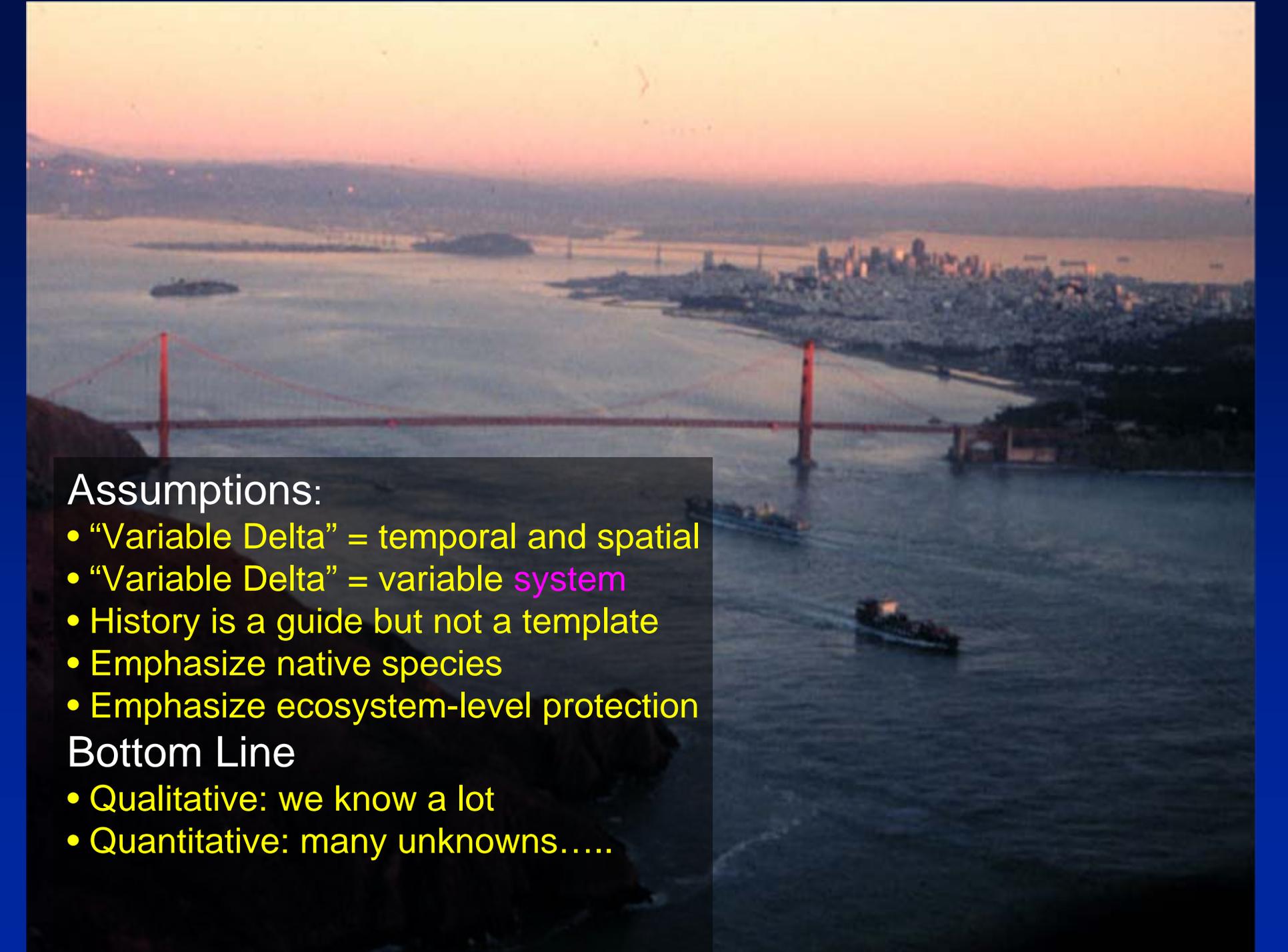


# What Are the Big Knowns and Unknowns for a Variable Delta?

# What Are the Big Knowns and Unknowns for a Variable Delta?

An aerial photograph of the Golden Gate Bridge in San Francisco, California, taken during sunset. The bridge's iconic red-orange towers and suspension cables are visible, spanning across the dark blue water of the bay. In the background, the city of San Francisco is illuminated by its lights, and the distant hills are silhouetted against the orange and pink sky. Several boats are visible on the water in the foreground.

## Assumptions:

- “Variable Delta” = temporal and spatial
- “Variable Delta” = variable system
- History is a guide but not a template
- Emphasize native species
- Emphasize ecosystem-level protection

## Bottom Line

- Qualitative: we know a lot
- Quantitative: many unknowns.....

An aerial photograph of the Golden Gate Bridge in San Francisco, California, taken during sunset. The bridge's iconic red-orange towers and suspension cables are visible, spanning across the water. In the background, the city of San Francisco is illuminated by its lights, and the bay is dotted with several boats. The sky is a mix of soft pinks, oranges, and blues.

## Assumptions:

- “Variable Delta” = temporal and spatial
- “Variable Delta” = variable system
- History is a guide but not a template
- Emphasize native species
- Emphasize ecosystem-level protection

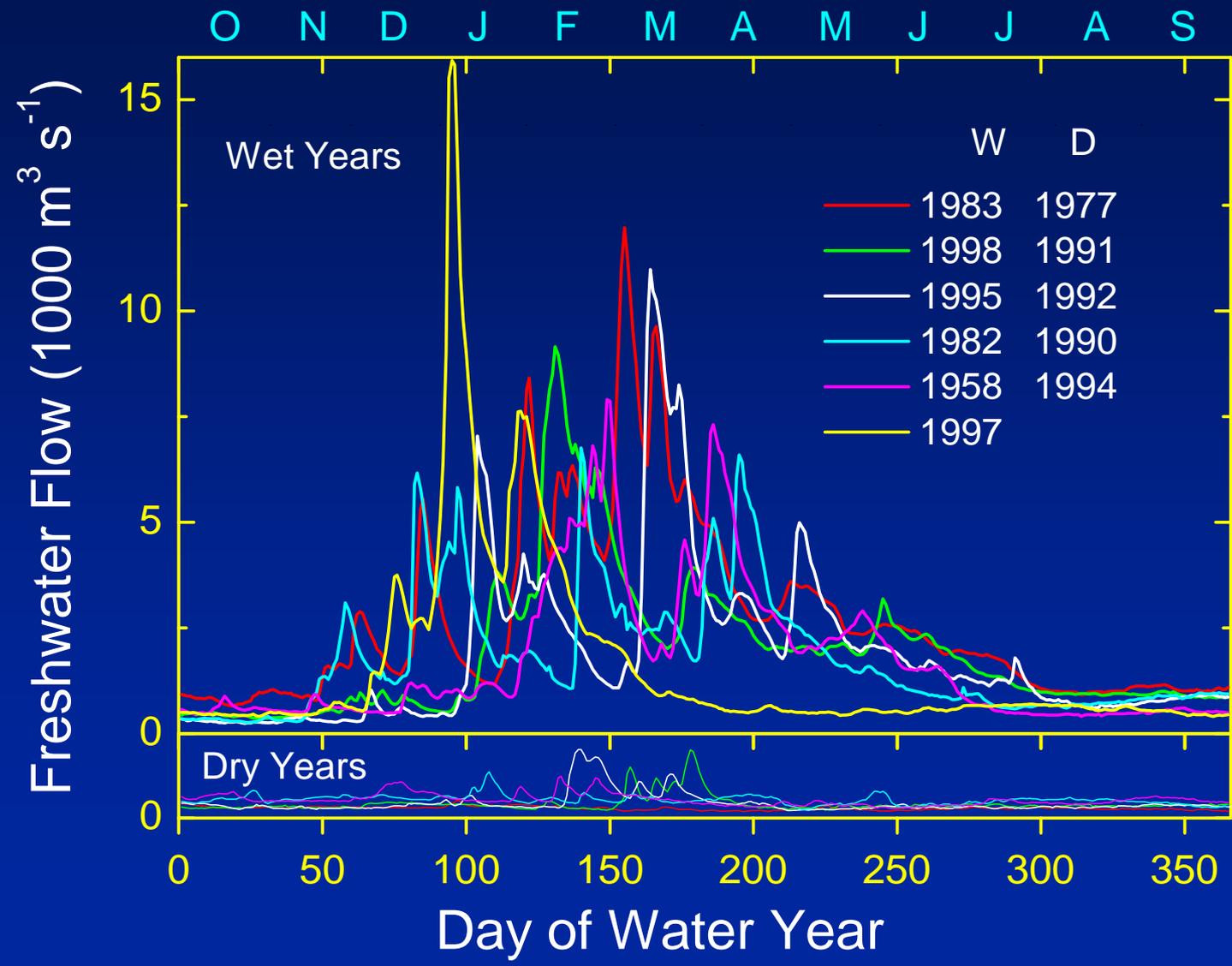
## Bottom Line

- Qualitative: we know a lot
- Quantitative: many unknowns.....

We are pretty  
sure the Delta  
will change!

# Knowns (current state)

- Freshwater flow is already variable



## Knowns (current state)

- Salinity range from seawater to fresh
- Estuary is all connected



# Knowns (current state)

- Physical system has changed
  - Marshes to islands / managed wetlands
  - Waterways
  - Flow patterns
- Assumption: species evolved in a different system



# Knowns (current state)

- Introduced species galore!  
*(not to scale)*

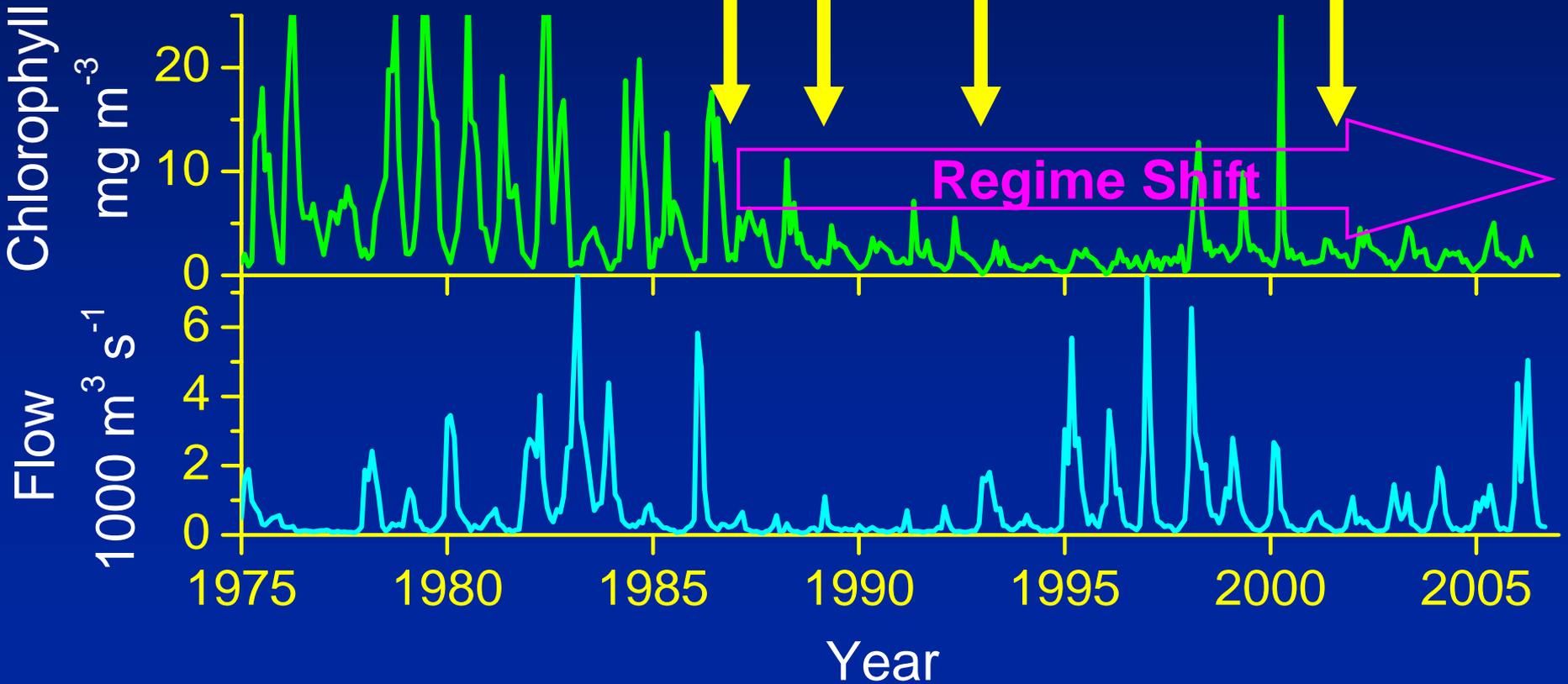


# Knowns (current state)

- Introduced species can have a big effect

*Corbula (Clams)*  
*Pseudodiaptomus forbesi*  
*Limnoithona tetraspina*

*Pelagic decline*



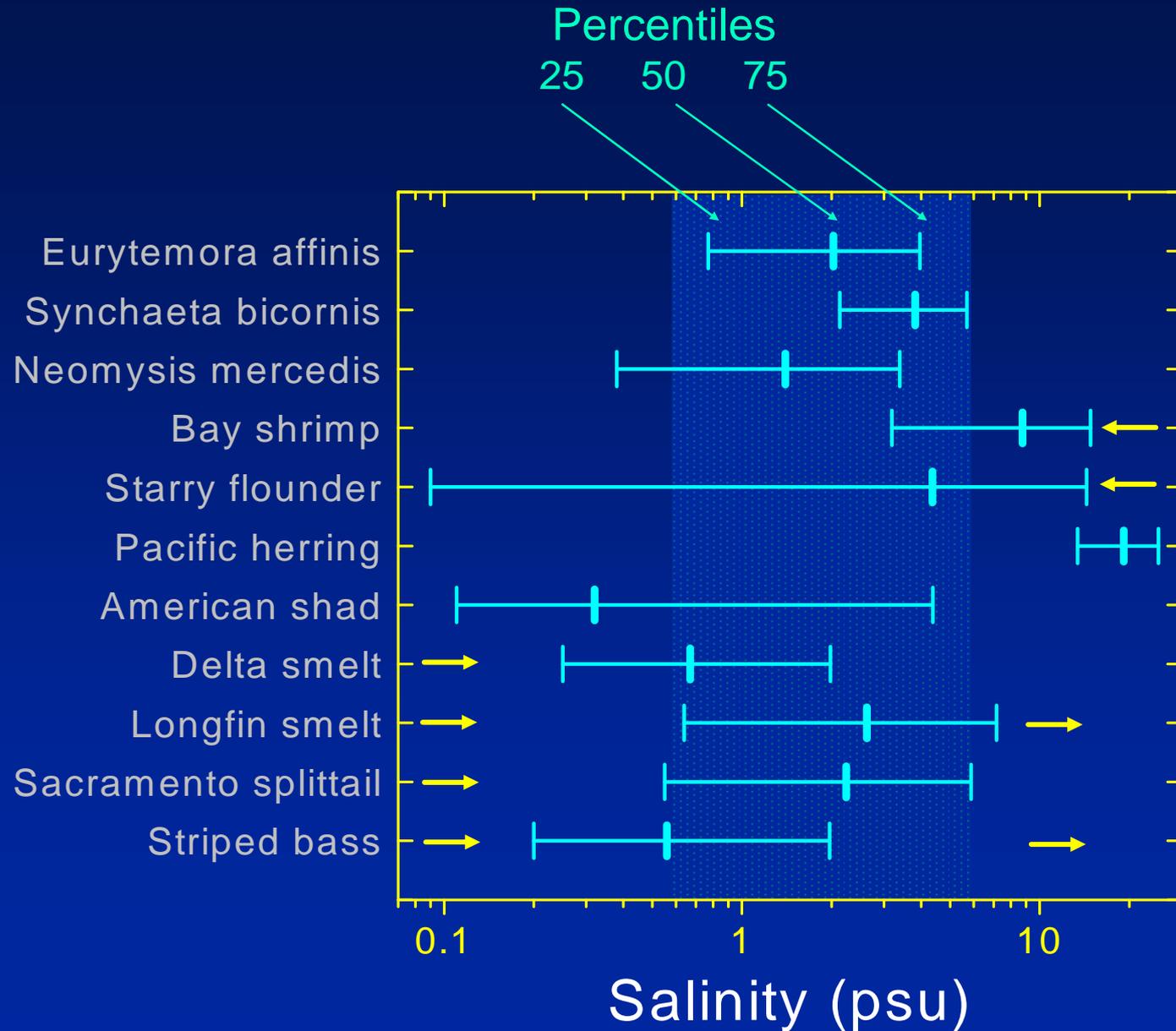
## Knowns (current state)

- Physical habitat not always the answer
- Not all habitat is created equal

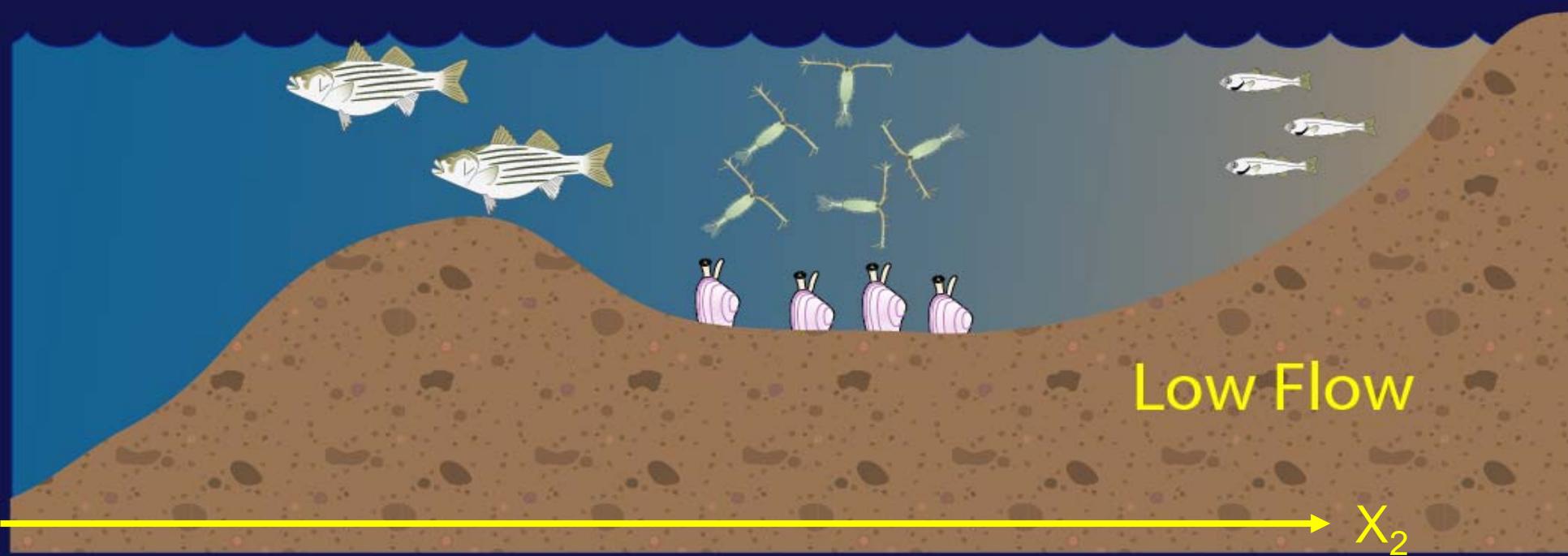


# Knowns (current state)

- Species / life stages each have their own salinity ranges...

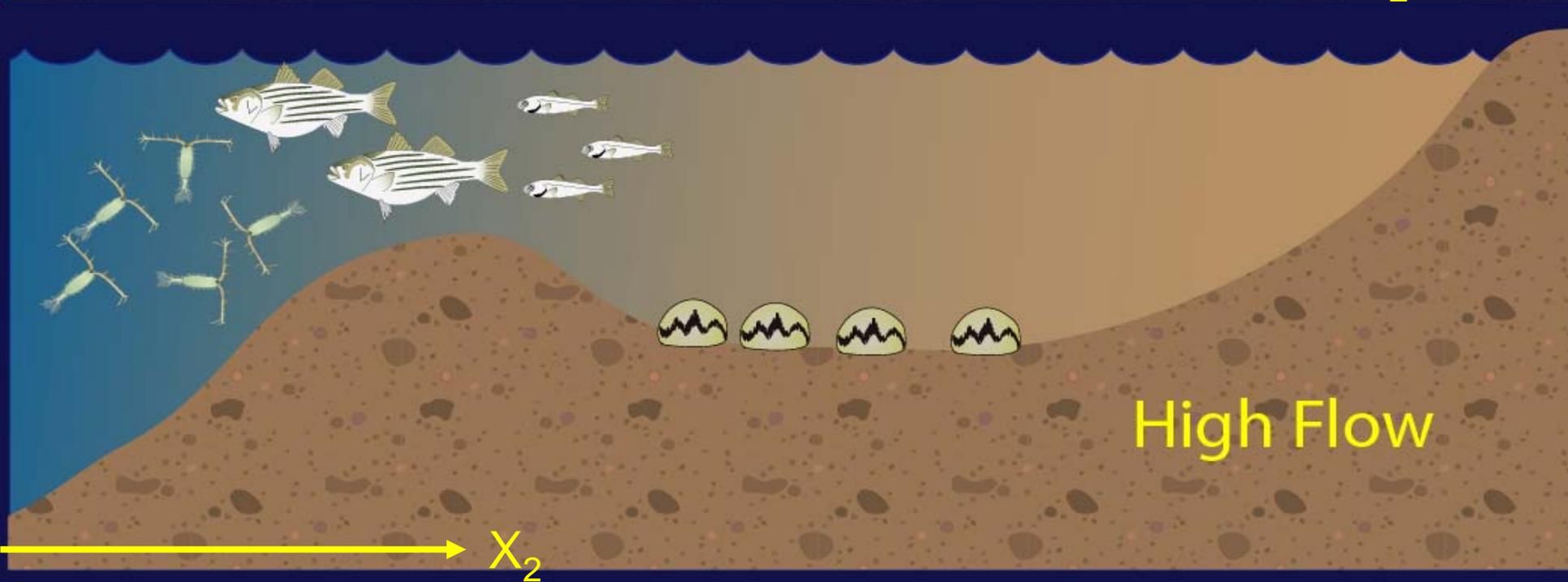
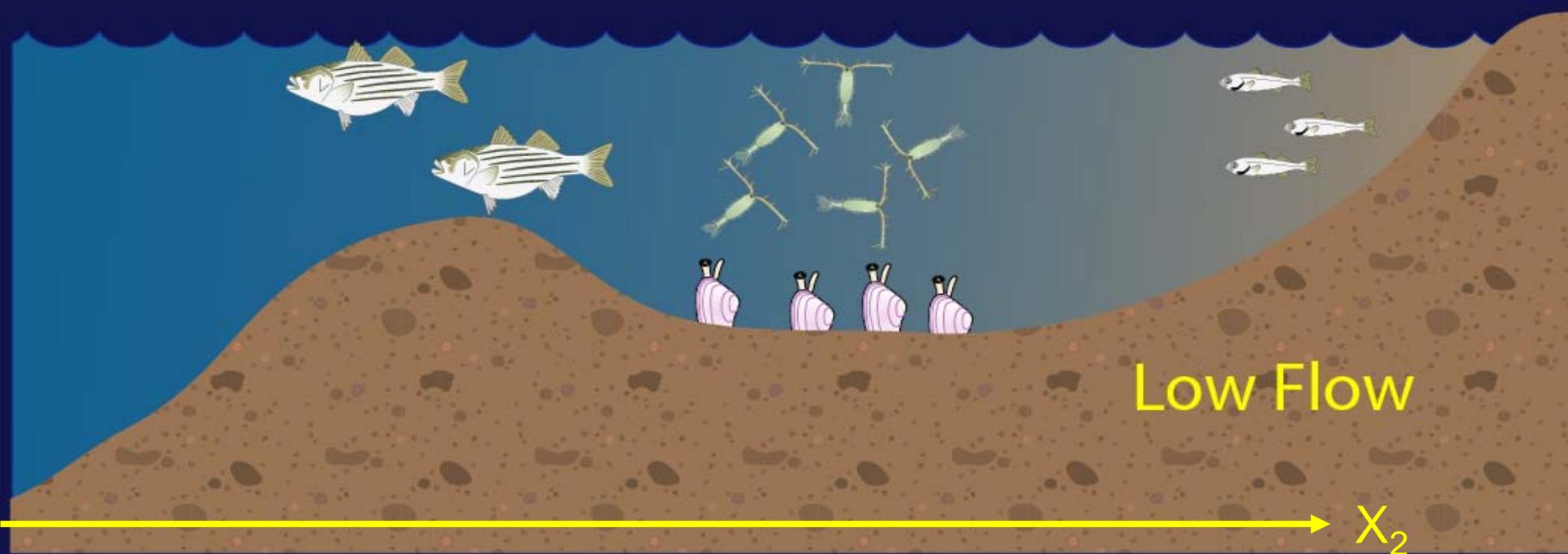


Data Source:  
SF Bay Study,  
IEP Zooplankton Study



Knowns (current state)

- ,,,but different species respond differently



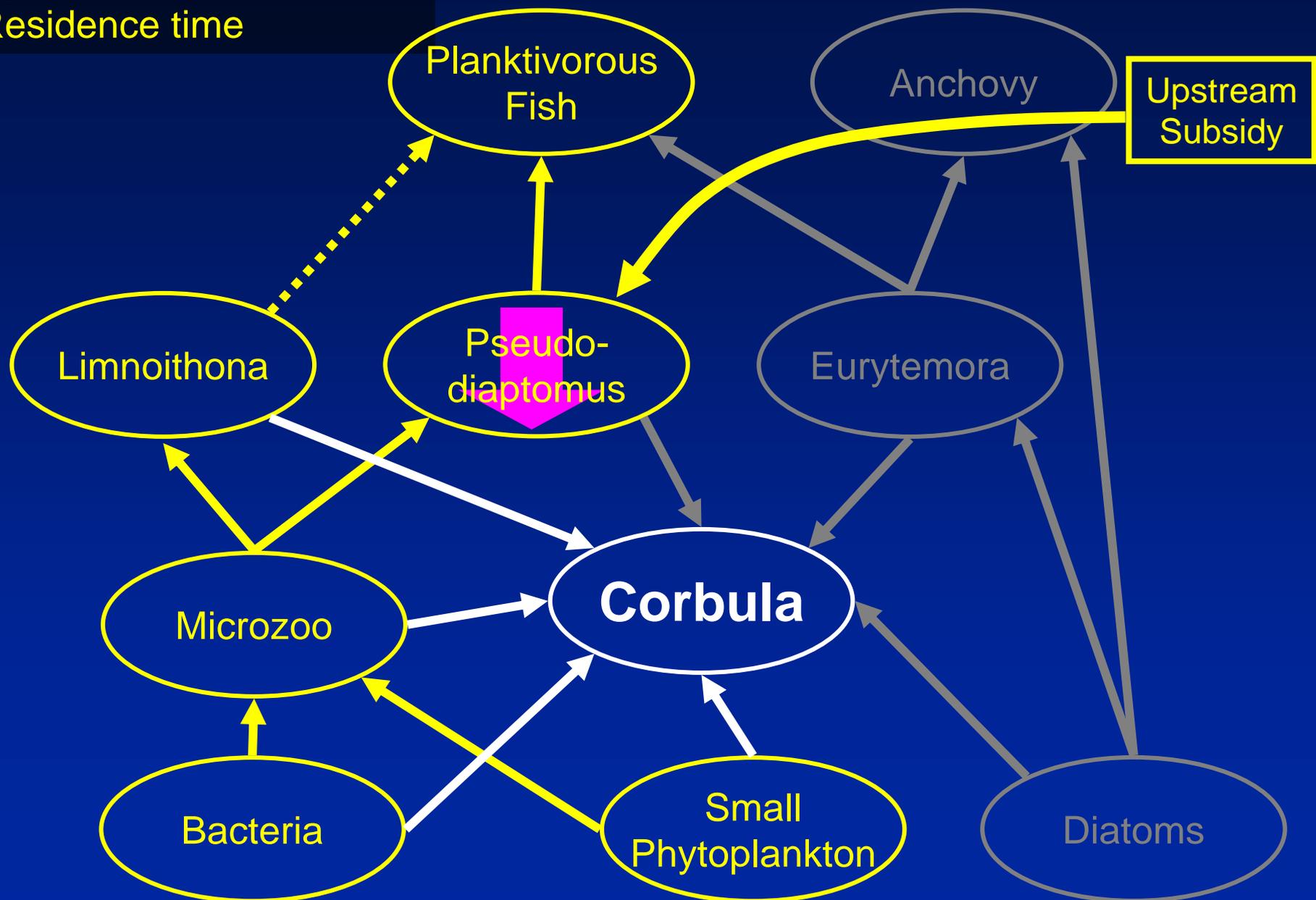
## Knowns (current state)

- Some species are “ecosystem engineers”
  - Habitat for predators
- Importance of residence time
  - Time for population growth
  - Exposure



# Knowns (current state)

- Open-water foodwebs
- Residence time



## Knowns (Trends)

- Timing in flow peak
- Sea level rise
- Population growth
- Water demand
- Reduced turbidity

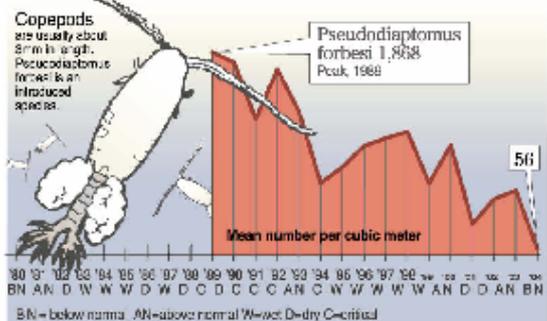
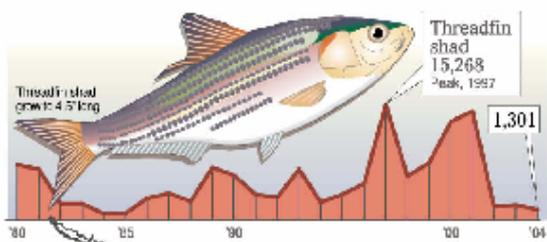
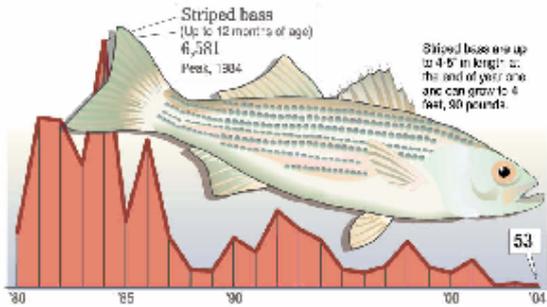
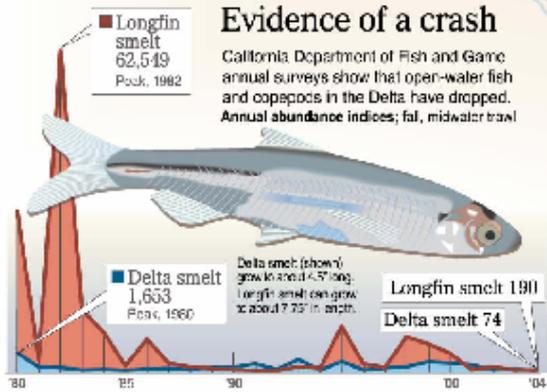
## Knowns (Probabilities)

- Levee failures  
    Seismic, flood, ...
- More introductions



# Unknowns (in general)

- Prediction capability
- Quantitative understanding
- What time scale of variability would benefit what species?

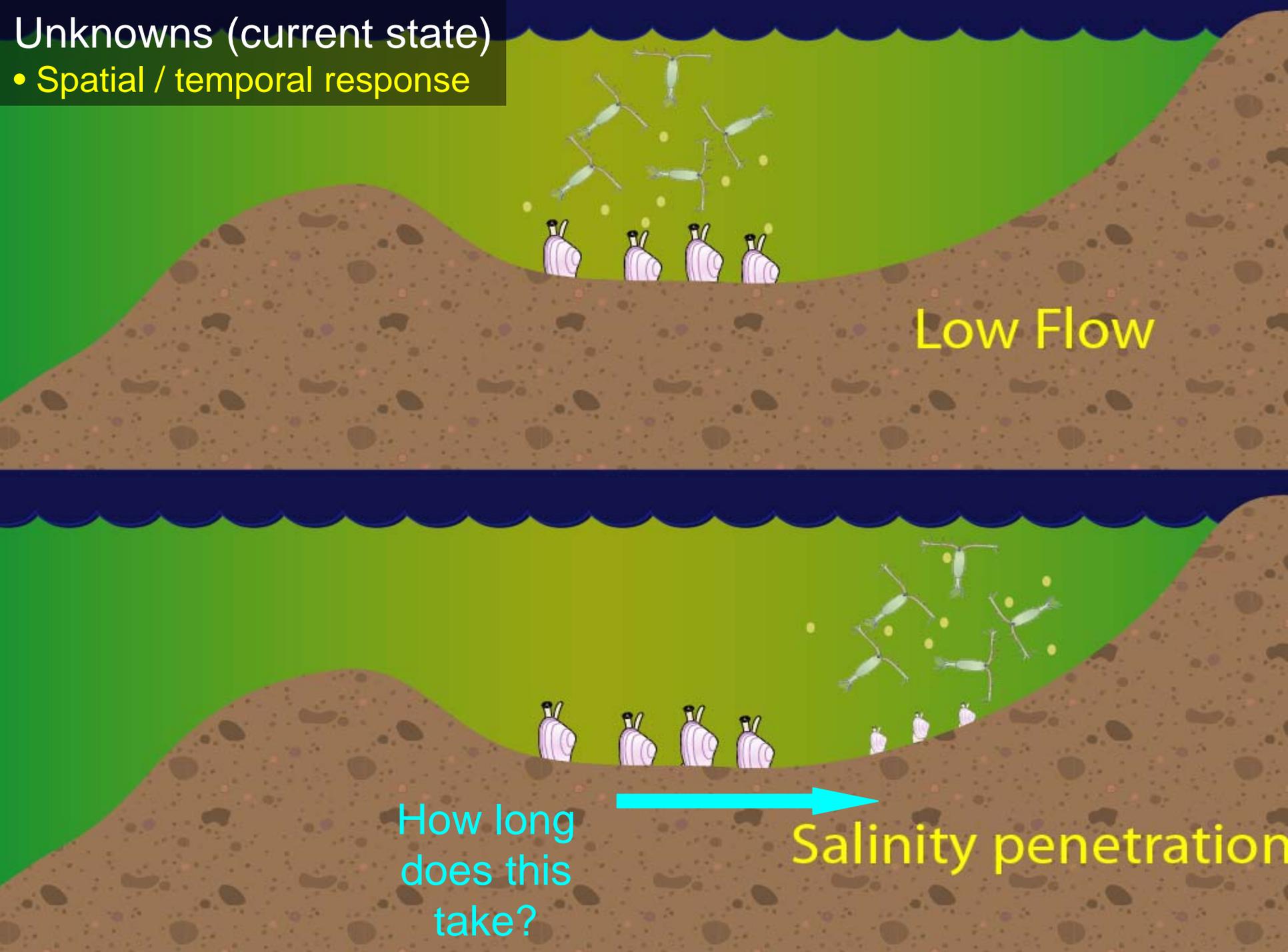


CONTRA COSTA TIMES

Source:  
Mike Tauger, CC Times

# Unknowns (current state)

- Spatial / temporal response



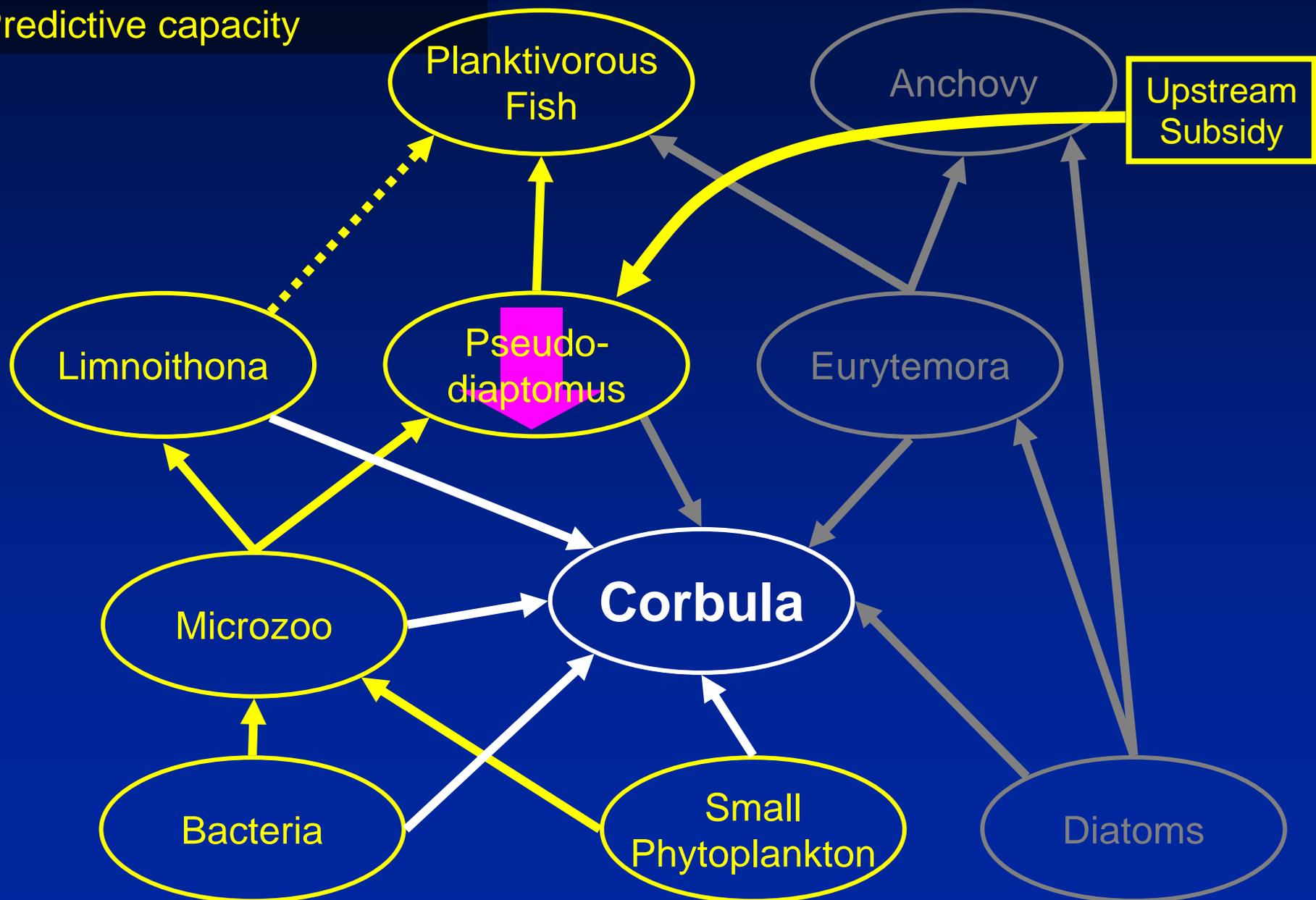
Low Flow

How long  
does this  
take?

Salinity penetration

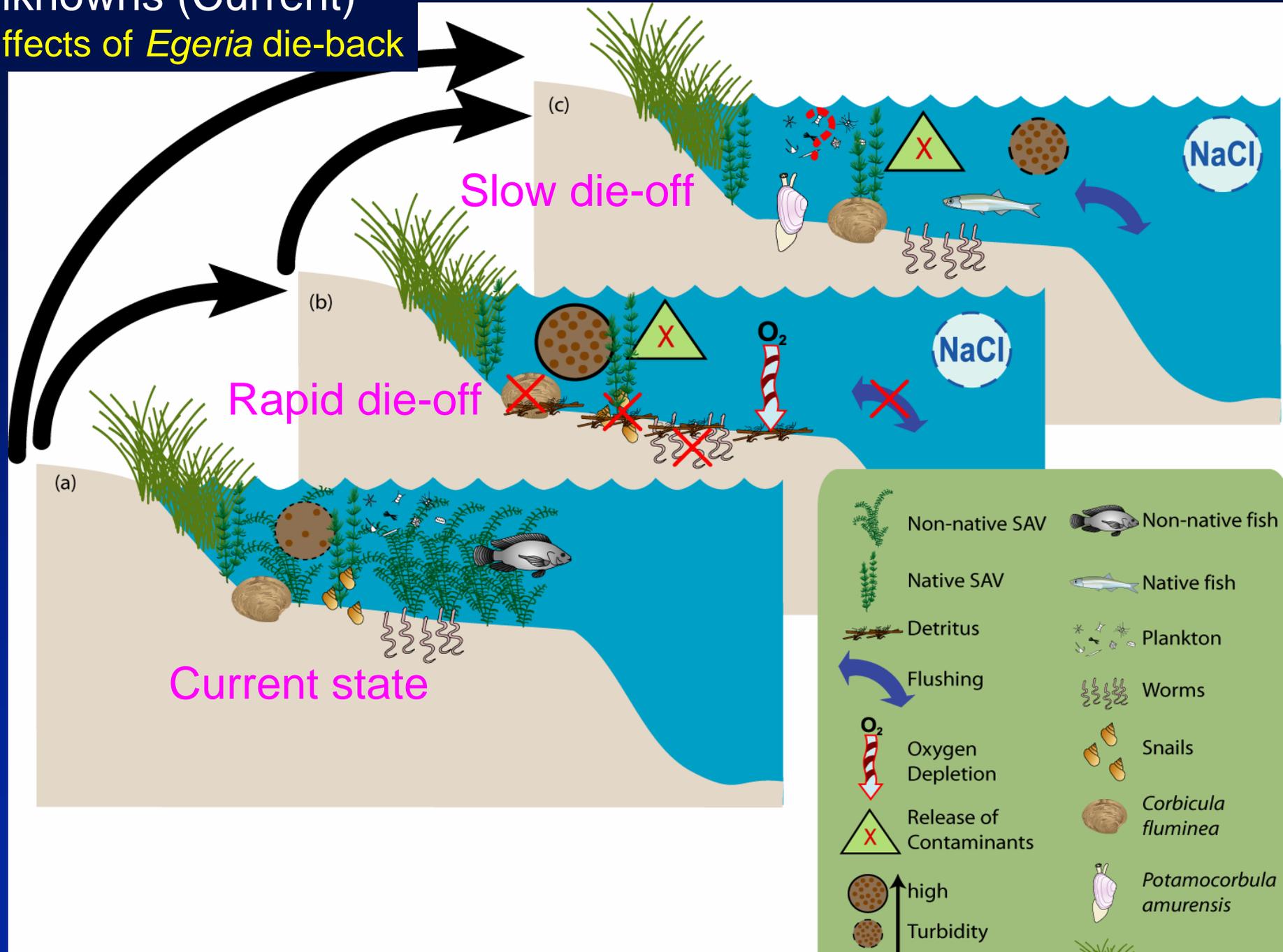
# Unknowns (current state)

- Quantitative picture
- Predictive capacity



# Unknowns (Current)

## • Effects of *Egeria* die-back



## Unknowns (Current)

- Effects of export pumping



# Unknowns (Current)

- Role of connectivity
  - How much is enough?



# Unknowns (Forecast)

- Introduced species : who is next?2



Photo: ©Myriah M. Richerson



Cercopagis pengoi

Photo: Juha Flinkman



Northern pike

# Unknowns (forecast)

- When and where will levees fail?
- Status of biological populations



**We have a lot of work to**



