# Otolith Chemistry Reveals the Diverse Rearing Habitats of Winter-Run Chinook Salmon

Corey Phillis, Metropolitan Water District
Anna Sturrock, U.C. Davis
Rachel Johnson, NOAA Fisheries
Peter Weber, Lawrence Livermore National Laboratory

# *10-year winter-run otolith study spanning hydroclimatic regimes*

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| BOR | |
| 2015 | |

| BY | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

| Return year | 2007 | 2008 | 2009 | 2012 | 2013 | 2014 | 2016 | 2017 | 2018 |
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| Funder | CALFED | | | IEP | | | ? | | |

Otolith Chemistry Reveals the Diverse Rearing Habitats of Winter-Run Chinook Salmon
*Corey Phillis, MWD*

Where They Go and How They Grow: Using Otoliths to Reconstruct Habitat-Specific Growth Patterns for Endangered Winter-Run Chinook
*Maya Friedman,* UC Santa Cruz*

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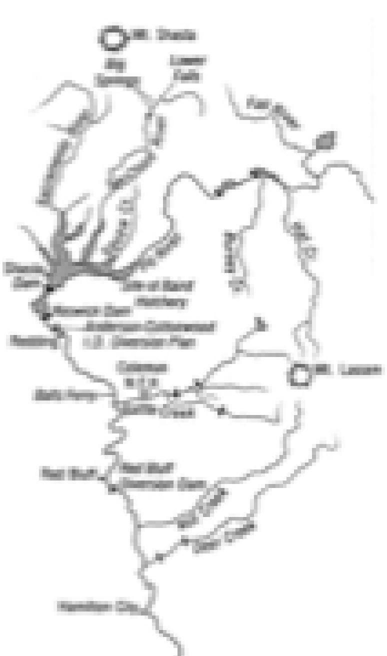

IEP salmon synthesis SAIL team recommendation:
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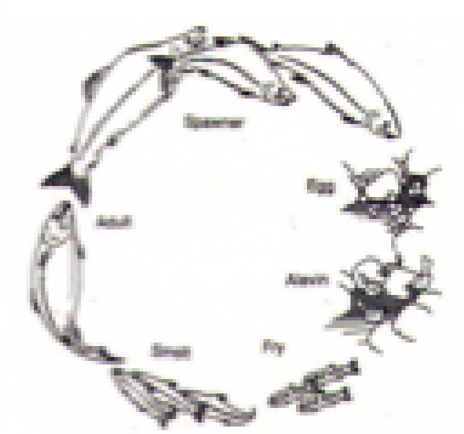

# *3 Research questions*

1. Where do the successful winter-run rear as juveniles?

2. Are both fry and parr migrants represented in the adult population (based on otolith size)?

   - Where do fry rear?

3. Are there differences in size at freshwater exit associated with juvenile rearing habitat?

   - Or escapement year?

# *Q1: Where do the successful winter-run rear as juveniles?*

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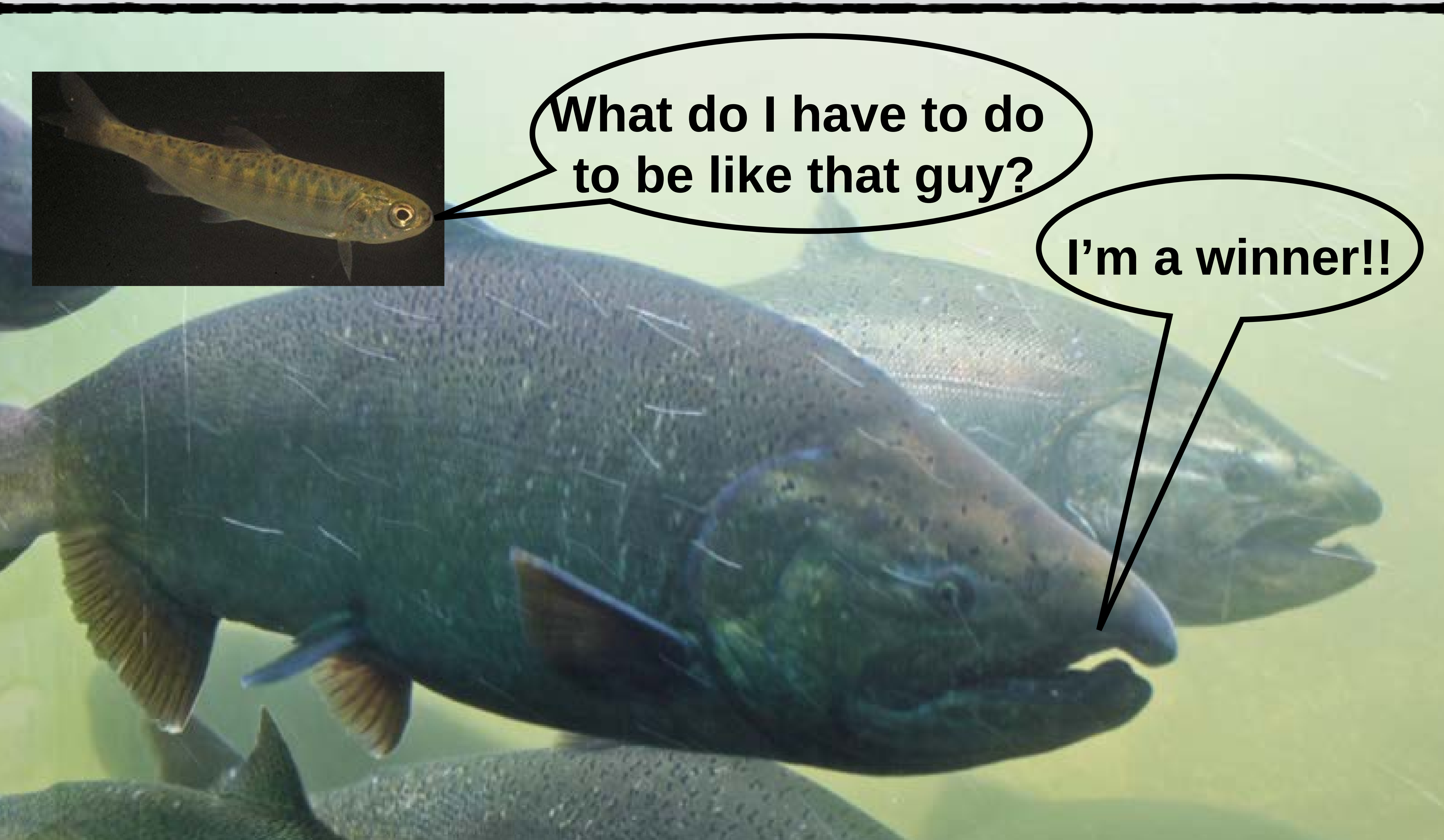


# *Our conceptual models assume juvenile rear in the Sacramento and Delta*

## Narrative model

**DEPARTMENT OF COMMERCE**

**National Oceanic and Atmospheric Administration**

**50 CFR Part 226**

**[Docket No. 920783–3085]**

**Designated Critical Habitat; Sacramento River Winter-Run Chinook Salmon**

**AGENCY:** National Marine Fisheries Service (NMFS), NOAA, Commerce.

**ACTION:** Final rule.

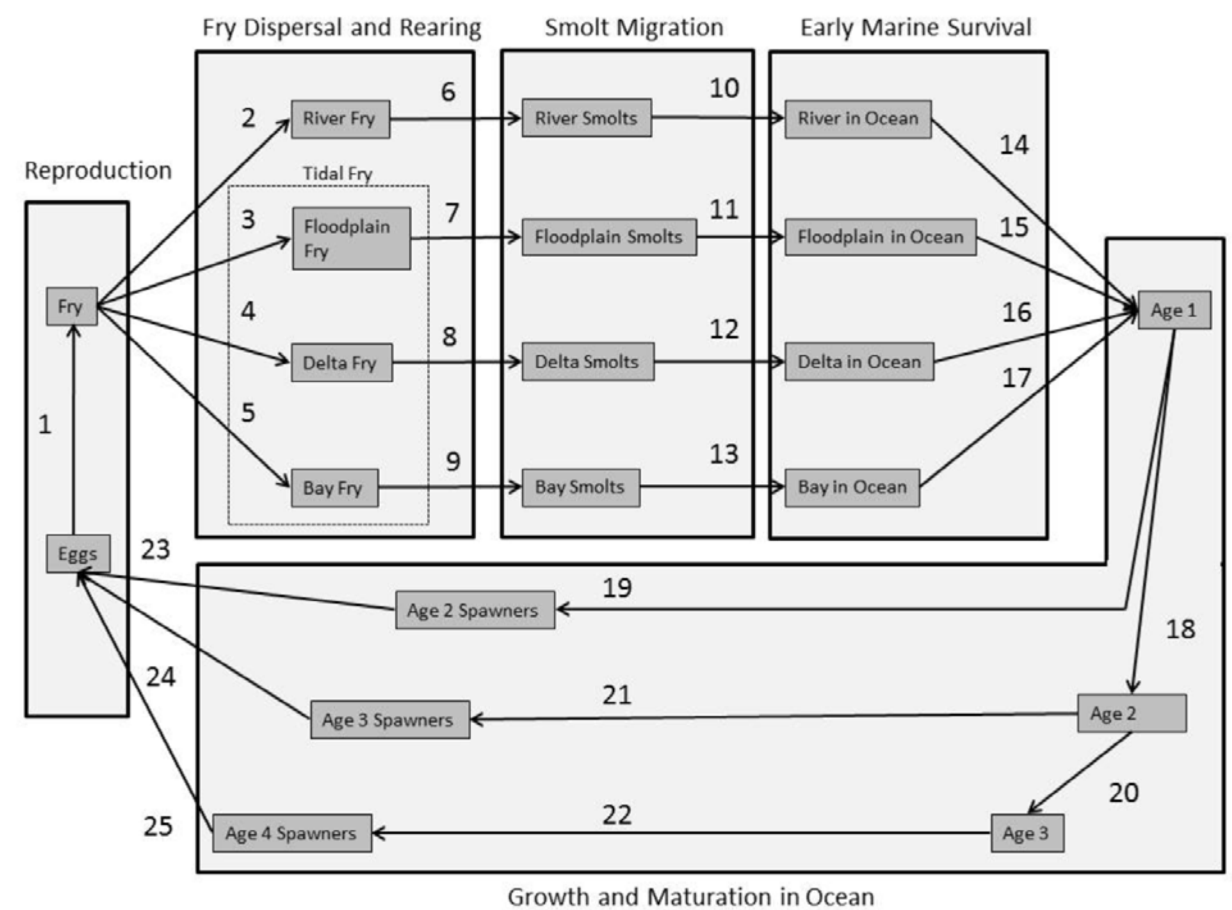
**SUMMARY:** NMFS is designating critical habitat for the Sacramento River winter-run chinook salmon (*Oncorhynchus tshawytscha*) pursuant to the Endangered Species Act (ESA). The habitat for designation includes: The Sacramento River from Keswick Dam, Shasta County (River Mile 302) to Chipps Island (River Mile 0) at the westward margin of the Sacramento-San Joaquin Delta; all waters from Chipps Island westward to Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and Carquinez Strait; all

*Federal Register Vol. 58, No.114: Designation of ESA critical habitat for Sacramento River winter-run Chinook, 6/16/1993*

## Life-Cycle Model

**The Chinook Salmon Life Cycle Model**

The life cycle model is a stage-structured, stochastic life cycle model. Stages are defined by development and geography (Figure 1), and each stage transition is assigned a unique number (Figure 4).

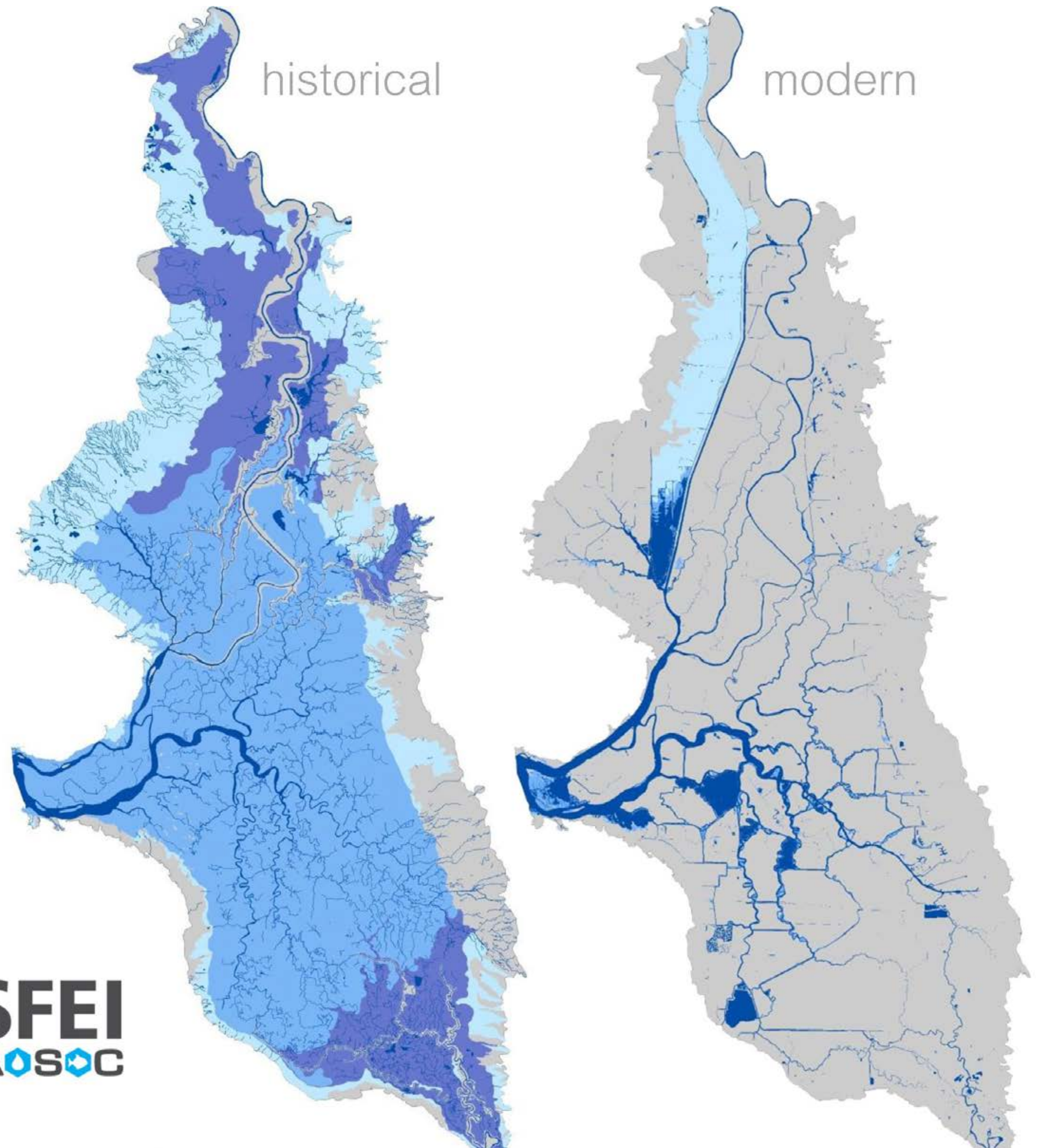



*Hendrix et al., Life cycle monitoring framework for Sacramento River winter-run Chinook salmon, 2014*

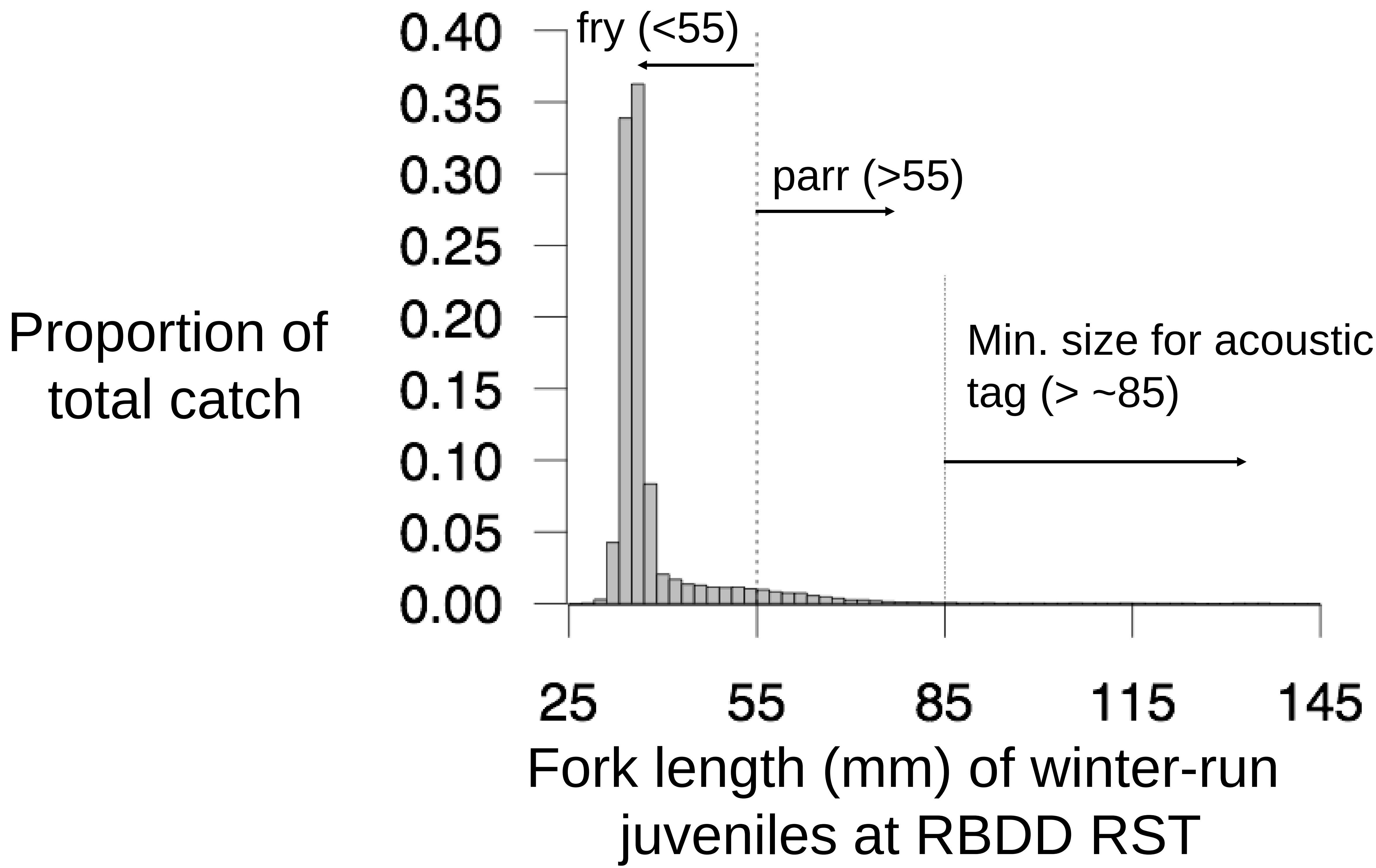
# *Q1: Where do the successful winter-run rear as juveniles?*

Is rearing in the Delta a viable strategy?

And if not the Delta, where?



# *Most juveniles begin moving downstream as fry*



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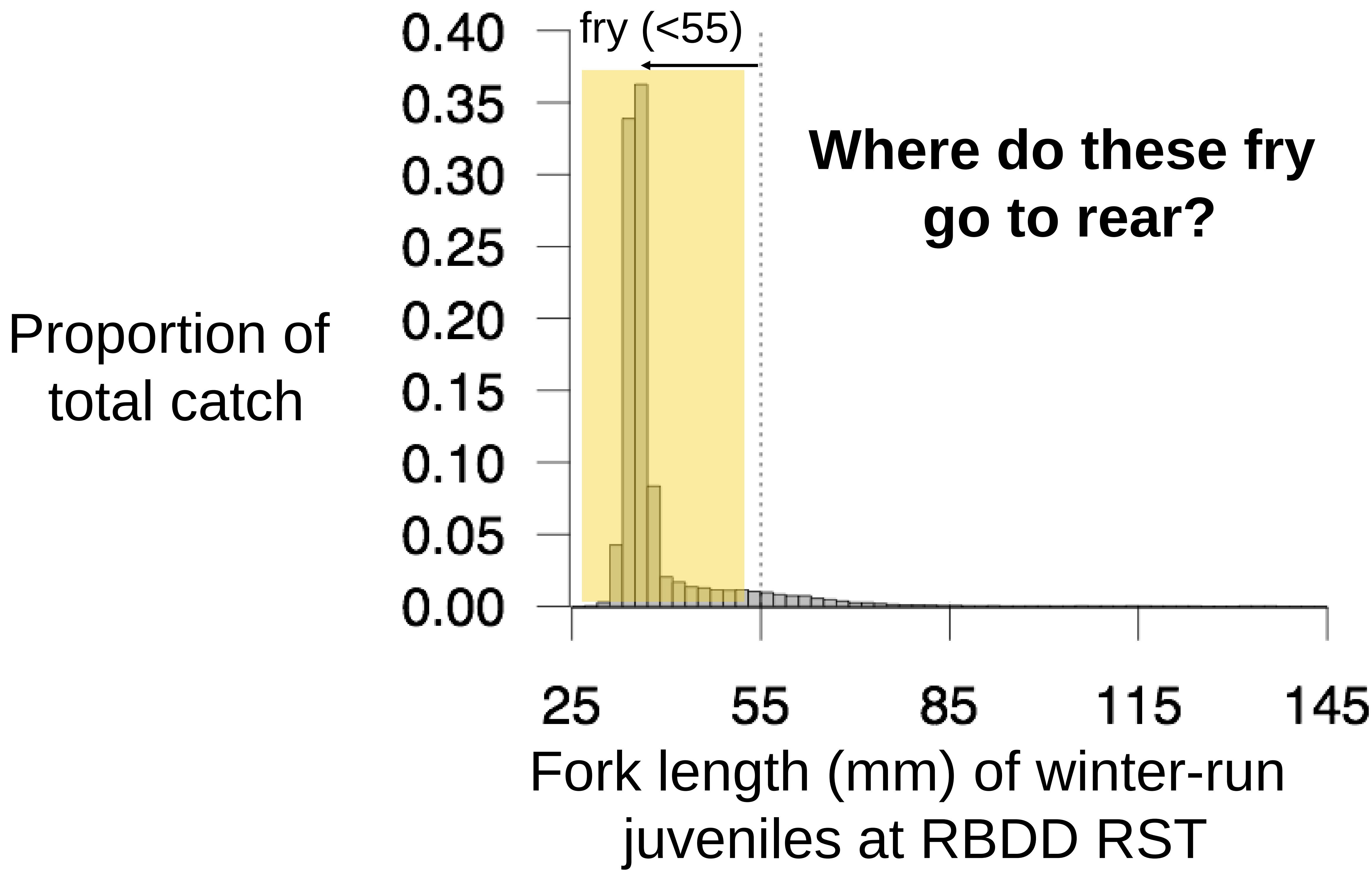


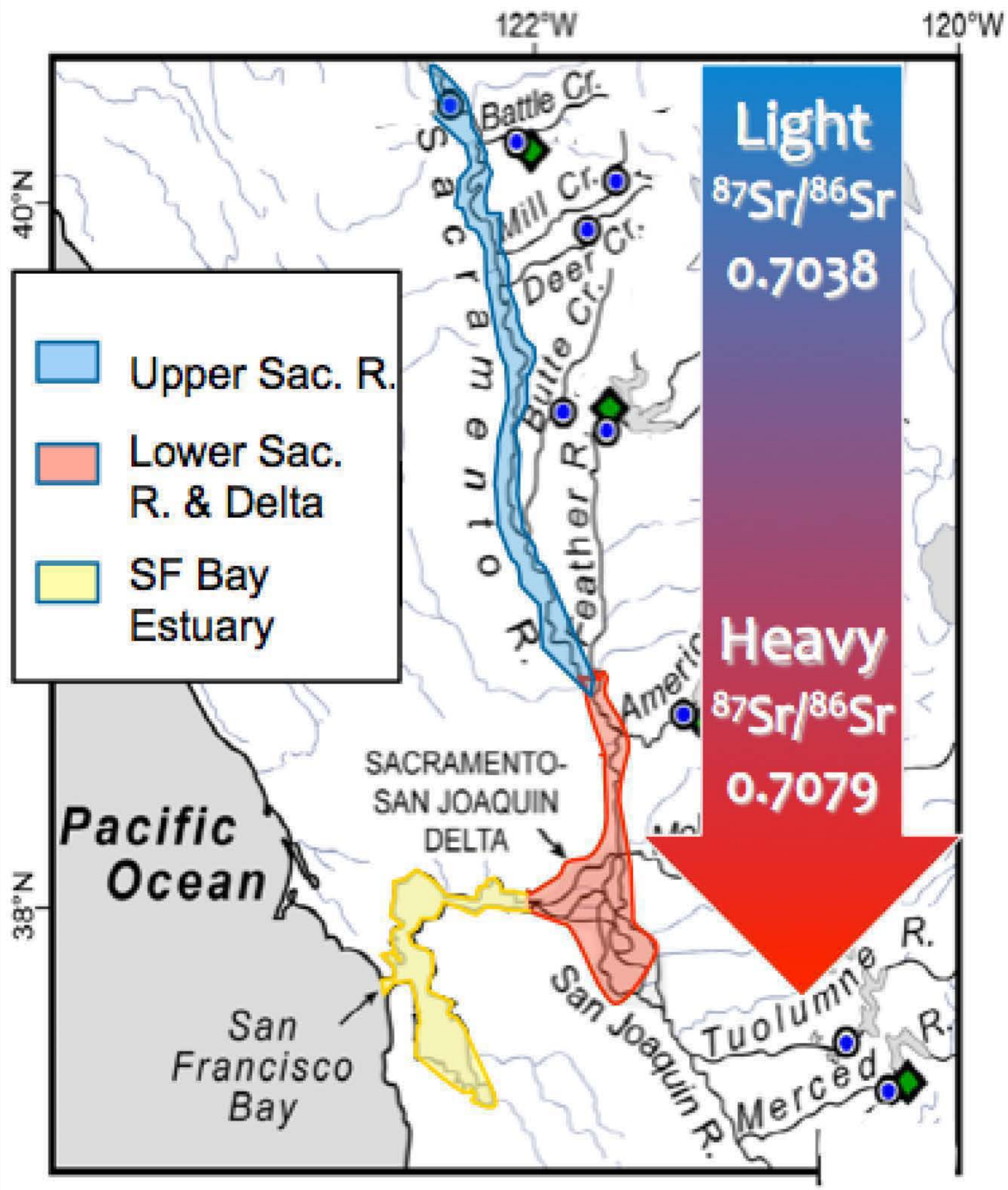

**Where do these fry go to rear?**

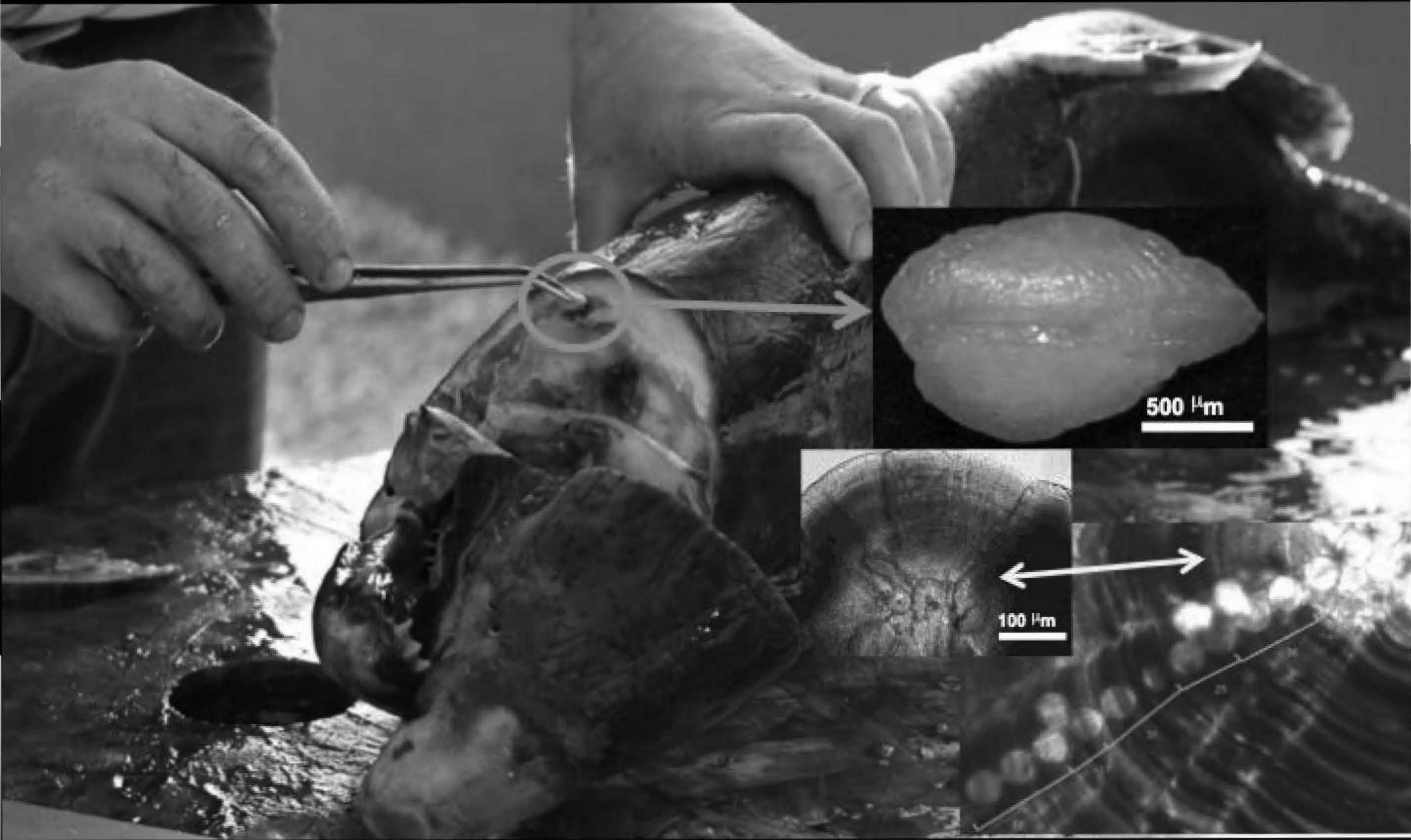
# *Sr isotopes discriminate habitats*

## Sr in the otoliths record outmigration

- Sr provides geographic data
  - North-south gradient
- $^{87}Sr/^{86}Sr_{otolith} = {}^{87}Sr/^{86}Sr_{water}$

**"What's in the water is in the otolith"**

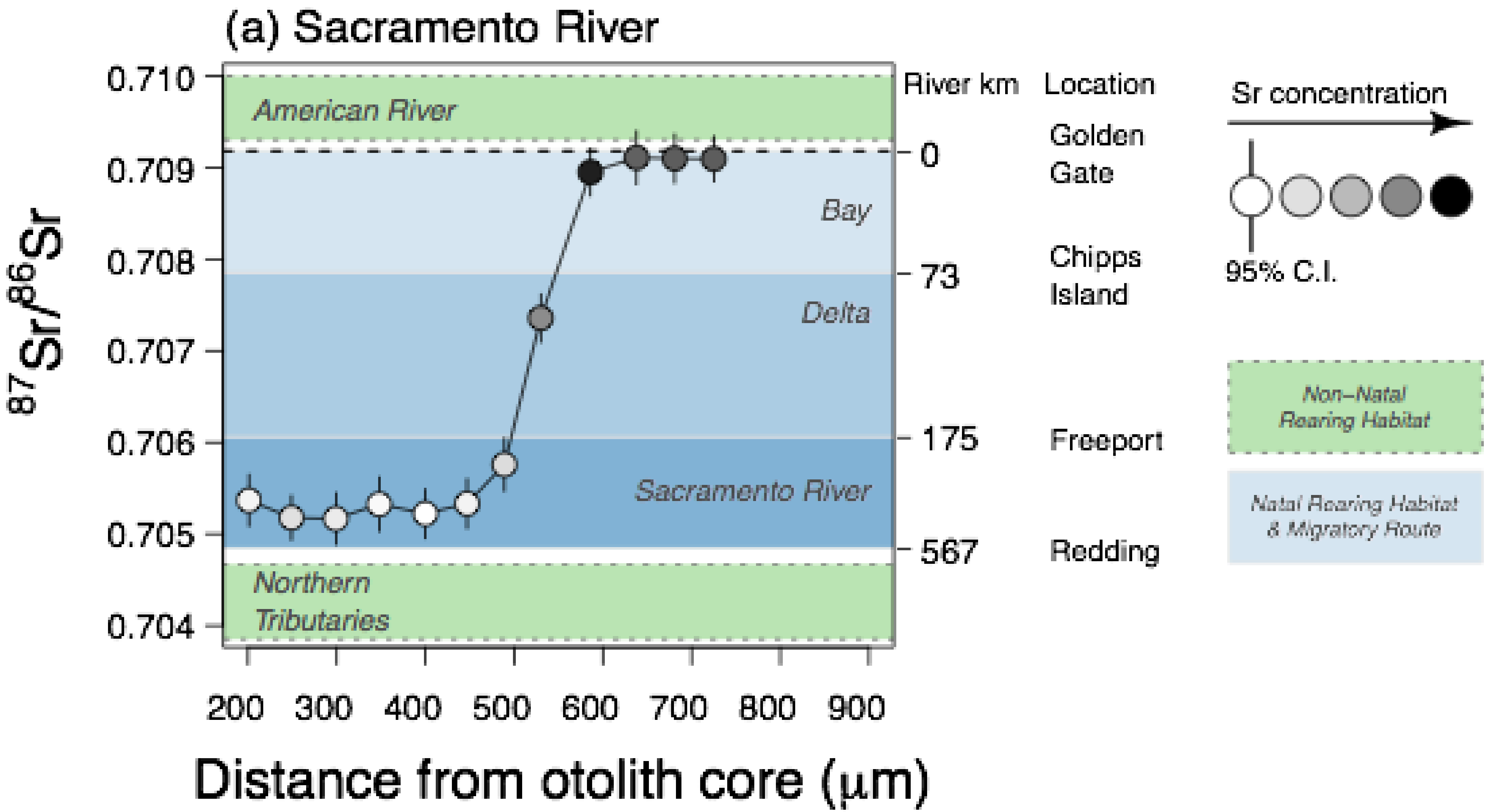




500 μm
100 μm

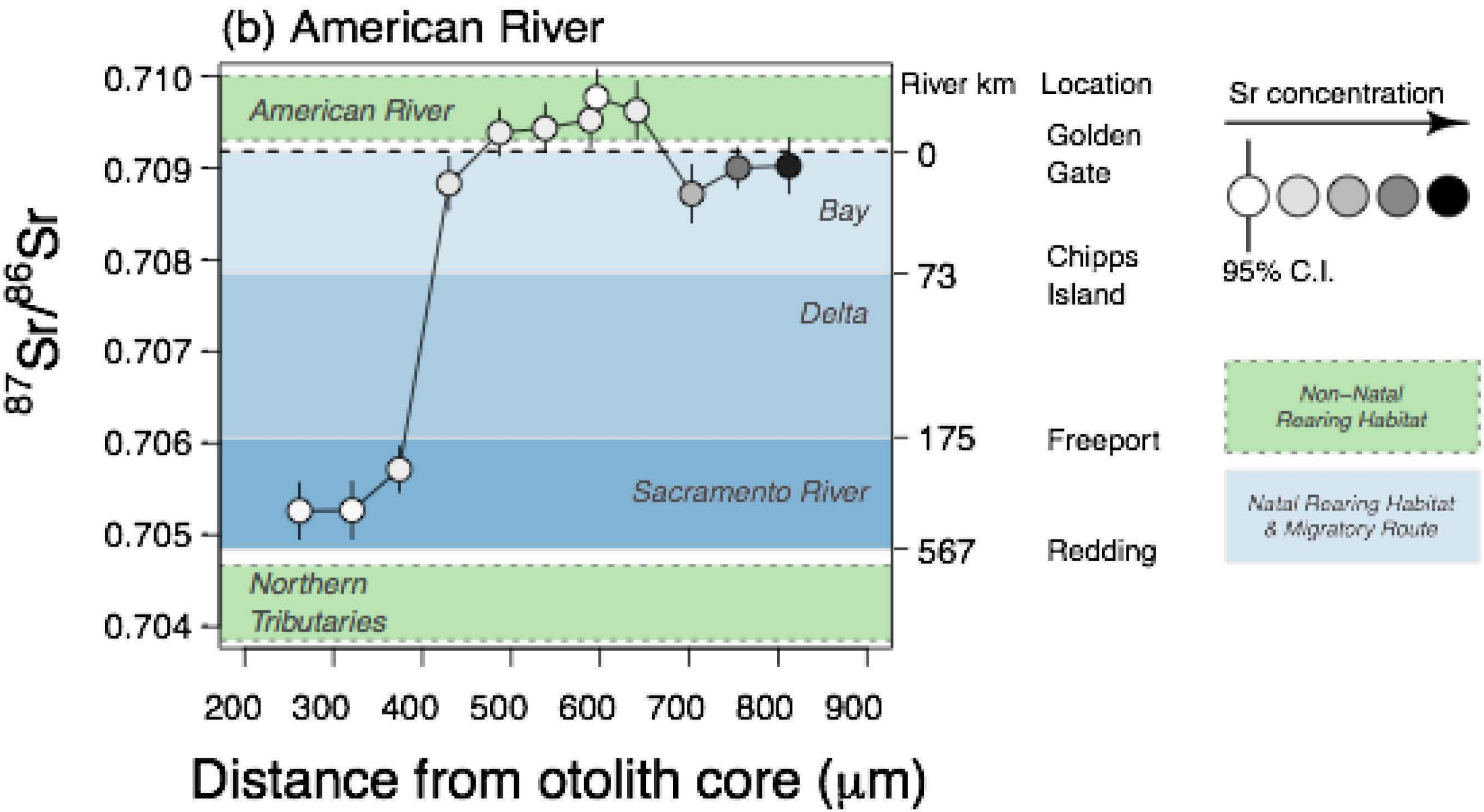
# *Individuals were assigned to juvenile rearing habitats*

- 188 otoliths (2007-2009 n = 29, 91, 68)
- Individuals assigned to 1 of 5 habitats:
  - Sacramento River (Keswick to Freeport)
  - American River
  - Northern Tributaries (e.g. Mill, Deer, Battle Creeks)
  - Delta or Feather River
  - “Habitat X”
- Detection limit for rearing in a habitat ~20 days

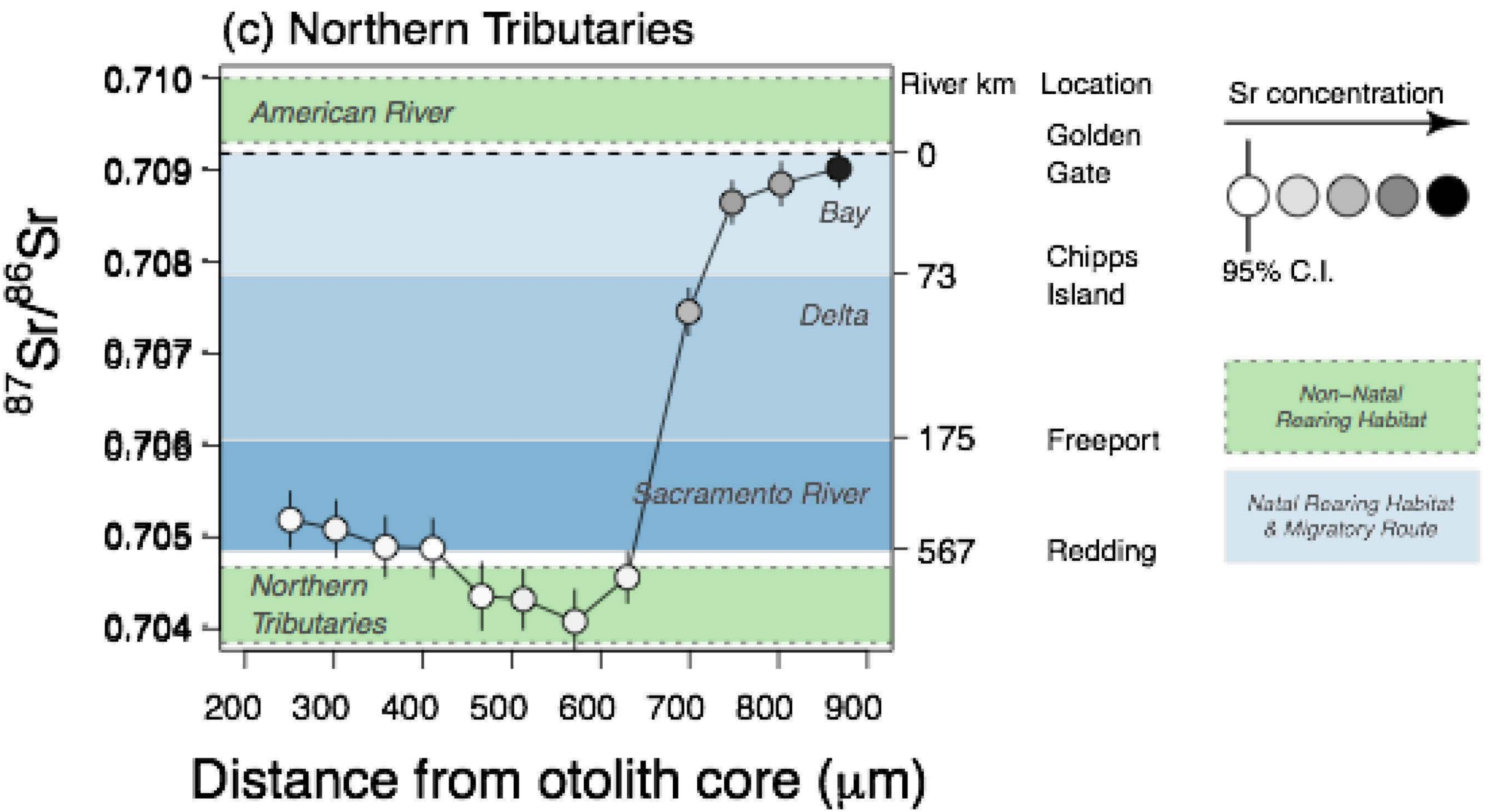
# Strontium isotopes in otoliths record juvenile life-history



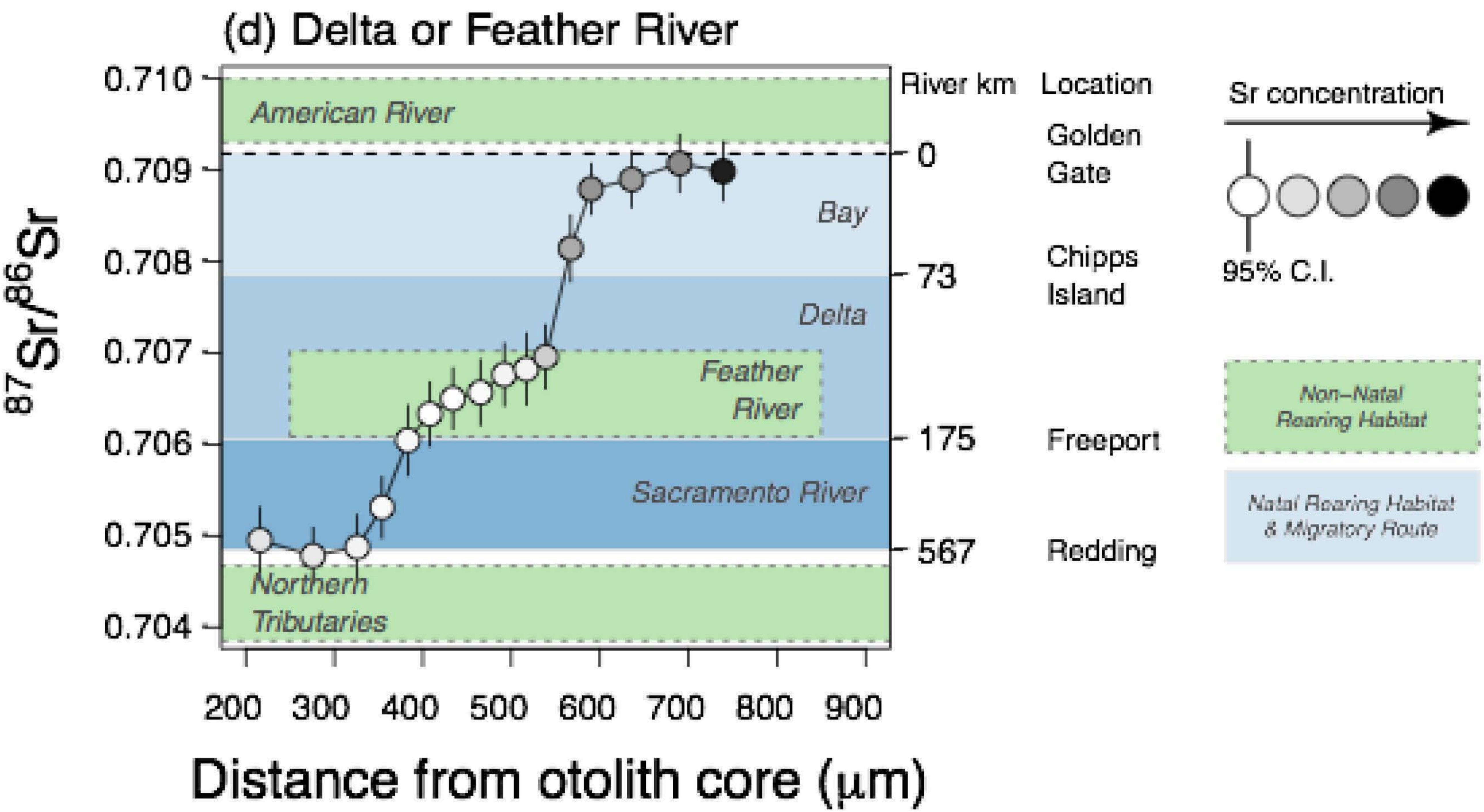
# High Sr-isotope ratio and low Sr concentration hallmark of American River rearing



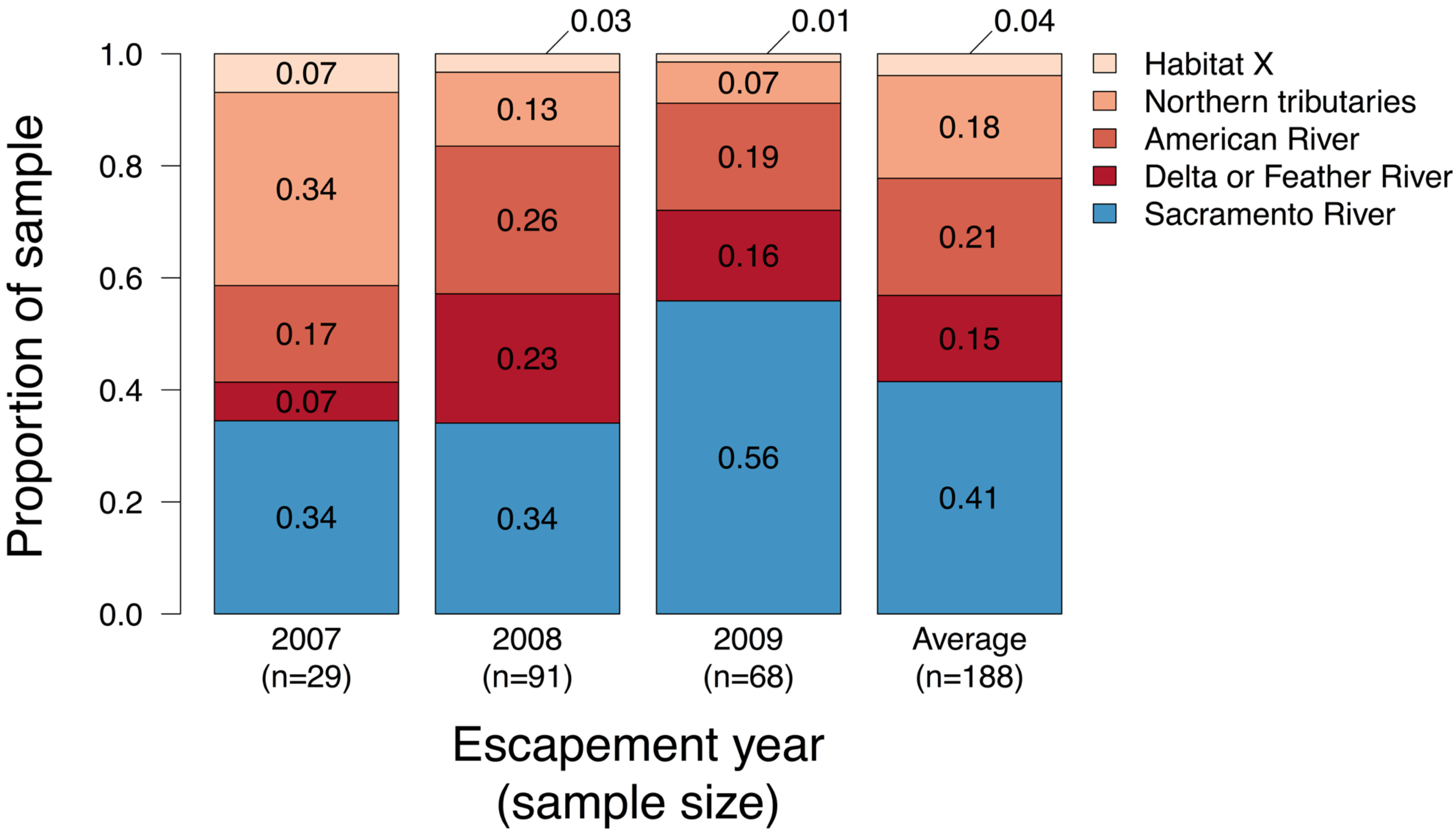
# *Rearing in the Northern tribs indicated by Sr-isotope ratio lower than Sac R. minimum*



# *Delta rearing is likely, but difficult to discriminate isotopically from Feather River*

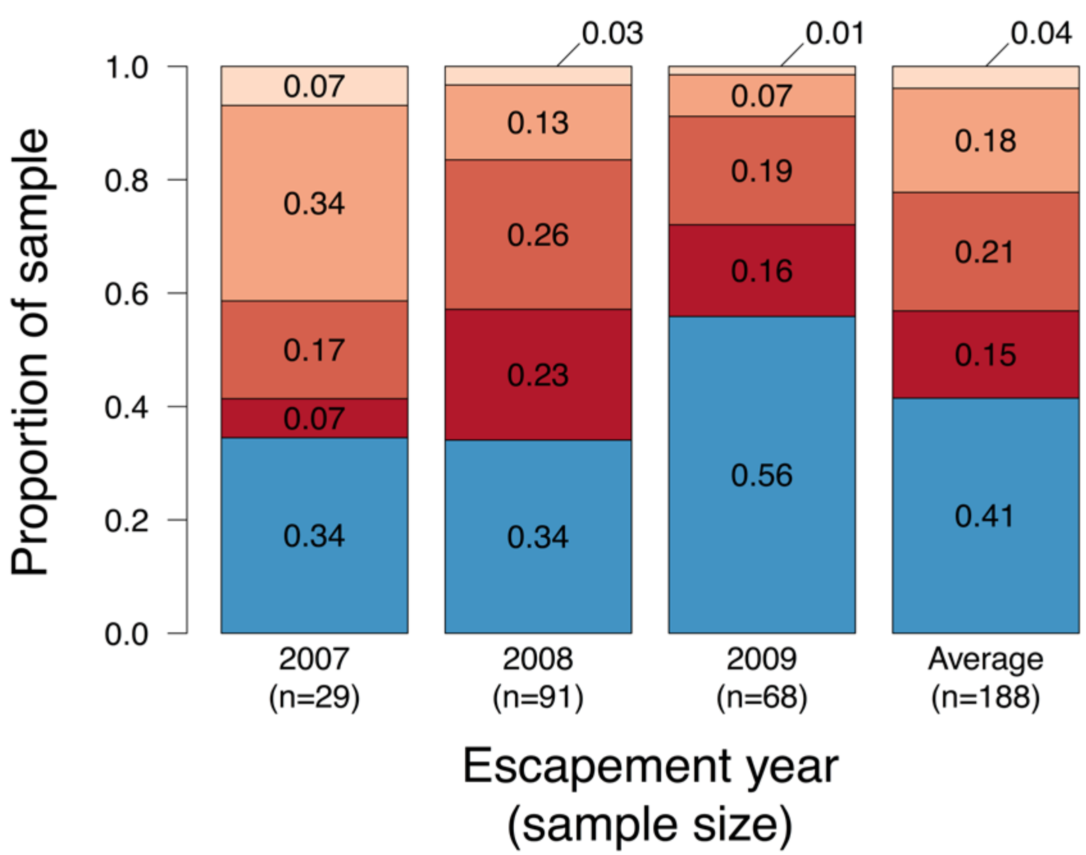


# *45-65% of adults reared in non-natal habitats as juveniles*

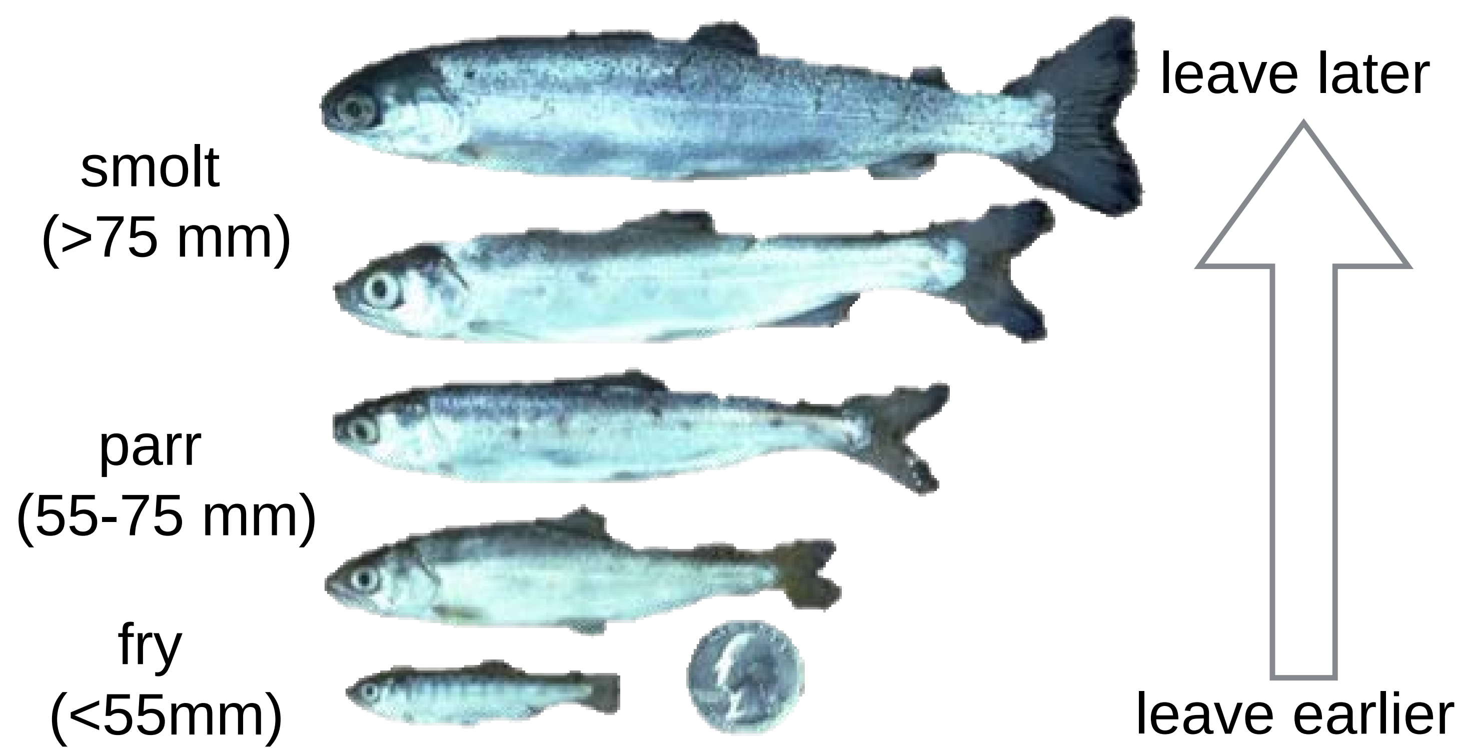


# Q2: Are both fry and parr migrants represented in the adult population?

Spatial diversity in rearing strategies

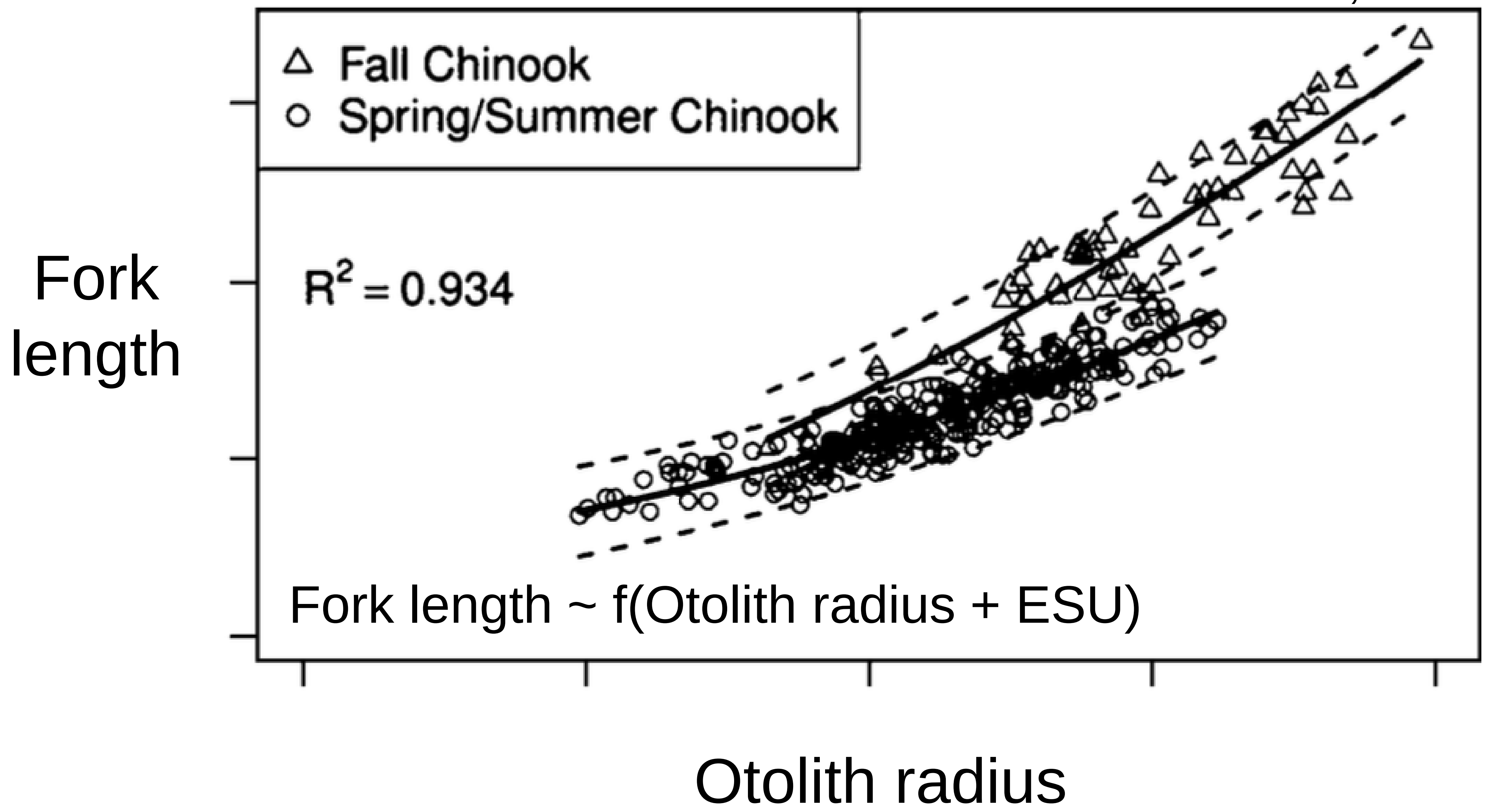



Temporal diversity in rearing strategies?



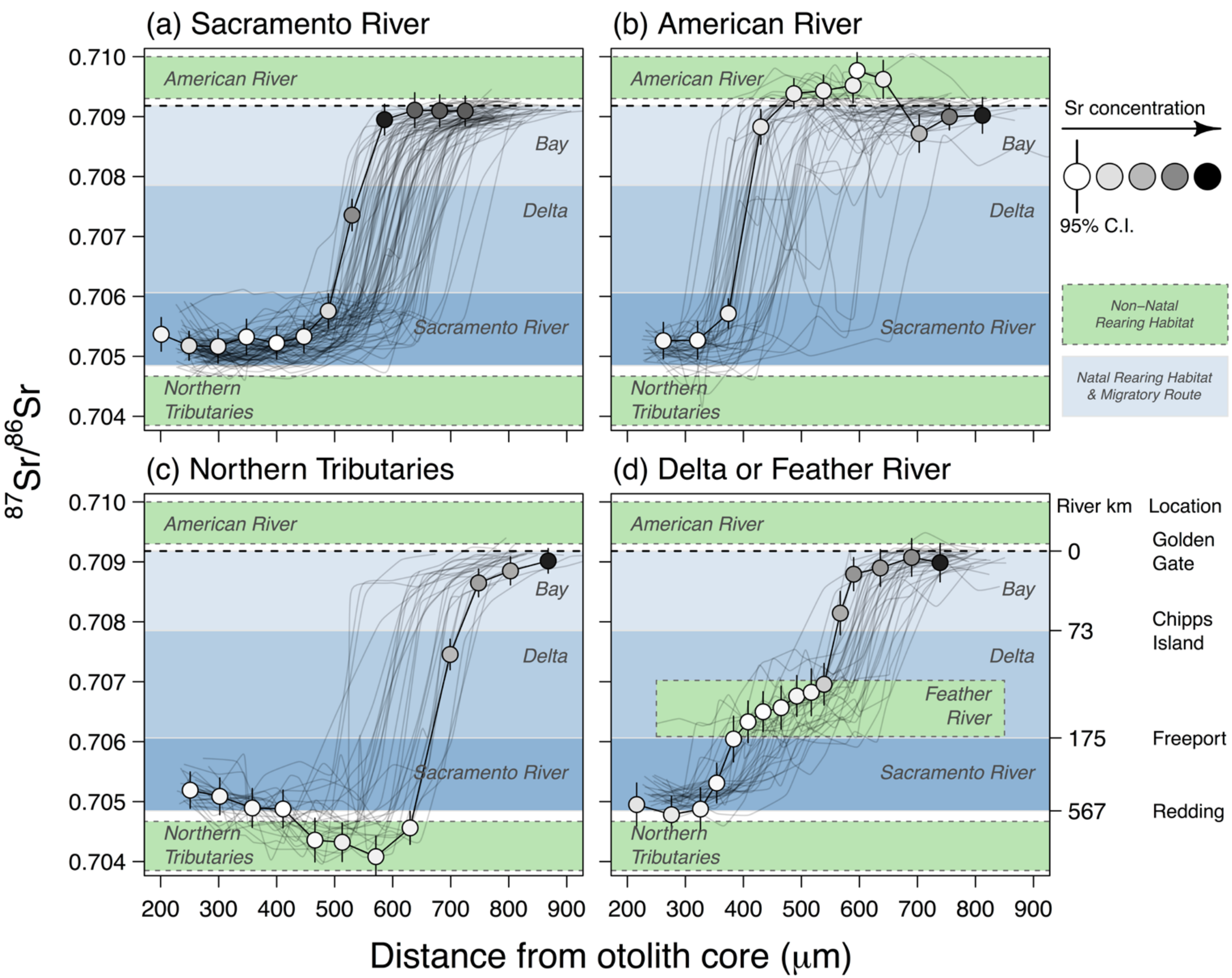
# *Otolith radius is a suitable proxy for body length, but it varies by ESU*

*Zabel et al., 2010*

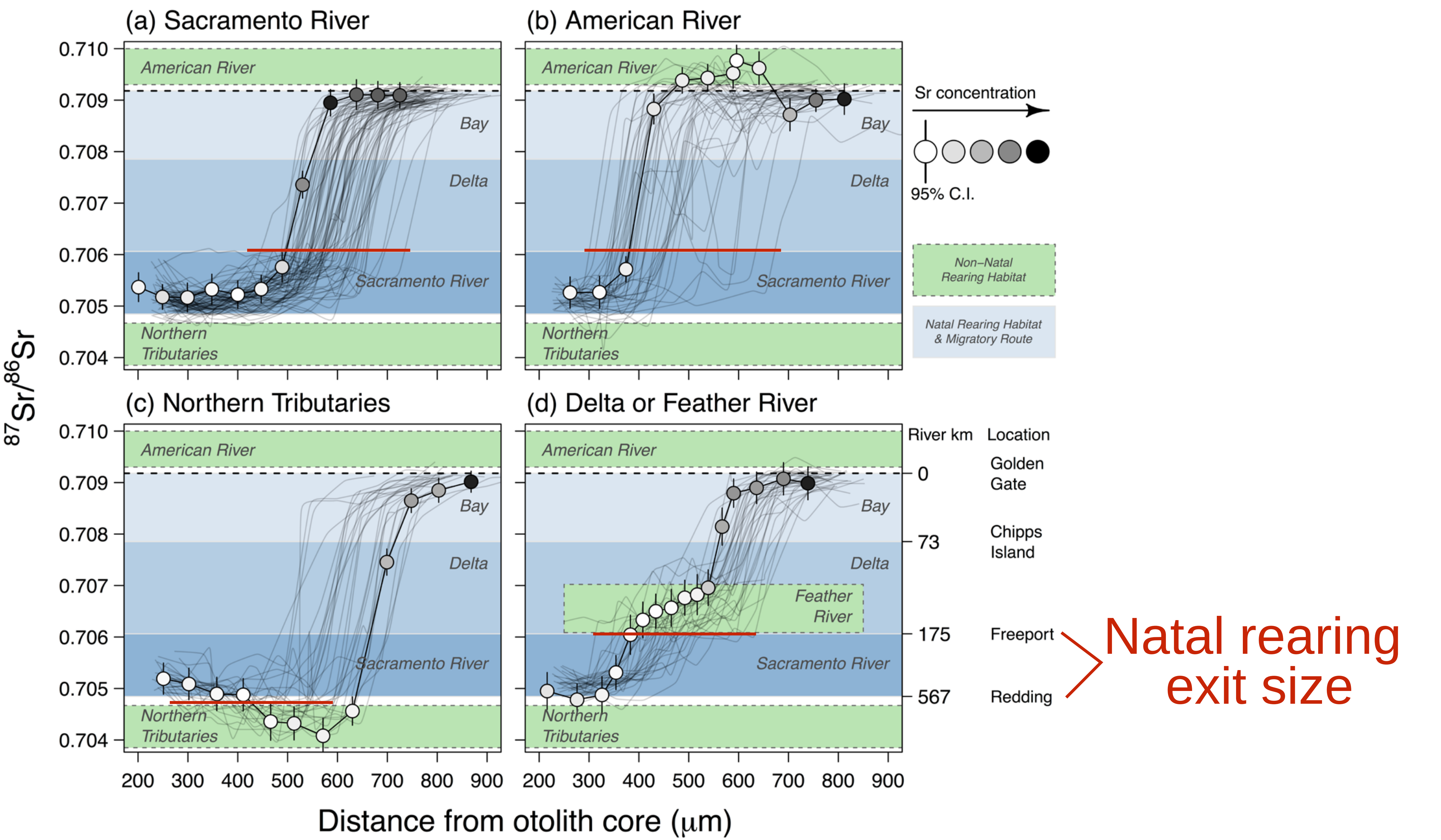



<u>***Currently no established relationship for SWRC ESU***</u>

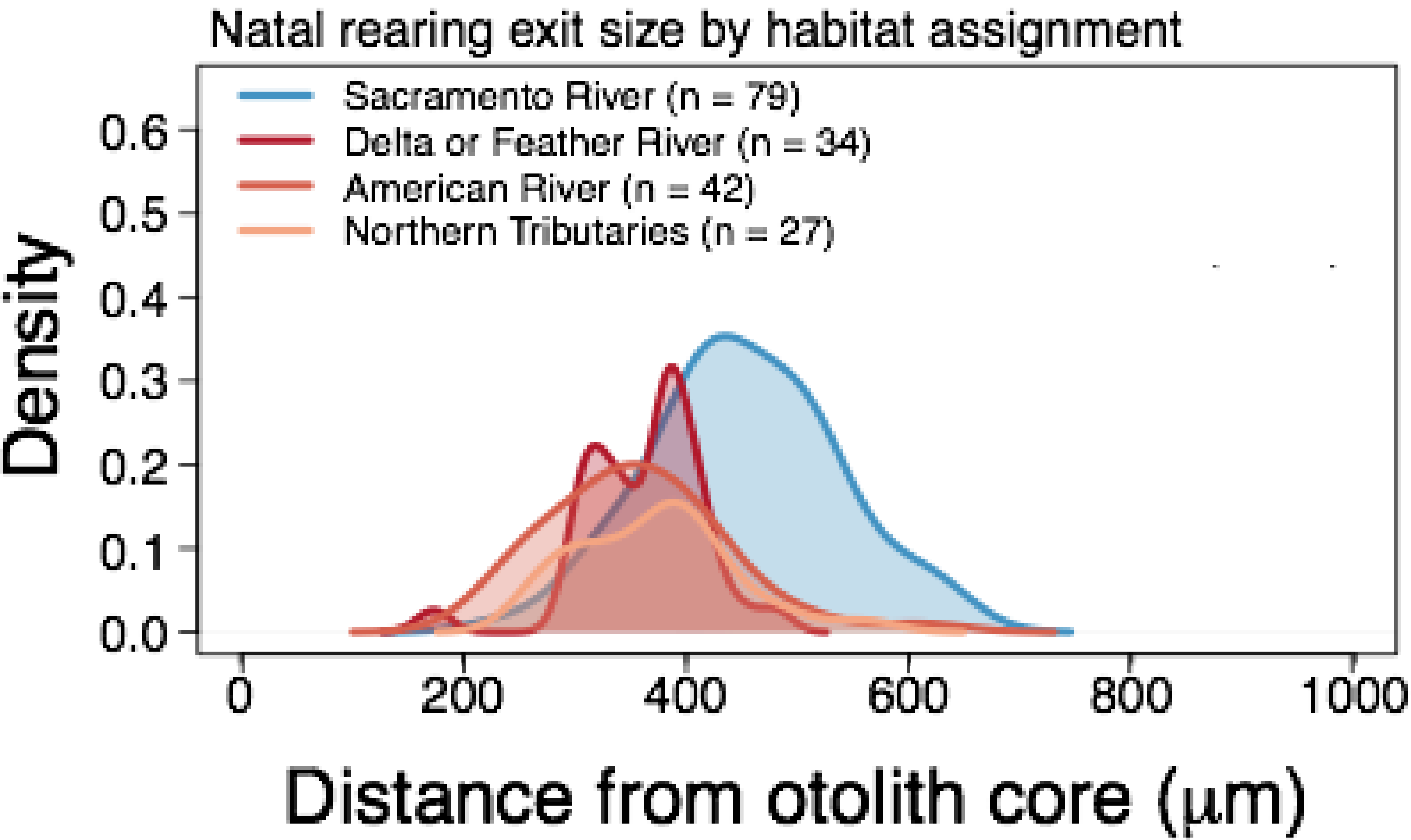
# Lots of variation in migration timing between individuals



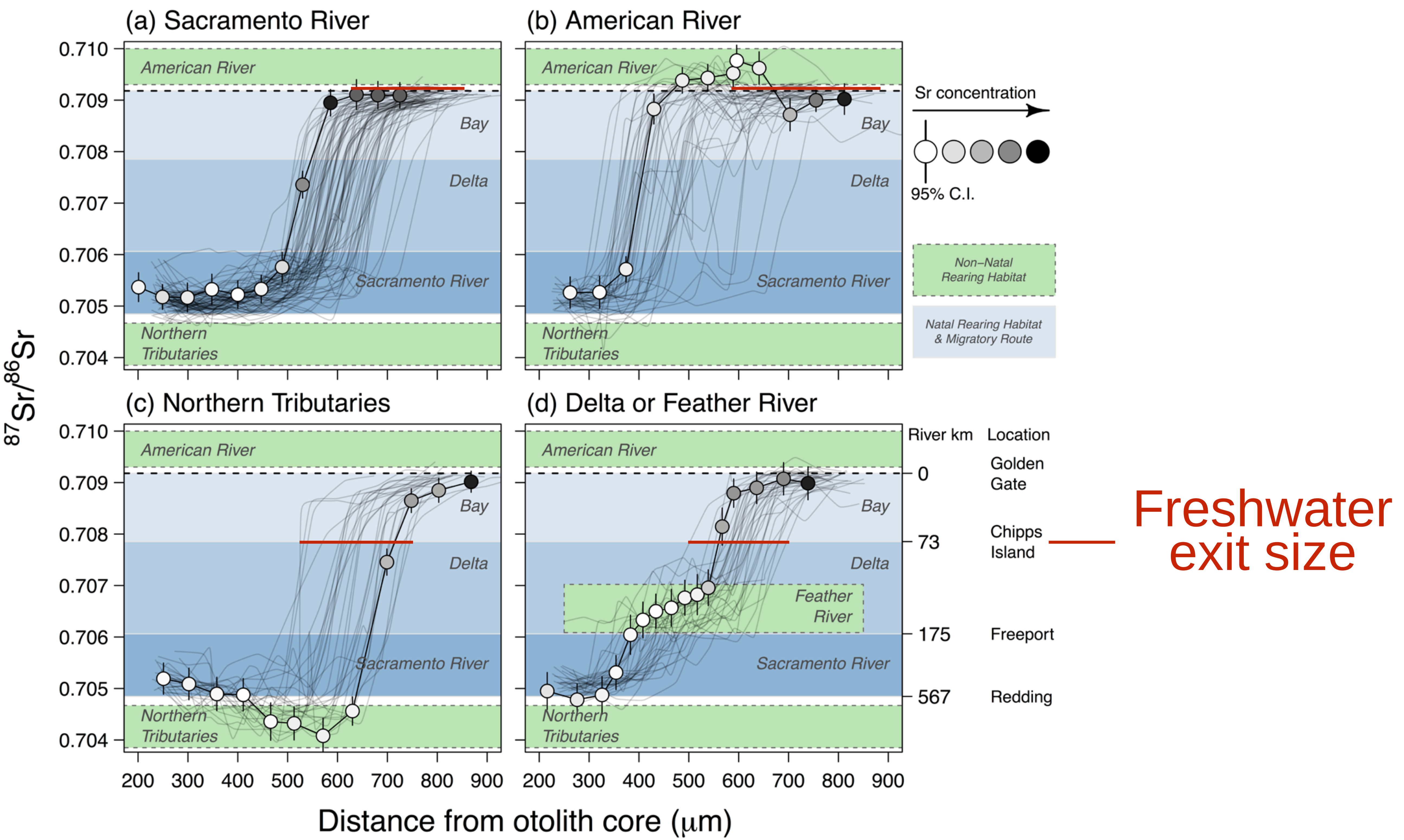
# Body size was estimated at exit from the natal rearing habitat



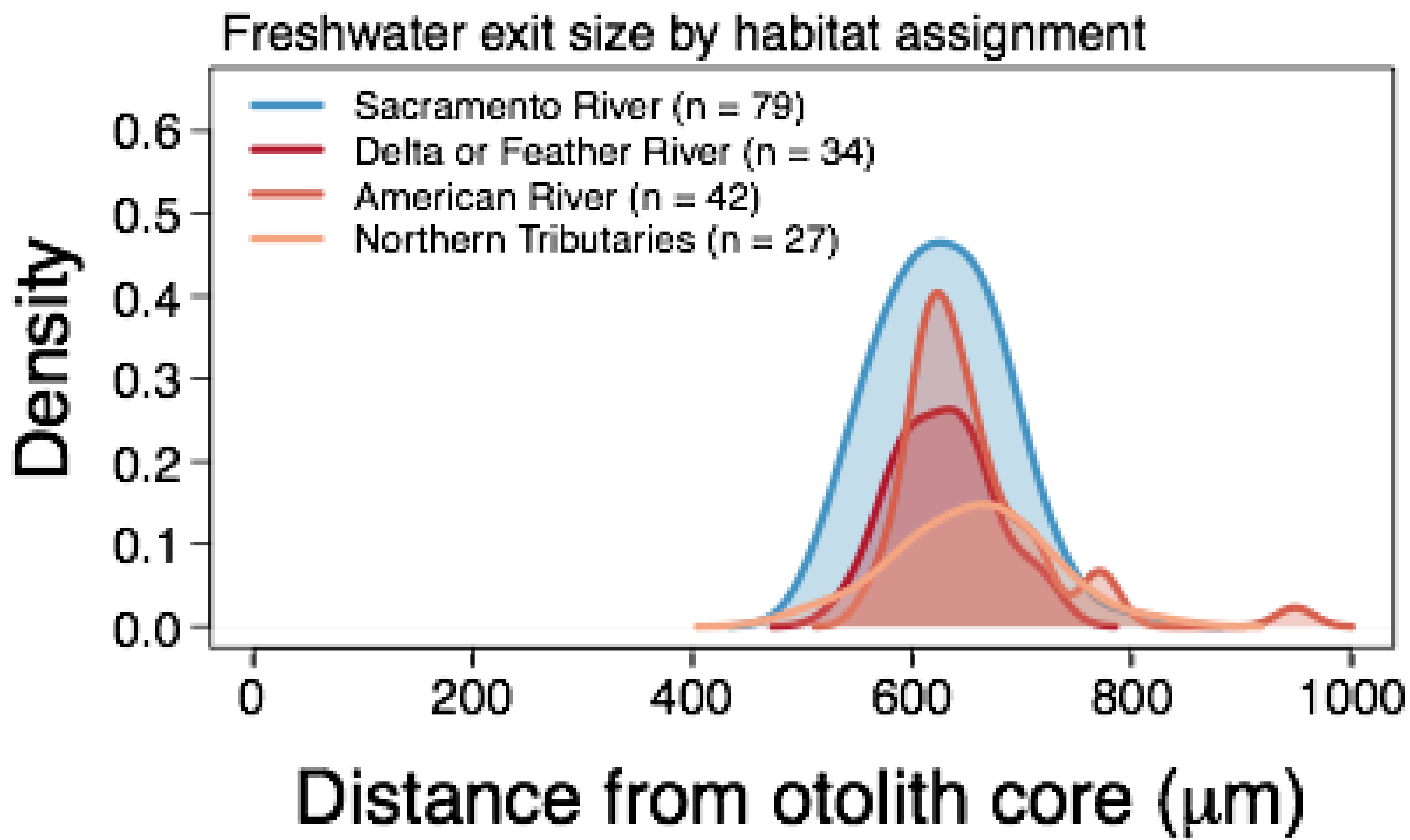
# *Fry migrate to non-natal rearing habitats*



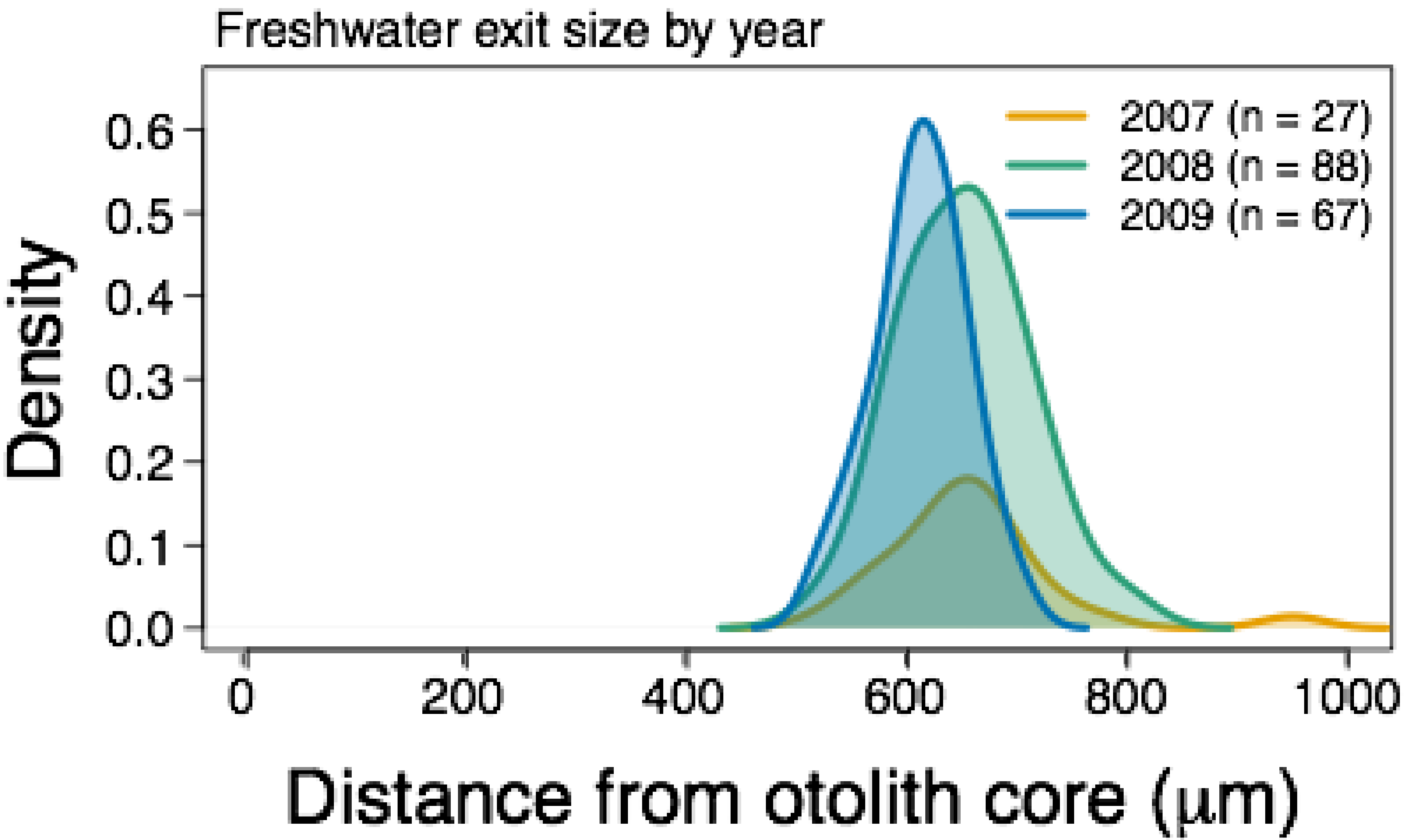
# Q3: Are there differences in size at freshwater exit associated with juvenile rearing habitat?



# *Size at freshwater exit is conserved across rearing habitats…*



# …But freshwater exit size differs across years



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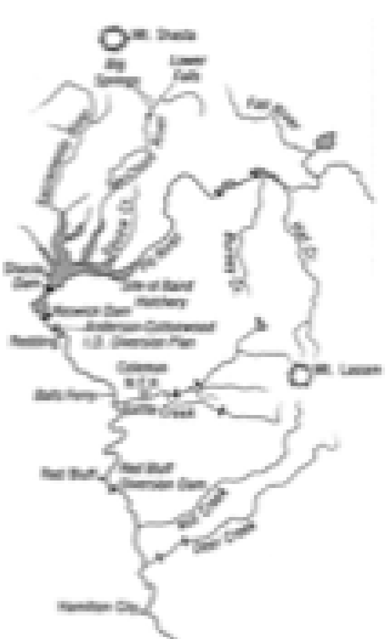

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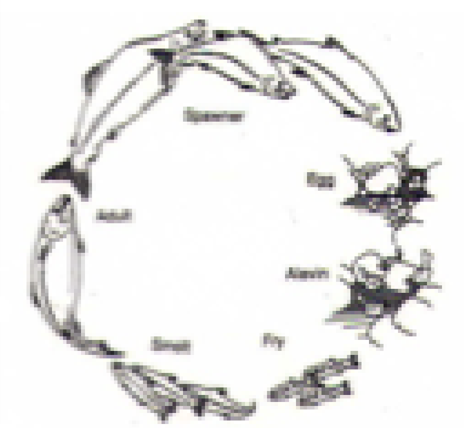

# *In summary:*

Q1: Where do the successful winter-run rear as juveniles?

A1: Winter-run rear in the Sacramento and Delta. But they also use non-natal habitats

Q2: Are both fry and parr migrants represented in the adult population?

A2: Yes, and the non-natal habitats are used successfully by fry

Q3: Are there differences in size at freshwater exit?

A3: Freshwater exit size is conserved across rearing habitats, but can vary between years


## Lessons from the Ocean for Integrating Science in Policy Decisions

*Steve Gaines, Dean, Bren School of Environmental Science and Management at UCSB*

## The Scientific Challenges of Establishing Appropriate Baselines for Watershed Restoration

*Daniel Schindler, Harriet Bullitt Endowed Chair in Conservation, School of Aquatic and Fishery Sciences, University of Washington*


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Ecosystems are not static. They are reshuffling in response to physical and biological drivers.

Populations are resilient when there are **options** to reshuffle into

For winter-run, non-natal rearing habitats are some of those **options**

# *Incorporate non-natal rearing habitats into our conceptual models*

## Narrative model

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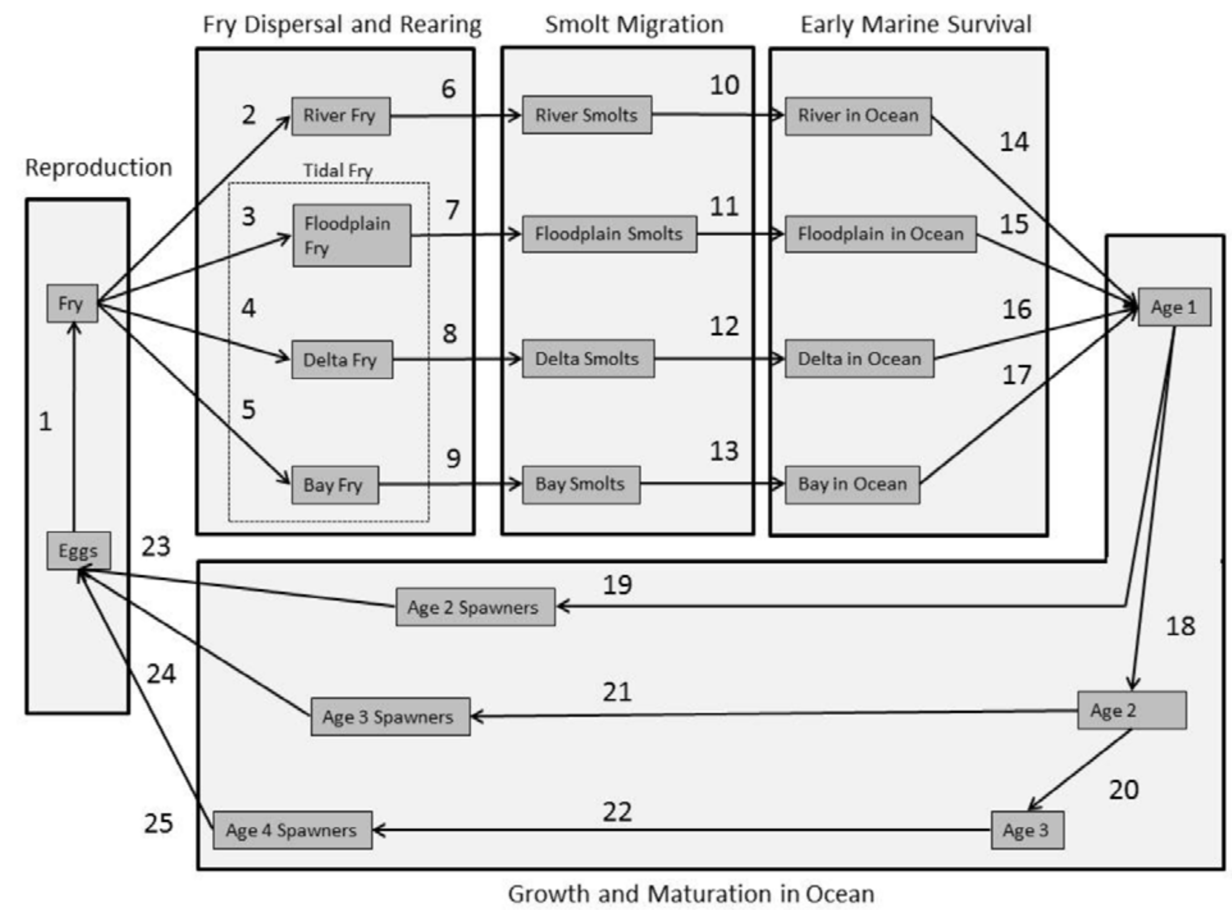
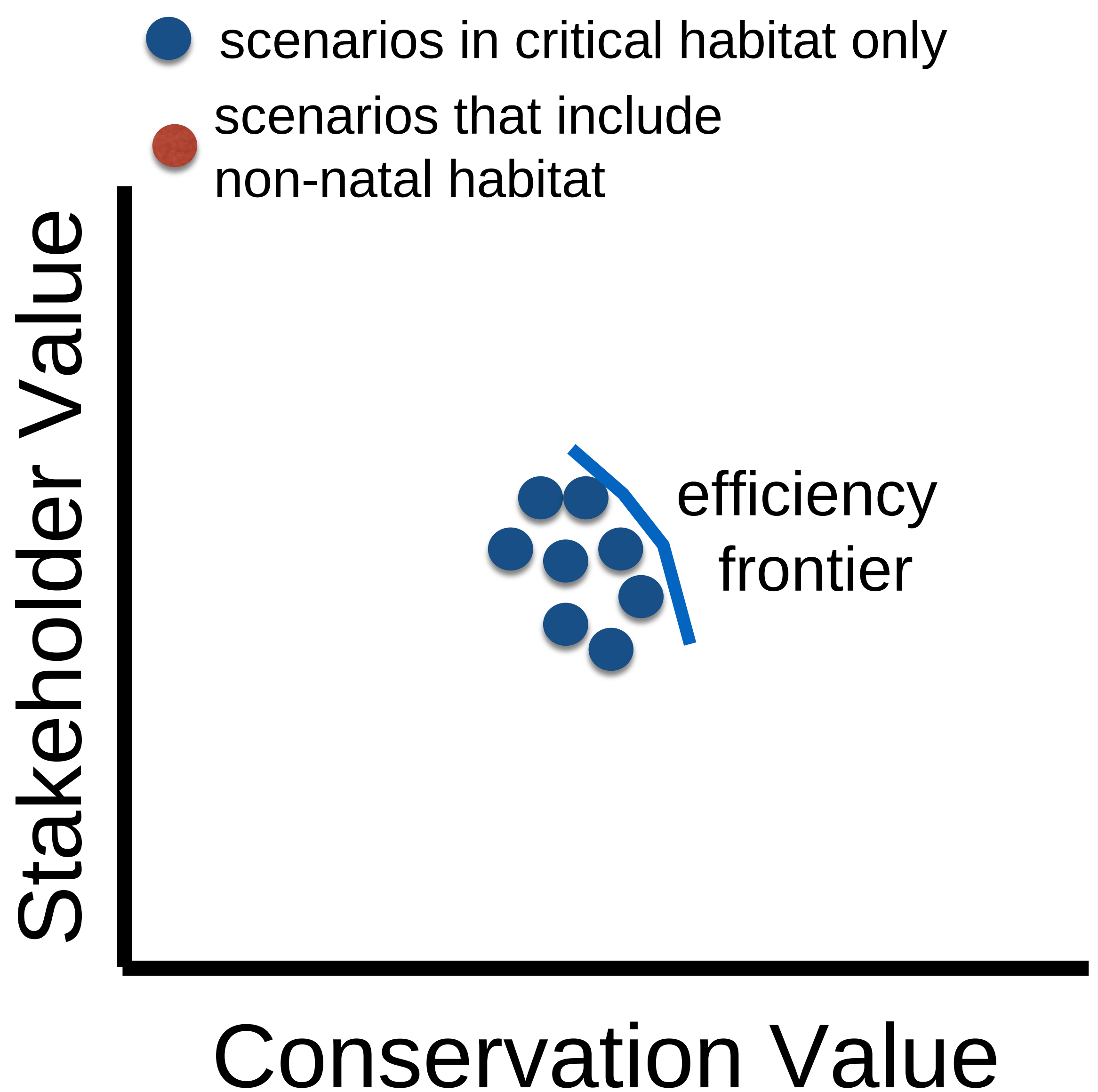



## Lessons from the Ocean for Integrating Science in Policy Decisions

*Steve Gaines, Dean, Bren School of Environmental Science and Management at UCSB*

Non-natal habitats represent **options** for fish

But they also represent management **options**

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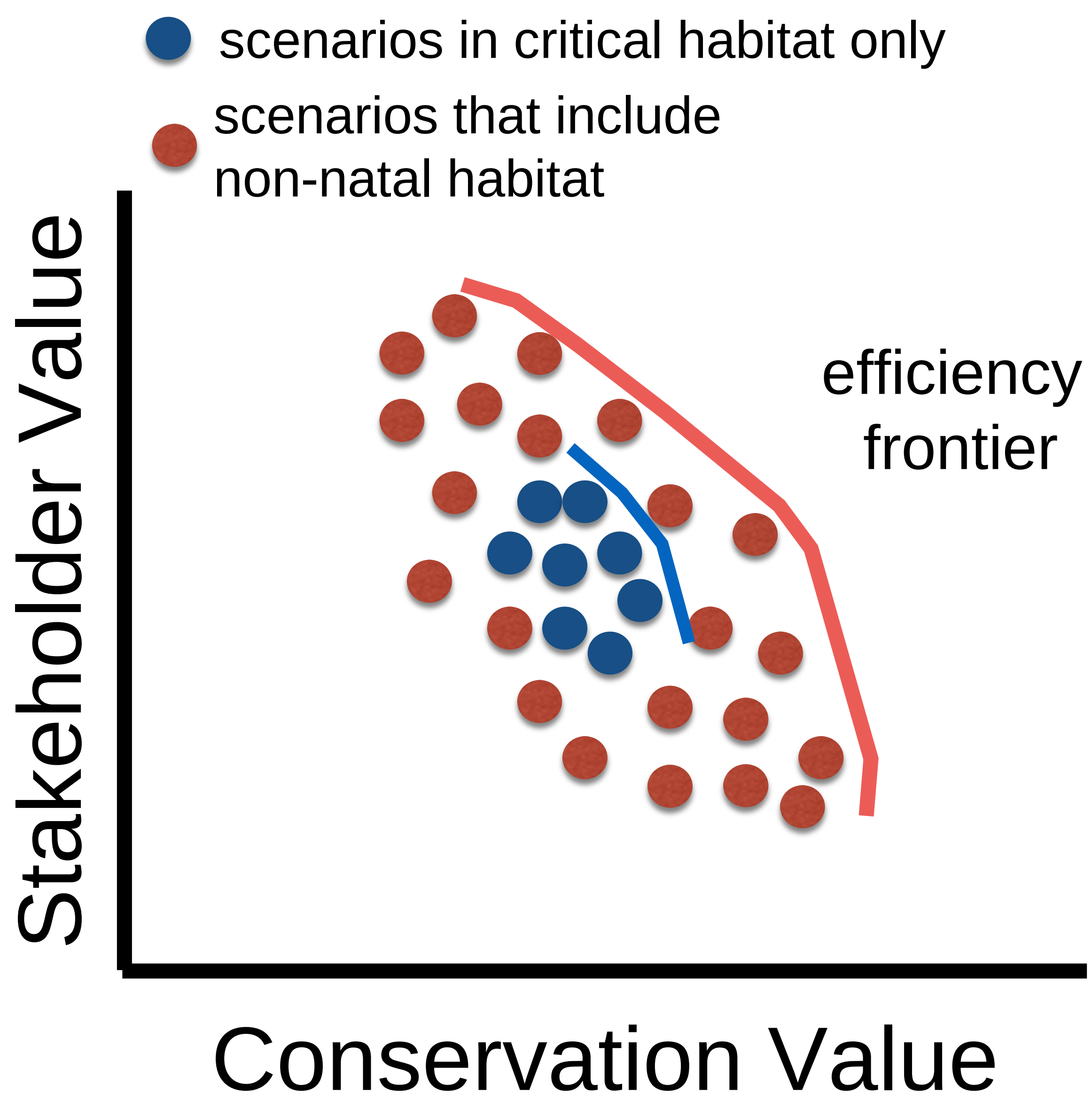
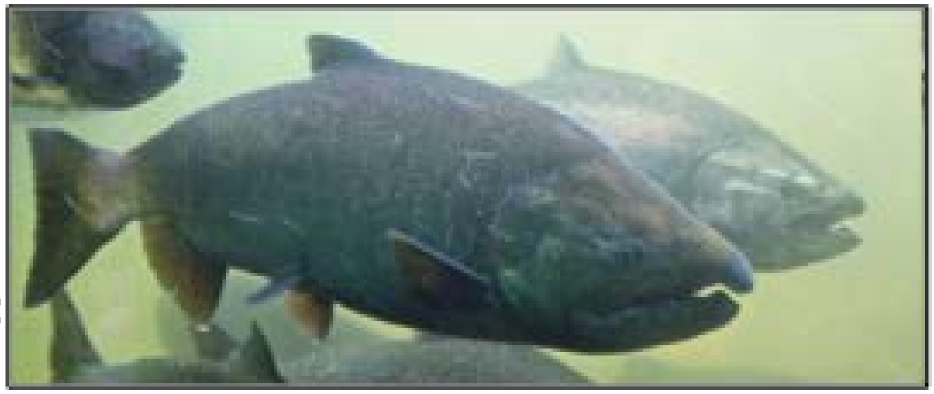


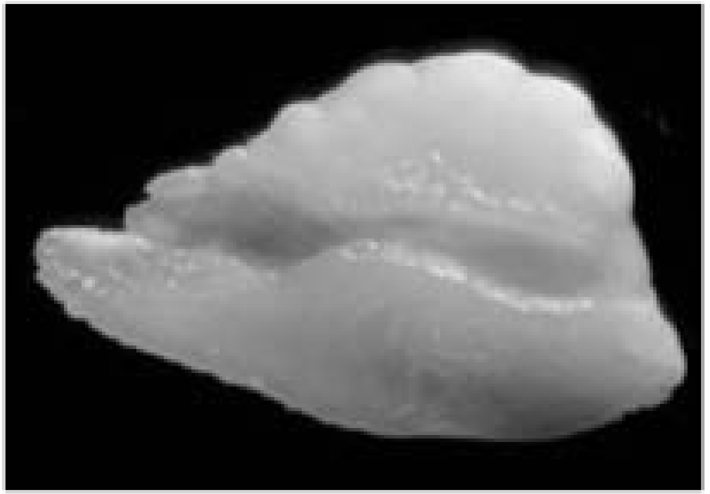
# Acknowledgements



Otolith samples
USFWS & Livingston Stone FH staff

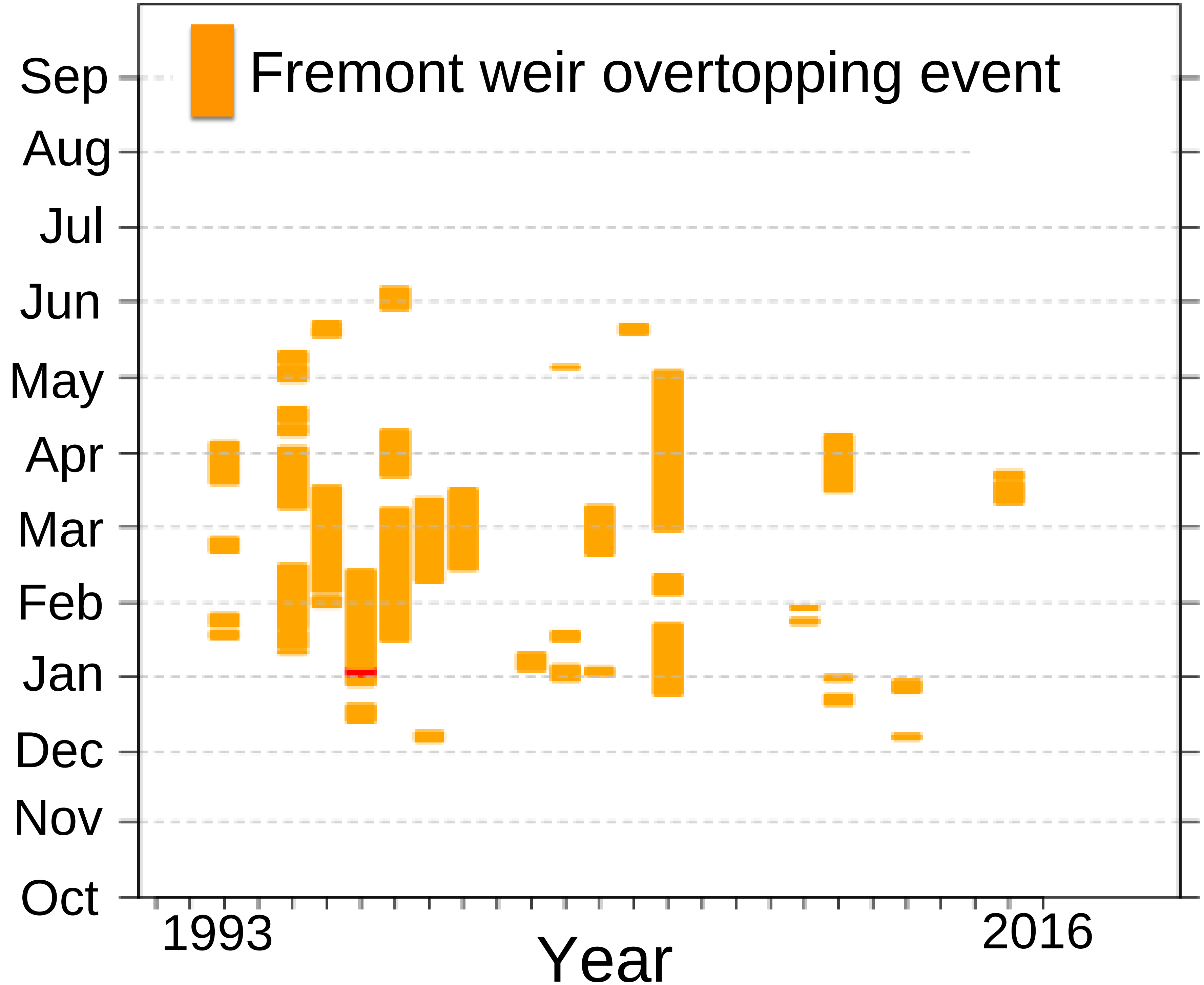
Otolith preparation & analyses
Justin Glessner & George Whitman

Funding
CALFED(!!!)
Delta Science Program
MWD



# *Timing and duration of Yolo Bypass inundation varies year-to-year*

http://www.cbr.washington.edu/sacramento/data/alert_weirs.html



# *Yolo bypass is rarely accessible when fry need rearing habitat*

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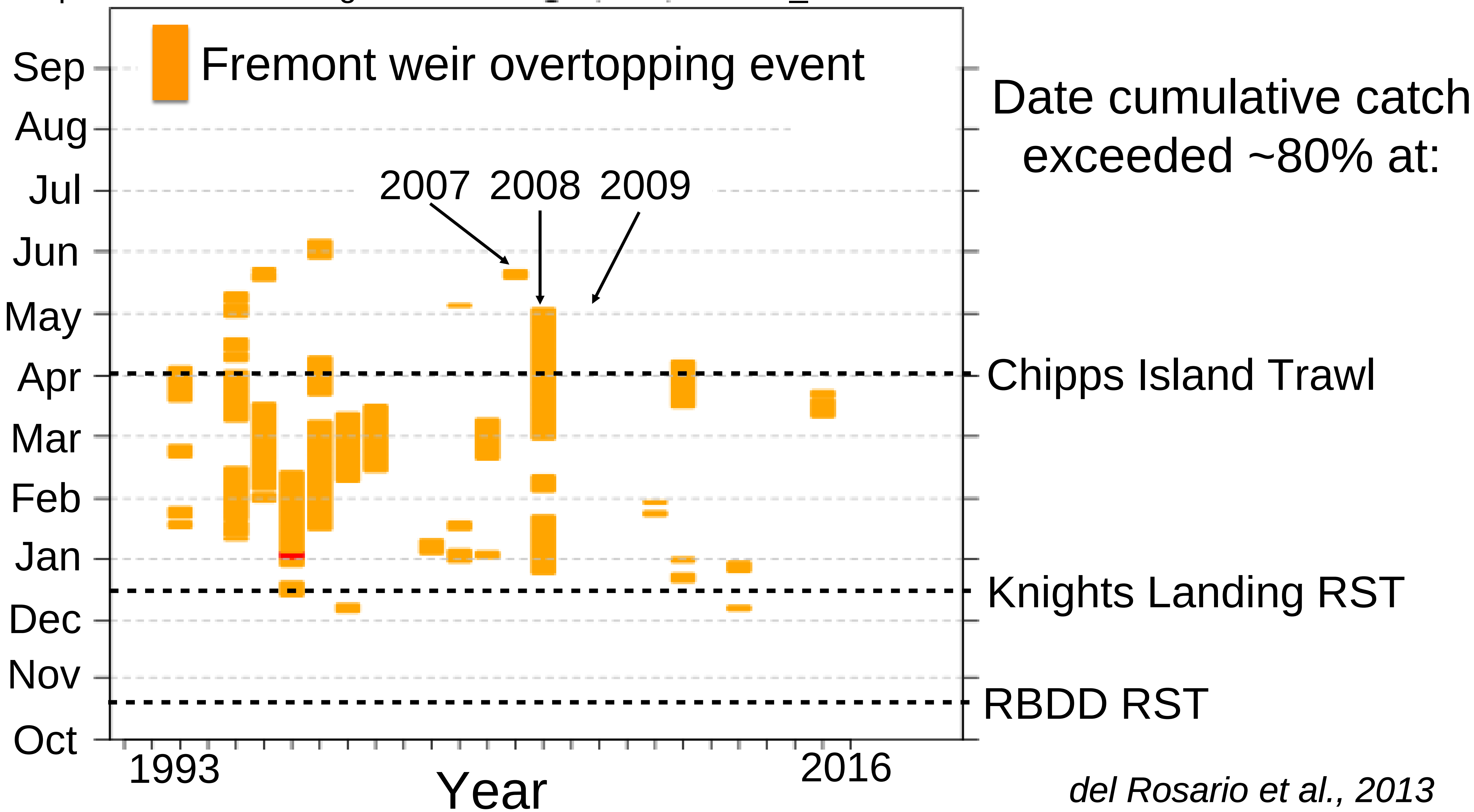


*del Rosario et al., 2013*