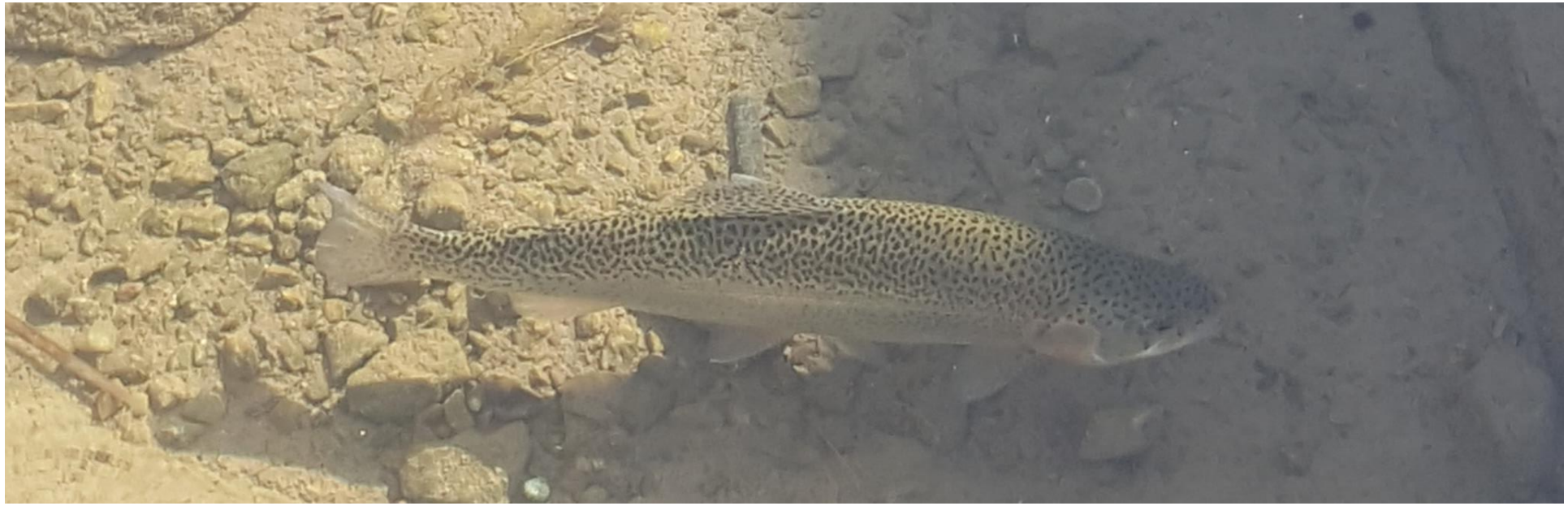
Putah Creek Case Study:
Fish Response to an Environmental Flow Regime

Ethan Baruch, Sarah Yarnell, Ted Grantham,
Jessica Ayers, Andrew Rypel, and Rob Lusardi

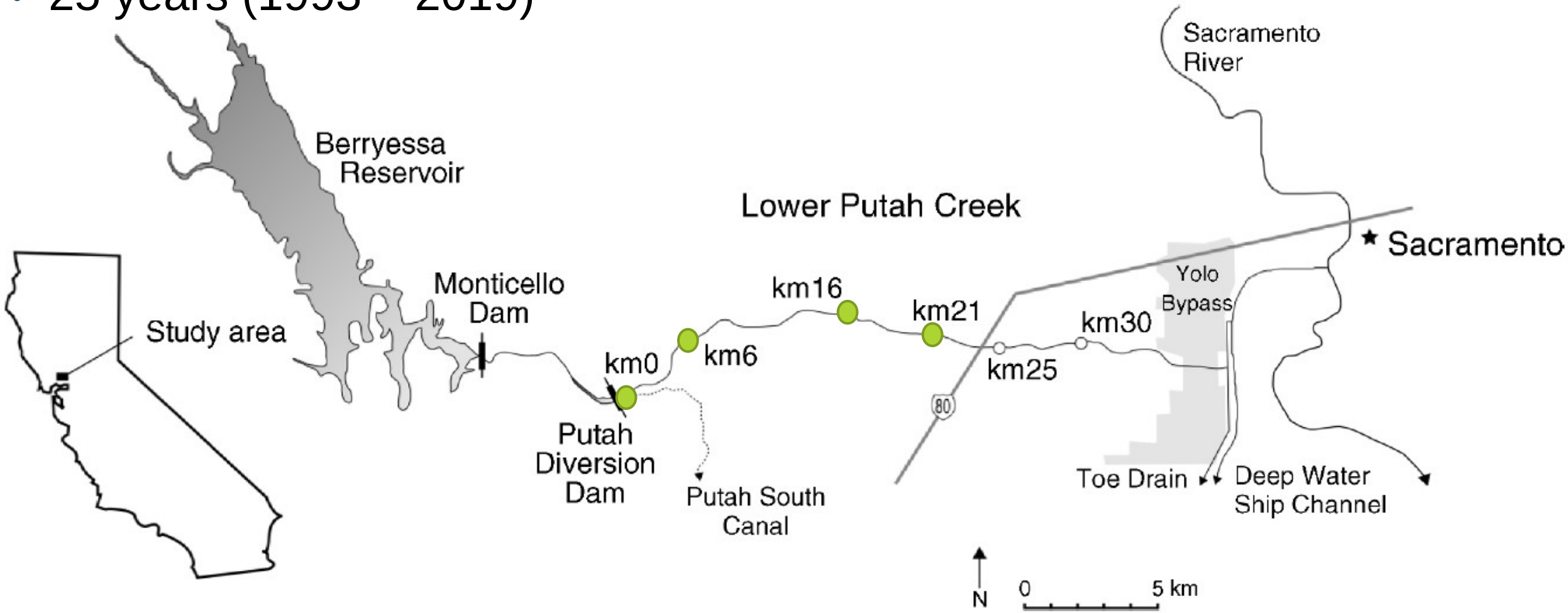


Ethan.Baruch@wildlife.ca.gov

Arthington et al. 2023

Putah Creek data collection

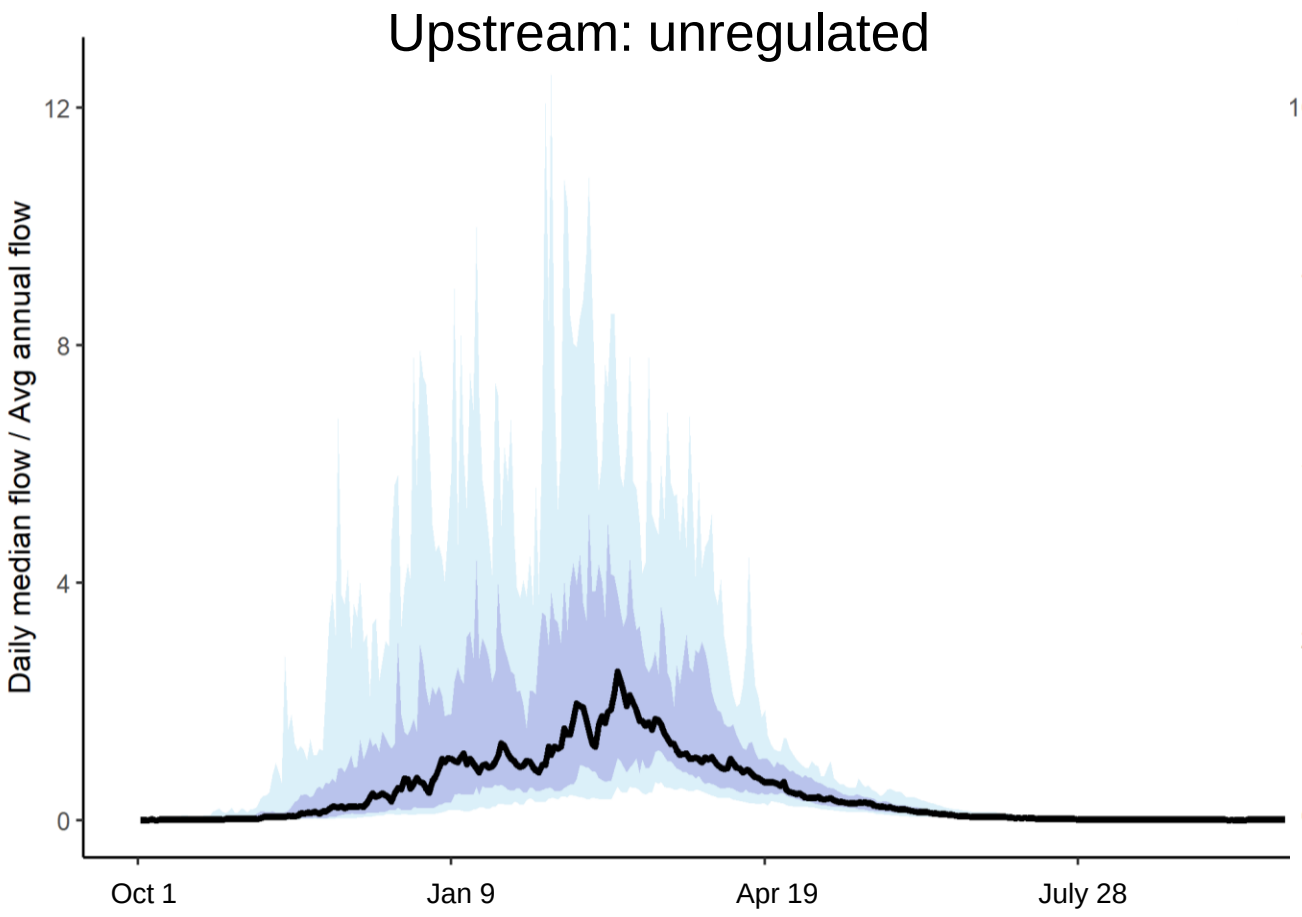
- Four sample sites
- 25 years (1993 – 2019)

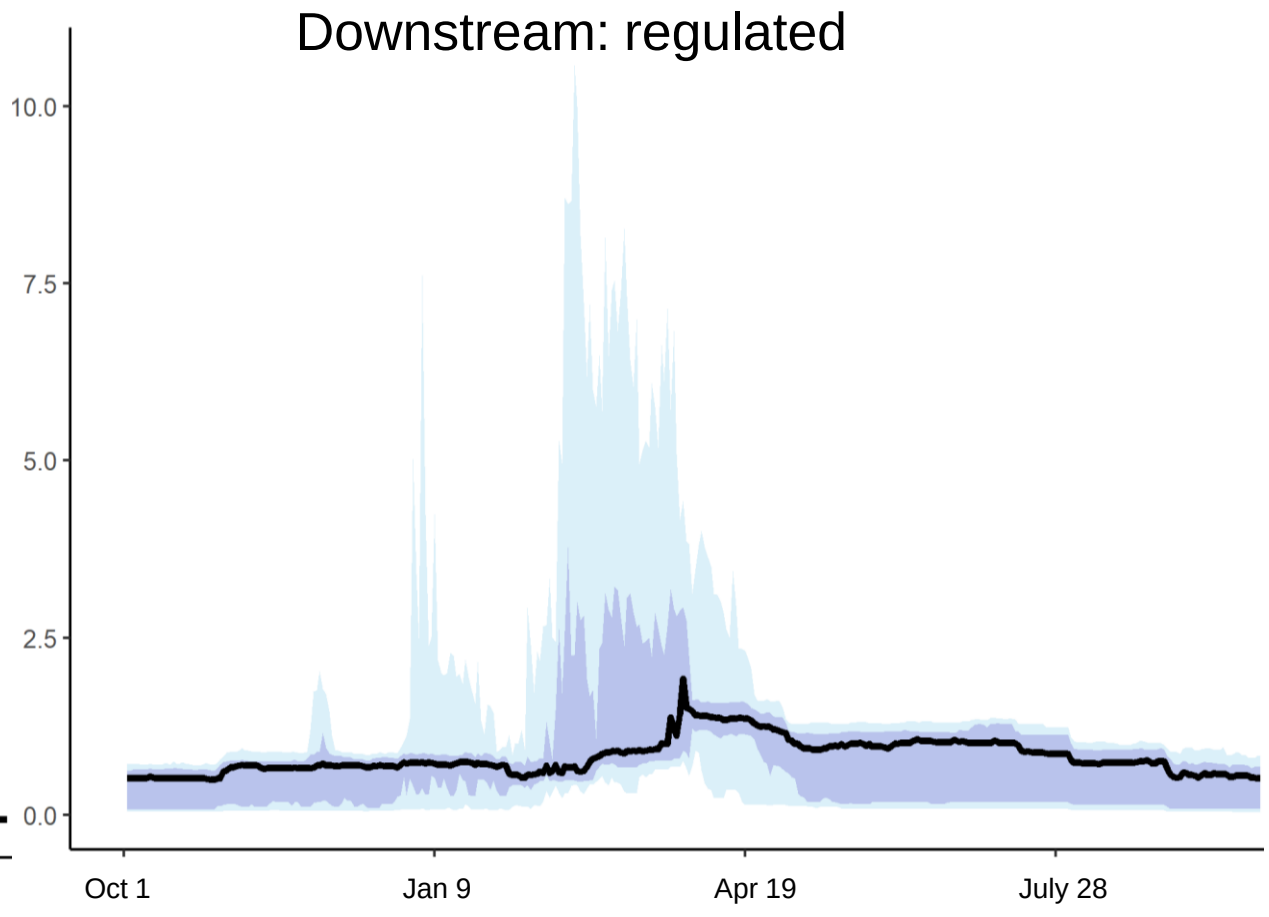


Map: Kiernan et al. 2012

Hydrograph of a regulated river

Daily median flow with 10/90 percentiles (light blue), and 25/75 percentiles (purple)





Putah Creek flow accord

- Five-day fall pulse (Nov or Dec)
- Three-day spring pulse (Feb 15 – Mar 31)
  - Followed by month-long release higher than baseflow
- Baseline monthly minimum flows

Before the Accord

Below Mace Blvd., June 1996

After the Accord

Above Mace Blvd., October 2019

Before the Accord

Pedrick Rd. Bridge, 1974, University mines gravel from creek and bridge construction

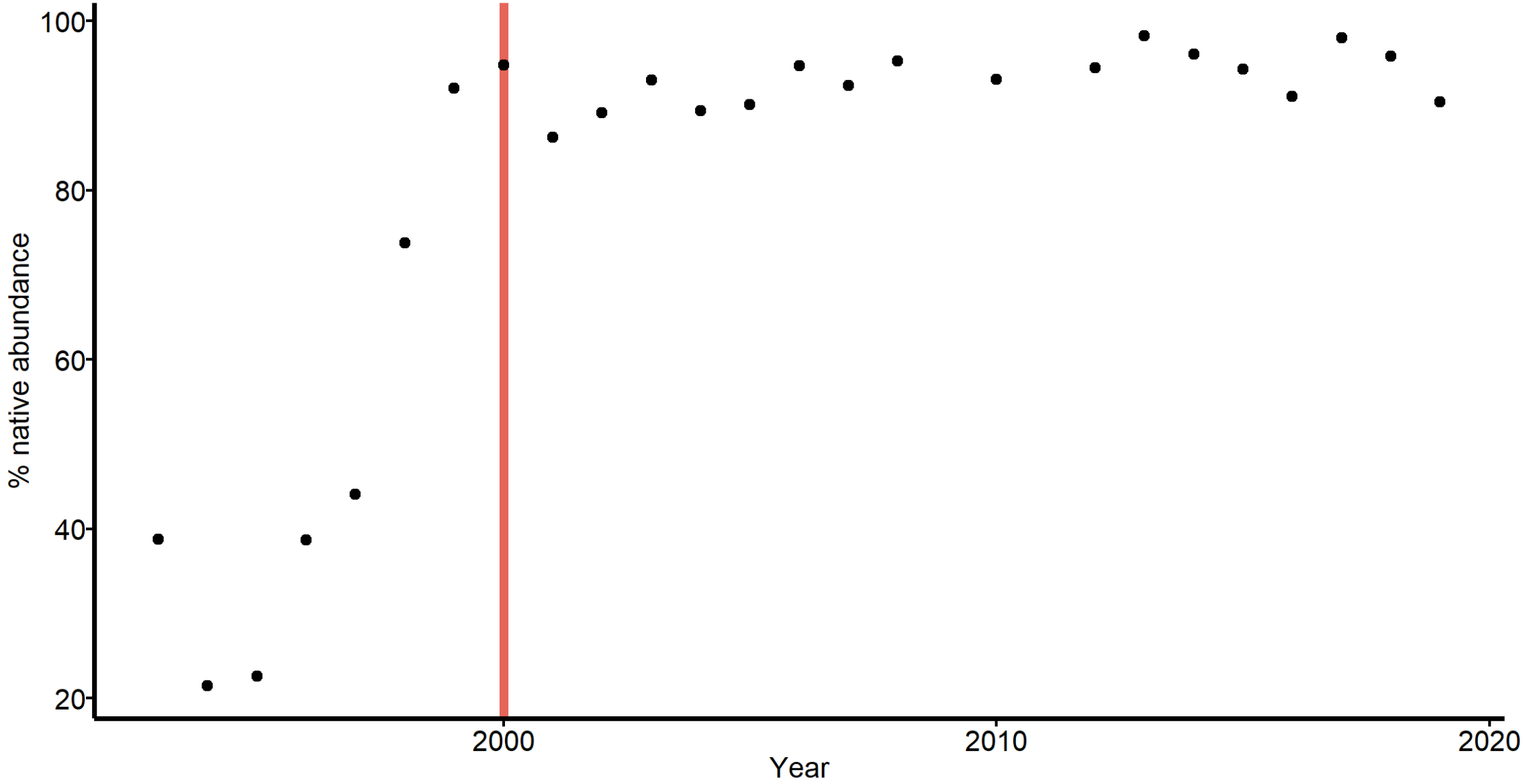
Above Pedrick Rd Bridge, 1991

After the Accord

Above Pedrick Rd Bridge, Oct 2018

Photos by Emily Jacinto with the exception of photos prior to 2018 which were taken by Peter Moyle.

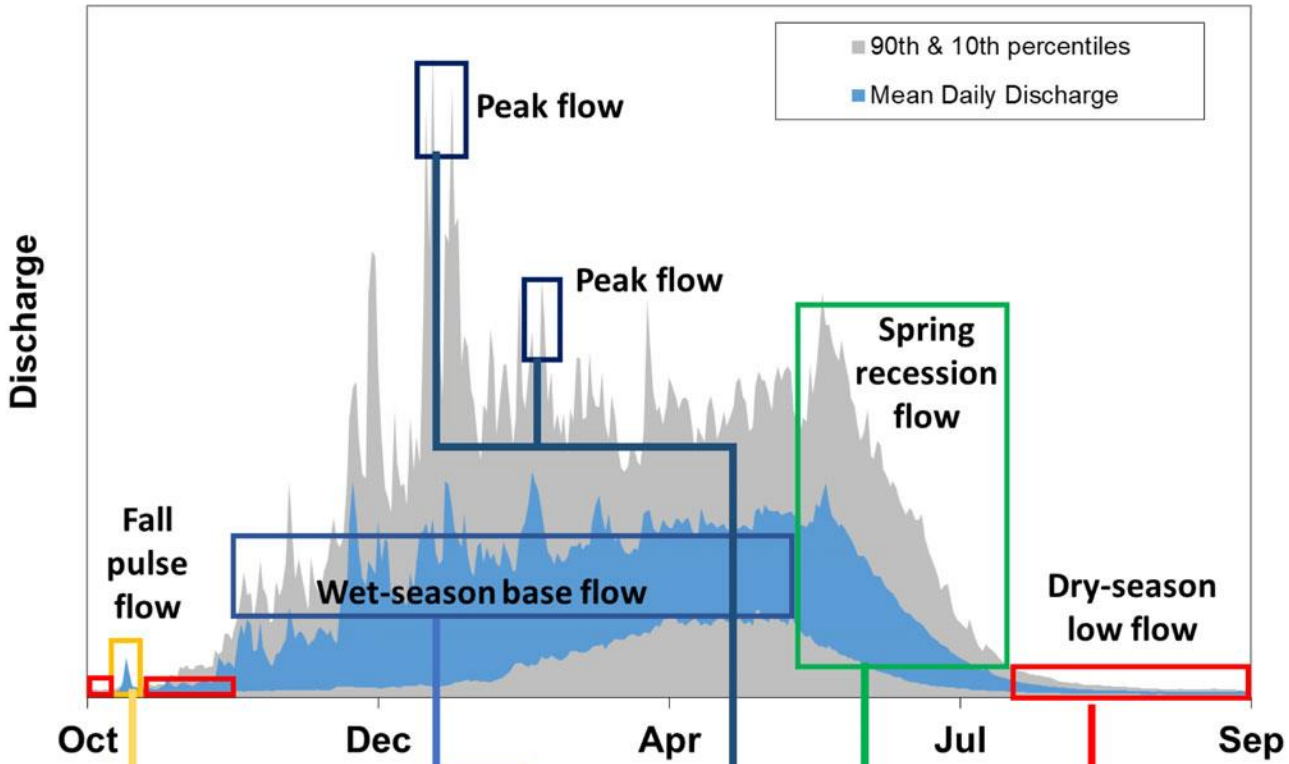
Putah Creek native fish



A functional flows approach to restoring a native fish community

- Which components of the flow regime influenced the fish community?
- How would the trajectory of the fish community differ under alternative flow regimes?

Functional Flow Components

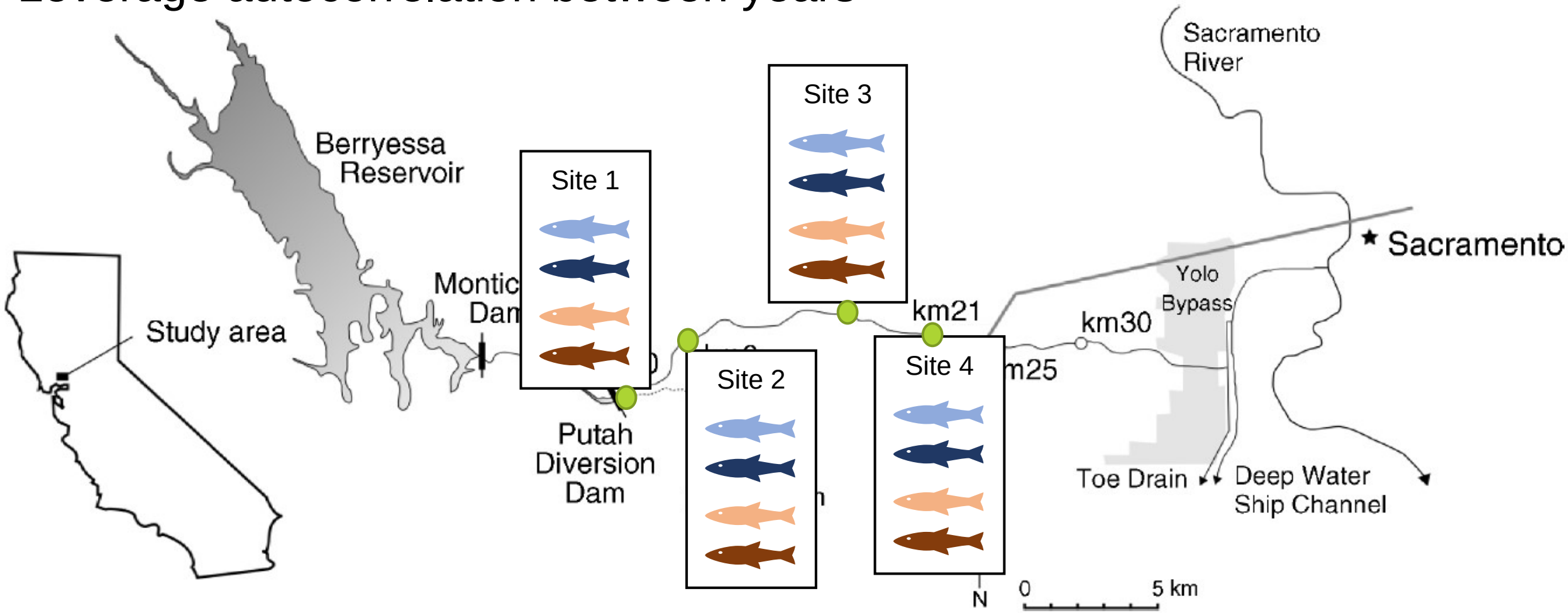


Flow Characteristics	Functional Flow Components: Fall Pulse	Wet Baseflow	Peak Flow	Spring Recession	Dry Low Flow
Magnitude	X	X	X	X	X
Timing	X	X	X	X	X
Duration		X	X	X	X
Frequency			X		
Rate of Change				X	X

Yarnell et al. 2020

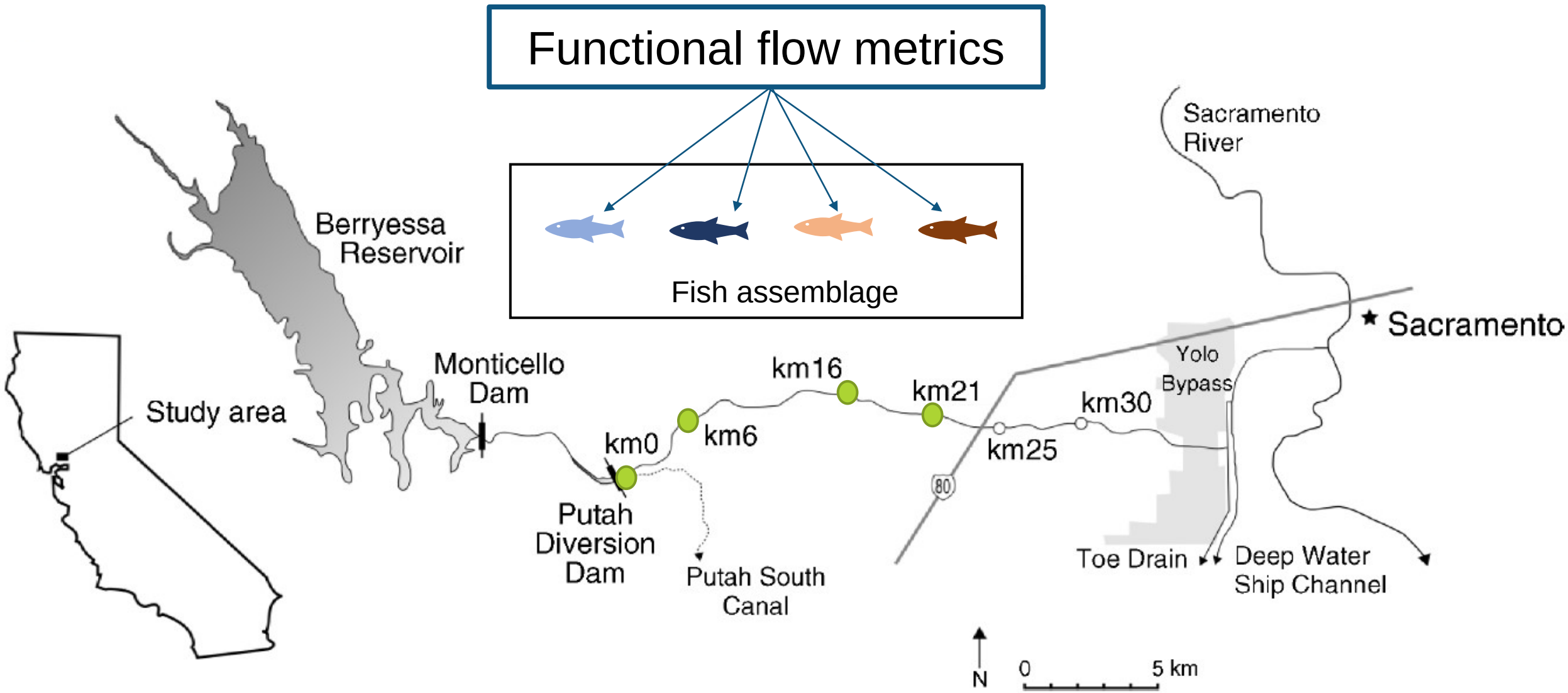
Fish population models

- Account for observation error
- Leverage autocorrelation between years



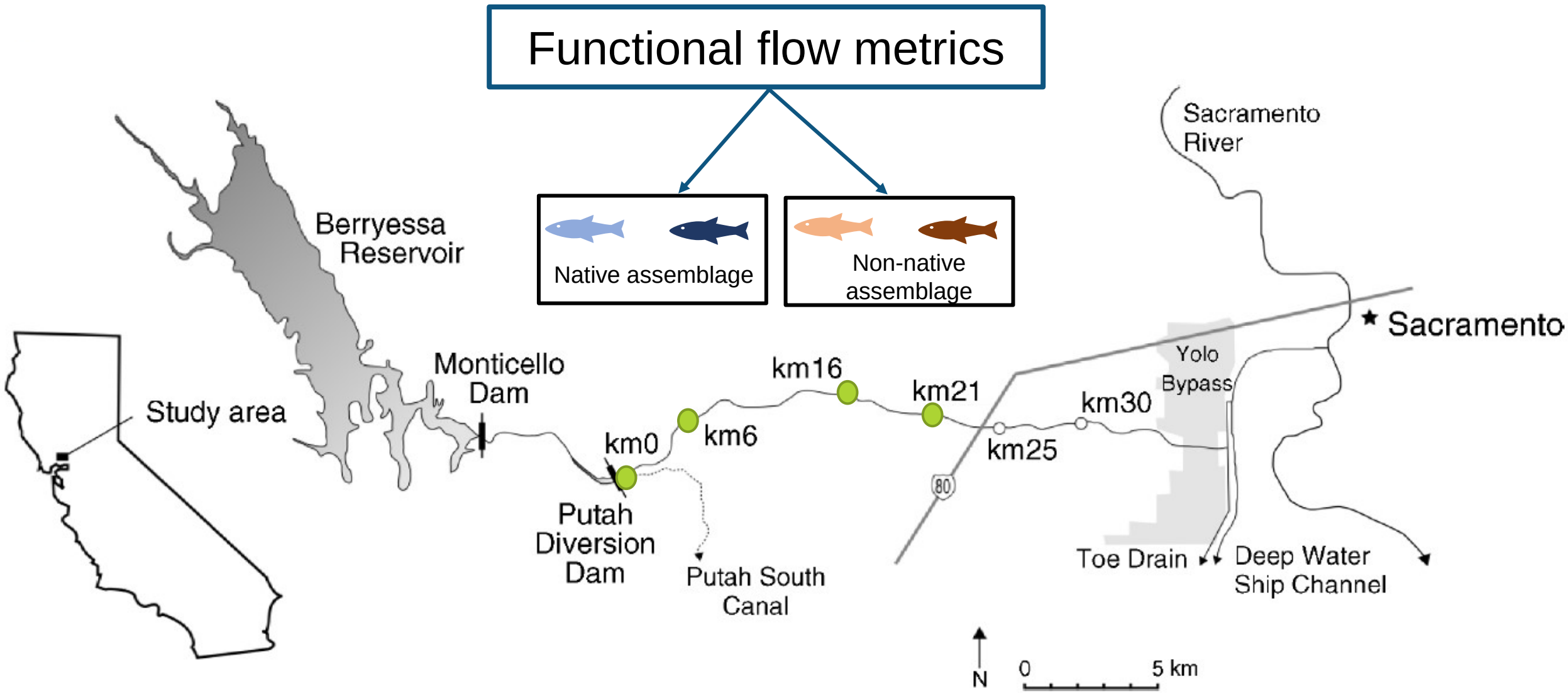
Map: Kiernan et al. 2012

Fish population models



Map: Kiernan et al. 2012

Fish population models



Map: Kiernan et al. 2012

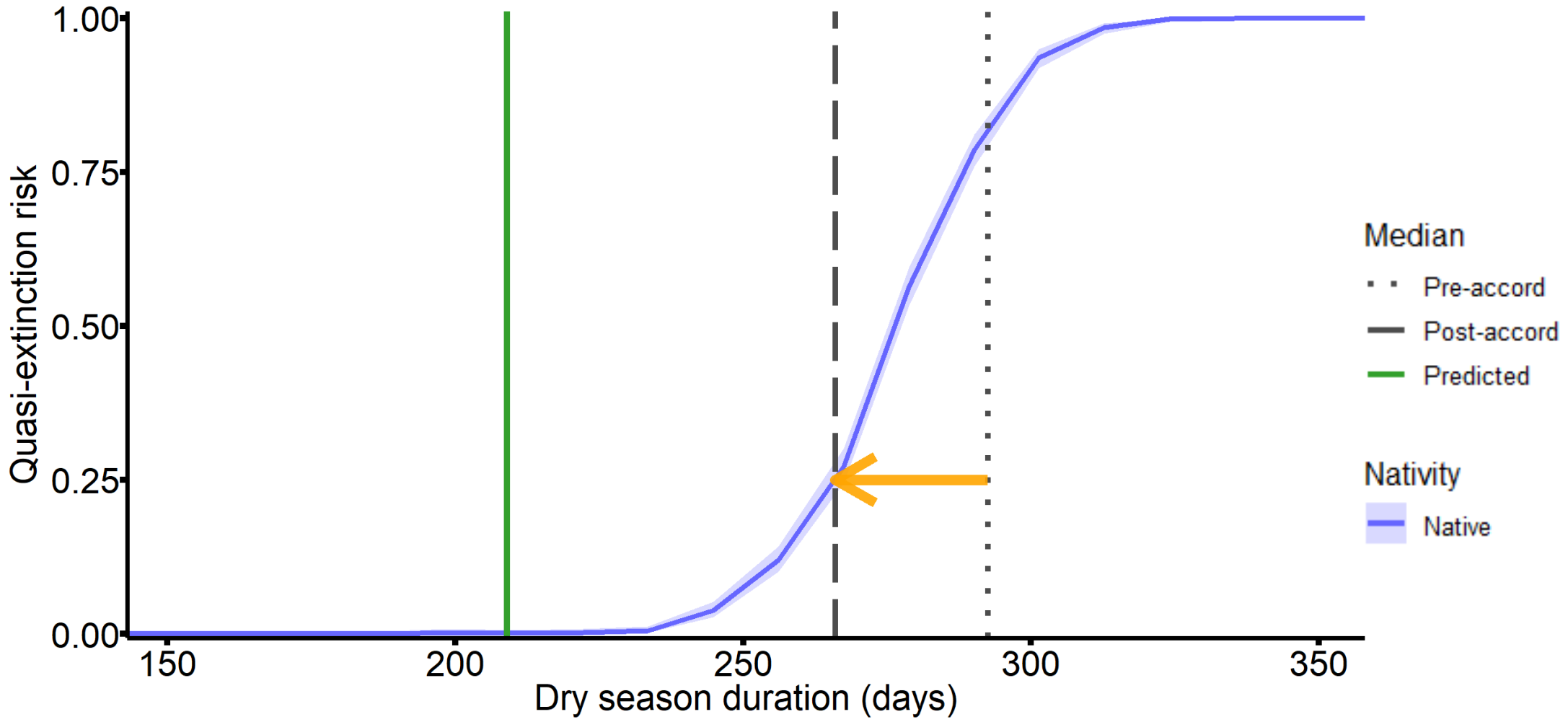
Restoring flows for native fish

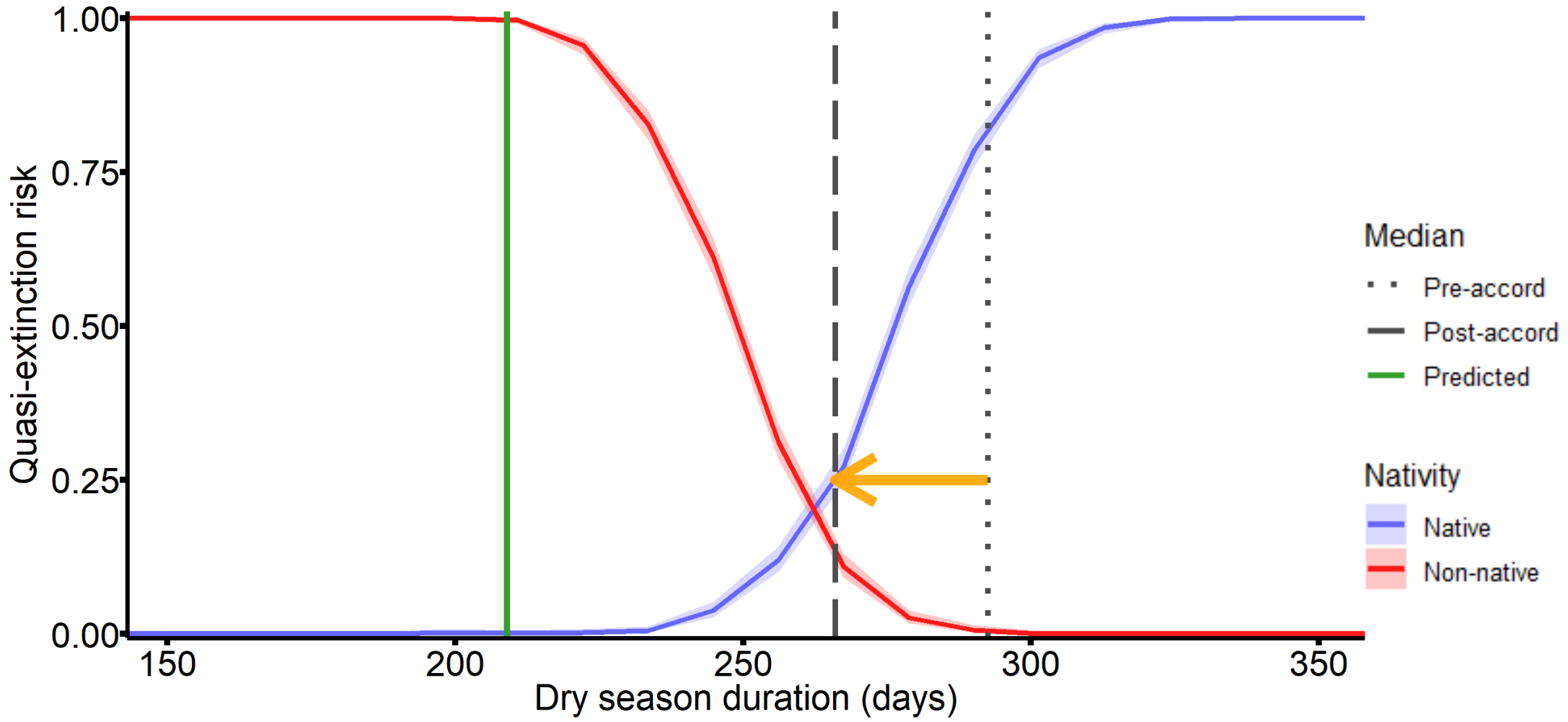
- Which components of the flow regime influenced the fish community?
- Do native and non-native assemblages have different responses?

Metric	Native response	Non-native response
Dry season duration	–	+
Dry season median magnitude	–	+
Fall pulse magnitude	+	
Wet season 10th percentile magnitude	+	–
Wet season median magnitude	+	–
Wet season timing	–	+
Spring recession magnitude	+	–
Spring recession rate of change		
Spring recession timing	+	–

A functional flows approach to restoring a native fish community

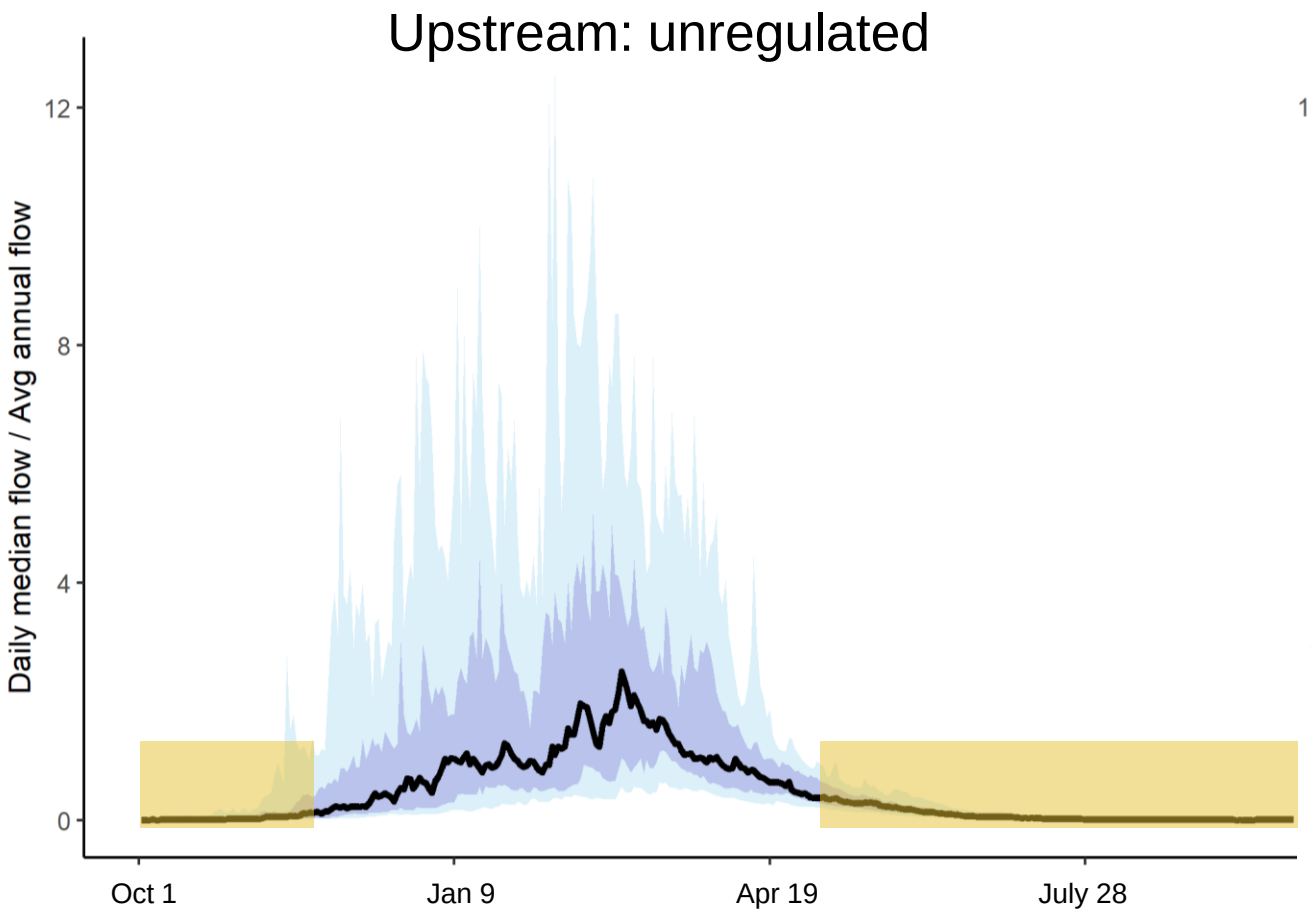
- Which components of the flow regime influenced the fish community?
- How would the trajectory of the fish community differ under alternative flow regimes?

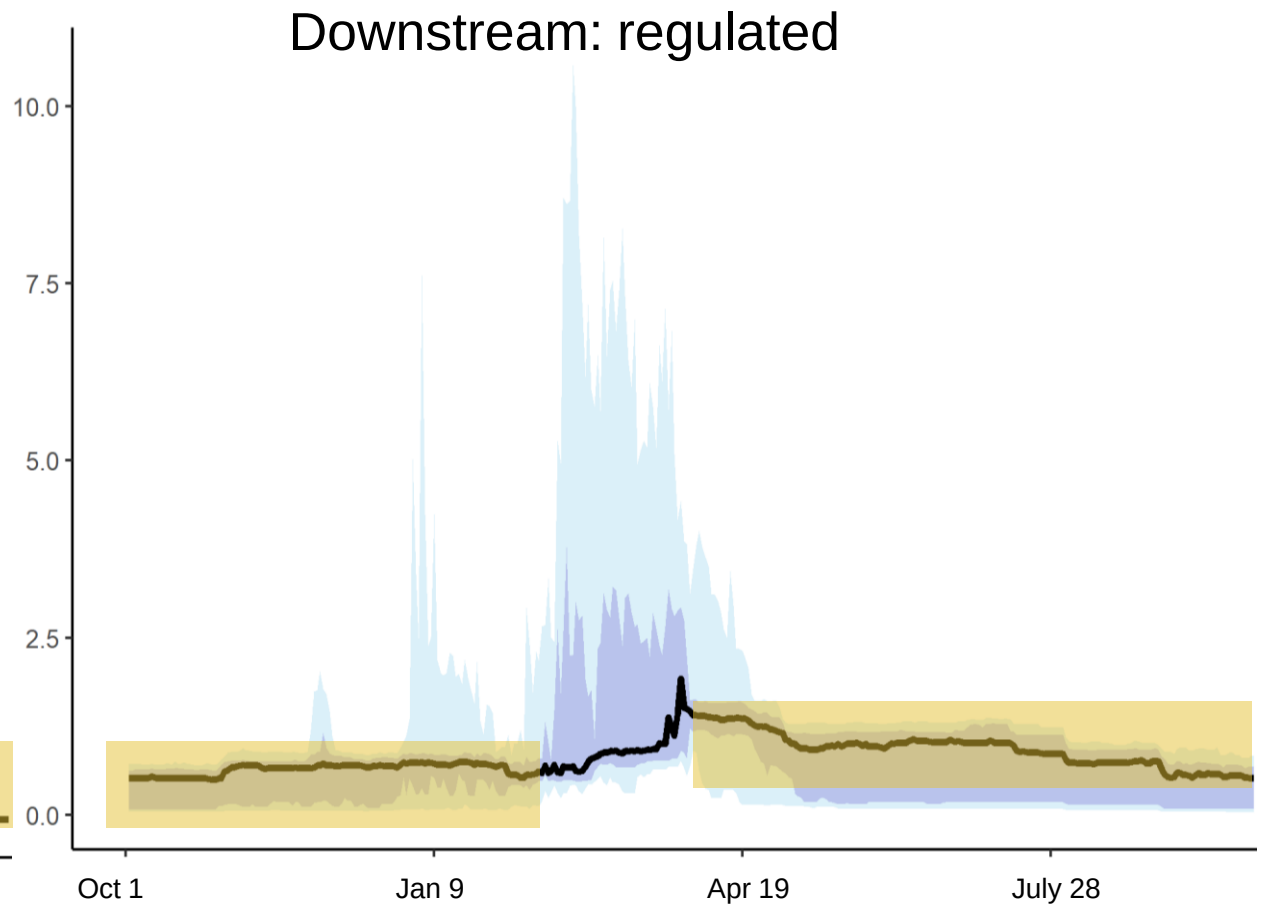

1.00
0.75
0.50
0.25
0.00
Quasi-extinction risk
150
200
250
300
350
Dry season duration (days)
Median
Pre-accord
Post-accord
Predicted
Nativity
Native

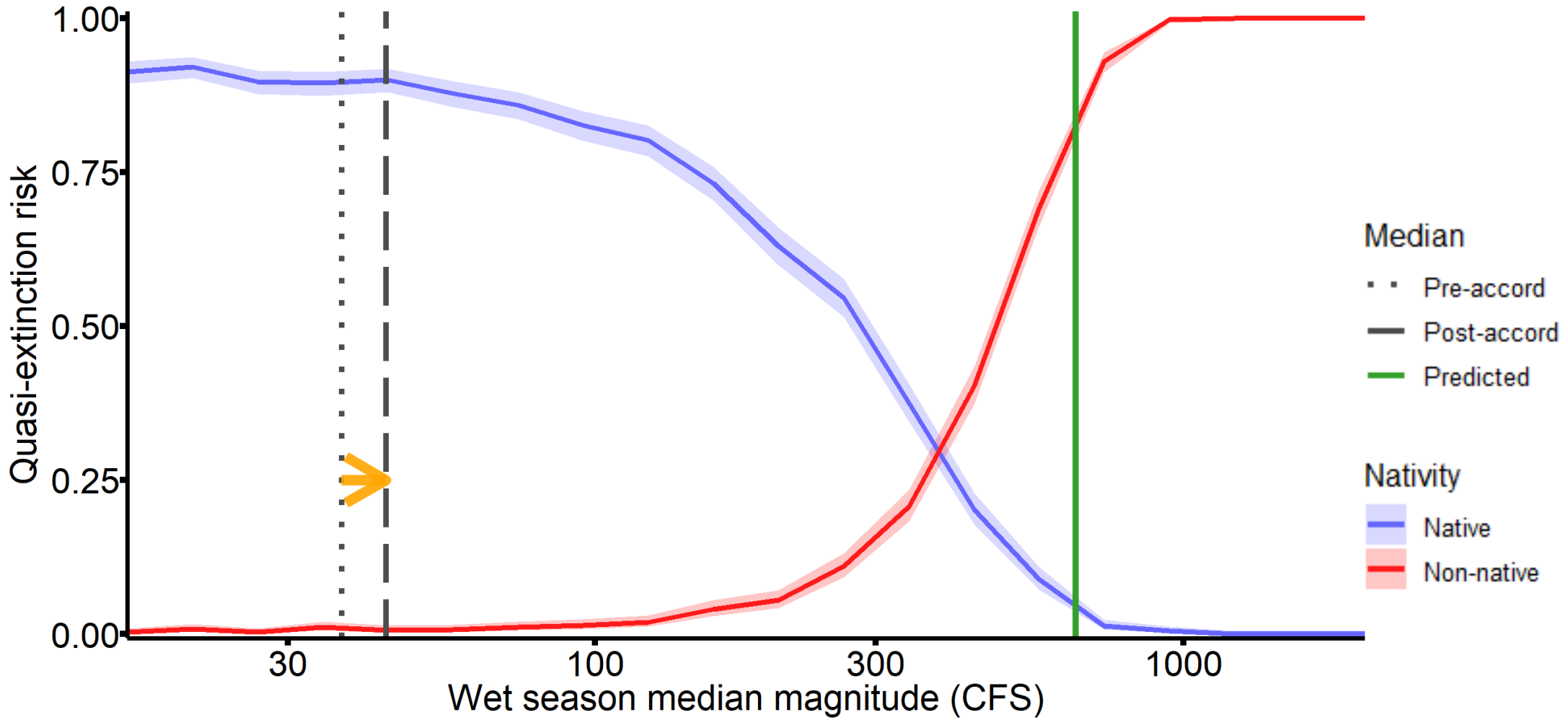

1.00
0.75
0.50
0.25
0.00
Quasi-extinction risk
150
200
250
300
350
Dry season duration (days)
Median
Pre-accord
Post-accord
Predicted
Nativity
Native
Non-native

Flow regulation increases dry season duration

Daily median flow with 10/90 percentiles (light blue), and 25/75 percentiles (purple)

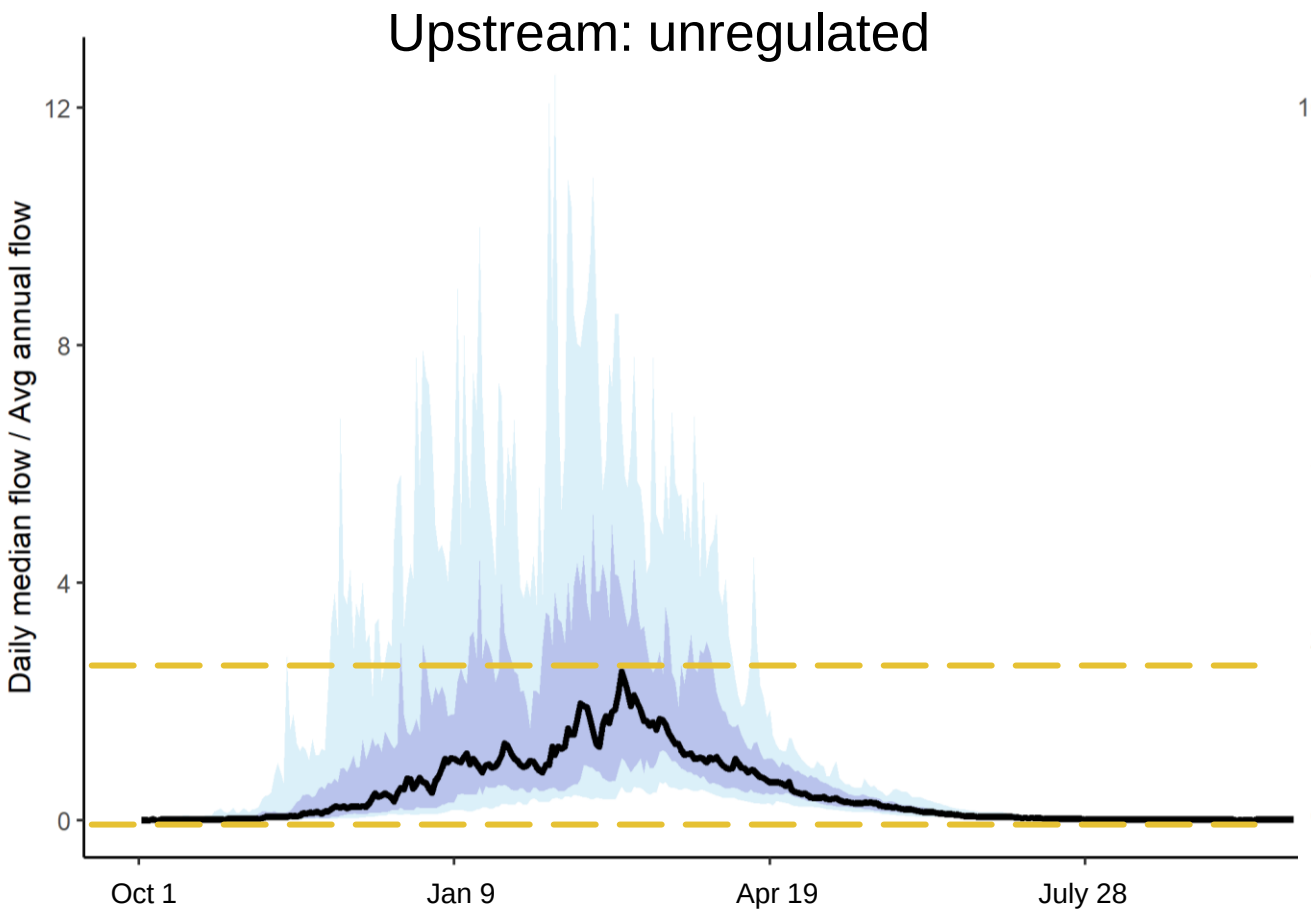


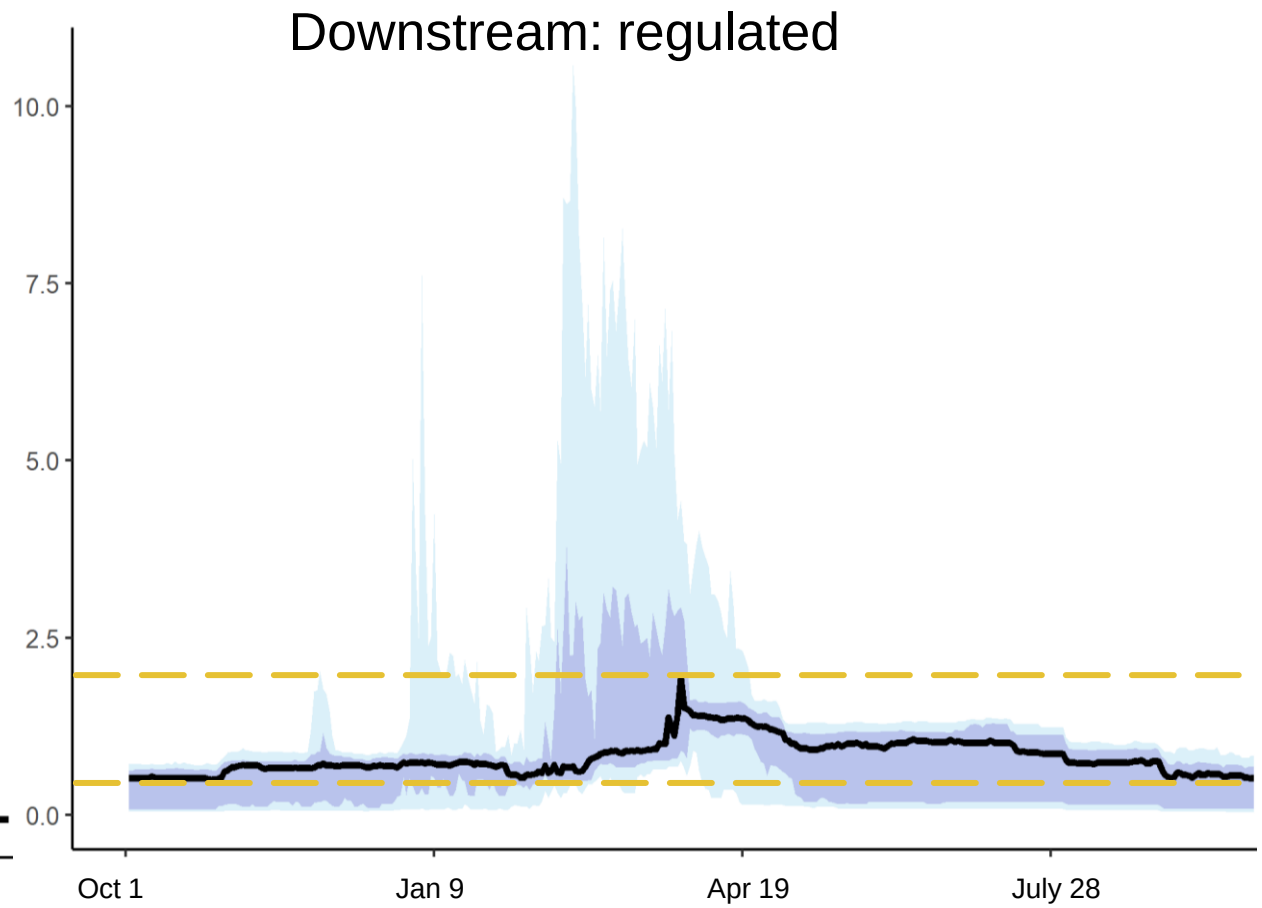


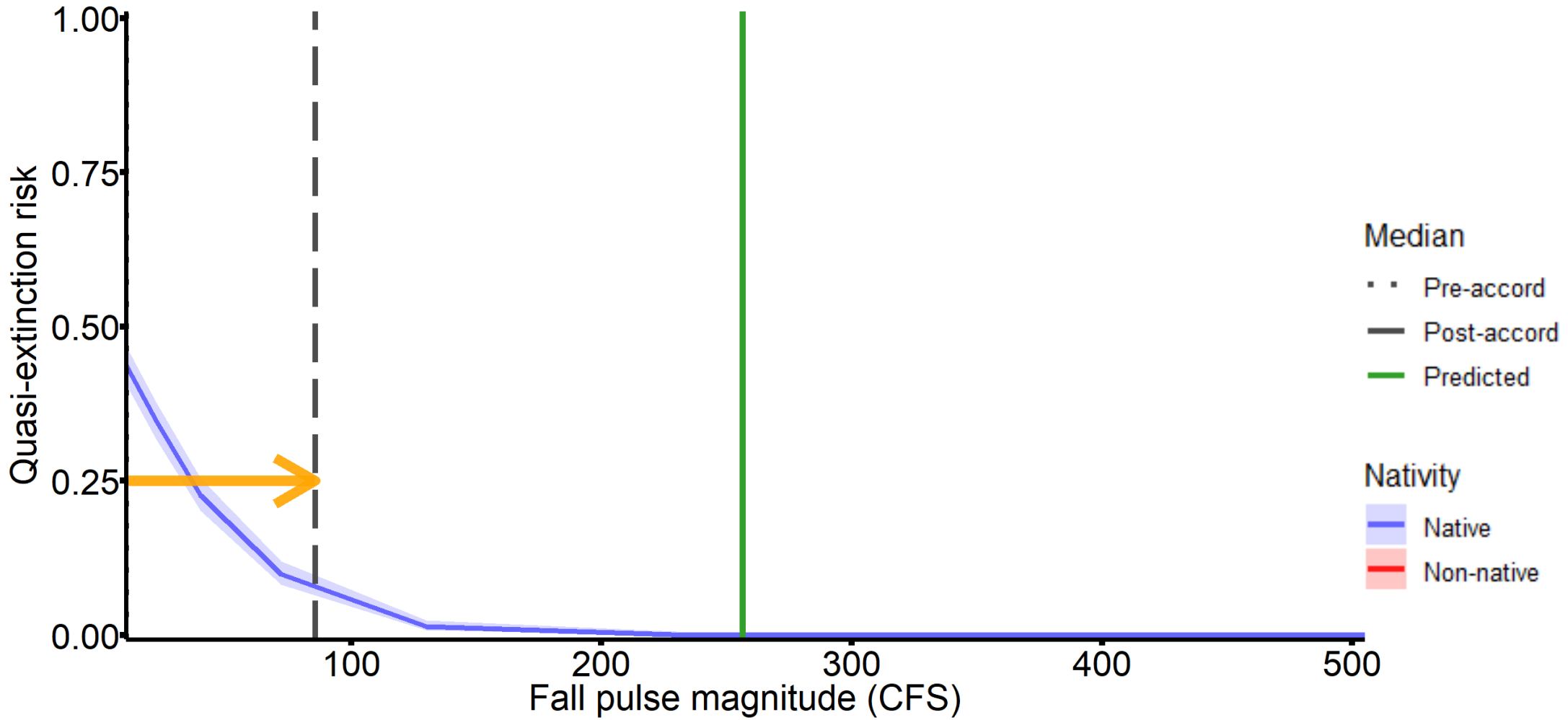

1.00
0.75
0.50
0.25
0.00
Quasi-extinction risk
30
100
300
1000
Wet season median magnitude (CFS)
Median
Pre-accord
Post-accord
Predicted
Nativity
Native
Non-native

Reduced seasonality benefits non-native fish

Daily median flow with 10/90 percentiles (light blue), and 25/75 percentiles (purple)






1.00
0.75
0.50
0.25
0.00
Quasi-extinction risk
100
200
300
400
500
Fall pulse magnitude (CFS)
Median
Pre-accord
Post-accord
Predicted
Nativity
Native
Non-native

Functional flows to support ecosystems

- Functional flows metrics predicted fish community change over time
- Natural flows can inform environmental flow management
- Habitat restoration may be necessary for flows to provide required functions

References

- Arthington, A. H. *et al.* 2023. Accelerating environmental flows implementation to bend the curve of global freshwater biodiversity loss. Environmental Reviews *in press*:1–64.
- Kiernan, J. D., P. B. Moyle, and P. K. Crain. 2012. Restoring native fish assemblages to a regulated California stream using the natural flow regime concept. Ecological Applications 22:1472–1482.
- Yarnell, Sarah M., *et al*. 2020. A Functional Flows Approach to Selecting Ecologically Relevant Flow Metrics for Environmental Flow Applications. River Research and Applications 36 (2): 318–24.

Acknowledgements

- Peter Moyle, Kris Taniguchi-Quan, Alyssa Obester, Albert Ruhi
- Funding: California Department of Fish and Wildlife
- Data: TRPA Fish Biologists

Photo: Peter Moyle