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Resolving Selenium Exposure and Risk in the San Francisco Estuary

A. Robin Stewart¹, James Bishop², Lisa Lucas¹, Fred Feyrer¹, Rachel Johnson³, Dominic Dal Porto⁴, Chase Wagner⁵, Noah Knowles¹, Rosanne Martyr-Koller⁶, Mick van der Wegen⁷

¹USGS, ²CA RWQCB, ³NOAA-NMFS, ⁴CA Poly, ⁵Tufts, ⁶Climate Analytics, ⁷IHE-Deltares



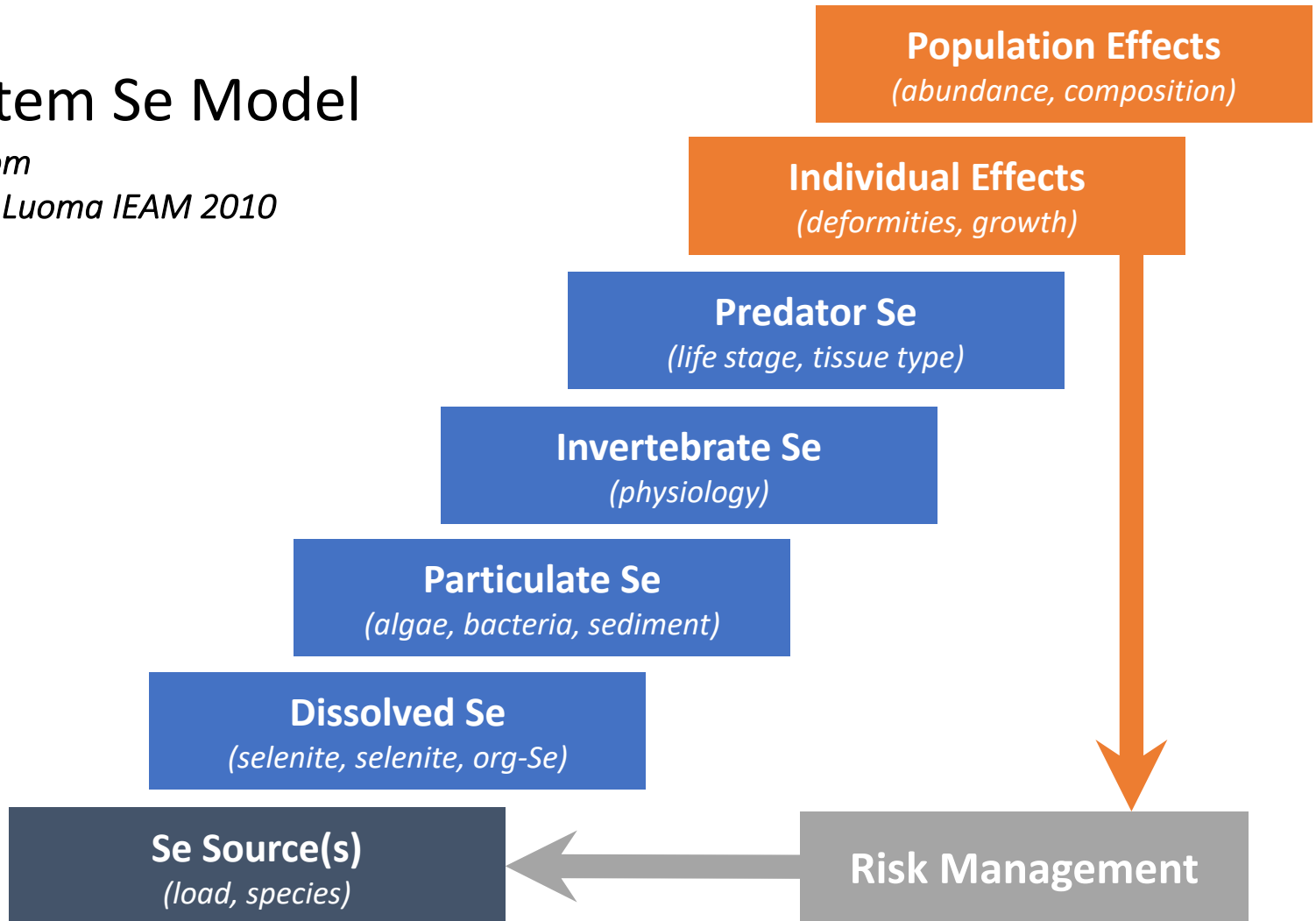
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Ecosystem Se Model

modified from

Presser and Luoma IEAM 2010



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Proposed Aquatic Life and Aquatic-Dependent Wildlife Criteria for Selenium in California's San Francisco Bay and Delta

Summary

EPA is proposing to revise the current federal Clean Water Act (CWA) selenium water quality criteria applicable to the salt and estuarine waters of the San Francisco Bay and Delta to ensure that the criteria are set at levels that protect aquatic life and aquatic-dependent wildlife, including federally listed threatened and endangered species.

Background

CWA section 101(a)(2) establishes the national goal that wherever attainable water quality should provide for the protection and propagation of fish, shellfish, and wildlife, and recreation in and on the water. To protect aquatic communities from the harmful effects of pollutants in surface waters, states must adopt water quality criteria for pollutants that are protective of such designated uses in water bodies. EPA periodically publishes national criteria recommendations for certain pollutants under CWA section 304(a) for states to consider using to protect aquatic life uses.

EPA promulgated the San Francisco Bay and Delta's existing selenium criteria on the state's behalf in 1992 as part of the National Toxics Rule (NTR), using EPA's CWA section 304(a) recommended aquatic life criteria for selenium at the time. However, the latest science on selenium fate and bioaccumulation

indicates that the existing criteria are not protective of aquatic life and aquatic-dependent wildlife in the salt and estuarine waters of the San Francisco Bay and Delta.

EPA determined that new or revised selenium criteria in the salt and estuarine waters of the San Francisco Bay and Delta are necessary to protect the designated uses for these waters. Therefore, to protect aquatic life and aquatic-dependent wildlife in the San Francisco Bay and Delta from the adverse effects of selenium, EPA is proposing the criteria in this rule using the best available science.

How EPA Derived the Proposed Selenium Aquatic Life and Aquatic-Dependent Wildlife Criteria

In 2016, EPA published revised CWA section 304(a) recommended criteria for selenium, based on the latest science on selenium bioaccumulation and toxicity (*Final Aquatic Life Ambient Water Quality Criterion for Selenium – Freshwater 2016*, US EPA, Office of Water, EPA 822-R-16-006). EPA considered the methodology and information used to derive the revised CWA section 304(a) recommended selenium criterion, along with additional information specific to the San Francisco Bay and Delta, in developing the selenium criteria in this proposed rule.

Site Specific Criteria*	Tissue $\mu\text{g/g}$ dry wt.	Compliance/ Monitoring
Bivalve	15	
Fish ovary	15.1	
Fish muscle	11.3	
Fish whole body	8.5	
Dissolved Total Se		0.2 $\mu\text{g/L}$
Particulate Total Se		1 $\mu\text{g/g}$

*for salt and estuarine waters

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Deformed juvenile Sacramento Splittail (2011)

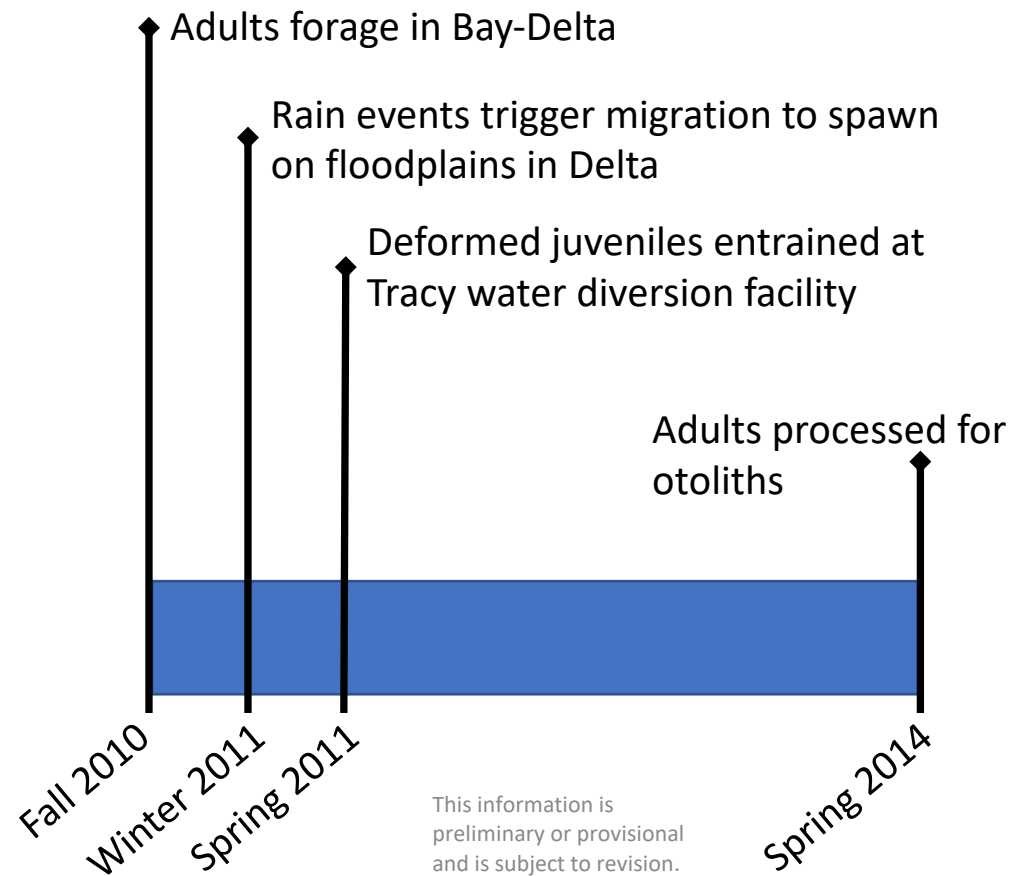
What were the primary sources of exposure?

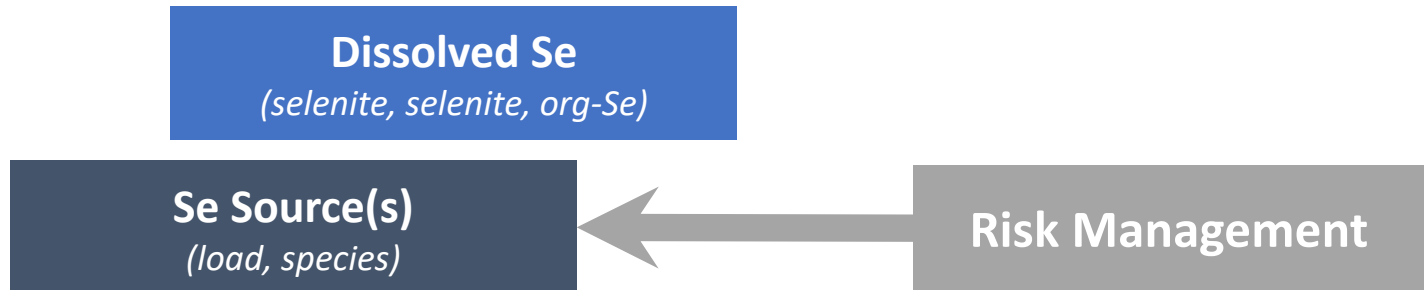
Were criteria exceeded?

What were the pathways of exposure:
Maternal vs. exogenous?



Splittail exposure timeline



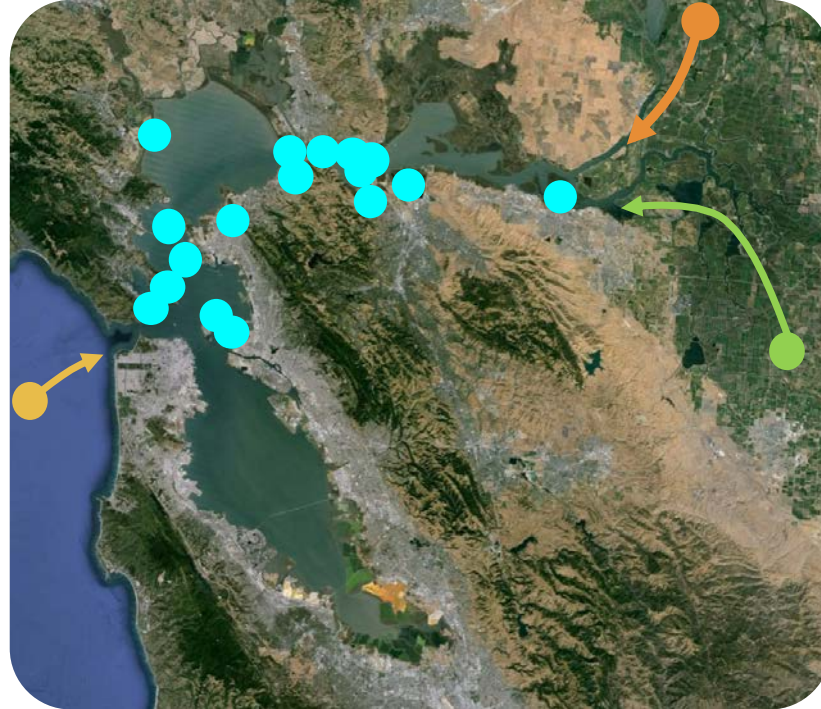


Multiple natural and anthropogenic Se sources

Oil refining/POTW



Ocean



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Sacramento River



Agriculture/SJR

-
- ⊗ River input
 - POTW
 - Refinery
 - Ocean

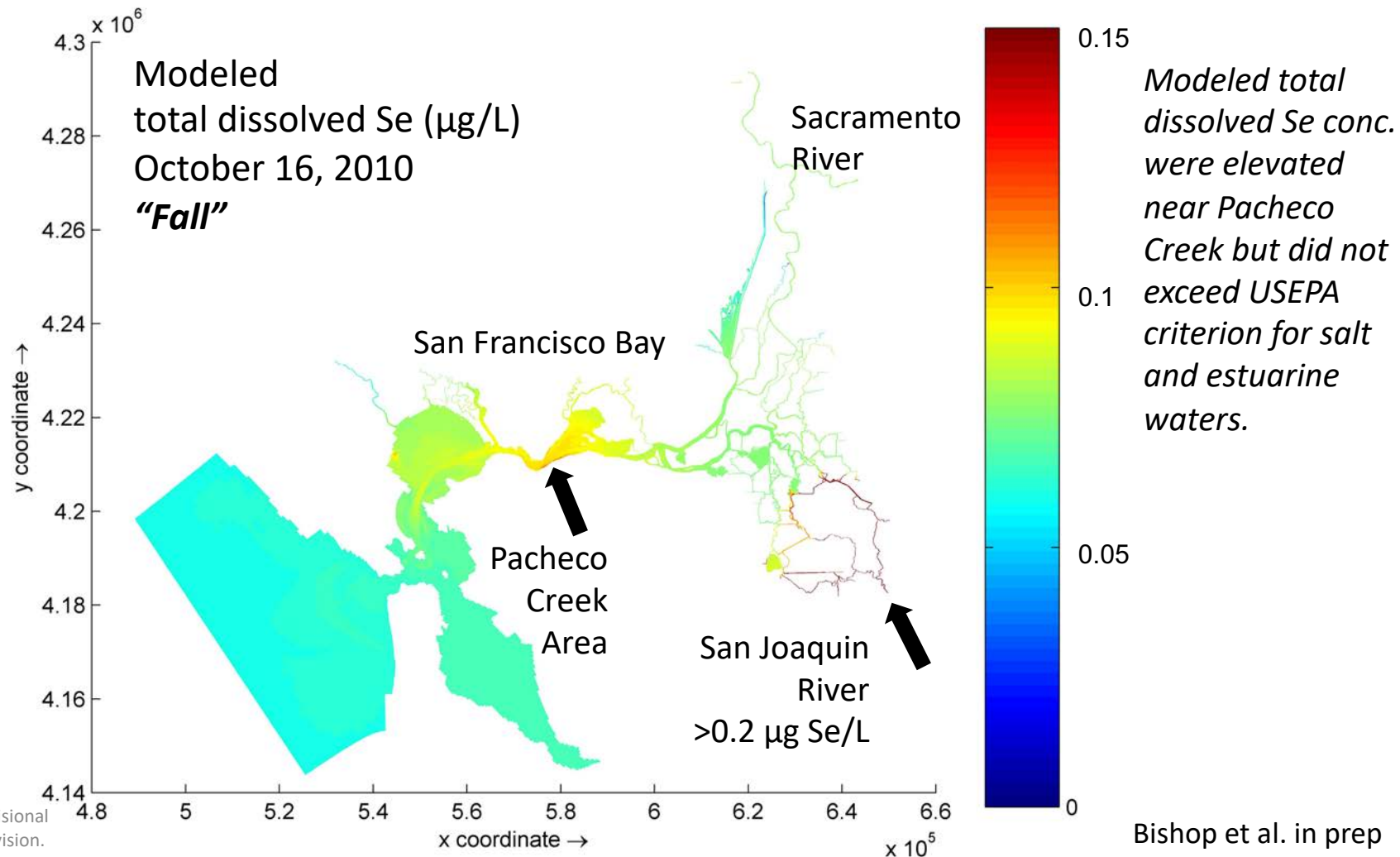
Coupled
Hydrodynamic-Water
Quality Model
Deltares, Netherlands

Delft3D-FM
Hydraulic forcings
from rivers, oceans,
operations

Delwaq
Se loads from river,
wastewater,
refineries, ocean

0 10 20 Miles

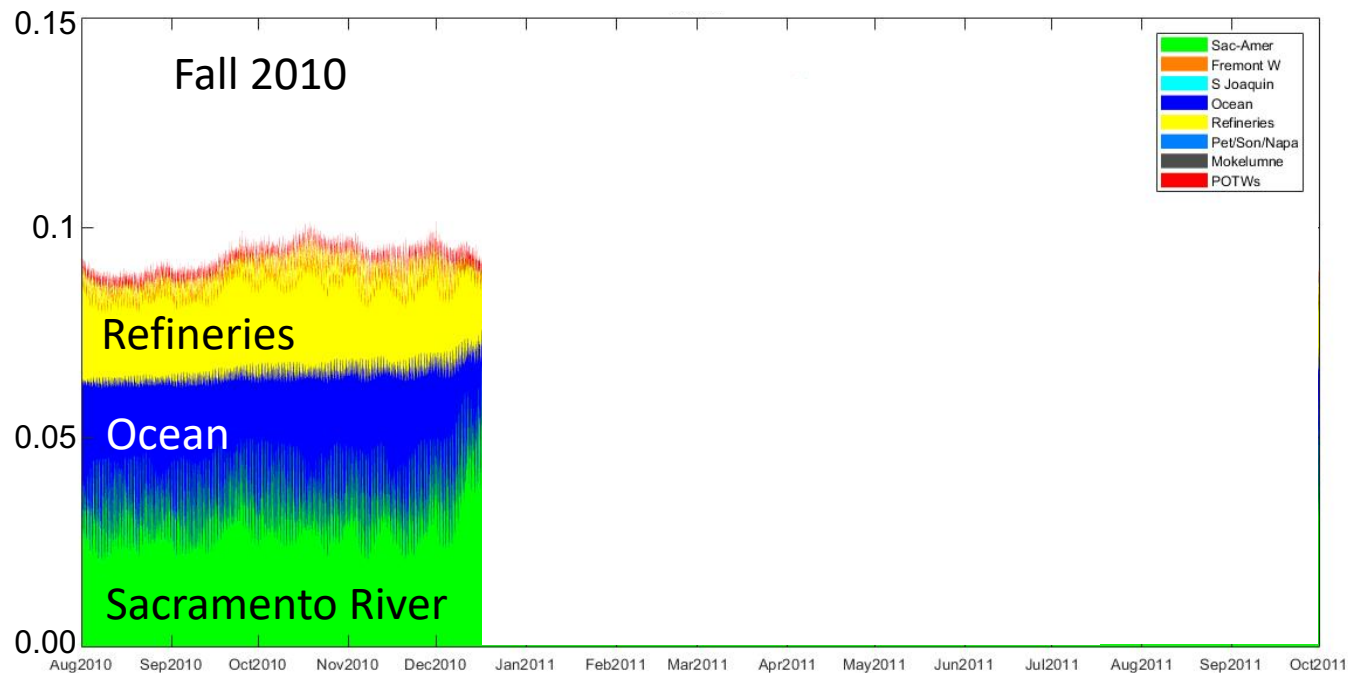
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Bishop et al. in prep

Modeled
total dissolved Se
($\mu\text{g/L}$) from
different Se
sources at USGS
Station 8.1 in
Carquinez Strait
(loading data not
shown)

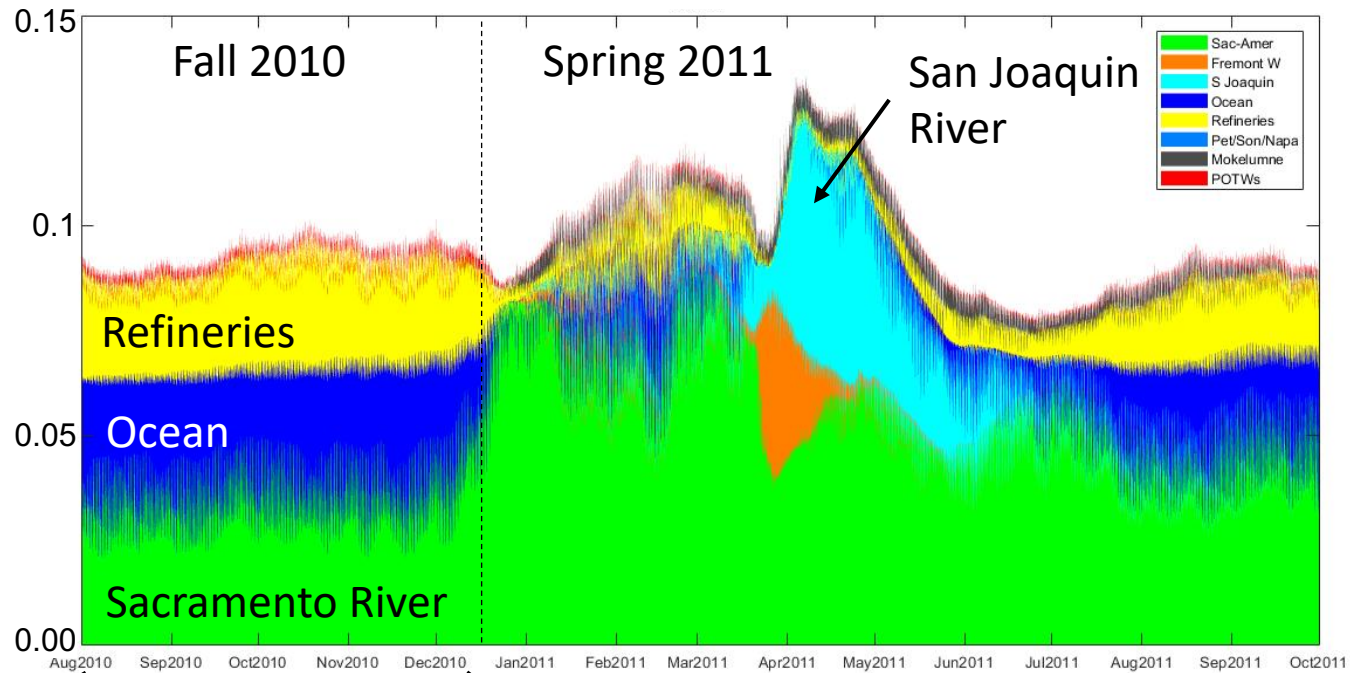


USGS Station
8.1 Carquinez
Strait

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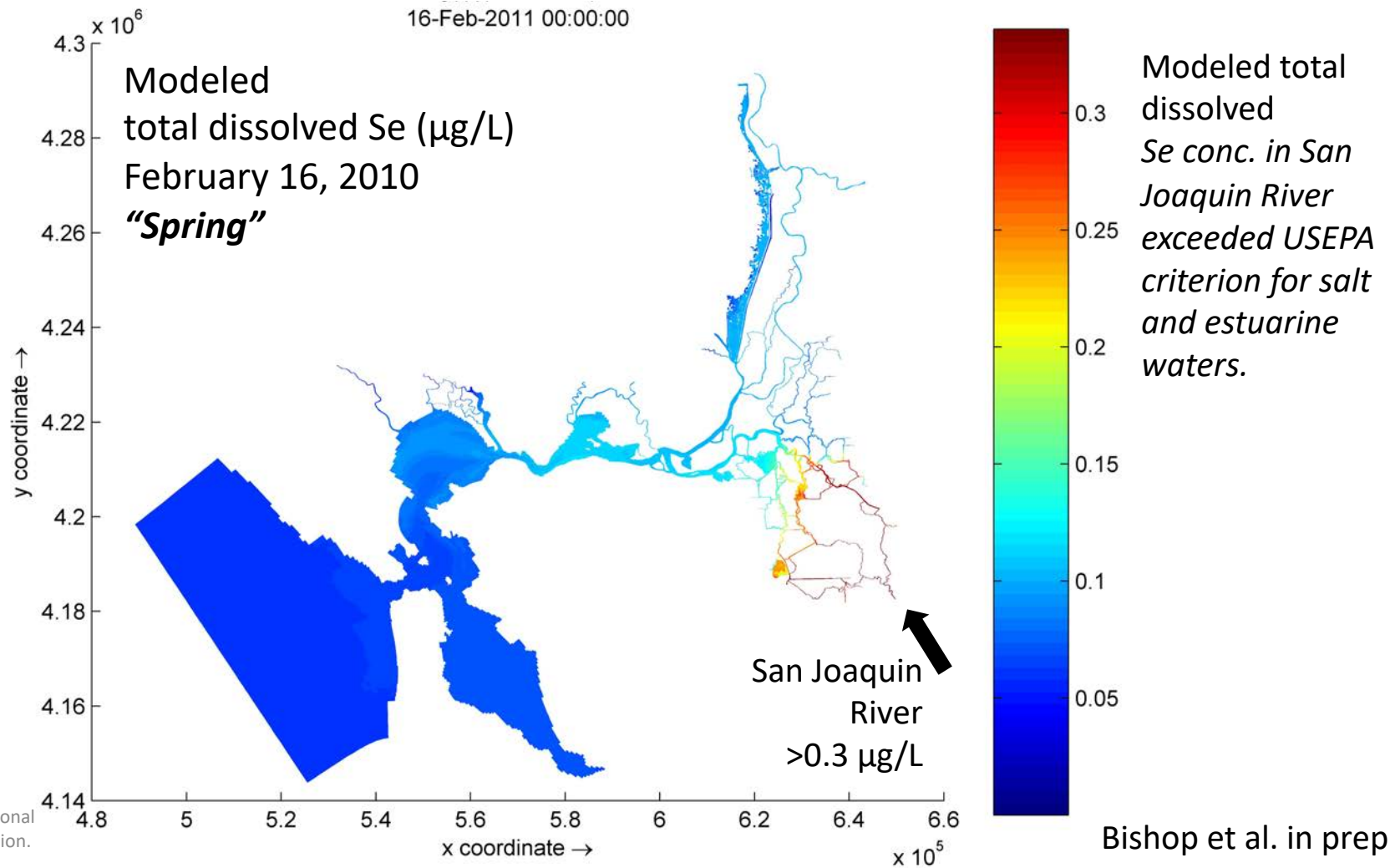


Resulting source contributions
vary seasonally

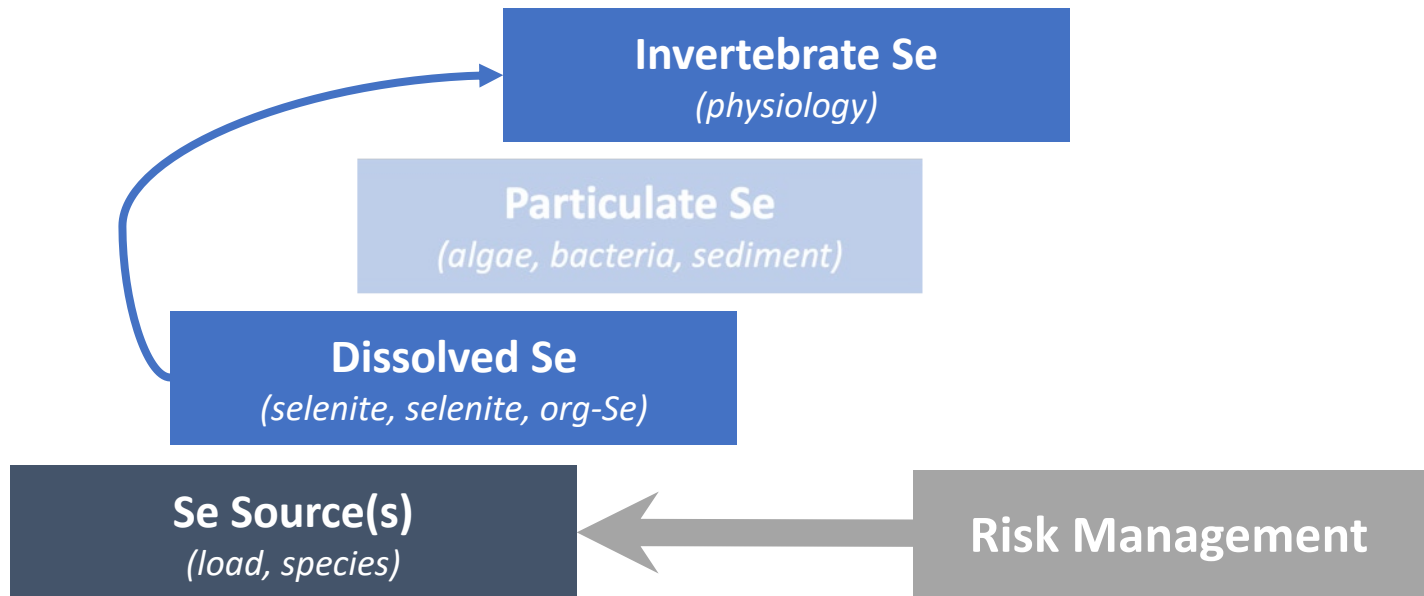


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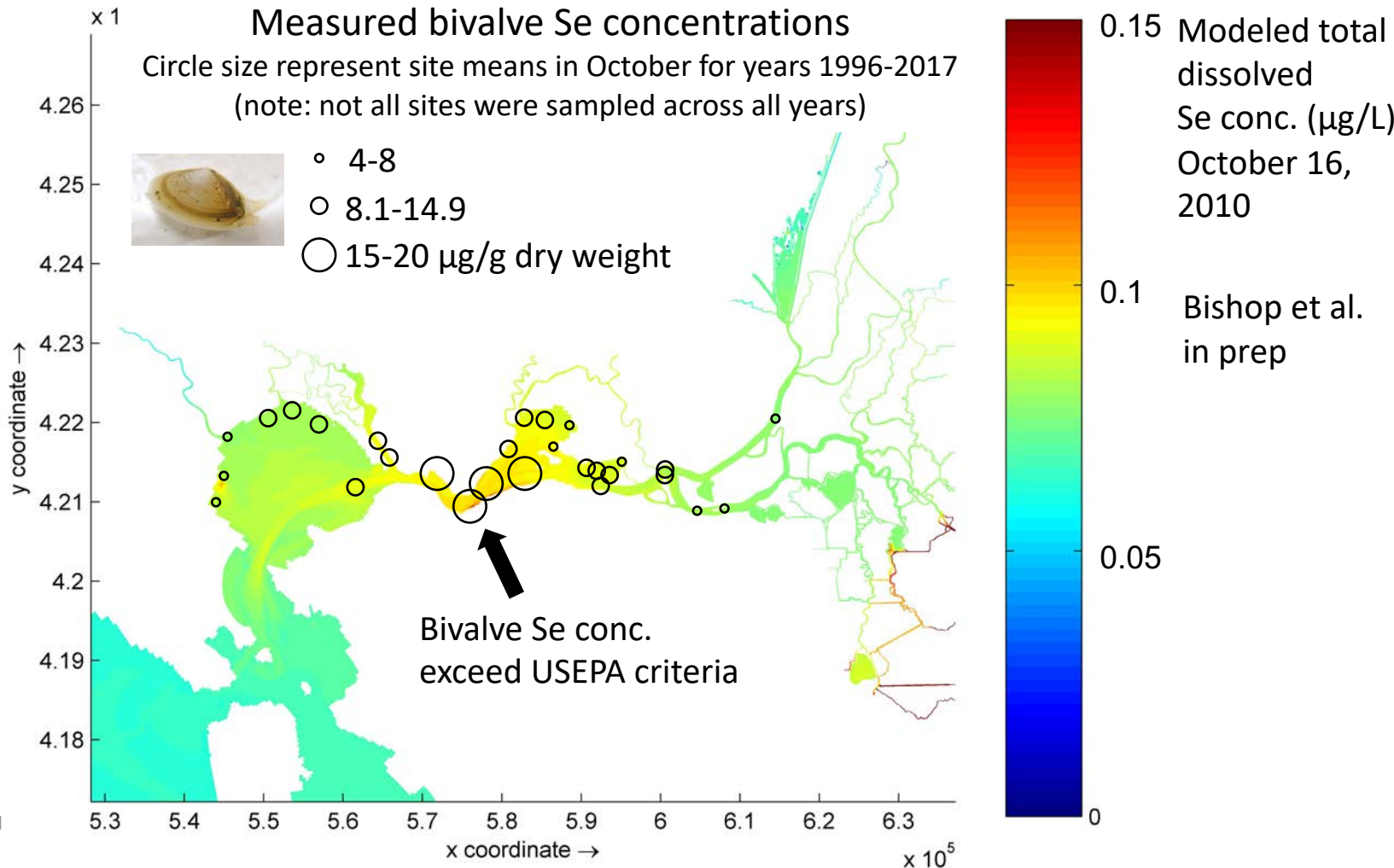
Bishop et al. in prep



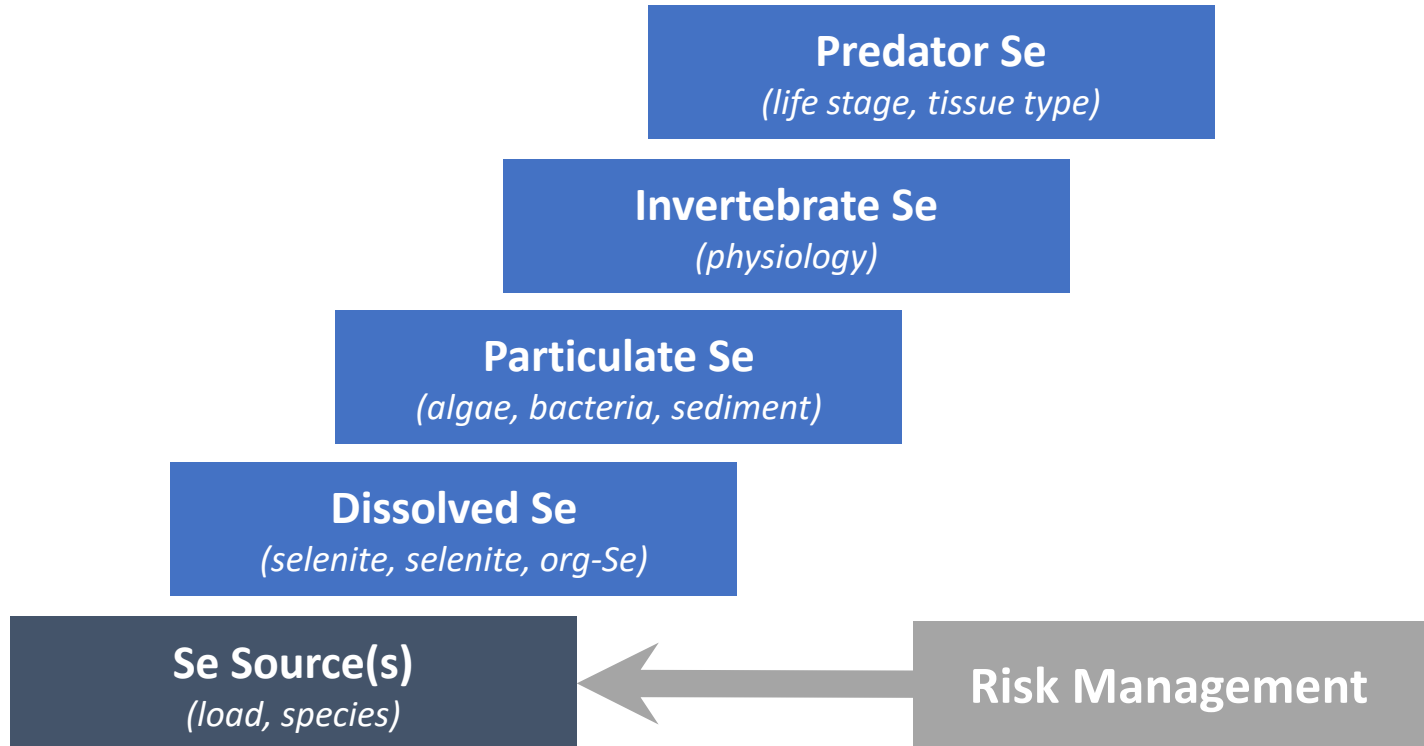
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Linville et al.
2002
Stewart et al.
2013

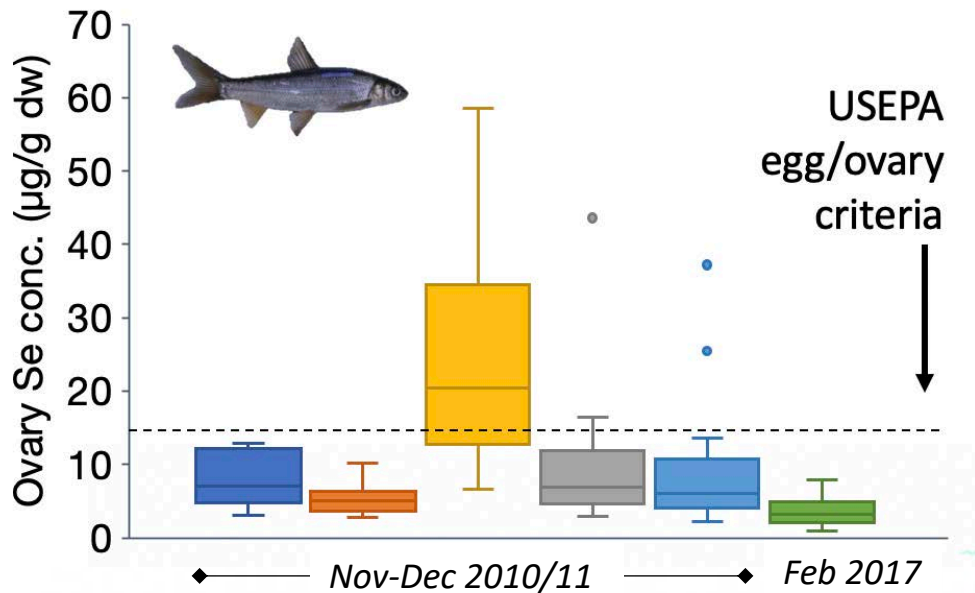


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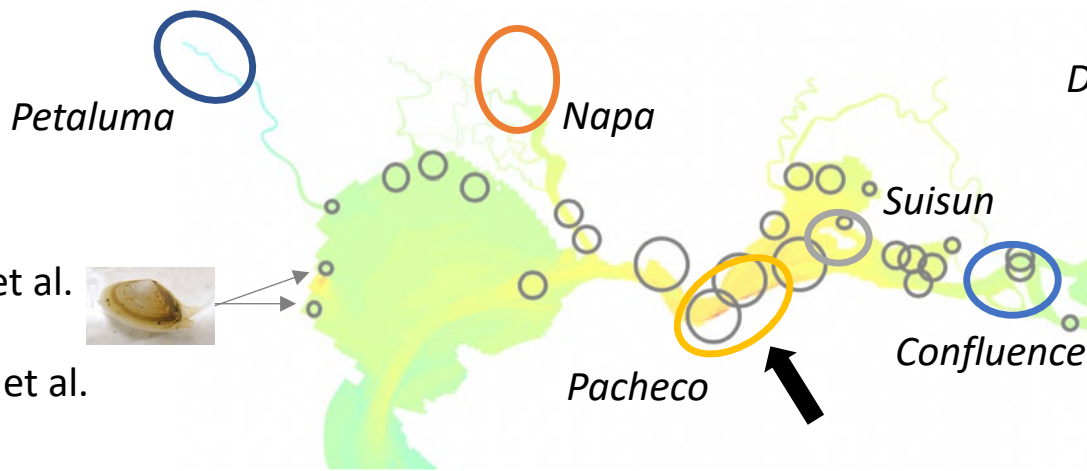
Box plots
(median,
quartile range,
min-max)
by site

Stewart et al.
in press



Measured Se levels in
Splittail ovary
exceeded USEPA
criterion in areas
near Pacheco Creek
corresponding to
elevated levels in
bivalves and modeled
total dissolved Se.

Se levels in muscle
tissue NOT exceeded
(data not shown)



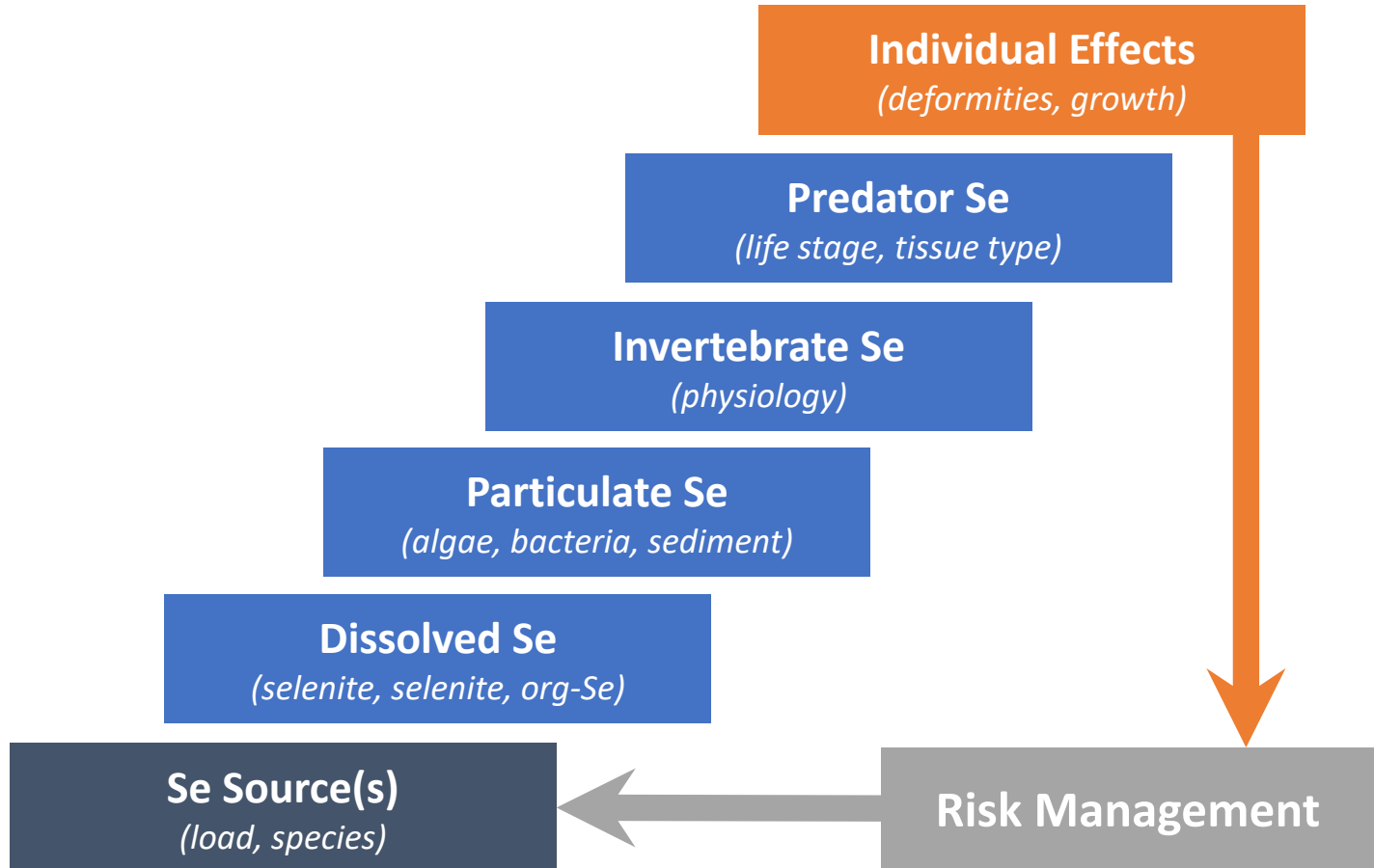
Linville et al.
2002



Stewart et al.
2013

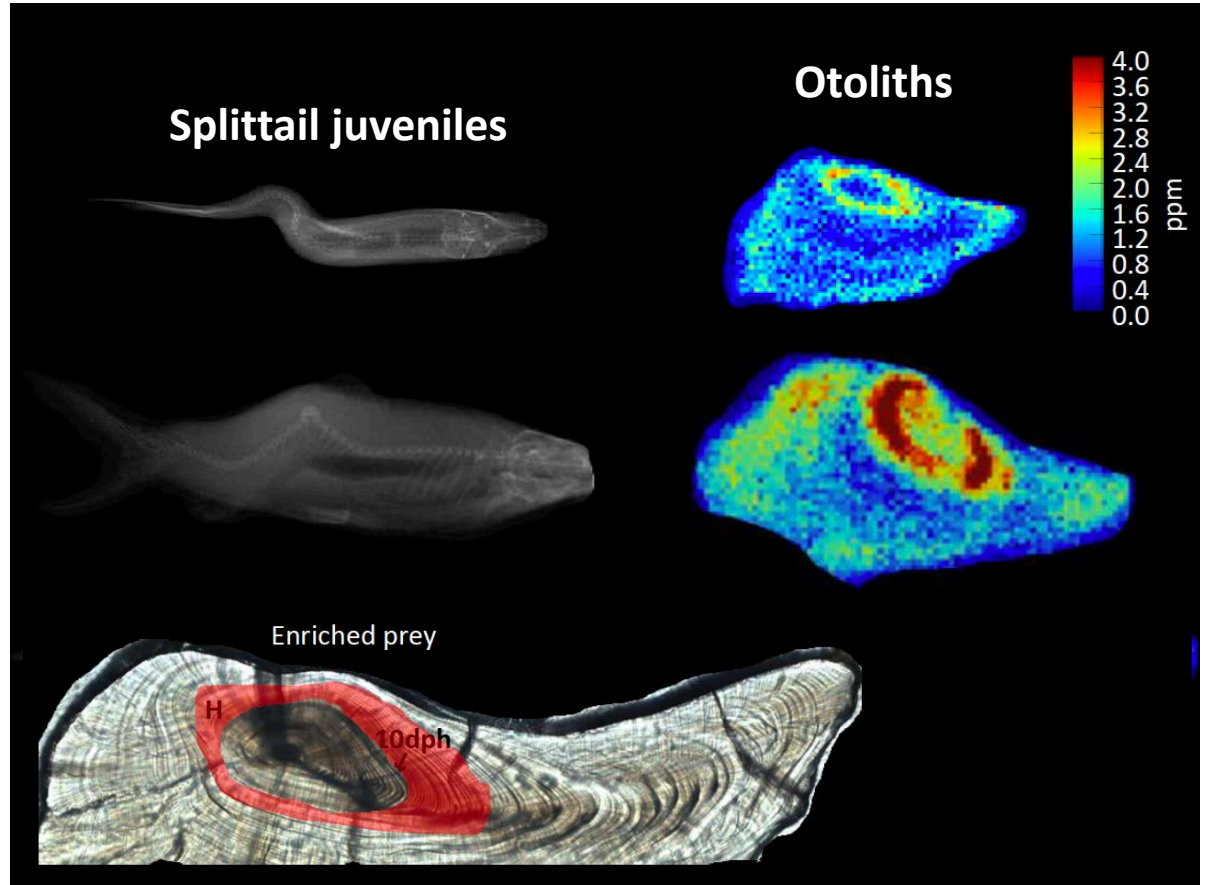
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in prep

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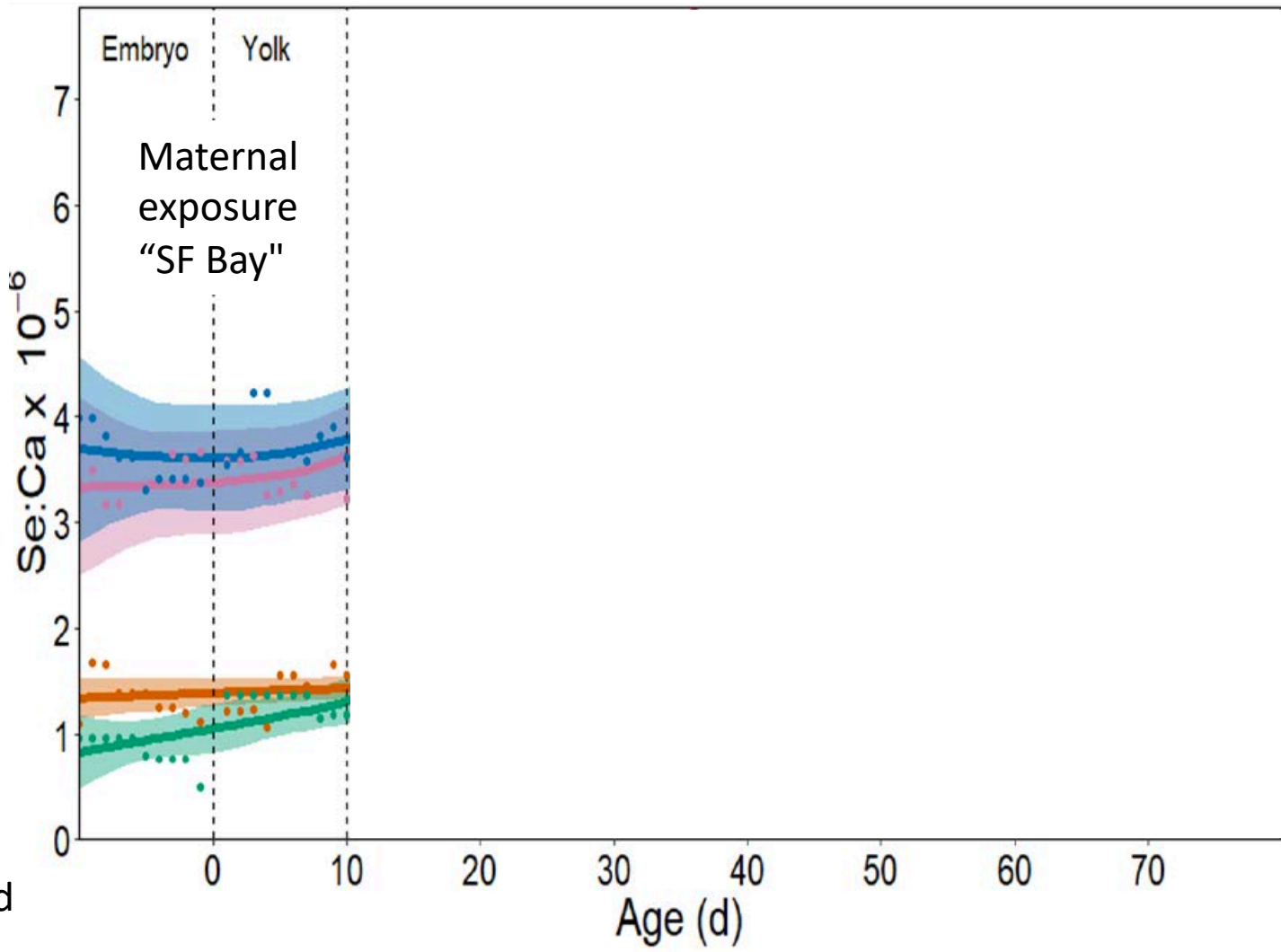
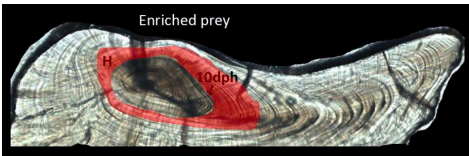


X-ray micrographs
confirmed deformities
in juveniles

Synchrotron @ Cornell
tracks daily Se and
Strontium levels



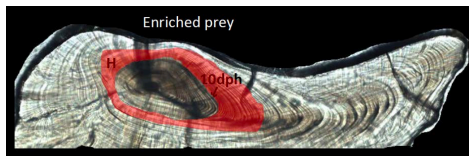
- Deformed
- Undiagnosed
- Control - wild
- Control - culture



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Johnson et al. submitted

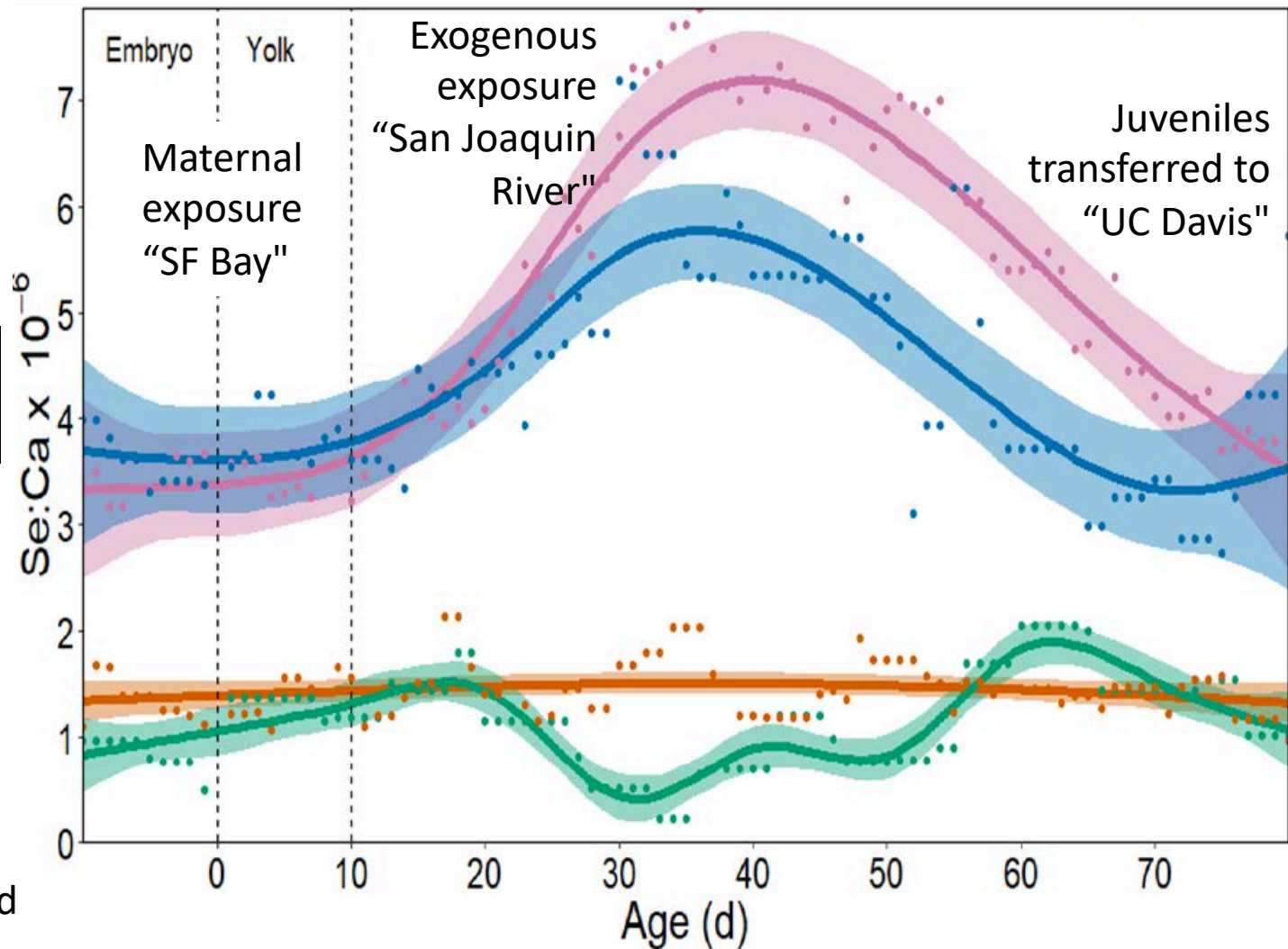
- Deformed
- Undiagnosed
- Control - wild
- Control - culture



Both maternal and exogenous exposures may have contributed to toxicity in juvenile Splittail

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Johnson et al. submitted



Summary

What were the primary sources of exposure?

- Ocean, Sacramento, Refineries
- San Joaquin River

Were criteria exceeded?

- Not in Bay water ($0.2 \mu\text{g/L}$), yes in SJR
- Yes in bivalves ($> 15 \mu\text{g/g}$)
- Yes in ovary tissue ($15.1 \mu\text{g/g}$), not in muscle ($11.3 \mu\text{g/g}$)
- Localized hotspots

What were the pathways of exposure:
Maternal vs. exogenous?

- Both were elevated over controls and may have contributed to toxicity event

Population Effects ??
(abundance, composition)

