# Abiotic and biotic drivers of native pondweed (*Stuckenia* spp.) distribution in SF Estuary

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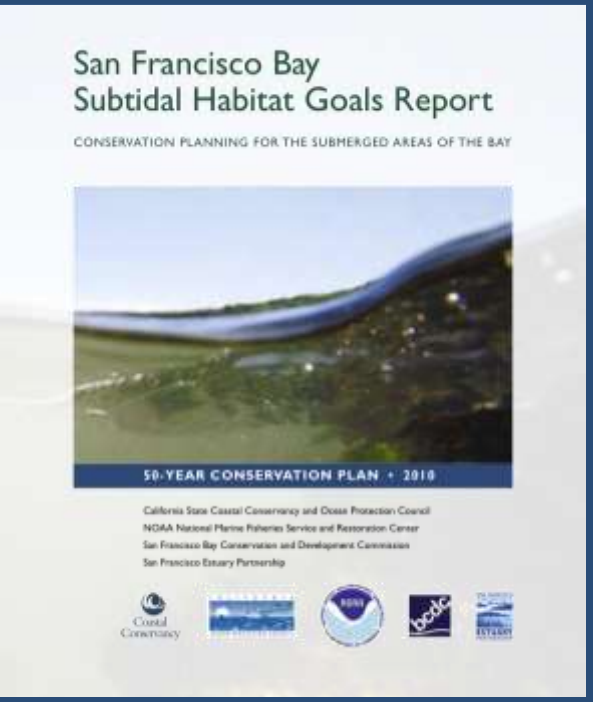
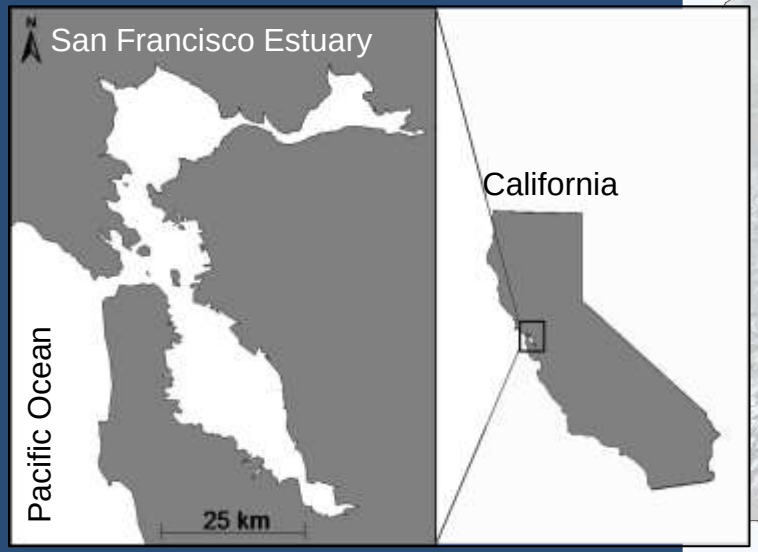
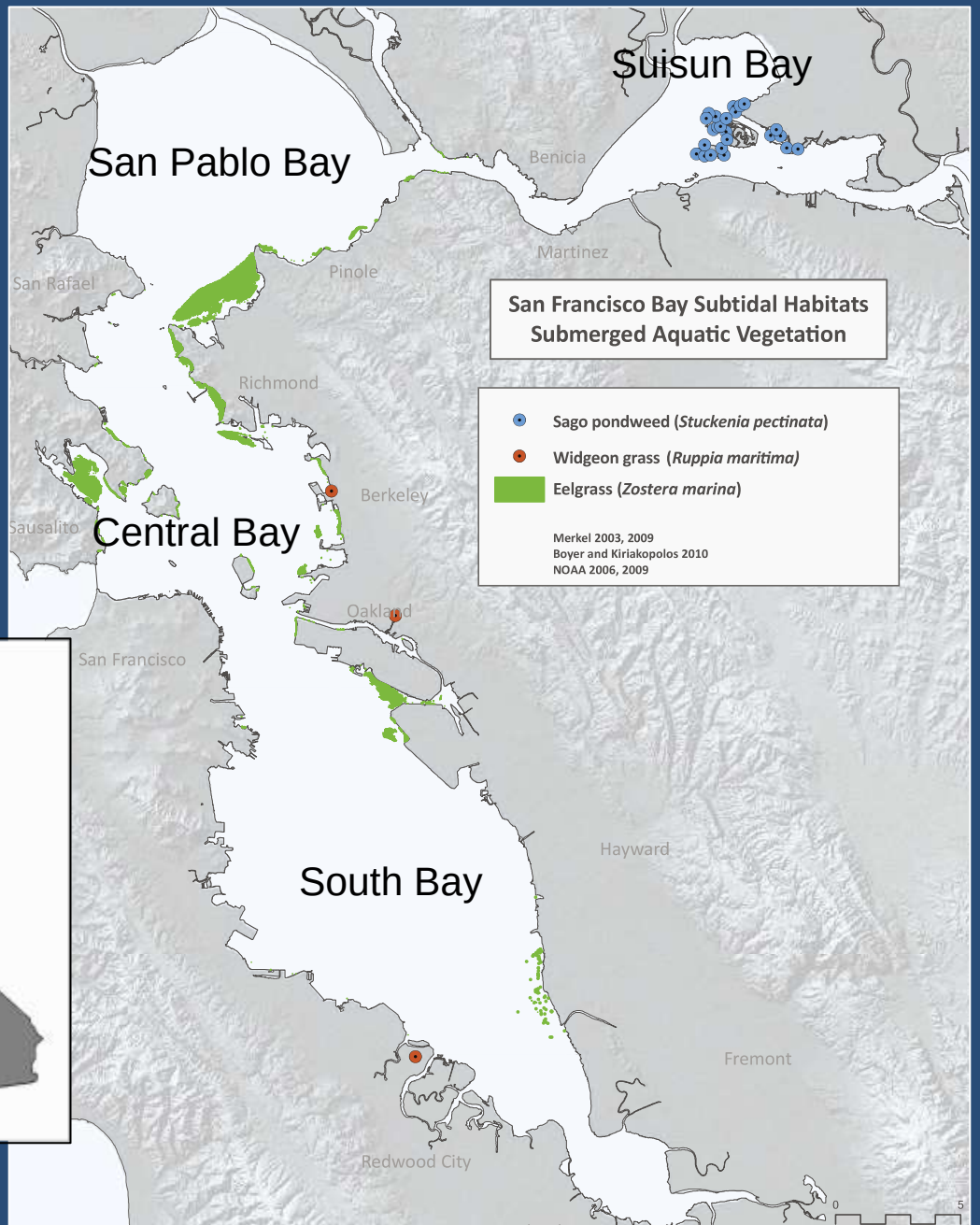
# In 2010, *Stuckenia* = dots on map




Delta →

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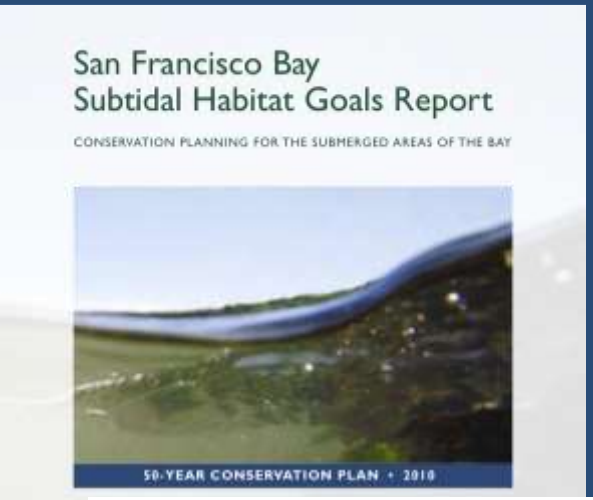
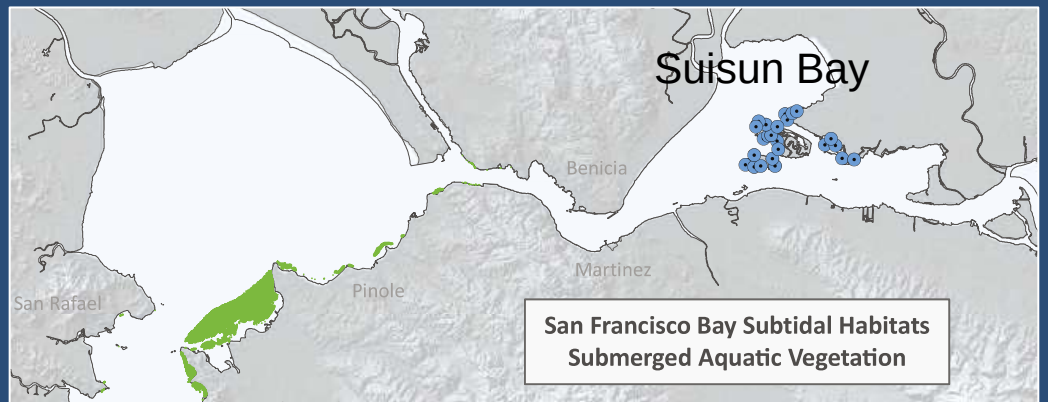



Delta →

## SUBMERGED AQUATIC VEGETATION SCIENCE GOAL 4

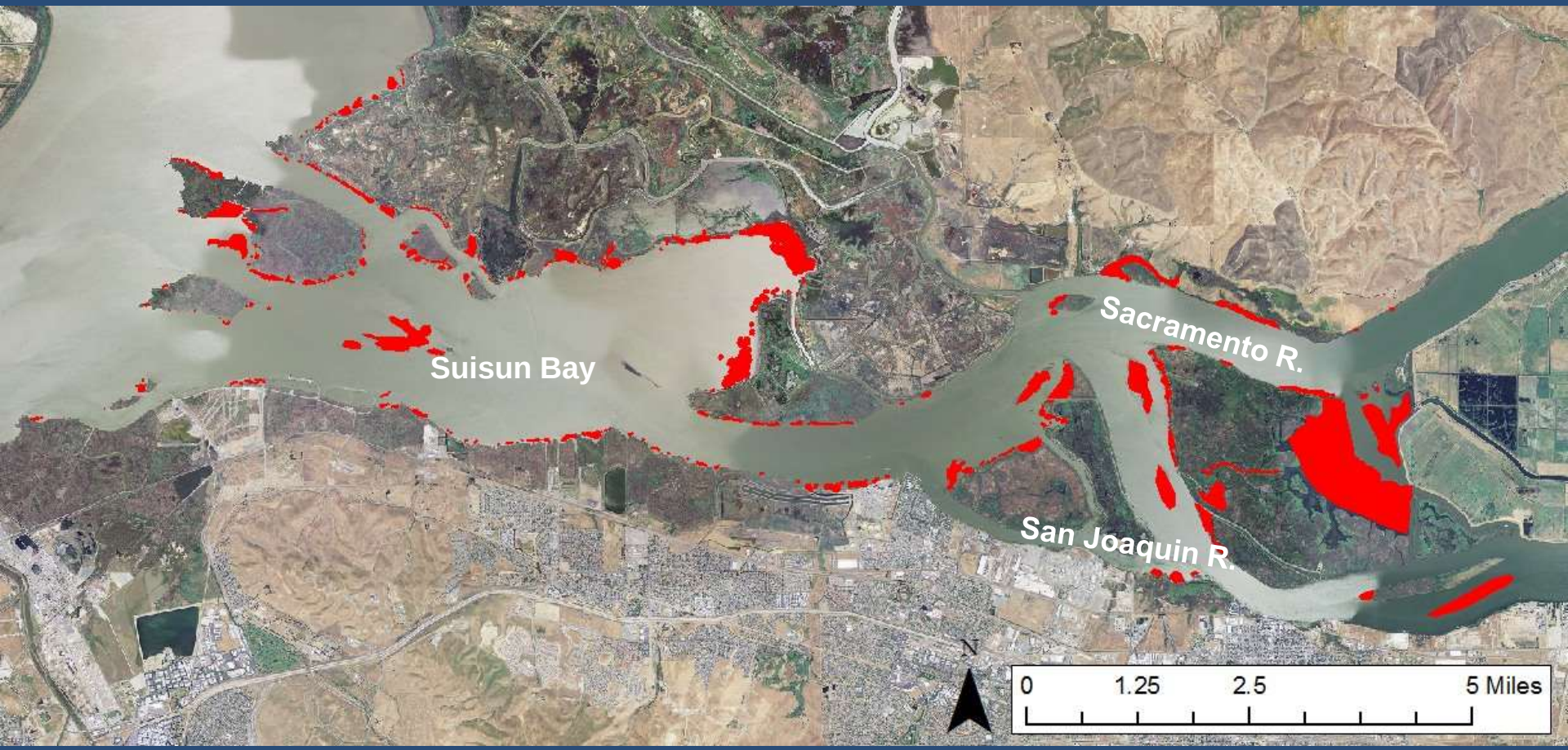
**Assess the status and distribution of other SAV.**

*Question A. What is the distribution and abundance of each of the native SAV species other than eelgrass?*

## SUBMERGED AQUATIC VEGETATION PROTECTION GOAL 5

**Protect existing sago pondweed habitat in San Francisco Bay.**

# >1200 acres of *Stuckenia* spp.




**“spp.”…**
***S. filiformis* and *pectinata***

Simmons Island

Chipps Island

Offshore shoal,
nr. Winter Island

# In the Delta – SAV gets a bad rap

**Invasive SAV, *Egeria densa*:**

- **Dense, reduces turbidity**
- **Shadowy, non-native predator refuge**
- **Negative effects on native fish**

# Working conceptual model

**Invasive SAV, *Egeria densa*:**

- **Dense, reduces turbidity**
- **Shadowy, non-native predator refuge**
- **Negative effects on native fish**

**Native SAV, *Stuckenia* spp.:**

- **Open canopy, turbid**
- **Visual refuge from predators**
- **Ample food resources**
- **Along migratory paths**
- **Positive effects on native fish**


Amphipods, isopods, gastropods, etc.

# Today

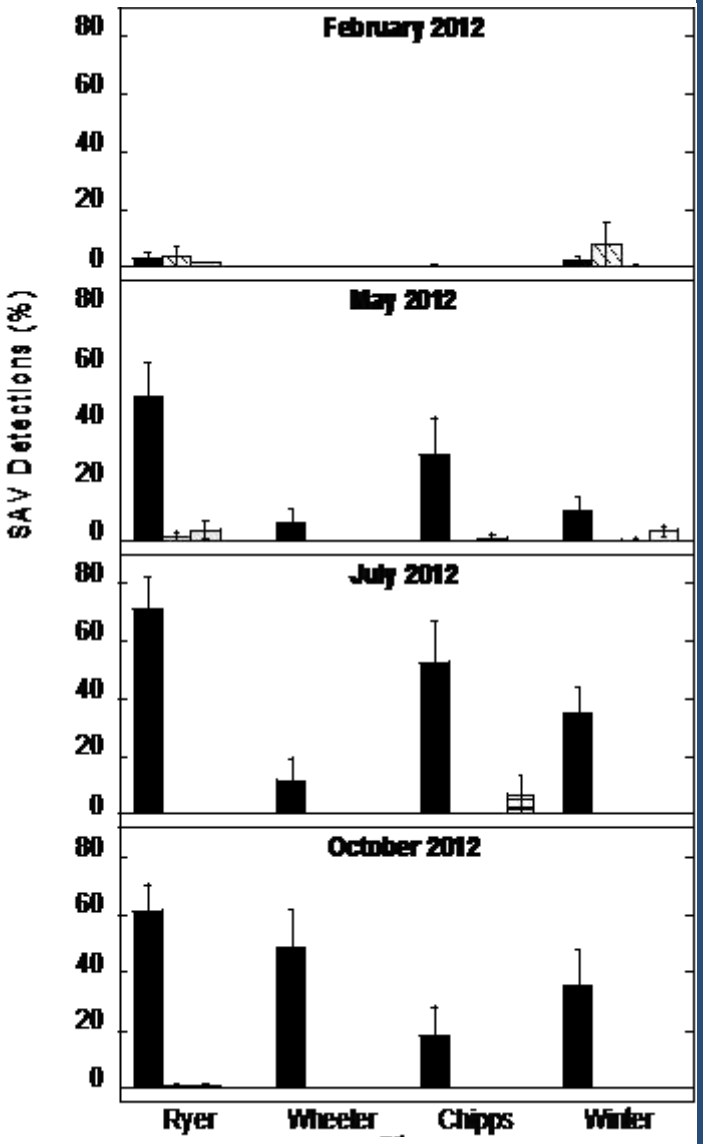
- Spatial and seasonal abundance patterns
- Salinity and turbidity effects
- Competition with *Egeria densa*
- Predictions and management implications

# Suisun SAV quarterly surveys, fall 2011-fall 2012

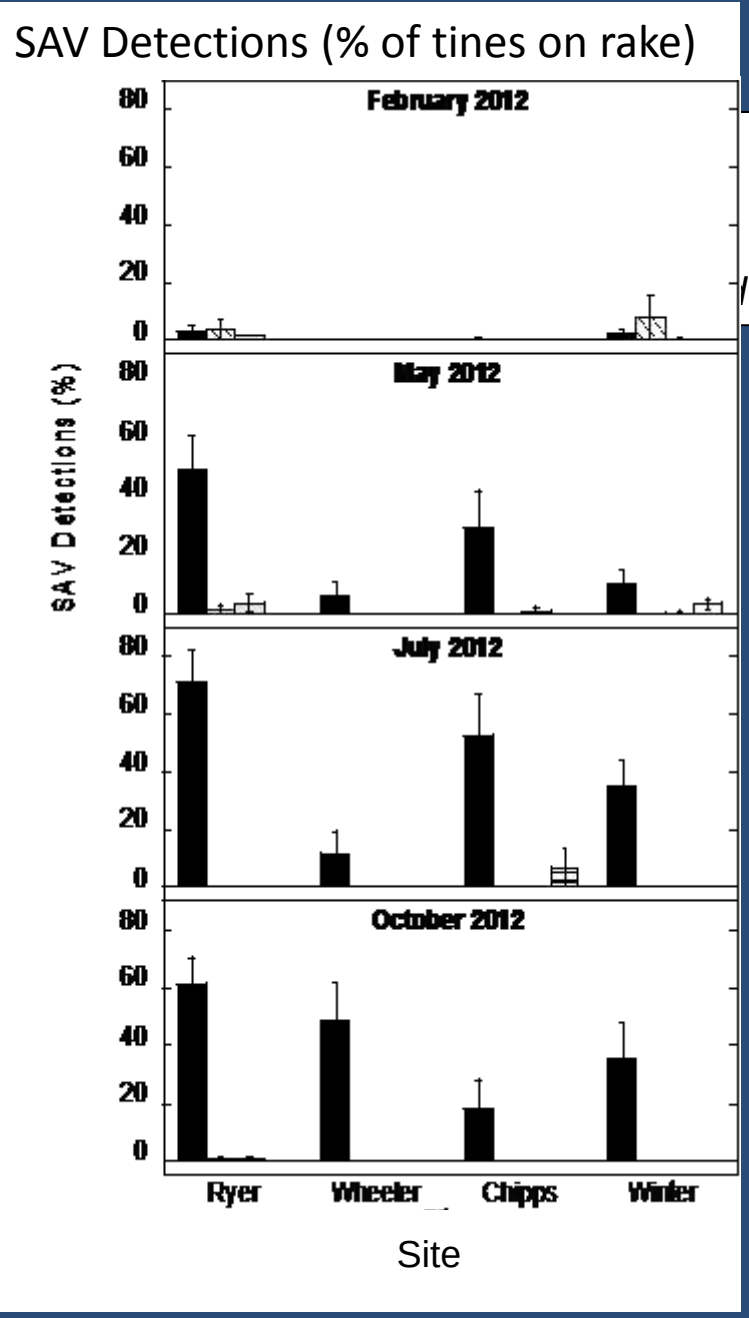

Question:

What are the spatial and seasonal patterns in these SAV beds?

# SAV Detections (% of tines on rake)




Mean (3 transects per site) of means (3 positions per transect) ± 1 SE



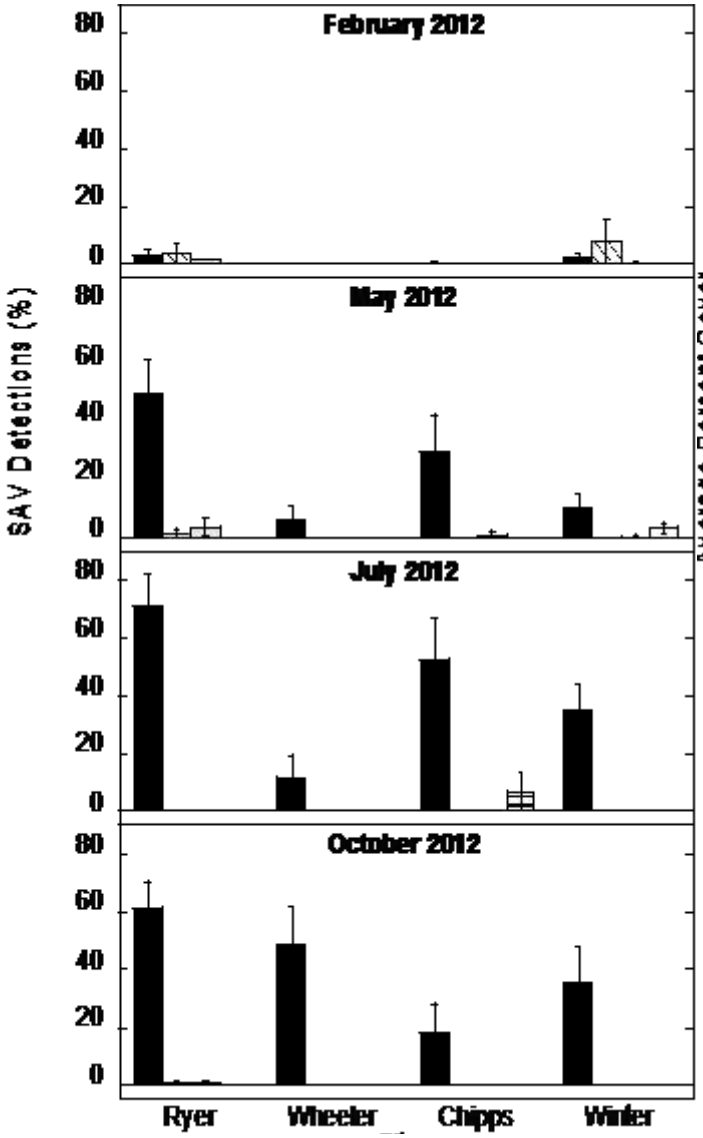

Mean (3 transects per site) of means (3 positions per transect) ± 1 SE

Primarily *Stuckenia* spp. in Suisun Bay

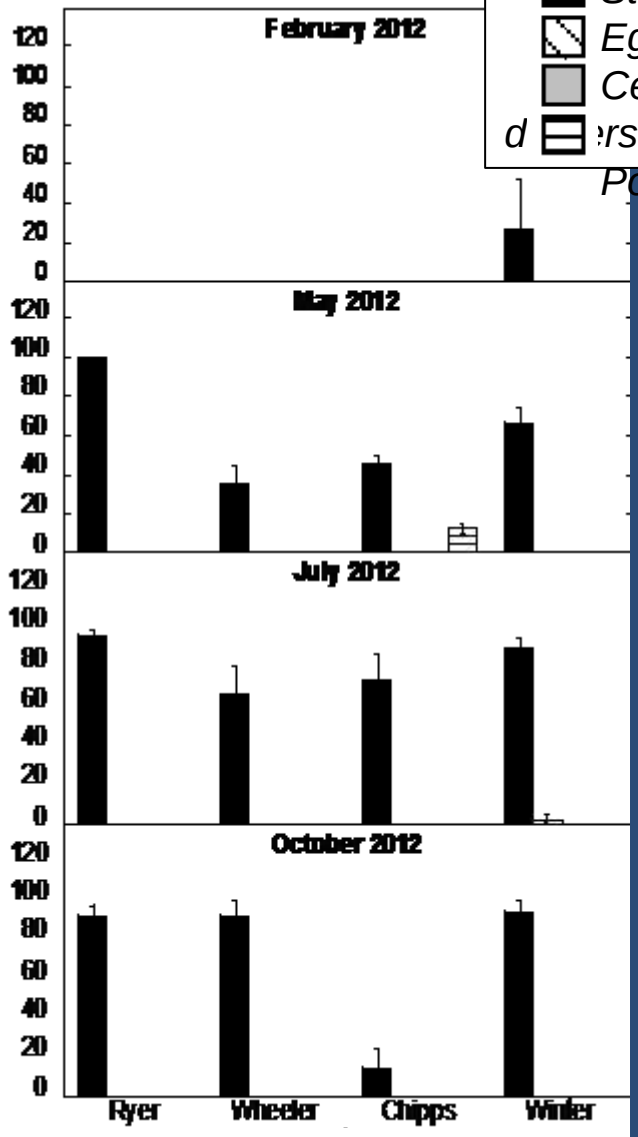
Aboveground tissues decline in winter

Rake catches rarer species

SAV Detections (% of tines on rake)




% Cover




*Stuckenia* spp.
*Egeria densa*
*Ceratophyllum*
*d* *ersum*
*Potamogeton crispus*

N
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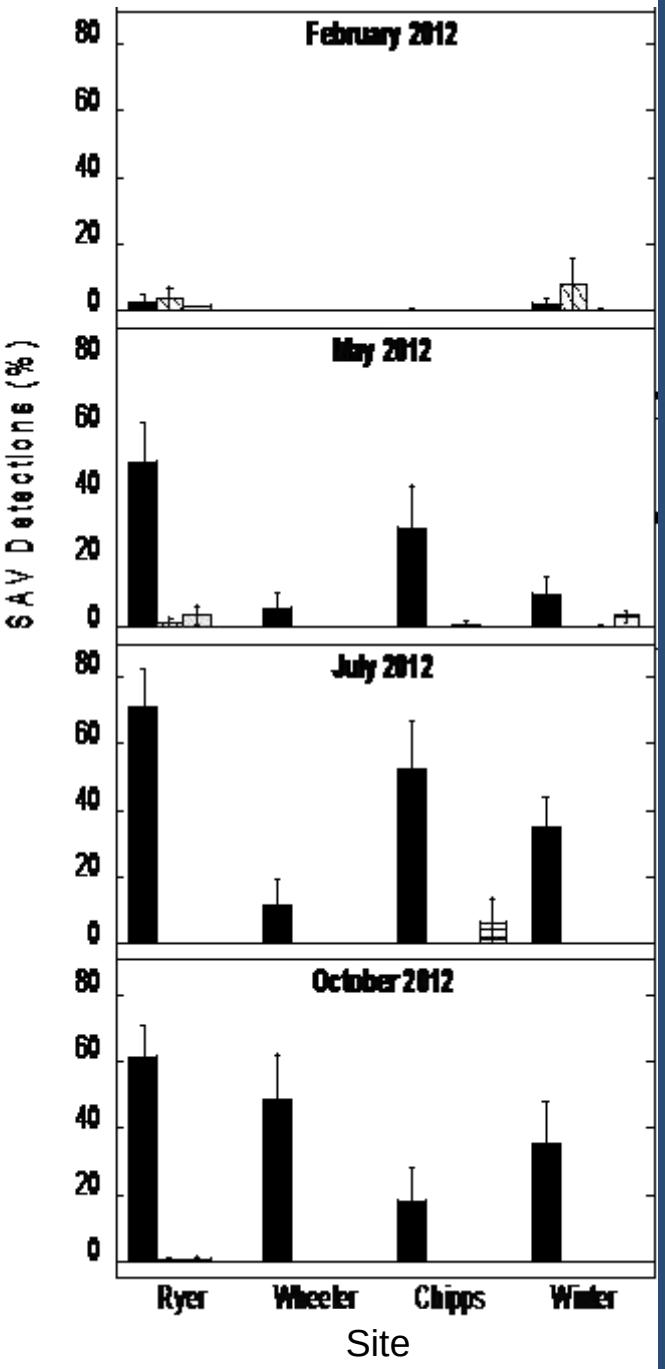
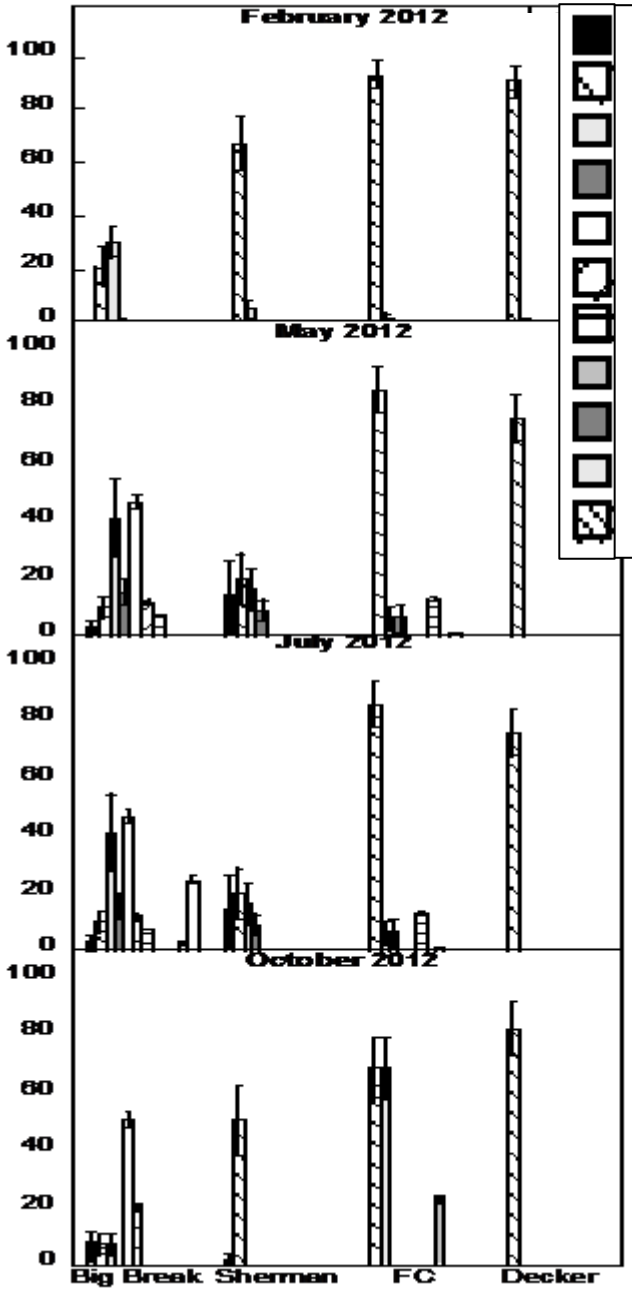
Cover shows same overall pattern, but misses rarer species


Ryer Is.
Wheeler Is.
Chipps Is.
Winter Is.
Decker Is.
Fisherman's Cut
Sherman Lake
Big Break

Suisun SAV Detections




Delta SAV Detections




- *Stuckenia* spp.
- *Egeria densa*
- *Ceratophyllum demersum*
- *Potamogeton crispus*
- *Elodea canadensis*
- *Myriophyllum spicatum*
- *Potamogeton foliosus*
- *Cladophora* (alga)
- *Cabomba caroliniana*
- *Potamogeton nodosus*
- *Ruppia* spp.

NINININININININ

Delta: *Egeria* dominates, remains in winter

More diverse

# Today

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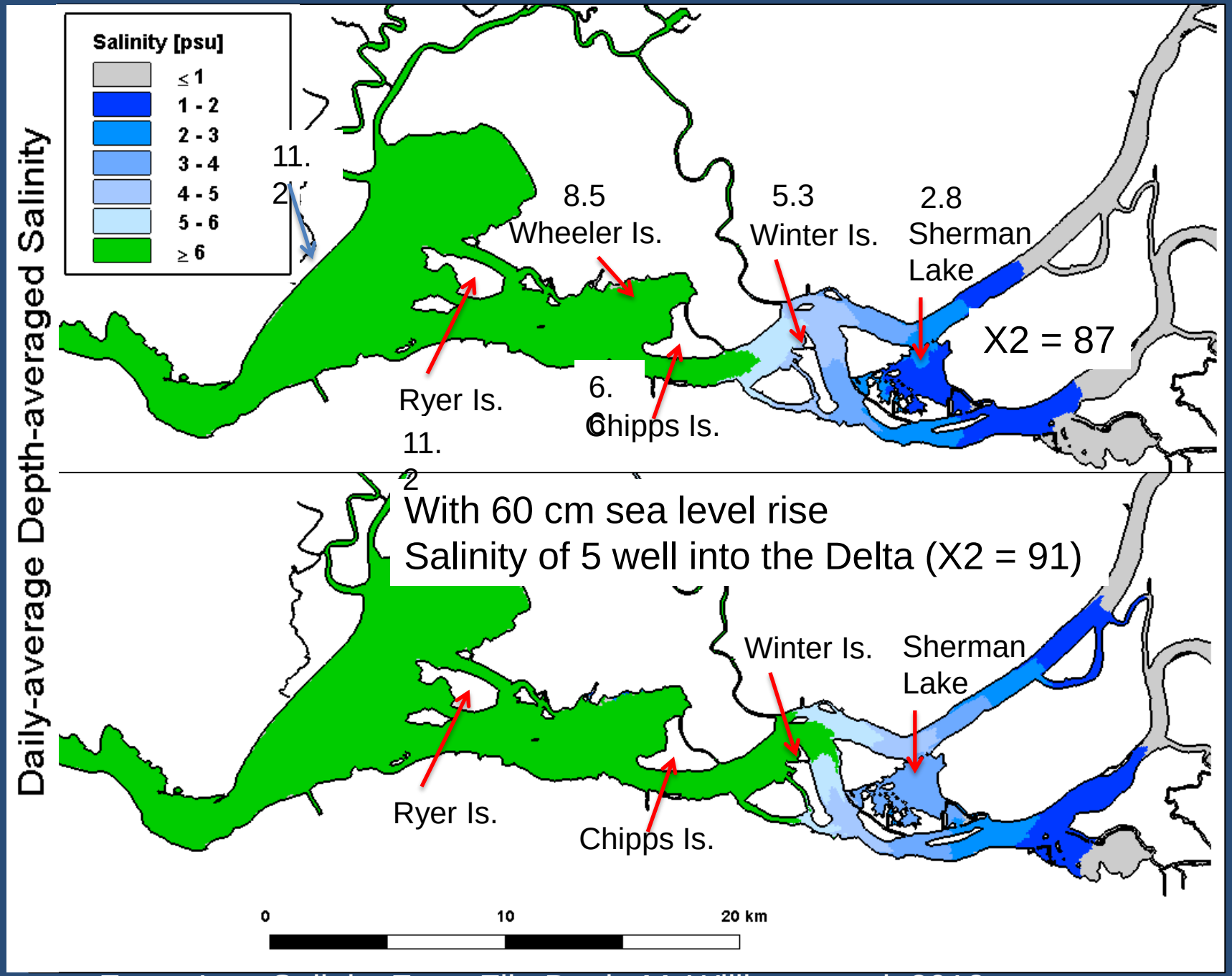
Fresh water
Salt water




From: Low Salinity Zone Flip Book, McWilliams et al. 2012

# Salinity Changes

Salinity predicted to increase due to:

- sea level rise
- management actions that control freshwater
- breaches of levees in the Delta

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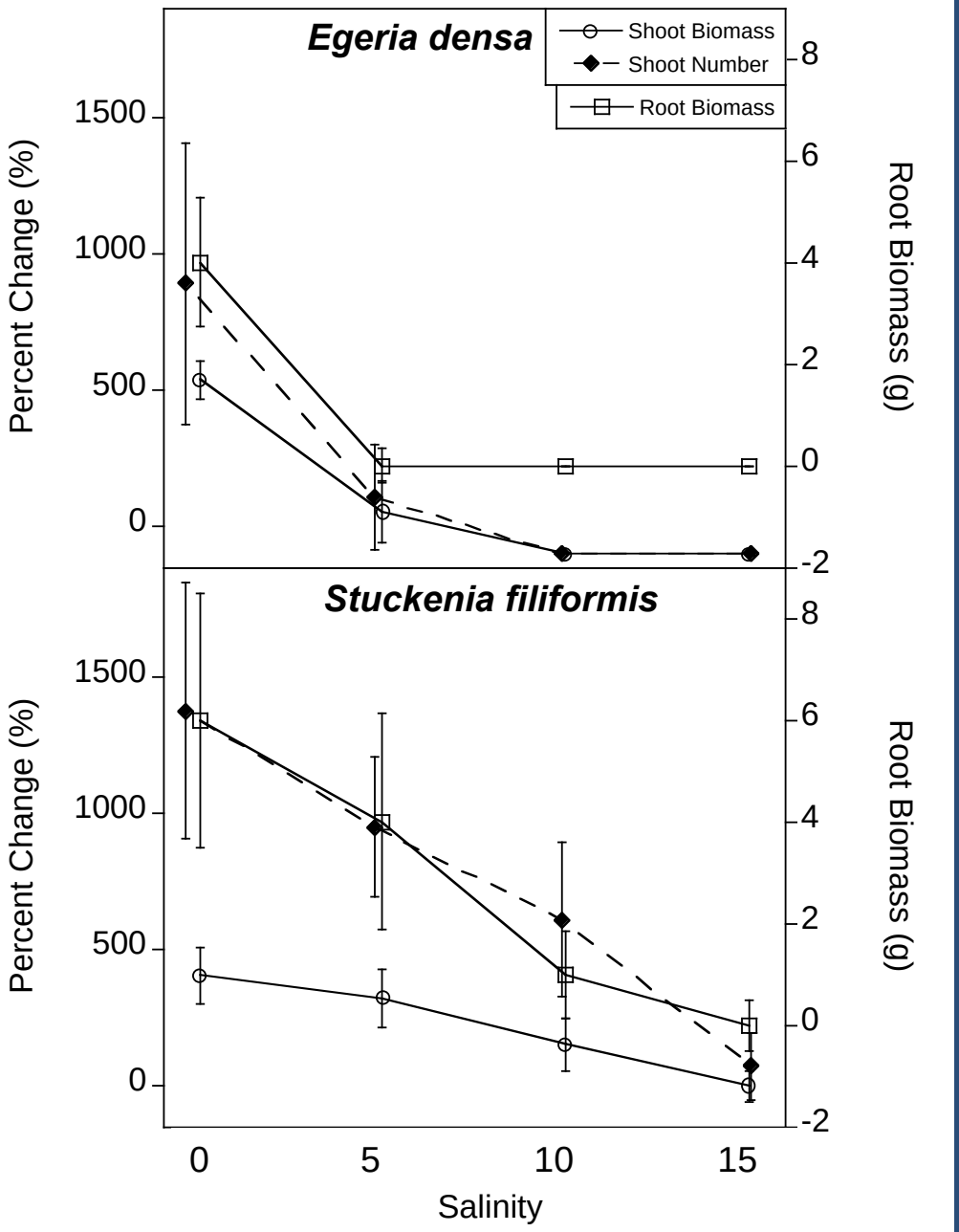
Question:
How will *Egeria densa* and *Stuckenia* sp. respond to an increase in salinity of 5?

# Salinity Experiment

200-liter mesocosms (June-Sept 2012)
Salinity of 0, 5, 10, 15
*Stuckenia* sp. or *Egeria densa*
N = 5

Evyan Borgnis

# Salinity Experiment

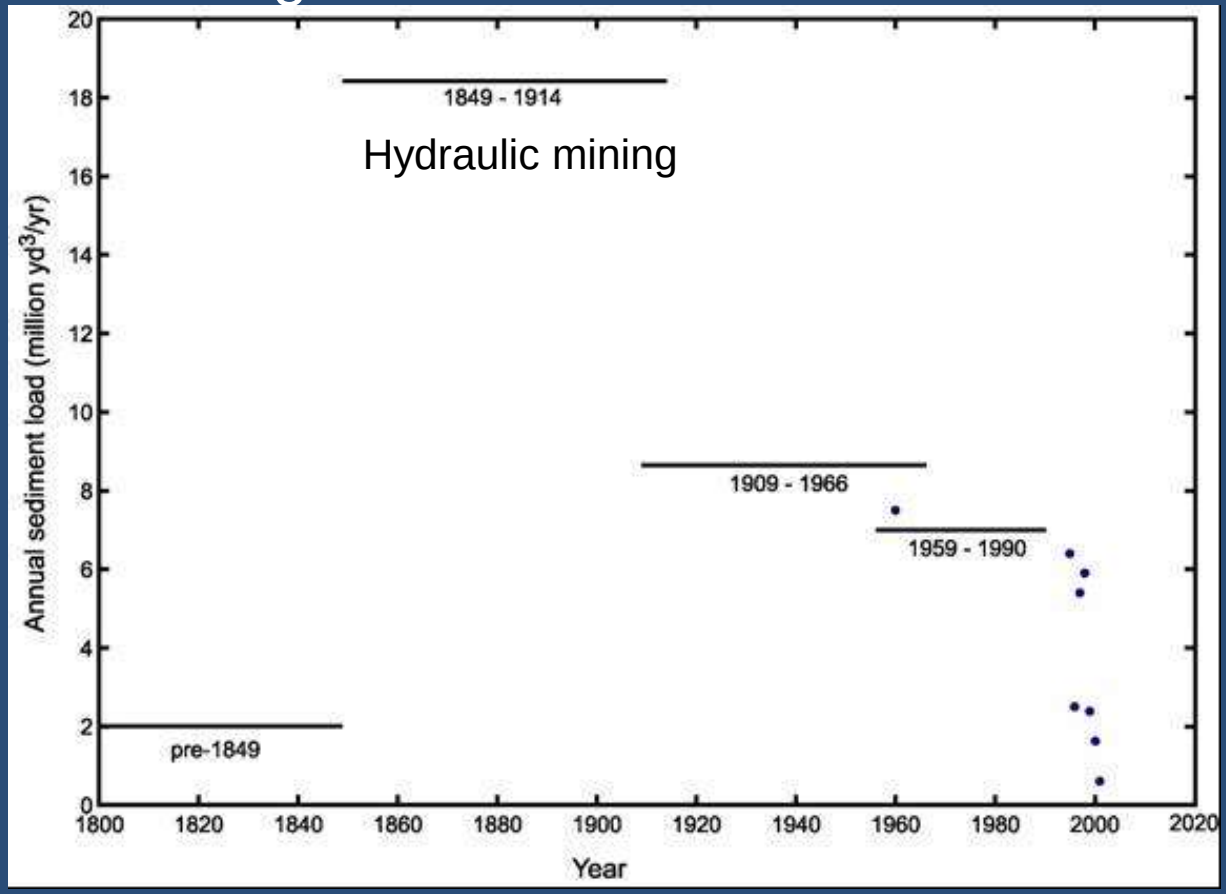



*Egeria* thrives in fresh water, declines at salinity of 5, complete mortality at 10 and 15

*Stuckenia* grows very well at 0 to 10, persists at 15

# What about changes in turbidity?

Turbidity decreasing with depletion of erodible sediment pool, light availability increasing (Schoellhamer 2011)




Schoellhamer, D.H. 2011. Sudden clearing of estuarine waters upon crossing the threshold from transport to supply regulation of sediment transport as an erodible sediment pool is depleted: San Francisco Bay, 1999. Estuaries and Coasts 34: 885–899.

# What about changes in turbidity?

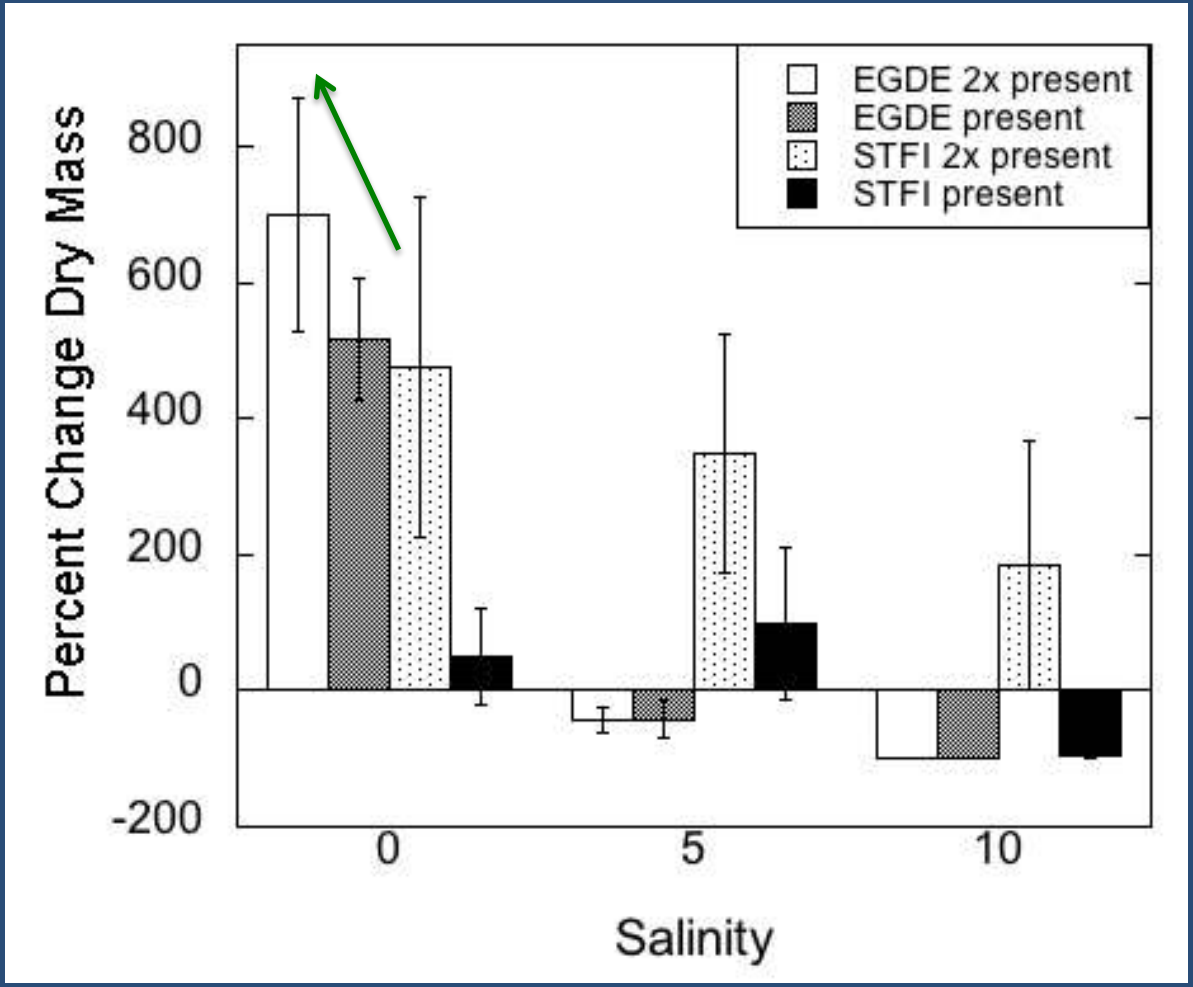
Turbidity decreasing with depletion of erodible sediment pool, light availability increasing
(Schoellhamer 2011)

Questions:
- Will increased light enhance SAV performance above present conditions?
- Will increased light compensate for negative salinity effects?

# Turbidity x Salinity Experiment

- Same mesocosm tanks (June-Oct 2013)
- Turbidity treatment: present PAR (215 $\mu MEm^{-2}s^{-1}$ simulated with window screen) versus future (2x present)
- Crossed with salinity treatment: 0, 5, 10
- *Stuckenia* sp. or *Egeria densa*

# Turbidity x Salinity Experiment

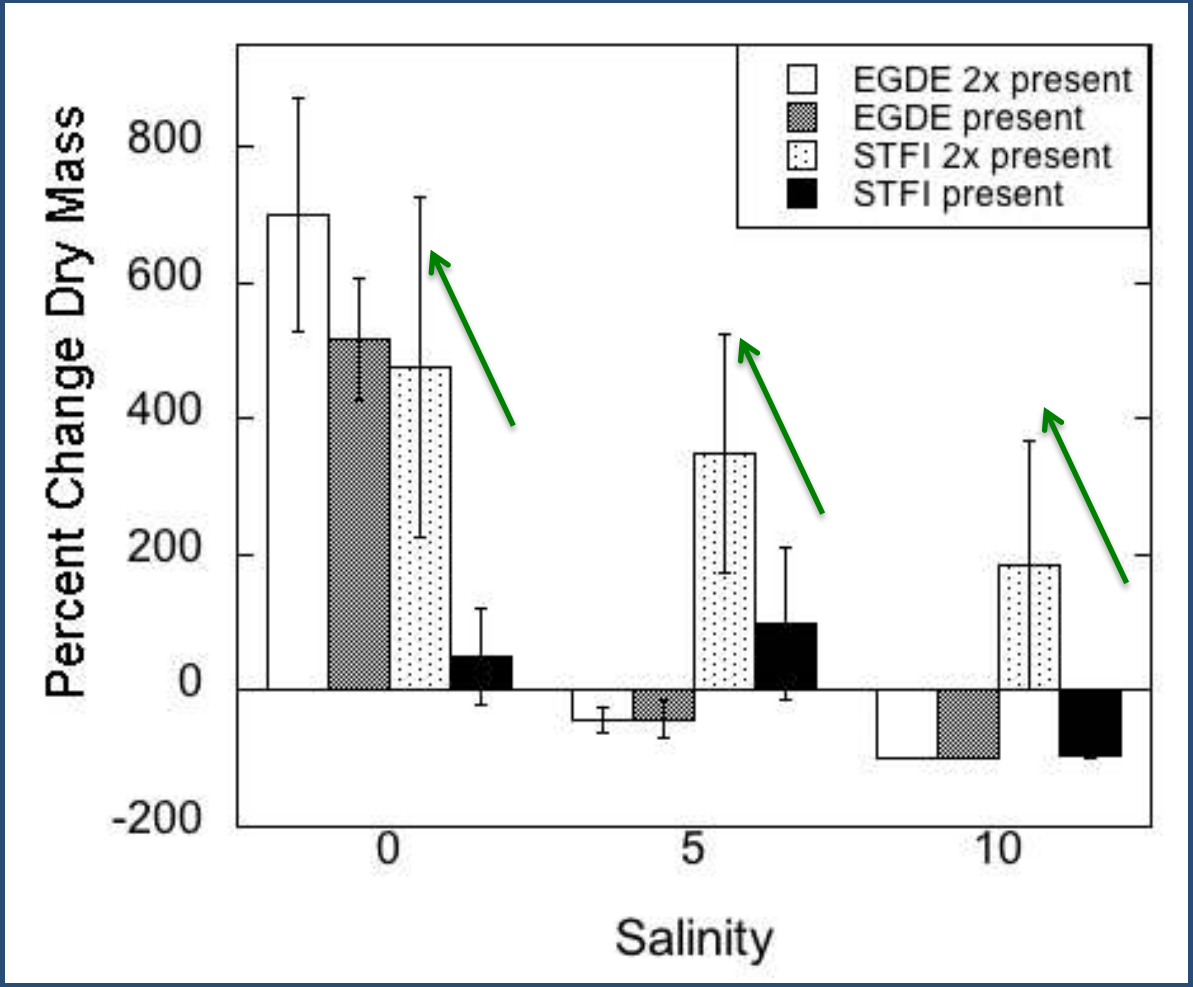



Light = present (215 $\mu Em^2s^{-1}$)
or 2x present

EDGE: trend of greater biomass with higher light in fresh water

Higher light no help at salinities of 5+

# Turbidity x Salinity Experiment




Light = present (215 $\mu Em^2s^{-1}$)
or 2x present

Egeria: trend of greater biomass with higher light in fresh water

Higher light no help at salinities of 5+

Stuckenia: greater biomass with higher light, at all salinities

# Salinity and turbidity

Questions:
How will *Egeria densa* and *Stuckenia* sp. respond to an increase in salinity of 5?
*Egeria* thrives at 0, declines at salinity of 5+
*Stuckenia* thrives at 0-10, persists at 15

Will increased light enhance SAV performance above ambient conditions?
*Egeria*: yes (at 0 salinity)
*Stuckenia*: yes, at all salinities (0-10)
- Will increased light compensate for negative salinity effects?
*Egeria*: no (mortality at 5+ regardless of light)
*Stuckenia*: yes, light enhanced growth at higher salinity

# Today

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- Competition with *Egeria densa*
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# Competition along a stress gradient

Tolerance to stress sorts estuarine plants along axis of osmotic stress

But competition keeps stress tolerant species from the most benign habitats

(Purer 1942; Connell 1972; Paine 1973; Crain et al. 2004)

## Competition along a stress gradient

Tolerance to stress sorts estuarine plants along axis of osmotic stress

But competition keeps stress tolerant species from the most benign habitats

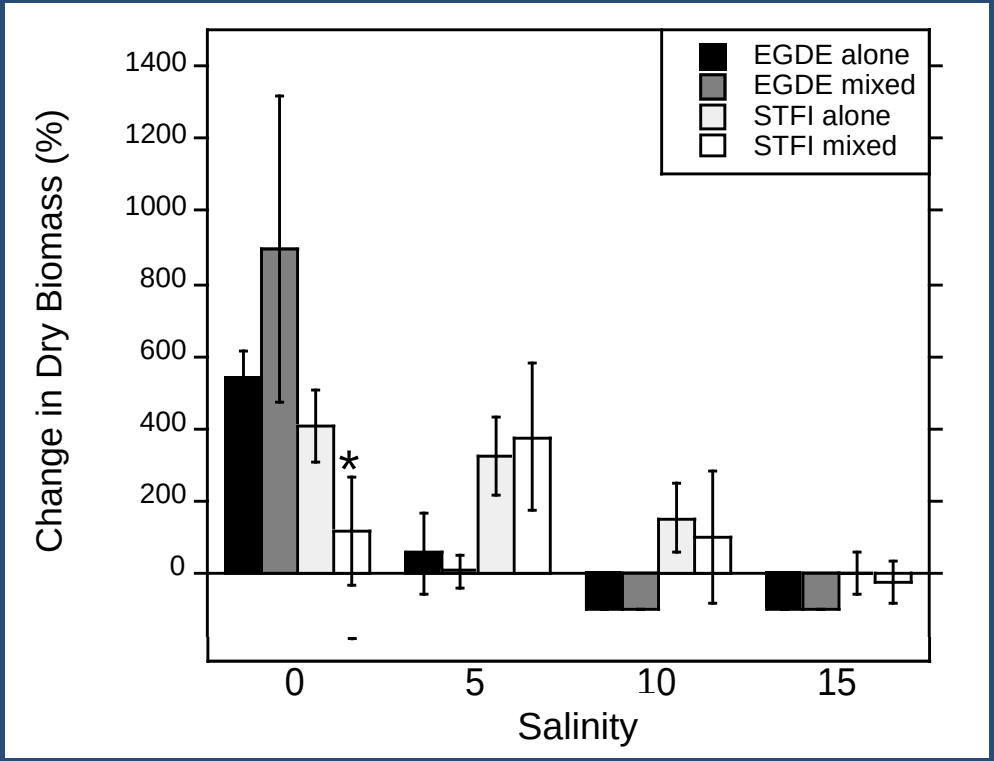
(Purer 1942; Connell 1972; Paine 1973; Crain et al. 2004)

Question: Might *Egeria* outcompete *Stuckenia* in fresher waters?

# Salinity x Competition Experiment

200-liter mesocosms (June-Sept 2012)
Salinity of 0, 5, 10, 15
*Stuckenia* sp. or *Egeria densa* **or both**
N = 5

# Salinity x Competition Experiment



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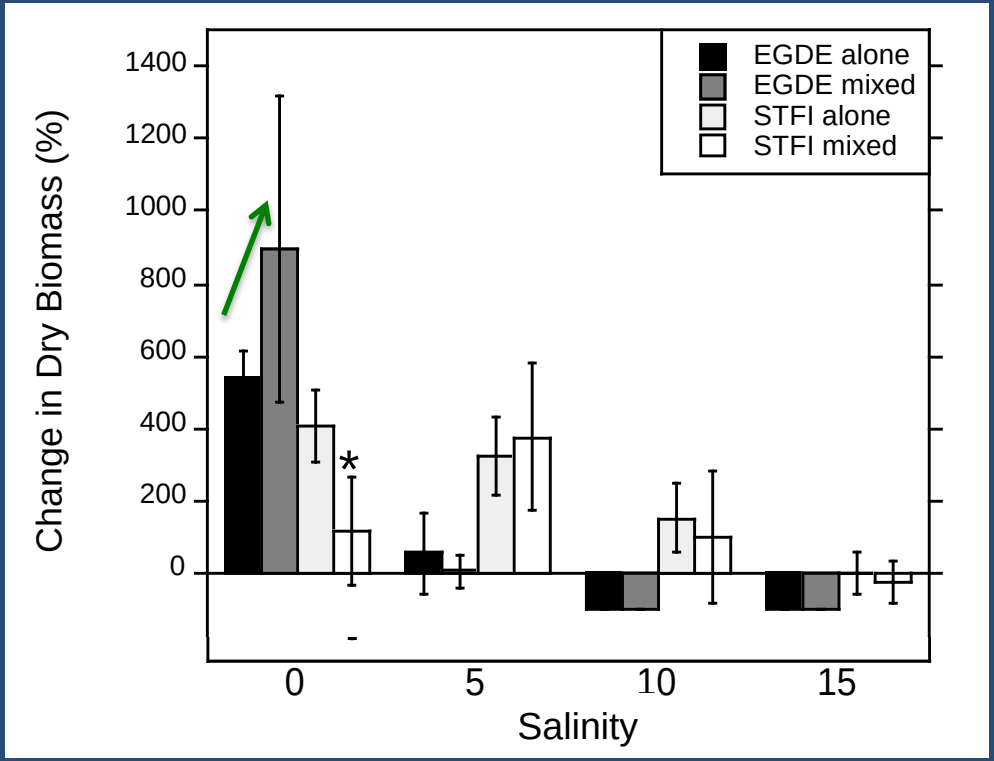
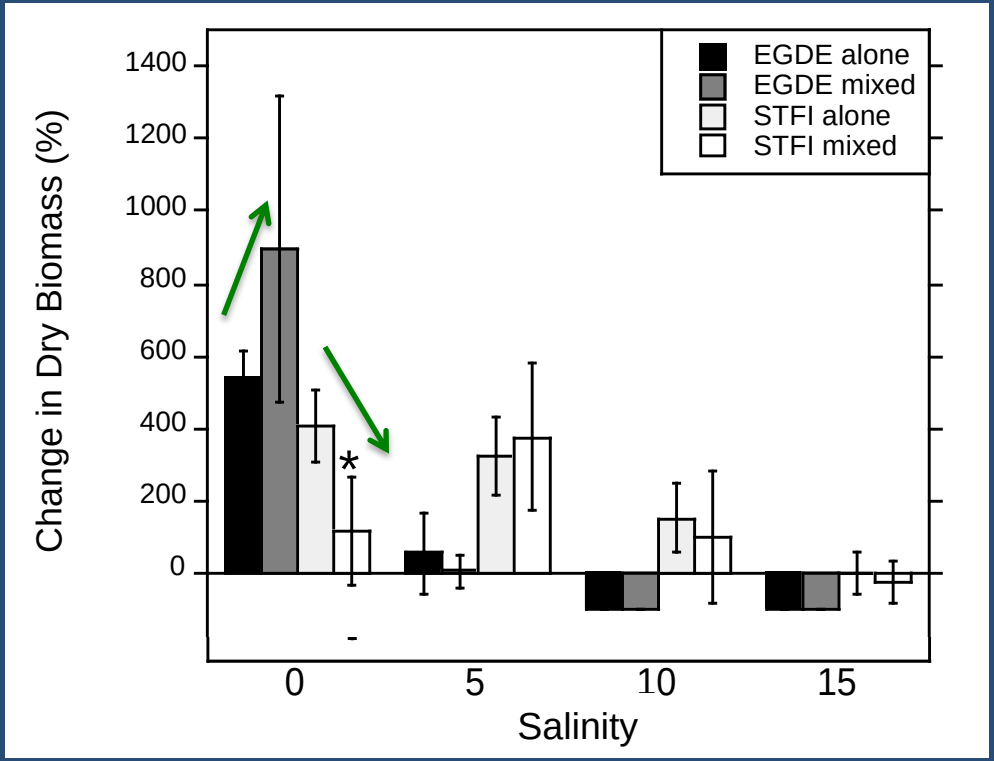



Salinity of 0:

*Egeria*: trend of inc. biomass when *Stuckenia* present in freshwater

# Salinity x Competition Experiment

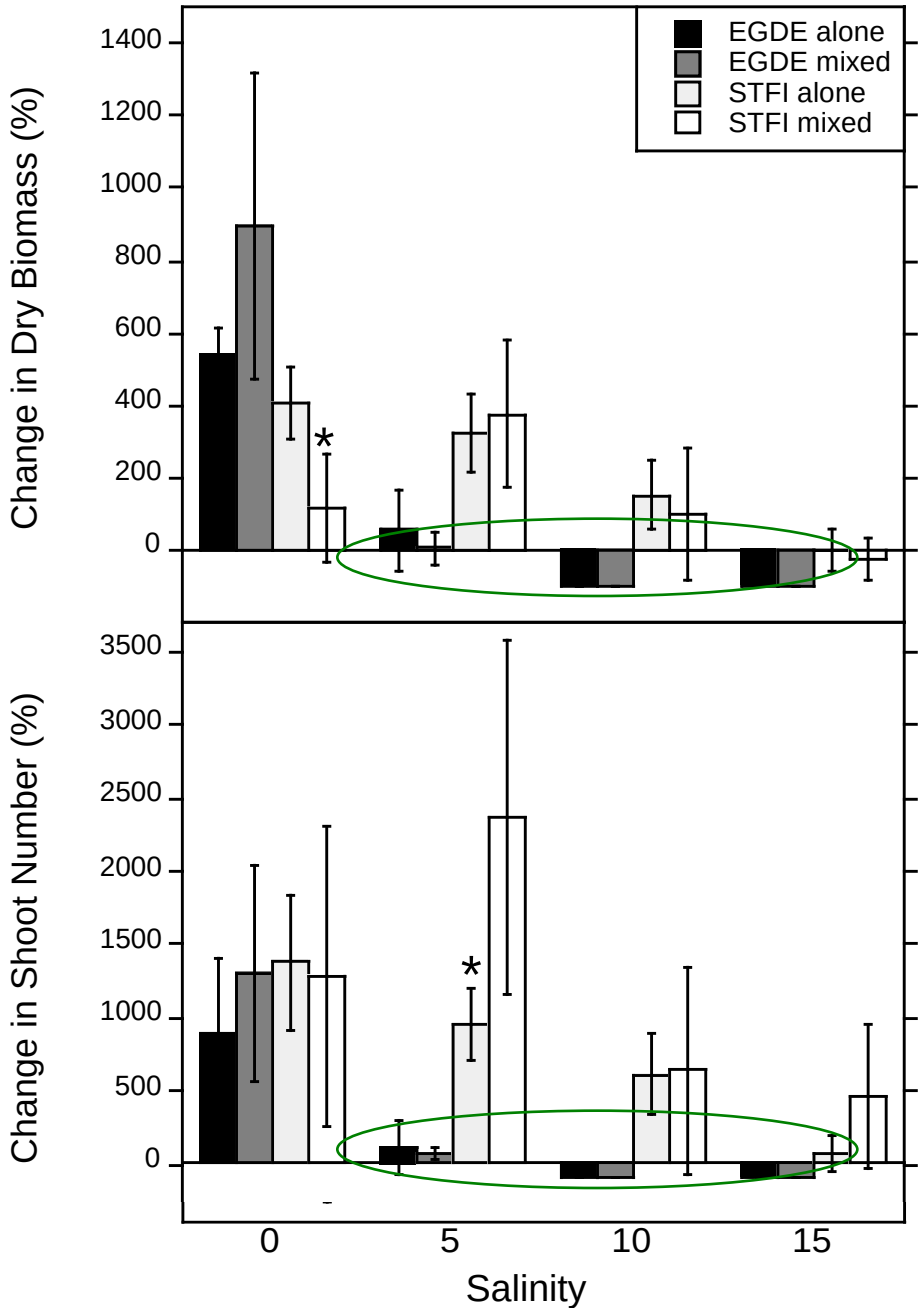



Salinity of 0:

*Egeria*: trend of inc. biomass when *Stuckenia* present in freshwater

Significantly less *Stuckenia* biomass when *Egeria* present

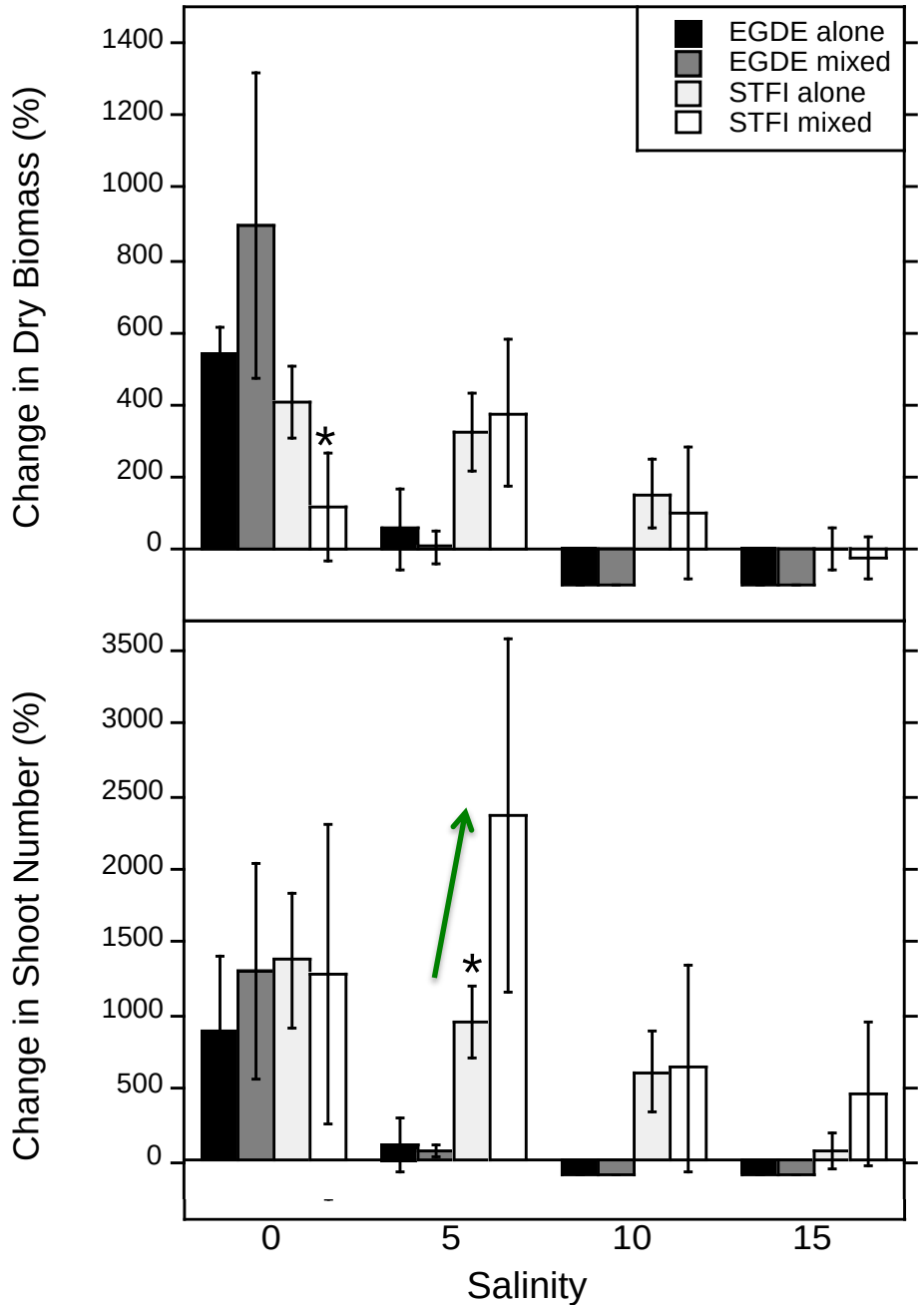
# Salinity x Competition Experiment




Salinity of 5 or higher:

*Egeria* much reduced

# Salinity x Competition Experiment

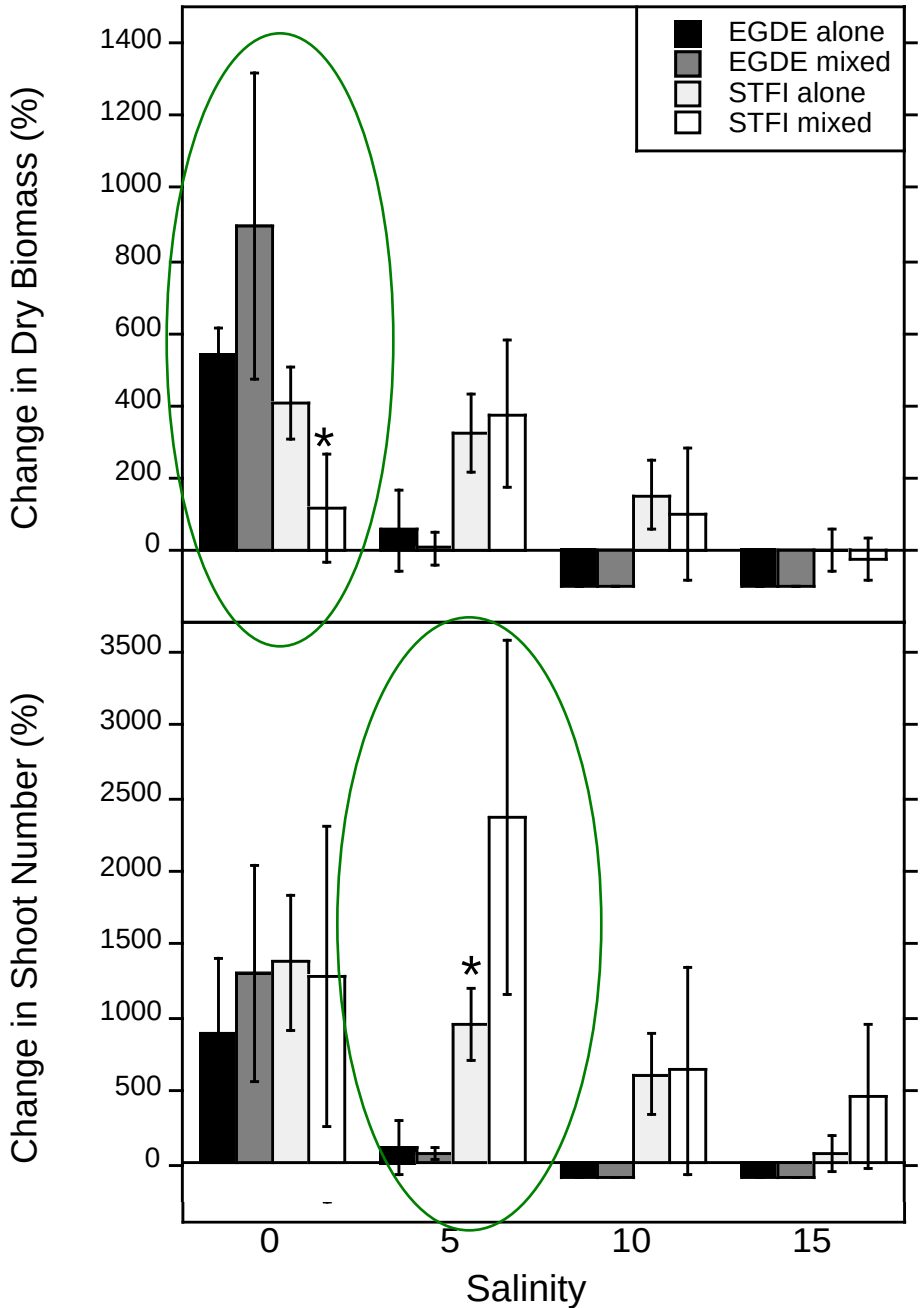



Salinity of 5 or higher:

*Egeria* much reduced

*Stuckenia* shoot number increased when *Egeria* present

# Salinity x Competition Experiment




Competition versus tolerance

*Egeria* better competitor in freshwater

*Stuckenia* tolerates brackish water and is released from competition there

# Key points

- Spatial and seasonal abundance patterns
  - SAV beds in Suisun ~entirely *Stuckenia* spp.
  - *Stuckenia* providing food/cover in spring-fall
  - *Egeria* dominates Delta beds year round, beds diverse

- Salinity and turbidity
  - *Stuckenia*: broad tolerance for salinity (0-15)
  - *Egeria* very limited by salinity (0 to <5)
  - Both species benefit from more light (*Egeria* only at 0)
  - Light may reduce salinity stress for *Stuckenia*

- Competition
  - *Egeria* may exclude *Stuckenia* from fresh water areas

# Today

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In a saltier, less turbid upper SF Estuary:

- *Stuckenia* will maintain current distribution
- *Stuckenia* will expand into the Delta
- *Egeria* will shift further into Delta (and be squeezed due to temperature)

Management potential:

Remove *Egeria* to advance *Stuckenia* into freshwater now?

-need a field experiment, perhaps a transplant

# Thank you!

## Boyer Lab, especially:

Stephanie Kiriakopolos, Jeff Lewis,
Whitney Thornton, Ace Crow

## Funding:

DELTA SCIENCE PROGRAM

DELTA STEWARDSHIP COUNCIL

ECOSYSTEM RESTORATION PROGRAM

California Department of Fish & Game
National Oceanic & Atmospheric Administration
US Fish & Wildlife Service

NOAA FISHERIES

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

For maps: rtc.sfsu.edu (search Boyer Lab)
http://online.sfsu.edu/katboyer/Boyer_Lab/Pondweeds!.html