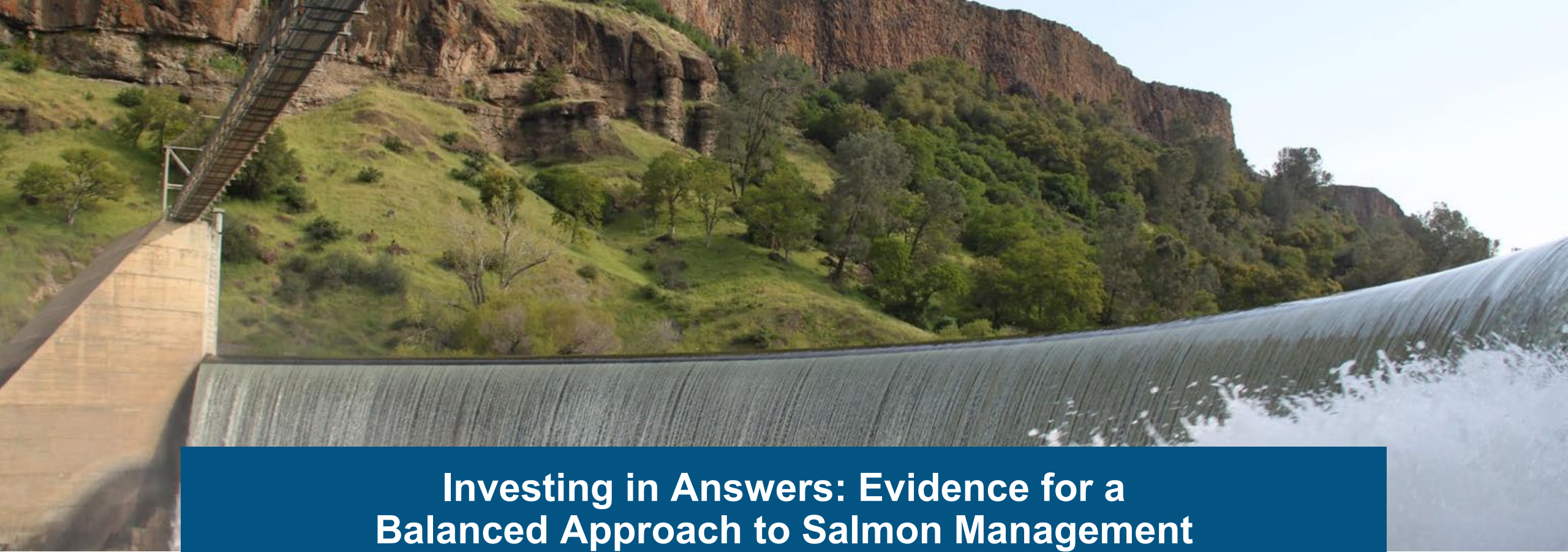




# Investing in Answers: Evidence for a Balanced Approach to Salmon Management

Integrating predation science into Central Valley water and fisheries policy

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Presenter: Andrea Fuller

Co-Authors: Dana Lee, Tara Lamb

ACWA Fall Conference | December 4, 2025





# Today's Talk

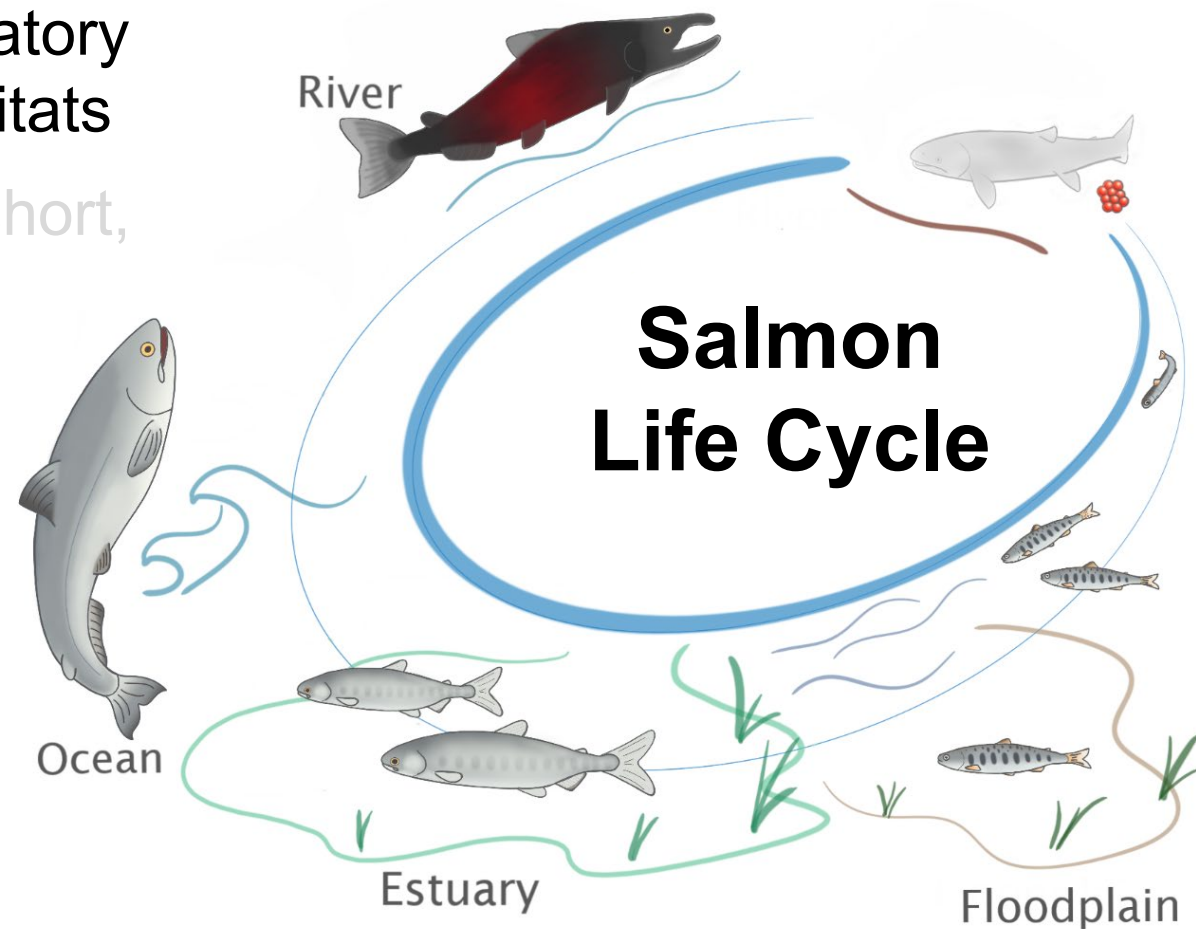
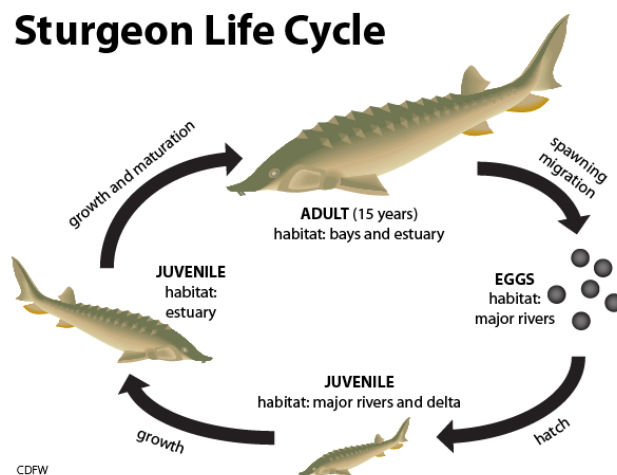
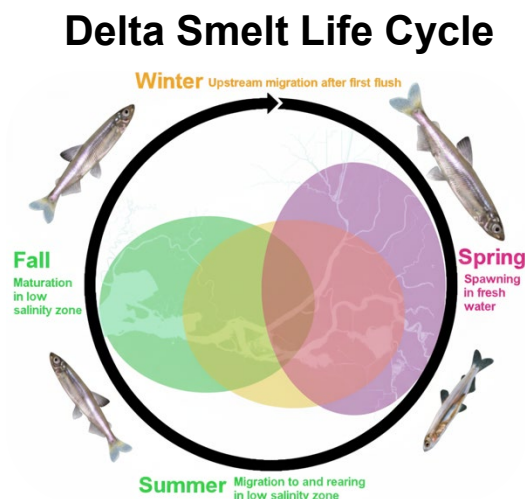
- Native species collapse in California's Central Valley
  - Why traditional management isn't working
- Drivers of population abundance
  - Habitat & hydrology
- Predation research
  - Quantifying the missing factor





# Life Cycles of Listed Species

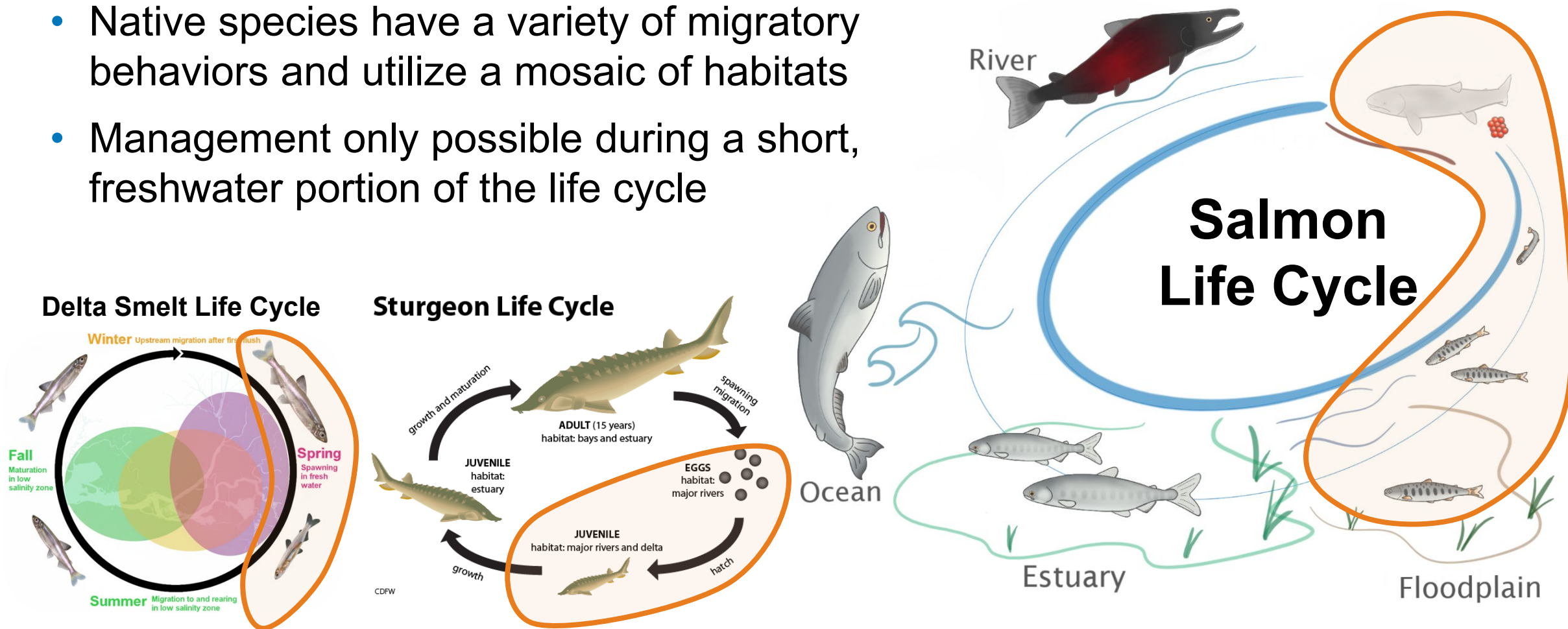
- Native species have a variety of migratory behaviors and utilize a mosaic of habitats
- Management only possible during a short, freshwater portion of the life cycle





# Life Cycles of Listed Species

- Native species have a variety of migratory behaviors and utilize a mosaic of habitats
- Management only possible during a short, freshwater portion of the life cycle

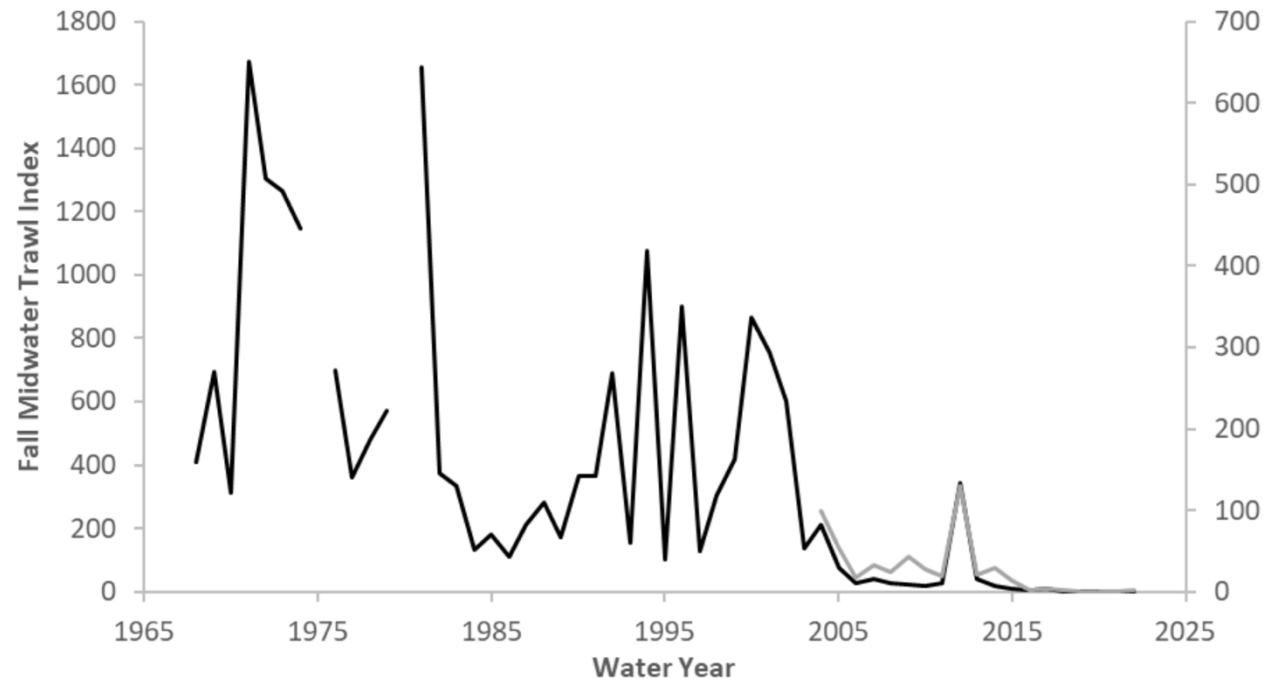




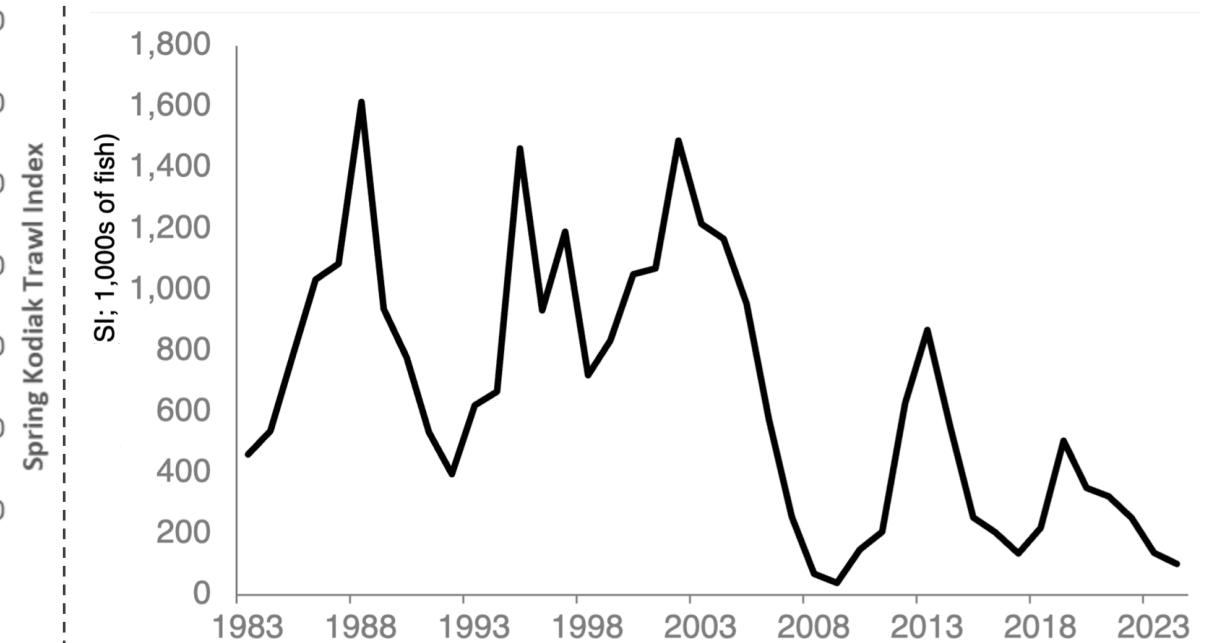
## Native Species at Risk

- Nearly all actions focused on *restoring habitats* and providing *additional flow for fish*
- No consistent improvement and most species remain imperiled

### Delta Smelt

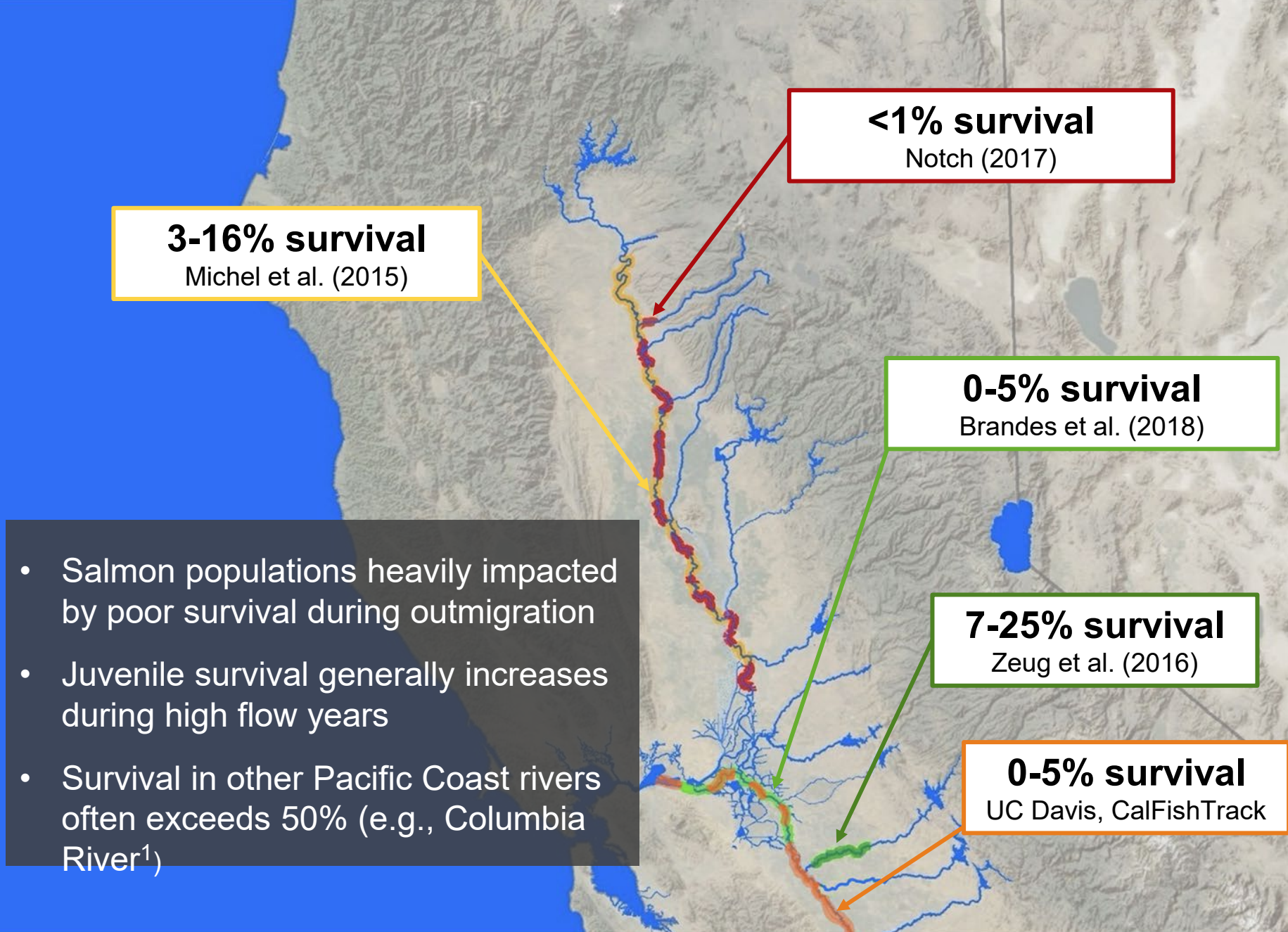


### Chinook salmon





## Poor Outmigration Survival across the Central Valley



<sup>1</sup>Rechisky et al. 2013



# What Drives Fisheries Management in the Central Valley?

- Numerous agencies, laws, policies, and plans
- ESA, BiOps, and SWRCB most impactful
  - Minimum flows
  - Delta exports curtailed
  - OMR management
  - X2 (salinity)
  - Temperature objectives
  - Restoration
- Nearly all actions are focused on providing ***additional flow for fish***
- Resulted in little success and most species remain imperiled



Green Sturgeon



Longfin Smelt



Delta Smelt



Steelhead

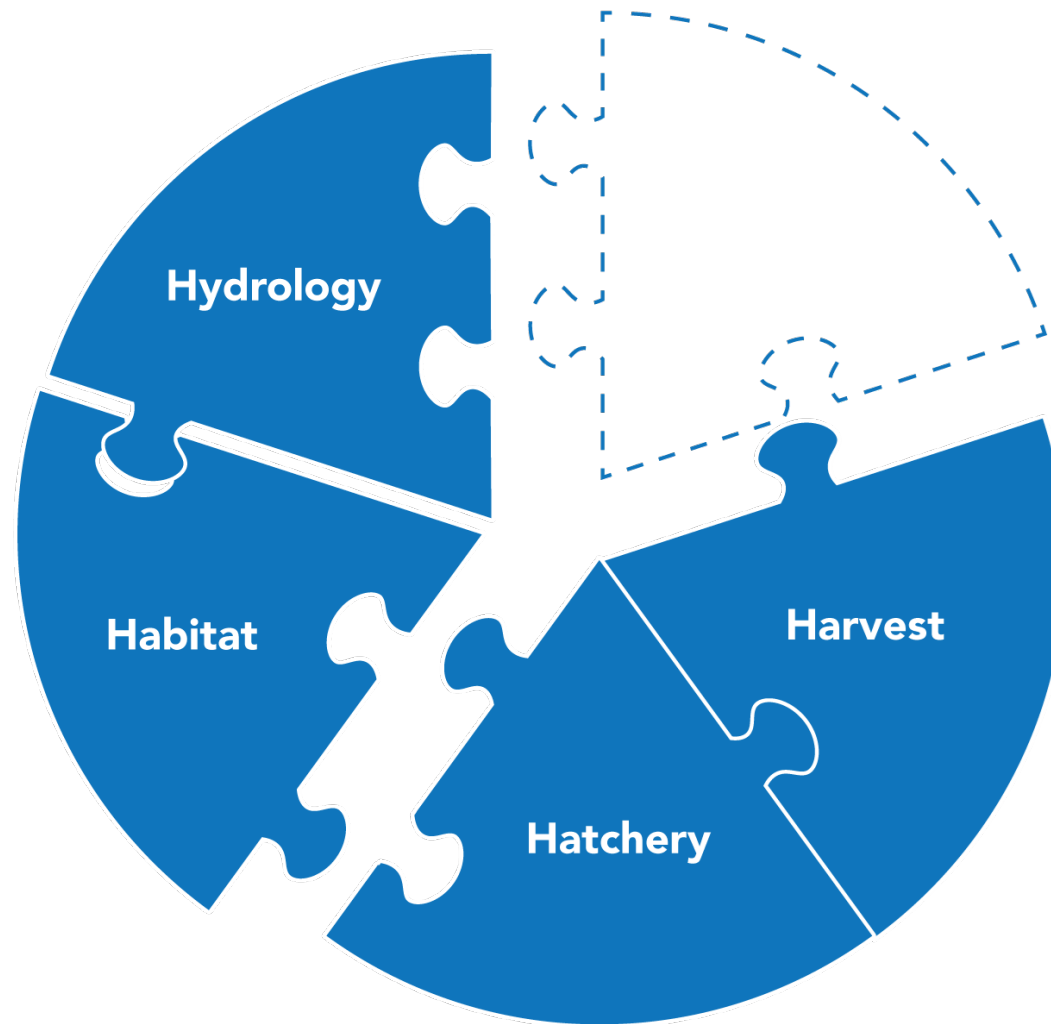


Chinook Salmon



## Drivers of Salmon Abundance - the 4 H's

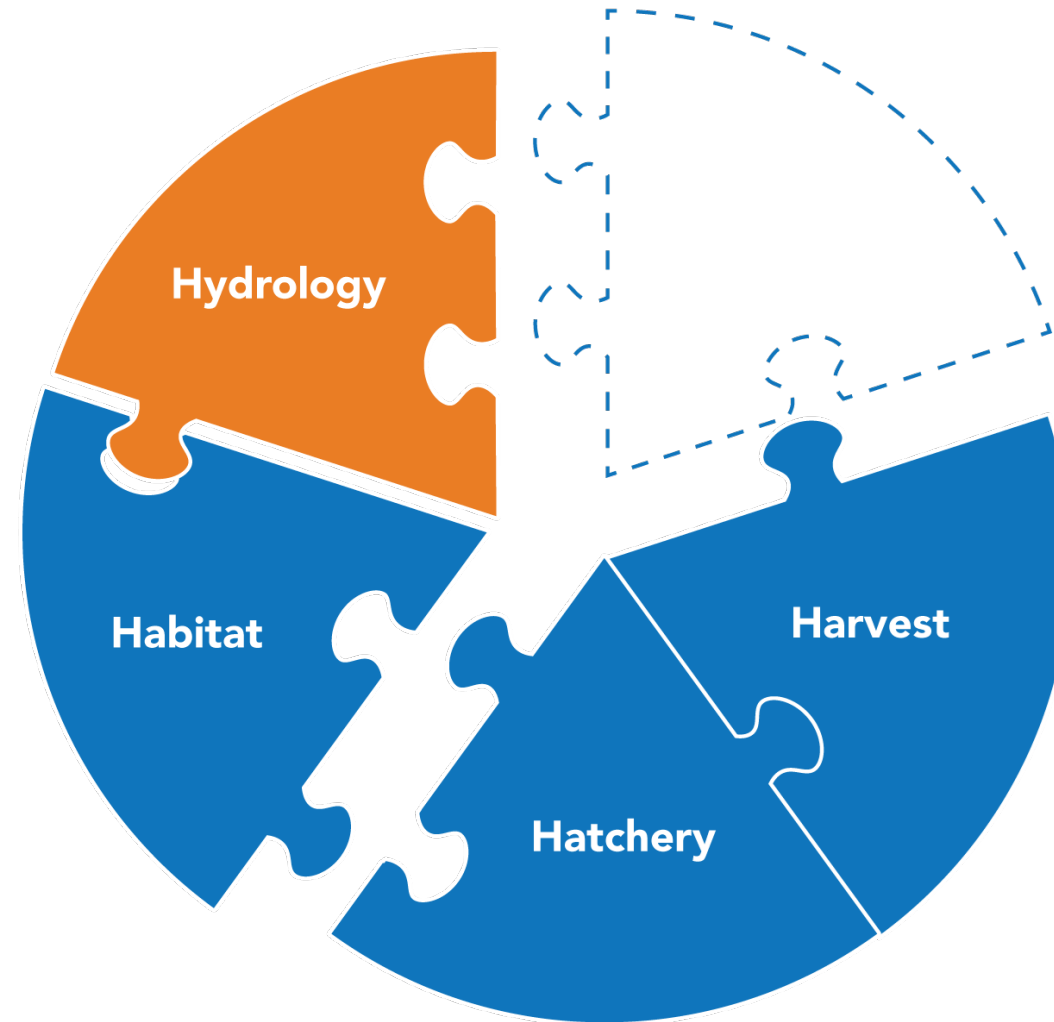
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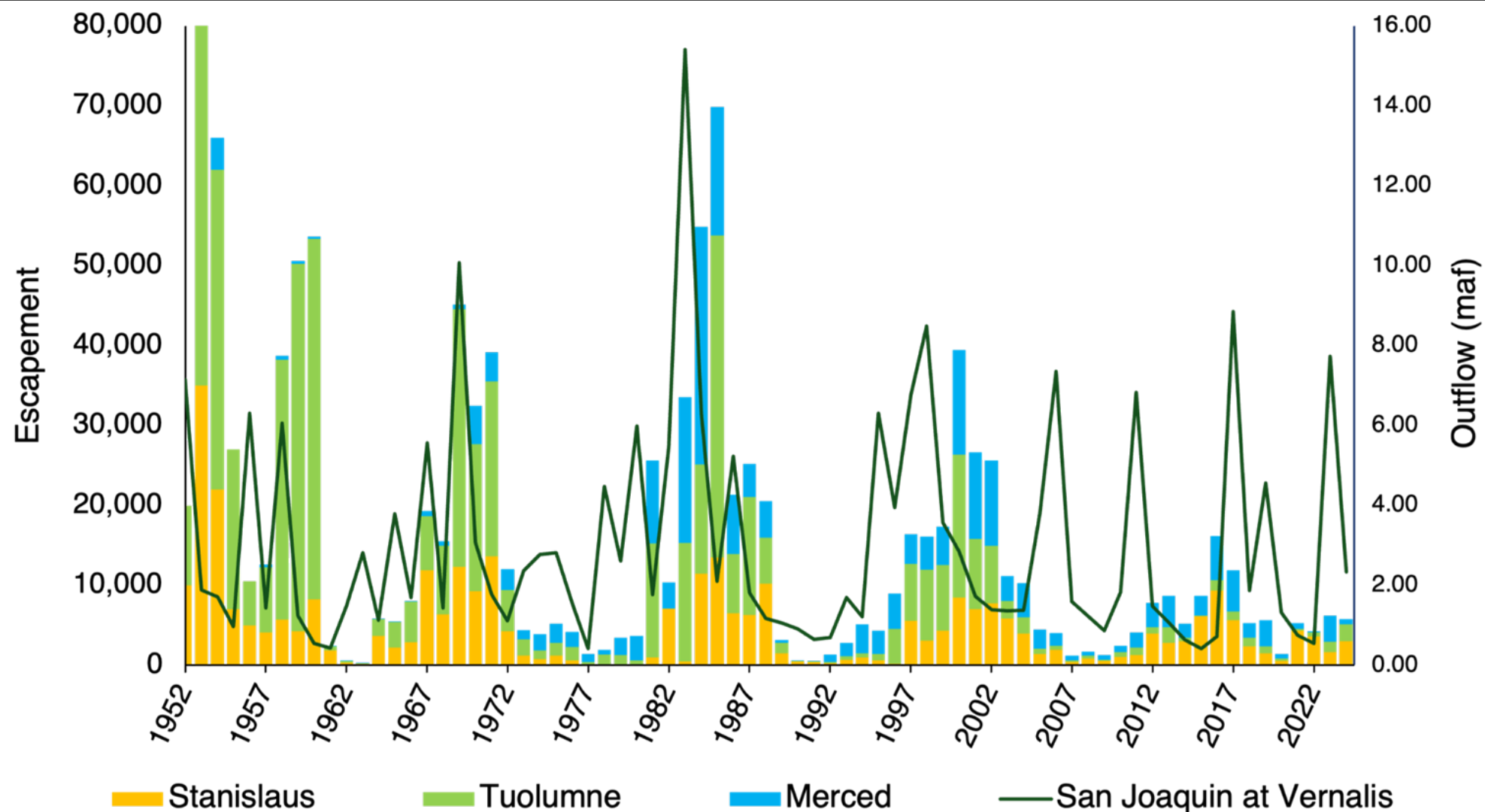
# Drivers of Salmon Abundance - the 4 H's

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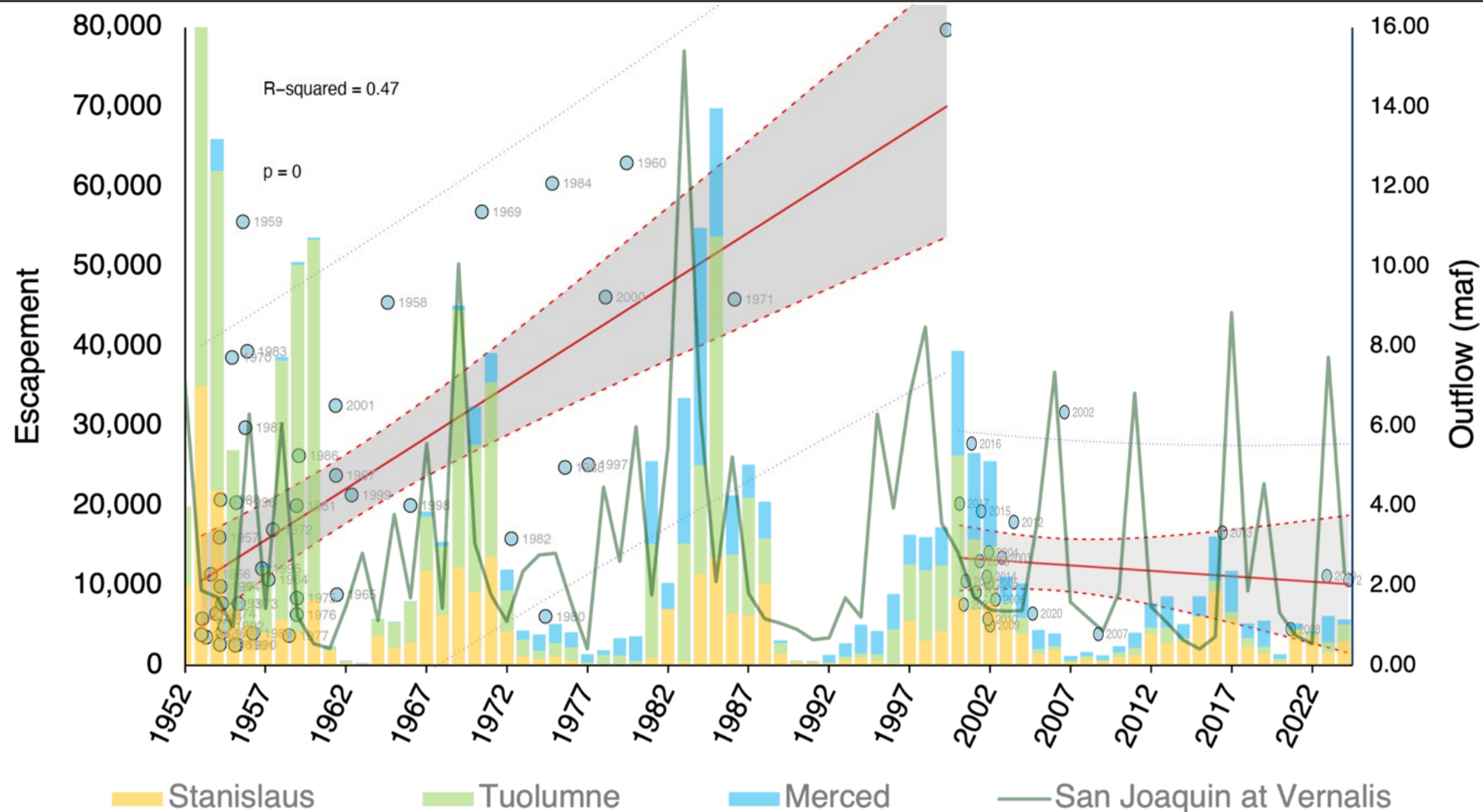


# The Flow Disconnect - Salmon





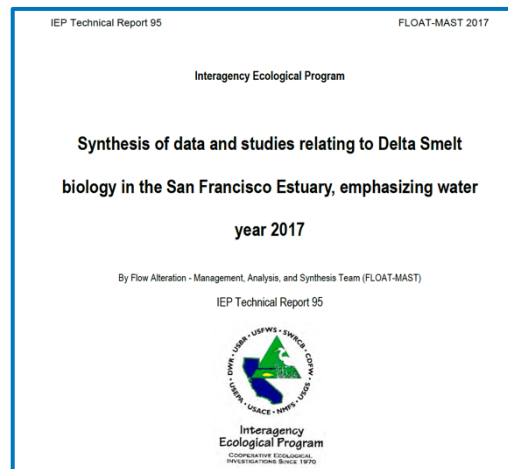
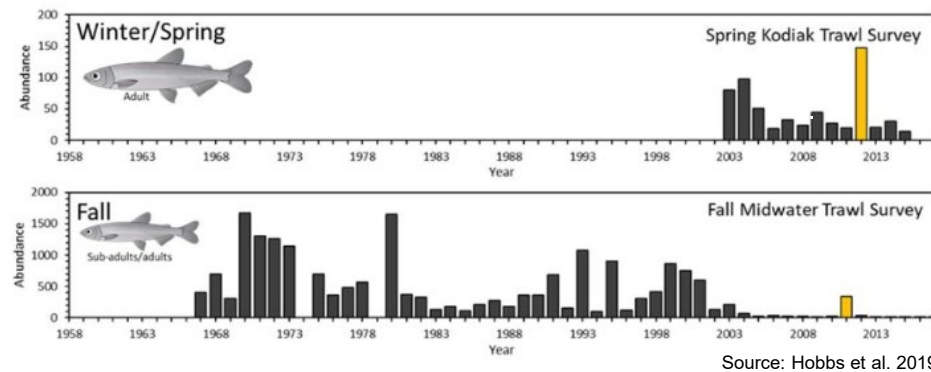
# The Flow Disconnect - Salmon





# The Flow Disconnect - Delta Smelt

- Lack of Delta Smelt population response to high flows in 2017



## IEP Review Results:

- Other factors besides flow acting limiting population abundance
  - e.g. high water temperatures

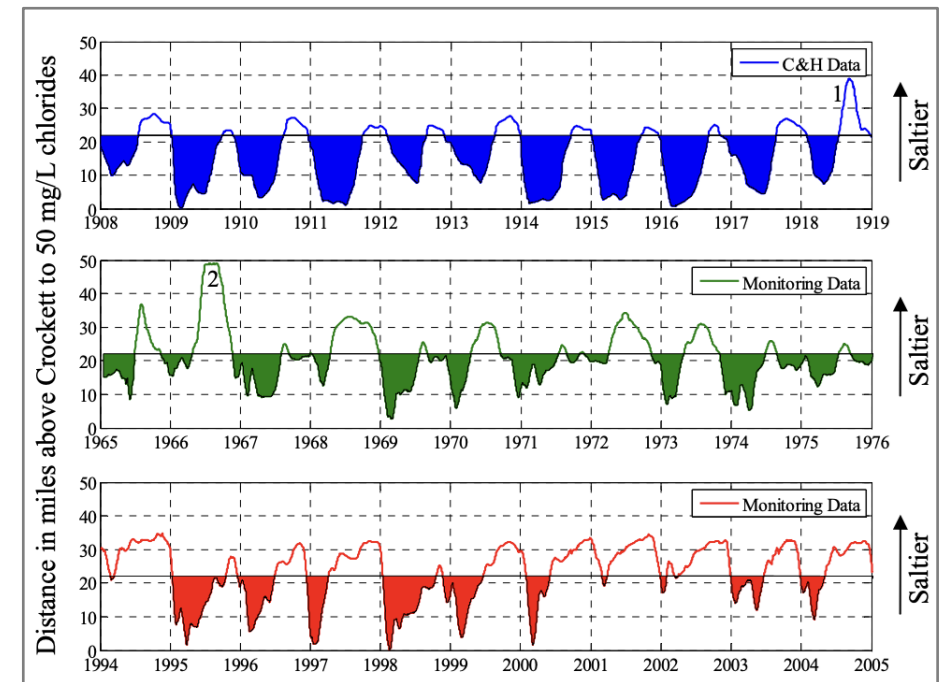
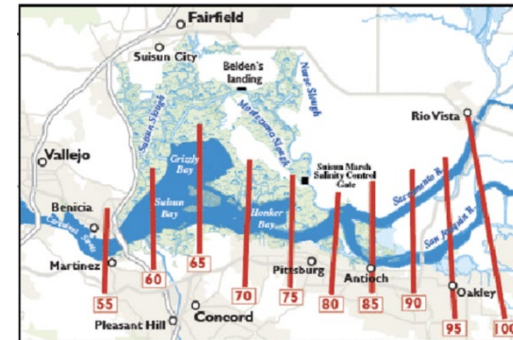
| Physical Habitat       | Low Flows  | High Flows | 2017   |
|------------------------|------------|------------|--------|
| Fall LSZ Location      | Confluence | Suisun     | Suisun |
| Area of LSZ            | ↓          | ↑          | ↑      |
| Turbidity              | ⊗          | ⊗          | ⊗      |
| Water Temperature      | ↔          | ↔          | ↑      |
| Delta Smelt            | Low Flows  | High Flows | 2017   |
| Distribution           | ⊗          | ⊗          | ⊗      |
| Growth and Survival    | ↔          | ↔          | ↓      |
| Health Metrics         | ↔          | ↔          | ↔      |
| Feeding Success        | ↔          | ↔          | ↓      |
| Life History Diversity | ↔          | ↔          | ⊗      |
| Biotic Habitat         | Low Flows  | High Flows | 2017   |
| Phytoplankton          | ↔          | ↔          | ↑      |
| Harmful algal blooms   | ↑          | ↓          | ↓      |
| Zooplankton            | ↔          | ↔          | ↑      |
| Clams                  | ↑          | ↓          | ↓      |
| Water Hyacinth         | ↑          | ↓          | ↓      |



# Managing for Non-Natives?

- High flows not consistently increasing native fish abundance
- Numerous impacts to the system have dampened the value of high flows
- Static flows benefit non-native species
- Fall X2 requirement keeps Delta salinity stationary
  - Models showed little/no benefit to Delta smelt
  - Off-ramps for Fall X2 starting in 2024

Static  
vs.  
Dynamic

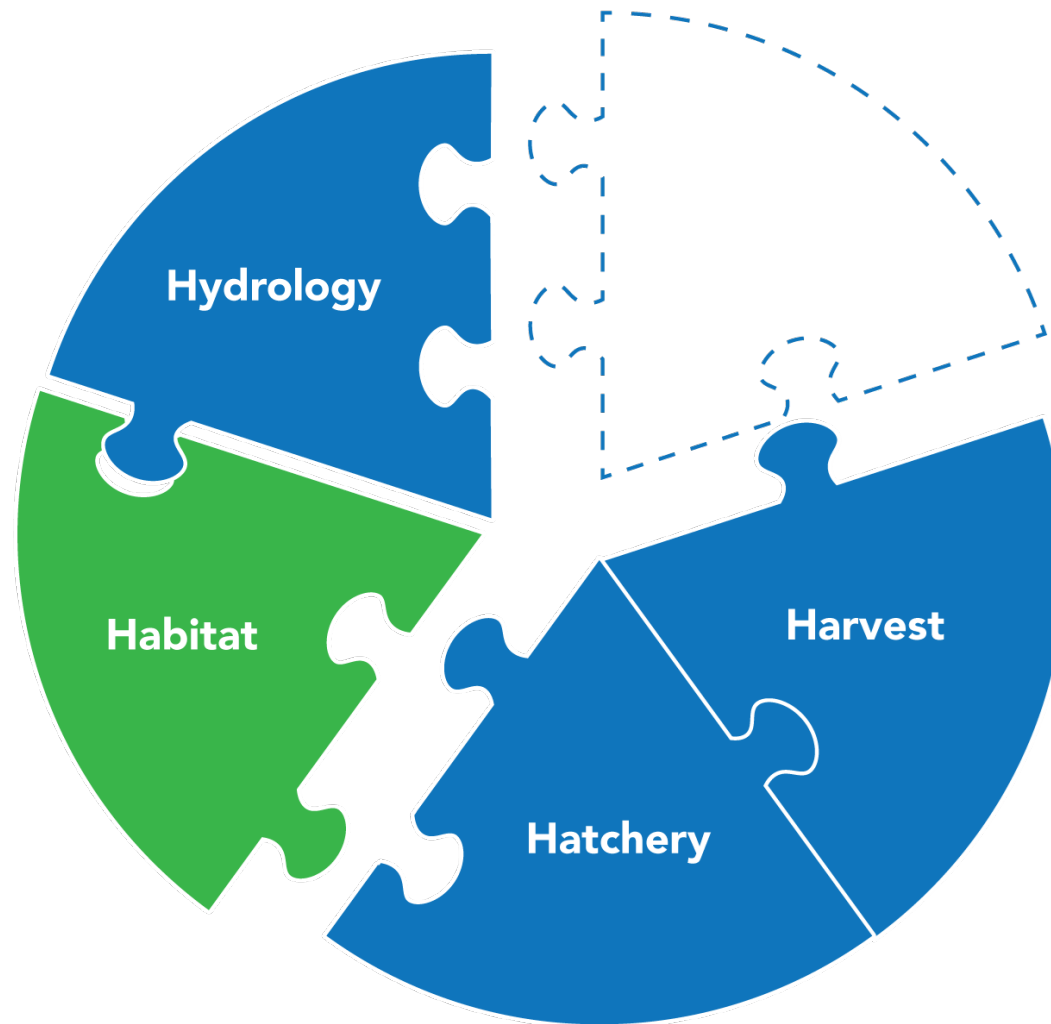


Source: CCWD 2010



## Drivers of Salmon Abundance - the 4 H's

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# Fundamentally Altered Salmon Habitat

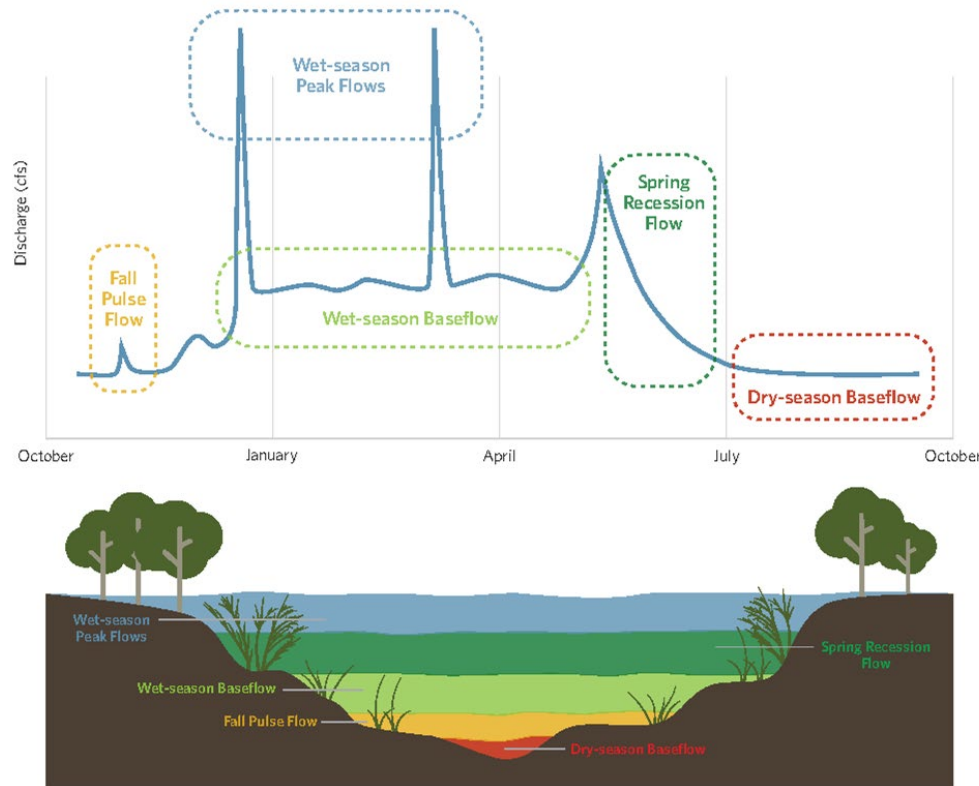
- Restoration has primarily occurred on the valley floor, outside of historical rearing areas
- Recent efforts led by NMFS to get fish above dams
- Trap and haul operations and poor habitat/survival below dams has not been addressed





# Banking on Habitat

**Major investments:** ~\$5 to \$8 billion on habitat improvements



Source: California Environmental Flows Framework Technical Team 2021

## **Problems remaining:**

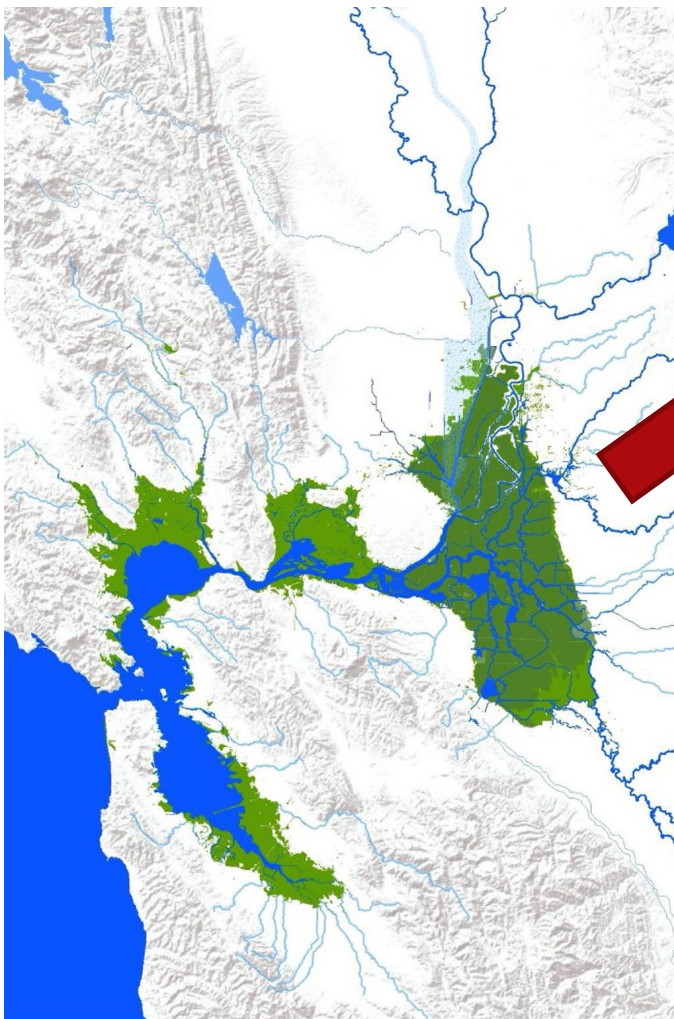
- Current habitat is less functional
  - Channelized rivers and Delta
- Focus on floodplain restoration:
  - Minimal survival benefits from rearing in the Yolo Bypass<sup>2</sup>
- Restored areas create habitat for non-native species
  - Restored wetland had more non-native predators than surrounding waters<sup>3</sup>

<sup>2</sup>Takata et al. 2017; Sommer et al. 2020

<sup>3</sup>Williamshen et al. 2021



# A Different Delta

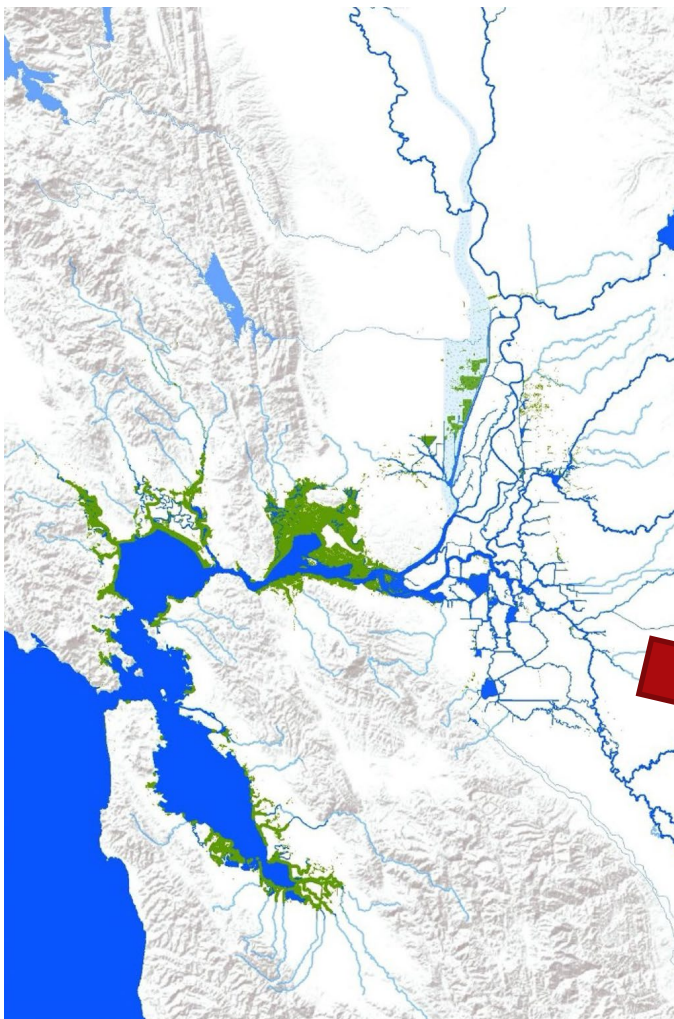


## Historical Habitat:

- High turbidity
- High primary productivity
- Habitat complexity
- Benefits for spawning/rearing



# A Different Delta



## Current Habitat:

- Food web collapse: invasive clams
- Invasive aquatic and riparian weeds
- low turbidity and primary productivity





# A Different Delta

## 10 Best Bass Fishing Destinations in the US for 2025

Updated on Aug 19, 2025 | 8 minute read | Written by [Marko](#)

8 Comments

Bass are iconic fish among freshwater anglers. They're smart, cunning creatures, with interesting behavioral patterns that make them fun and challenging to catch. And since they're widespread across the US, it comes as no surprise that they're popular. If you, like many others, simply can't get enough of Bass, read on. In this article, we'll present you with the 10 best Bass fishing destinations in the US.



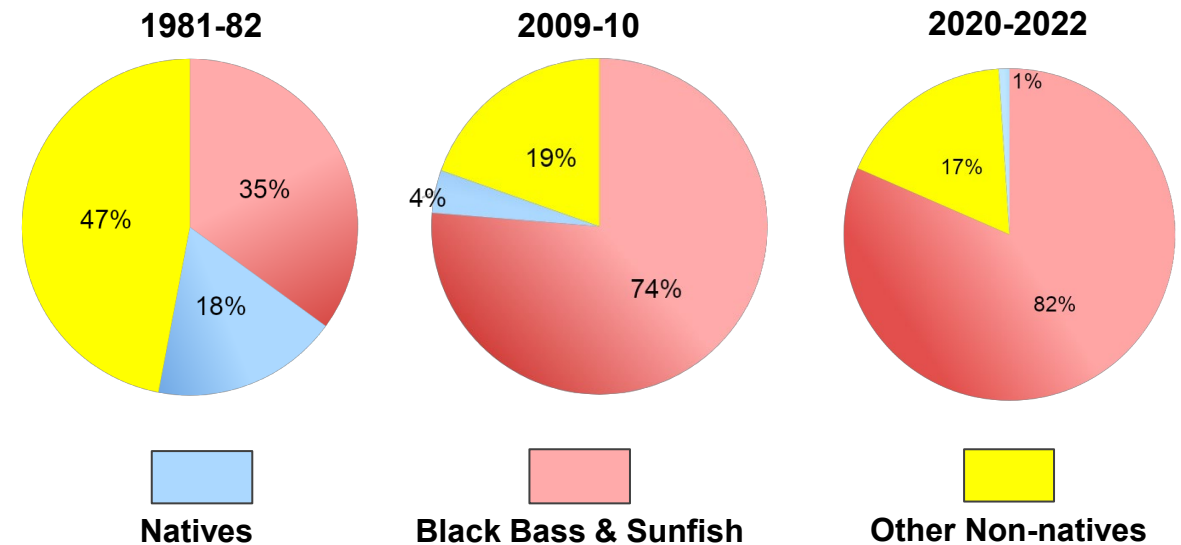
**Result:**  
**World-class  
bass fishery**



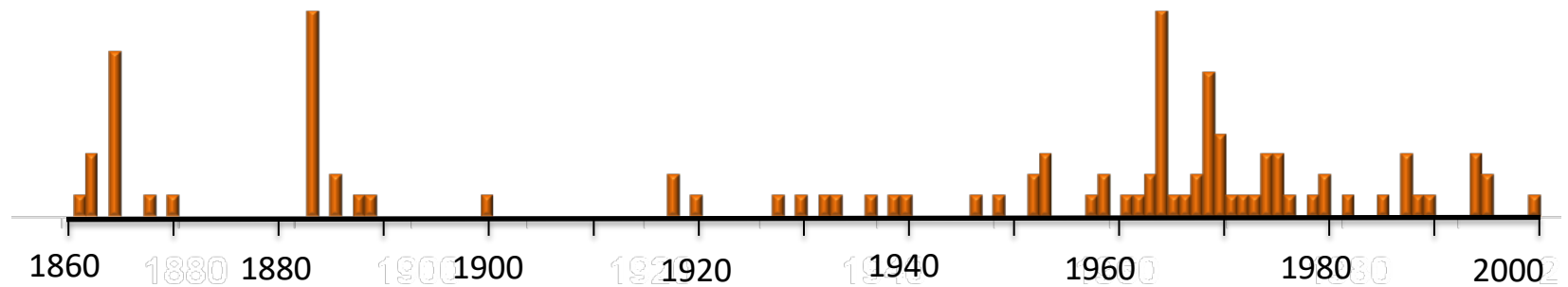


# Nonnative Introductions and Impacts to the Fish Community

- Long history of nonnative species introductions, primarily by CDFW
- Population explosions for most non-natives
- Management for non-natives focused on improving sportfishing



Conrad et al. 2010. More big bass: Understanding the role of largemouth bass as top predators in the littoral zone. Delta Science Council Conference Sacramento, California September 2010



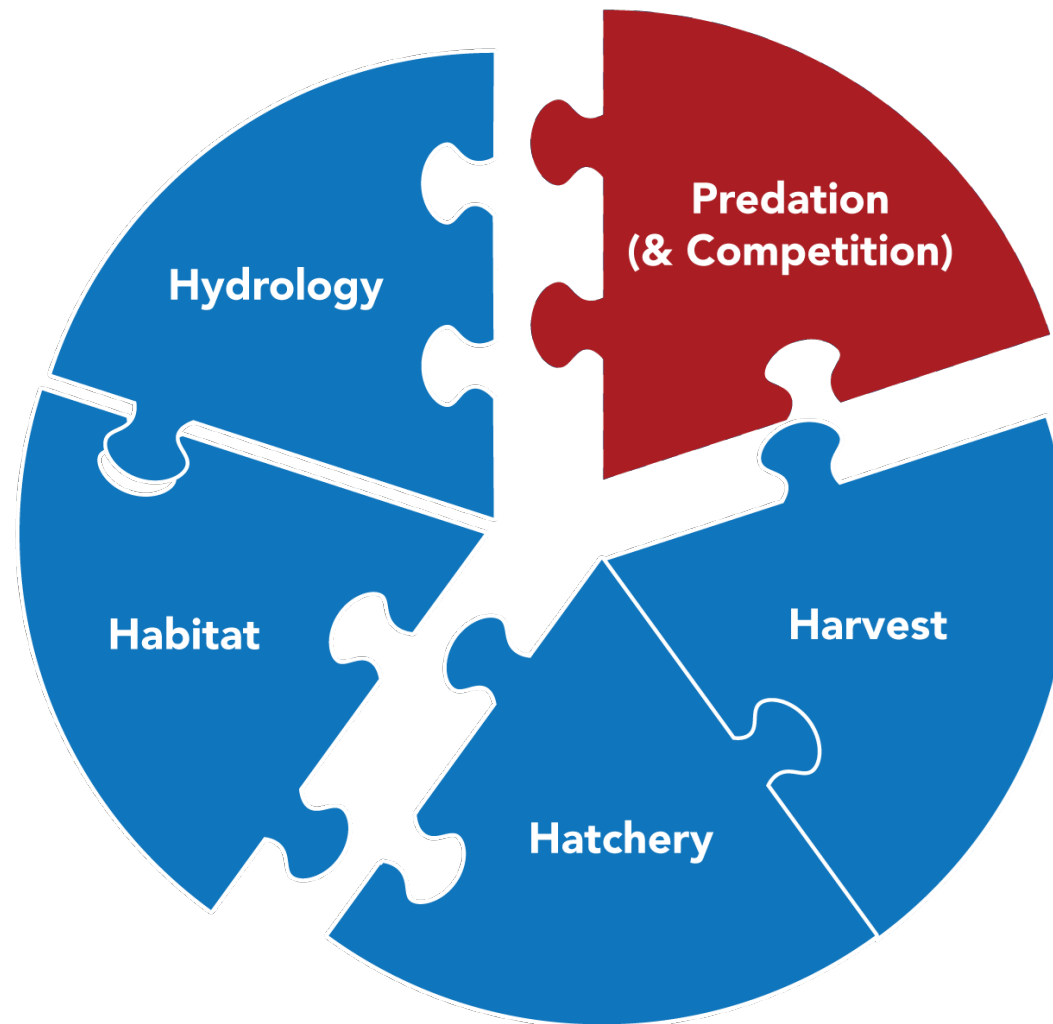
Data from Cohen and Moyle 2004

Nonnative Fish Introduction Timeline



# Drivers of Salmon Abundance - the *Missing Piece*

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# Time for a New Approach - Address Predation and Competition

## Increasing evidence of non-native species impacts:

- Increasing research focus
- *Nobriga and Smith 2020*: Striped bass were major predators of Delta smelt historically, contributing to their decline
  - Striped bass targeting delta smelt during temporary rebounds
  - Predation impacts masked by habitat alterations

## Efforts to manage non-native predators:

- Oregon/Washington - no limits/size restrictions for bass
- Disruption of bass spawning in the Colorado River
- Studies on predator and SAV removals in the Delta<sup>4</sup>

### Policy Directives



#### 1b. Rivers, Streams, and Natural Lakes:

Where non-native game fish are present and pose a risk to the conservation or recovery of native fish or wildlife, or would be detrimental to the reestablishment of extirpated native fish or wildlife populations, ODFW will actively manage against the expansion of non-native game fish.

At some specific locations, this may include efforts to reduce or remove non-native game fish depending on the degree of conservation risk, management options and resources available, and likelihood of success.

### The battle rages on against bass in the Pacific Northwest

May 2, 2022

ARTICLE • INTERMOUNTAIN PARK SCIENCE: DROUGHT IN THE SOUTHWEST

### Smallmouth Bass: Not a Small Threat to the Grand Canyon

Glen Canyon National Recreation Area, Grand Canyon National Park

- Melissa Trammell, Fisheries Biologist, National Park Service
- Brian Healy, Supervisory Research Fish Biologist, Southwest Biological Science Center, U.S. Geological Survey, Grand Canyon Monitoring and Research Center
- Kirk Young, Biologist, U.S. Fish and Wildlife Service (retired)

#### Abstract

Decades of climate-driven drought, and a consistent imbalance between supply and demand for Colorado River water have led to low reservoir levels in the Colorado River Basin. Low water levels have implications to rivers located both upstream and downstream of the reservoirs, particularly in the Colorado River in Grand Canyon, located below Glen Canyon Dam, and above Lake Mead. Lower water elevation in Lake Powell brings the warmer surface water and nonnative game fish in closer proximity to the power turbine intakes where they can become entrained and may survive passage to the river below. Smallmouth bass (*Micropterus dolomieu*), a popular and abundant game fish in Lake Powell, are undesired invasive predators below the dam. Preventing the establishment of a new predatory invasive species is essential to protecting and facilitating recovery of the federally listed humpback chub (*Gila cypha*) in the Colorado River in Grand Canyon. We modeled the probability that smallmouth bass would establish a self-sustaining population below the dam under a



Written by  
**Robert Montgomery**

In the Pacific Northwest, bass anglers can relate to comedian Rodney Dangerfield, who often lamented, "I don't get no respect."

<sup>4</sup>Michel et al. 2020; Michel et al. 2026



## Take Home Messages

- Flows and habitat marginally help juvenile survival
- **However**, no corresponding adult returns
- **Conflating issues**: numerous factors affecting success of native fishes
  - Hatchery effects, harvest management
- **Core problem**: Non-natives masking any gains in native abundance





# Questions?



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Andrea Fuller

[andreafuller@fishbio.com](mailto:andreafuller@fishbio.com) | 209.847.6300



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Vientiane Capital, Lao PDR





# Impacts of Nonnative Fish on Salmon Recovery

Lessons Learned from Long-Term Predation Studies in the San Joaquin Basin

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Presenter: Dana Lee

Co-Authors: Tara Lamb, Tyler Pilger, Matt Peterson, and Andrea Fuller

ACWA Fall Conference | December 4, 2025





# Today's Talk

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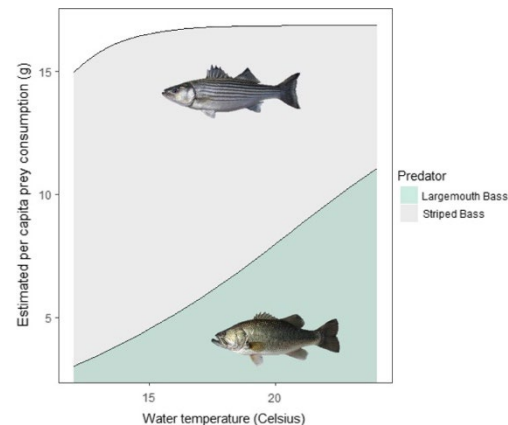
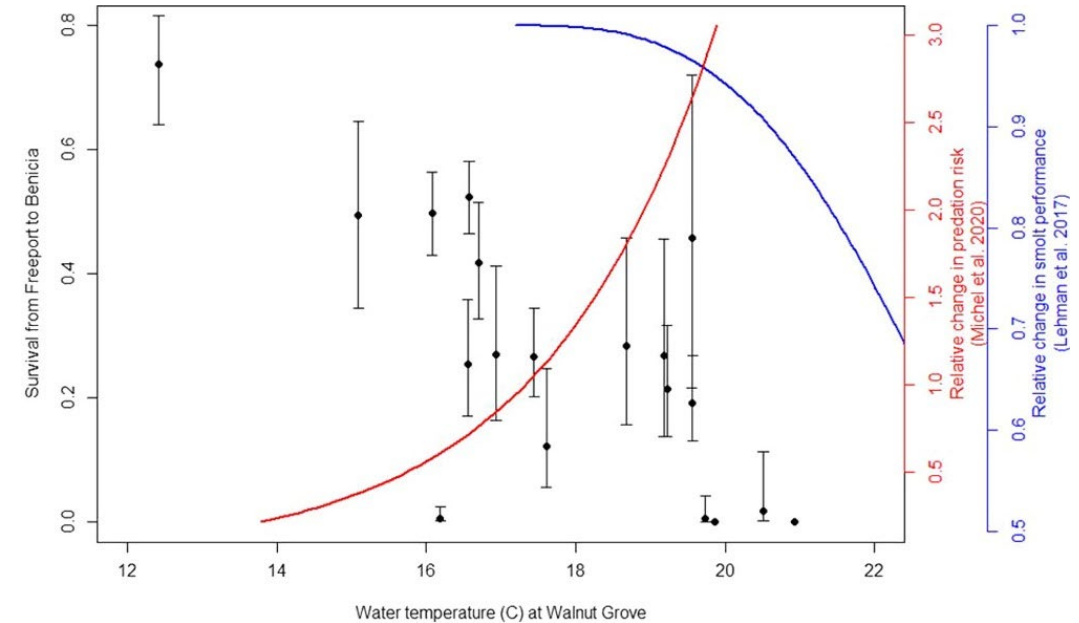
- History of predation research in the Central Valley
- FISHBIO research in the San Joaquin Basin
  - Quantifying the missing factor
- Broader research needs





# Increasing Evidence of Impacts

- **Chinook Salmon Recovery Plan (2009):** Reduce abundance of striped bass to *“prevent extinction or to prevent the species from declining irreversibly”*
- **Loboschefsky et al. (2012):** Striped bass consume 55,000,000 lbs of fish per year. *Eating every single juvenile salmon would still only be ~2% of their annual diet.*
- **Sabal et al. (2016):** Striped bass predation on juvenile Chinook had *population-level impacts of up to 29%* at a single spot in the Mokelumne River
- **Nobriga et al. (2021):** Nearly *100% mortality of salmon* in the Delta once temperatures reach 20°C

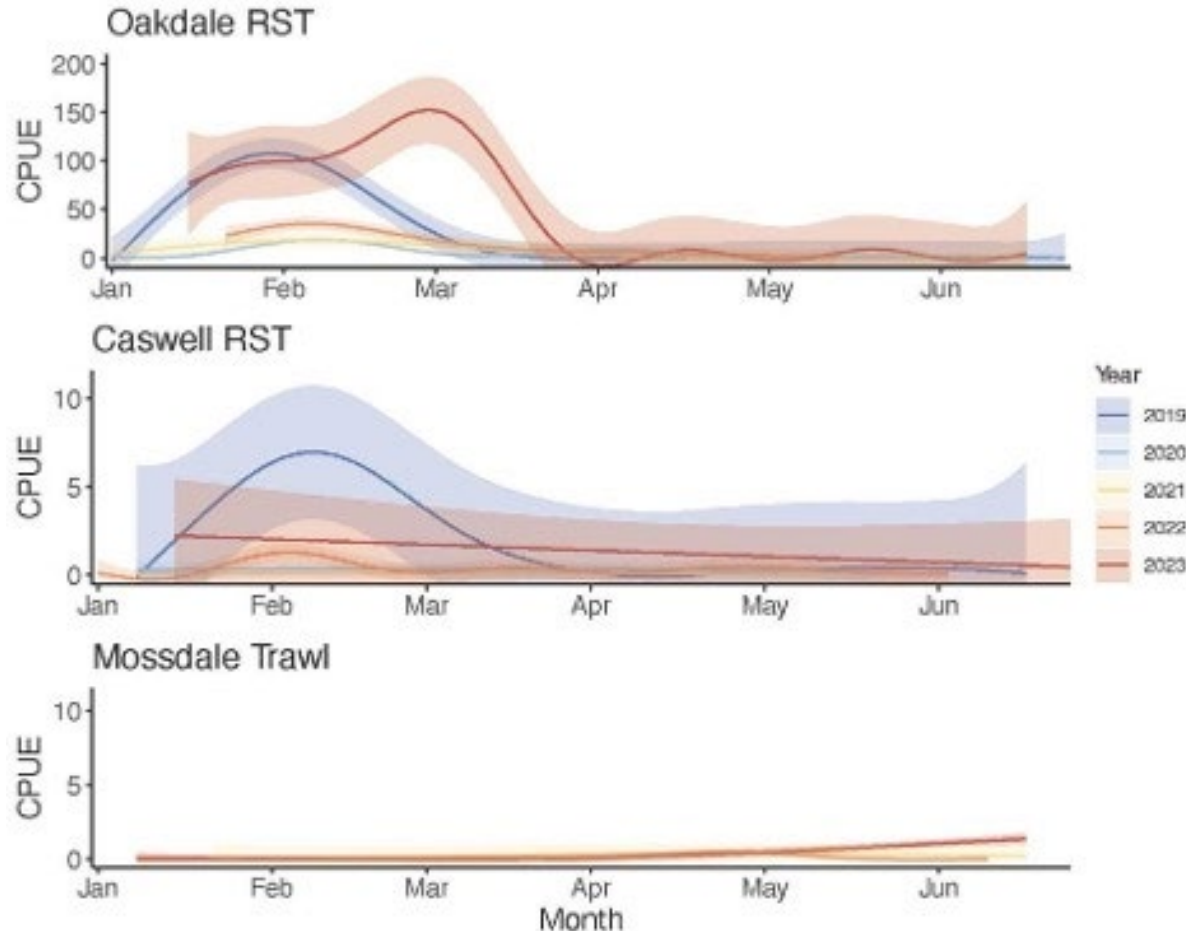


Juvenile salmon pumped from striped bass stomach



# FISHBIO Studies – The Missing Salmon

**Research Driver:** Massive loss between screw traps



## 2012 Tuolumne River Predation Study

- Only 4% of Chinook estimated to survive the 25-mile migration
- Predator abundance and predation rates indicate potential for 96% loss due to predation

## 2019-2024 Stanislaus River Native Fish Plan

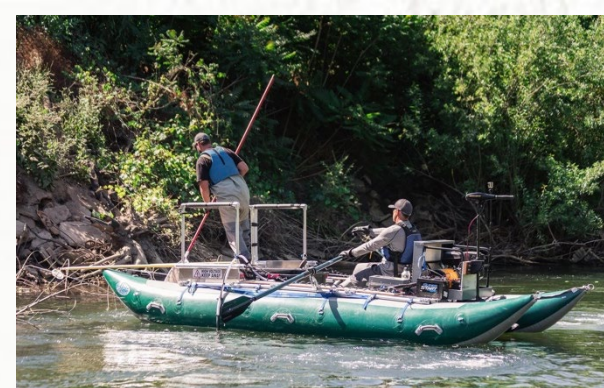
- Multi-year predation research program in the Stanislaus River

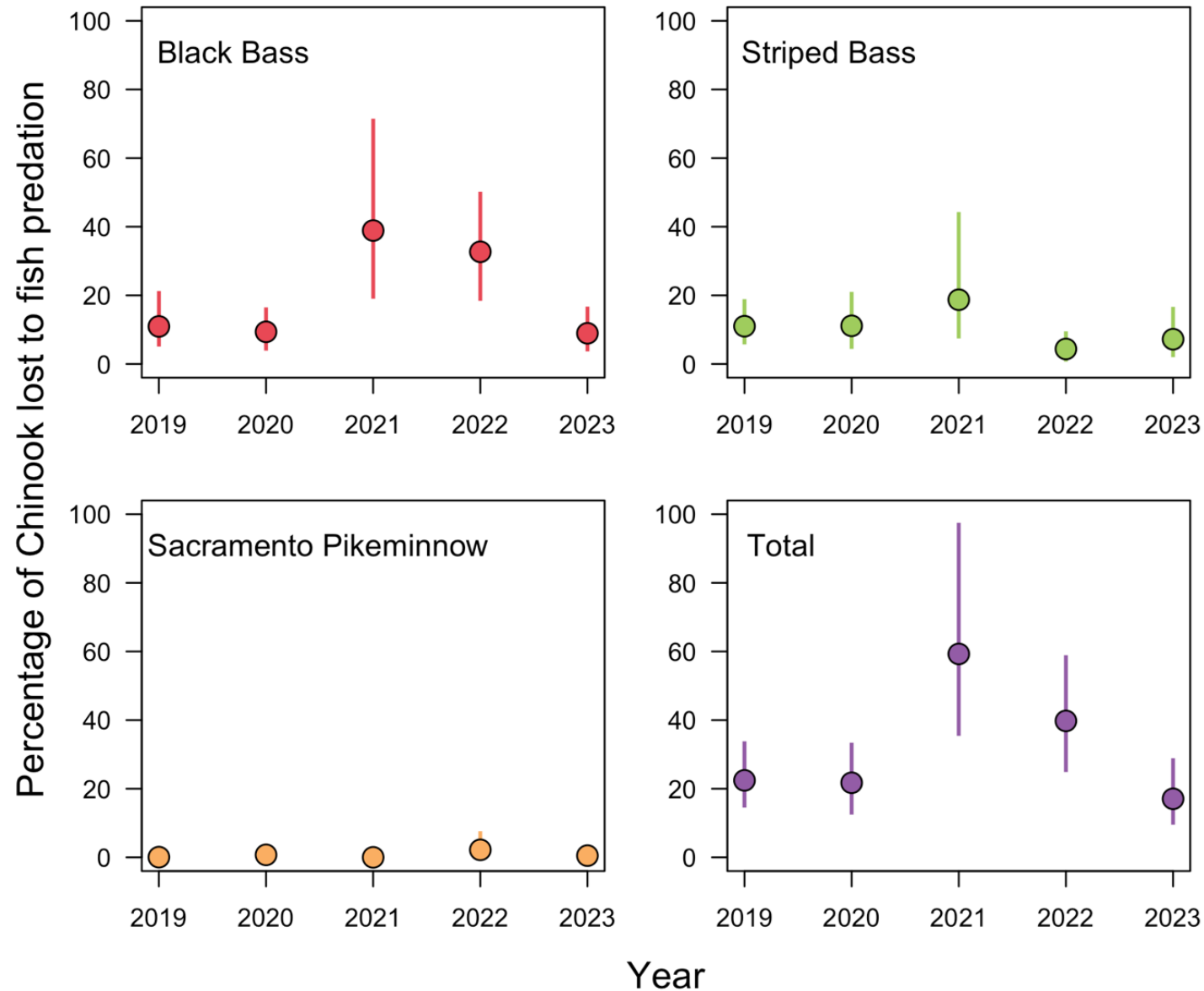
## 2020-2025 South Delta Predation Study

- Largest and most comprehensive nonnative research program in the CV

# Stanislaus Predation Research

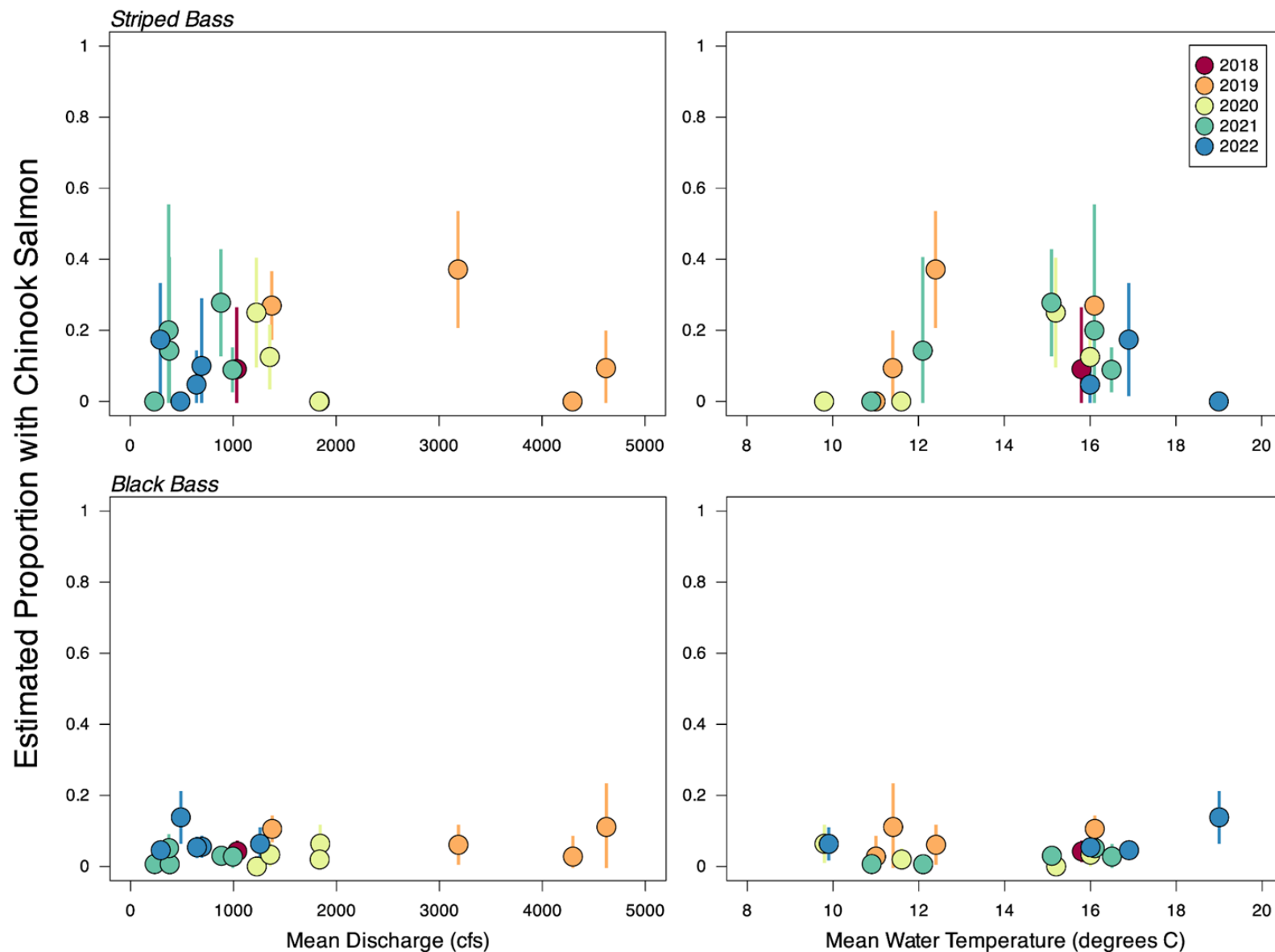
- First proposed in 2009, required Congressional Act to obtain permits
- Project Goals:
  - Estimate abundance of nonnative predators
  - Estimate total salmon lost to predation



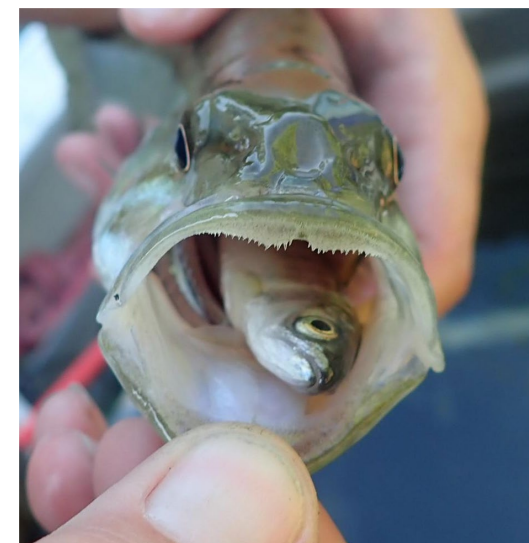


**Nonnative  
Predators primarily  
responsible for  
Chinook  
Consumption**





## Chinook Salmon Predation Observed in Stanislaus River across range of conditions



# San Joaquin River and South Delta Research

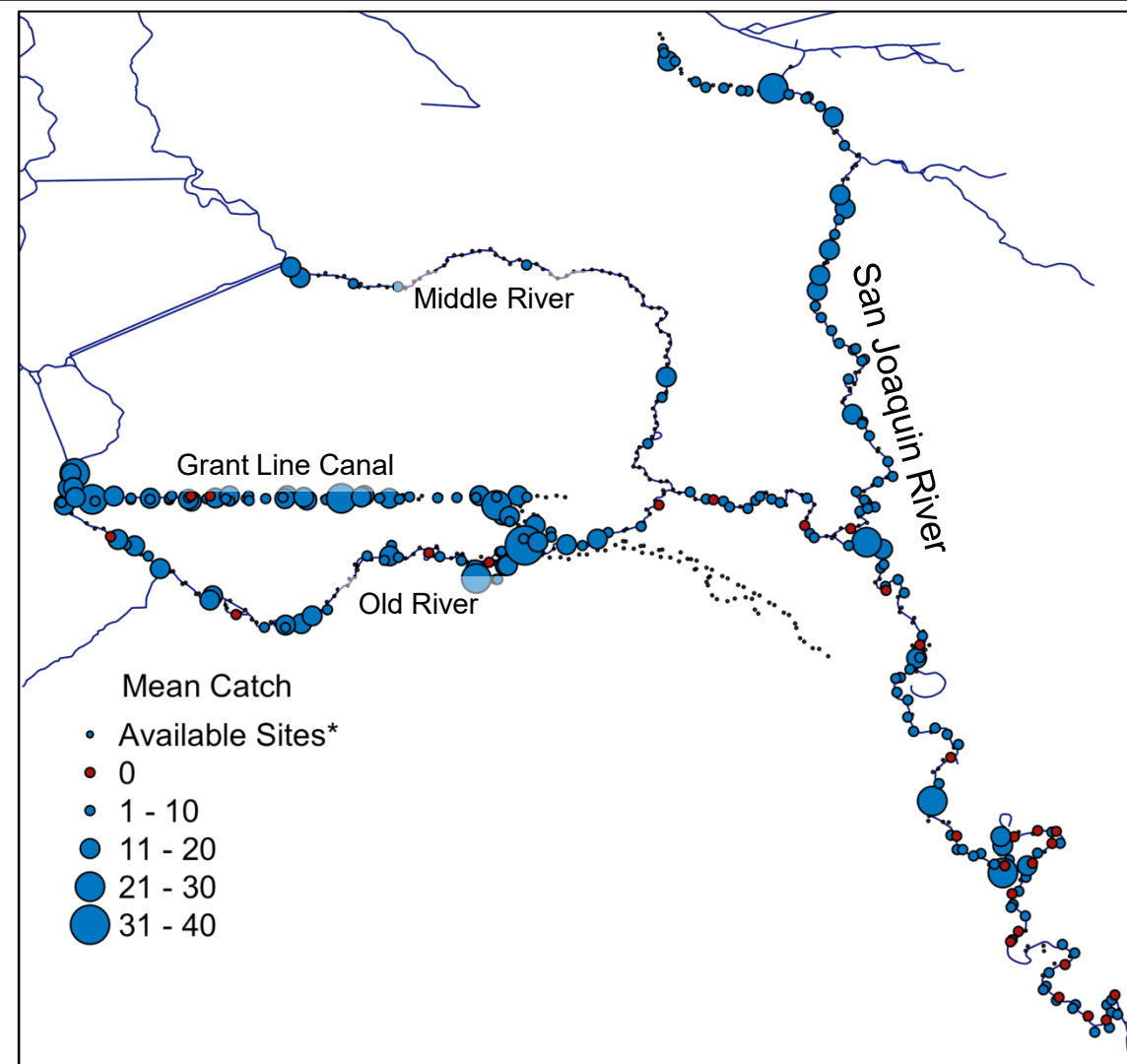
- Electrofishing began in 2020
- Project Goals:
  - Estimate the abundance of nonnative predators
  - Assess movement patterns of predators in the south Delta
  - Assess population-level impacts of predation





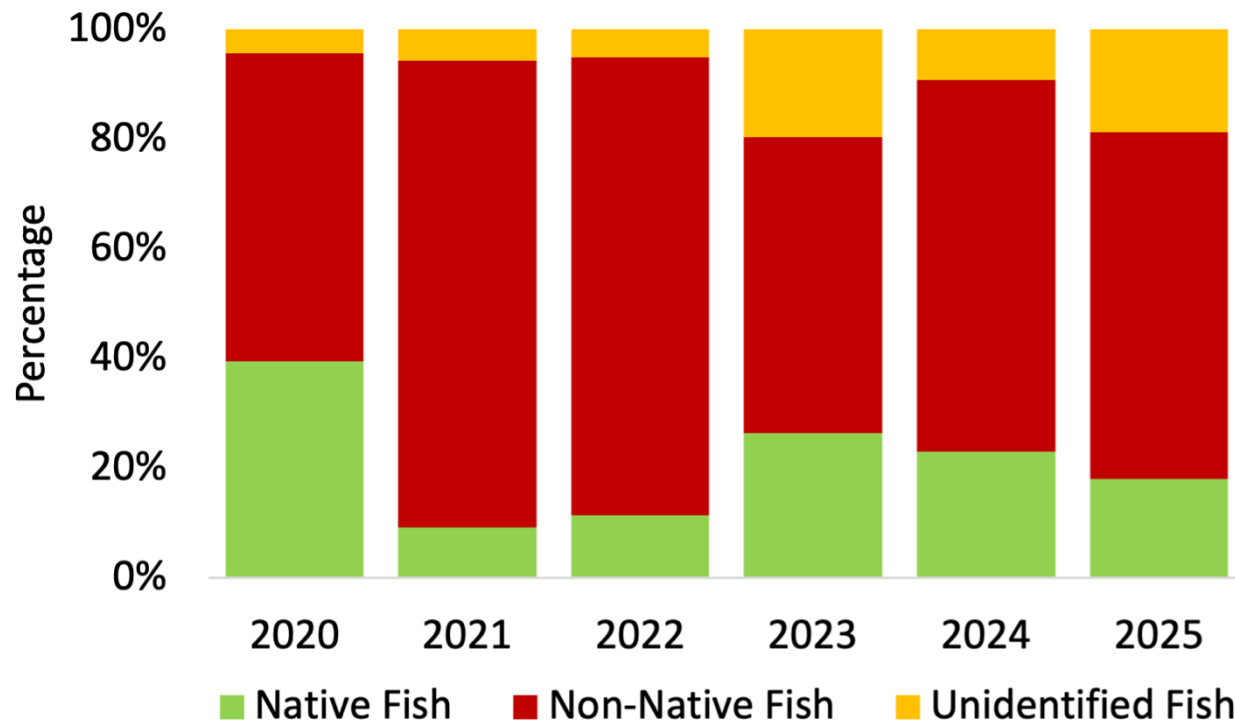
## South Delta – Where are the salmon?

- Bass bass are everywhere
  - Abundance: ~4-12k in Study Area
- **Unexpected result:** <15 salmon found in 6 years of sampling
  - First consumed salmon observed in 2024
- 100x more predators than salmon
- **Conclusion:** Salmon consumed before reaching the Delta





# Predation on Native Fish Species



- Native fish proportionally higher in diets than in catch
  - 9-40% of all fish observed in diets are native

**SAN FRANCISCO ESTUARY & WATERSHED SCIENCE**  
Sponsored by the Delta Stewardship Council and UC Davis Institute of the Environment

**RESEARCH**

## Diets of Native and Non-Native Piscivores in the Stanislaus River, California, Under Contrasting Hydrologic Conditions

Matthew L. Peterson<sup>1</sup>, Tyler J. Pilger<sup>1\*</sup>, Jason Guignard<sup>2</sup>, Andrea Fuller<sup>2</sup>, Doug Demko<sup>1</sup>

**ABSTRACT**

The fish communities of the Sacramento-San Joaquin Delta and its tributaries in California's Central Valley have been irreparably altered through introductions of numerous fish species, including Striped Bass (*Morone saxatilis*), black bass (*M. chrysops*), and other non-native species. We collected predator diets to the 3 strong primary species: tshawytrid and Lamprey. than any other potential fish prey species, particularly by Striped Bass and black bass. The frequency of native fishes in predator diets was similar across years, despite contrasting hydrologic conditions; 2019 (wet year), 2020 (dry year), and 2021 (critically dry year). Our results

**Fish in the Stanislaus were 9x more likely to consume native prey vs nonnative prey**

\* Corresponding author: [tpilger@ucdavis.edu](mailto:tpilger@ucdavis.edu)  
1. FISHBIO, Chico, CA 95926 USA  
2. FISHBIO, Oakdale, CA 95361 USA

It is well known that freshwater fish communities are becoming more similar as popular species are translocated and native species are extirpated or go extinct (Rahel 2002; Olden and Poff 2003; ...)



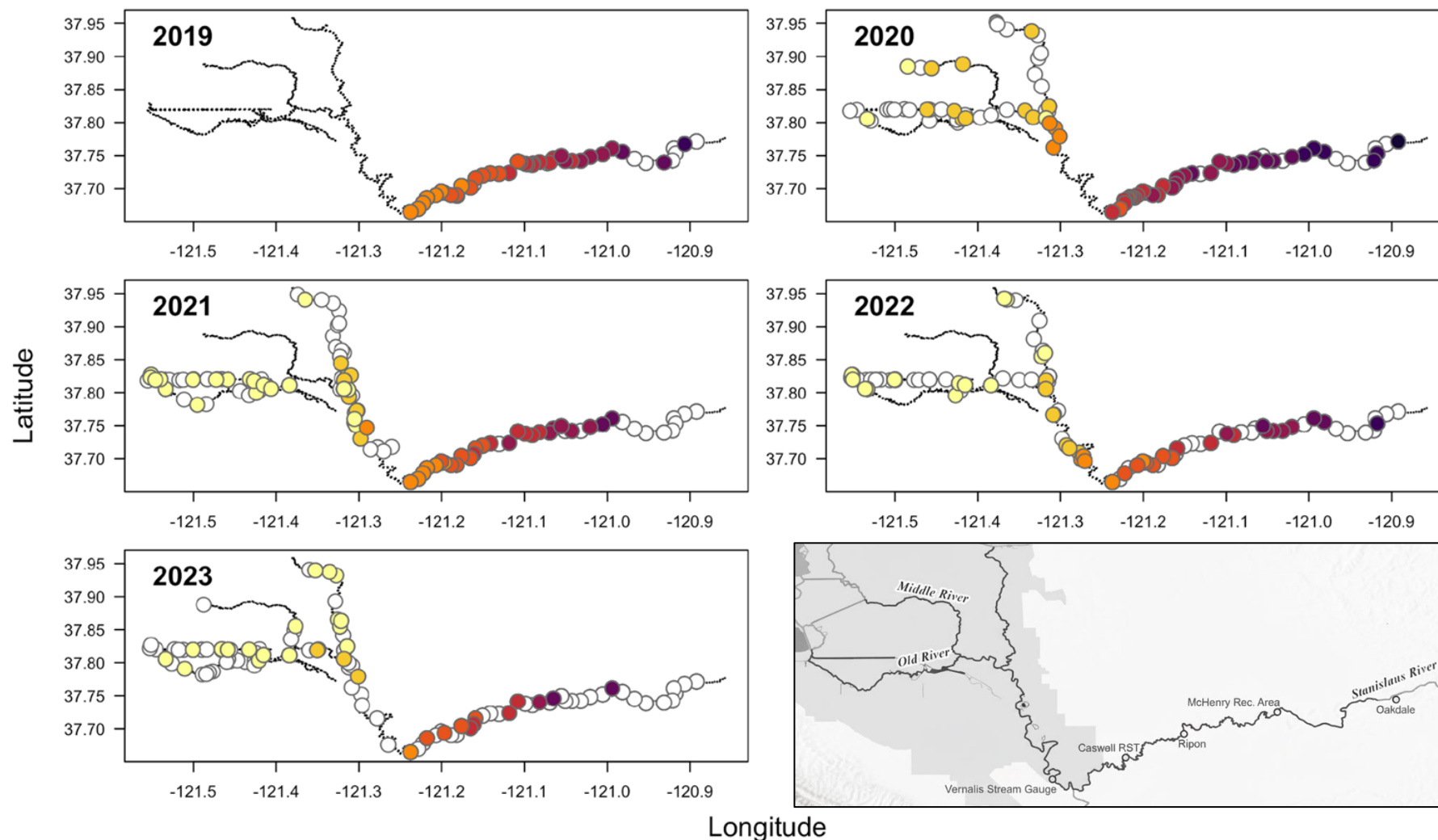
## Publication of the Joint Manuscript

- Patterns of salmon consumption across migratory corridor
- Predation research not previously analyzed on this scale
  - Benefits of coordinated long-term research
- Important management implications

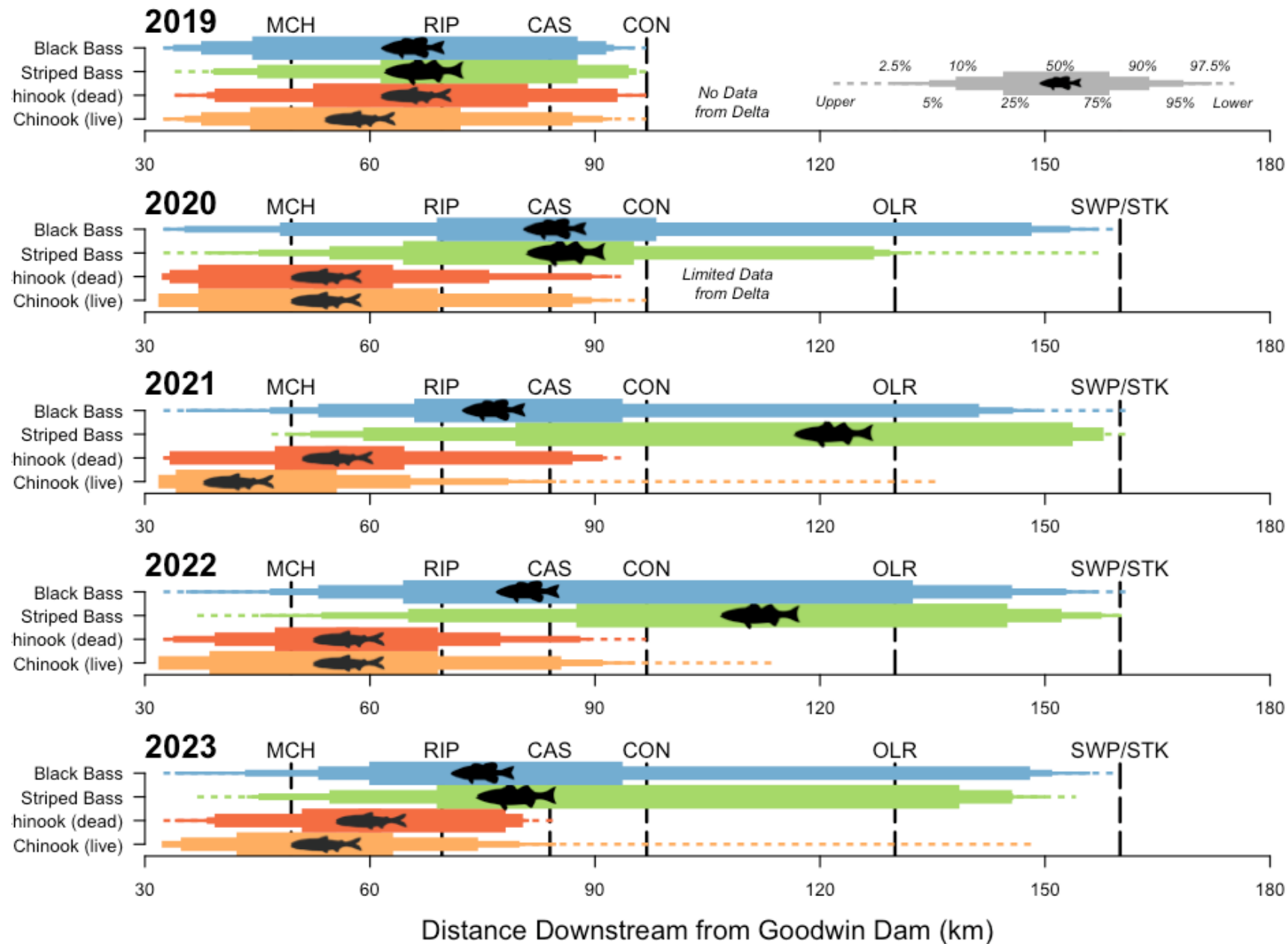




# Where are the Salmon Being Consumed?



**Salmonid Consumption primarily occurs in the Tributaries – *what was thought to be better habitat!***



## Distribution of Predators and Prey



Predator Abundance

X

Salmon Consumption Rate

=

# salmon eaten

# salmon eaten

=

# salmon available

**Predation impact**



**What do we know  
about the impacts  
of predation?**

Predator Abundance

X

Salmon Consumption Rate

=

# salmon eaten

# salmon eaten

=

# salmon available

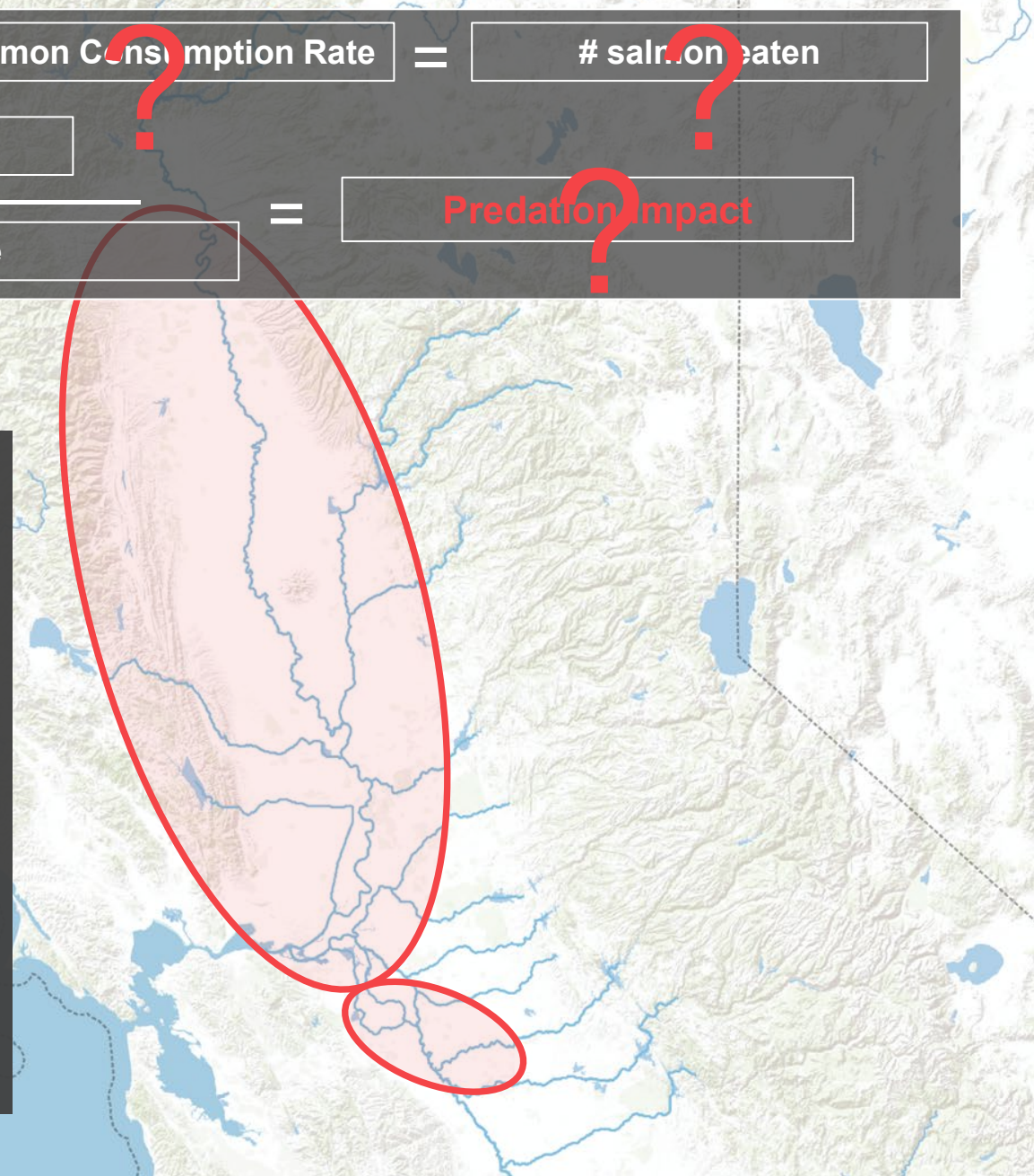
**Predation impact**



**What do we know  
about the impacts  
of predation?**

- Significant effort to collect data on predator populations and consumption rates




$$\begin{array}{l} \text{Predator Abundance} \times \text{Salmon Consumption Rate} = \text{\# salmon eaten} \\ \frac{\text{\# salmon eaten}}{\text{\# salmon available}} = \text{Predation Impact} \end{array}$$

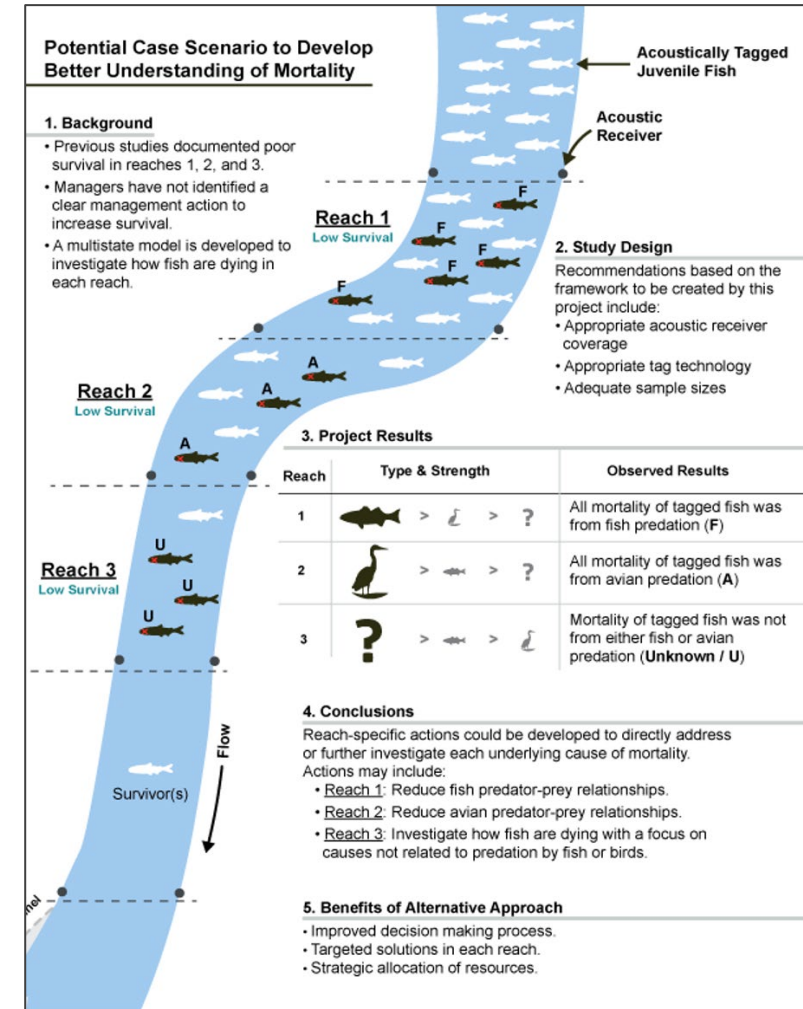
- Data needed from across CV to understand impacts
- Sacramento Basin is critical
  - Majority of CV flow
  - Listed species driving water operations
  - High abundance of striped bass suspected
- Eradication not possible, but predator research & management is achievable

**What do we know about the impacts of predation?**



# A Model for Statewide Research

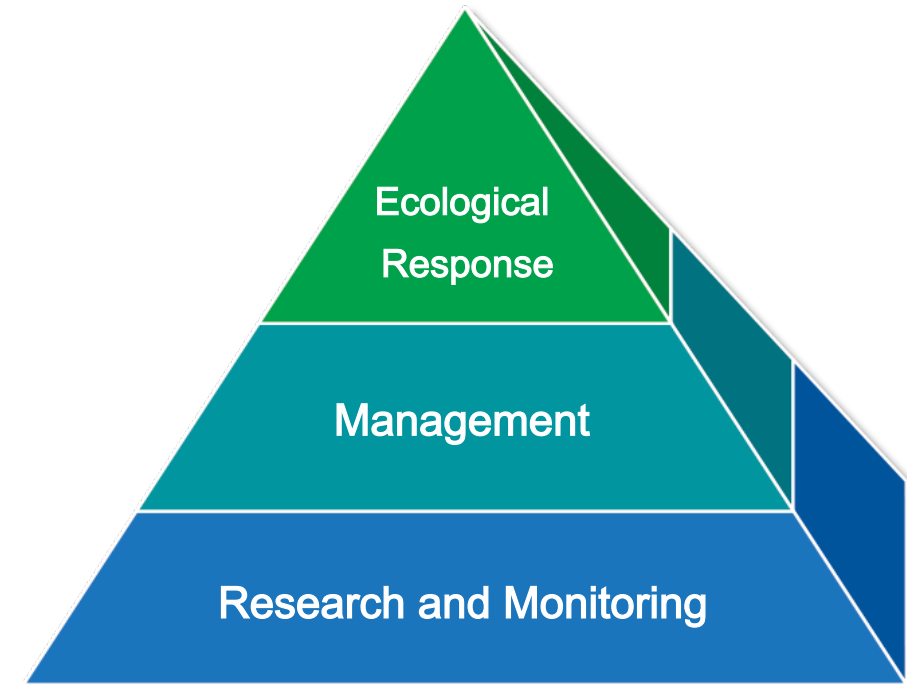
- Need for increased understanding of nonnative population dynamics
  - Abundance and Distribution
  - Spawning and recruitment patterns
- Numerous sources of mortality for juvenile salmon - new technology and modeling tools to identify culprits
  - Quantify impacts of piscivores on survival
  - Stranding/predation in floodplains & off-channel habitats
  - Contributions of 'hotspots' and anthropogenic alterations
- Multistate modeling effort currently funded by SWC





# Take Home Messages

- Multiple factors influencing salmon abundance
  - Nonnative fish have substantial impacts to native species survival
  - Management solutions focused primarily on flow and habitat
- Integrated approach needed to recover listed species
  - Requires coordinated long-term data collection across Central Valley
- Overall goal is recovery of salmonids and other native fish
  - Management of nonnative species may be necessary to prevent extinction





# Questions?



Dana Lee

danalee@fishbio.com | 530.892.9686

Funding Provided By:

