Sea-level rise impacts on salt marsh vegetation in the San Francisco Bay estuary

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Oregon State UNIVERSITY OSU USGS science for a changing world

Acknowledgements

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Site access

CA Dept Fish and Wildlife &
US Fish and Wildlife Service

Funding

Southwest Climate Science Center

USGS DOI on the landscape

USGS

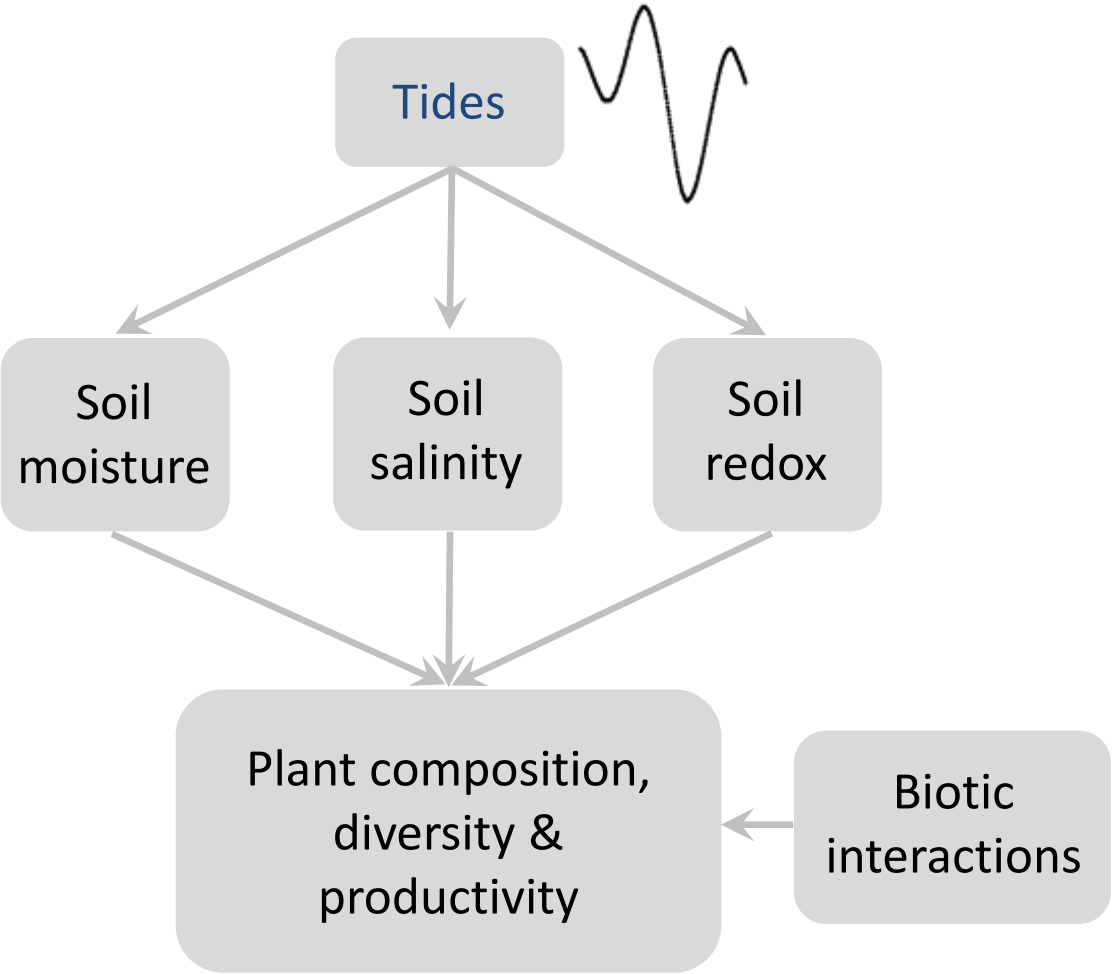
Plants are critical to marsh function

- Primary production
  - Food webs
  - Builds local sediments (accretion & “blue carbon”)
  - Exported to other estuarine/marine ecosystems
- Uptake nutrients
- Stabilize coastal sediments and buffer against storms
- Provide physical structure for wildlife

Peterson et al. 1986 Ecology; Shepard et al. 2011 PLoS 1; Duarte et al. 2013 Nature

C. Janousek, EPA & OSU

Tidal wetlands have steep environmental gradients



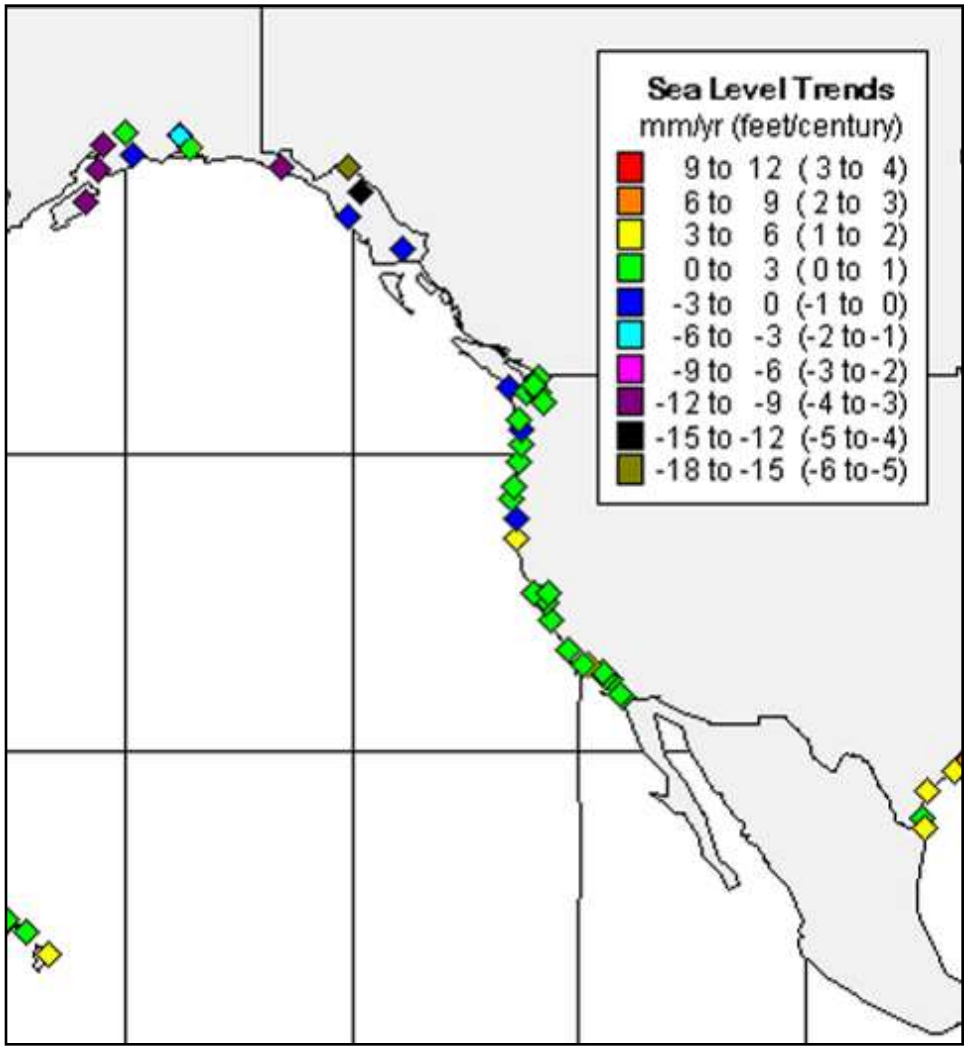
Howes et al. (1986) J Ecol; Bertness & Ellison (1987) Ecol Monogr.

Detailed species responses still largely unknown

We are still trying to understand …

- How are individual species distributed along these gradients?
- How does the shape of the productivity-flooding response vary by species?
- What will happen to plant composition and productivity as gradients are altered by climate change?

SLR may reshape wetland gradients



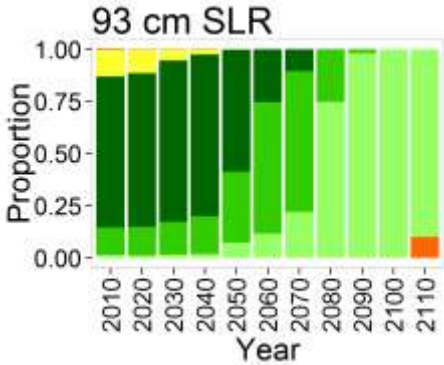
http://tidesandcurrents.noaa.gov/sltrends/slrmap.html

- Increase flooding duration
  - Soil redox
  - Light flux
  - Nutrient delivery
- Increase salinity

West coast SLR program

Site-specific surveys

SLR experiments → Models → Habitat & species vulnerability



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Images: C Freeman, USGS; K Buffington & C Janousek, OSU & EPA

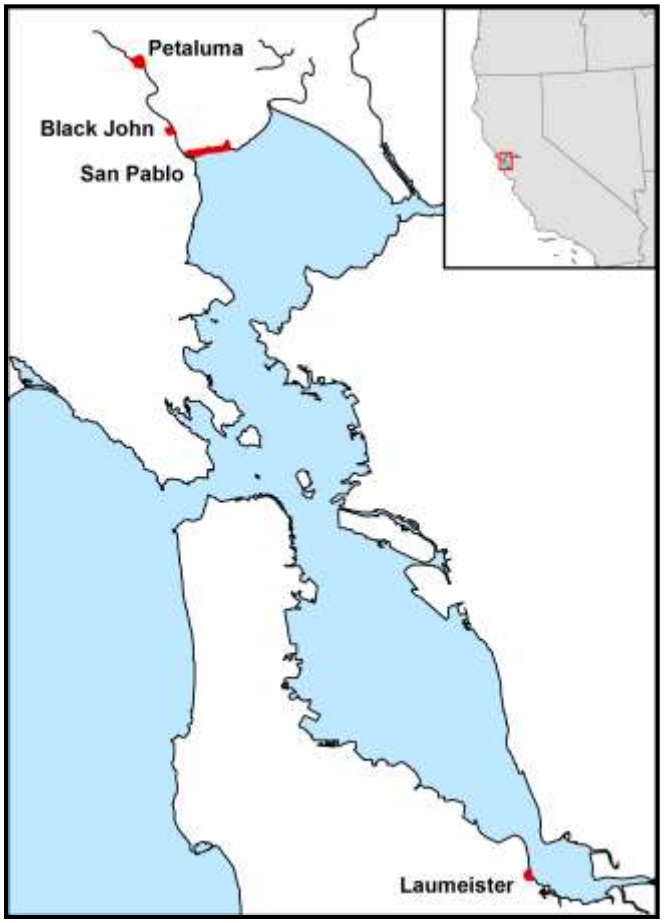
Objectives

1. How are common species in San Francisco Bay marshes distributed with elevation?
2. How are plant growth rates affected by a range of flooding conditions?
3. Are species actually distributed above or below elevations where they show optimum productivity?

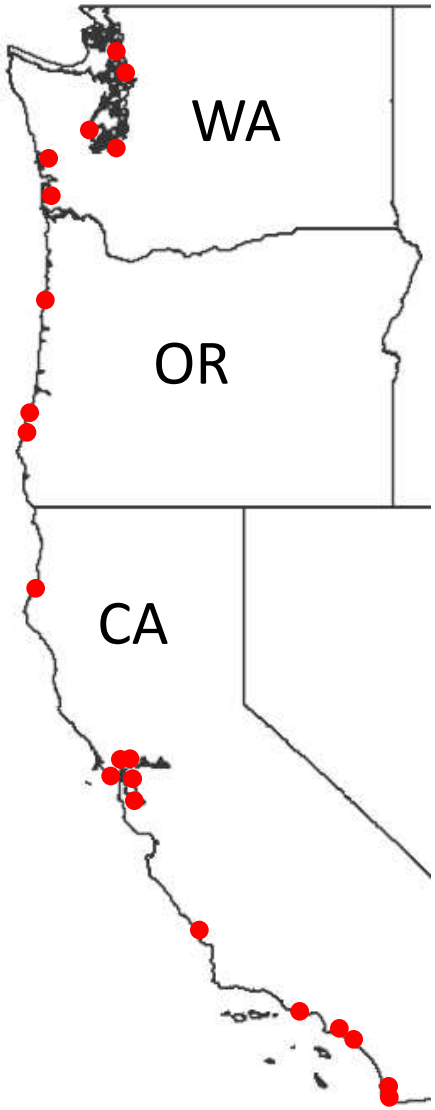
Vegetation and elevation surveys

Site	Year	n
San Pablo	2009	309
Black John	2010	108
Laumeister	2010	72
Petaluma	2014	120

Takekawa et al. (2013)



K Buffington, OSU

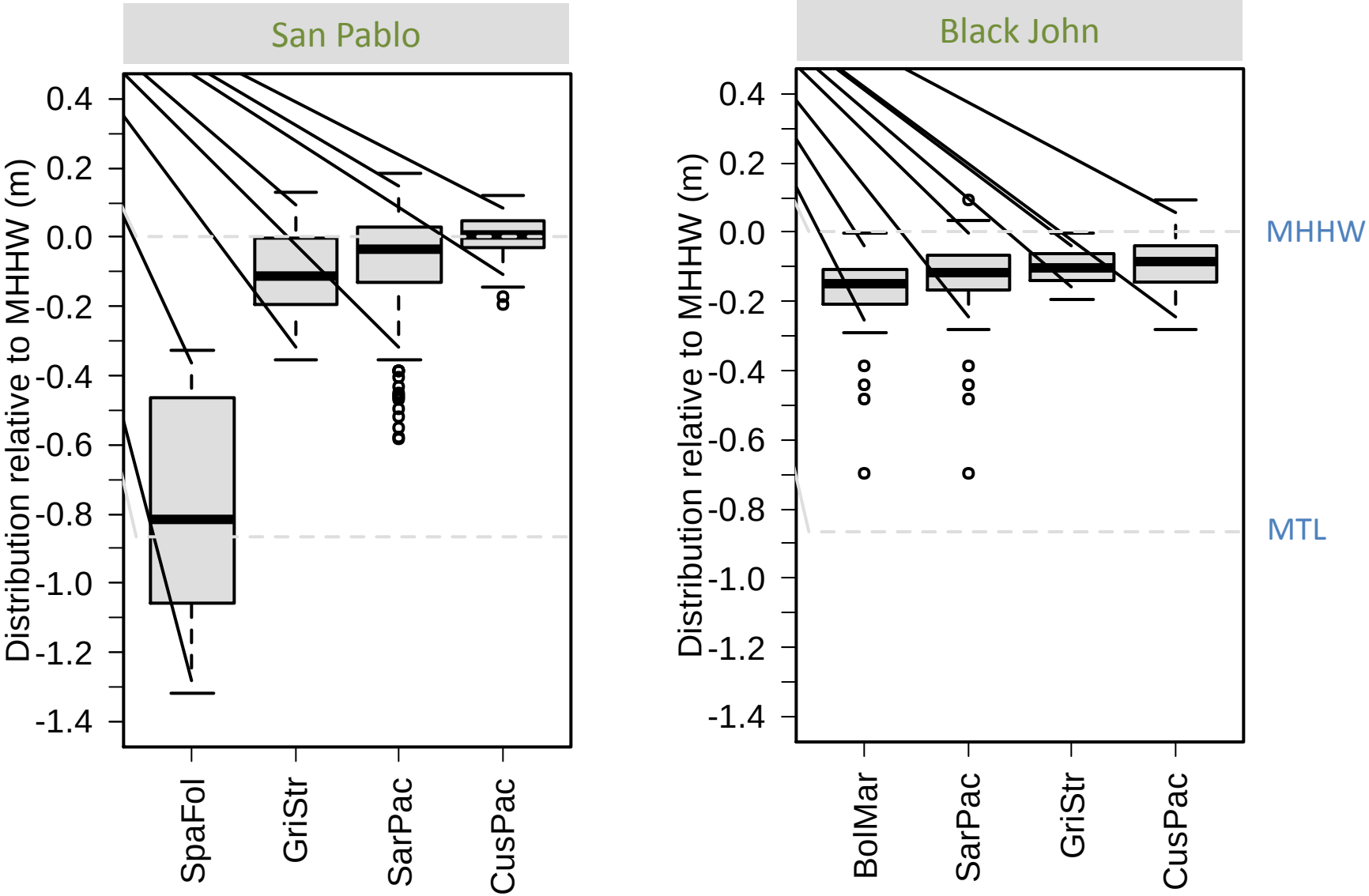


Vegetation and elevation surveys

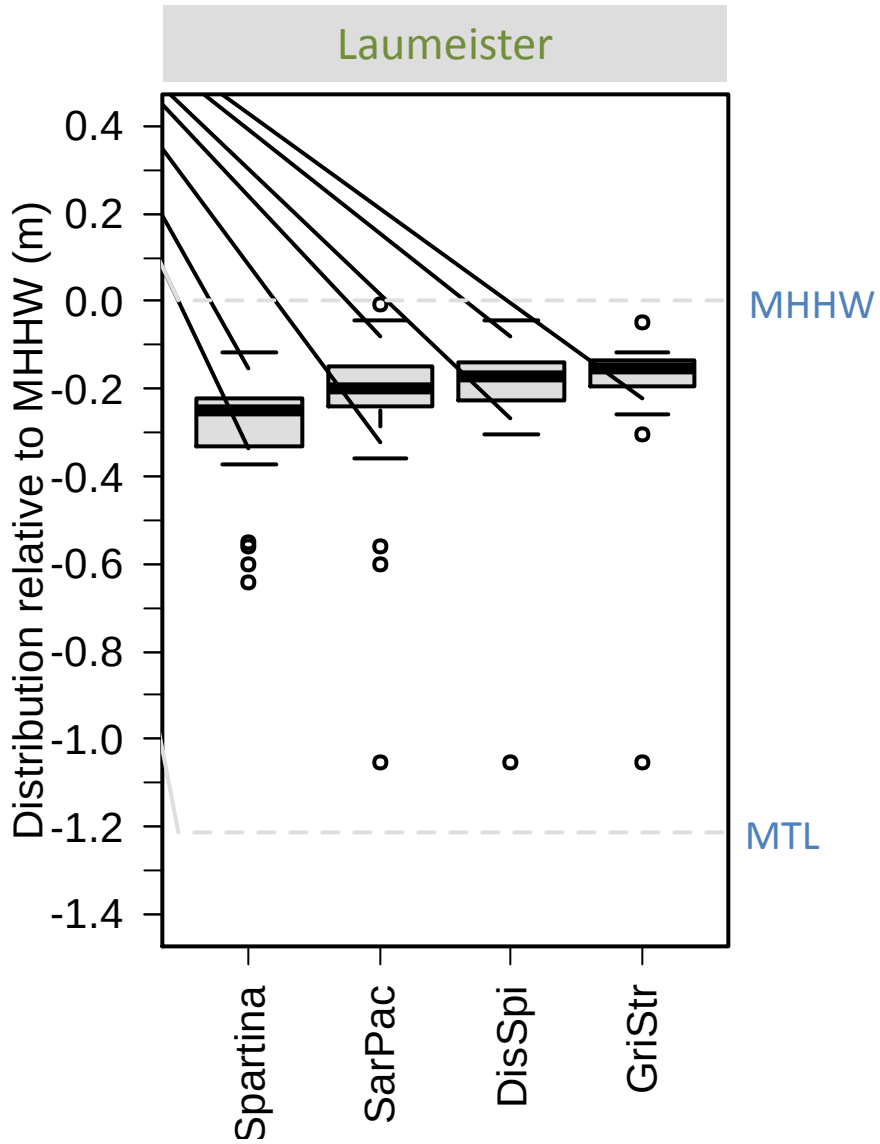
T. Edgarian, USGS

USGS

Results – elevation distributions



Results – elevation distributions



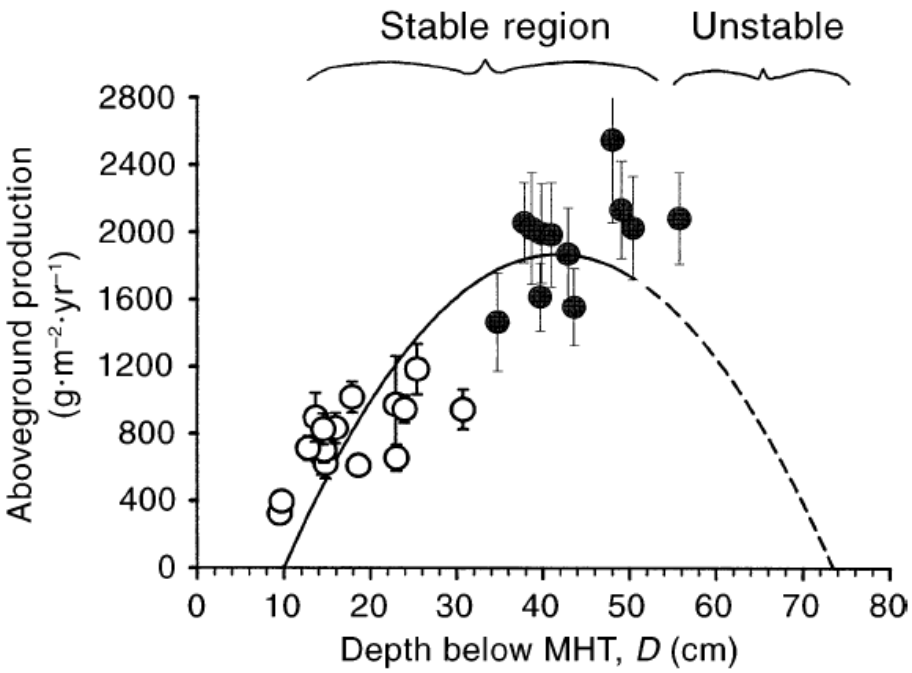
Some findings

- Significant elevation overlap between common species
- Intensity of zonation varied by site
- Species ordering was not always the same across sites

Plant productivity helps maintain wetland elevation

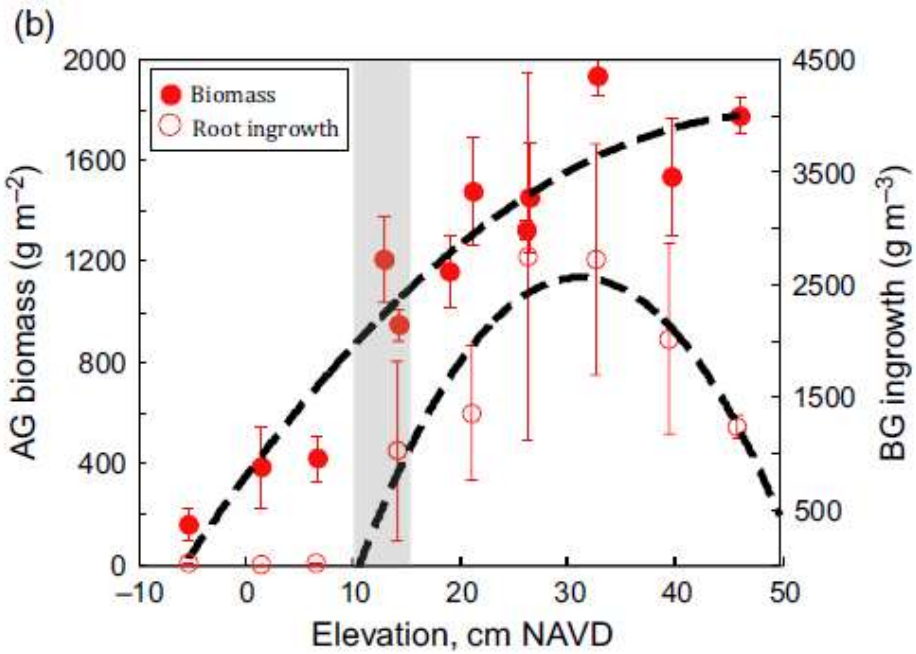
$$E_t = E_o + \text{accretion} + \text{OM input} - \text{decomp} - \text{compaction} \pm \text{tectonics} - \text{SLR}$$

Spartina alterniflora



Inundation

S. patens

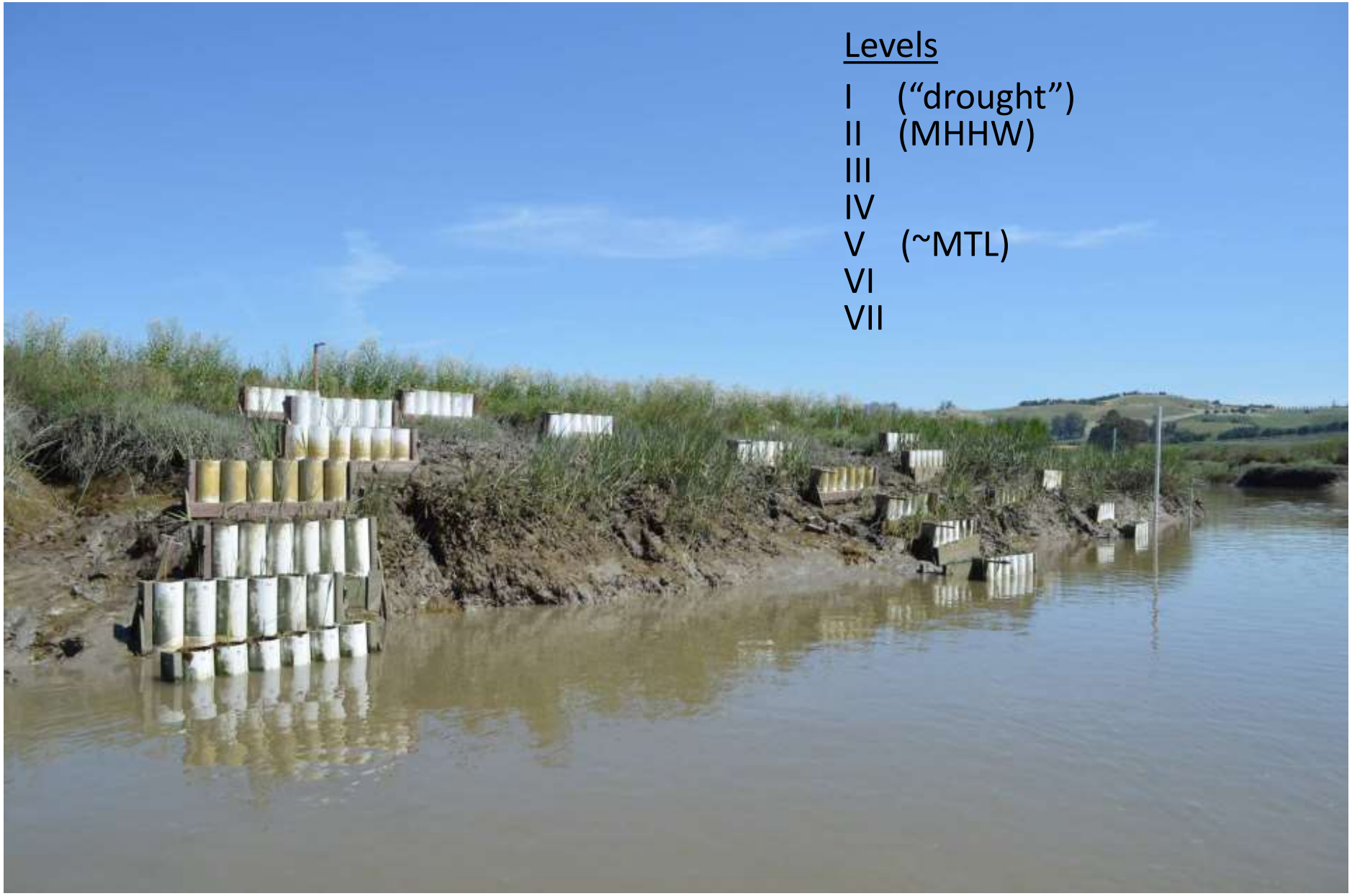


Morris et al. (2002) Ecol

Ecology, 83(10), 2002, pp. 2869–2877
© 2002 by the Ecological Society of America

Kirwan & Guntenspergen (2012) J Ecol

“Marsh organs”



Transplanted early April 2014

Sarcocornia pacifica	*Spartina foliosa*	*Bolboschoenus maritimus*
Perennial forb	Perennial grass	Perennial sedge

Species zonation at Petaluma

Sarcocornia pacifica

Bolboschoenus maritimus

Spartina foliosa

2014 growing season

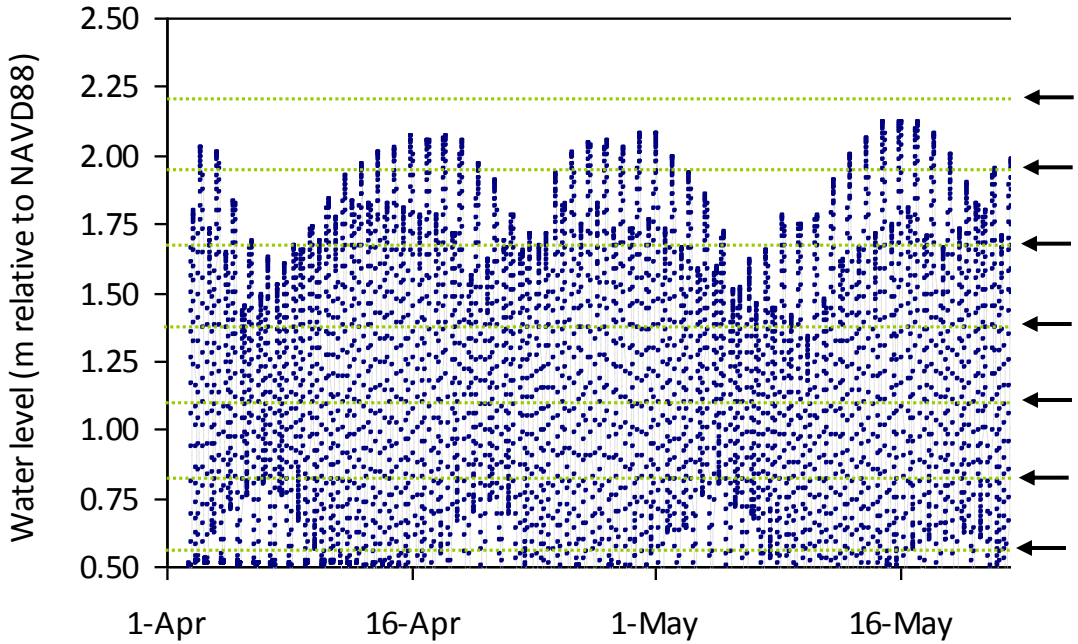
April-August

- Periodically assessed plant health and height
- Time series of salinity, temp, and water levels

August harvest

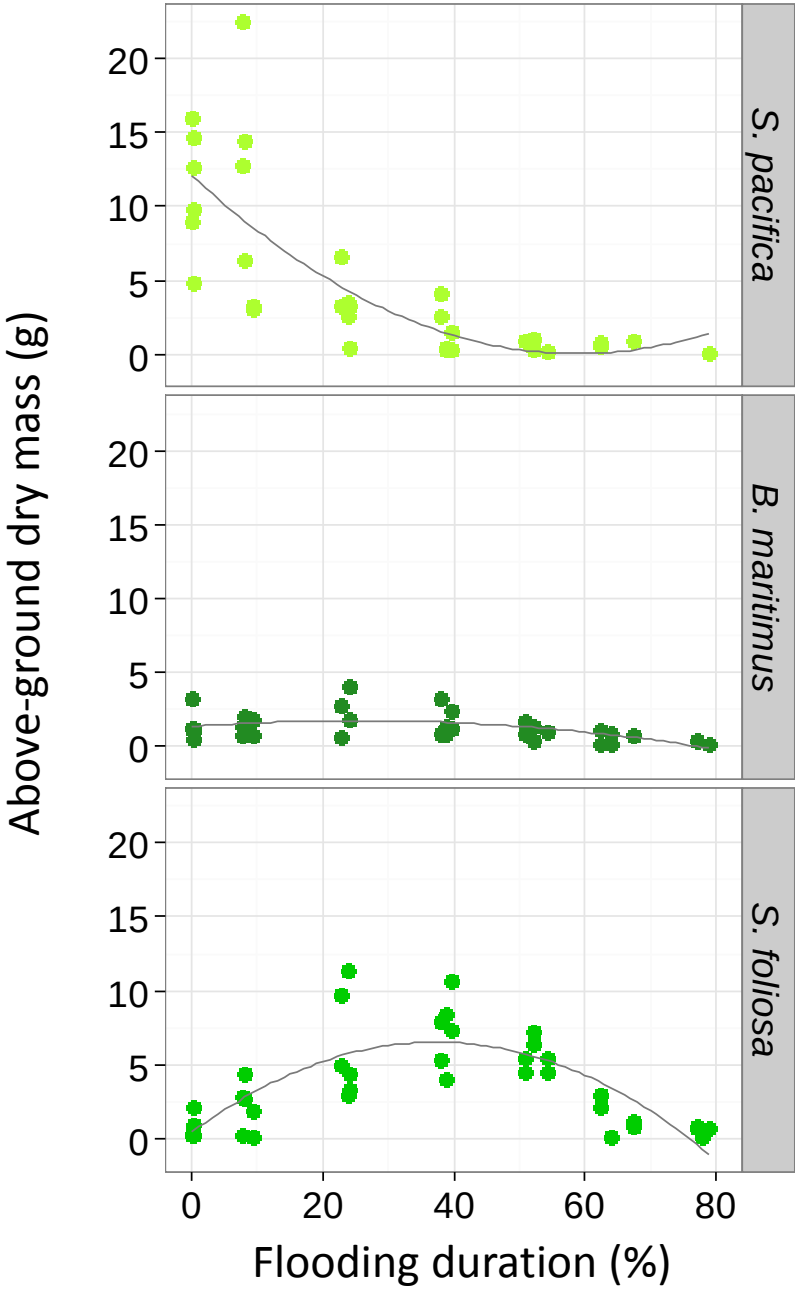
- Plant height, above- and below-ground biomass
- Secondary shoot production
- Leaf and branch number
- Decomposition in litter bags

Flooding duration in the mesocosms

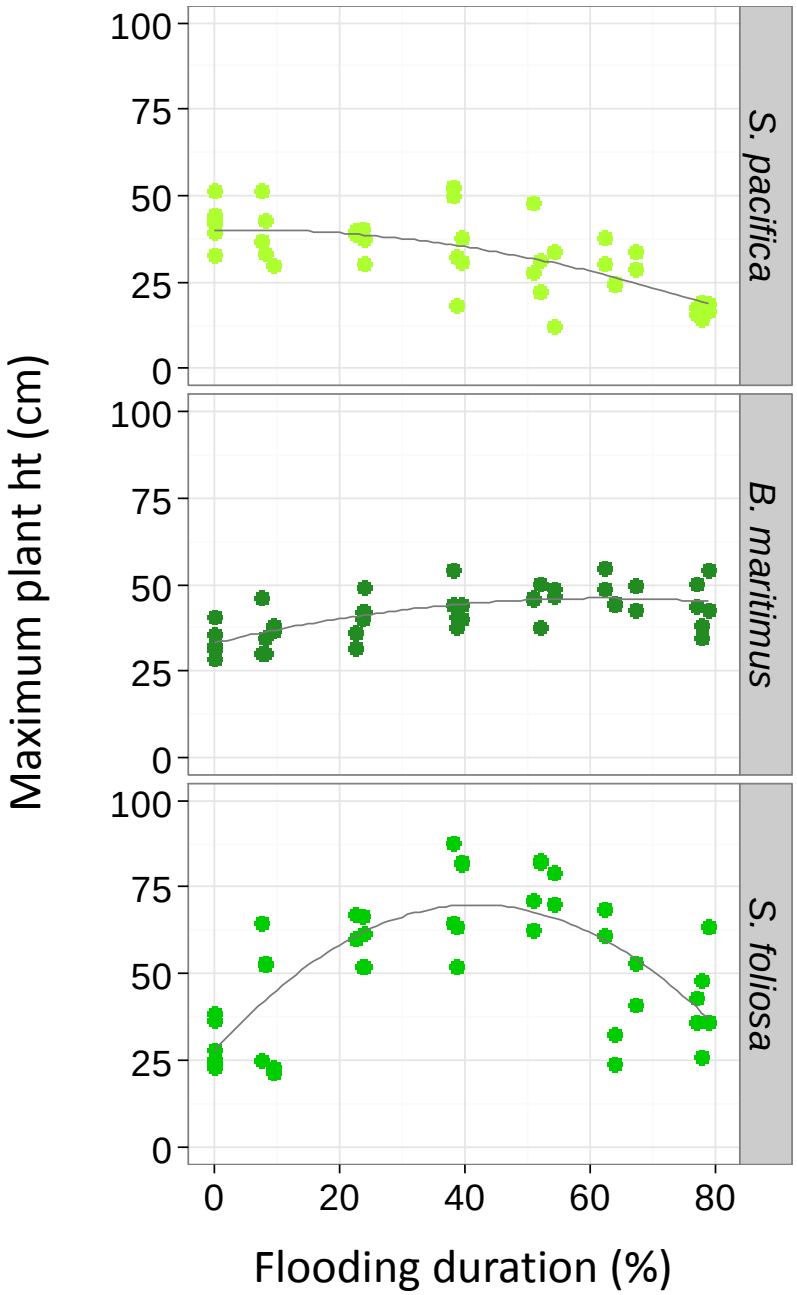


Level	Mean % time flooded	
I	0.2	
II	8	MHHW
III	23	
IV	39	
V	52	~MTL
VI	65	
VII	78	

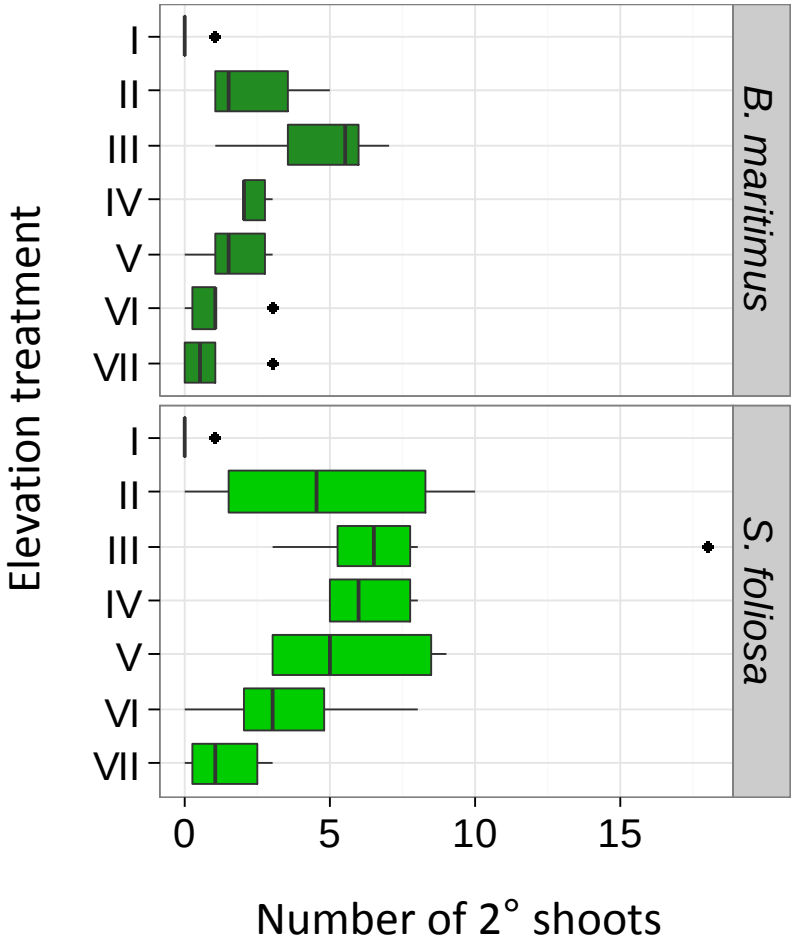
Above-ground productivity



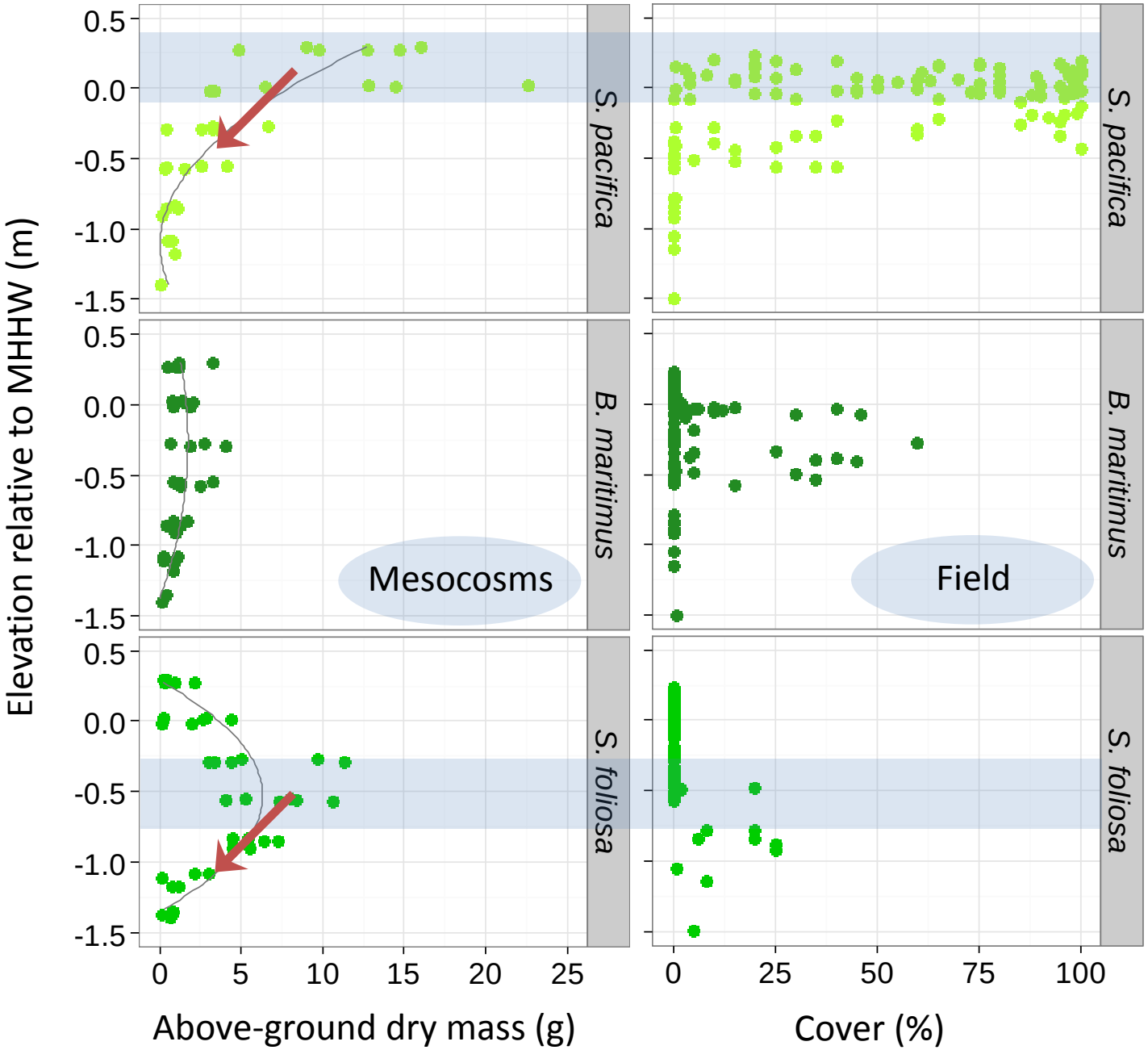
Maximum shoot length



Secondary shoot production



Are plants found at their optimum elevation?



Key findings

- *Bolboschoenus* growth peaked early. High salinity may have slowed later growth
- Optimum flooding levels varied by species
  - *Spartina*: 30-50%
  - *Bolboschoenus*: 20-40%
  - *Sarcocornia*: 0-10%
- High inundation (>50%) decreased growth of all species
- *Sarcocornia* & *Spartina* frequently grow below their optimal productivity. SLR may thus decrease growth further.

Implications for marsh structure and function

Community composition

- Relative SLR may shift dominant species
- Will drowning marshes be more at risk of hybrid *Spartina* invasion?

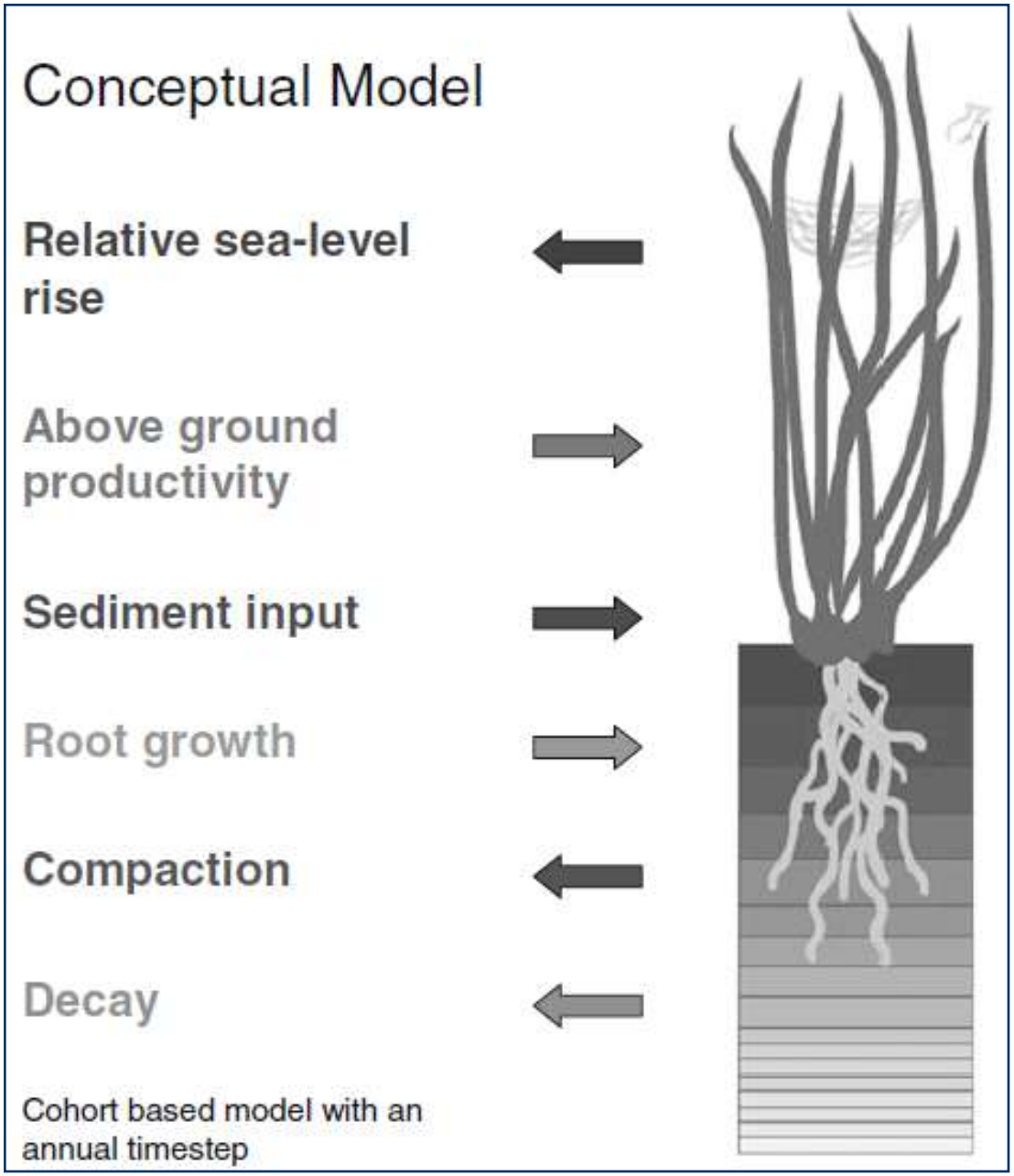
Physical structure of marshes

- Loss of plant biomass may reduce habitat complexity for wildlife
- Lower organic matter production may decrease sediment buildup (negative feedbacks for marsh elevation)

Thank you

Photos: C. Janousek, EPA & OSU

WARMER (1D SLR model)



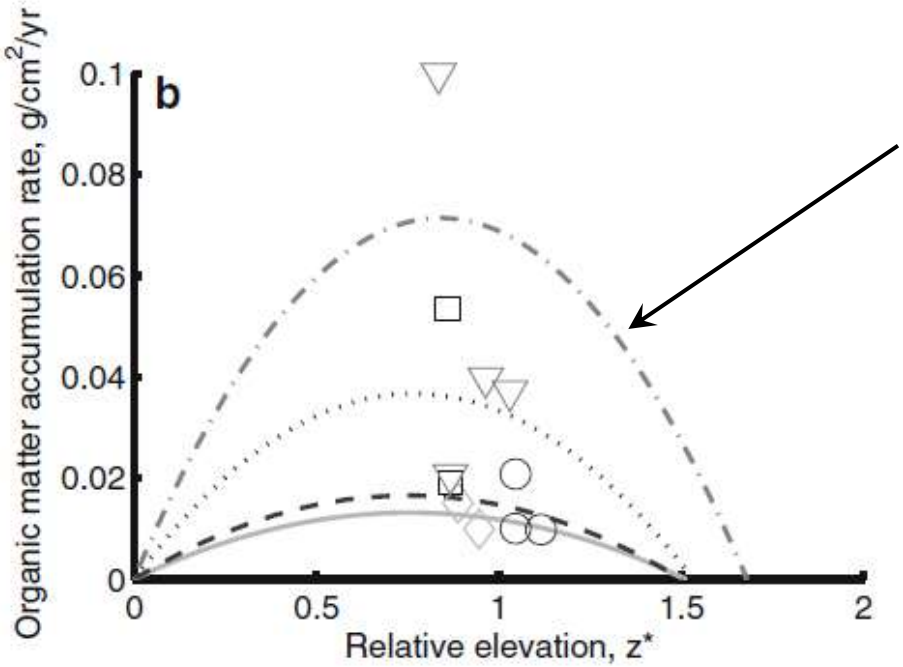
Model inputs

- Accretion rate
- OM input rate (above, below)
- Sediment compaction (porosity)
- Root: shoot ratio
- Decomposition rate
- SLR

Swanson et al. (2013) Est Coasts

Productivity experiments inform modeling efforts

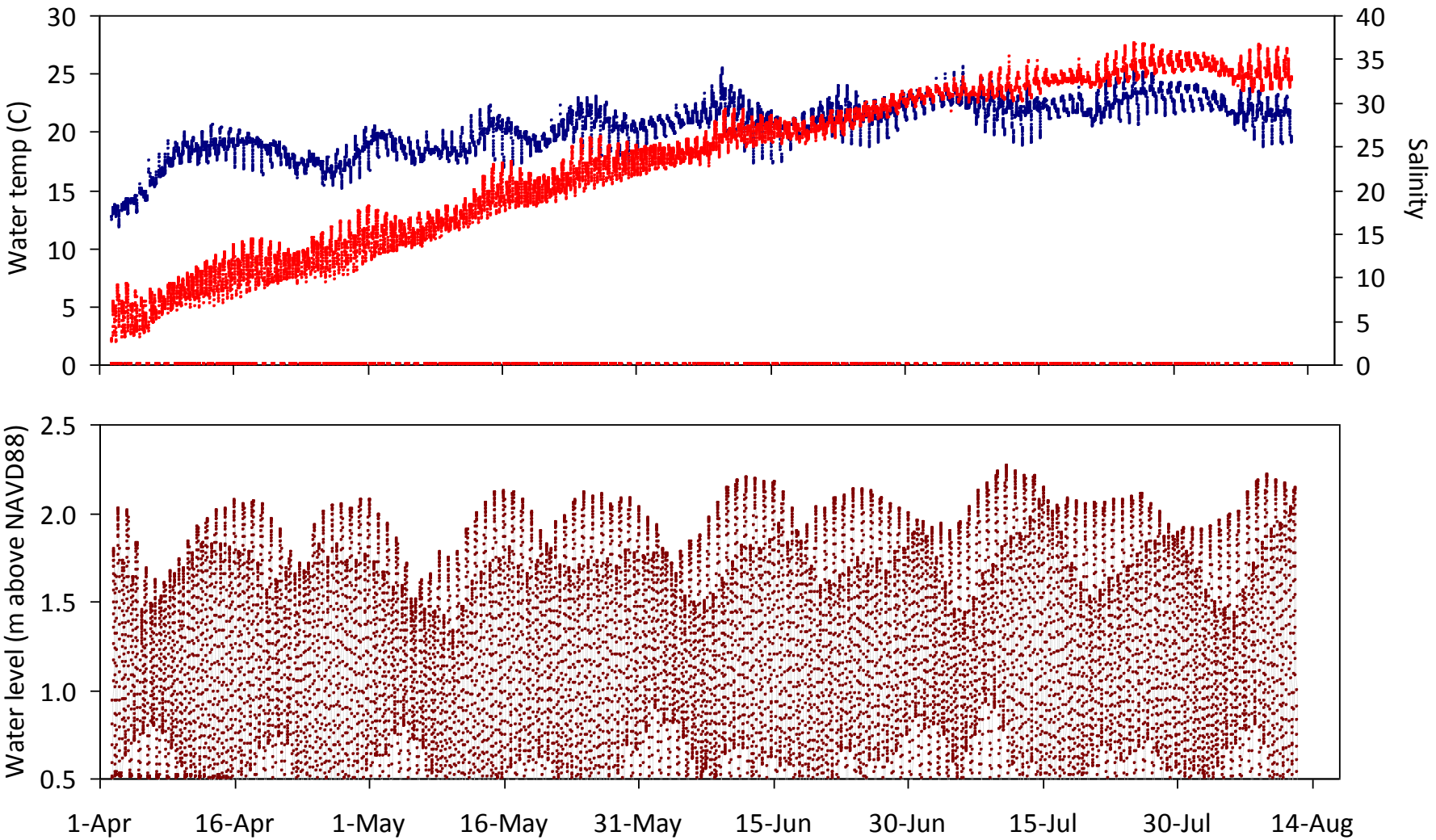
Improve WARMER functions



The shape of this relationship, developed for east coast *Spartina*, may be inaccurate for many west coast species

Swanson et al. (2013) Est Coasts

Water level, water temp, salinity time series



Christopher N. Janousek
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All photos by CNJ @ OSU, unless noted.
Dry mass data are preliminary.