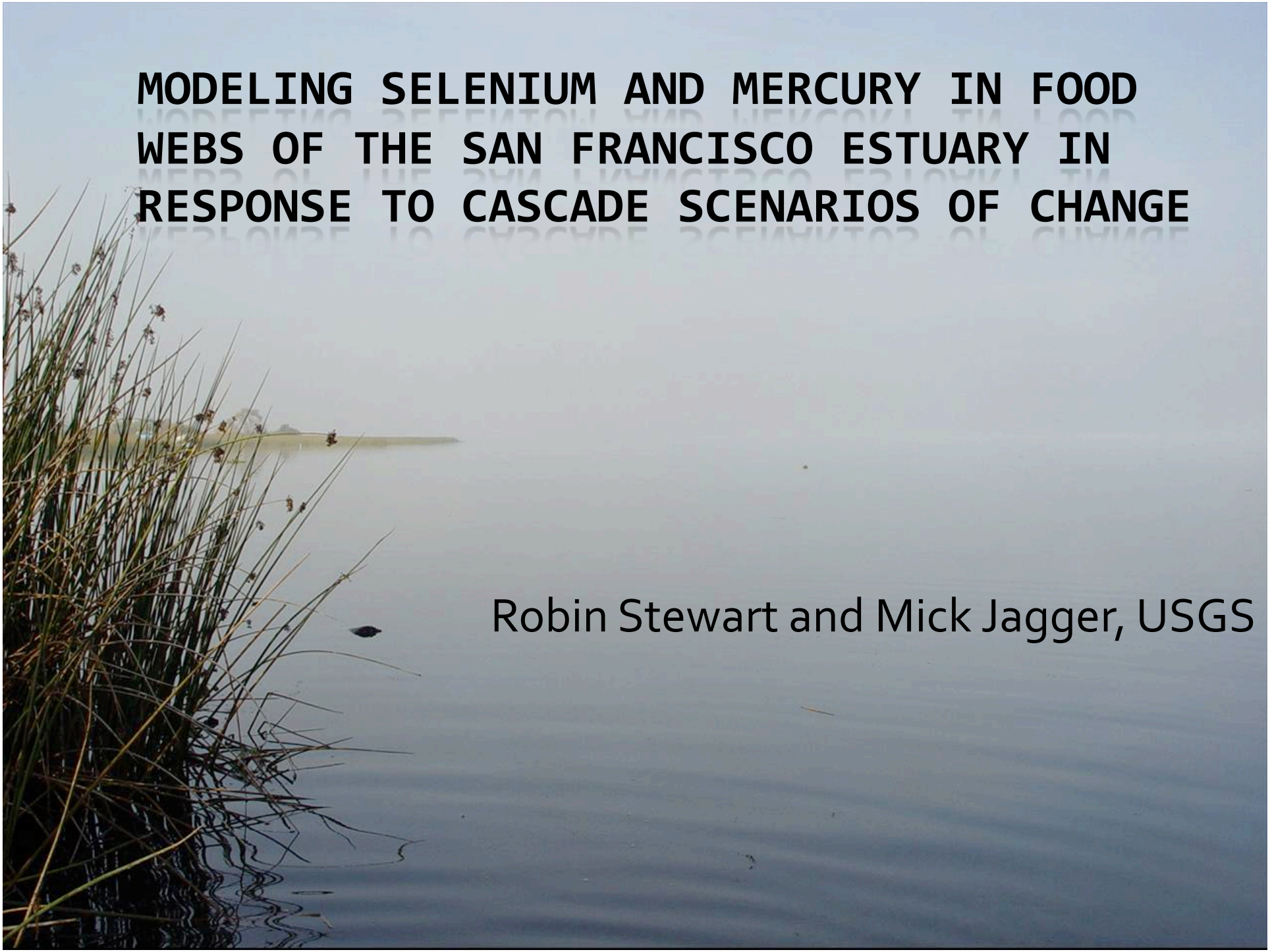


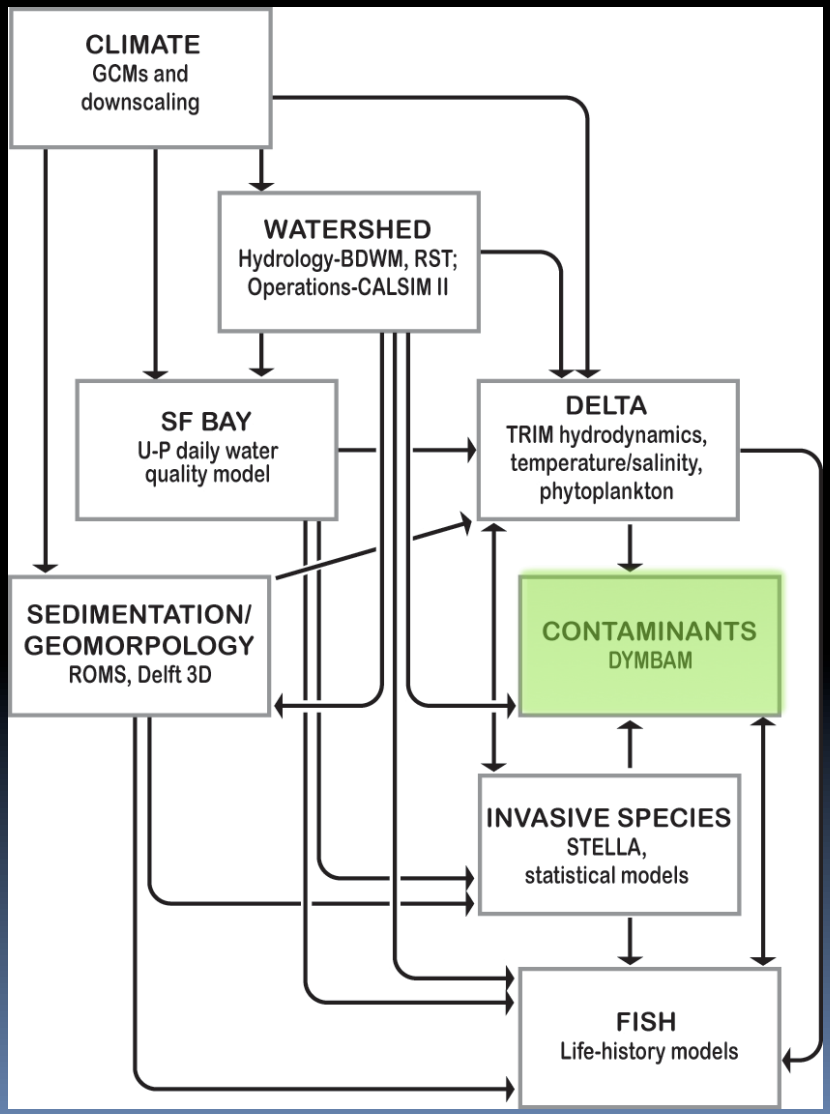
MODELING SELENIUM AND MERCURY IN FOOD WEBS OF THE SAN FRANCISCO ESTUARY IN RESPONSE TO CASCADE SCENARIOS OF CHANGE

Robin Stewart and Mick Jagger, USGS

Contaminants will play an important role in assessing outcomes of scenarios change in the Bay-Delta:

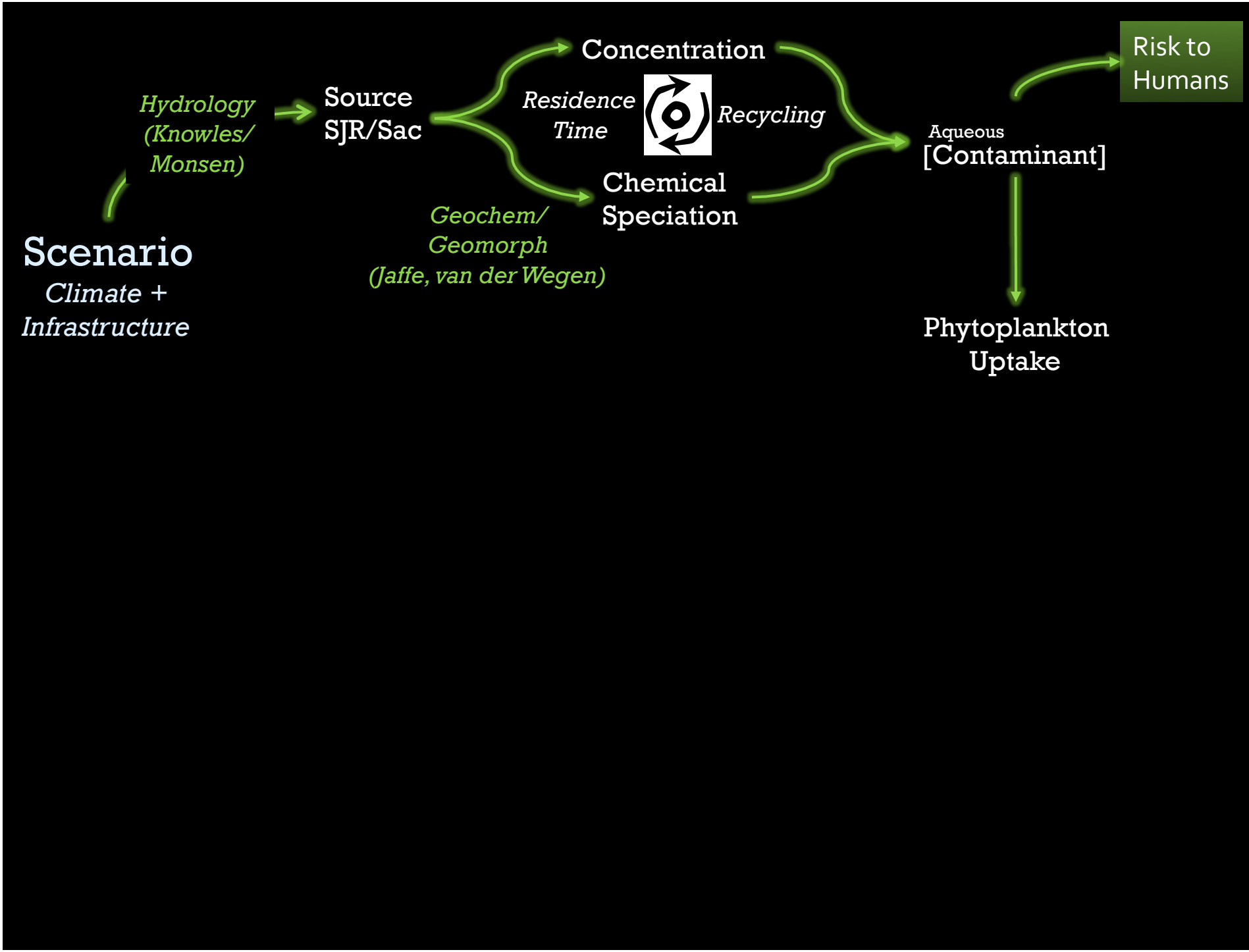
Hydrology

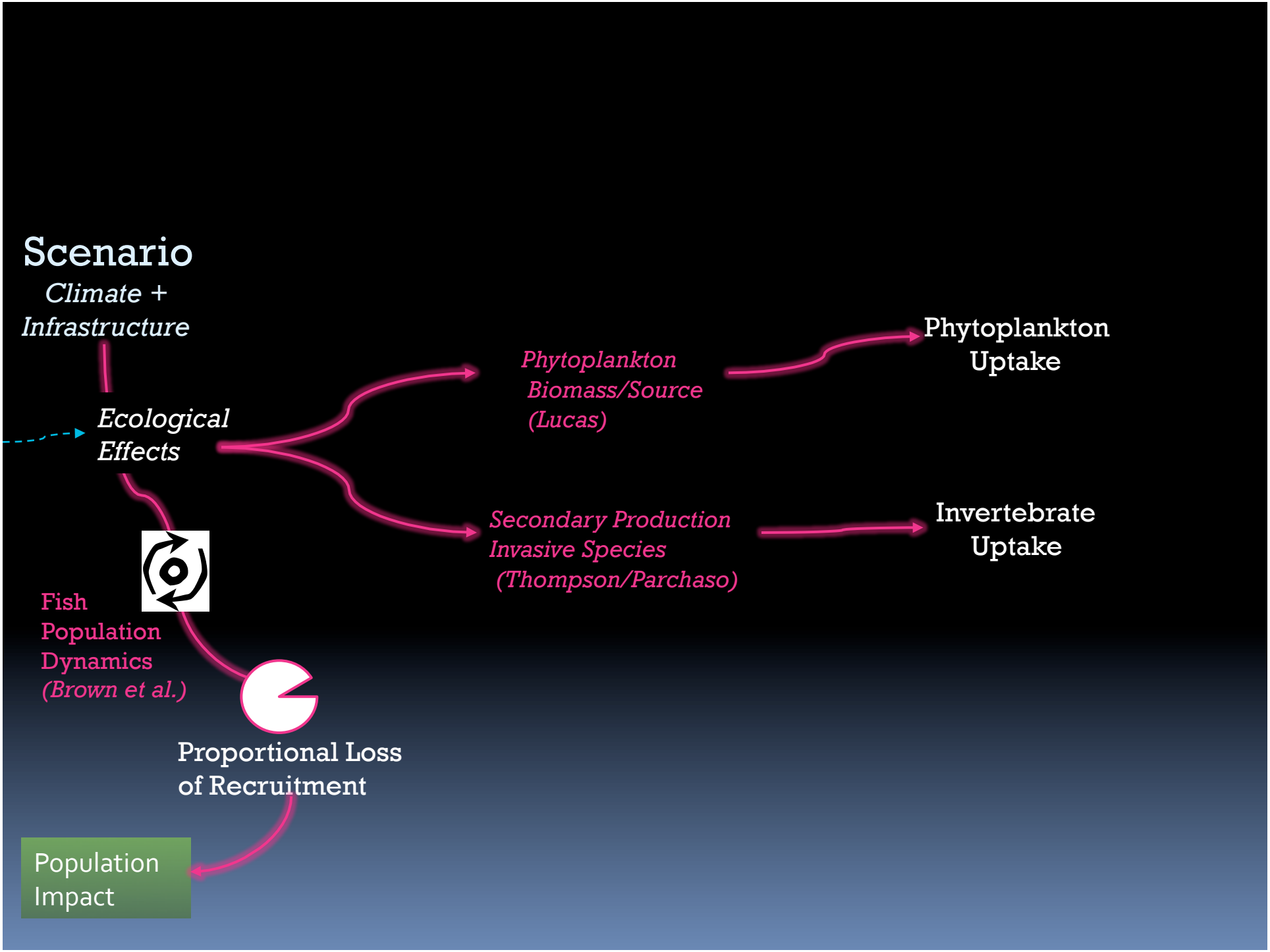
Ecology

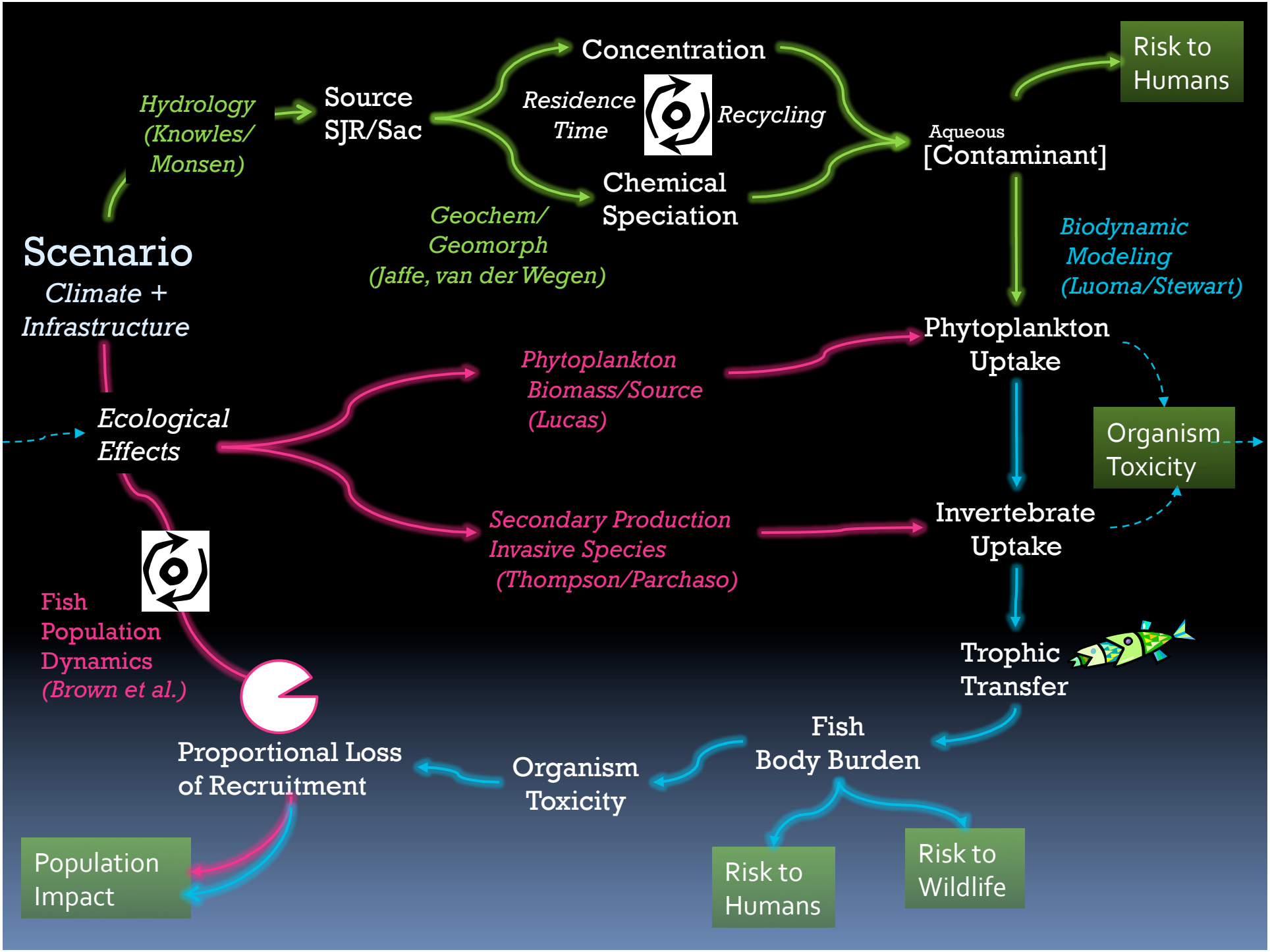


Within the CASCaDE contaminants:

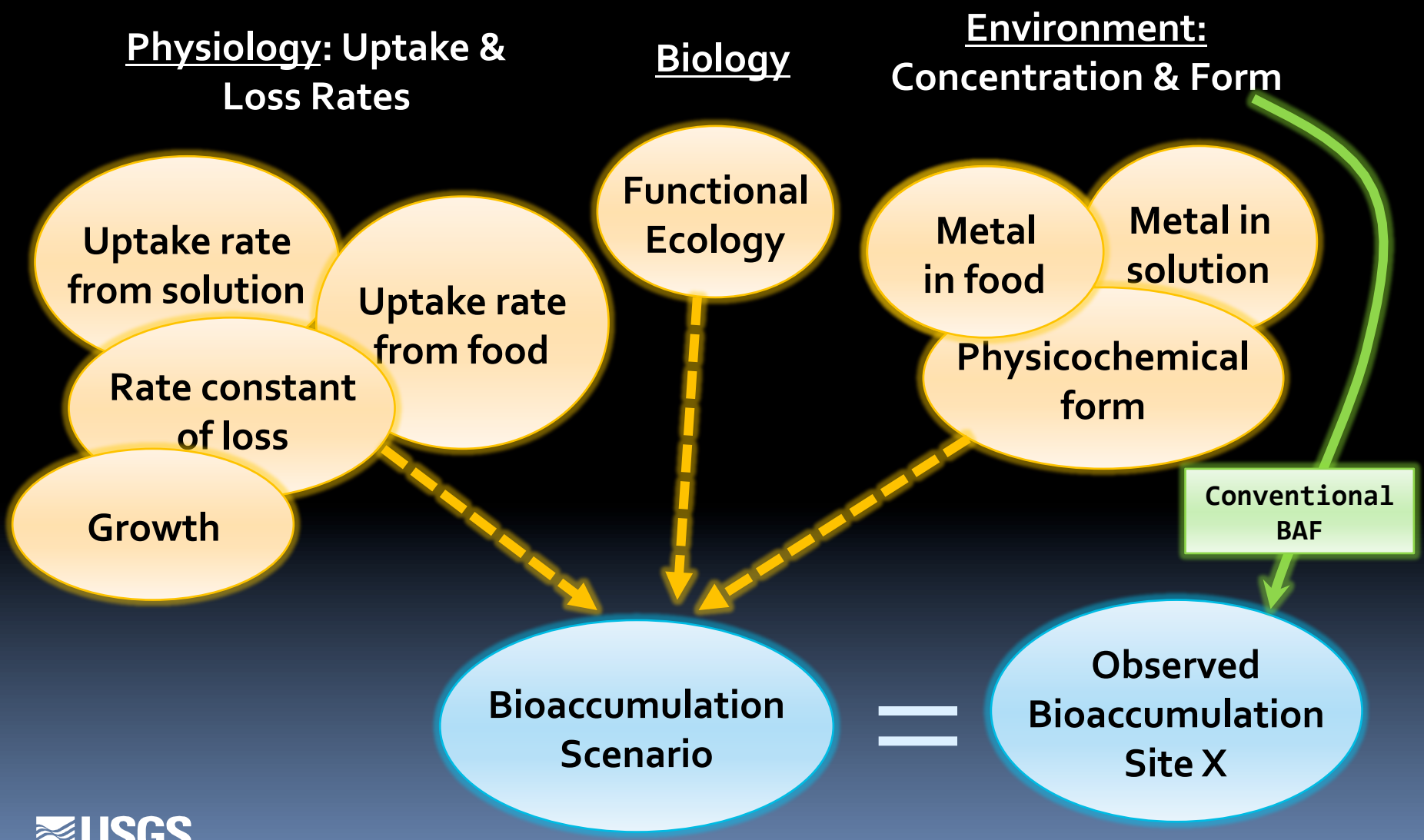
Integrate ecosystem processes and Influence population dynamics


Concentration
Risk to Humans
Hydrology (Knowles/ Monsen)
Source SJR/Sac
Residence Time
Recycling
Aqueous [Contaminant]
Chemical Speciation
Geochem/ Geomorph (Jaffe, van der Wegen)
Scenario
Climate + Infrastructure
Phytoplankton Uptake


Scenario
Climate +
Infrastructure
Ecological
Effects
Phytoplankton
Biomass/Source
(Lucas)
Phytoplankton
Uptake
Secondary Production
Invasive Species
(Thompson/Parchaso)
Invertebrate
Uptake
Fish
Population
Dynamics
(Brown et al.)
Proportional Loss
of Recruitment
Population
Impact


Concentration
Risk to Humans
Hydrology (Knowles/ Monsen)
Source SJR/Sac
Residence Time
Recycling
Aqueous [Contaminant]
Chemical Speciation
Geochem/ Geomorph (Jaffe, van der Wegen)
Biodynamic Modeling (Luoma/Stewart)
Scenario
Climate + Infrastructure
Phytoplankton Uptake
Phytoplankton Biomass/Source (Lucas)
Ecological Effects
Organism Toxicity
Secondary Production Invasive Species (Thompson/Parchaso)
Invertebrate Uptake
Fish Population Dynamics (Brown et al.)
Trophic Transfer
Fish Body Burden
Proportional Loss of Recruitment
Organism Toxicity
Population Impact
Risk to Humans
Risk to Wildlife

Biodynamic model concept



USGS
science for a changing world

Biodynamic Model Parameters

Uptake from water & food

steady-state $[\text{Contam.}]_{org} =$

$$= \frac{k_u [C]_w + AE \cdot IR \cdot [C]_{food}}{k_e + k_g}$$

Loss from efflux and growth

	Laboratory derived	Field measured
k_u (/d)	AE (% from food)	$[C]_w$ (ug/L)
ke (/d)	IR (g food/g tiss·d)	$[C]_{food}$ (µg/g food)
kg (/d)		

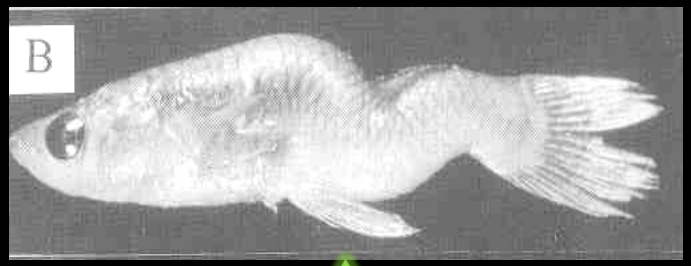
Selenium Primer - Toxicology

Element – metalloid, sulfur analogue, inorganic contaminant

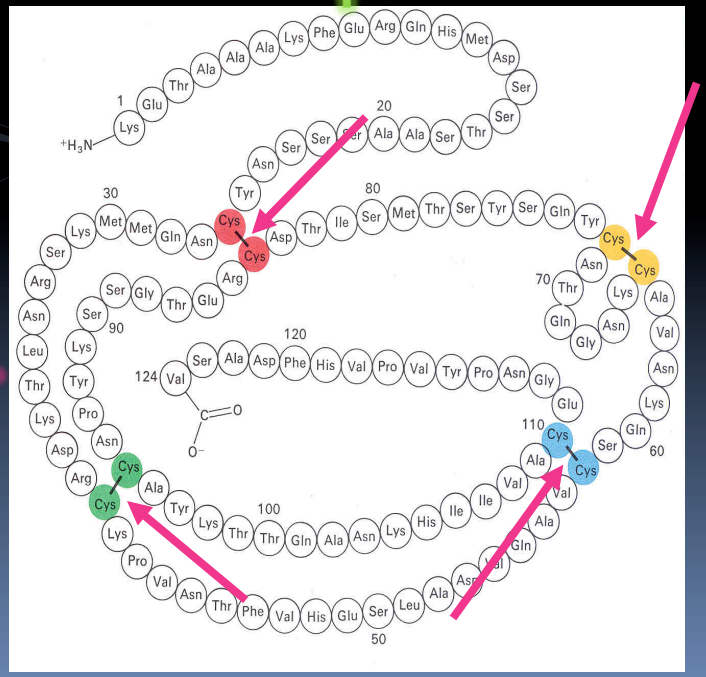
Nutrient – required by a cellular antioxidant enzyme

Poison - potent teratogen

Adult Mosquito fish

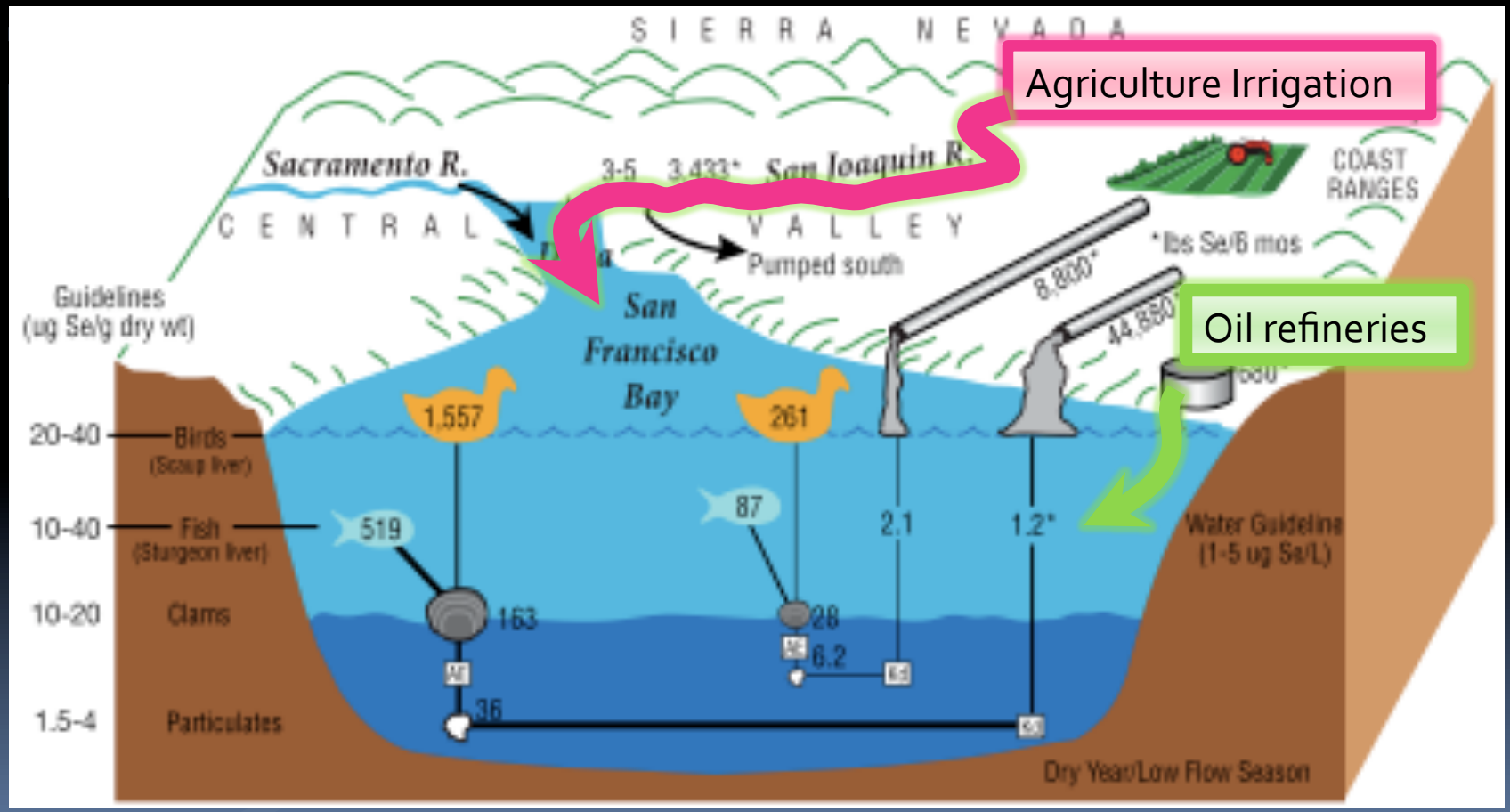


Se substitutes for S in ionic disulfide bonds of proteins ⇒tertiary structures (e.g. tissues)



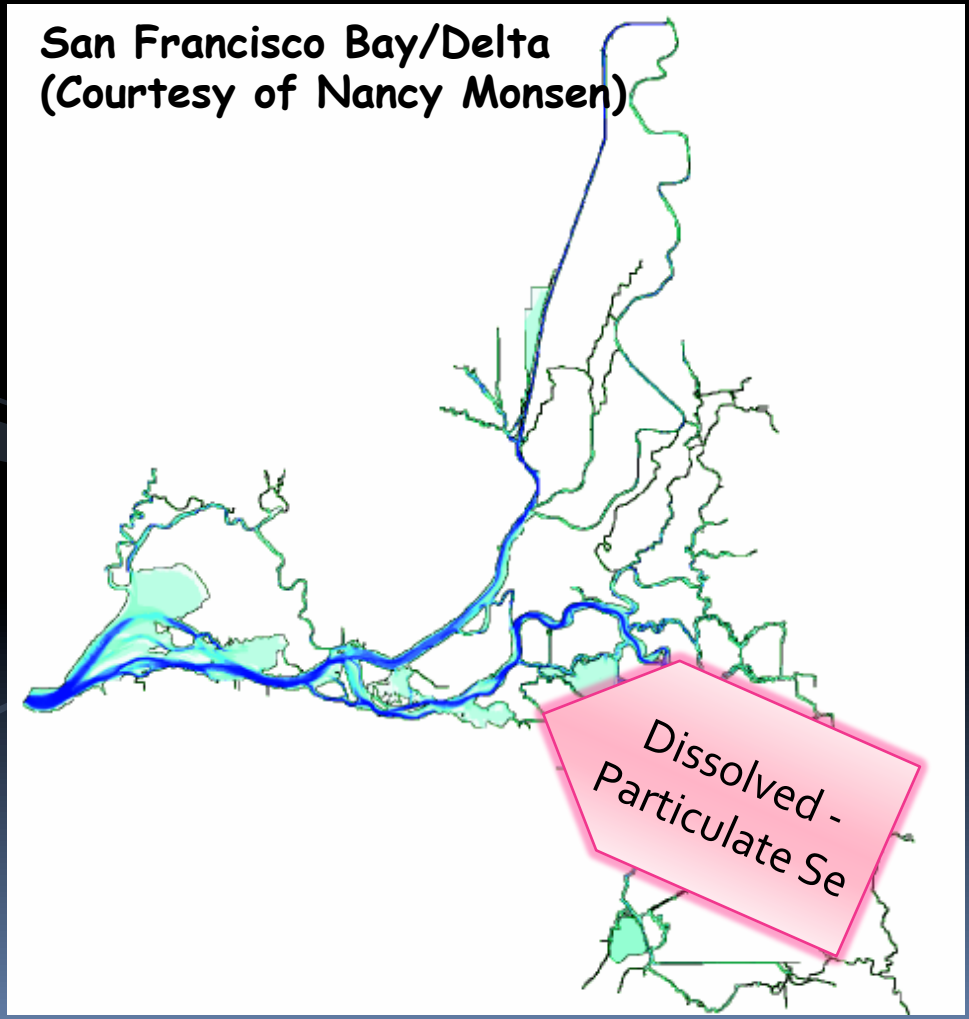
Selenium Primer - Sources

Presser and Luoma, 2006

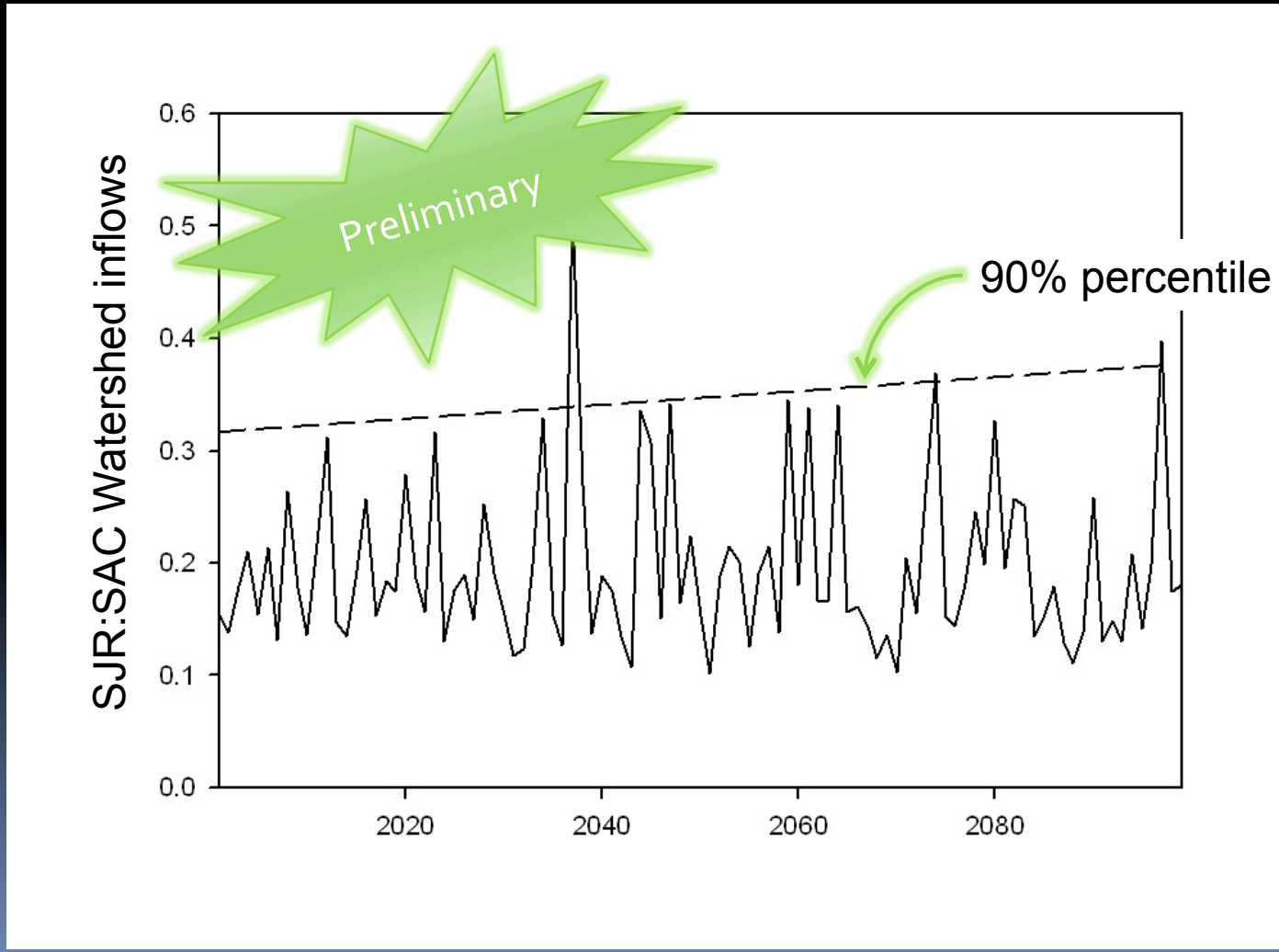


The Selenium CASCaDE

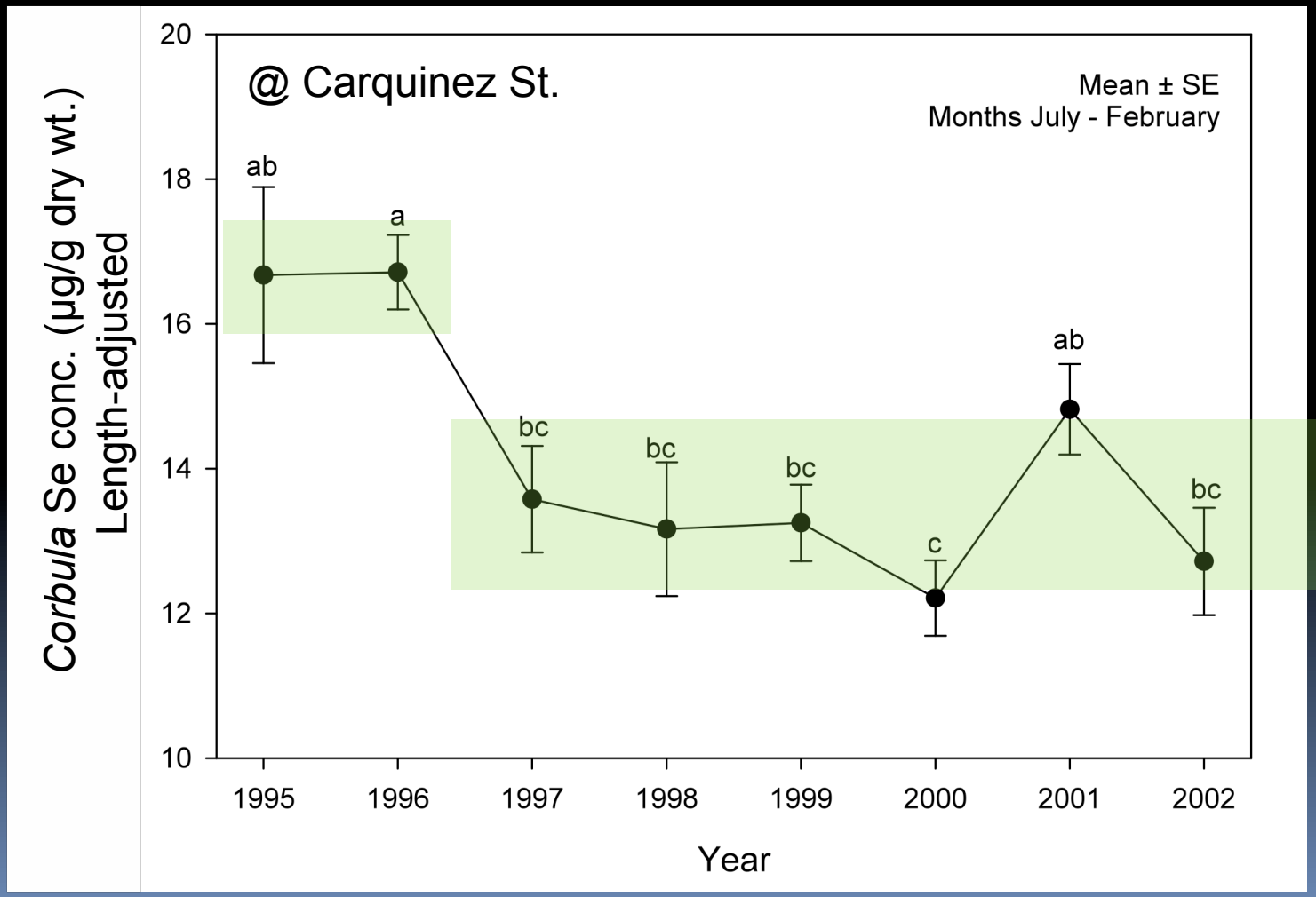
The amount and proportion of San Joaquin (Selenium source) relative to Sacramento River water entering the Bay-Delta will likely change under different scenarios



Watershed inflows to SJR:SAC Delta in gfdl-a2 scenario

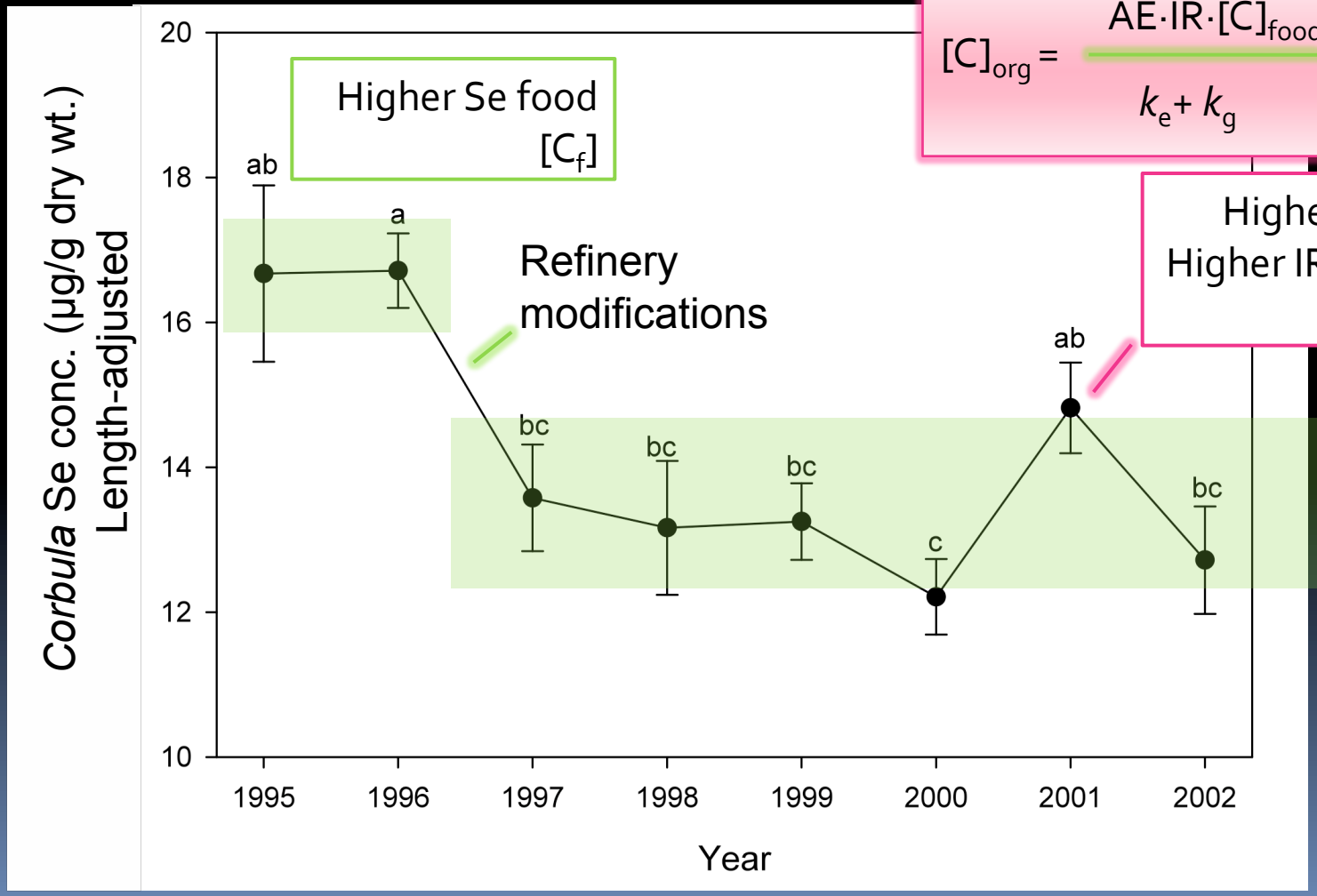


Se concentrations in *Corbula* have changed over time



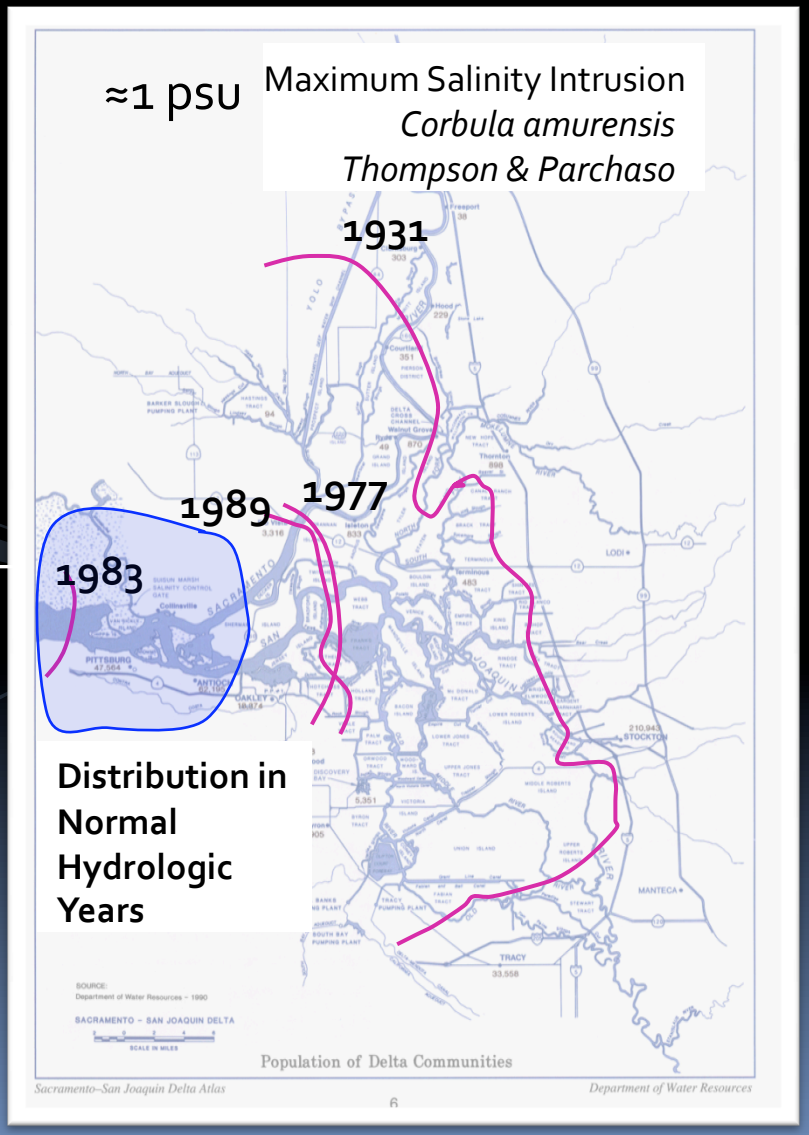
Extend dataset through 2008

Se concentrations in *Corbula* have changed over time, but perhaps for different reasons

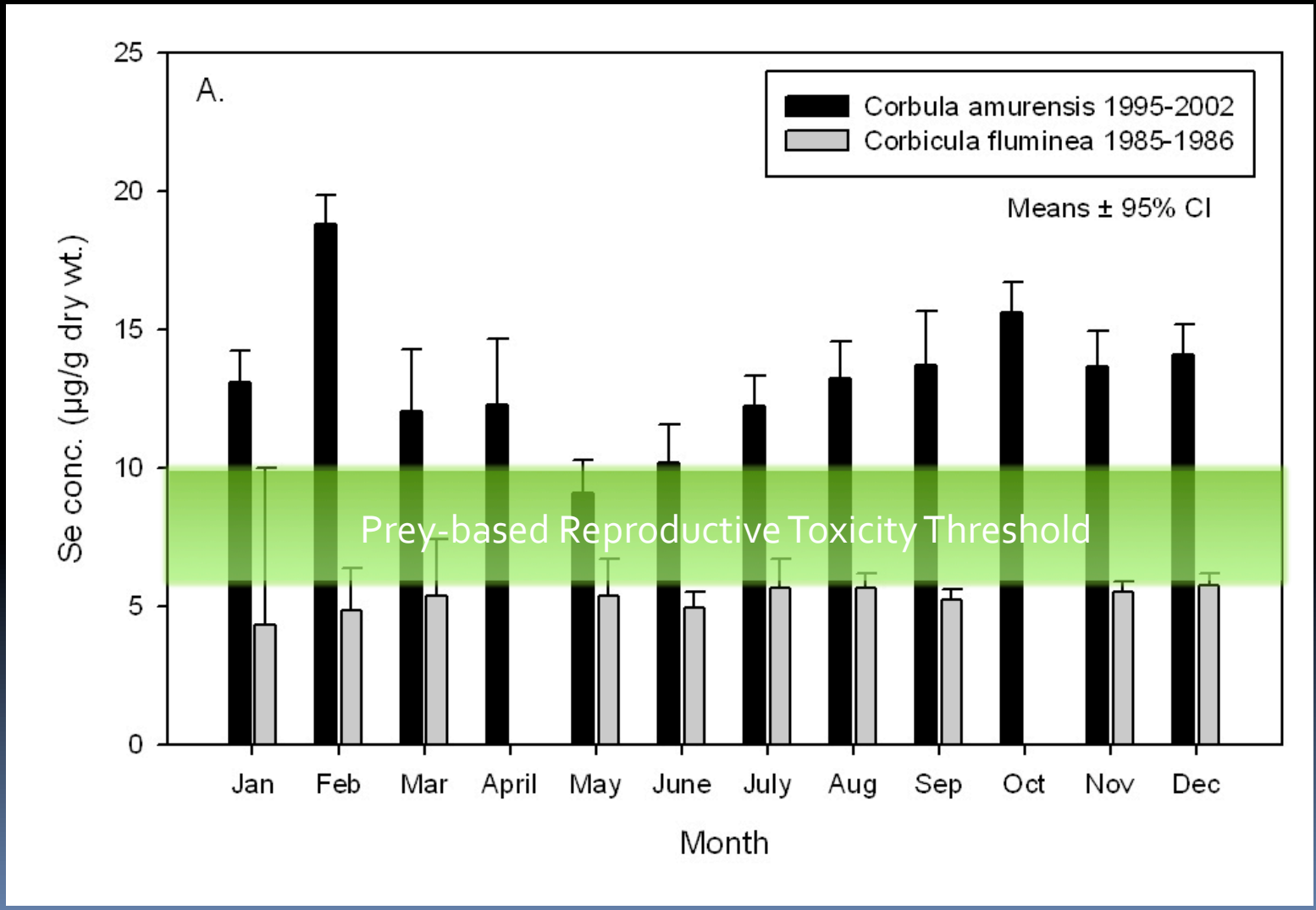


The Selenium CASCaDE

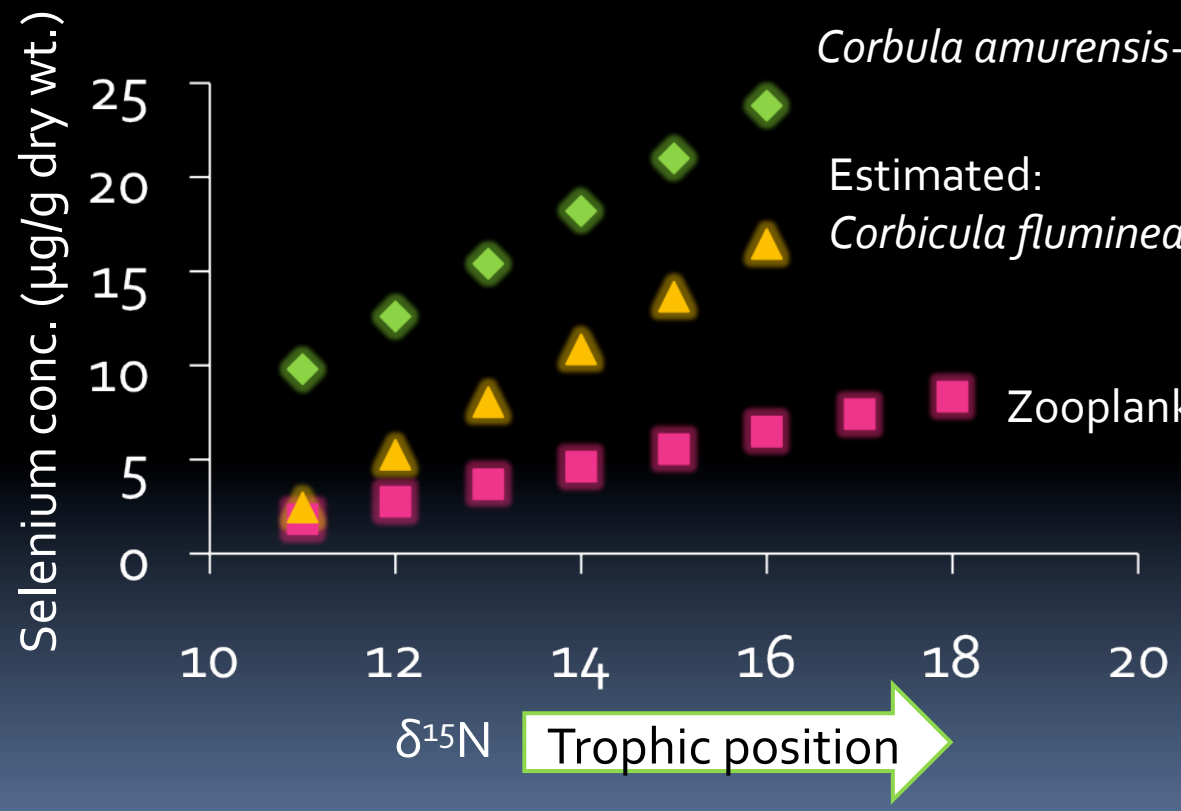
How will changes in distributions of clams influence Se bioaccumulation and trophic transfer of Se to top predators?



Species-specific physiology can enhance Selenium uptake

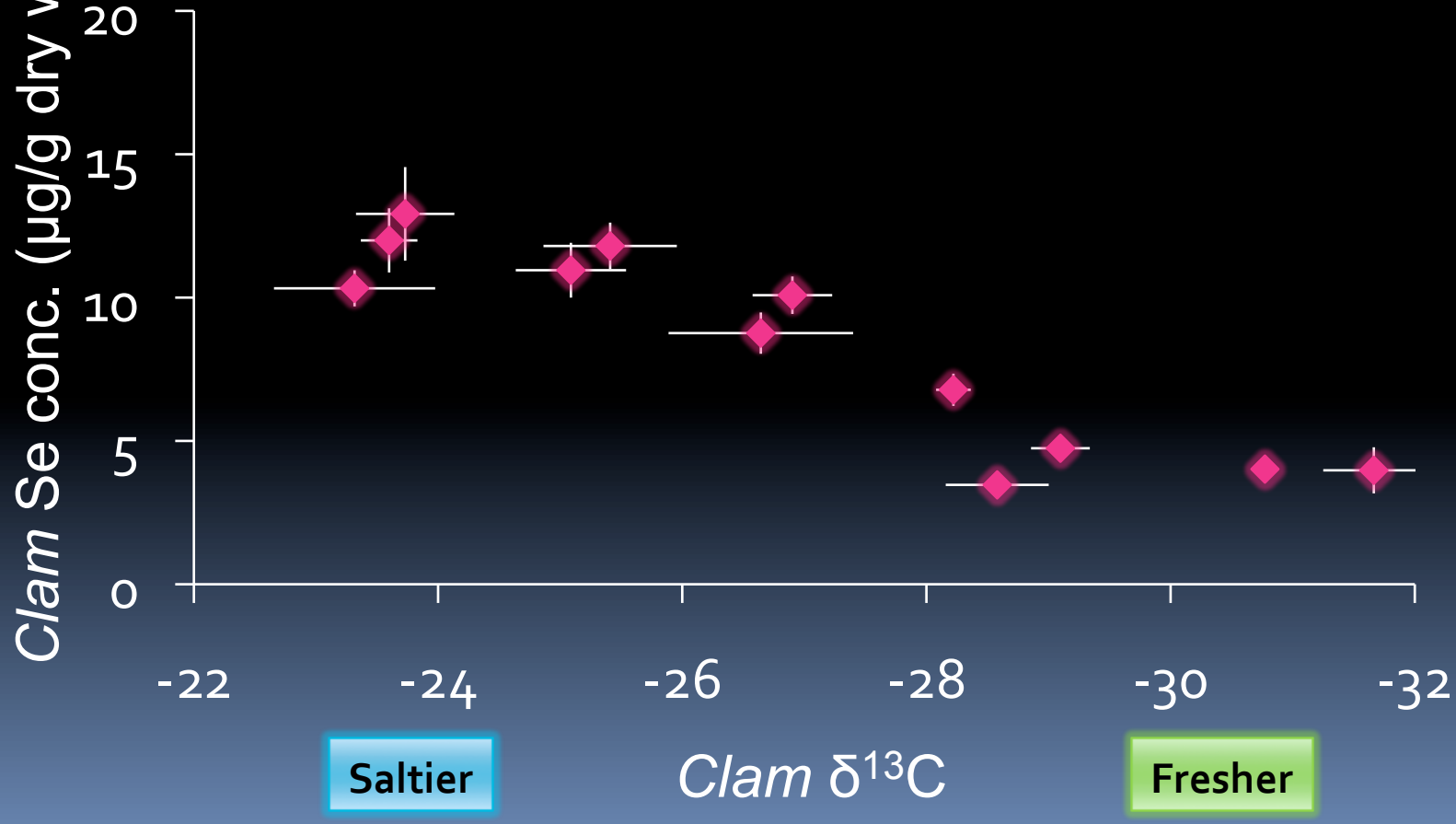


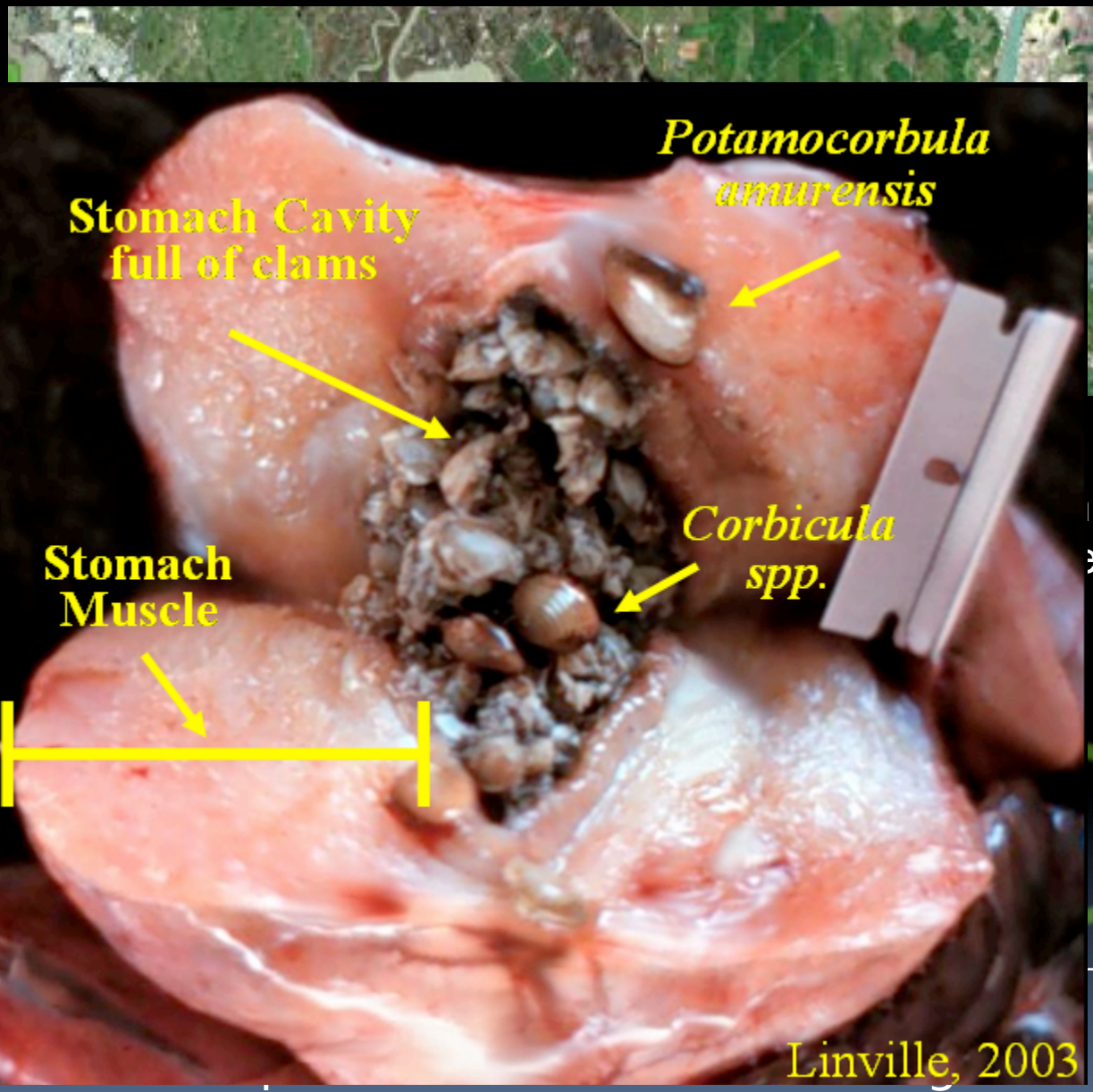
Difference in Se accumulation at the base of the food chain is propagated to top predators



Stewart et al. 2004

Mercury trophic transfer
Stewart et al. 2008
Luoma et al. 2008


Clam Se conc. (µg/g dry wt.)
20
15
10
5
0
-22
-24
-26
-28
-30
-32
Saltier
Clam δ13C
Fresher



Clam Se conc. (µg/g dry wt.)

20
15
10
5
0

and
ecies

-32

Saltier

Clam $\delta^{13}C$

Fresher

Clam and White sturgeon Se conc. (µg/g dry wt.)

White sturgeon Se conc. decline upstream with Clam Se conc.

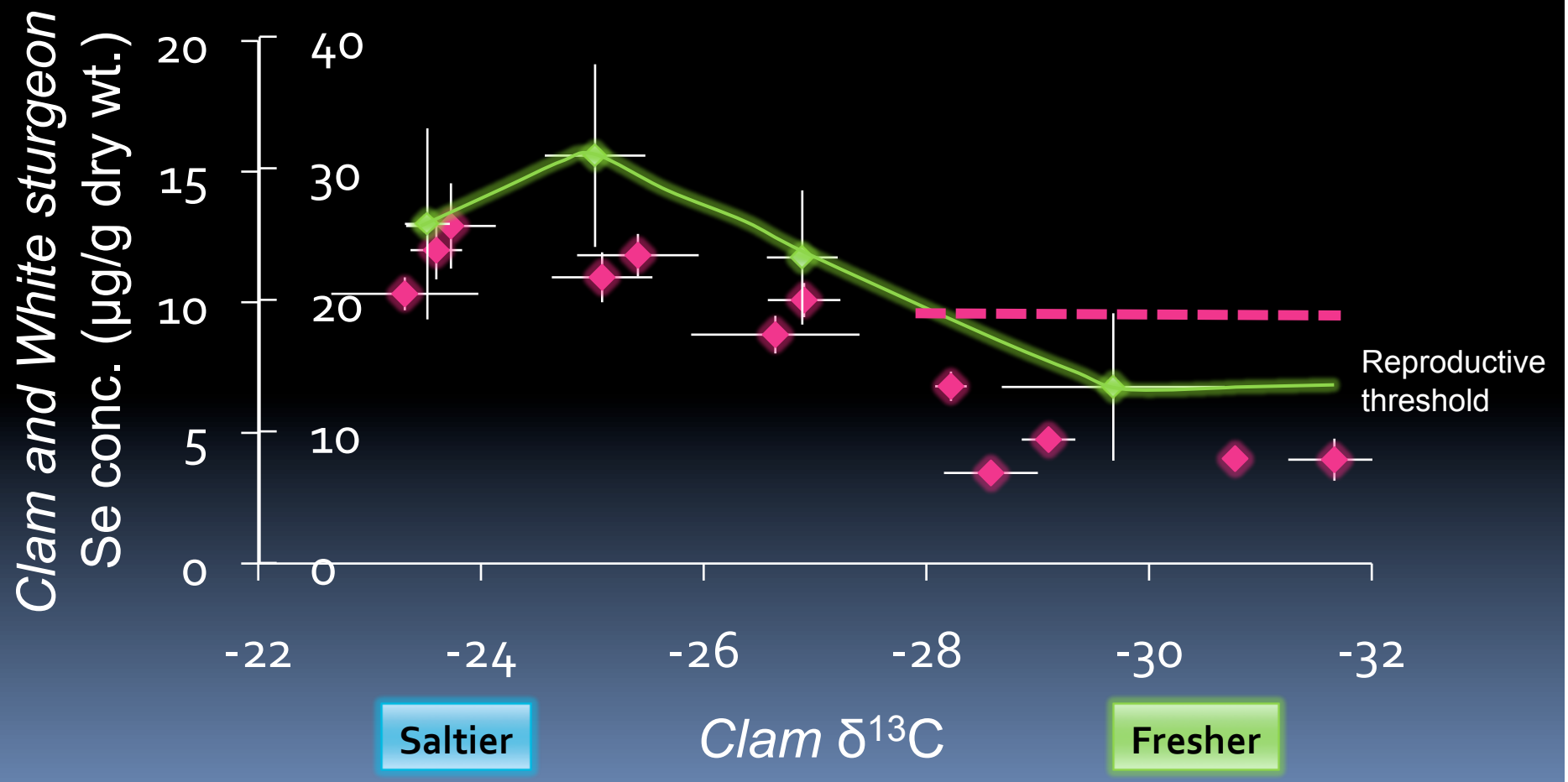
Reproductive threshold

Clam or W. sturgeon $\delta^{13}C$

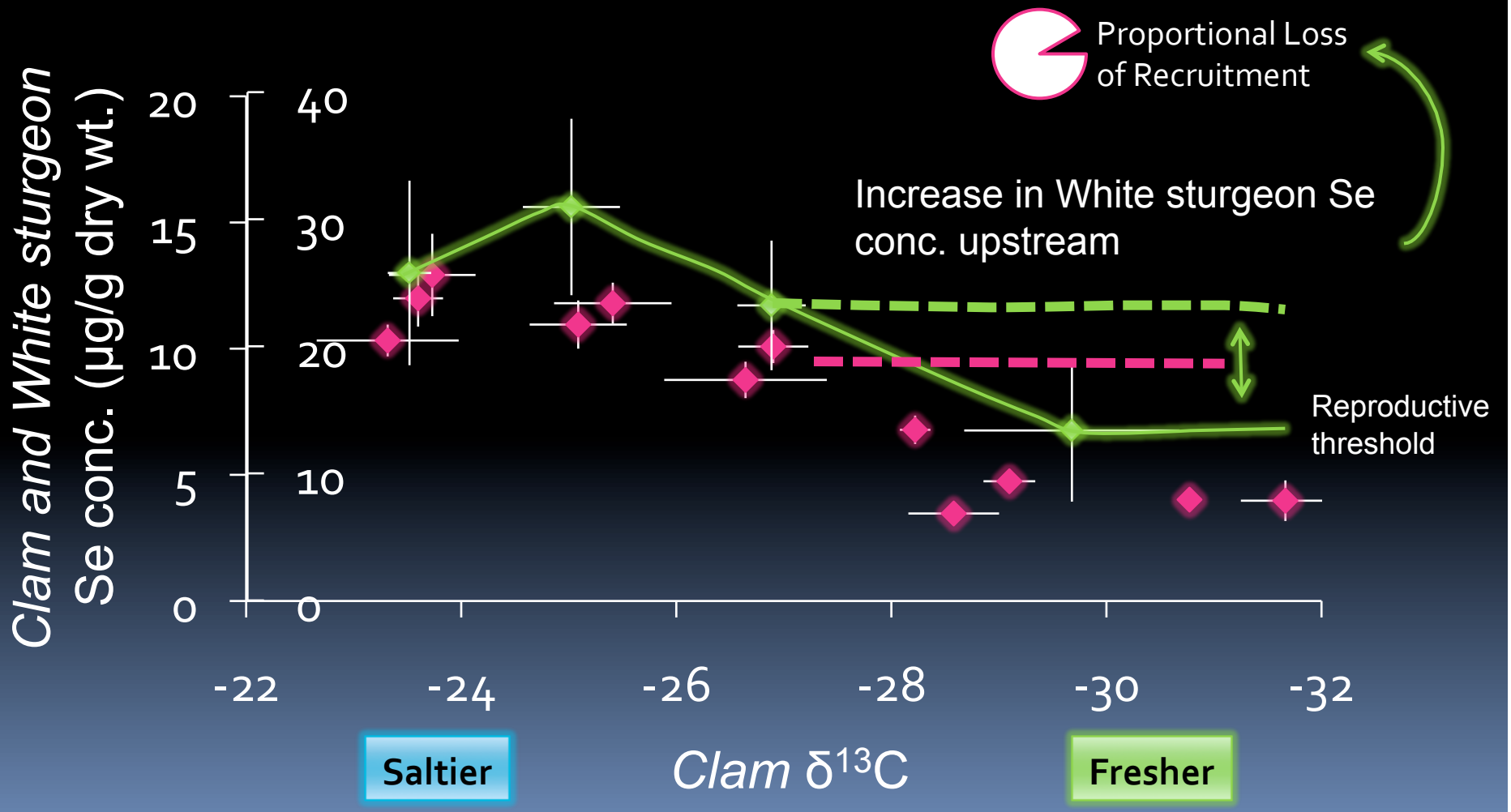
Saltier

Fresher

So what happens under maximum salinity intrusion into the Delta and we extend *Corbula* occurrence upstream?



So what happens under maximum salinity intrusion into the Delta and we extend *Corbula* occurrence upstream?



Conclusions

- Hydrological and ecological changes driven by climate change could be influential in determining the impacts of Se contamination in this estuary

Next steps

- Use model to distinguish the relative contribution of:

  FOOD AVAILABILITY

  SE CONCENTRATIONS IN FOOD

- Evaluate changes in clam tissue Se concentrations relative to changes in food availability and Se concentrations in food under different scenarios
- Invasive species
- Estimate impacts on fish populations