Quantifying hatchery versus wild origin of Chinook salmon on the Feather River

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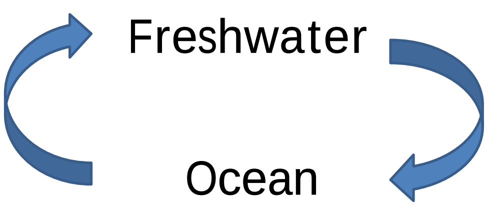
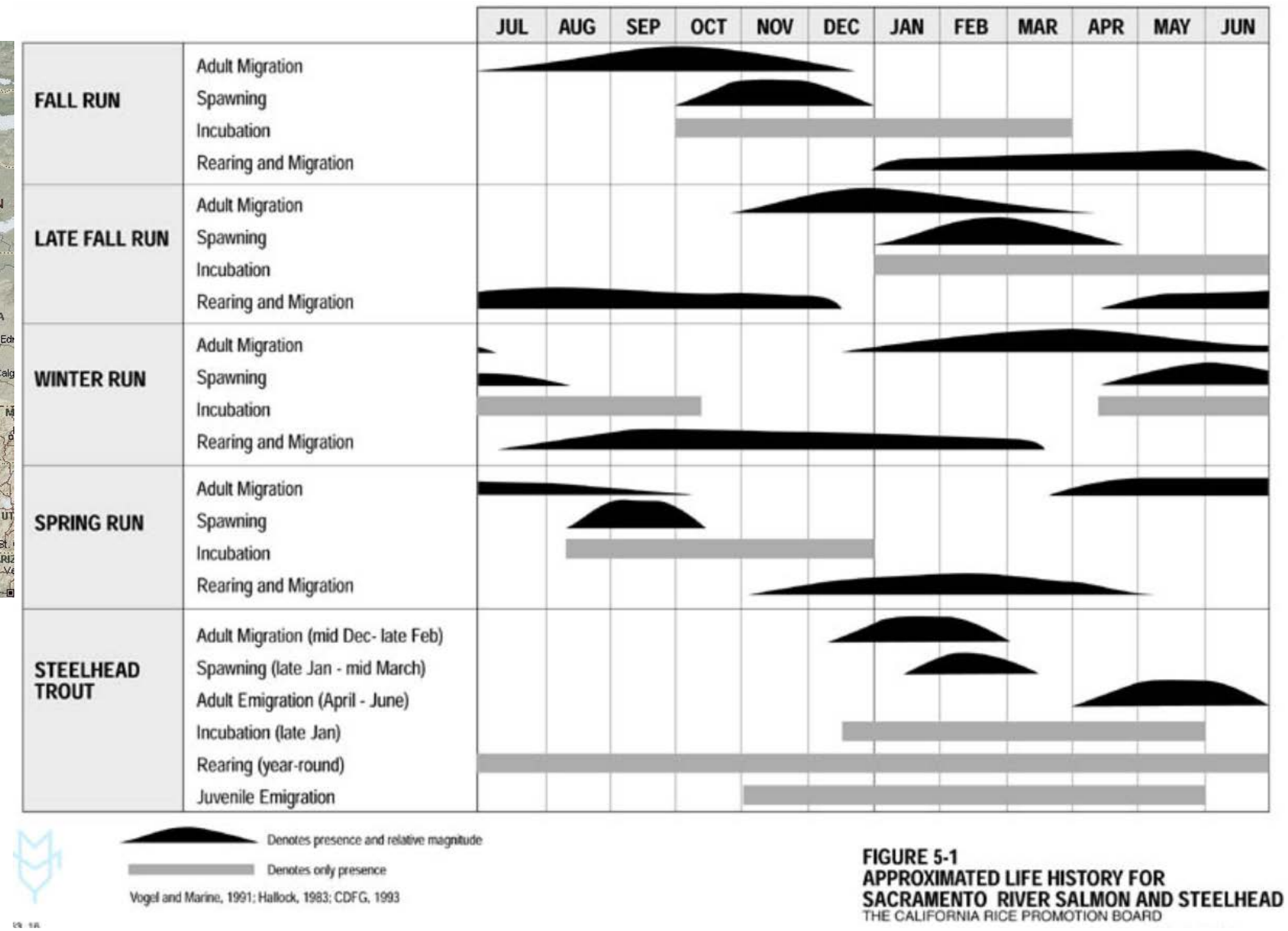
Chinook salmon in California

- Chinook salmon have persisted in California's variable climate by utilizing a wide array of run types and life history strategies, and wide geographic distribution





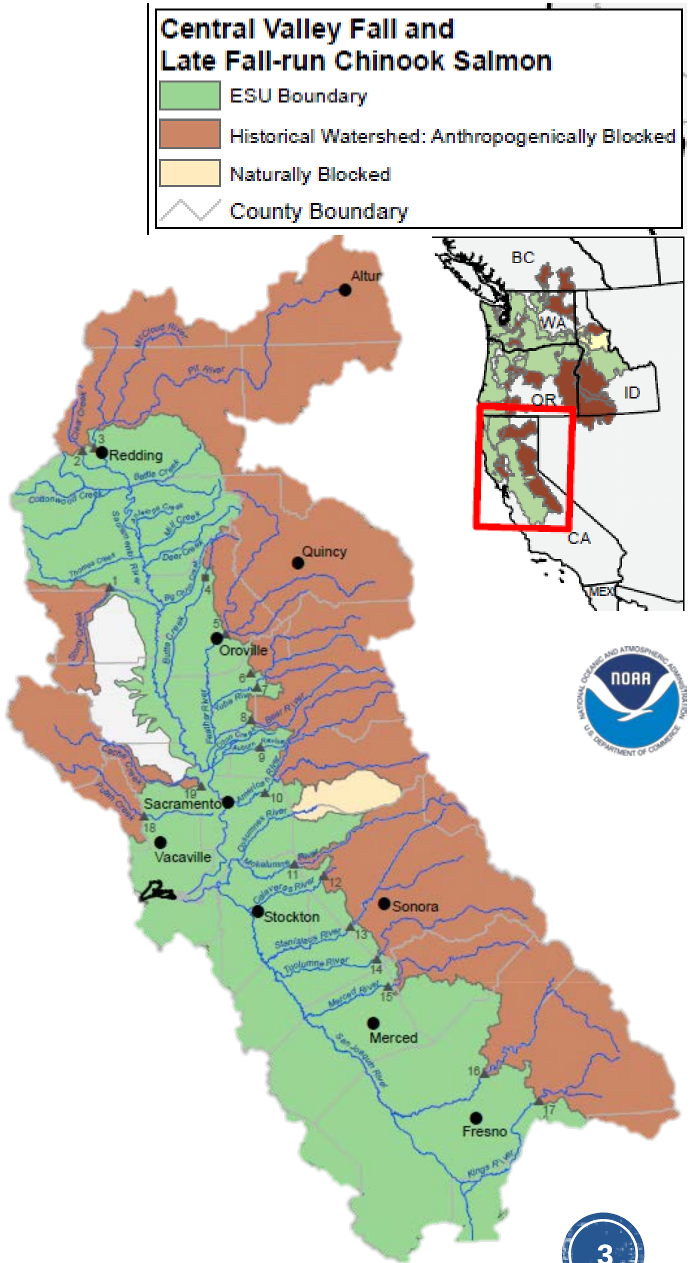
Vogel and Marine, 1991; Hallock, 1983; CDFG, 1993

Fall run chinook salmon in California

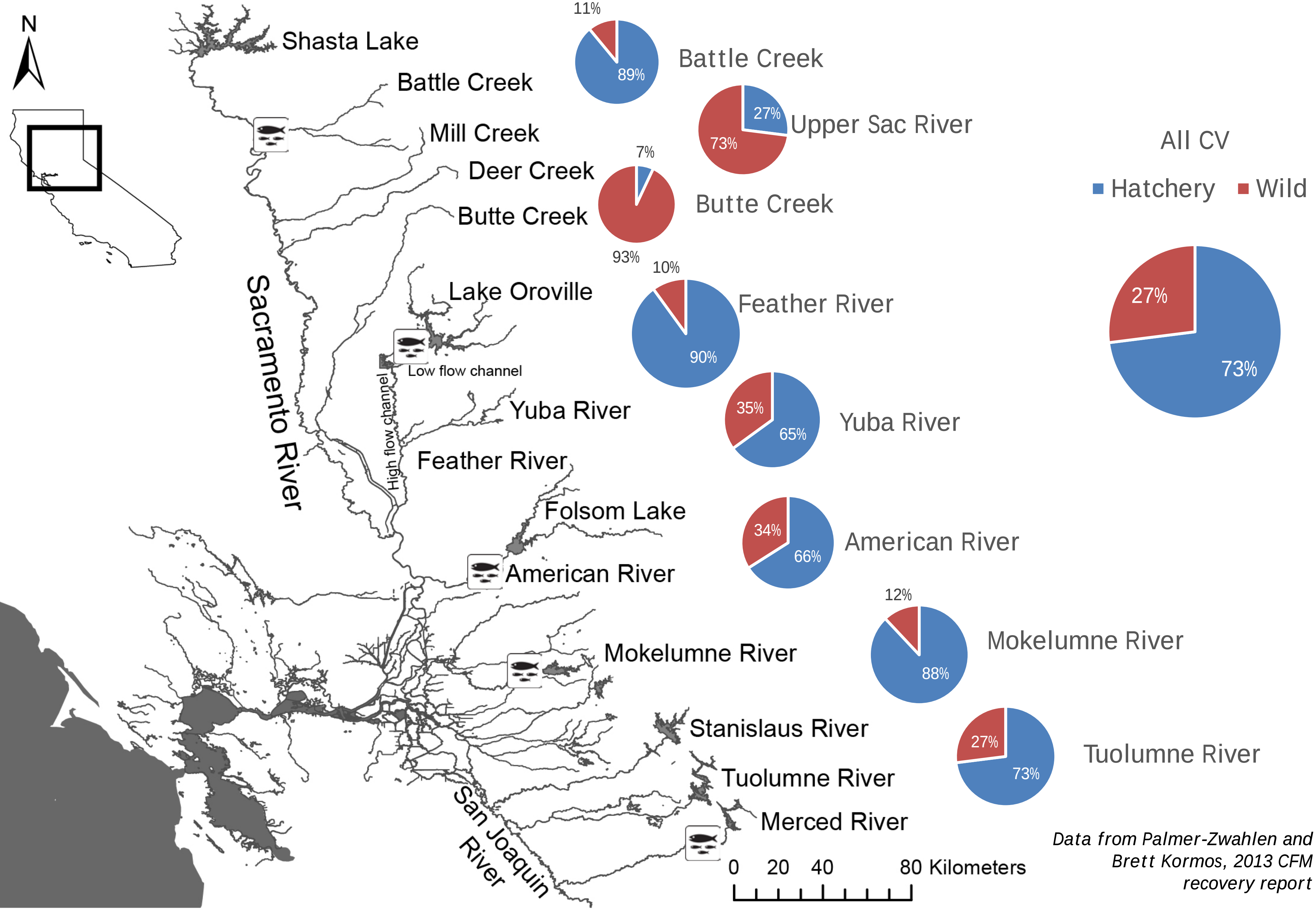
- Fall run
  - form the backbone of California’s salmon ocean fishery
  - are heavily subsidized with the production of hatchery fish
  - hatchery practices can influence their long term resilience
- Managing salmon stocks requires a detailed understanding of environmental and anthropogenic drivers

What is the contribution of hatchery vs wild fish to the population?

- Feather river as a case study
  - “Wild”= A fish that reared in the river
  - “Hatchery”= A fish that reared in the hatchery
- Constant fractional marking (CFM)



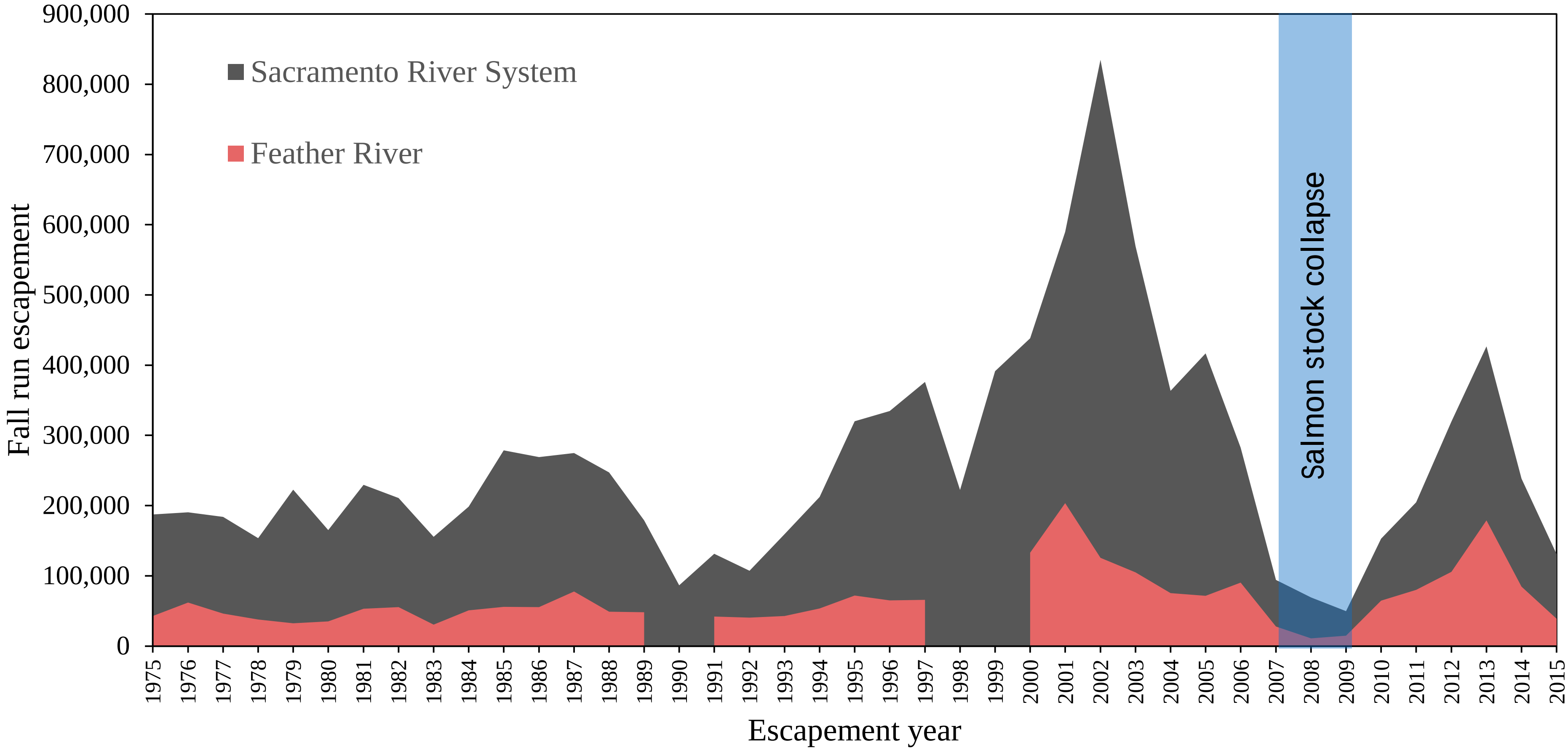
Constant fractional marking 2011



Data from Palmer-Zwahlen and Brett Kormos, 2013 CFM recovery report

Salmon stock collapse

- The proximate cause of the salmon stock collapse were poor coastal ocean conditions (Lindley et al., 2009) that led to low food availability
- Underlying cause is the loss of life history diversity in the CV



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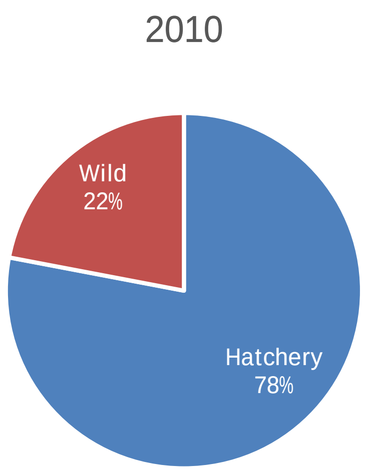
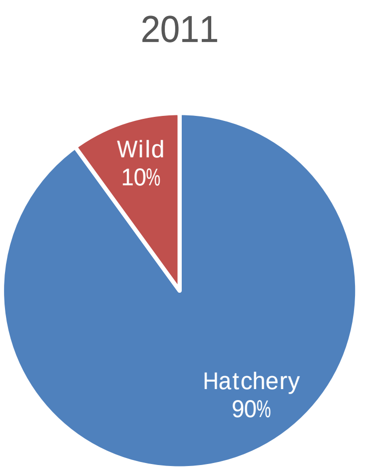
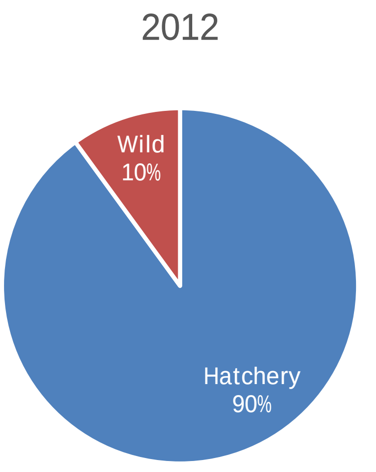
Feather river CFM





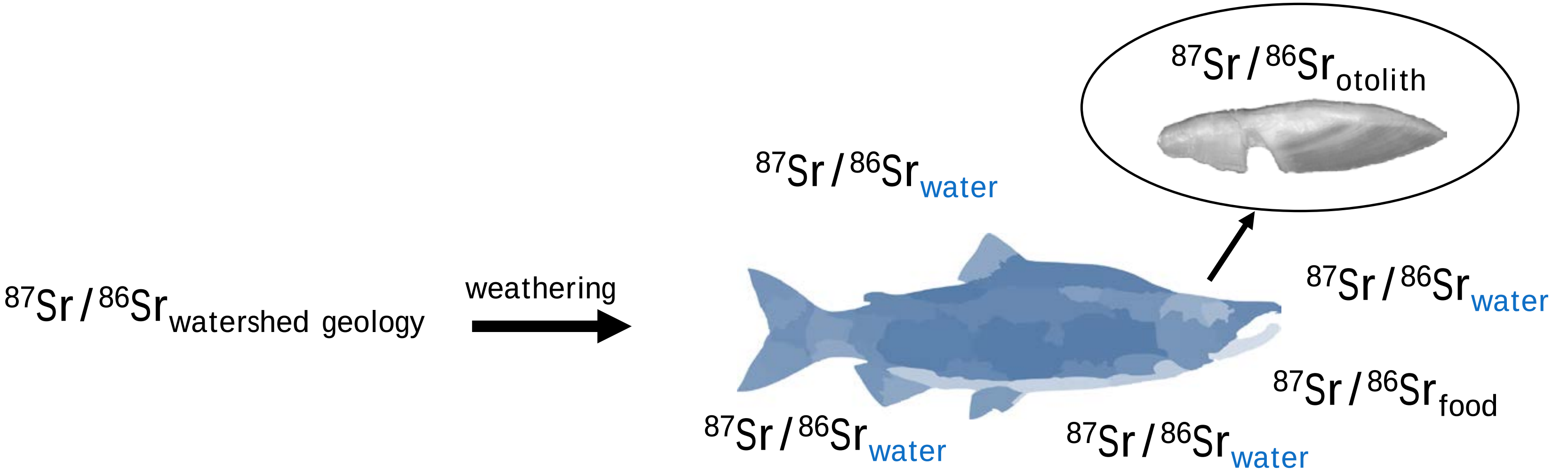


Data from Palmer-Zwahlen and Brett Kormos, 2013, 2015 CFM recovery report

- What was the contribution of hatchery vs wild fish before 2010?

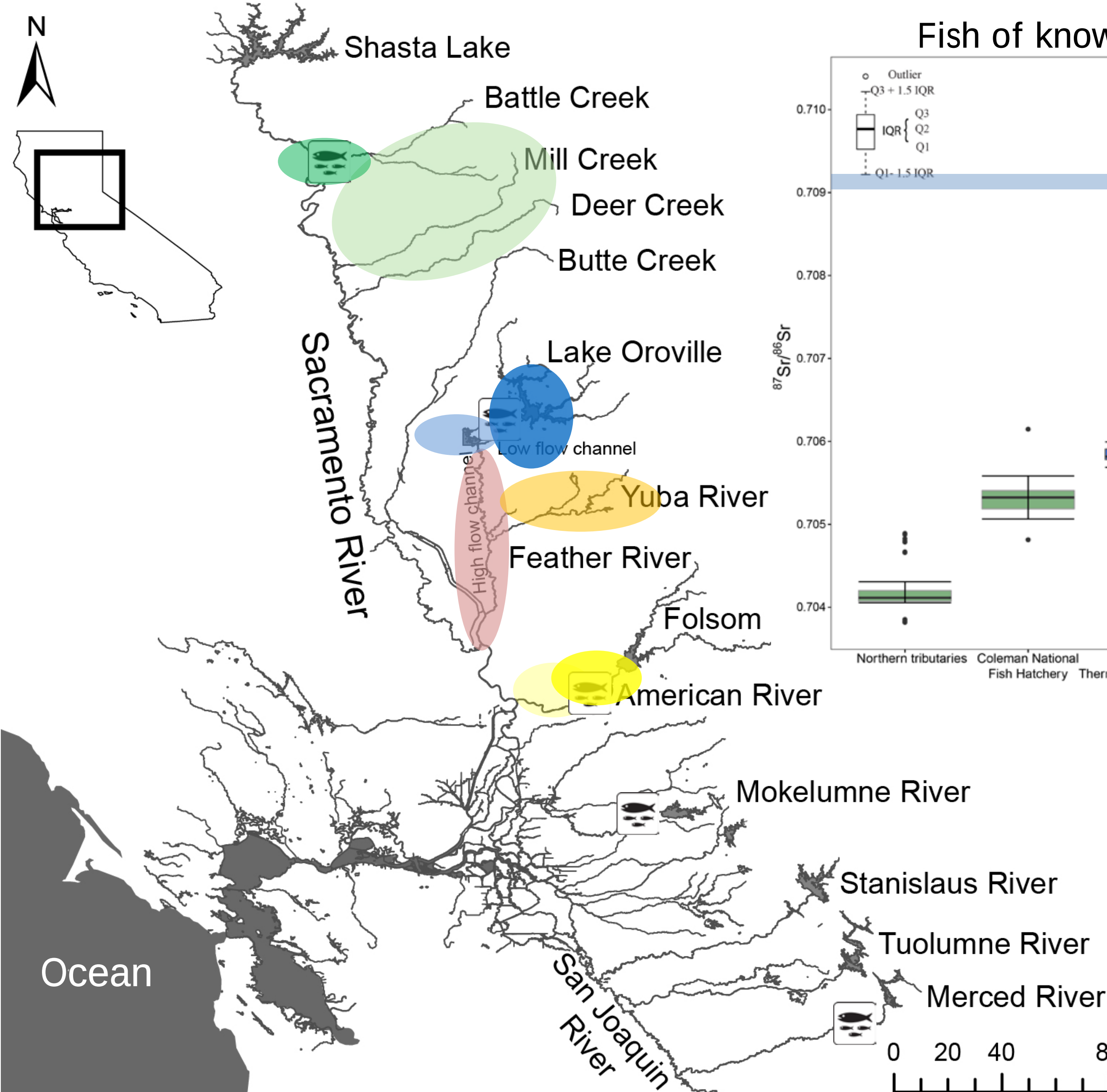
-> Otolith microchemistry

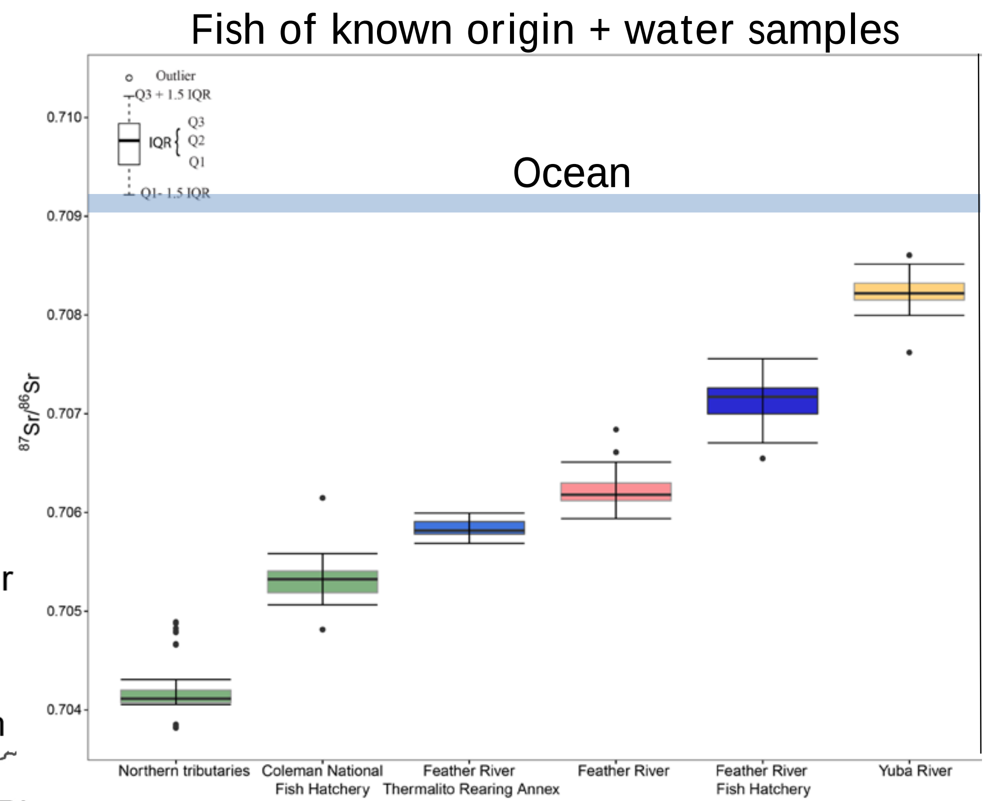
Otolith microchemistry



- Otoliths ("ear bones") can provide a detailed life-long archive of movement across different environments (watersheds, rivers, ocean)
- Strontium isotope ratios vary depending on the underlying geology, age, and geochemistry of the watershed
- Reconstruct life history by matching $^{87}Sr/^{86}Sr_{Otolith}$ to $^{87}Sr/^{86}Sr_{Watershed}$

Environmental $^{87}Sr/^{86}Sr$ in the Central Valley





Data from Sturrock et al. (2015), Barnett-Johnson et al. (2008), Ingram and Weber (1999)

Feather River sample analysis

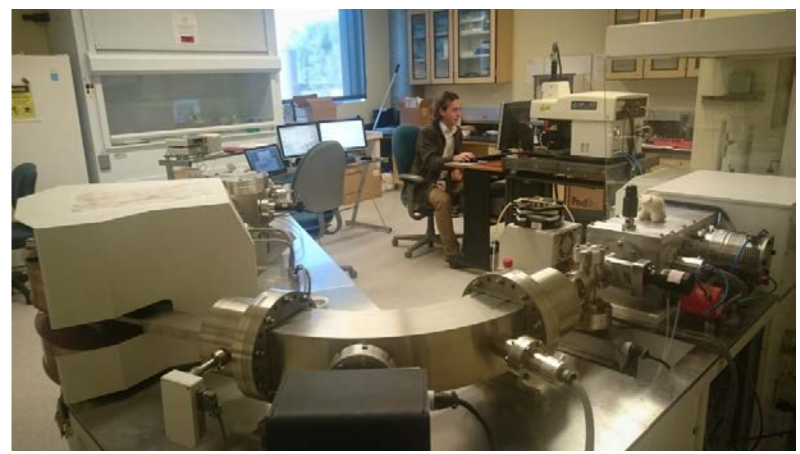
Samples (n=755) collected by carcass survey from 2002-2010, stratified by location and time

Otolith extraction and preparation

Aging

Analysis

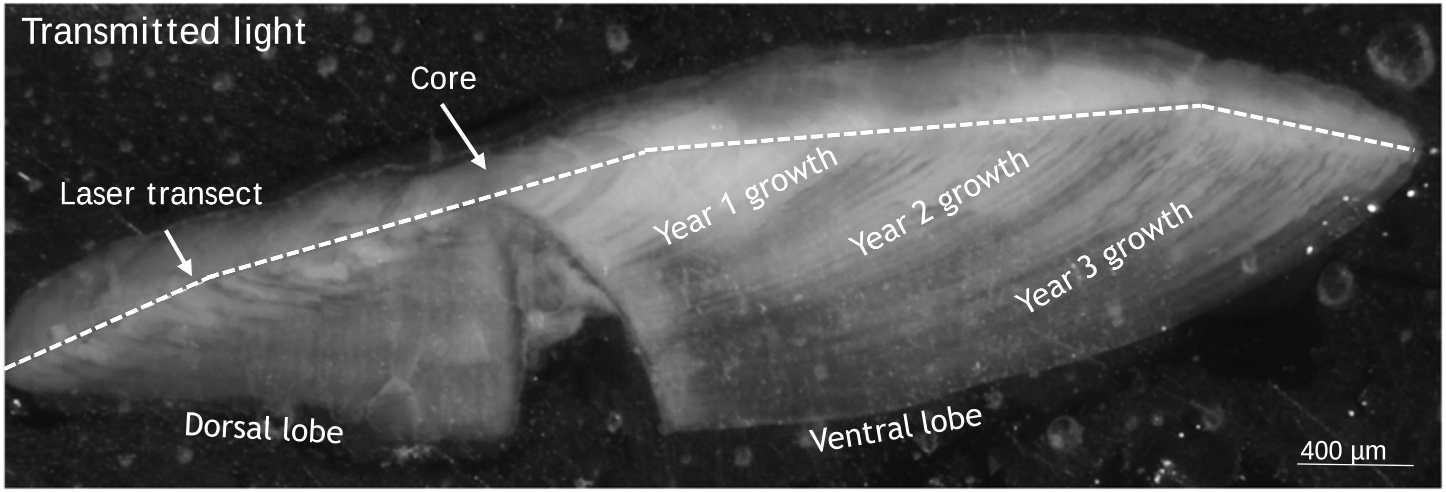
Interdisciplinary Center for Plasma Mass Spectrometry

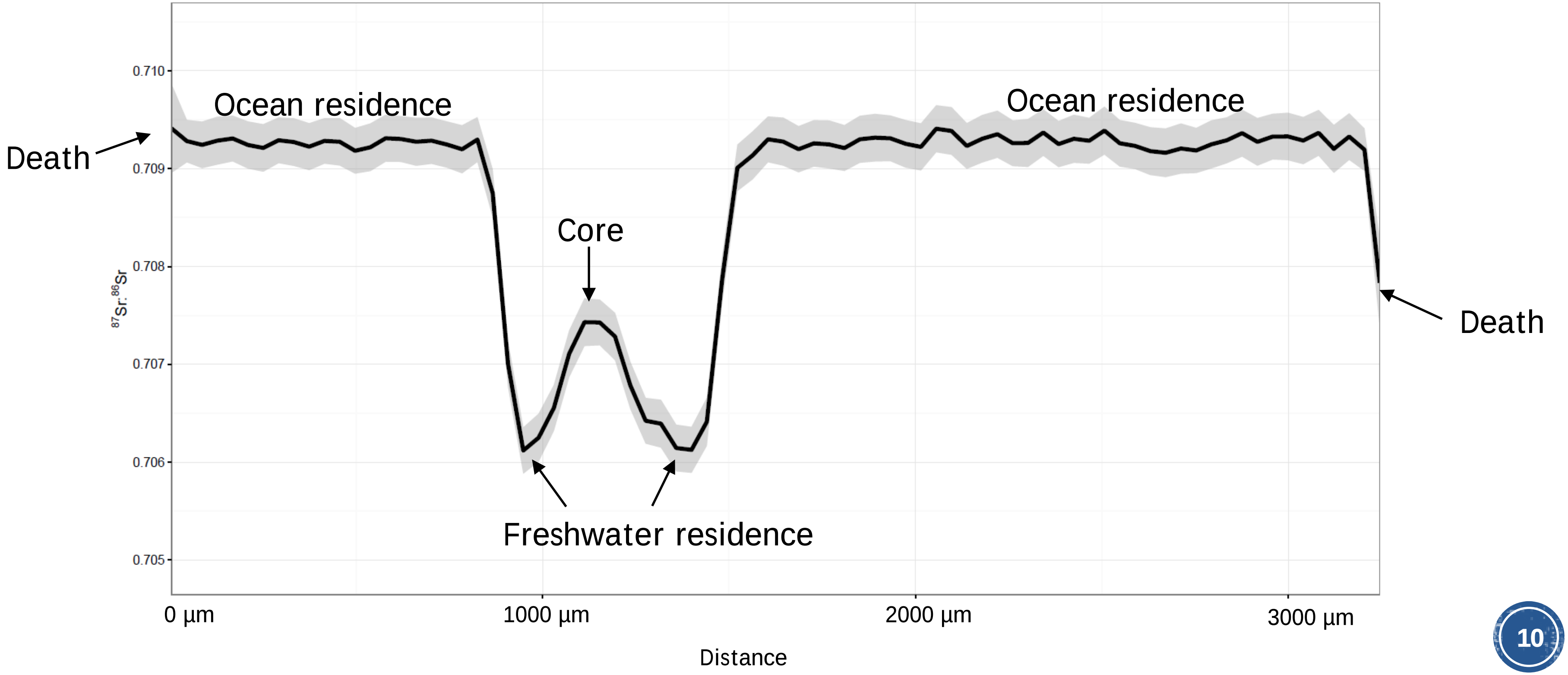


Nd:YAG 213 nm laser + Nu Plasma HR MC-ICP-MS

$^{87}Sr/^{86}Sr$ isotope life history for each individual fish

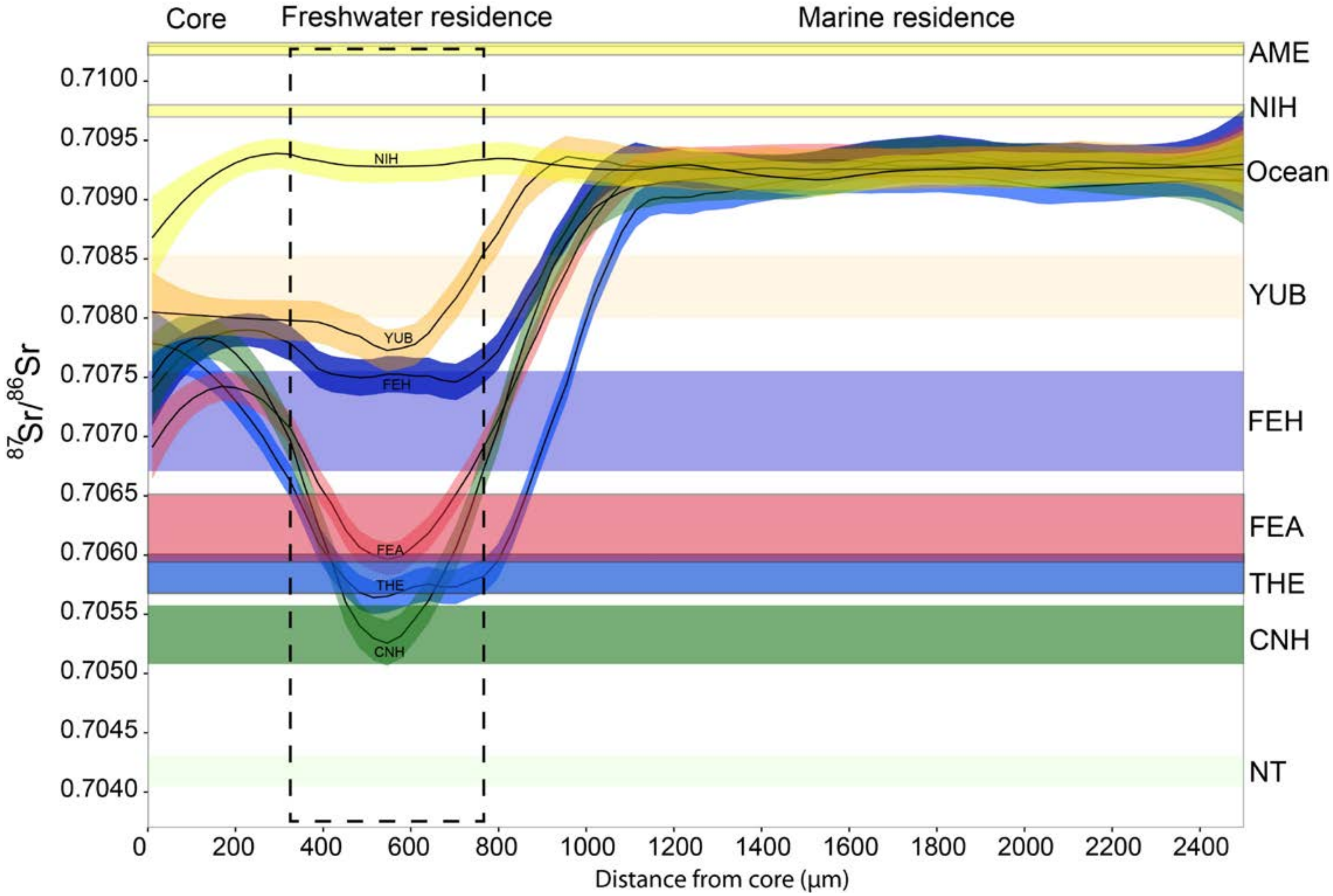
Otolith analysis



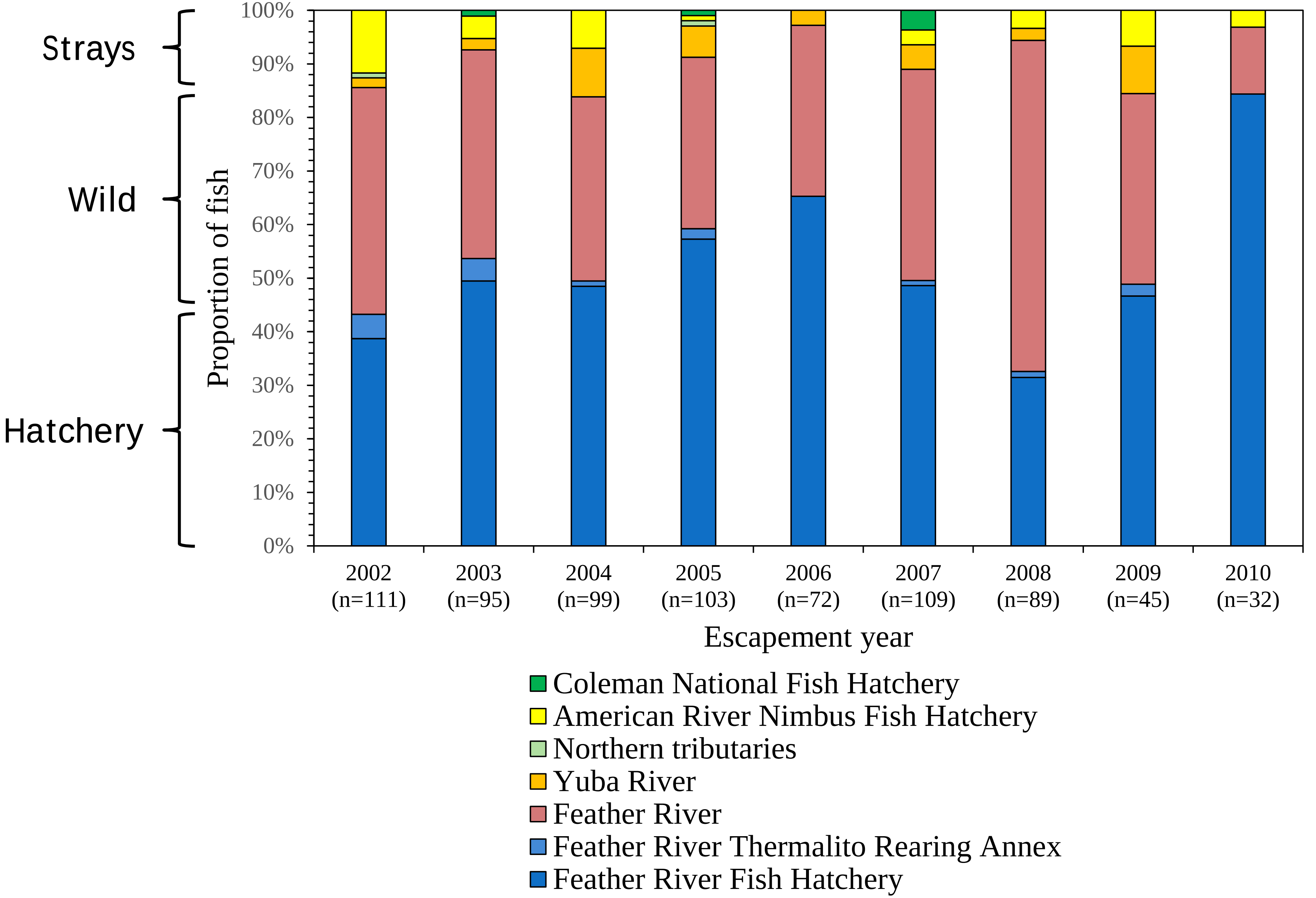


Natal origins

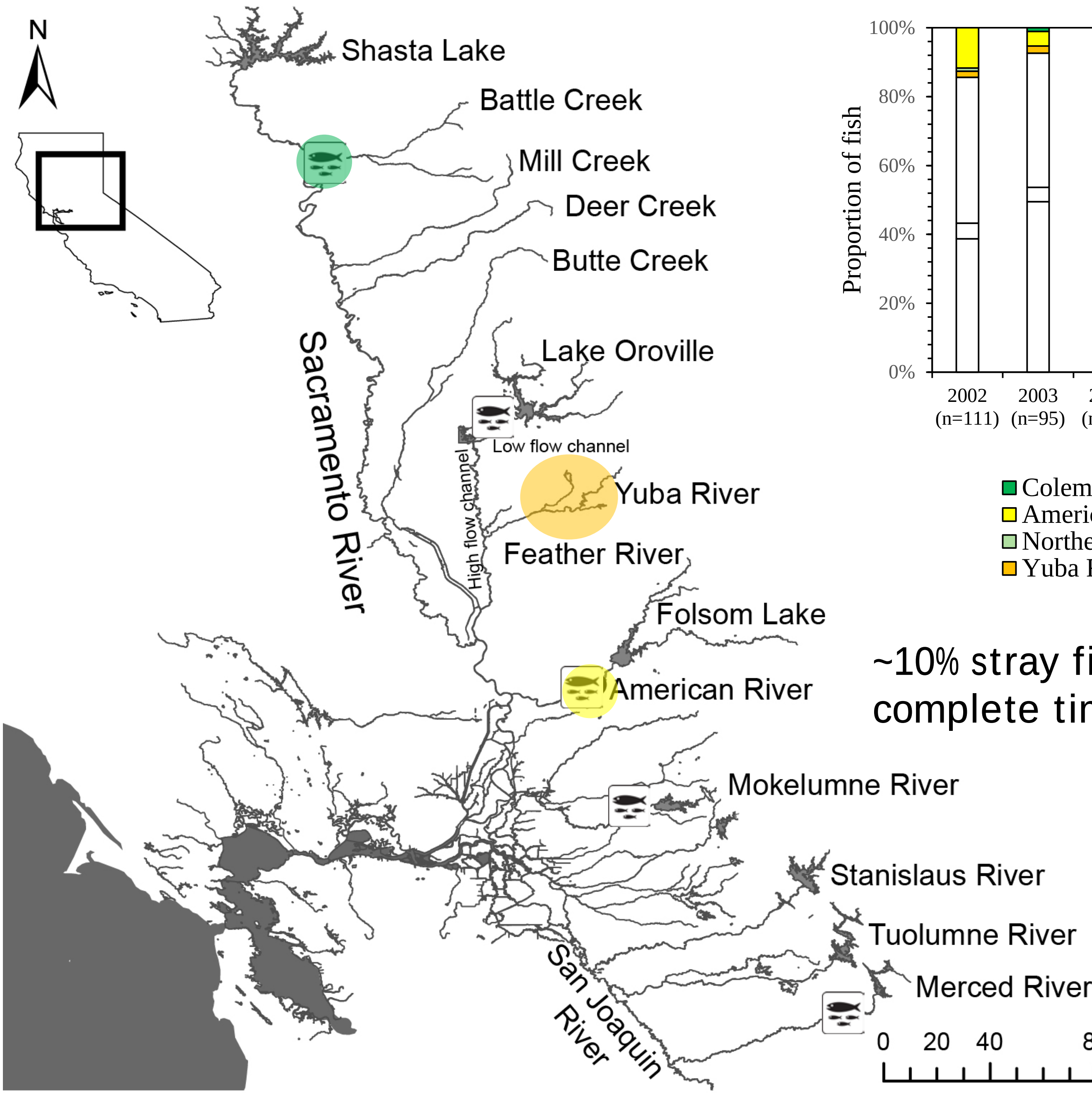
- Match otolith freshwater residence to river isotope baseline using quadratic discriminant function analysis
- Evaluation using known CWT fish (n=110): ~95% classification success

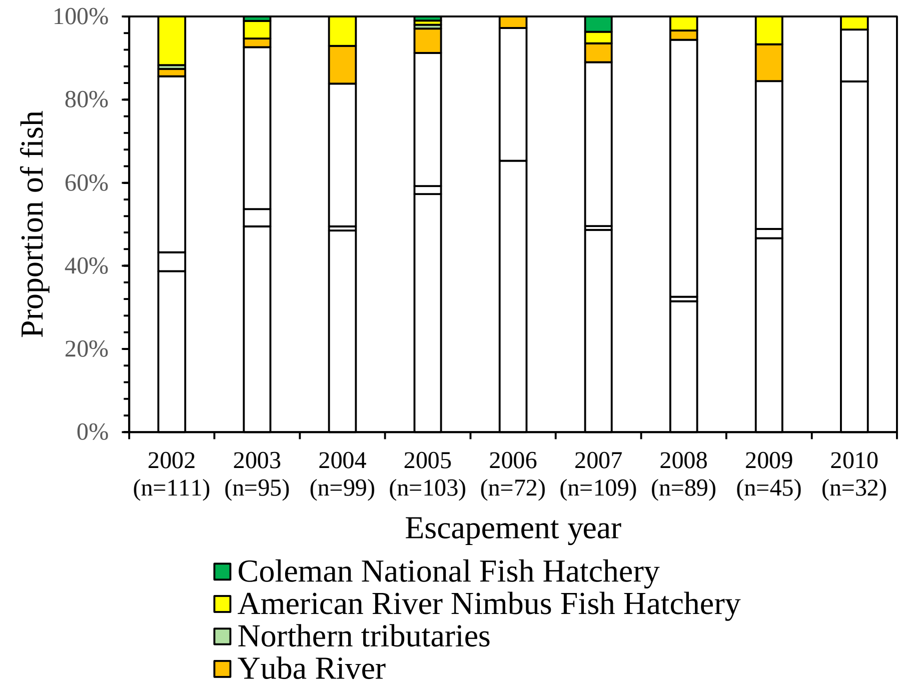


Natal origins



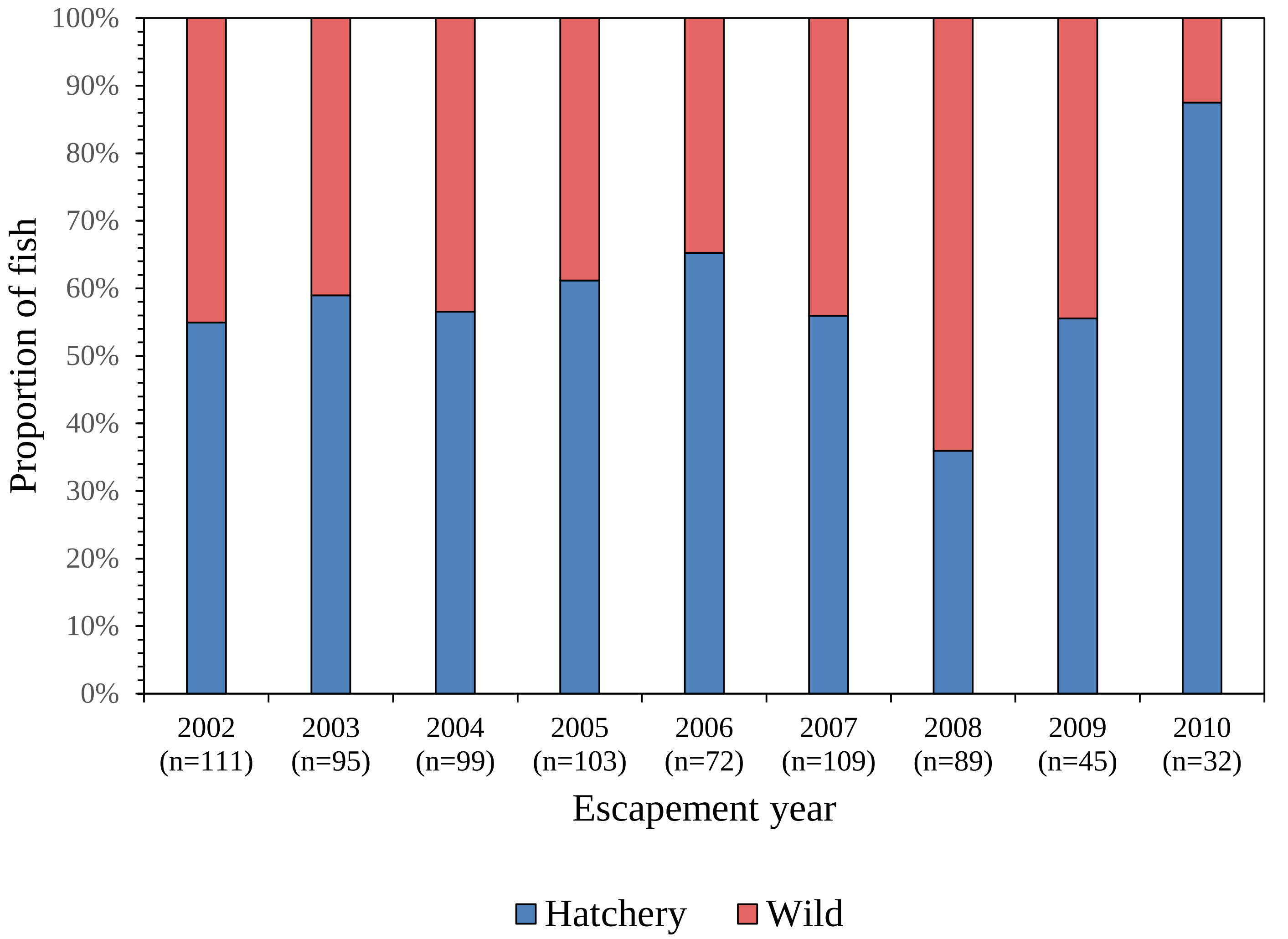
Strays





~10% stray fish in the complete time series

Hatchery vs wild origin



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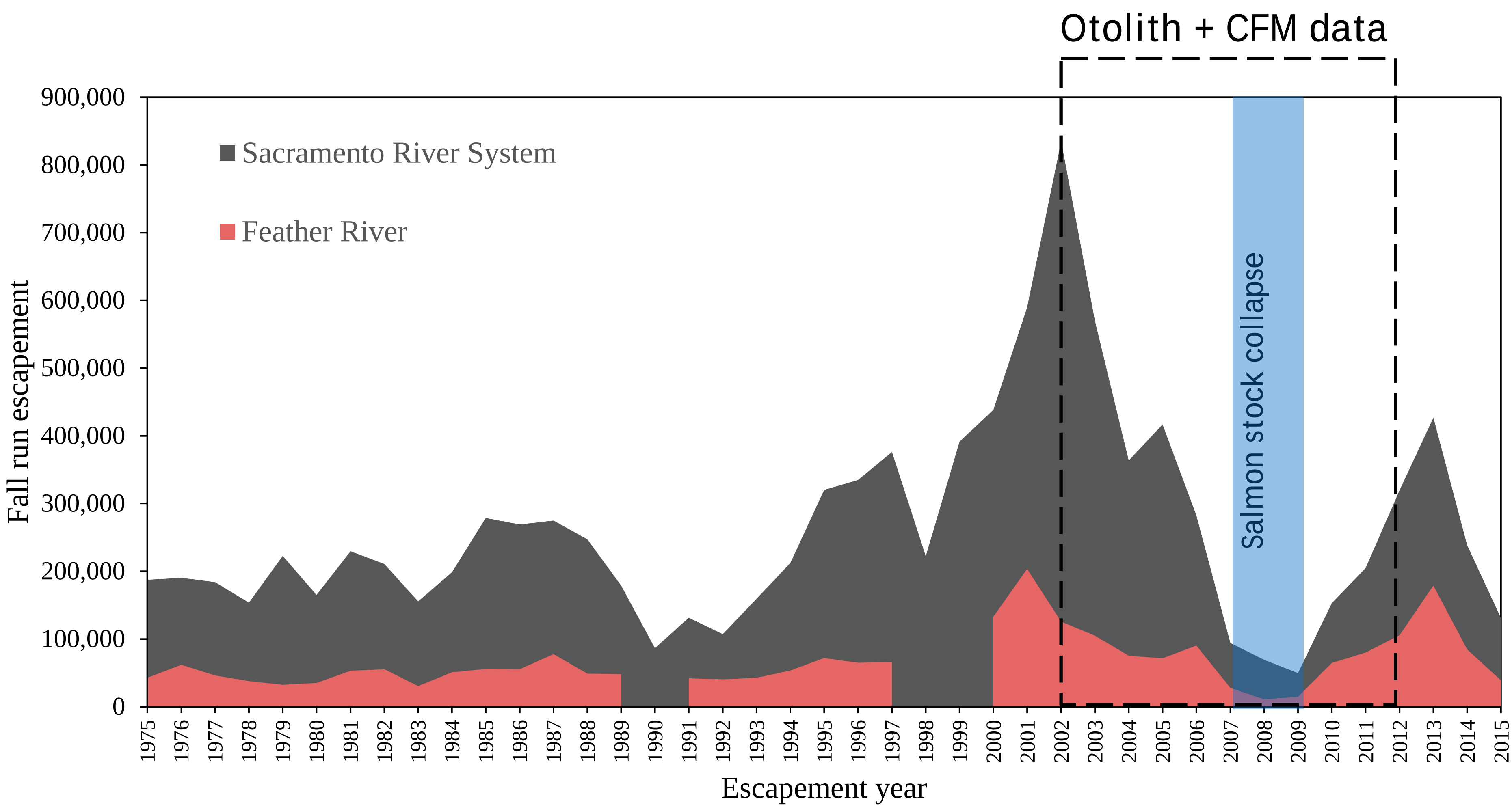

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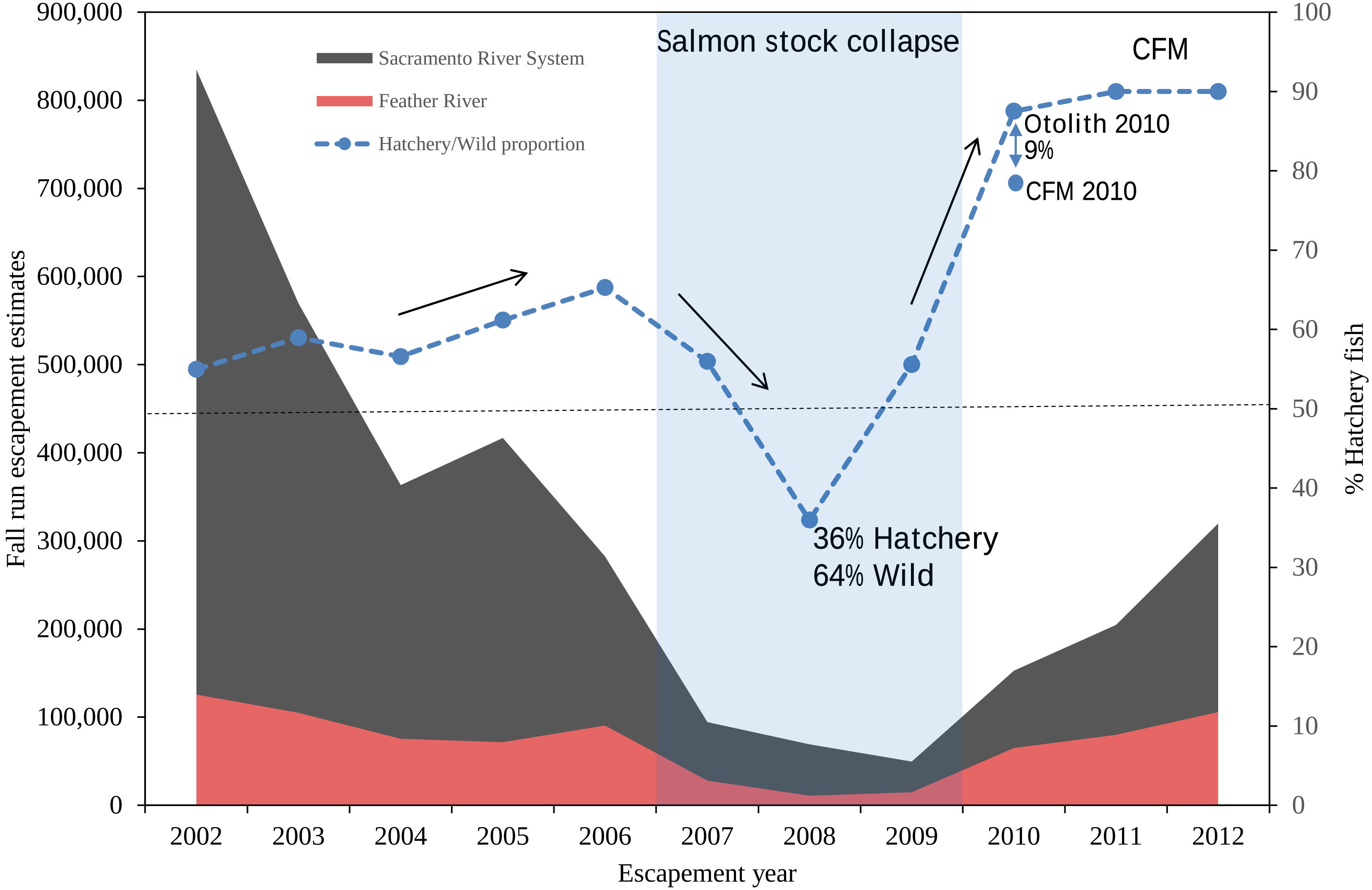
Hatchery vs wild origin



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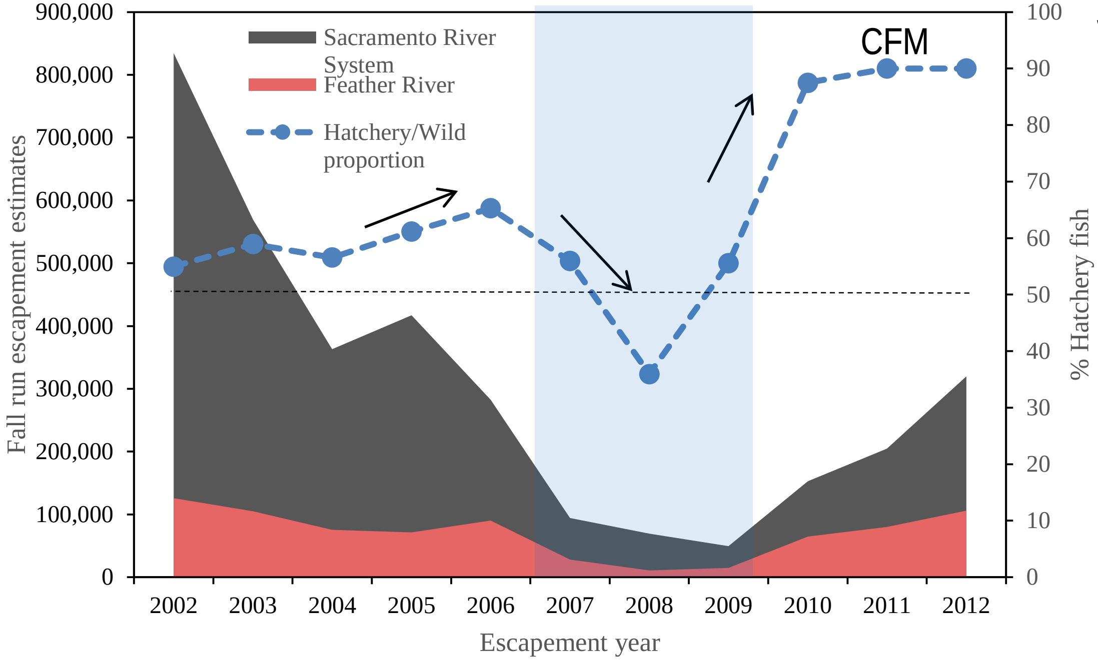
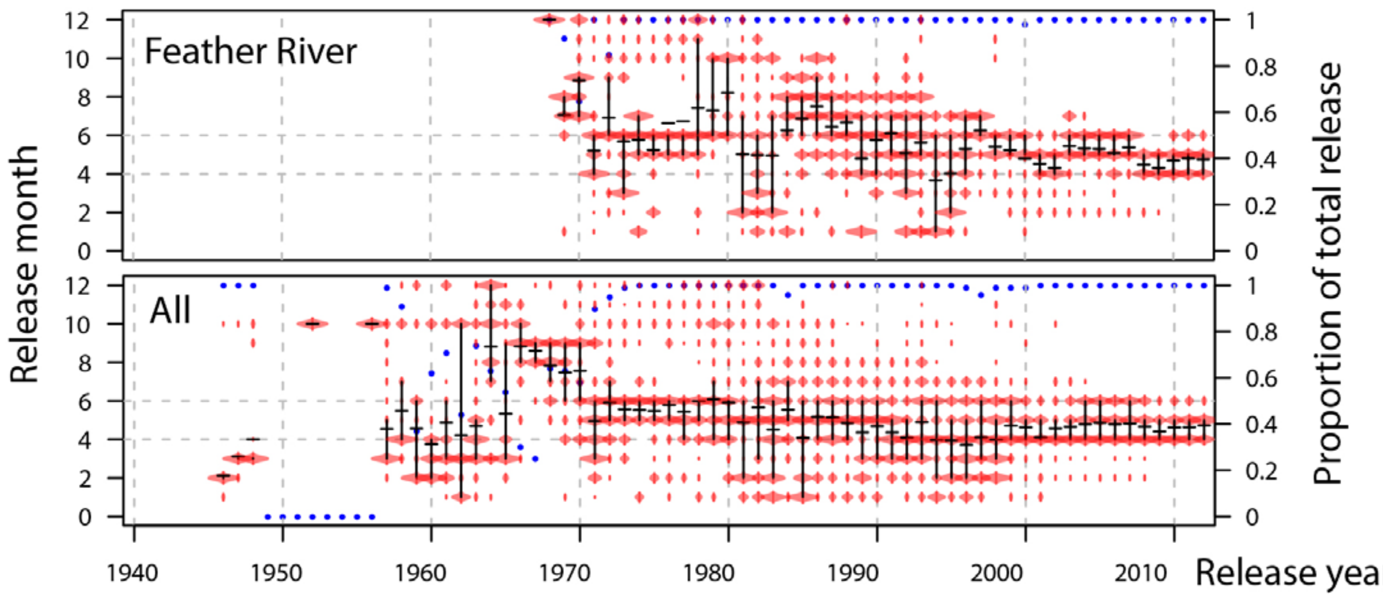
Hatchery vs wild origin



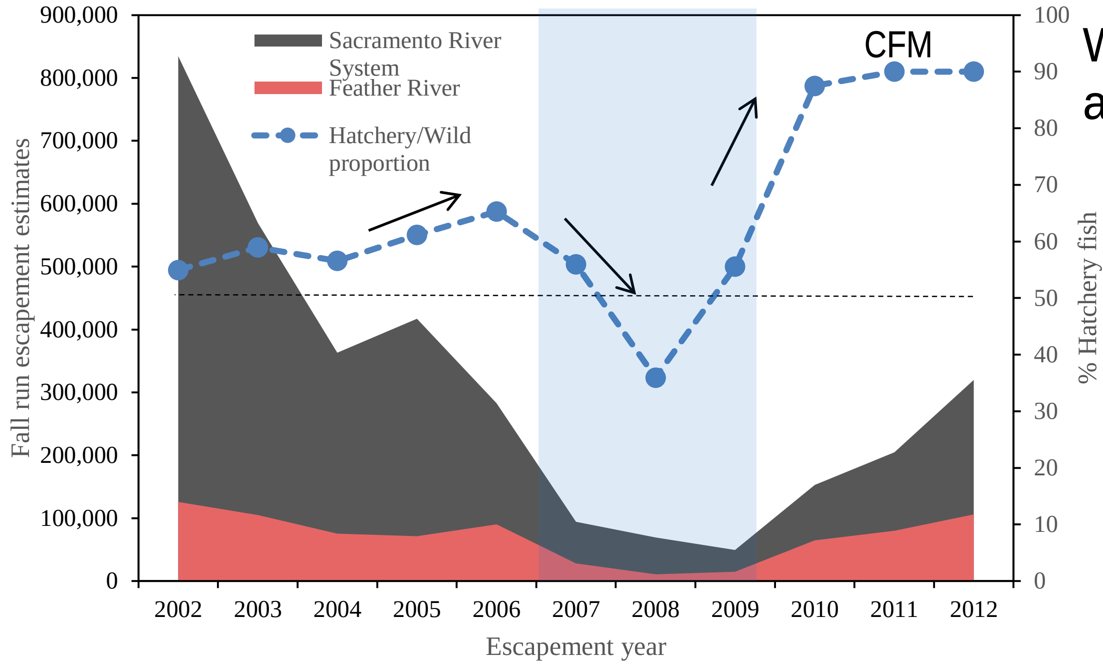
Why did the % hatchery fish decrease during the salmon stock collapse?

- Hatchery release occurs over a short time window
- Outmigration of wild fish occurs over a wider time window

Huber and Carlson, 2015



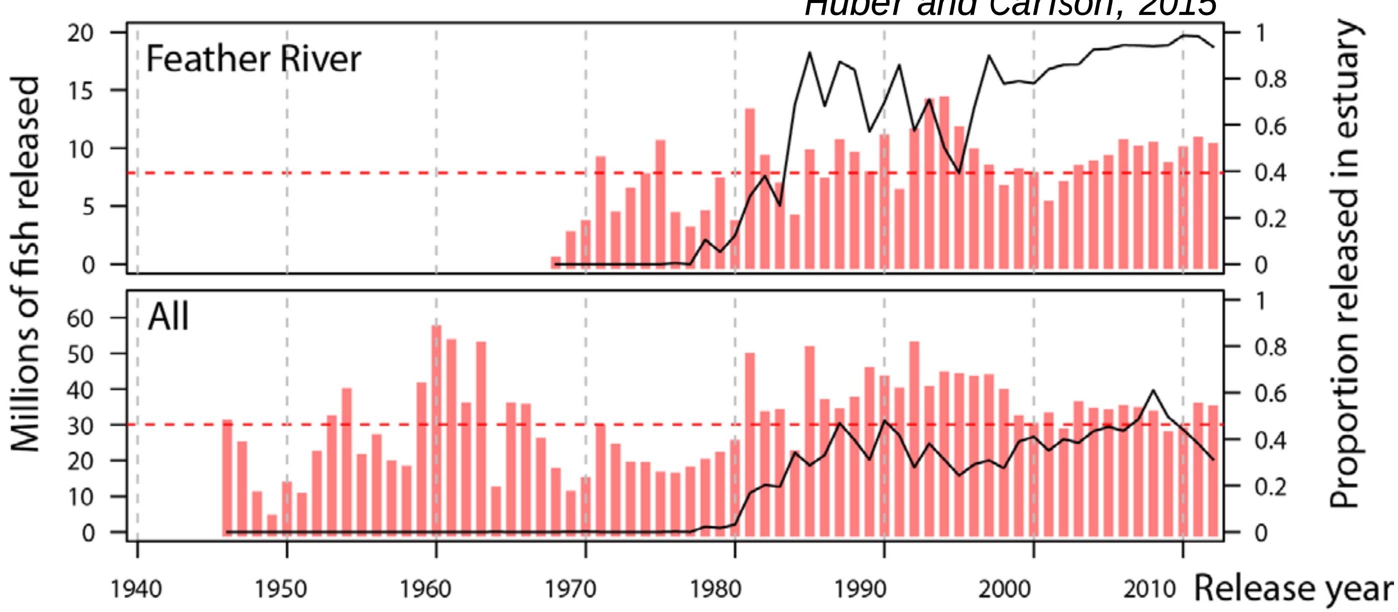
Hatchery vs wild origin



Why did % hatchery fish increase after the salmon stock collapse?

- Production of hatchery fish remained stable (or increased)
- Wild fish spawning was lower during the stock collapse

Huber and Carlson, 2015



Take home points

- $^{87}Sr/^{86}Sr$ isotope ratios of otoliths can provide detailed insights into fish life history and natal origin
- Pre salmon stock collapse we observed an increase of 51% - 65% of hatchery fish over time
- During the salmon stock collapse proportionally more wild fish returned, indicating that they survived better than their hatchery counterparts
- After the salmon stock collapse the in-river spawning grounds became dominated by hatchery fish (~90%), indicating a faster rebound of the hatchery fish population

Future directions

- Extend this dataset to include more escapement years
- Look at the effect of the recent drought
- Investigate additional markers in otoliths (e.g. microstructure, vaterite)
- Determine timing and size at outmigration

Otolith analysis