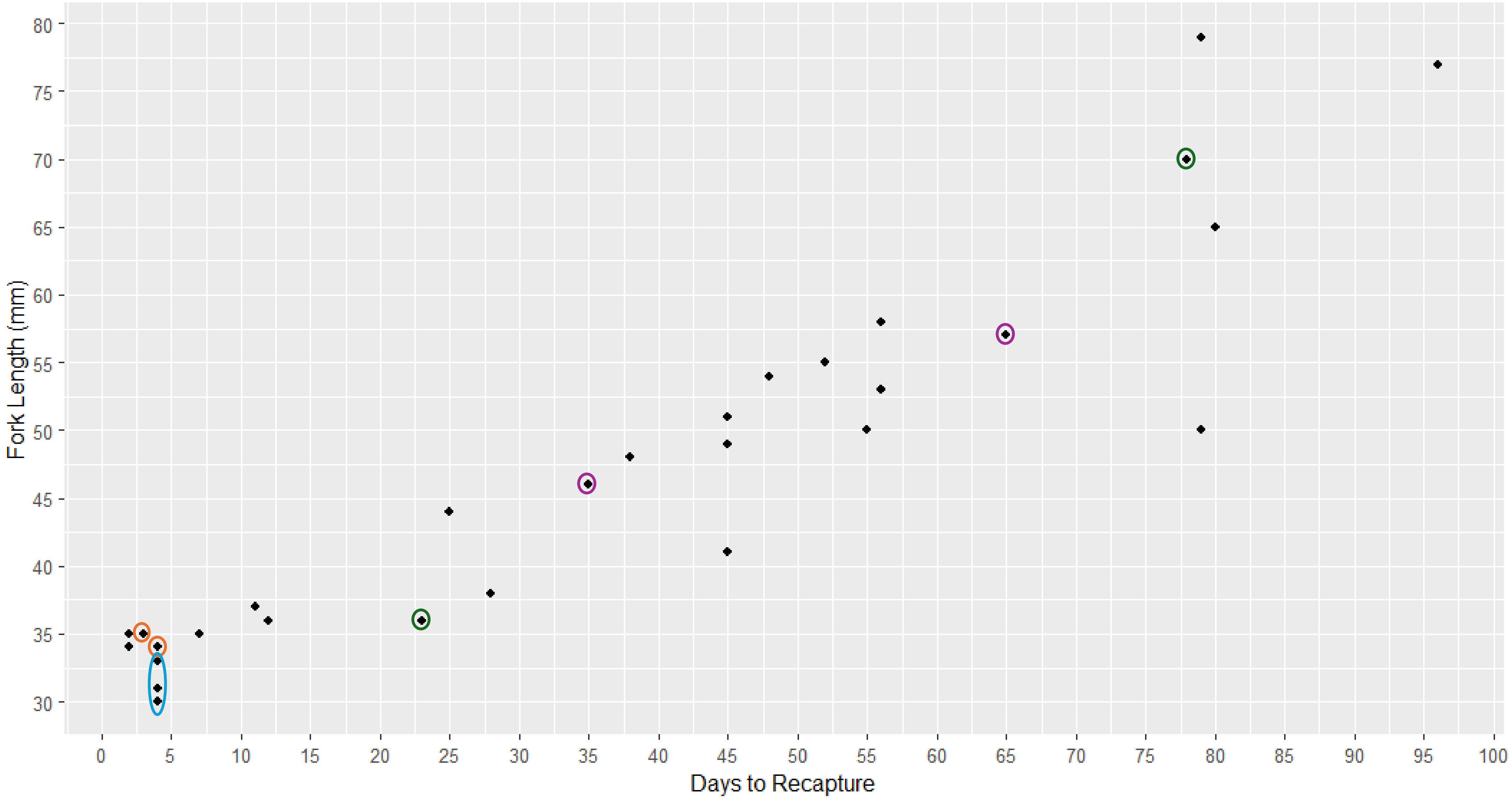
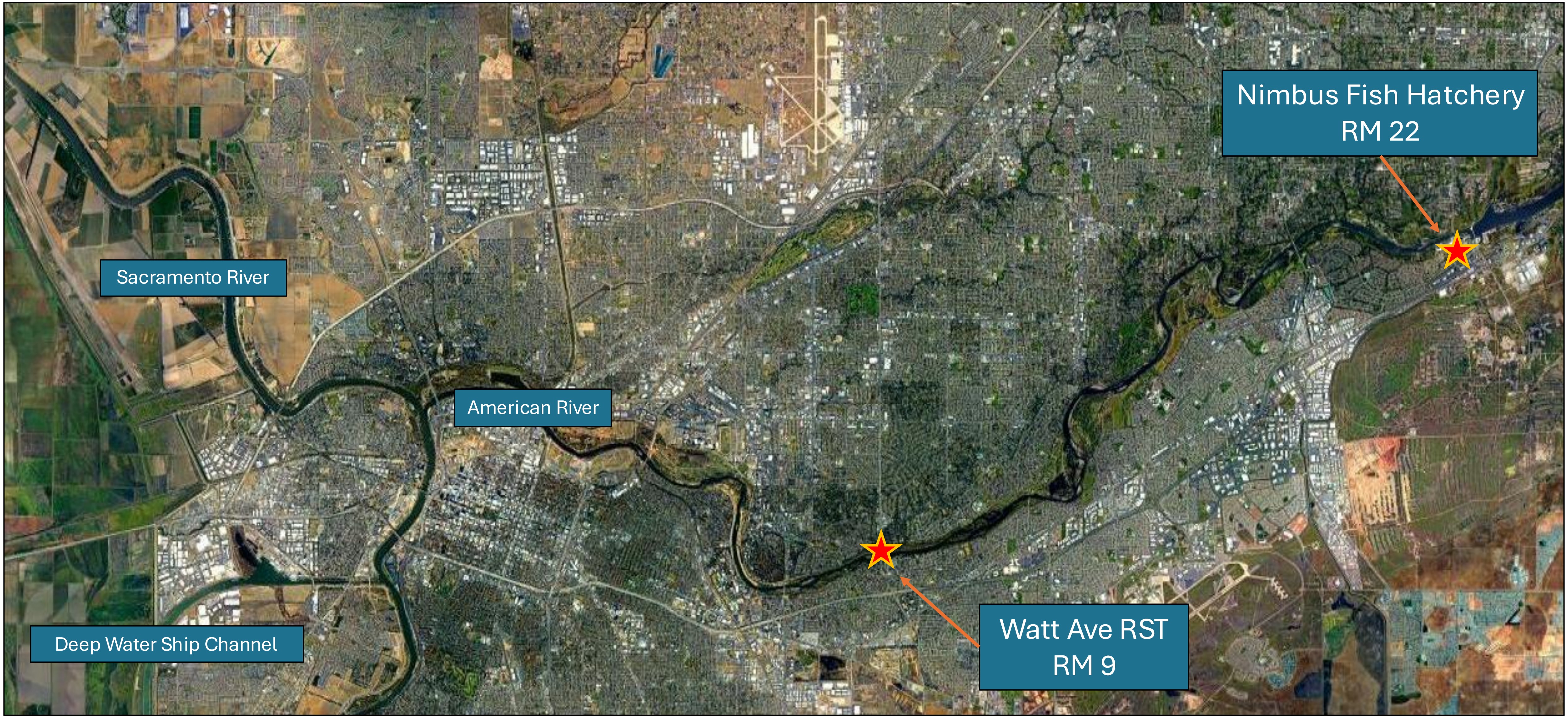


Lower American River Emigration Recoveries



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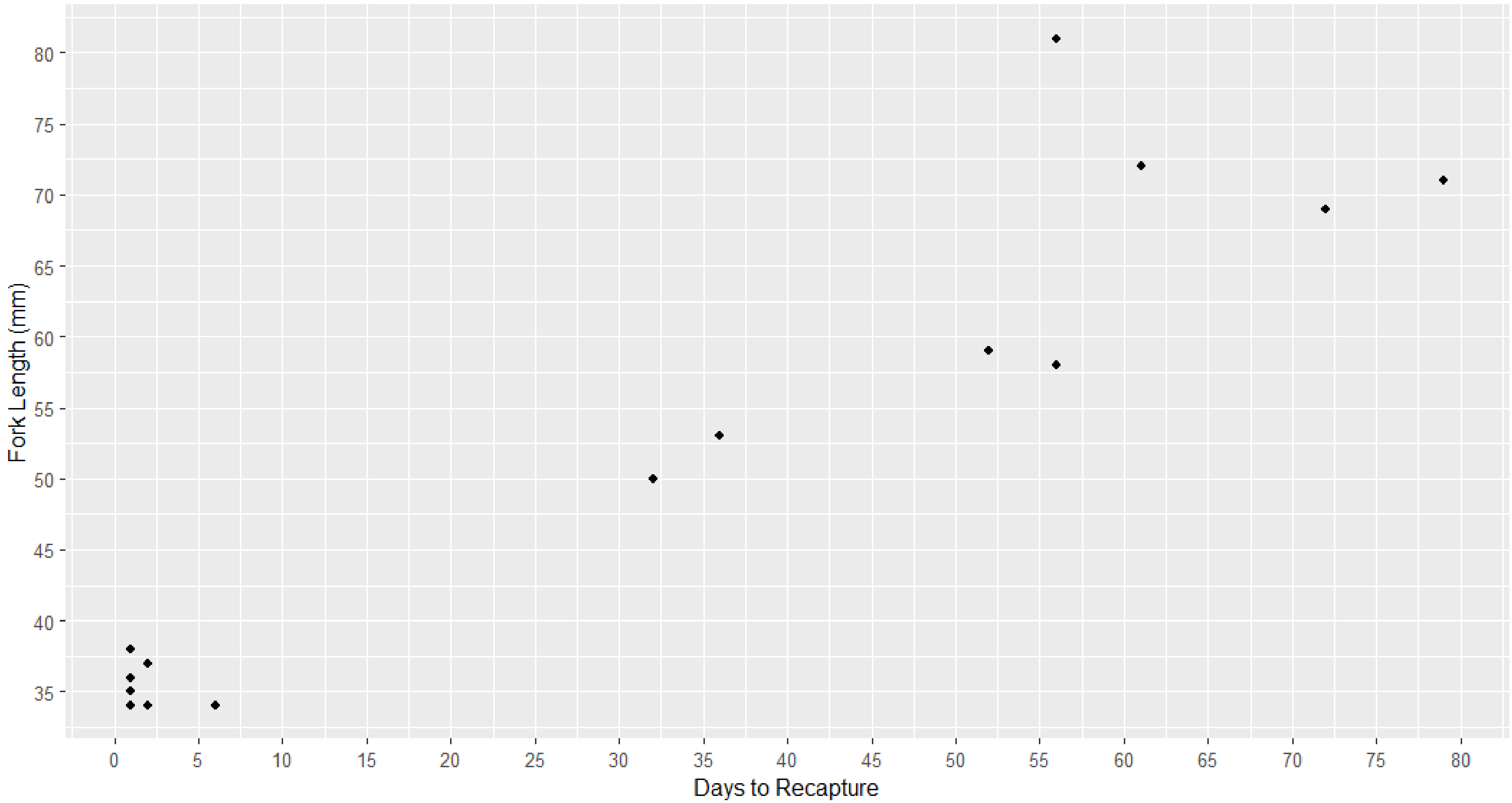

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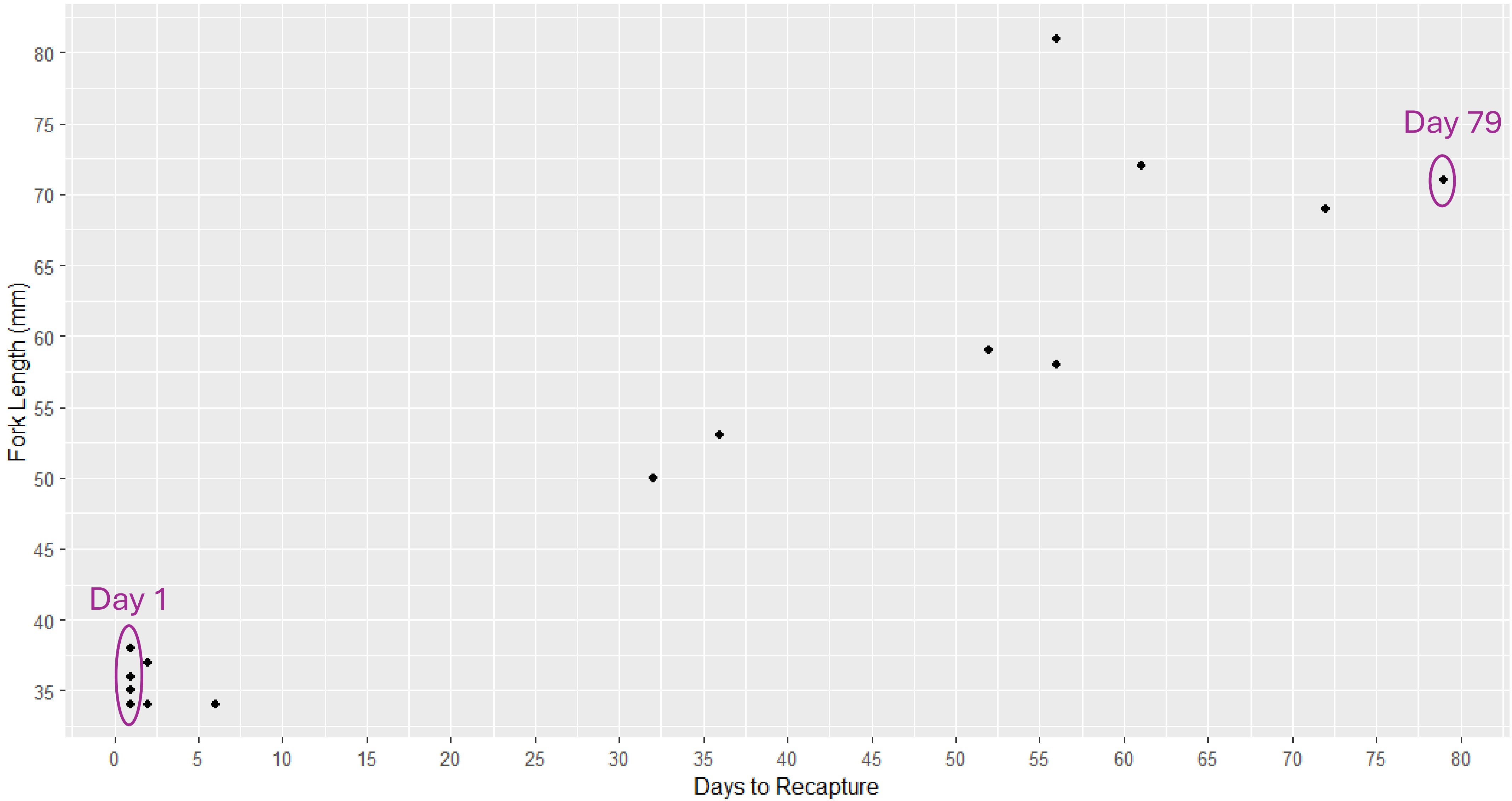

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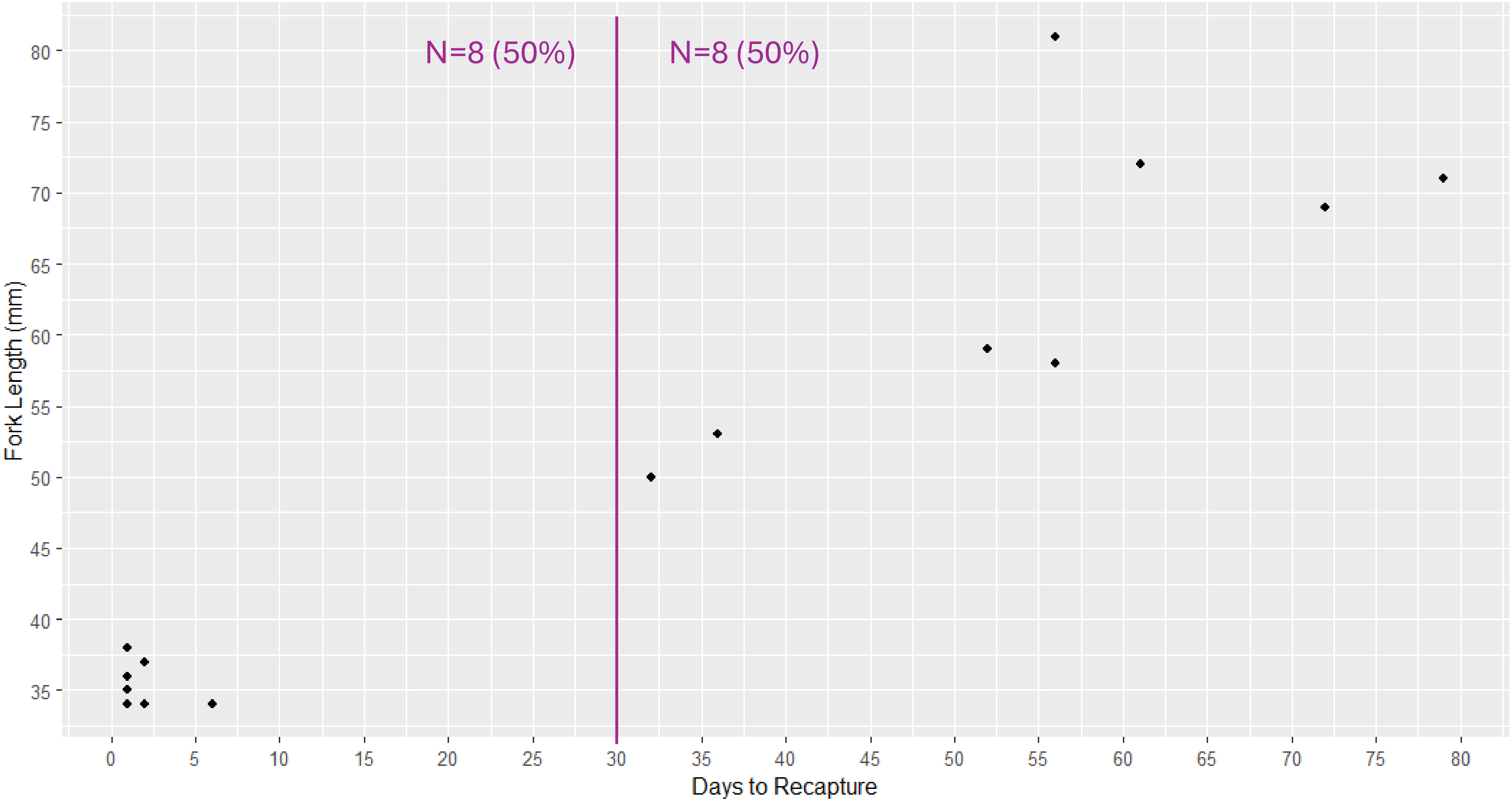

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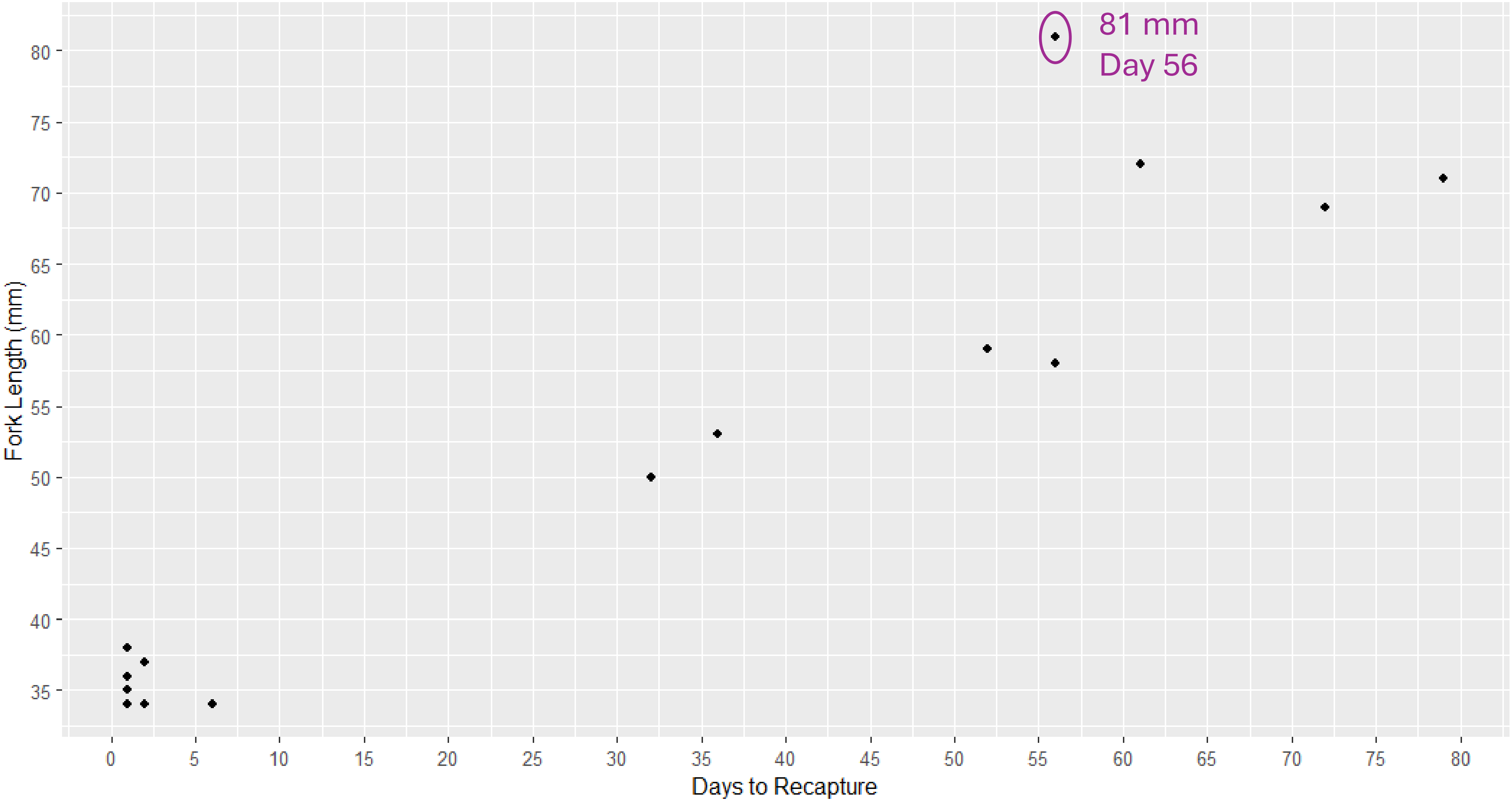

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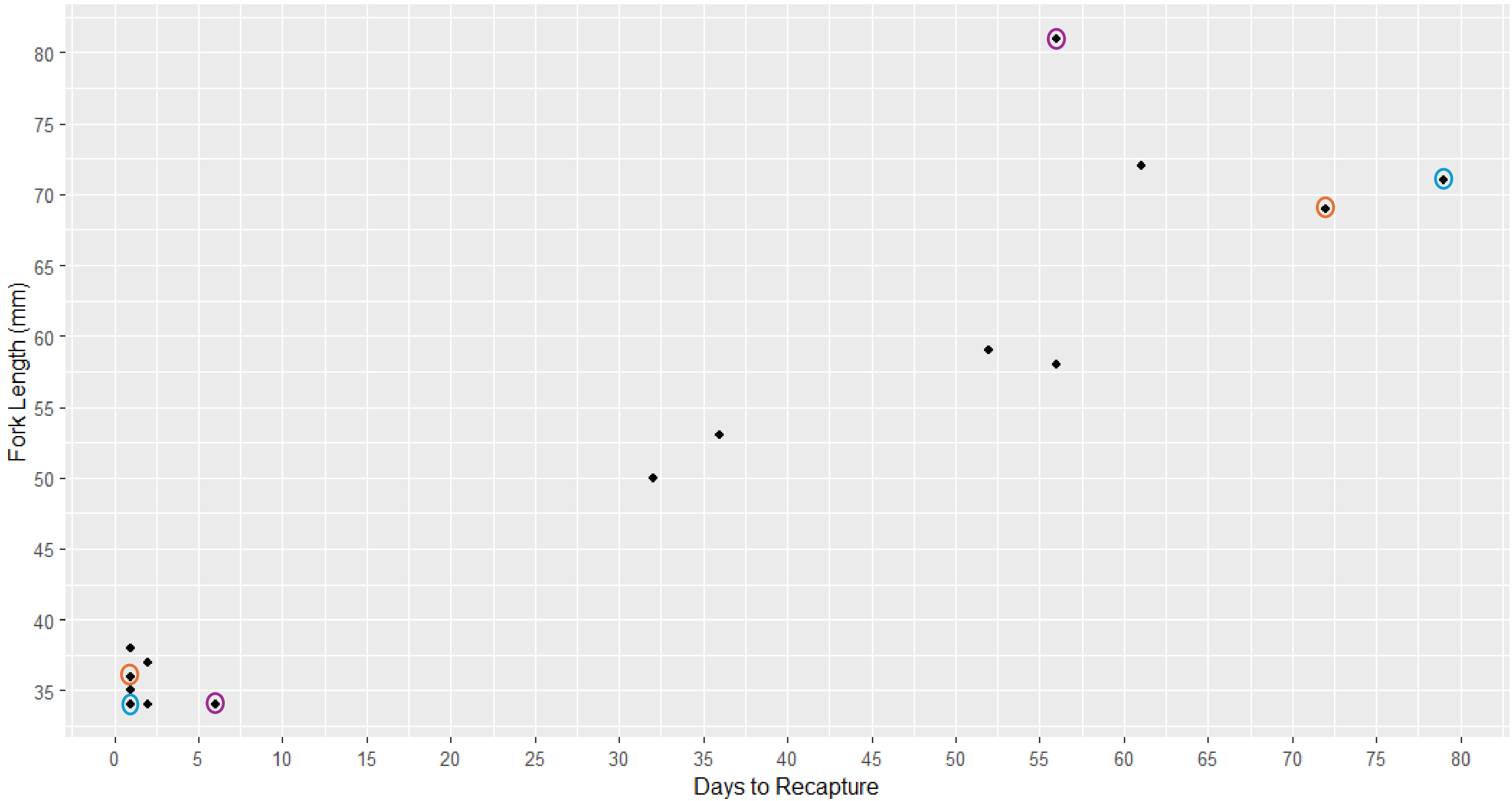

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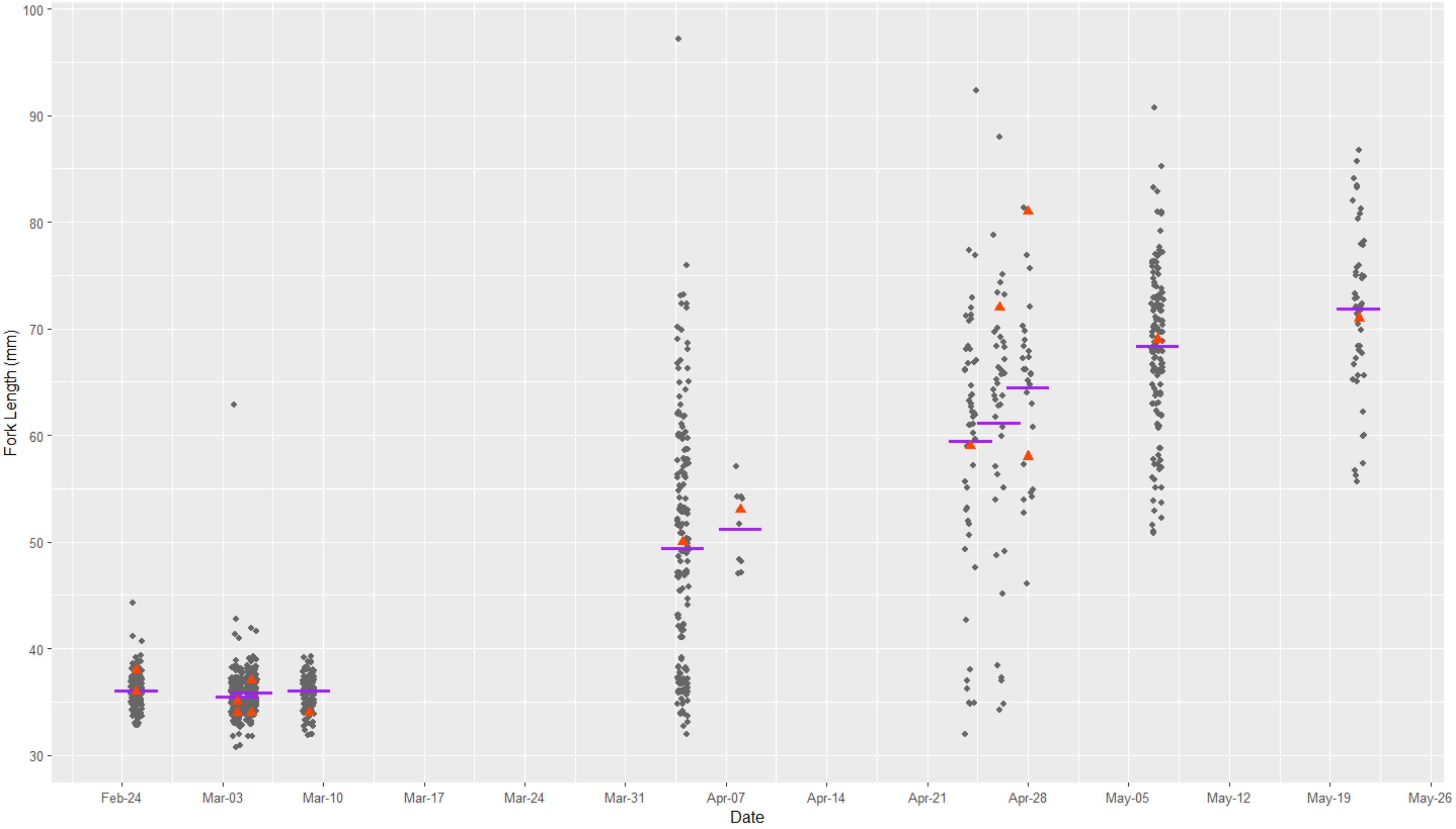
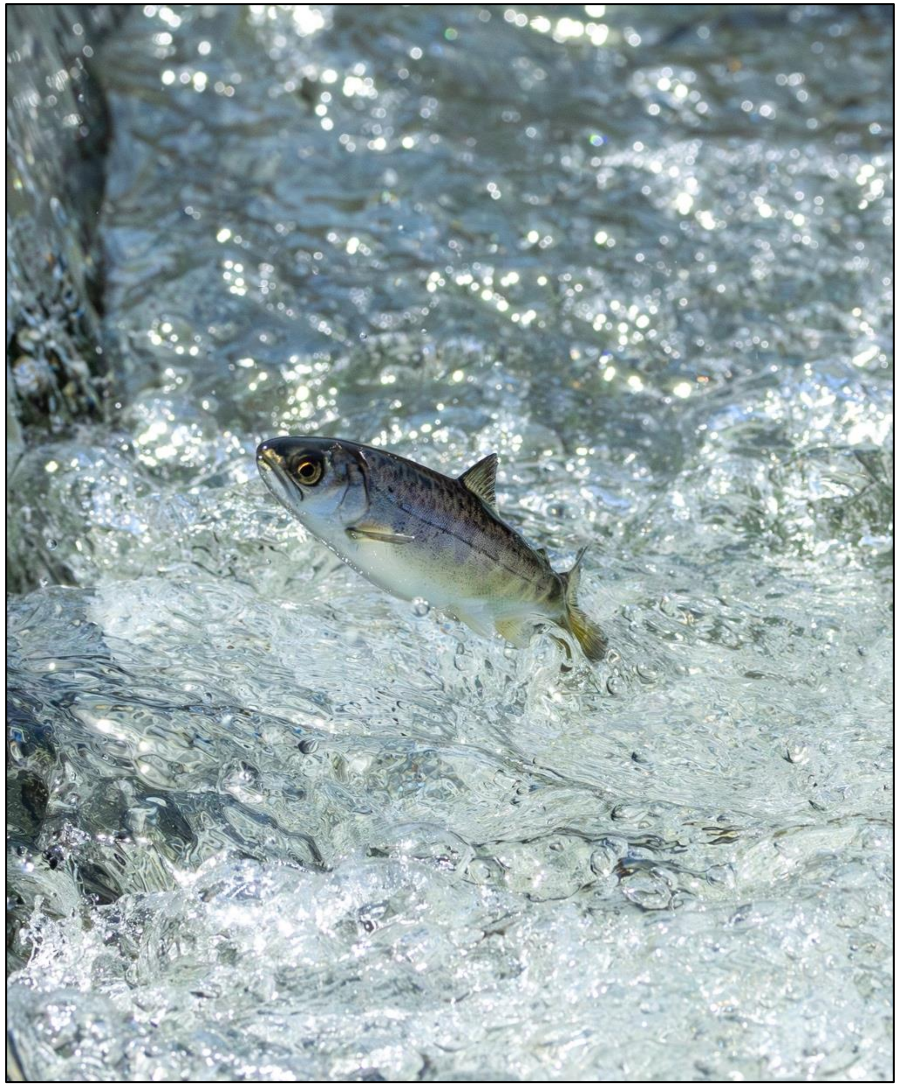


PBT Implementation Challenges: Tag & Recovery



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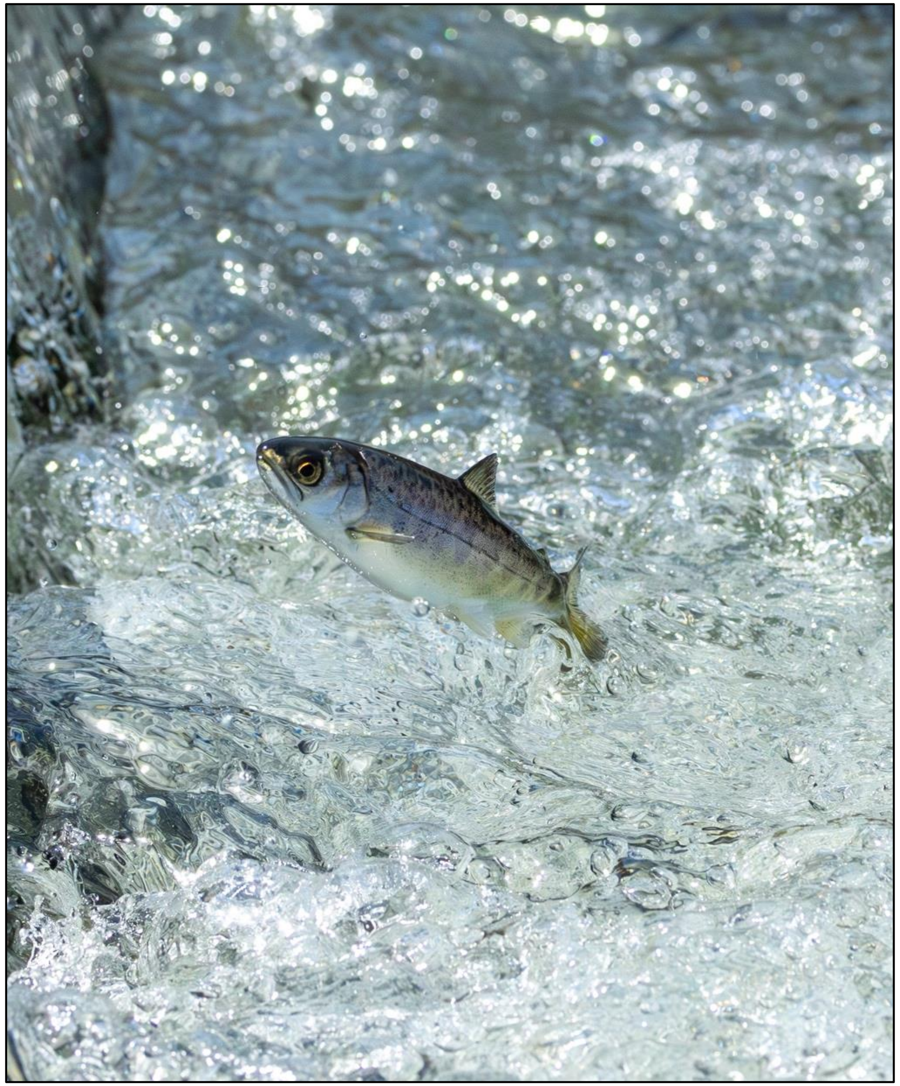

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    - Depends on PBT+ proportion of the population but survival of released fry is unknown

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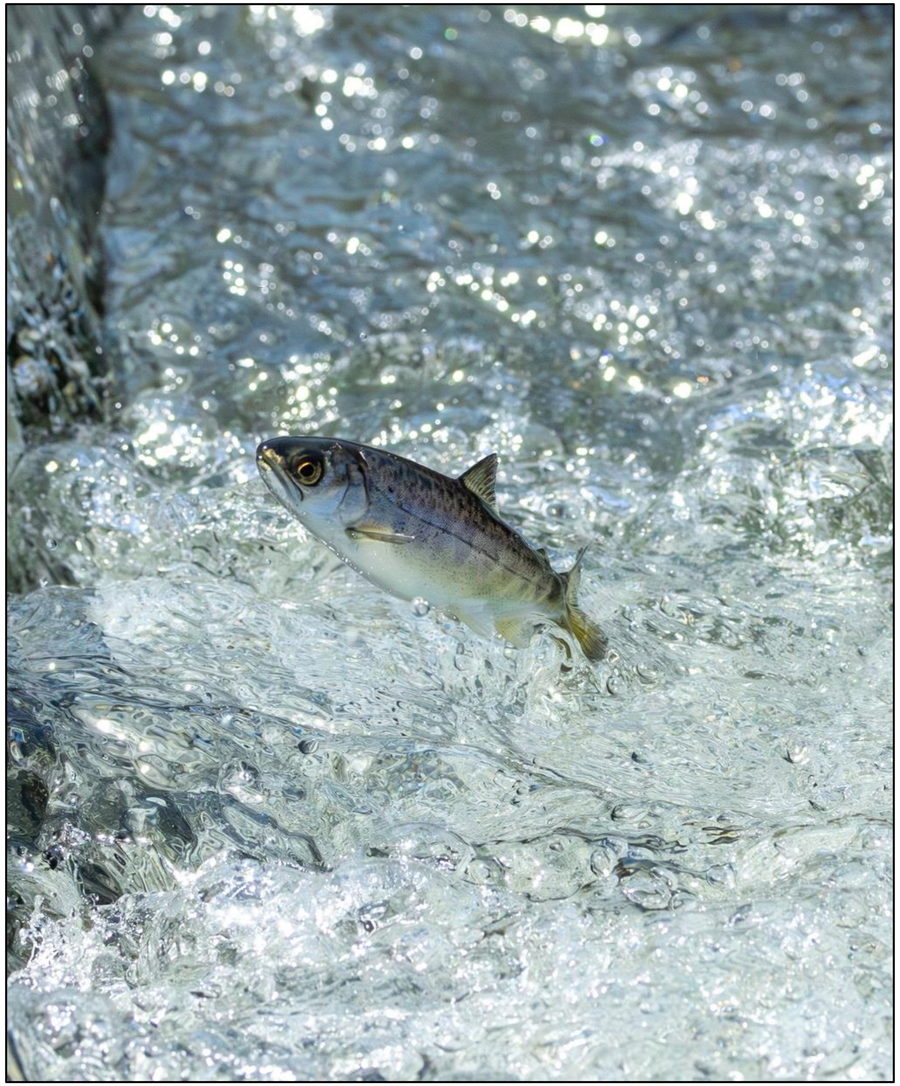

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- Genotyping challenges
  - Extraction success varies based on recovery sector

PBT Implementation Challenges: Results & Data

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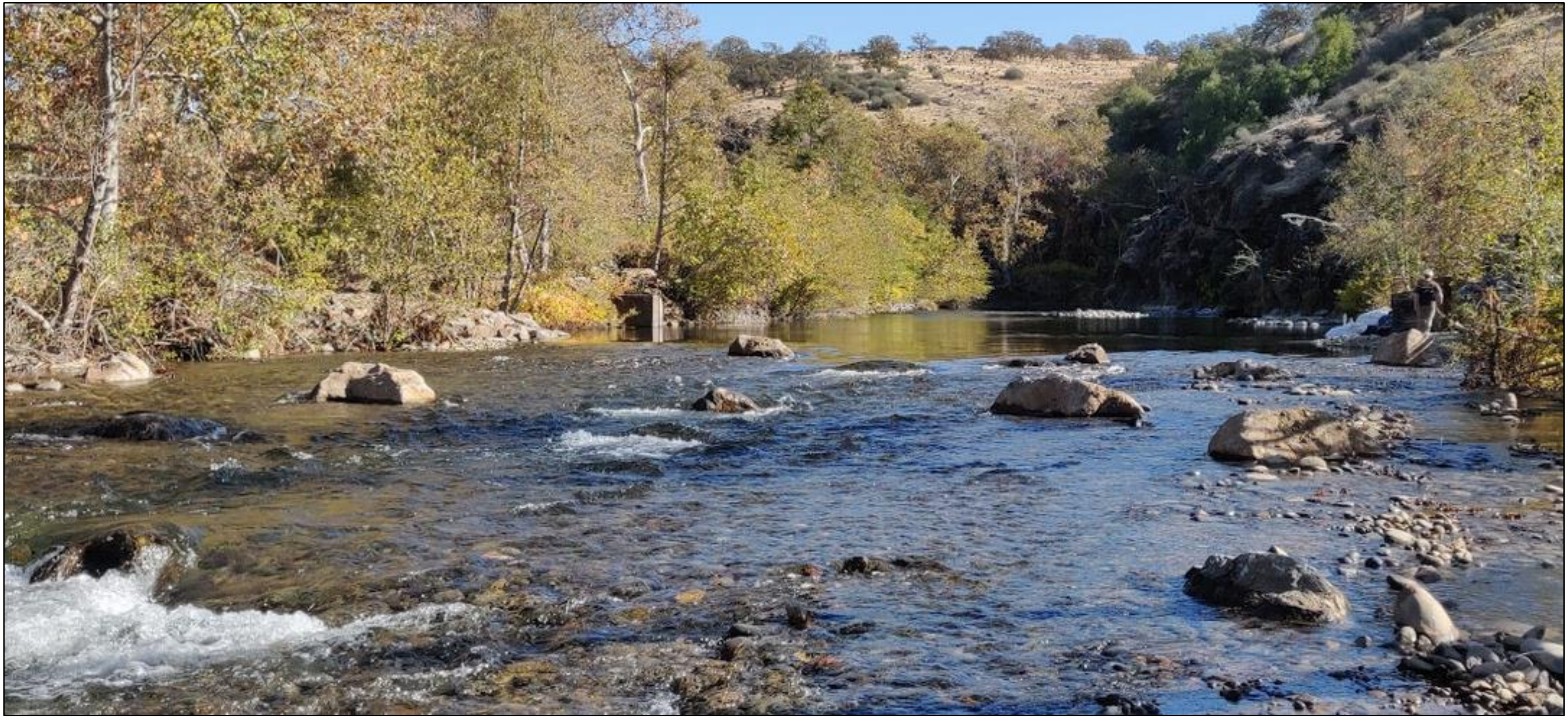
- Interpreting results for hatchery & fisheries management
- Rapid results needed to provide information for fisheries management on an in-season basis
- Data management
  - Need to standardize data collection across recovery sectors
  - Develop a centralized repository for PBT results and associated metadata
- Data sharing between agencies

Collaborators

- CDFW
  - Fisheries Branch
    - Fish Production, Distribution and Laboratories
    - Central Valley Tissue Archive
    - Genetic Research Laboratory
  - North Central Region Fisheries Program
  - CDFW North Region Fisheries Program
  - CDFW Marine Region
    - Ocean Salmon Project
    - California Recreational Fisheries Survey
- Cramer Fish Sciences
- DWR
  - Healthy Rivers & Landscapes
  - Genetics Lab
- NMFS
  - California Central Valley Office
  - Sustainable Fisheries Unit
  - Southwest Fish Science Center
  - Carlos Garza Lab
- Pacific States Marine Fisheries Commission
- USFWS
  - CNFH
  - Abernathy Genetics Lab

Questions?



Parentage-Based Tagging

Questions & Discussion

We'll be right back!

12:10	**A Modern Ghost Story: Using Chemical Tracers to Reconstruct the Migration Behaviours and Relative Survival of Juvenile Salmon from the American River** *Dr. Anna Sturrock, Associate Professor, School of Life Sciences, University of Essex, UK*
12:55	**Emigrating Salmon Habitat Estimation (ESHE) Model: Predicting Rearing Habitat Needs to Meet Population and Restoration Goals** *Kirsten Sellheim, M.S., Senior Scientist, Cramer Fish Sciences*
1:35	***10-minute Break***
1:45	**Parentage-based Tagging: Using Genetics to Monitor Central Valley Chinook Salmon** *Elyse Freitas, Senior Environmental Scientist, Fisheries Branch, California Department of Fish and Wildlife*
2:25	**Fine-scale Vegetation Mapping of the American River Parkway** *Sarah Norris, Consulting Arborist, Wild Rye Consulting, LLC*
3:10	**2-minute Teasers on Other Topics of Interest** **Announcements & Suggestions for Future Science Shares**

American River Parkway Fine-Scale Vegetation Mapping

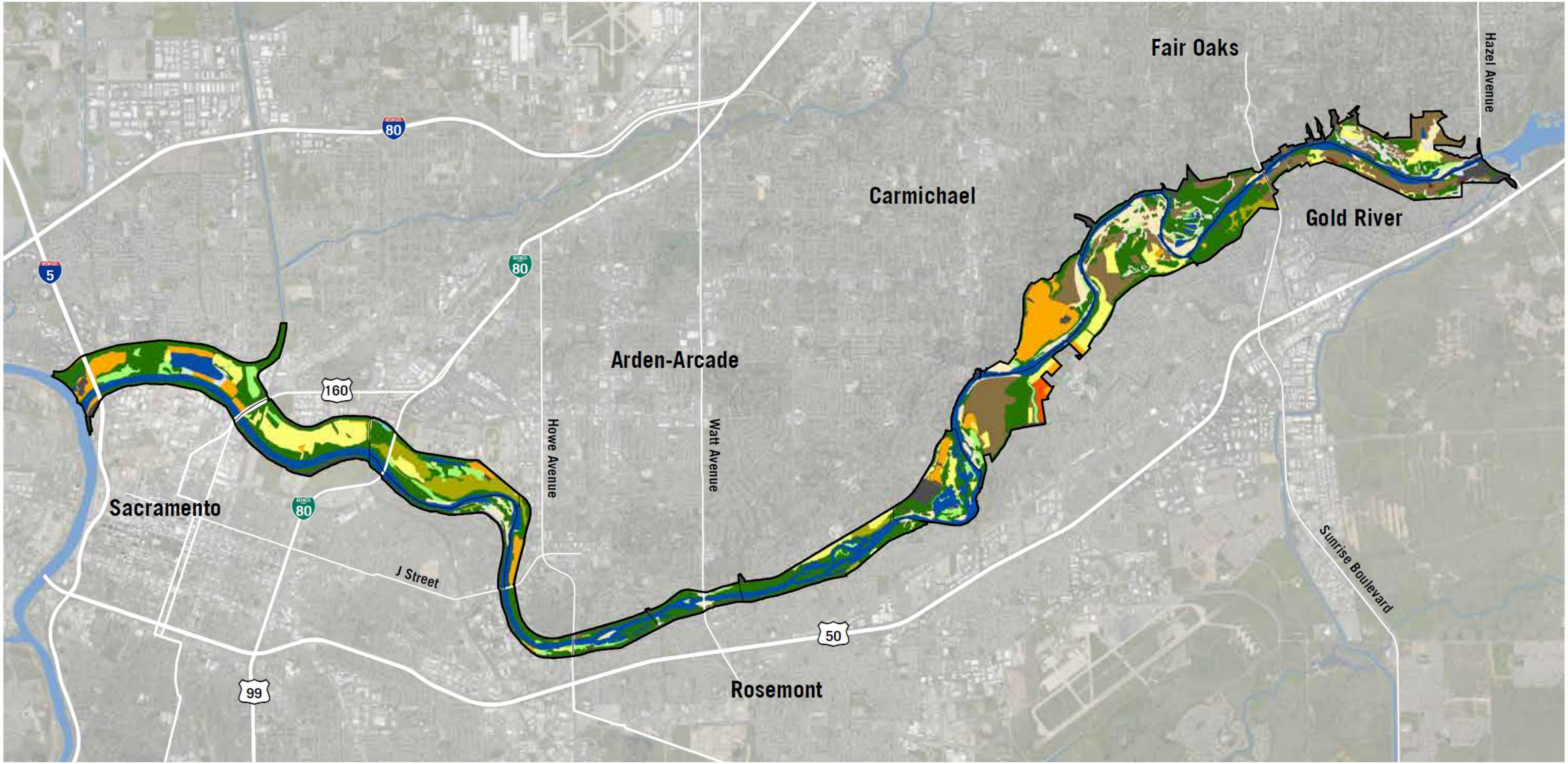
Sarah Norris
Wild Rye Consulting, LLC

Lower American River Science Share
June 9, 2026

American River Parkway

NATURAL RESOURCES MANAGEMENT PLAN

Sacramento County



ESRI 2021

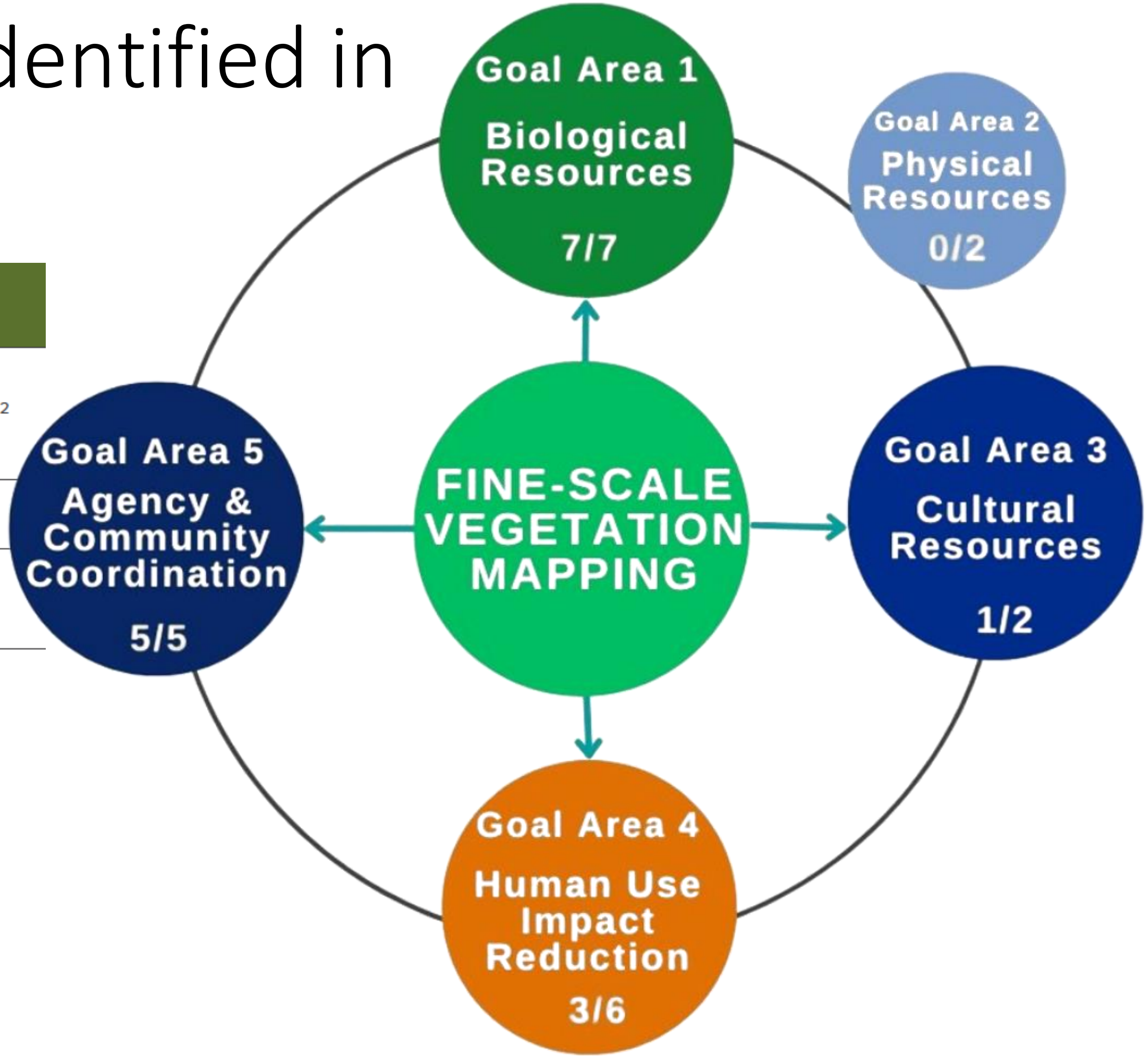
- Agricultural (27 ac)
- Developed (453 ac)
- Elderberry Savannah (227 ac)
- Freshwater Emergent Wetland (3 ac)
- Foothill Pine (6 ac)
- Gravel Bar Chaparral (277 ac)
- Open Water (1,131 ac)
- Oak Woodland/Forest (729 ac)
- Riparian Woodland/Forest (1,813 ac)
- Riparian Scrub (218 ac)
- Turf/Turf with Trees (422 ac)
- Unvegetated (174 ac)
- Valley Foothill Grassland (525 ac)

0 1 2 Miles

Figure 4-1
Vegetation Communities

Fine-scale vegetation mapping is the cornerstone to achieve multiple Goal Areas identified in NRMP

GOAL	OBJECTIVES/PERFORMANCE MEASURES
1.1 Assess biological resources within the Parkway.	1.1a Update vegetation community maps, including a frequently inundated floodplain/shaded riverine aquatic habitat (SRA) map. [2]
	1.1b Complete Parkway-wide surveys for sensitive species habitat.
	1.1c Update invasive plant species surveys and maintain a tracking system.
	1.1d Develop and maintain a tracking system for homeless encampments in the Parkway.

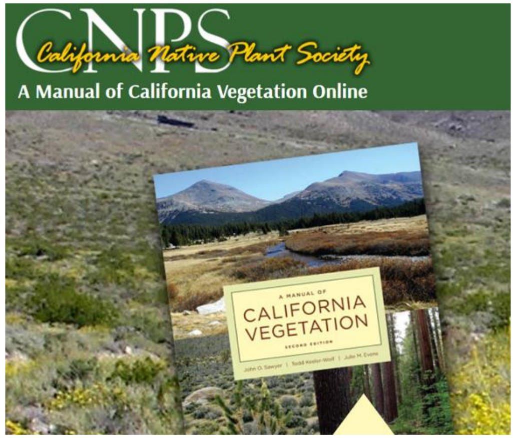


4 of the 5 Goal Areas
16 of 22 Goals
32 of 45 Objectives/Performance Measures

What is a vegetation mapping?

VegCAMP

- Minimum map unit (MMU)
- Standardized classification
  - Hierarchical
  - Repeatable
  - Predictable
- An interpretation. Nature does not draw lines.



Defining a Stand

A stand is the basic physical unit of vegetation in a landscape. It has no set size. Some vegetation stands are very small, such as a portion of a vernal pool, and some may be several square kilometers in size, such as a forest type.

A stand is defined by three main unifying characteristics:

1) It has **compositional** integrity. Throughout the site, the combination of species is similar. The stand is differentiated from adjacent stands by a discernable boundary that may be abrupt or indistinct.
2) It has **structural** integrity. It has a similar history or environmental setting that affords relatively similar horizontal and vertical spacing of plant species. For example, a hillside forest originally dominated by the same species that burned on the upper part of the slopes but not the lower would be divided into two stands. Likewise, sparse woodland occupying a slope with very shallow rocky soils would be considered a different stand from an adjacent slope with deeper, moister soil and a denser woodland or forest of the same species.
3) It is typically a **repeating** pattern on the landscape, in which the plant assemblage occurs in other sites with similar plant composition and environmental setting.

The structural and compositional features of a stand are often combined into a term called **homogeneity**. For an area of vegetated ground to meet the requirements of a stand, it must be homogeneous (uniform in structure and composition throughout).

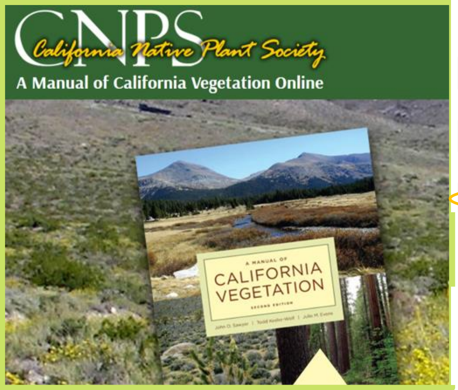
Stands vary in size and may be sampled even if they are below a "minimum mapping unit" area (a mapping rule of set size such as 1 acre or 1/2 acre specific to a mapping project). For

https://wildlife.ca.gov/Data/VegCAMP

American River Parkway Standard

- MMU forest/woodland and shrubland = 0.25 ac.
- MMU herbaceous = 0.5 ac.
- Standardized classification
  - California Manual of Vegetation
  - Alliance-level map (woody)
  - Group-level
    - Herbaceous
      Temporal variation
    - Riparian gravel bars
      Disturbance
- Anthropogenic Landcover

An interpretation. Nature does not draw lines.



Avena spp. - *Bromus* spp. Herbaceous Semi-Natural Alliance
Wild oats and annual brome grasslands

Other Habitat, Alliance and Community Groupings

MCV (1995):	California annual grassland series
NVCS (2009):	Avena fatua herbaceous alliance, Bromus (diandrus, hordeaceus, madritensis) herbaceous alliance
Calveg:	Annual grasses and forbs, Non-native/ornamental grass
Holland:	Valley and foothill grassland, Non-native grassland
Munz:	Valley grassland
WHR:	Annual grassland
CDFW CA Code:	42.027.00

National Vegetation Classification Hierarchy

Formation Class:	Mesomorphic Shrub and Herb Vegetation (Shrubland and Grassland)
Formation Subclass:	Mediterranean Scrub and Grassland
Formation:	Mediterranean Grassland and Forb Meadow
Division:	California Grassland and Meadow
Macro Group:	California Annual and Perennial Grassland
Group:	Mediterranean California naturalized annual and perennial grassland

Salix exigua Shrubland Alliance
Sandbar willow thickets

Other Habitat, Alliance and Community Groupings

MCV (1995):	Narrowleaf willow series
NVCS (2009):	Salix (exigua, interior) temporarily flooded shrubland alliance
Calveg:	Riparian mixed shrub, Willow (riparian scrub)
Holland:	Southern cottonwood-willow riparian forest, Modoc-Great Basin cottonwood-willow riparian forest, Mojave riparian forest, Sonoran cottonwood-willow riparian forest, North Coast riparian scrub, Central Coast riparian scrub, Southern willow scrub, Great Valley willow scrub, Modoc-Great Basin riparian scrub
Munz:	Not treated
WHR:	Desert riparian, Montane riparian, Valley foothill riparian
CDFW CA Code:	61.209.00

National Vegetation Classification Hierarchy

Formation Class:	Mesomorphic Tree Vegetation (Forest and Woodland)
Formation Subclass:	Temperate Forest
Formation:	Temperate Flooded and Swamp Forest
Division:	Western North America Warm Temperate Flooded and Swamp Forest
Macro Group:	Southwestern North American Riparian, Flooded and Swamp Forest
Group:	Southwestern North American riparian/wash scrub

Fine-Scale Vegetation Mapping Provides Detail

Fine-Scale Vegetation Mapping is a Powerful Management Tool

a power tool is needed

- Best-available science
- Define habitat quality
  - Locate areas for conservation, restoration, naturalization to achieve NRMP goals
- Track response and change
- Defensible decision making
- Adaptive management
- Scalability

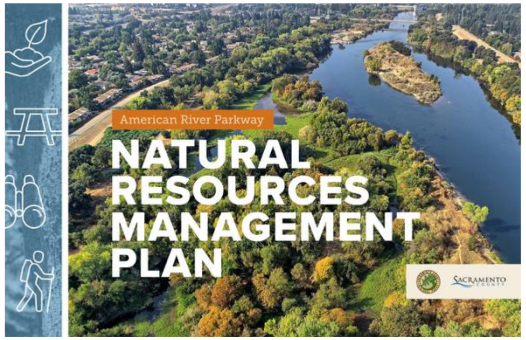


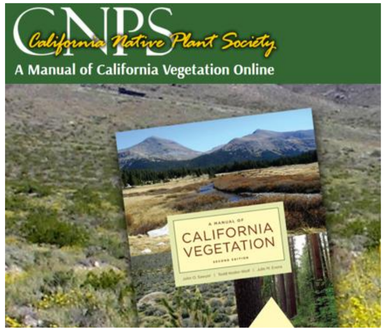


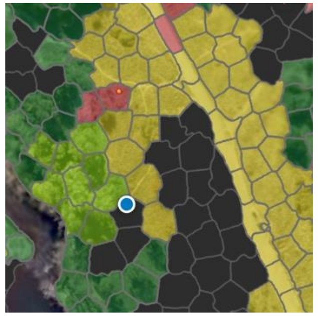


What this is …

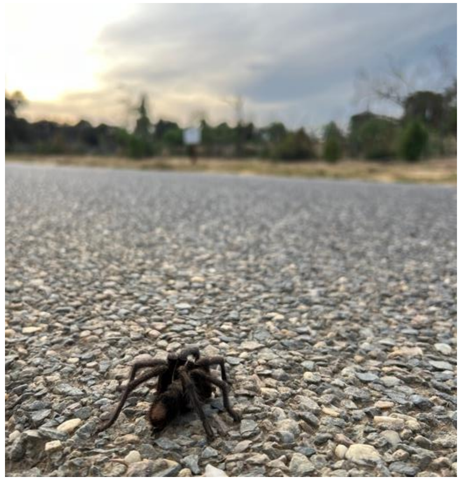
- Vegetation map
  - Fine-scale MMU
  - Based on MCV2
- Intended to advance NRMP goals and objectives
- A novel approach
- Working tool
- Easy to use, update, and refine





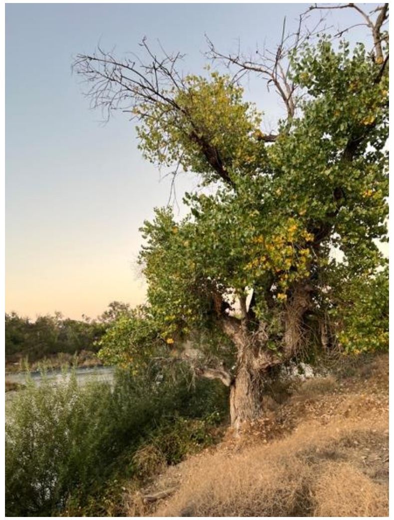


What this is not…

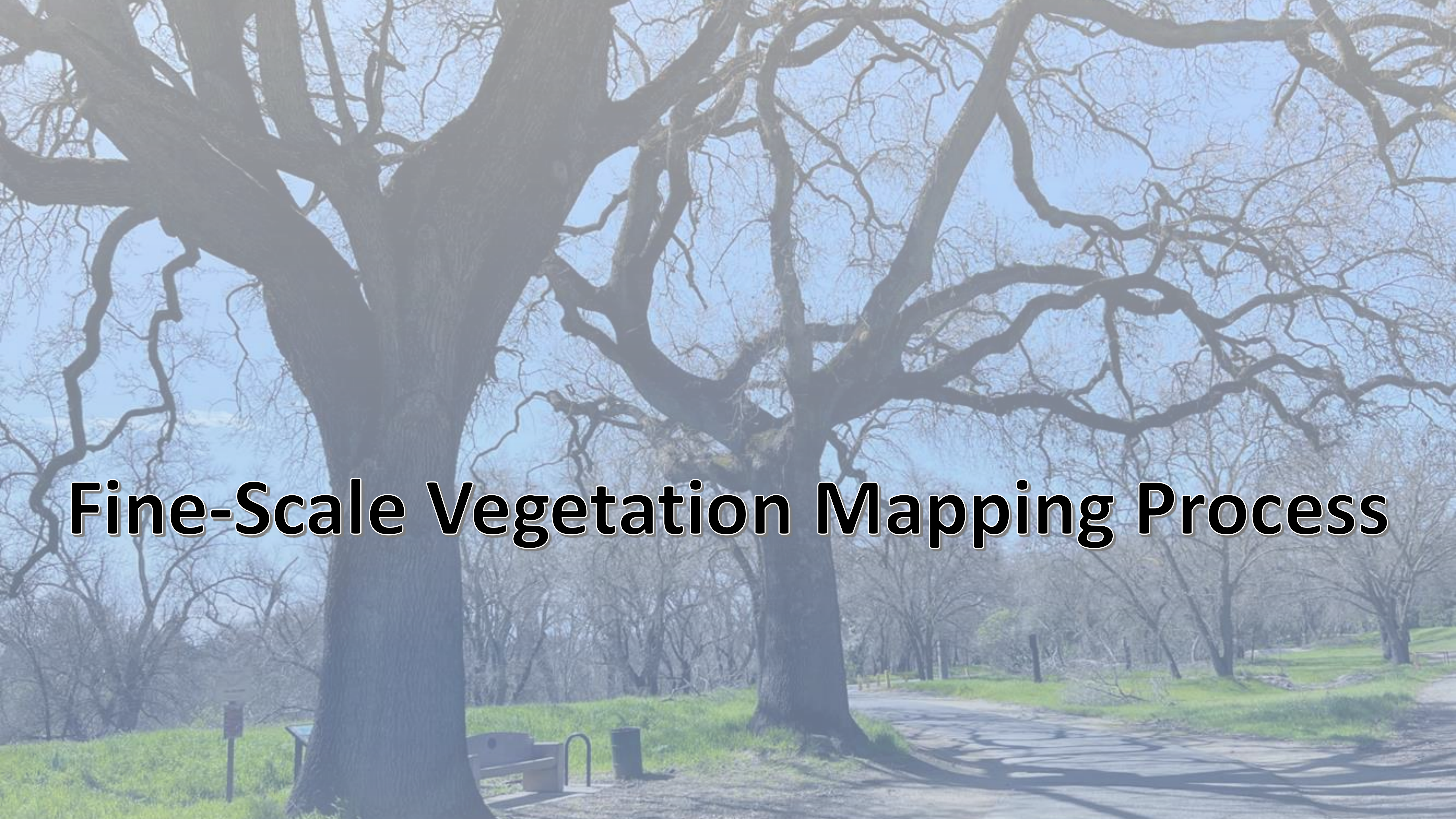


- Habitat map
- Tree inventory
- 100% ground-truthed

What this means…



- There are inaccuracies
- Temporal vegetation changes
- Additional field work is warranted
- Evaluate the question against the tool

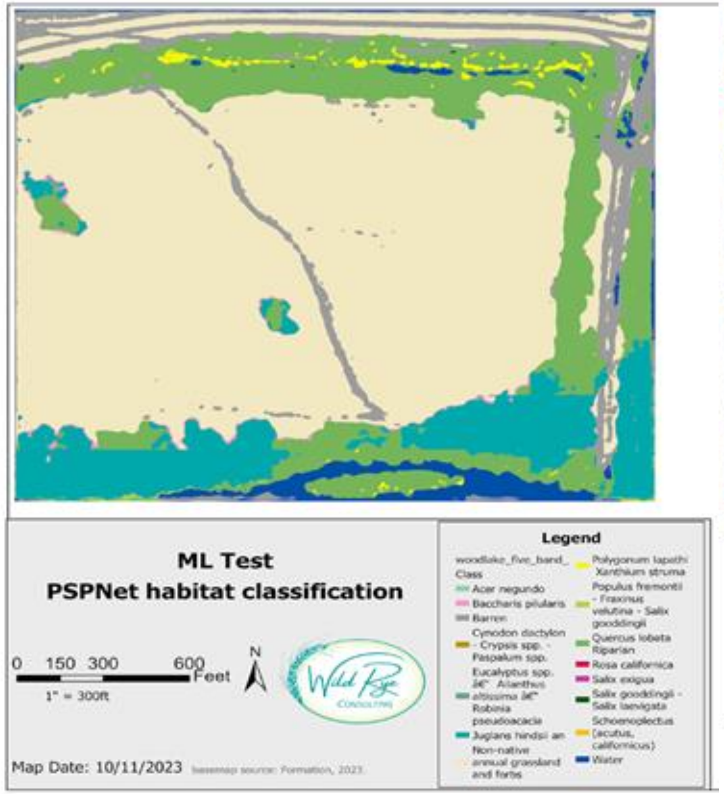


Fine-Scale Vegetation Mapping Process

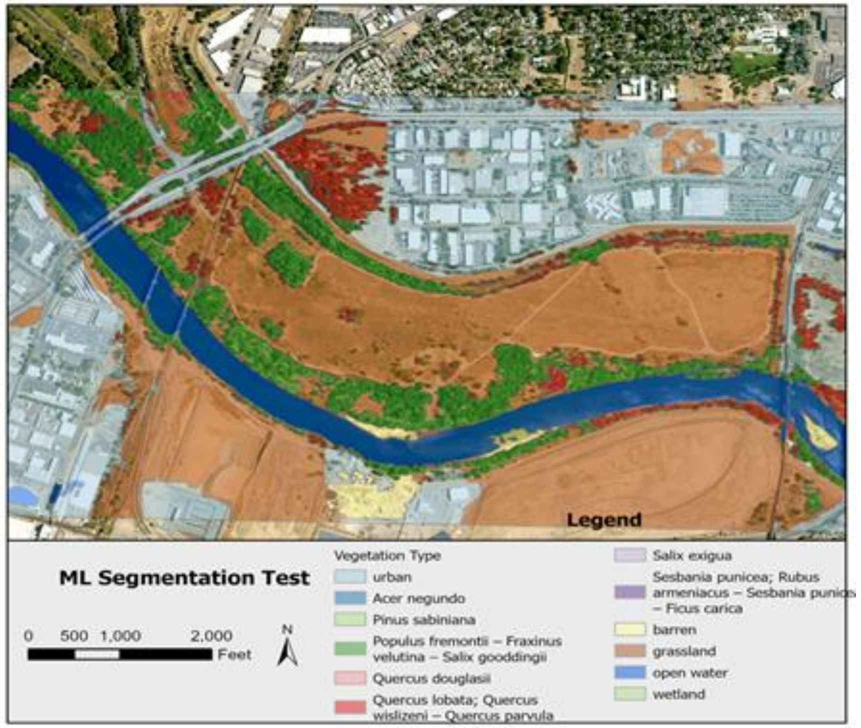
DWR Central Valley Flood Protection Plan Map

- MMU = 1 acre
- Results in aggregation of habitats
- Informative over large areas
- Training data source for the project

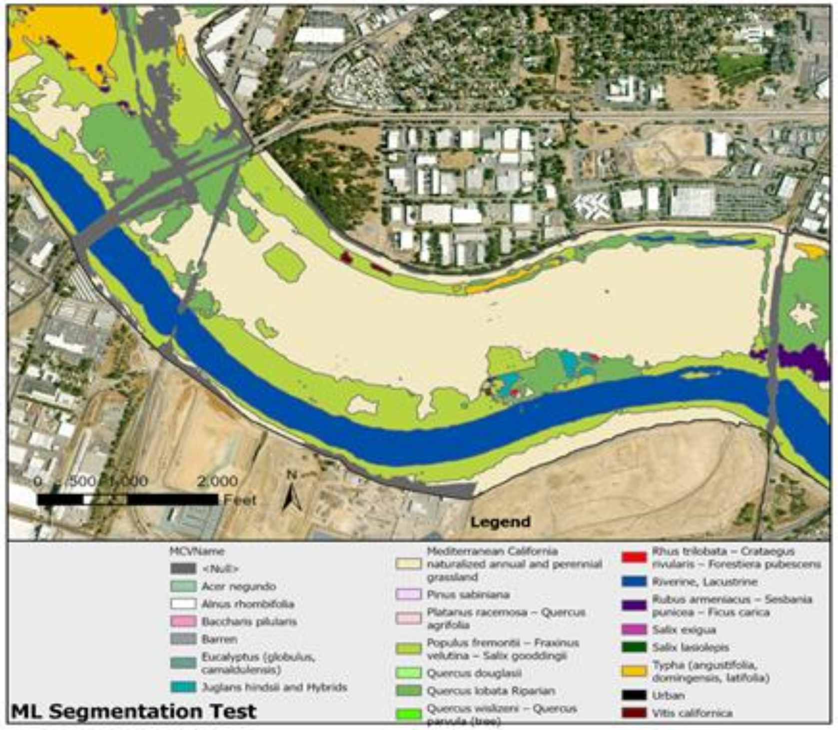
Progression & Iteration



- Using ArcGIS Pro Deep Learning Framework
- Trained only on Woodlake data field mapped by WR (58 ac.)
- Was good at classifying urban and grassland
- Struggled with forest alliances and shrubs.

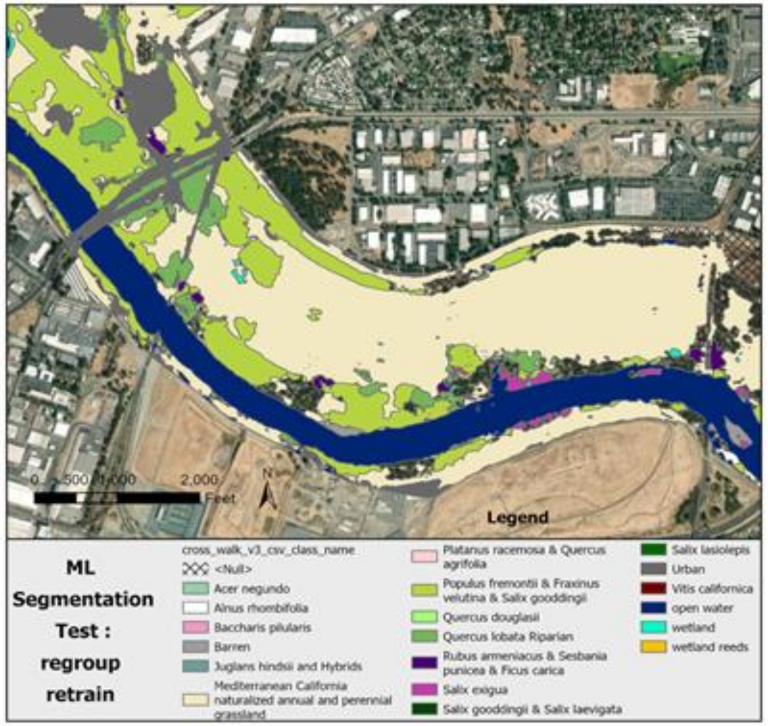


- First map trained with VegCamp 2016
- All maps used 2016 USDA NAIP imagery (60cm, RGB-IR)
- First map used Meta (Facebook) CHM
- Used MMSegment model

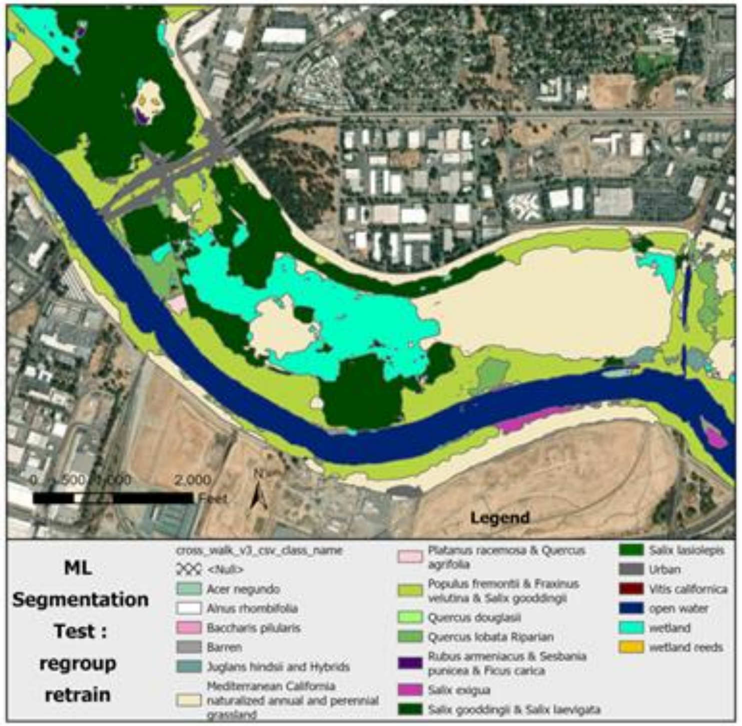


- Used a FEMA LiDAR to make an improved canopy height model.
- Not all legend items in frame
- Difficulty with shrubs

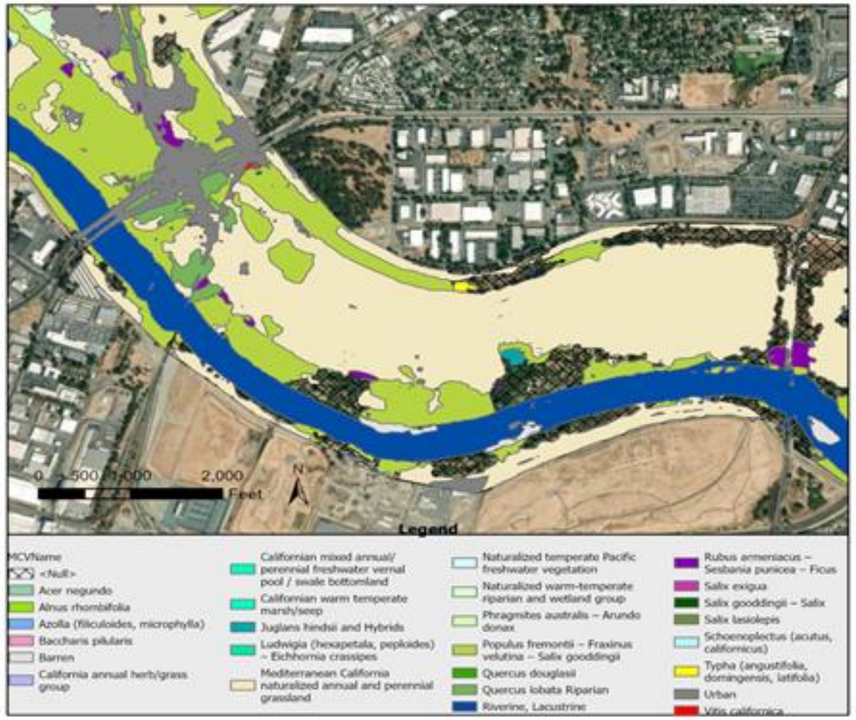
Progression & Iteration



- Screened VegCAMP data to eliminate higher classifications (Group, Macro Group) and consolidate herbaceous vegetation alliances



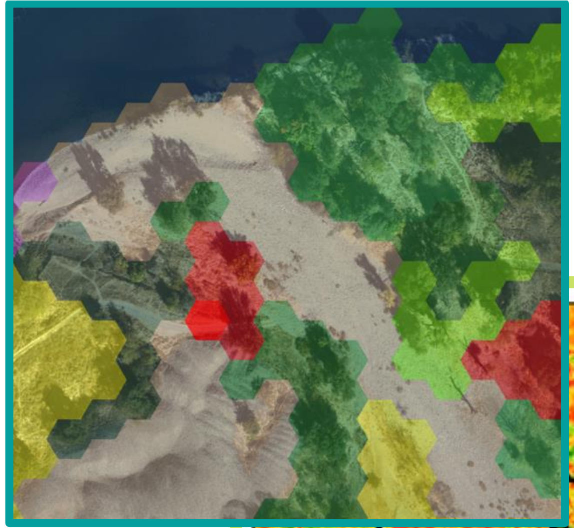
- Update: grouped VegCAMP into several alliances into wetland for resurvey.
- Retrained on additional data up north with more *Juglans hindsii* and *Baccharis pilularis*

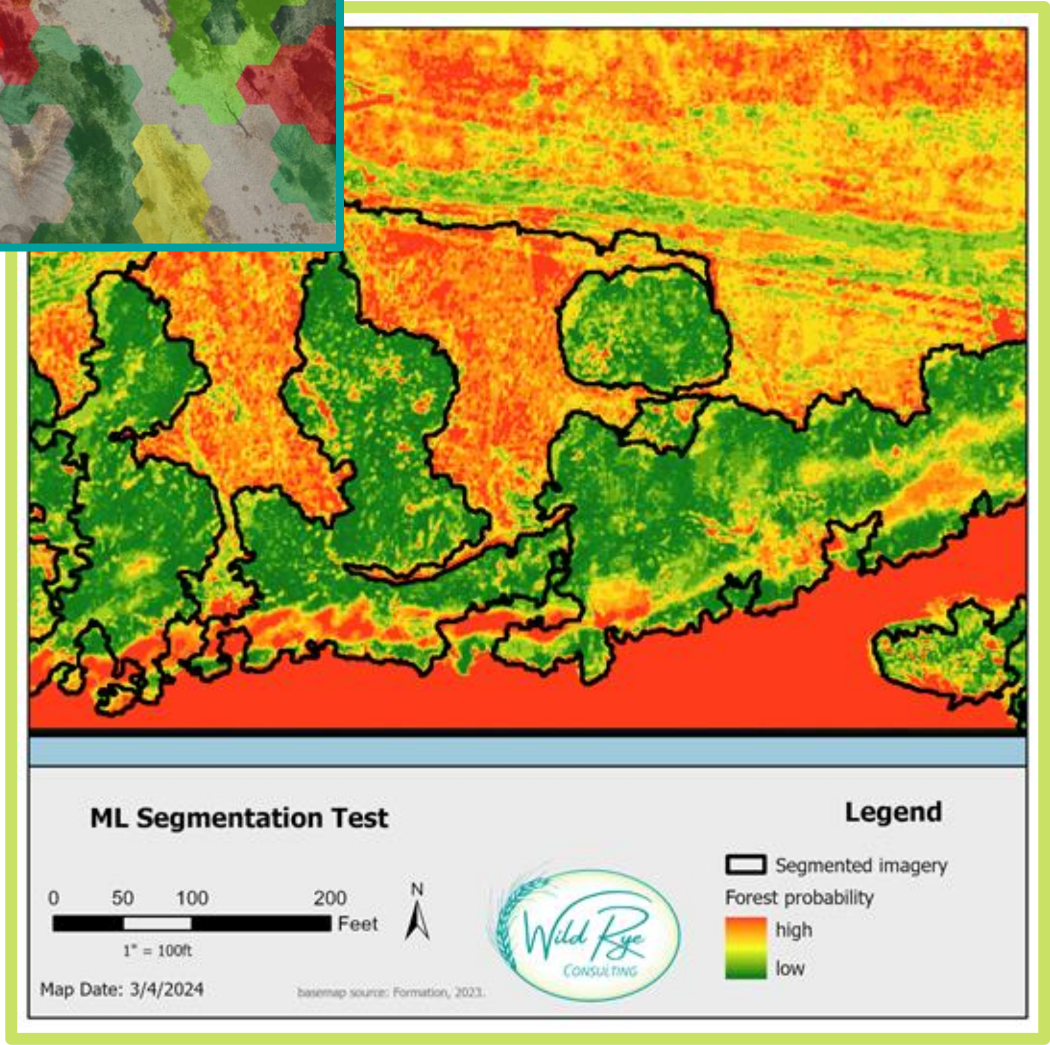


- Rerun ML for larger area of ARP simultaneously instead of in series

Progression & Iteration

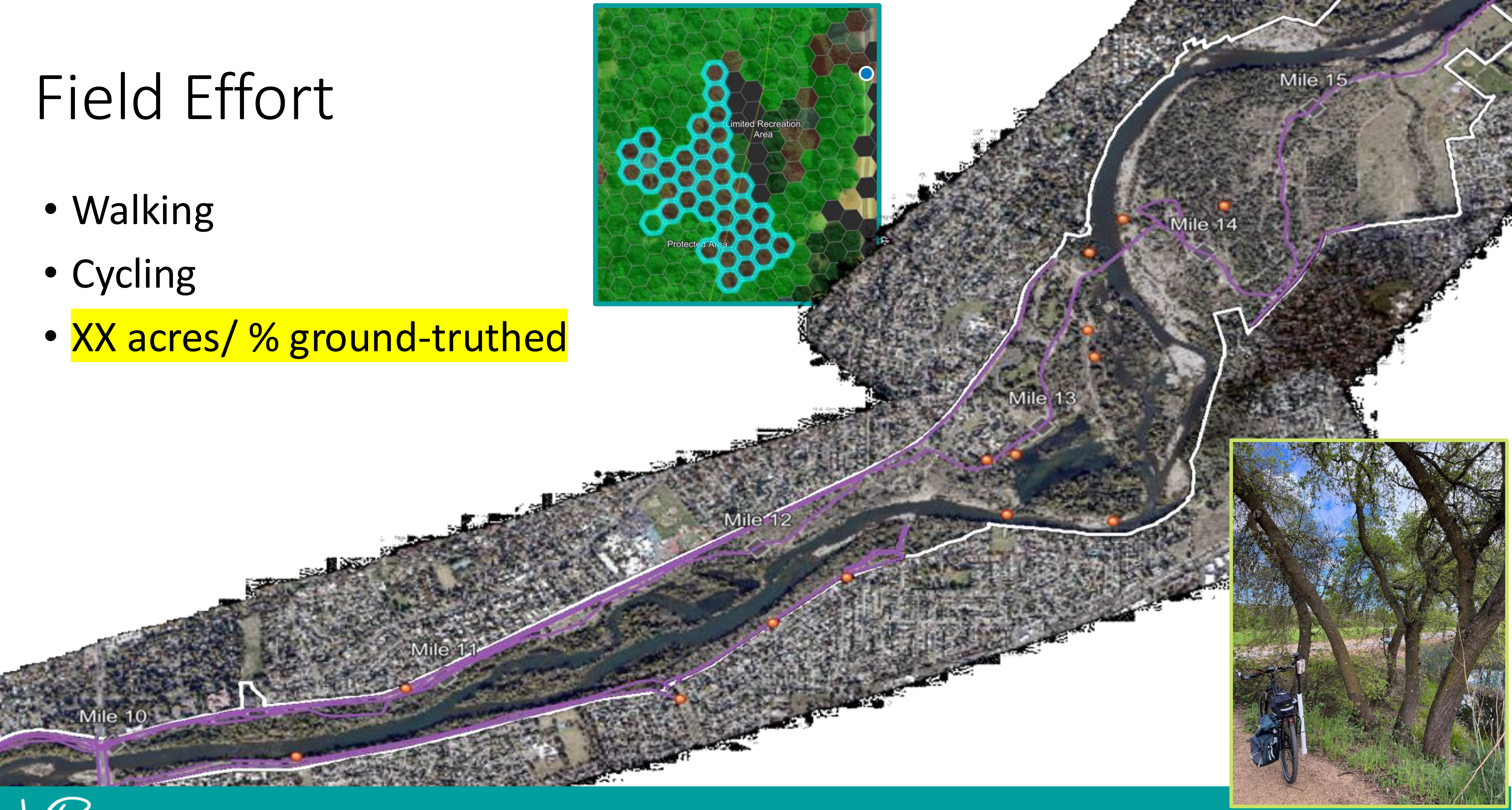
- ML map vegetation and keep confident areas.
- Field map hard to identify or unclassified vegetation.
- Ground-truth map without having to field map each boundary by foot.
- Tessellation allow for rapid re-classification

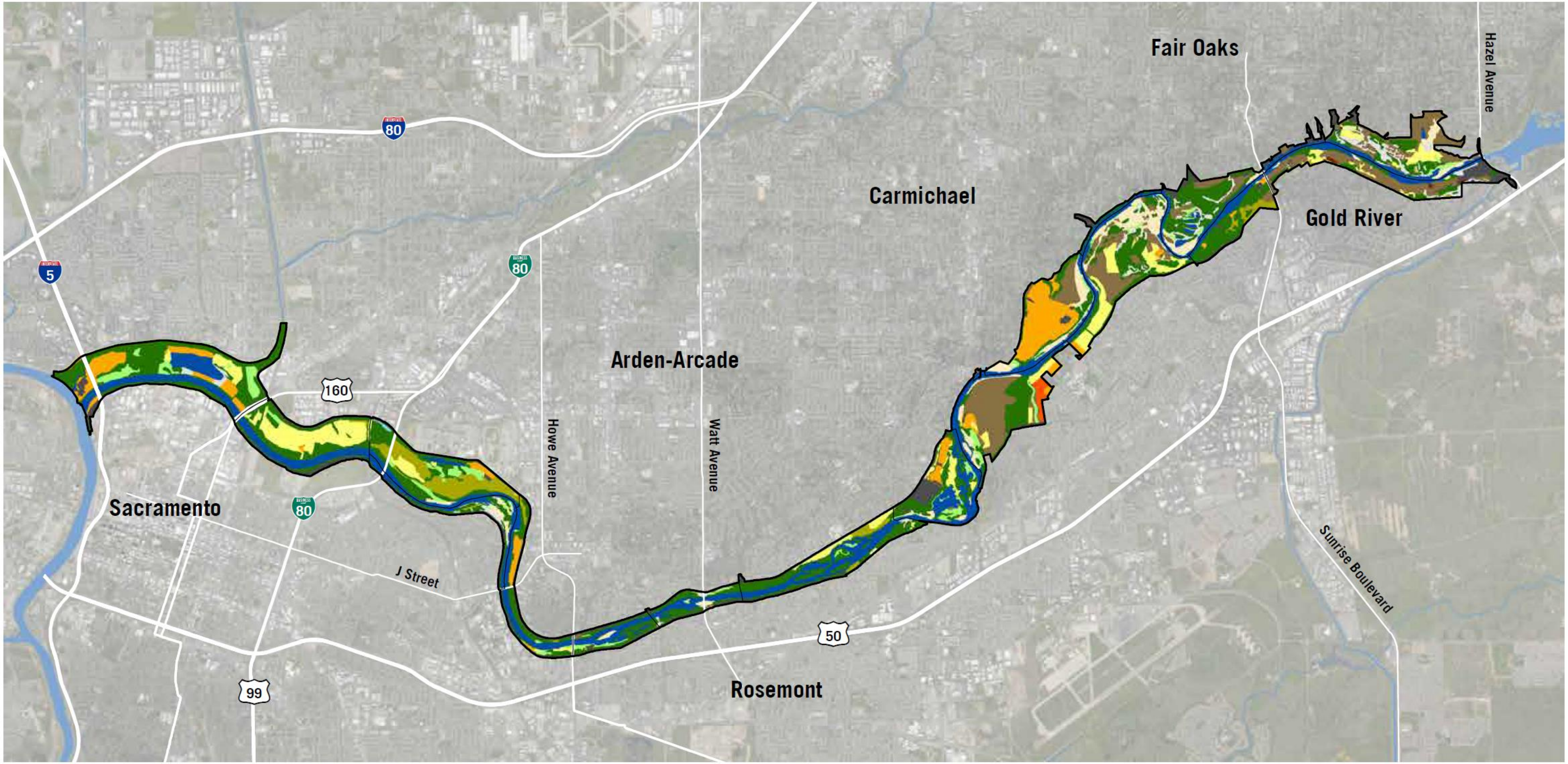




Field Effort

- Walking
- Cycling
- XX acres/ % ground-truthed



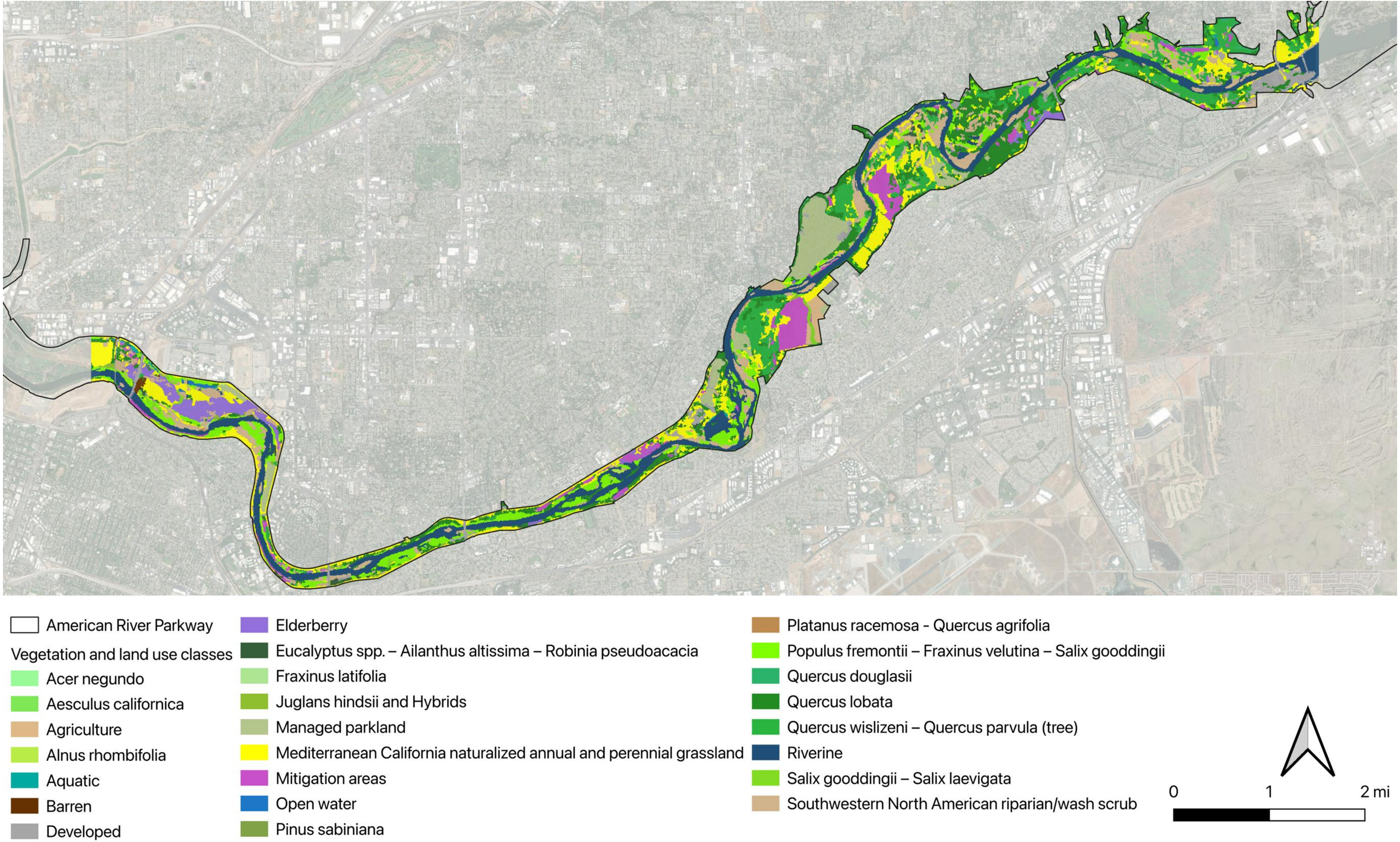


ESRI 2021

Agricultural (27 ac)
Developed (453 ac)
Elderberry Savannah (227 ac)
Freshwater Emergent Wetland (3 ac)
Foothill Pine (6 ac)
Gravel Bar Chaparral (277 ac)
Open Water (1,131 ac)
Oak Woodland/Forest (729 ac)
Riparian Woodland/Forest (1,813 ac)
Riparian Scrub (218 ac)
Turf/Turf with Trees (422 ac)
Unvegetated (174 ac)
Valley Foothill Grassland (525 ac)

0 1 2 Miles

Figure 4-1
Vegetation Communities


American River Parkway
Vegetation and land use classes
Acer negundo
Aesculus californica
Agriculture
Alnus rhombifolia
Aquatic
Barren
Developed
Elderberry
Eucalyptus spp. – Ailanthus altissima – Robinia pseudoacacia
Fraxinus latifolia
Juglans hindsii and Hybrids
Managed parkland
Mediterranean California naturalized annual and perennial grassland
Mitigation areas
Open water
Pinus sabiniana
Platanus racemosa - Quercus agrifolia
Populus fremontii – Fraxinus velutina – Salix gooddingii
Quercus douglasii
Quercus lobata
Quercus wislizeni – Quercus parvula (tree)
Riverine
Salix gooddingii – Salix laevigata
Southwestern North American riparian/wash scrub
0
1
2 mi

What we learned

- Vegetation Alliances in ARP not all represented in training data
- Significant variability in 0.25 acre
- Training data limited, prediction errors (POFR → AIAL)
- Edge effect
- Anthropogenic landcover/natural and semi-natural Alliances – mitigation areas are a challenge!
- Color differentiation challenges
- Machine learning is site-specific and requires quality drone imagery
- ML accelerates process and less expensive

Next Steps

Importance of fine-scale mapping

- Achieve NRMP Goals and Objectives
- Process/map will evolve
- Facilitate project implementation
  - CEQA screening tool
- Change detection
- Rapidly update map
- Wildlife management
- Forest health/pest tracking

Thank you

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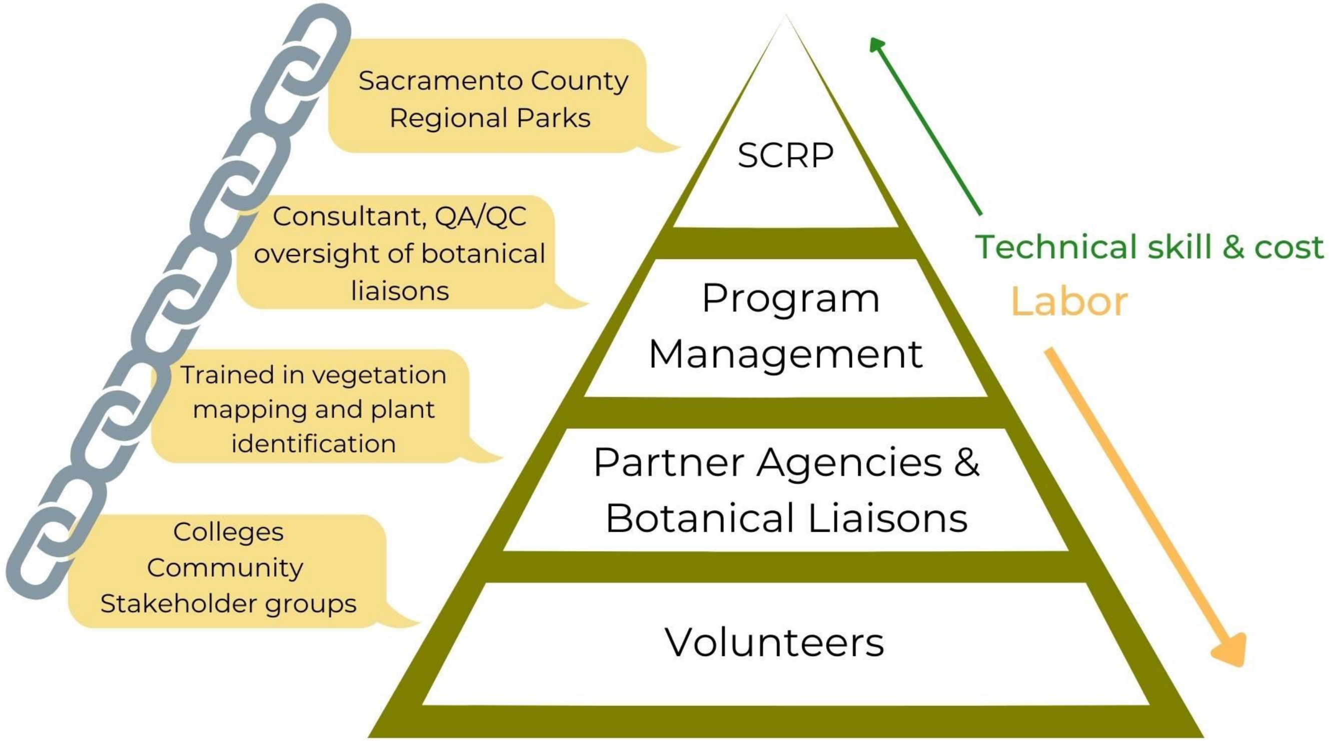
References

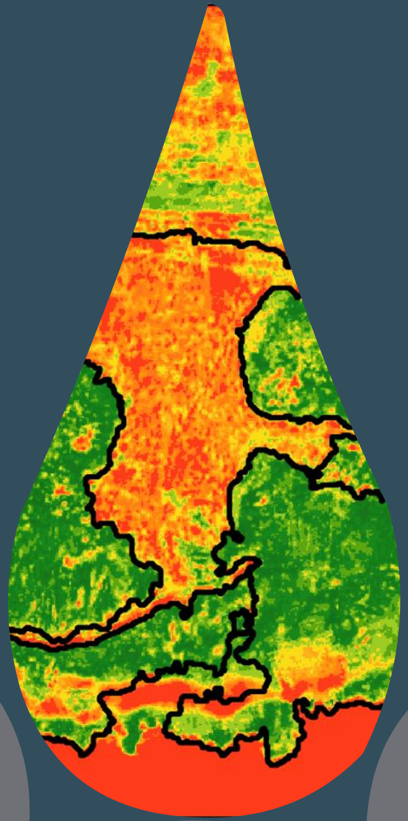
- Sacramento County NRMP, https://regionalparks.saccounty.gov/content/dam/regionalparks/docs/archive/ARP-NRMPFinal-2023-01-26.pdf
- DWR, Central Valley Flood Protection Planning Area Update, https://data.cnra.ca.gov/dataset/vegetation-central-valley-flood-protection-planning-area-update-2016-ds2890
- CDFW Vegetation Classification and Mapping Program, https://wildlife.ca.gov/Data/VegCAMP
- CNPS California Manual of Vegetation, https://vegetation.cnps.org/

Fine-Scale Vegetation Mapping Strategy

- Leverage power of partner agencies and stakeholder groups
- Community engagement
- Positive public relations
- Based on science, management decisions are defensible
- Long-term fine-scale vegetation mapping strategy will evolve
- Iterative process

Leverage relationships to build consensus and achieve a comprehensive map product





Vegetation Mapping

Questions & Discussion

What's Coming Up?

- 2-minute Teasers on Other Topics of Interest
- Suggestions for Future Science Shares
- Announcements

Thank you!