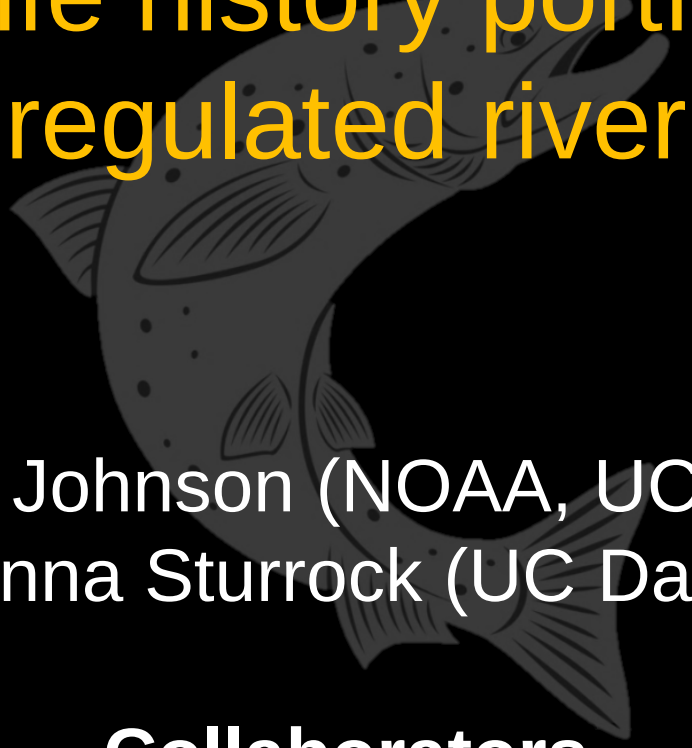
Salmon life history portfolios in a regulated river



Rachel Johnson (NOAA, UC Davis)
& Anna Sturrock (UC Davis)

Collaborators

JD Wikert (US Fish & Wildlife Service), Tim Heyne (CA Department of Fish & Wildlife), Stephanie Carlson (UC Berkeley), Sebastien Nussle (UC Berkeley), Joe Merz (Cramer Fish Sciences, UC Santa Cruz)

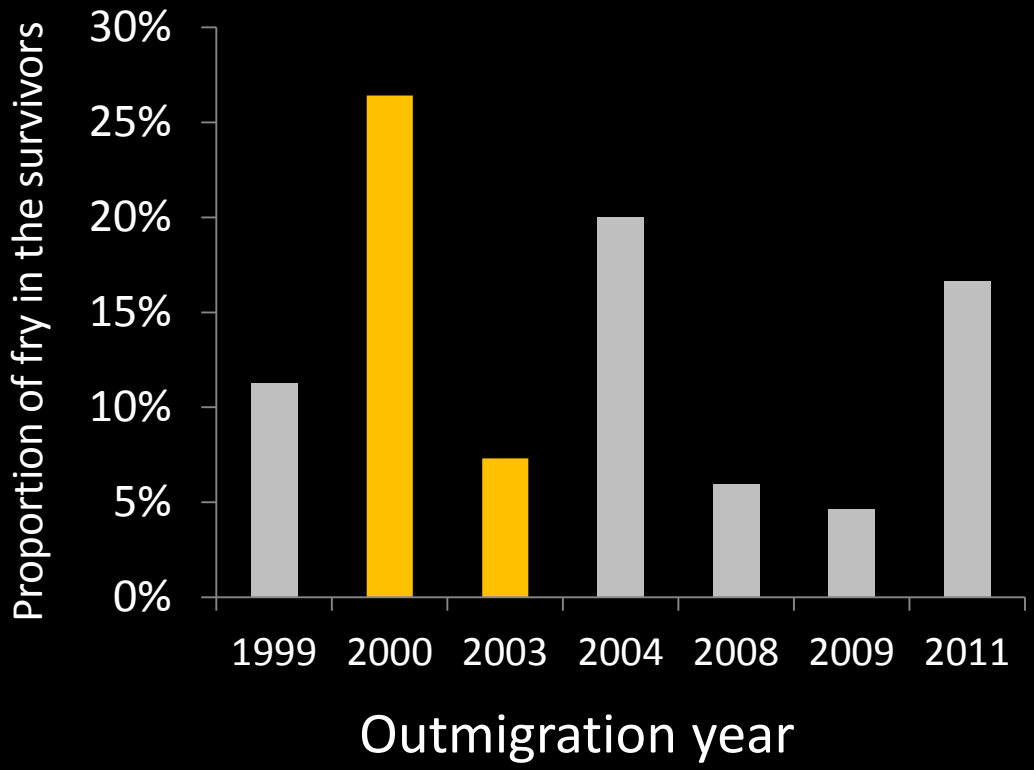
What do we already know?

1. Juvenile salmon express diverse life history strategies. Most typically leave the natal stream as early dispersing fry (Williams 2006), which we know very little about. **Our data shows that all strategies are viable.**

What do we already know?

1. Juvenile salmon express diverse life history strategies. Most typically leave the natal stream as early dispersing fry (Williams 2006), which we know very little about. **Our data shows that all strategies are viable.**

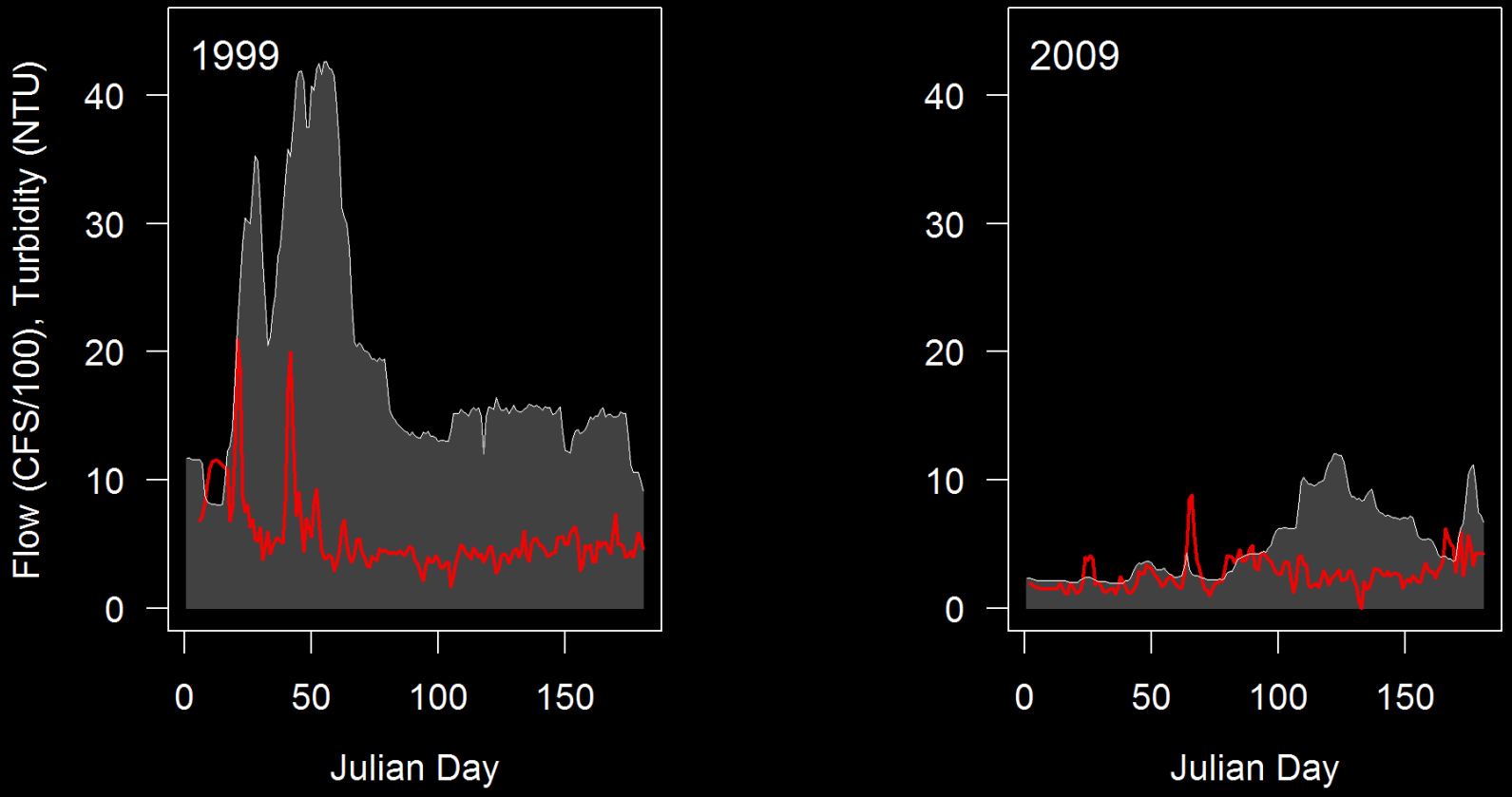
www.science.calwater.ca.gov/images/scinews_0610_tags_04_lg.jpg



Sturrock et al. 2015, Sturrock et al. unpubl

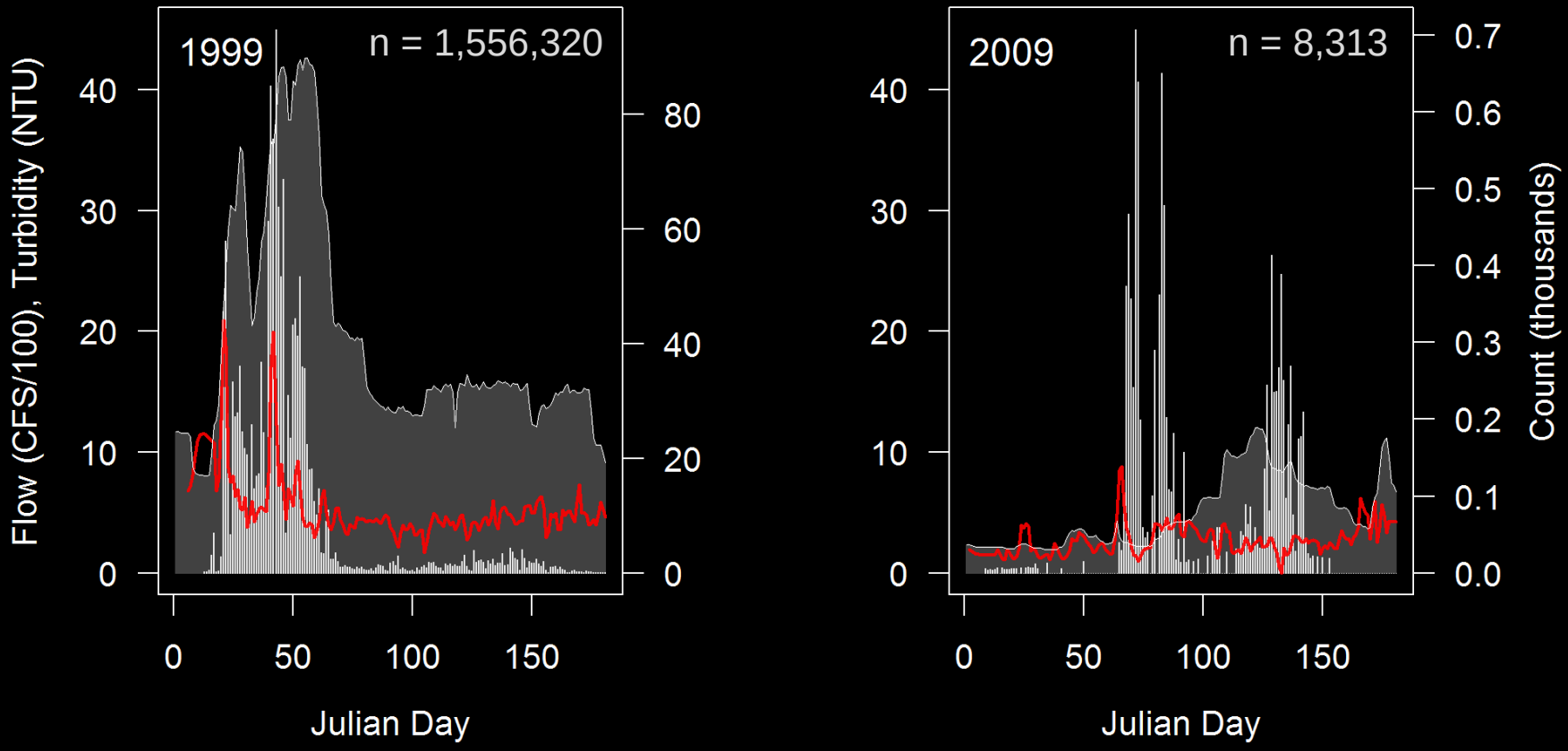
What do we already know?

2. Flow magnitude and variance promote life history diversity (e.g. expression of early dispersing fry), and instream survival.



What do we already know?

2. Flow magnitude and flow variance promote life history diversity (e.g. expression of early dispersing fry), and instream survival.



What do we already know?

2. Flow magnitude and flow variance promote life history diversity (e.g. expression of early dispersing fry), and instream survival.

Fisheries Management and Ecology

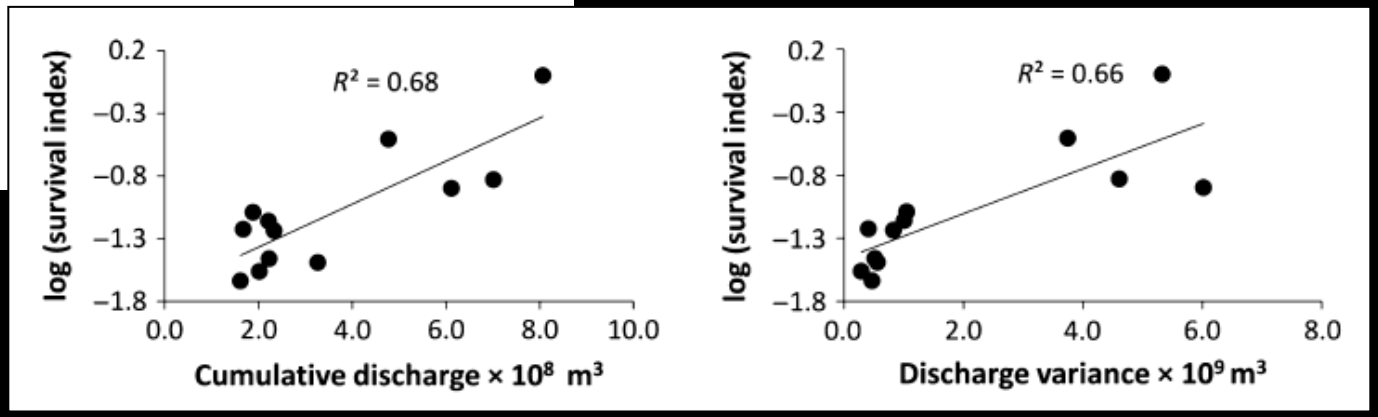
Fisheries Management and Ecology, 2014

Response of juvenile Chinook salmon to managed flow: lessons learned from a population at the southern extent of their range in North America

S. C. ZEUG, K. SELLHEIM & C. WATRY,
Cramer Fish Sciences, Auburn, CA, USA

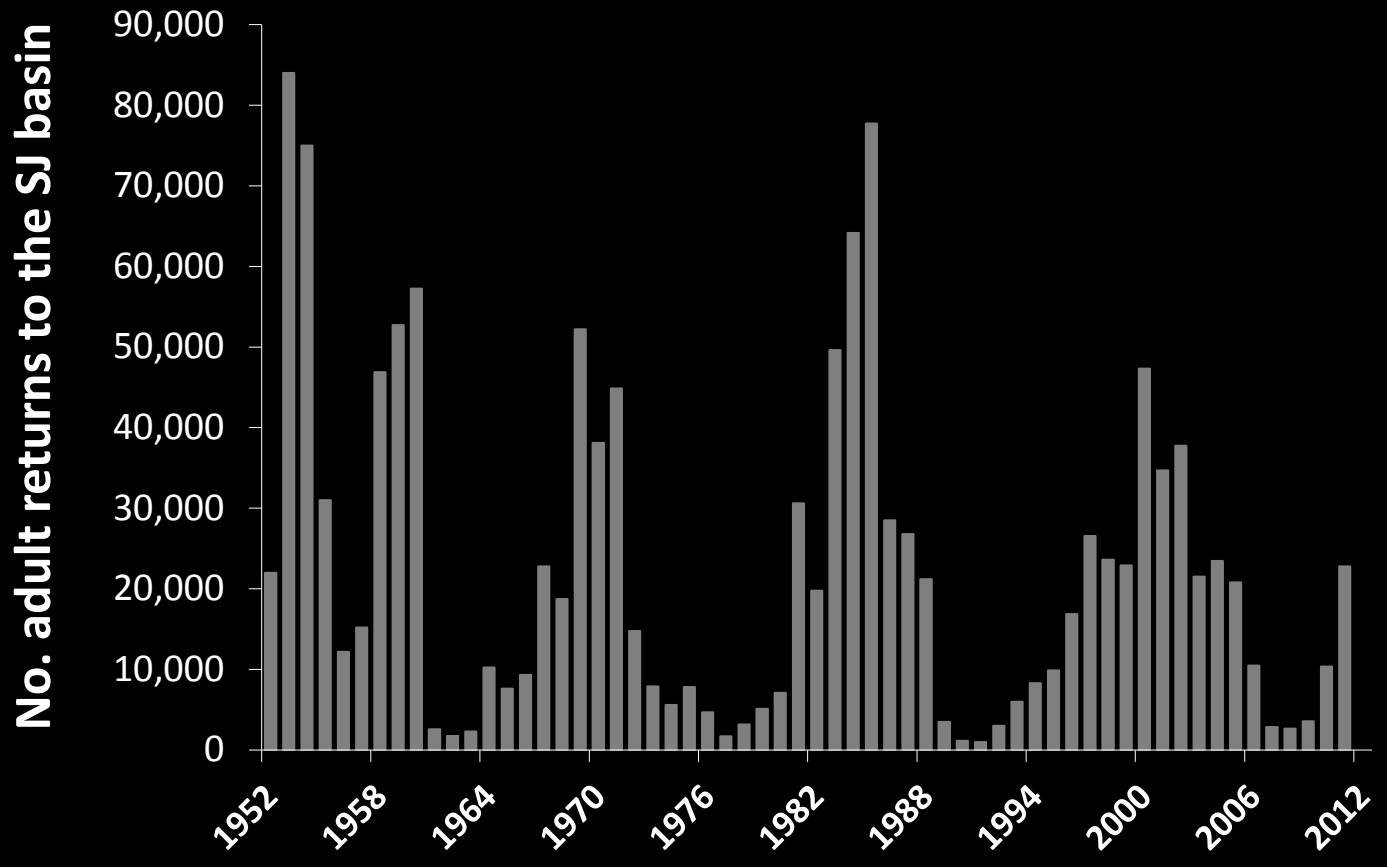
J. D. WIKERT
U.S. Fish and Wildlife Service, Lodi, CA, USA

J. MERZ
Cramer Fish Sciences, Auburn, CA, USA



What do we already know?

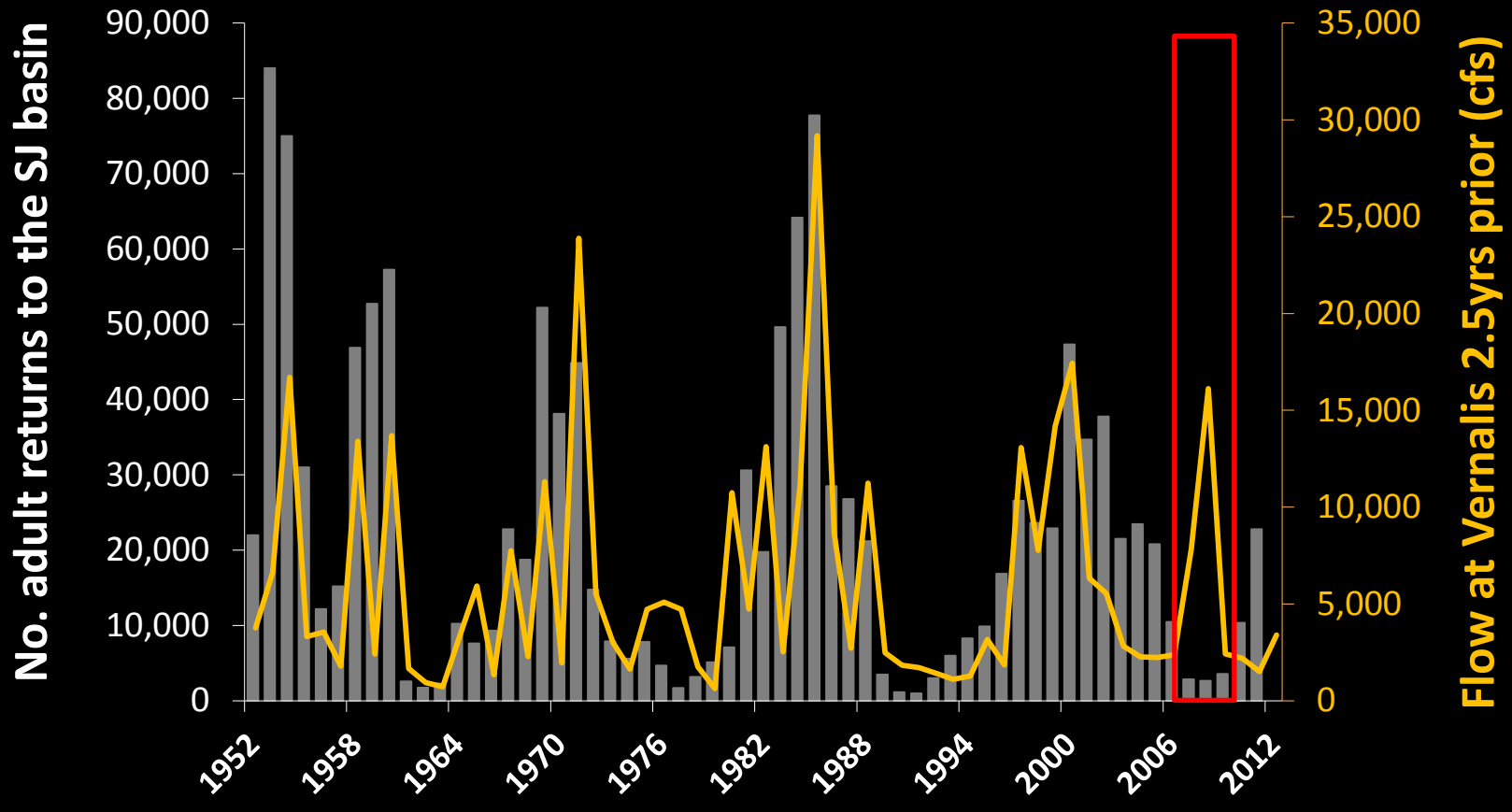
3. Juvenile rearing flows correlate with numbers of adult returns (Sturrock et al. 2015)



Sturrock et al (2015) PLoS ONE **10**(5): e0122380.
Adapted from The Bay Institute (2013) http://thebayinstitute.org/page/detail/3866
Data sources: **GrandTab (CDFW), CDEC**

What do we already know?

3. Juvenile rearing flows correlate with numbers of adult returns (Sturrock et al. 2015)

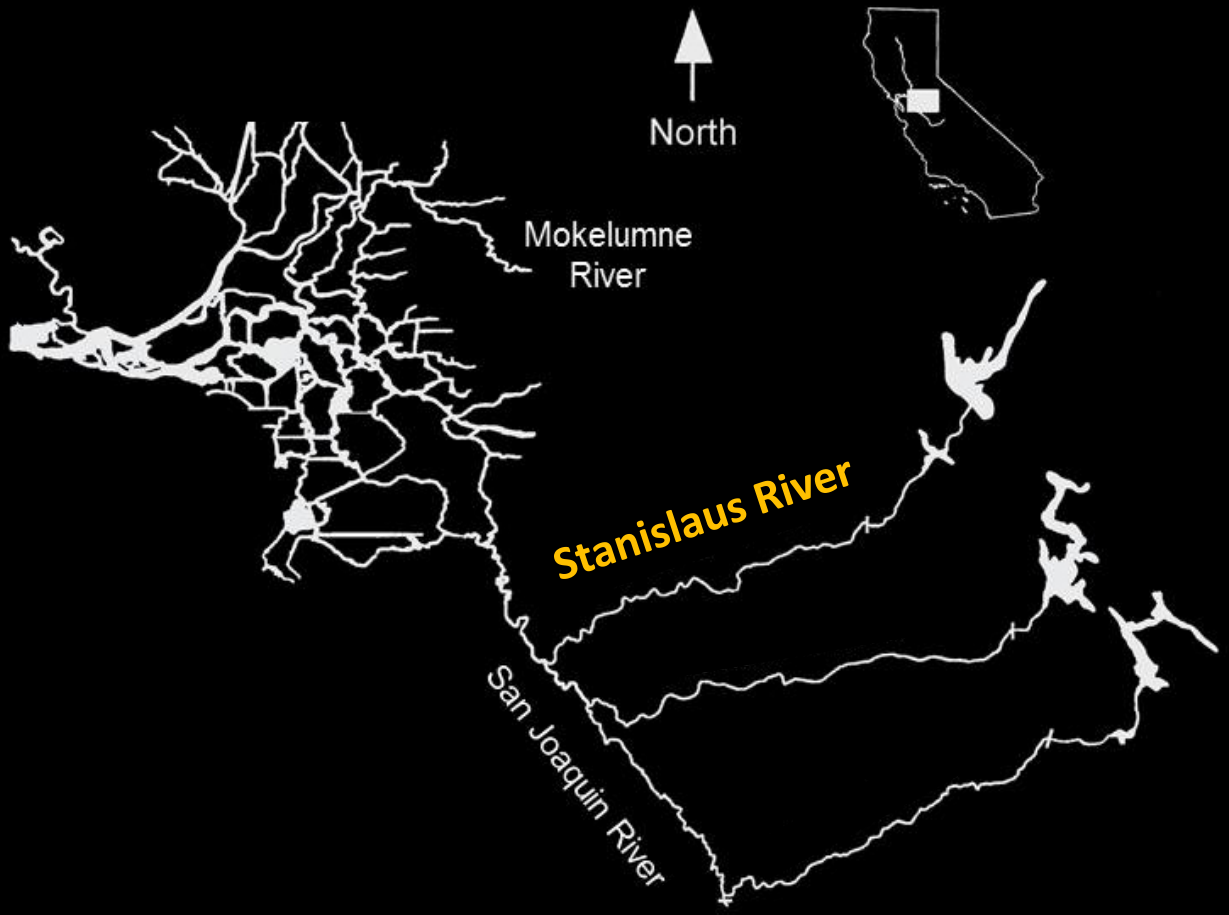


Sturrock et al (2015) PLoS ONE **10**(5): e0122380.

Adapted from The Bay Institute (2013) http://thebayinstitute.org/page/detail/3866

Data sources: **GrandTab (CDFW), CDEC**

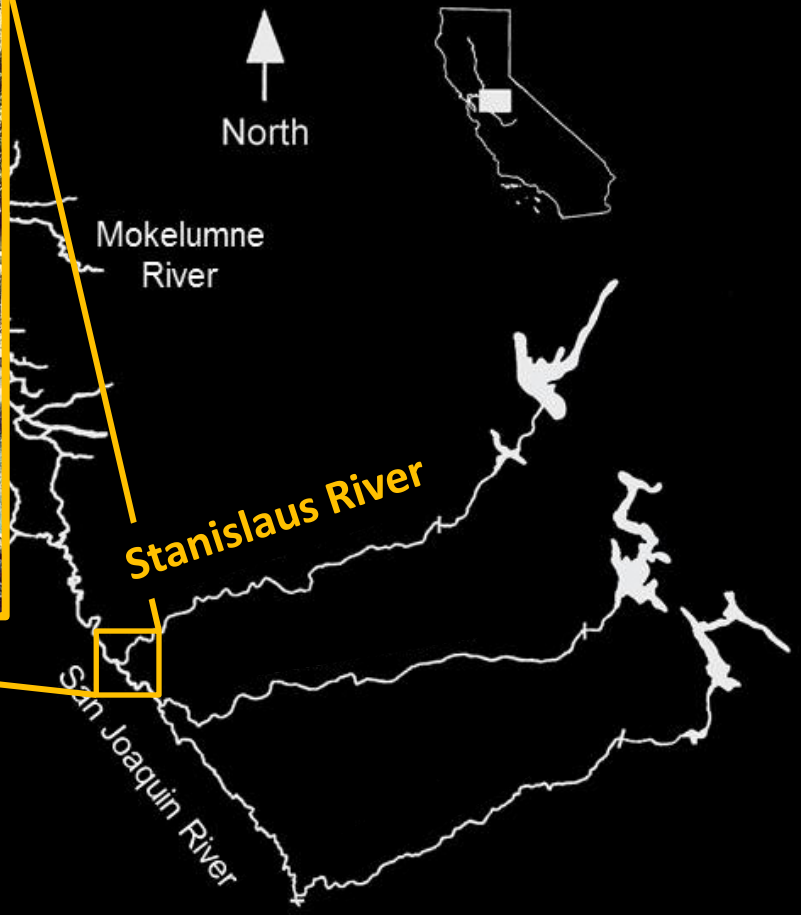
1. Juvenile outmigration (Jan-Jun)



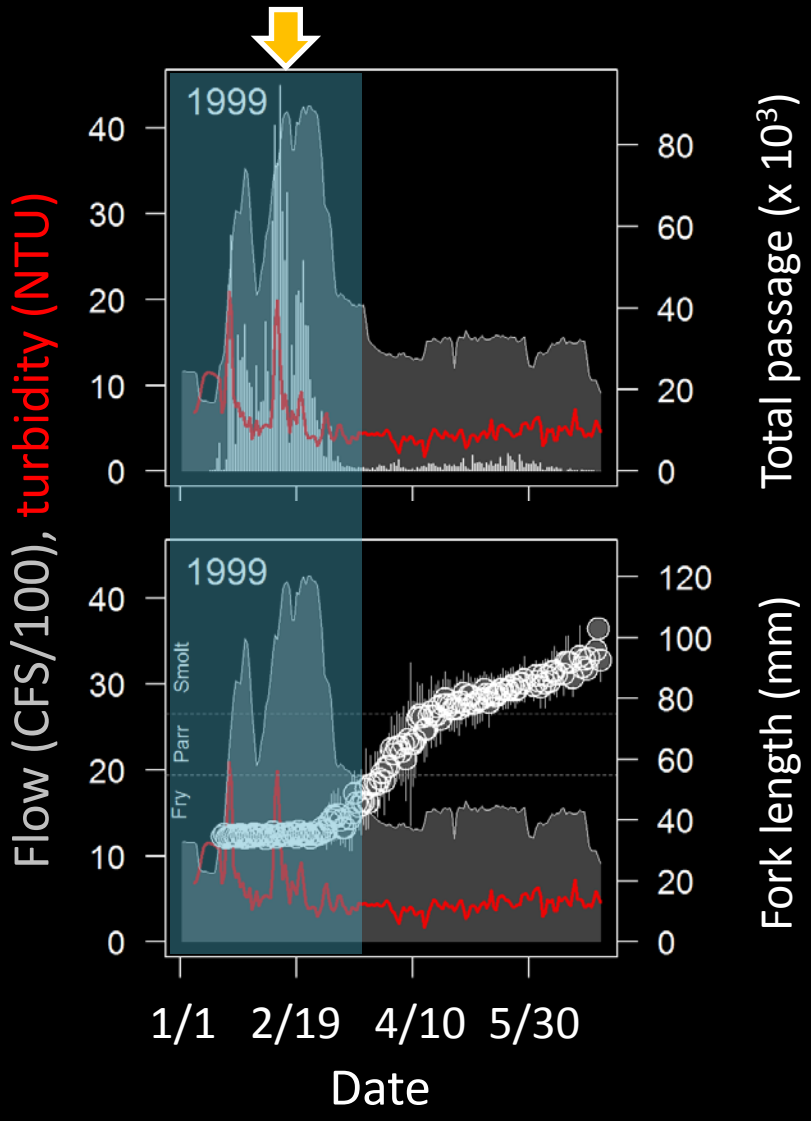
1. Juvenile outmigration (Jan-Jun)

ROTARY SCREW TRAP
(N, timing, size)

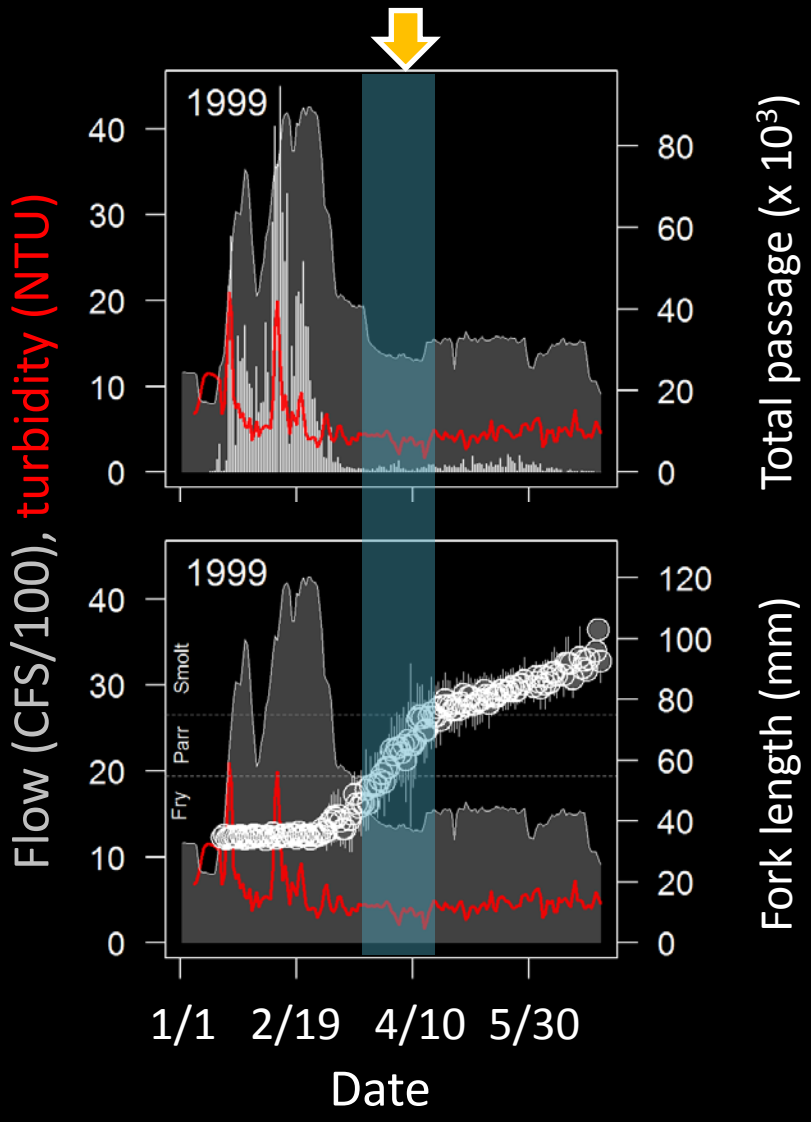
CRAMER FISH SCIENCES®
Oregon • California • Washington • Idaho • Alaska



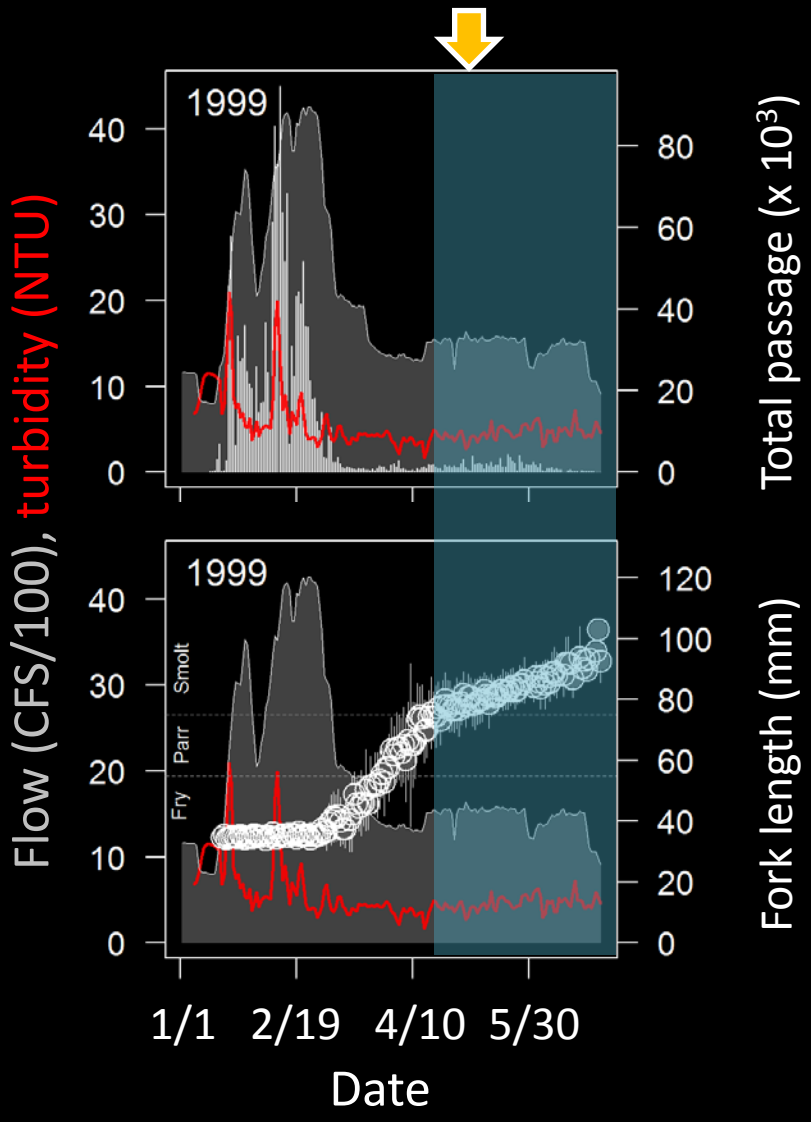
1. Juvenile outmigration (Jan-Jun)



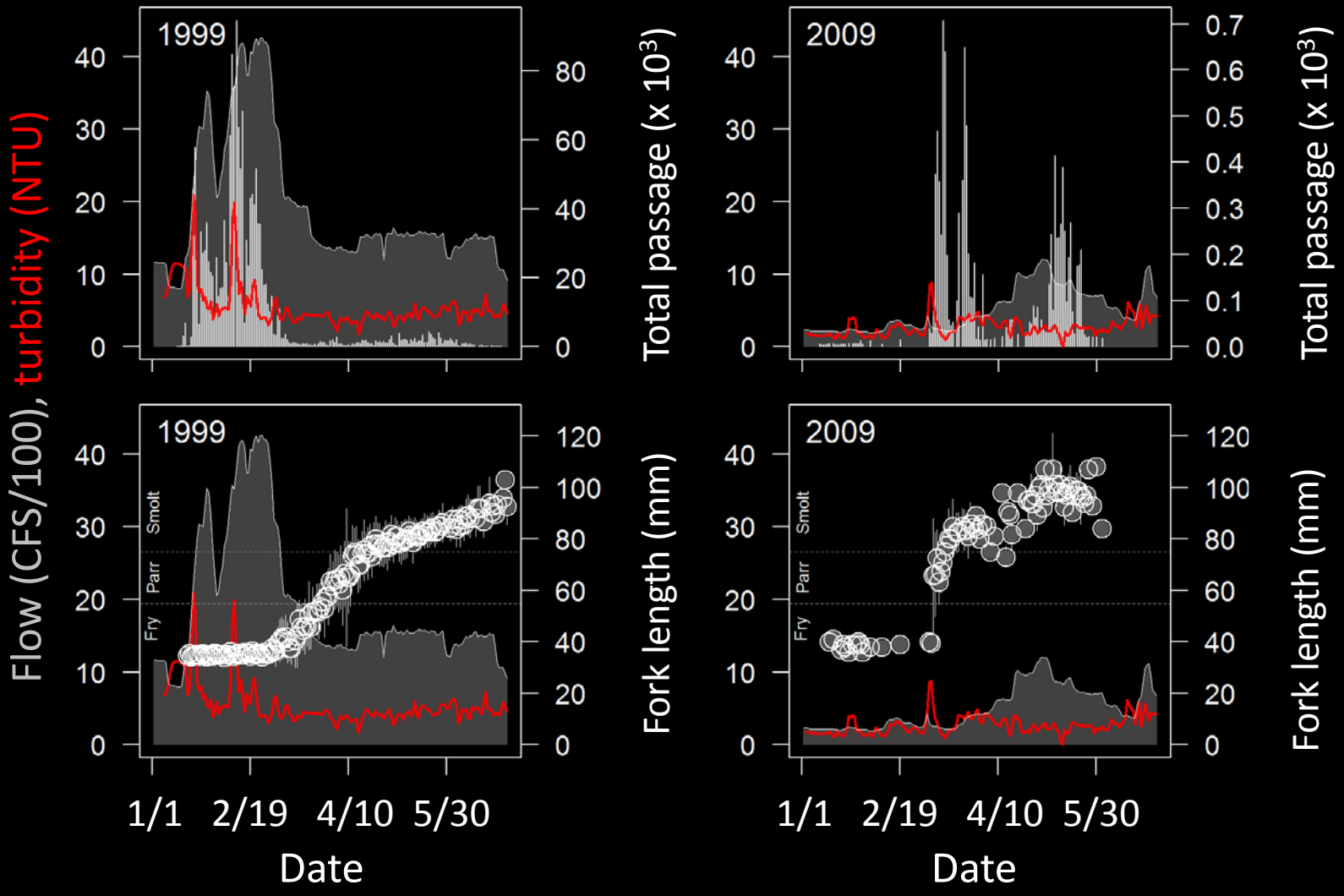
1. Juvenile outmigration (Jan-Jun)



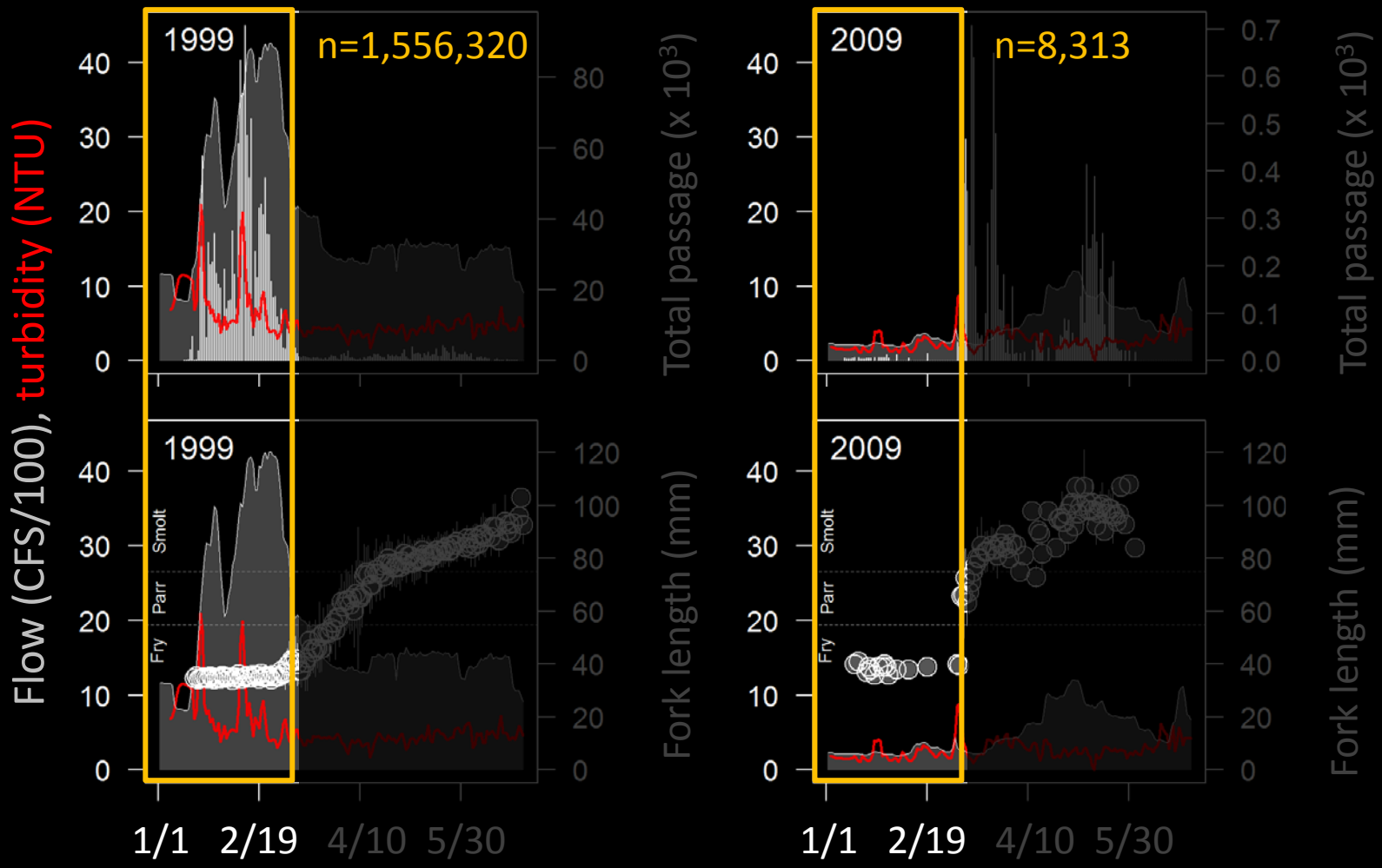
1. Juvenile outmigration (Jan-Jun)



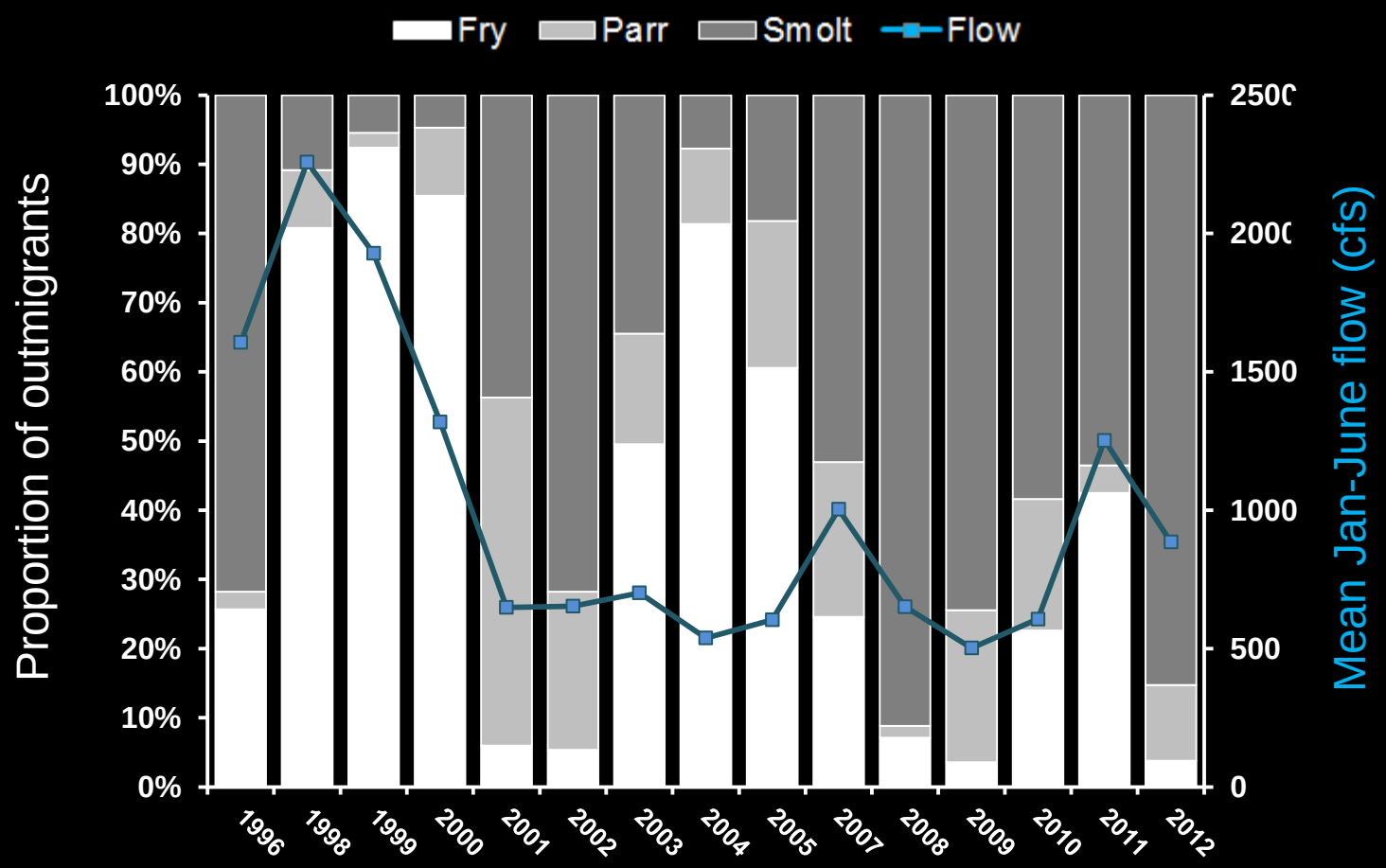
1. Juvenile outmigration (Jan-Jun)



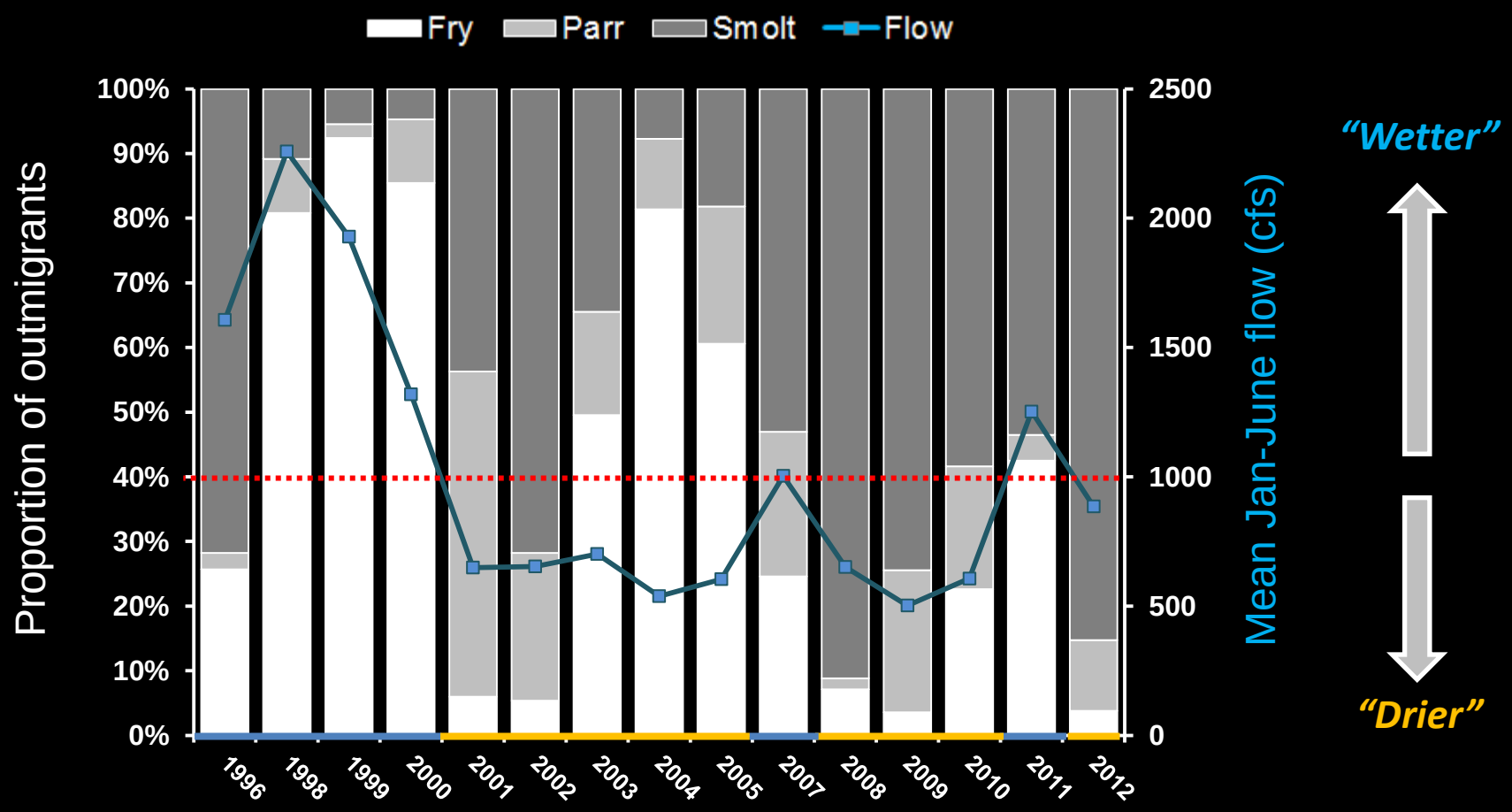
1. Juvenile outmigration (Jan-Jun)



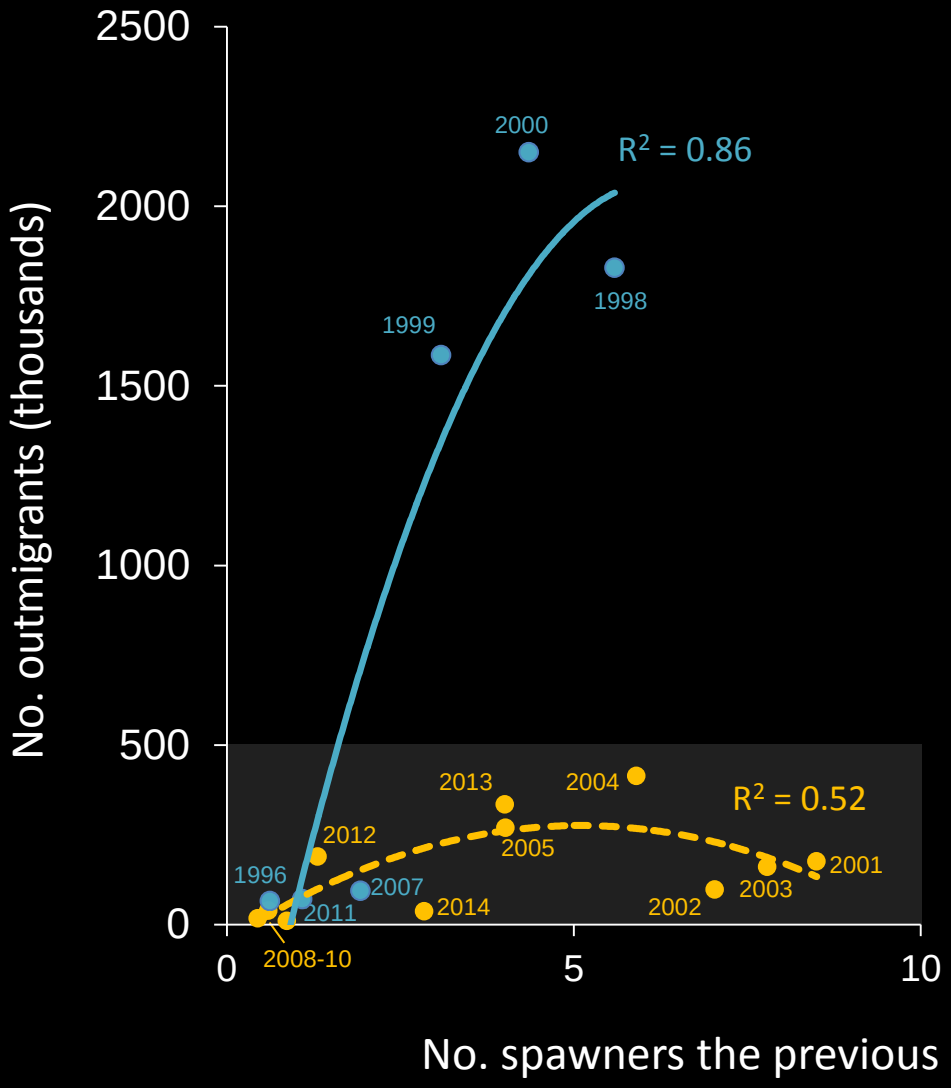
1. Juvenile outmigration (Jan-Jun)



1. Juvenile outmigration (Jan-Jun)



1. Juvenile outmigration (Jan-Jun)

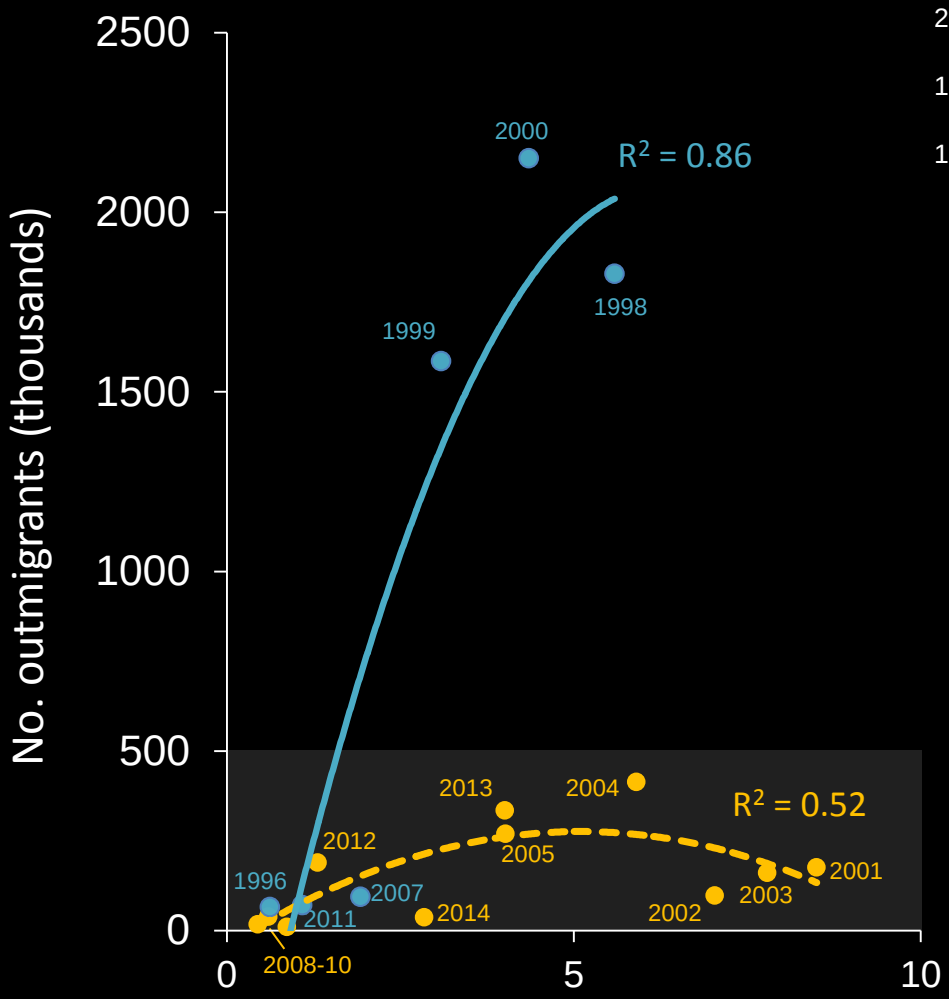


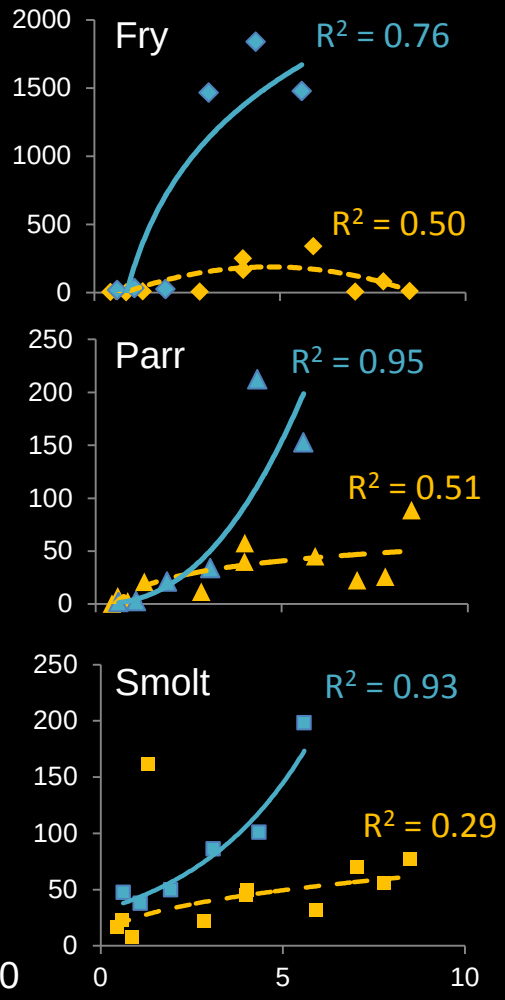
Wetter years produce more juveniles per spawner than drier years.

Lower carrying capacity and less migration in drier years

increased density dependent mortality.

1. Juvenile outmigration (Jan-Jun)





No. spawners the previous fall (thousands)

Wetter years produce more juveniles per spawner than drier years.

Lower carrying capacity and less migration in drier years

increased density dependent mortality.

2. Who survives? (Adult returns Oct-Dec 2-4 yrs later)

Carcass survey *(CDFW)*

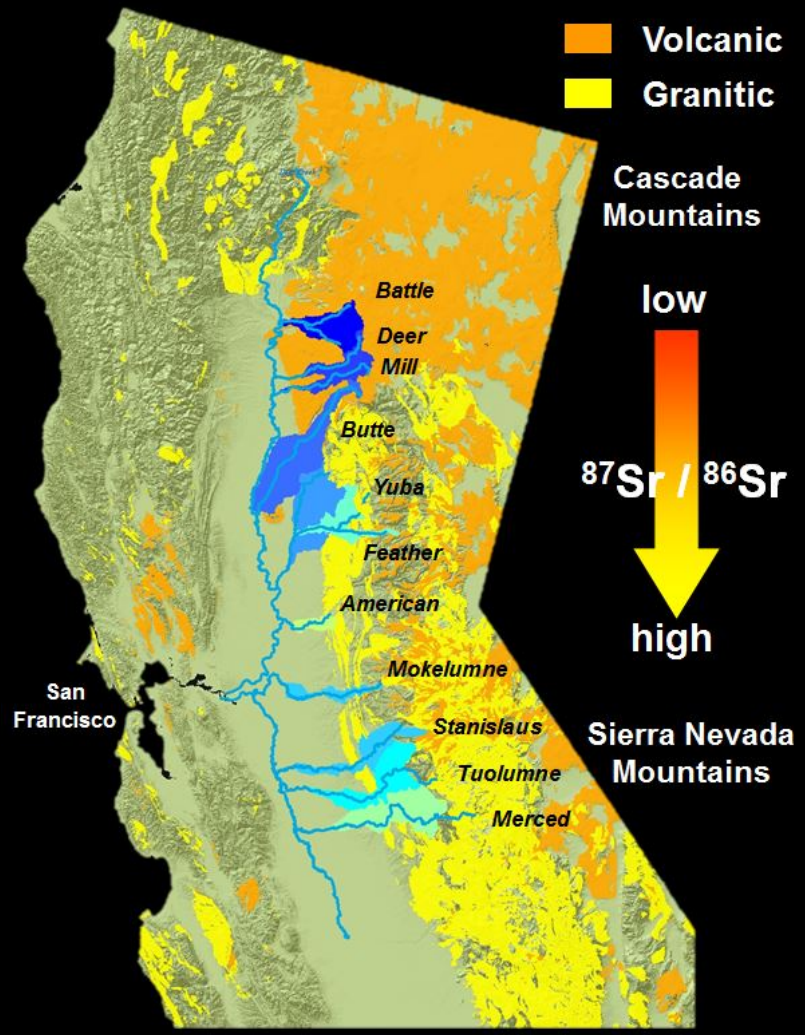
Scales *(age, cohort)*

Otoliths *(origin, size)*

Mark-recapture *(abundance)*

2. Who survives?

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

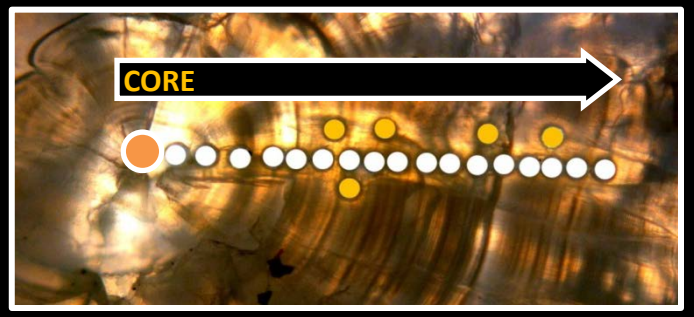


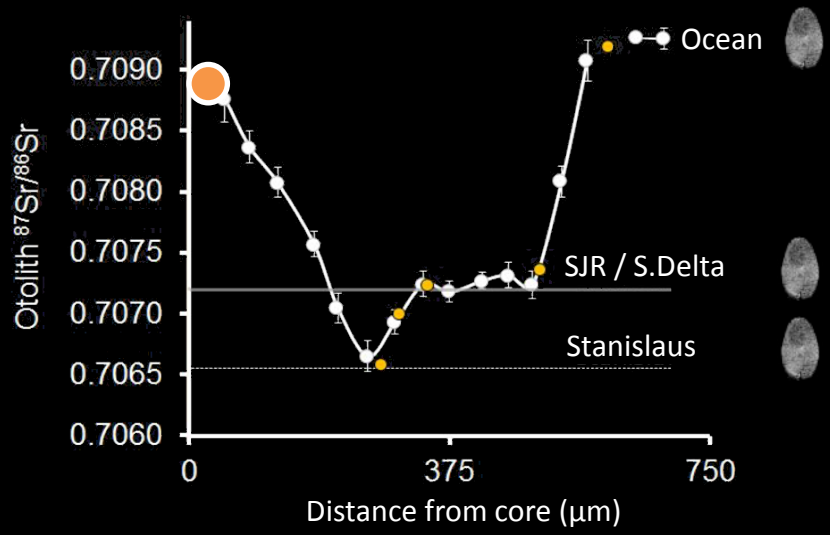
2. Who survives?

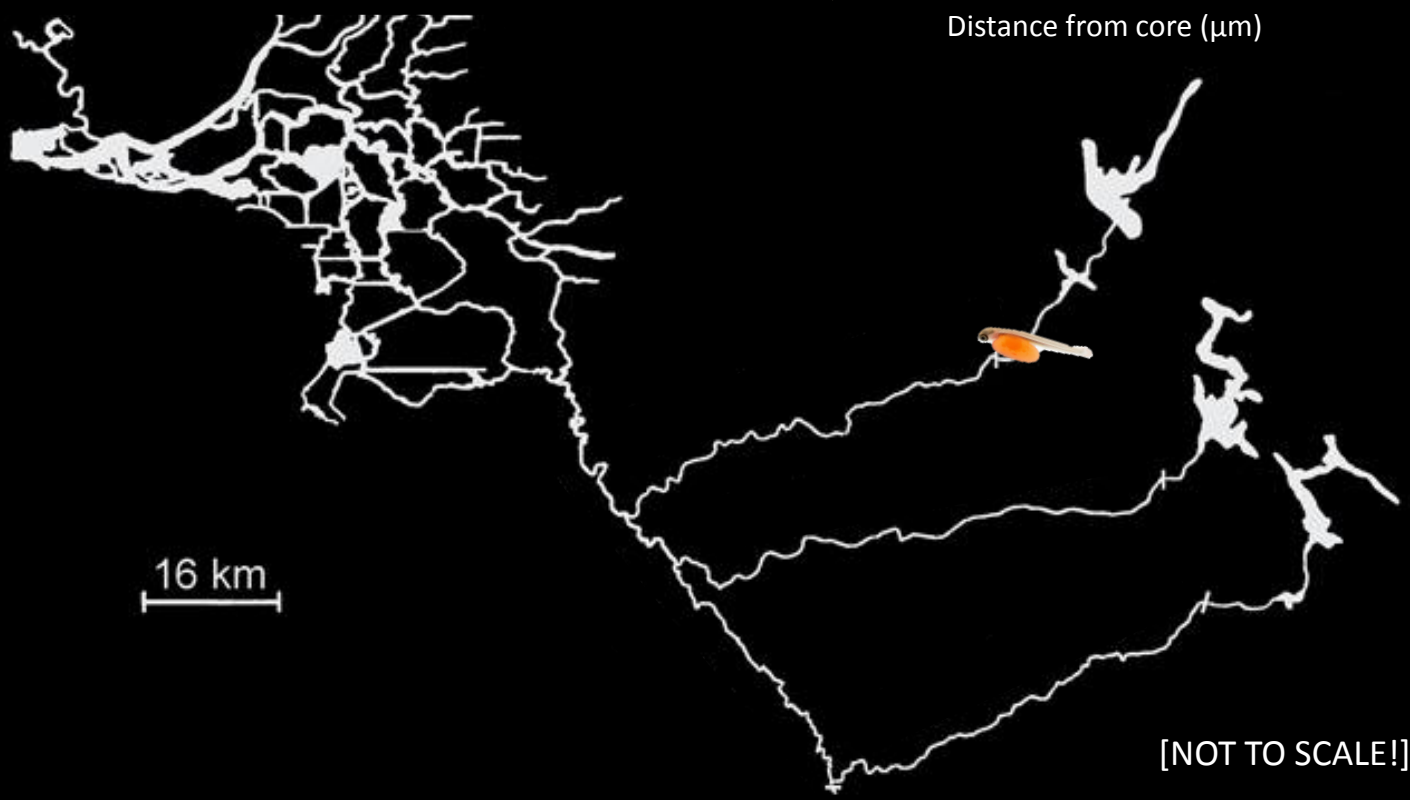
UC DAVIS
UNIVERSITY OF CALIFORNIA

LASER ABLATION MULTI COLLECTOR INDUCTIVELY COUPLED PLASMA MASS SPECTROMETER (LA-MC-ICPMS)

2. Who survives?

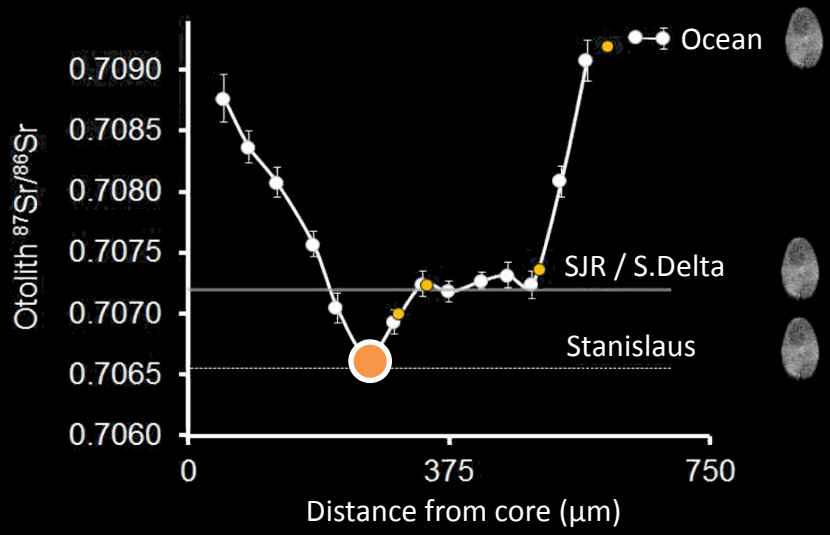


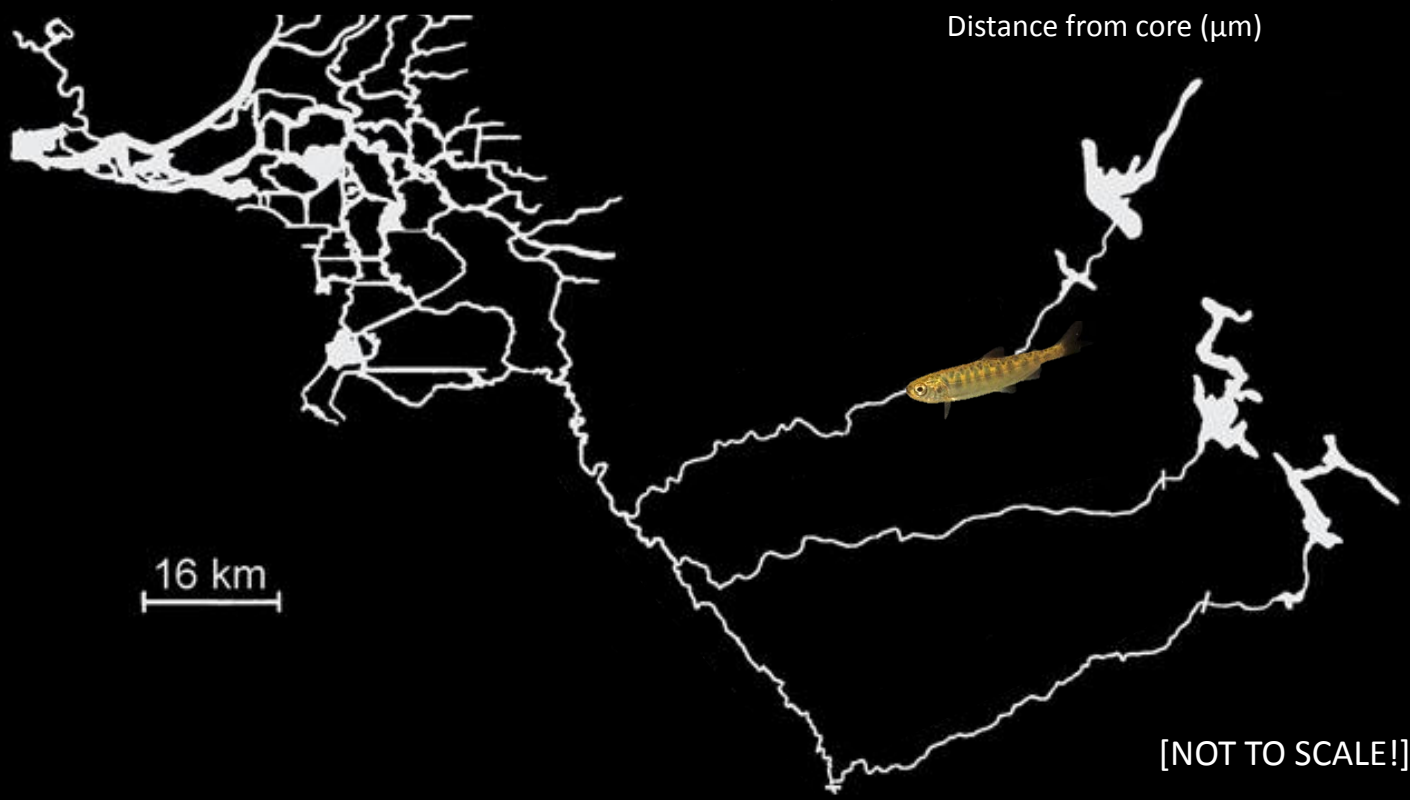




[NOT TO SCALE!]

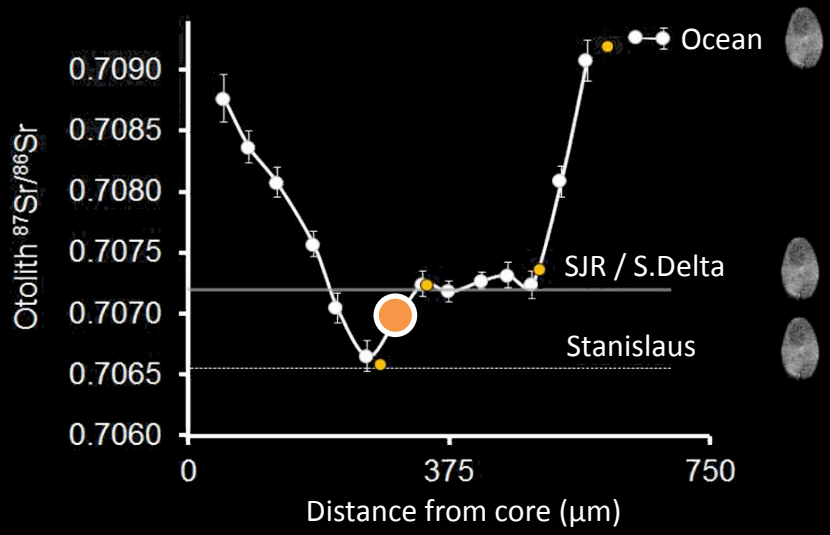
2. Who survives?

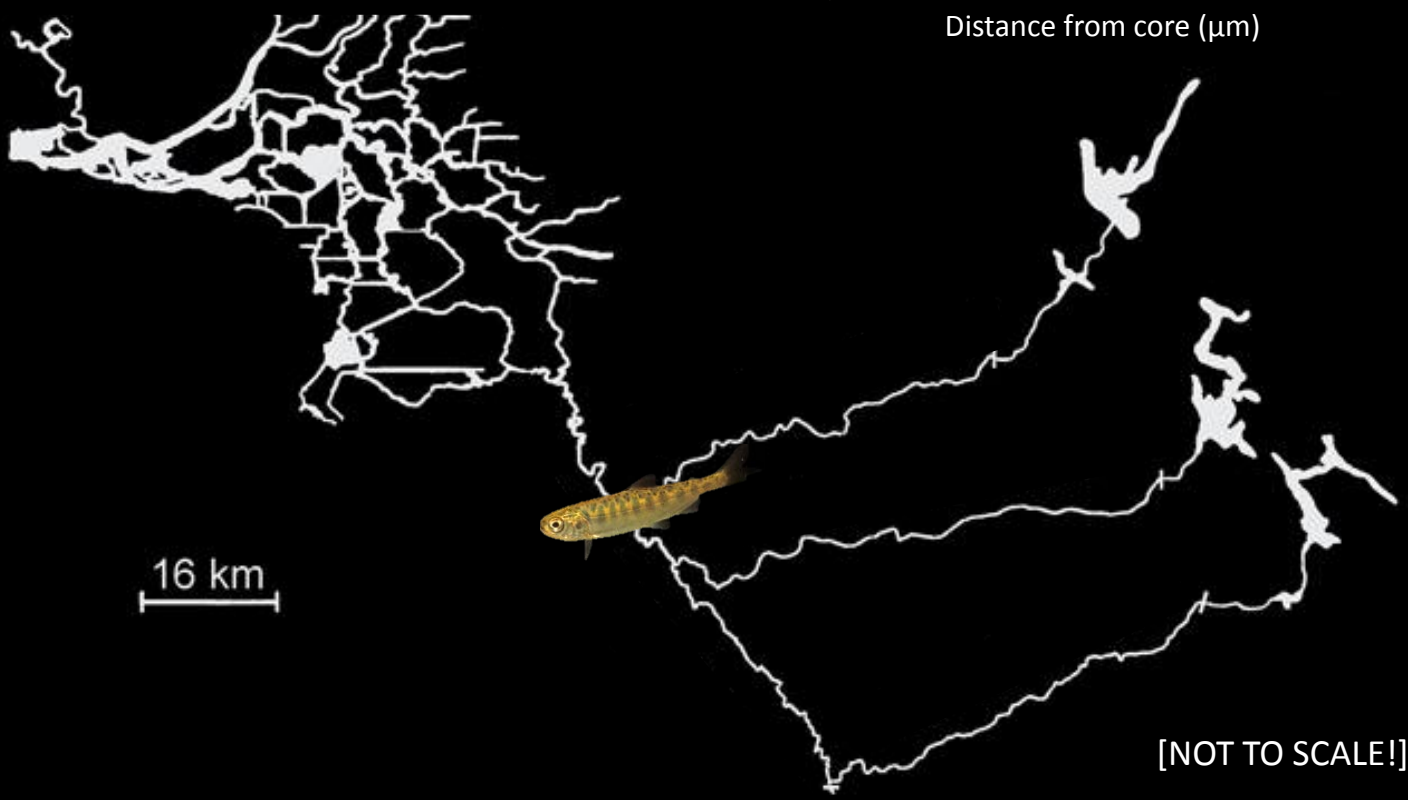




[NOT TO SCALE!]

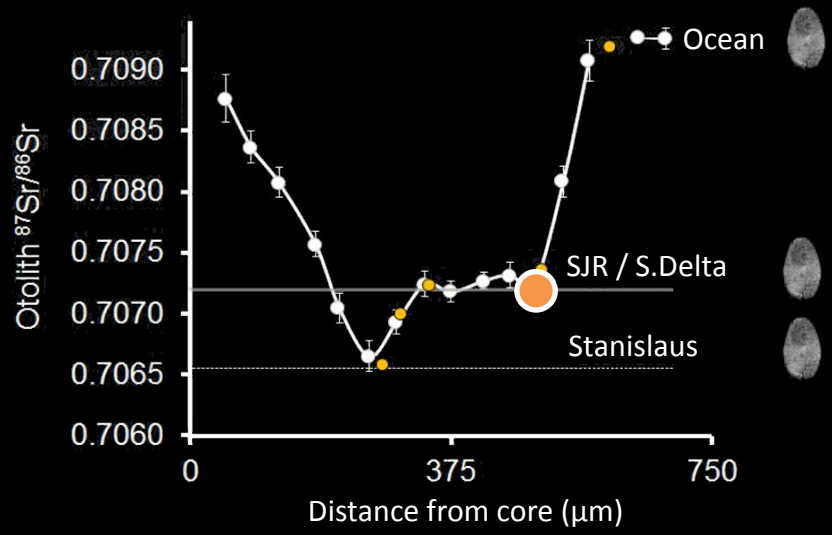
2. Who survives?

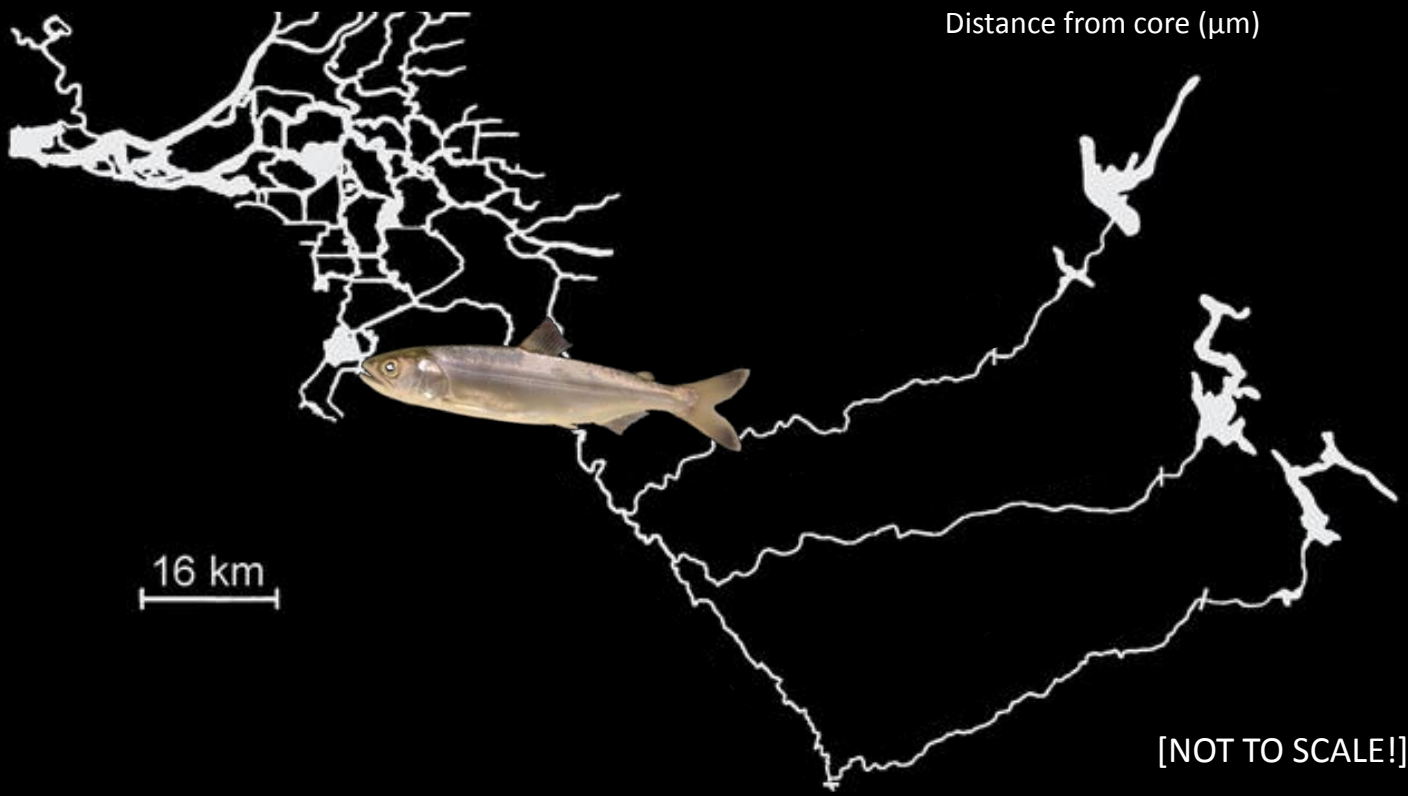




[NOT TO SCALE!]

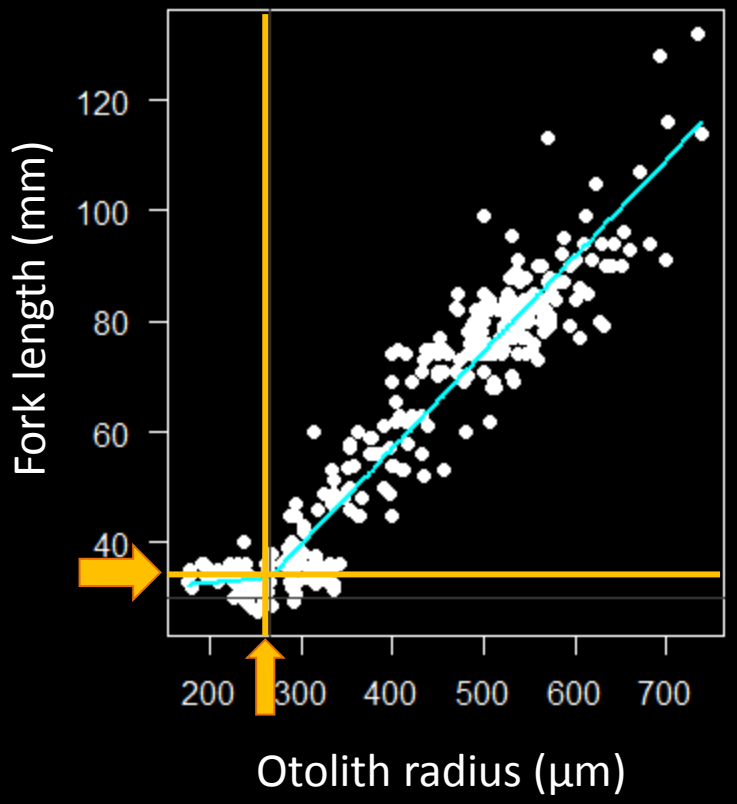
2. Who survives?



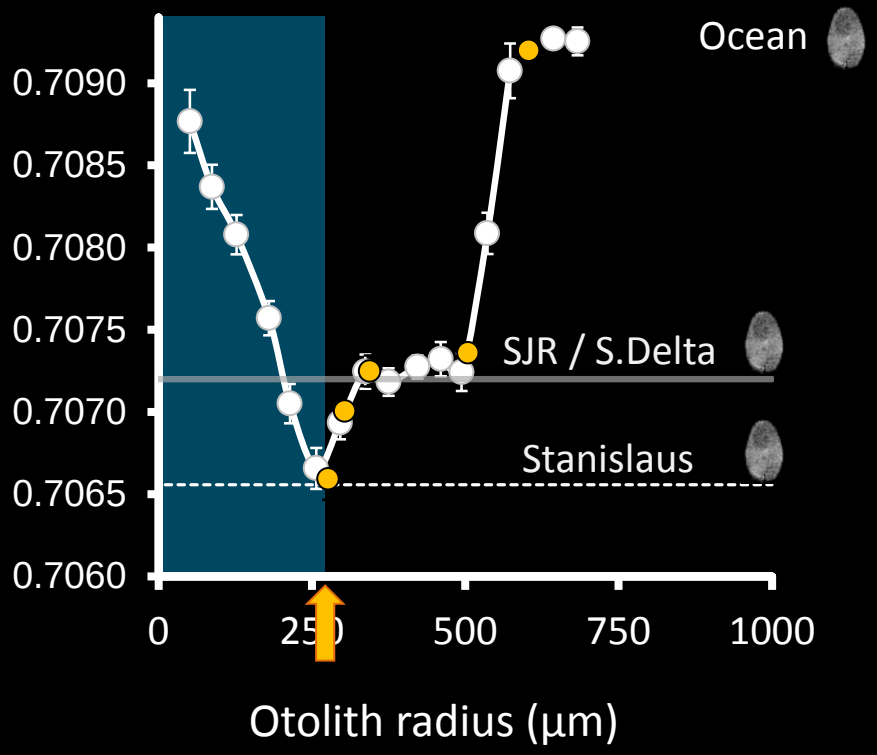


[NOT TO SCALE!]

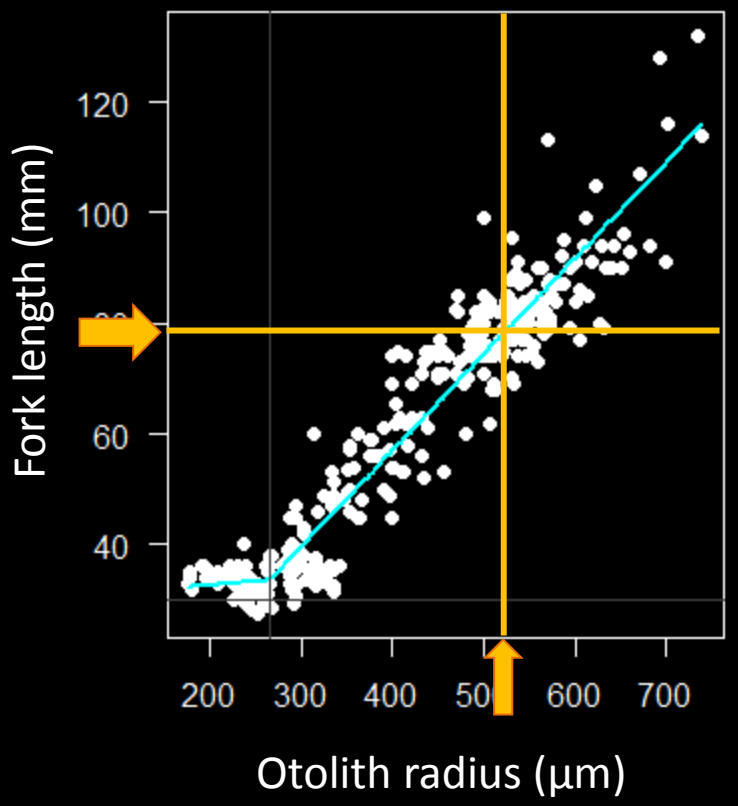
2. Who survives?



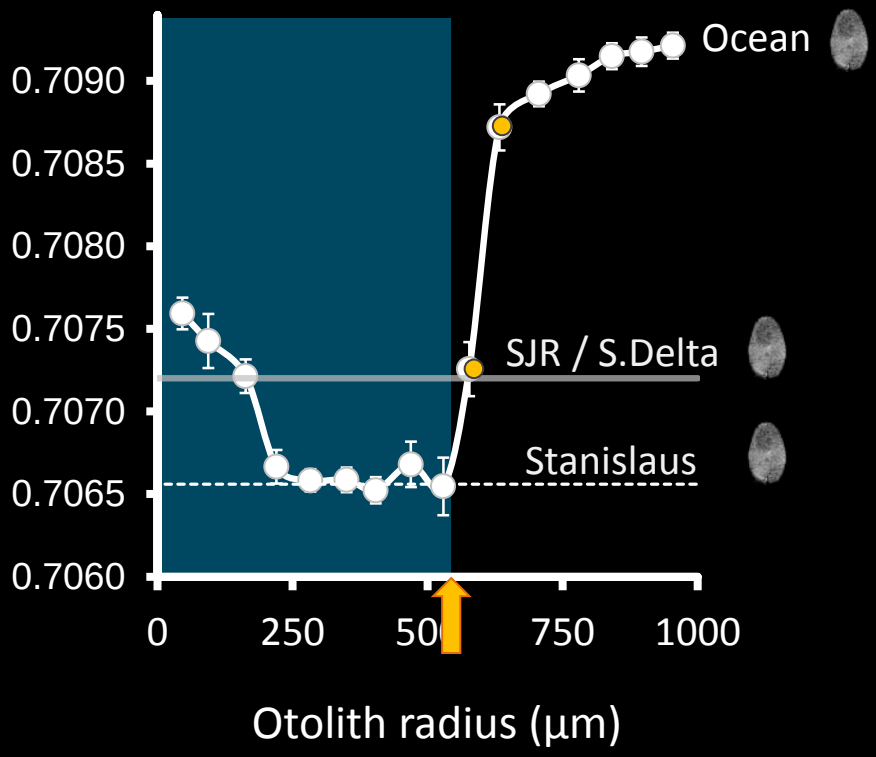
FRY OUTMIGRANT



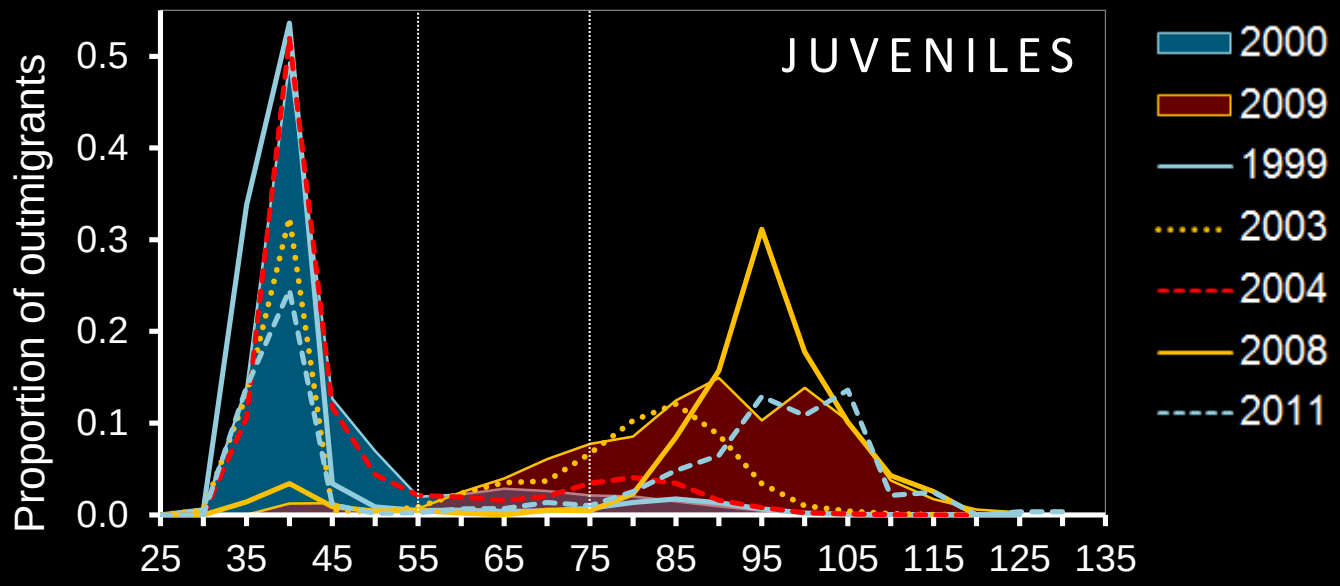
2. Who survives?



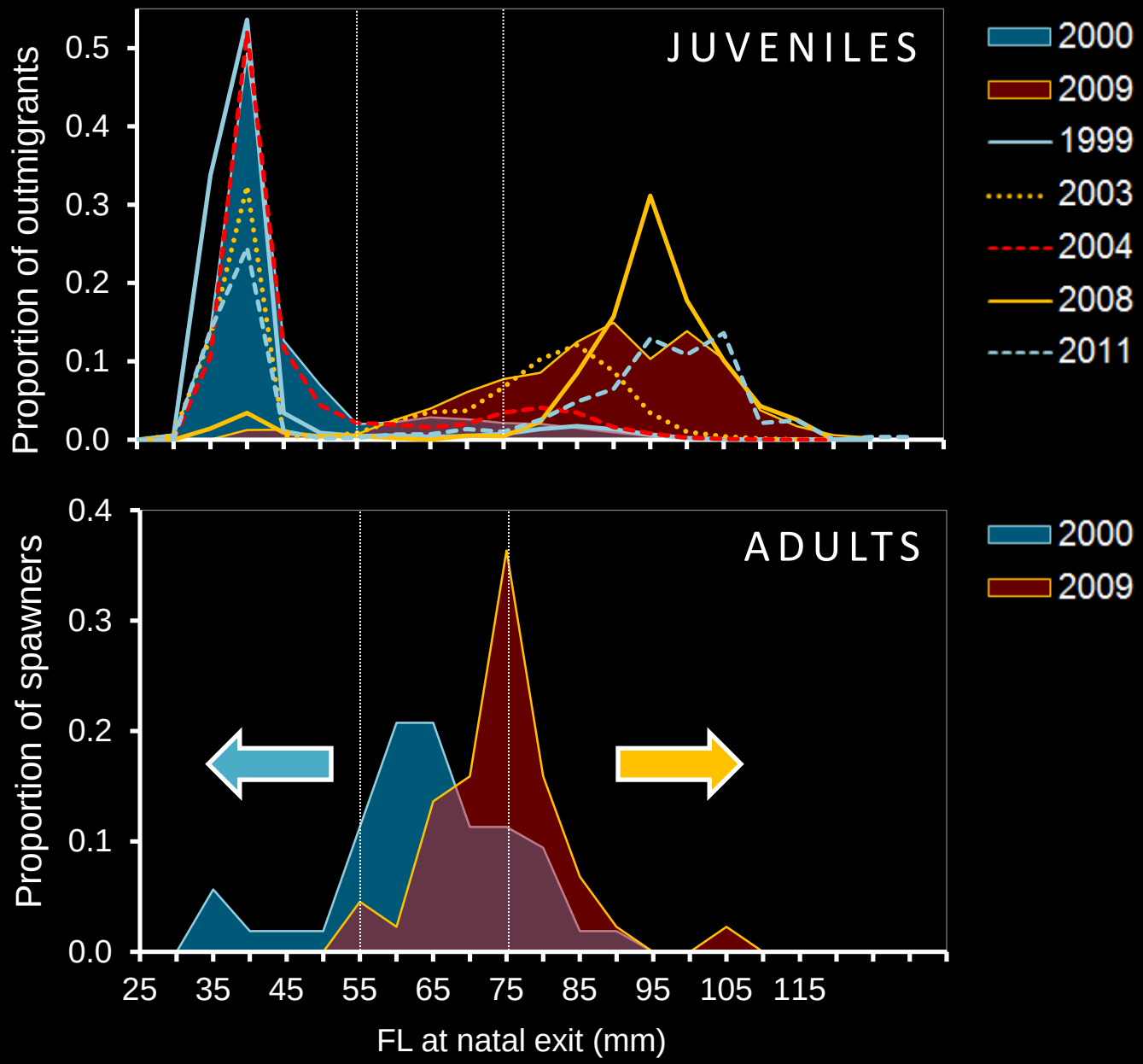
SMOLT OUTMIGRANT



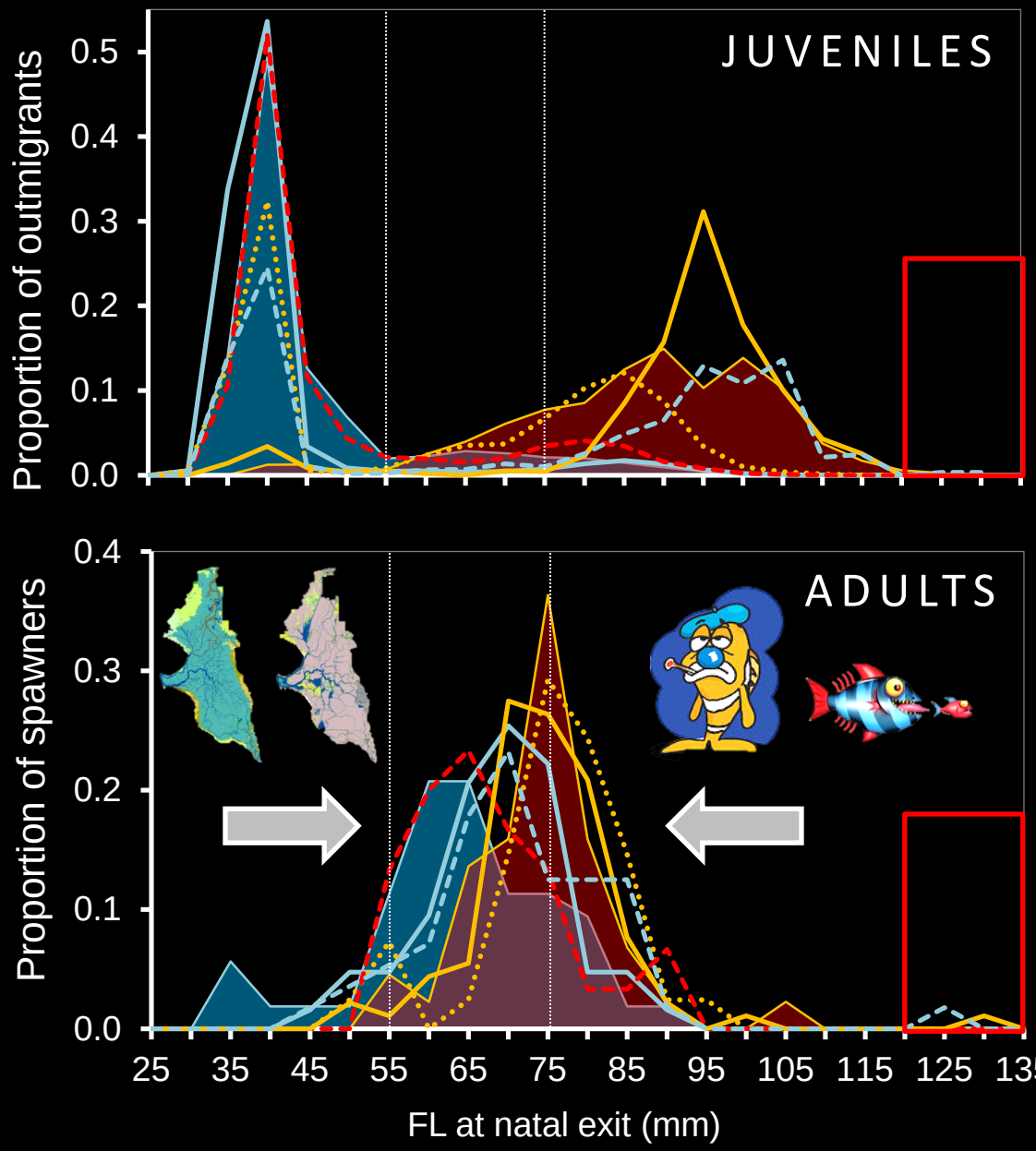
2. Who survives?



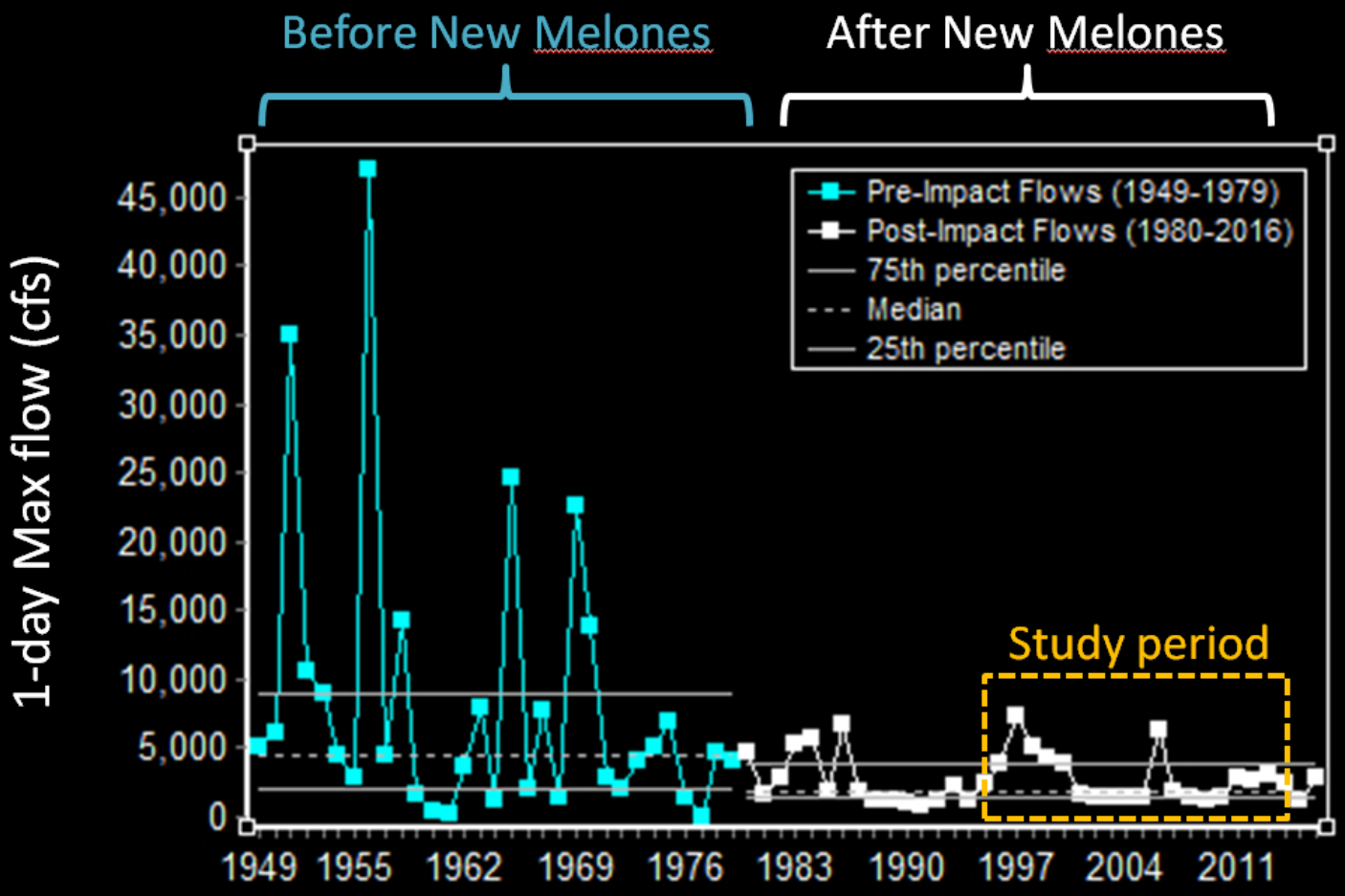
2. Who survives?



2. Who survives?



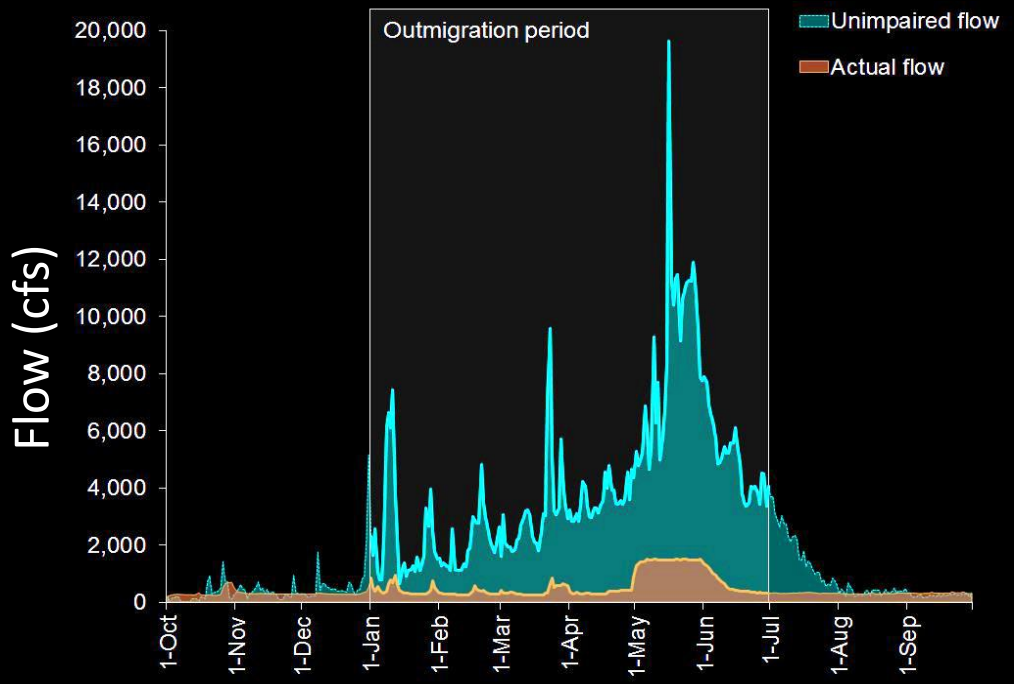
Environmental considerations



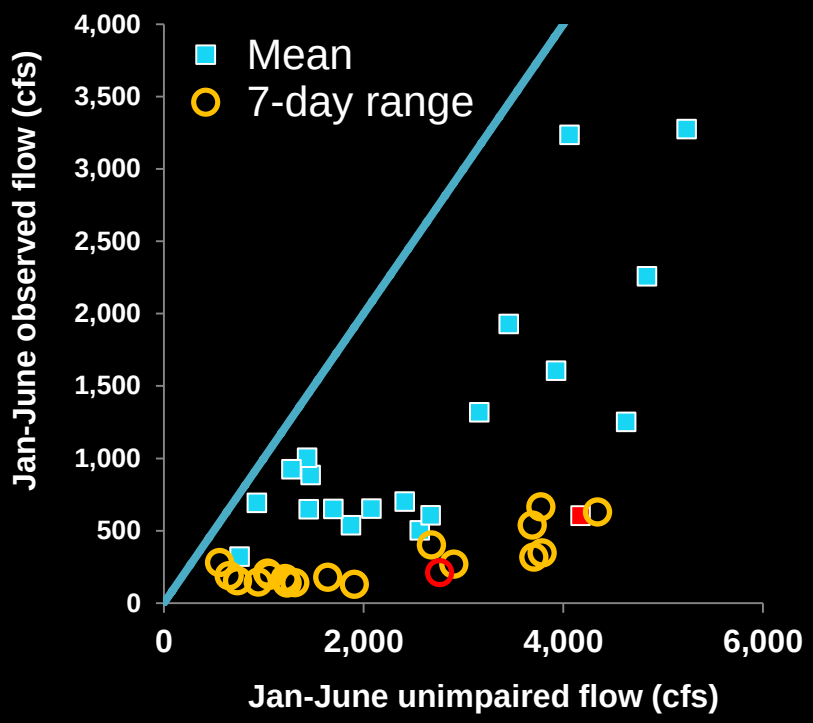
Reduced flow magnitude & variance

Environmental considerations

2005 (observed vs. unimpaired flow)

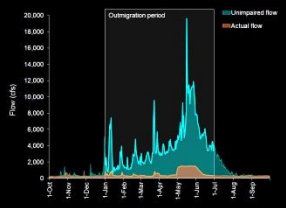


1996-2014 study period



Reduced flow magnitude & variance

Environmental considerations



Flow magnitude & variance

DECREASED

Reduced instream carrying capacity
(less habitat, warmer temps)
Fewer migration cues

Increased density dependent mortality (FEWER FISH)

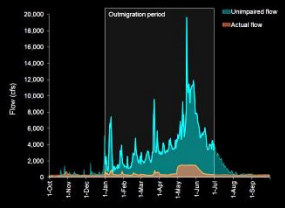
Reduced life history diversity
- Fewer migration events
- Narrower window
- Fewer rearing habitats
(LESS RESILIENT)

INCREASED

Increased instream carrying capacity
(more habitat, cooler temps)
More frequent migration cues

MORE FISH
MORE RESILIENCE

Environmental considerations



Flow magnitude & variance

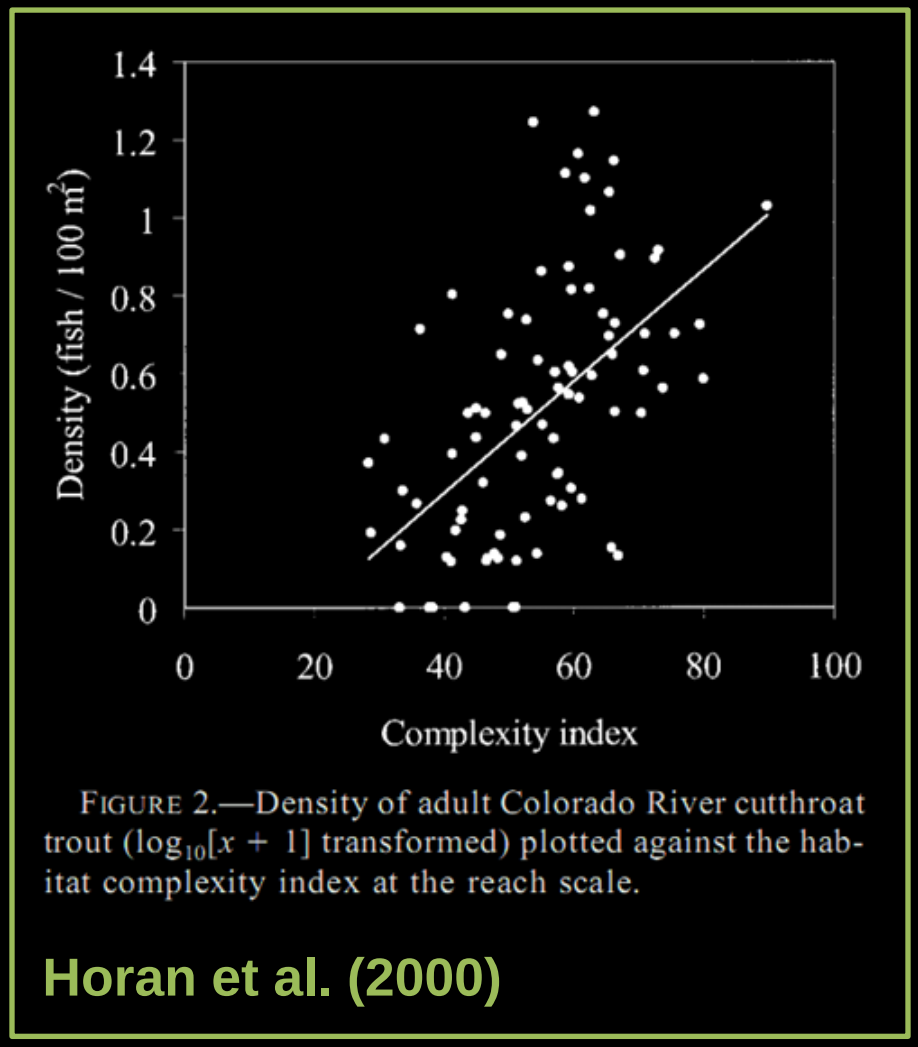


FIGURE 2.—Density of adult Colorado River cutthroat trout ($\log_{10}[x + 1]$ transformed) plotted against the habitat complexity index at the reach scale.

Horan et al. (2000)

INCREASED

Increased instream carrying capacity
(more habitat, cooler temps)
More frequent migration cues

MORE FISH
MORE RESILIENCE
(particularly when paired with habitat restoration)

3 KEY MESSAGES

1. While contributions vary among years, **all juvenile life history strategies are viable**. i.e. Life history diversity is key to resilience.

2. Early dispersers can survive, but require flow cues in Jan-March. Their survival would likely be improved with increased flow and habitat in the San Joaquin River & south Delta.

3. Increased flow magnitude and variability increase juvenile salmon survival (**abundance**) and life history diversity (**resilience**).

Acknowledgements

George Whitman, Justin Glessner, Mike Miller (**UC Davis**)

Alan Hubbard (**UC Berkeley**)

Peter Weber (**Lawrence Livermore National Laboratory**)

Carl Mesick, Doug Threloff (**USFWS**)

USFWS Comprehensive Assessment and Monitoring Program provided the RST data.

Gretchen Murphy, Crystal Sinclair, Shelly Schubert, Dom Giudice and all the scale readers and carcass survey teams at **CDFW**

Travis Hinkelman, Clark Watry, Steve Zeug and all the RST operators at **CFS**.

Jason Wyman (**14 Black Poppies**) for his wonderful salmon graphic.

Funding was provided by the Delta Science Fellowship Program, CDFW (Water Quality, Supply, & Infrastructure Improvement Act of 2014, CWC §79707[g]), & USBR (Agreement R09AC20043)

asturrock@ucdavis.edu