Drought Indices in Texas Estuaries

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Drought Impact and Recovery in Texas Estuaries
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Estimation of Freshwater Inflow Requirements for a Semi-arid Salt Marsh Using Emergent Plants as Indicators of Ecosystem Condition

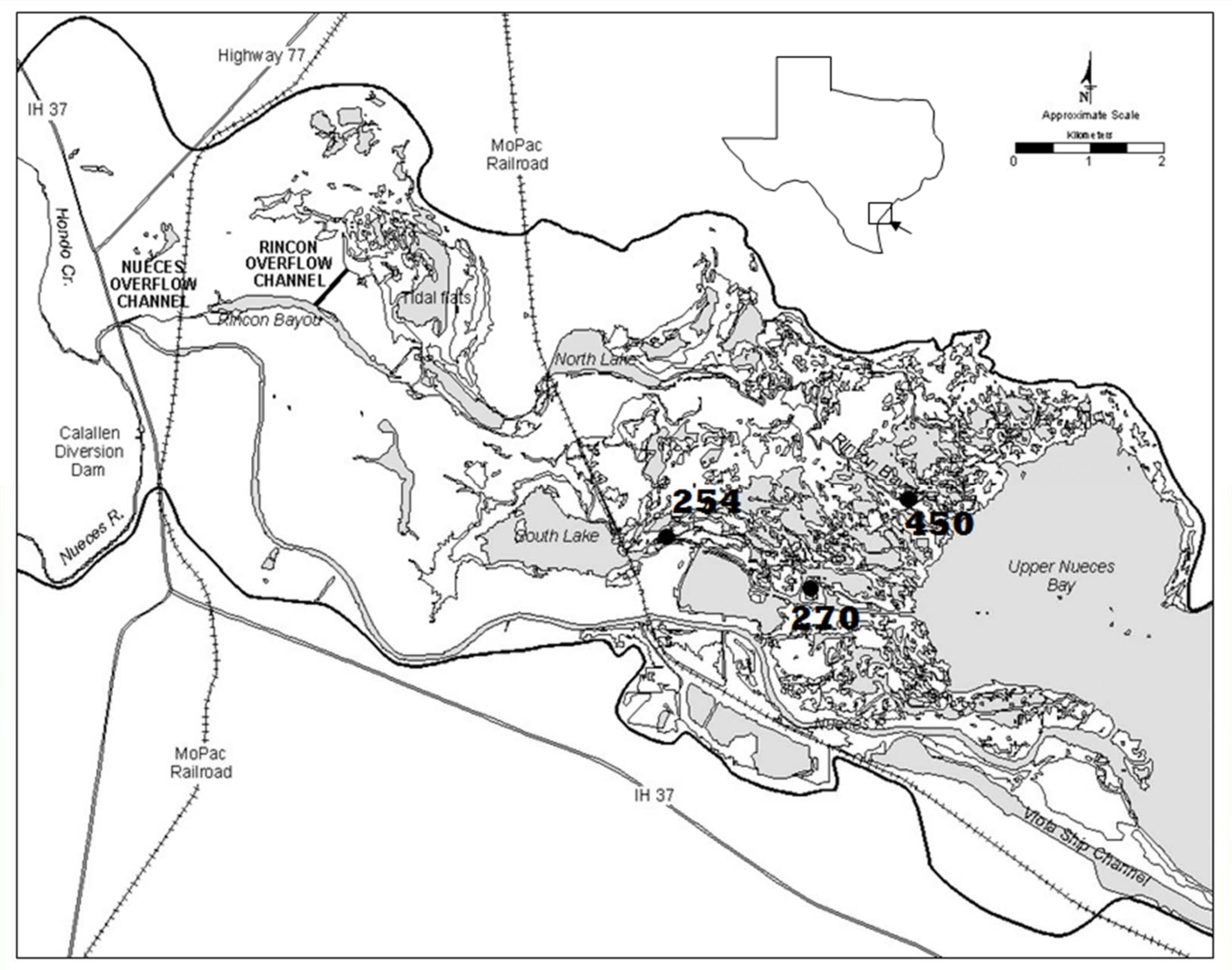
(Joe Stachelek, MS 2012)

- Community composition as a function of wet/dry period
- Evaluation of potential indicator species
- Estimation of freshwater inflow requirements

Long Term Monitoring (1999-2011)

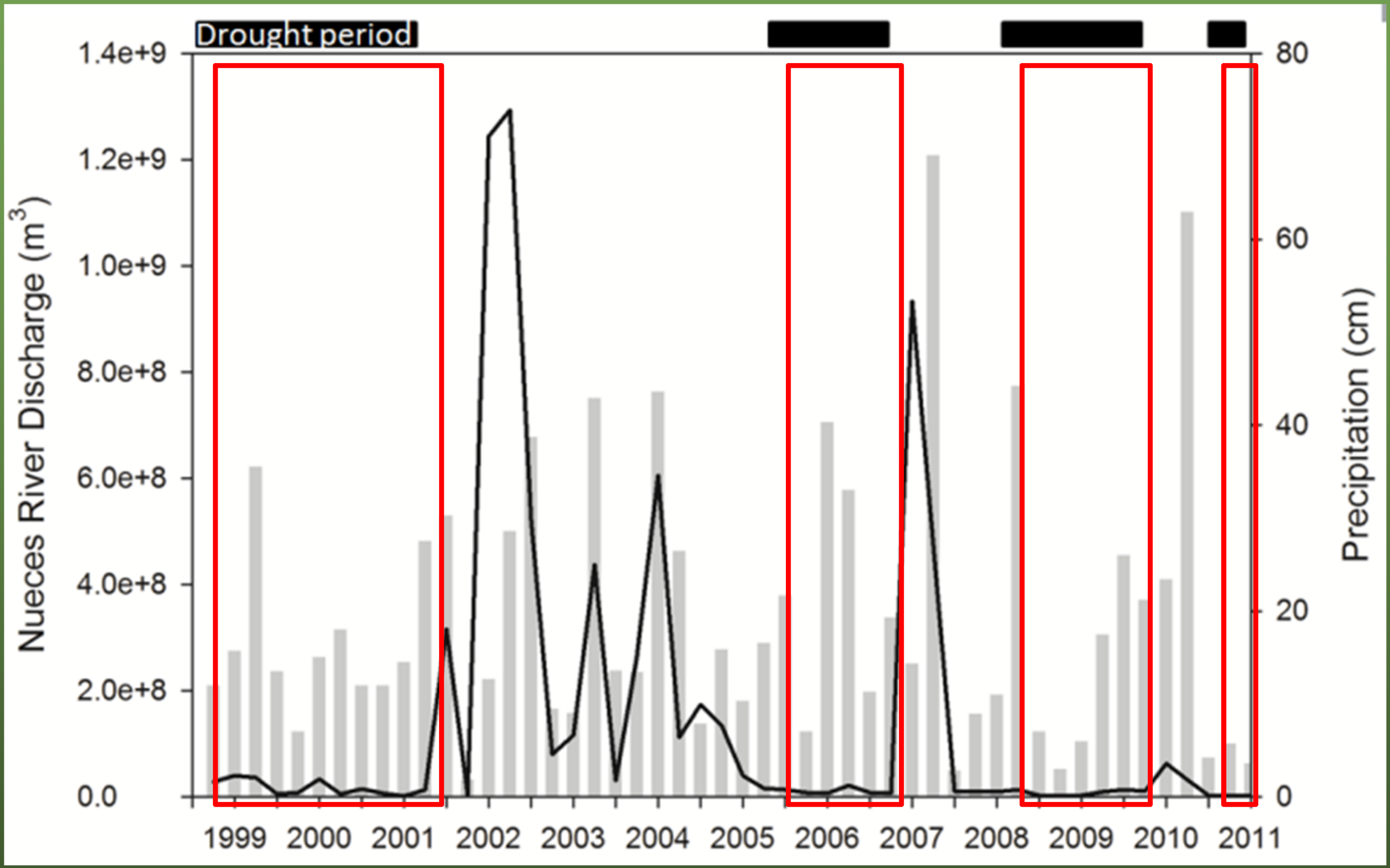
1. Plant abundance measured by quadrat on a percent cover basis
2. Porewater collection
3. Gauged freshwater inflows

Study Area



3 Study Sites – 254, 270, 450

Freshwater Inflow



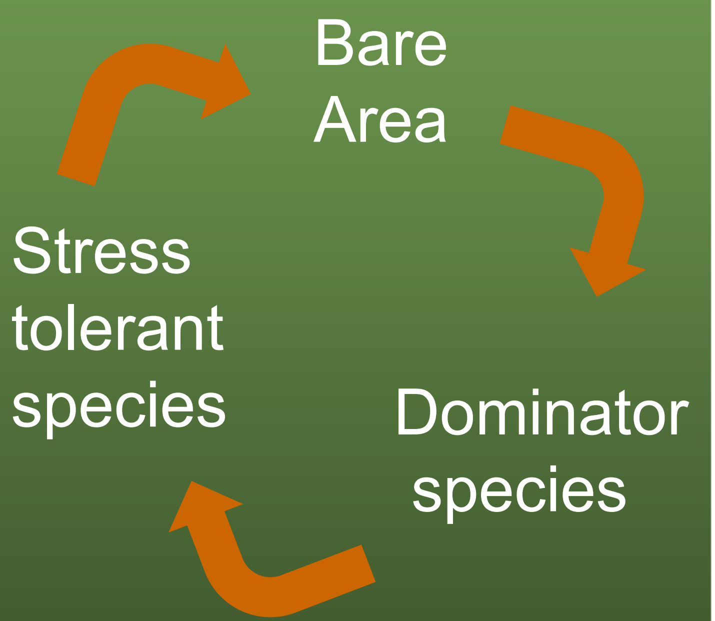
- 3 wet periods: 2002-2004, 2007, 2010
- 3 dry periods: 1999-2001, 2005-06, 2008-09

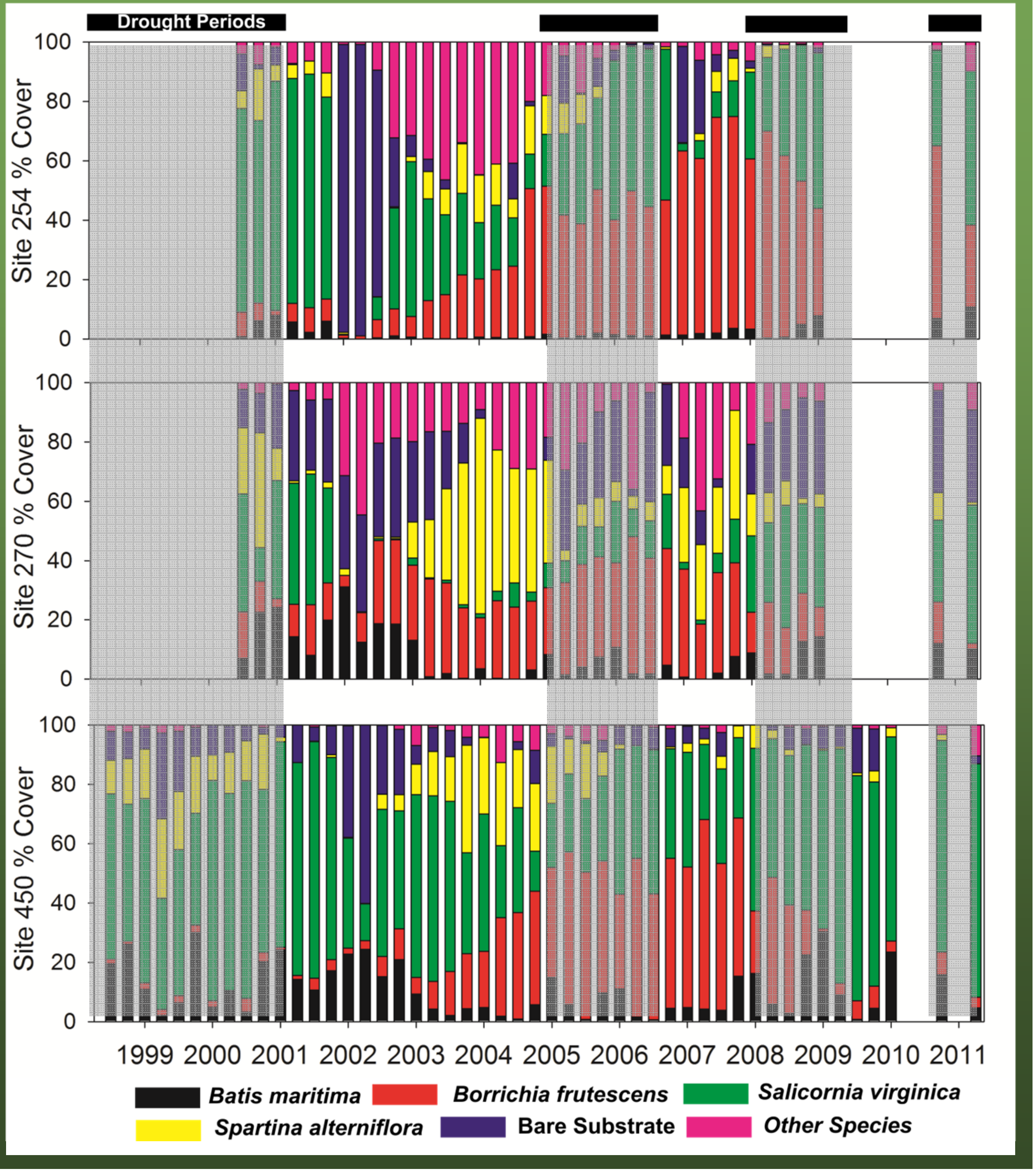
Environmental Controls (CCA)

Scores for constraining variables	Axis 1	Axis 2
Porewater Salinity	**0.59**	-0.45
Porewater Ammonium	-0.01	0.34
Soil Moisture	**-0.94**	0.27
Distance to Tidal Creek	0.40	0.37
Distance to Nueces Bay	0.59	0.64
% Variance Explained	**77.93**	14.08

- Soil moisture and porewater salinity have large impacts on the overall vegetation assemblage

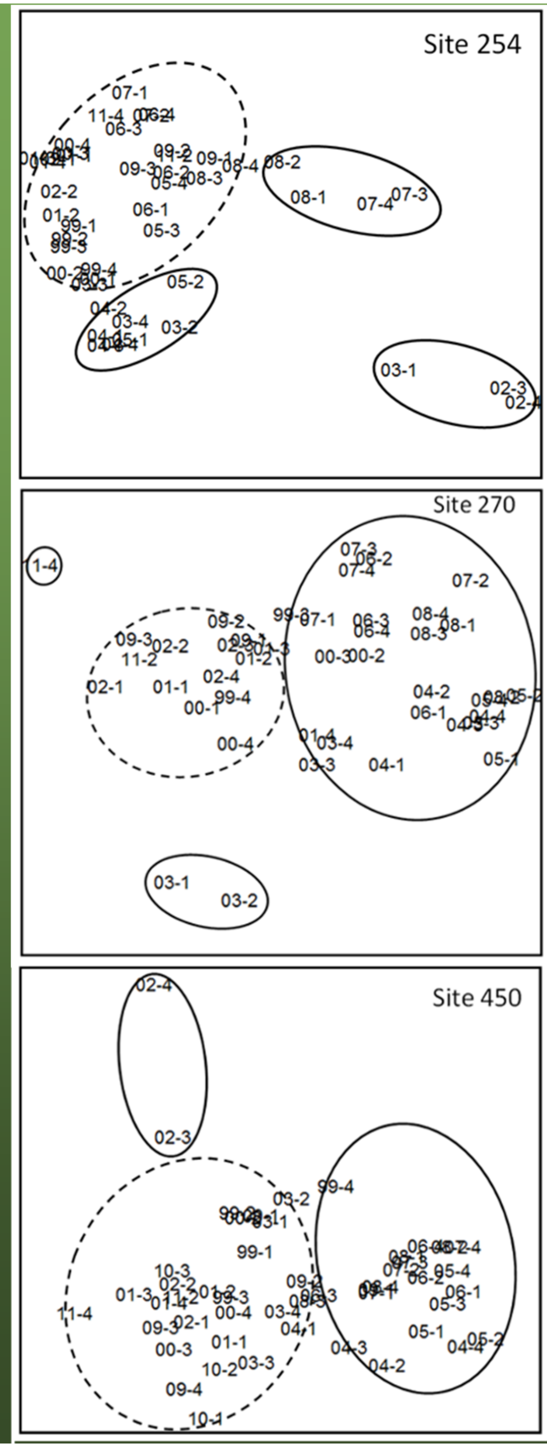
Vegetation Community





Vegetation Cont'

- Dry period assemblages (dashed circles) group together
  - Site 254 = 73% overlap
  - Site 270 = 38% overlap
  - Site 450 = 92% overlap
- Demonstrates a consistent link between ecosystem condition and hydroclimatic period



Indicator Species

- Facilitate ecosystem function

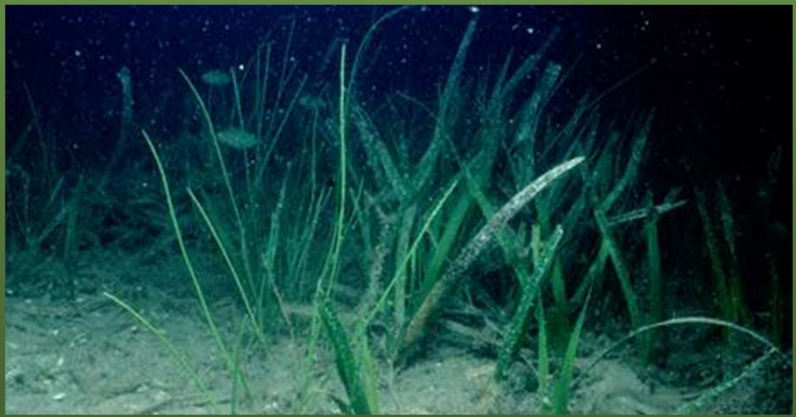
1. Do they provide habitat or food?

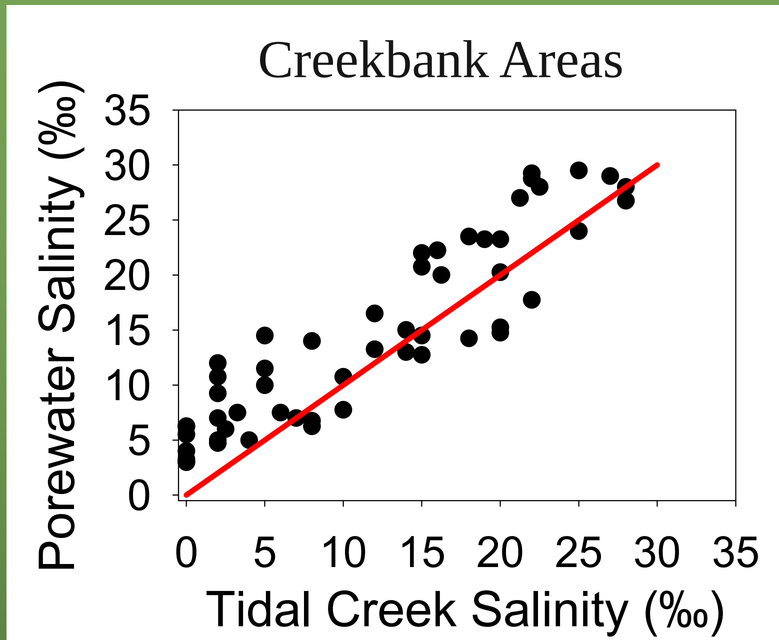
- Abundance reflects natural flow regimes and habitat features

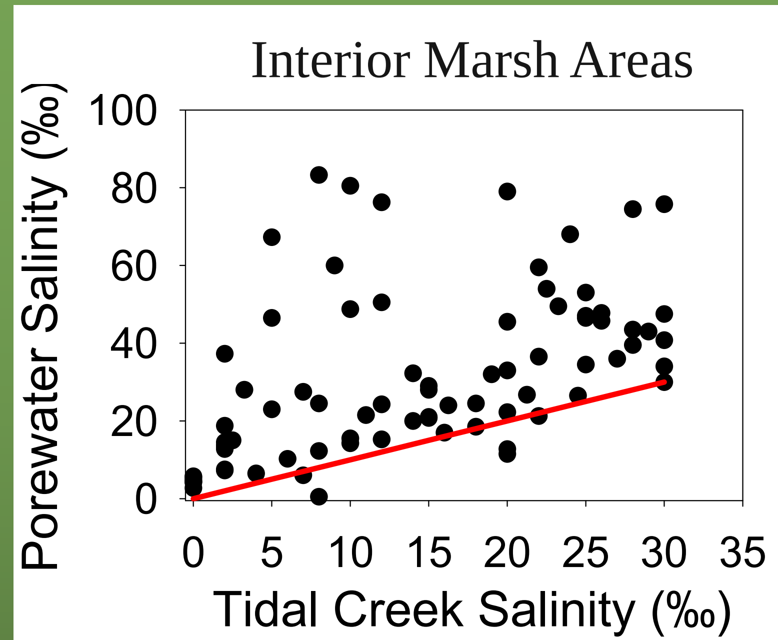
2. Are they exposed to conditions that reflect the overall ecosystem?

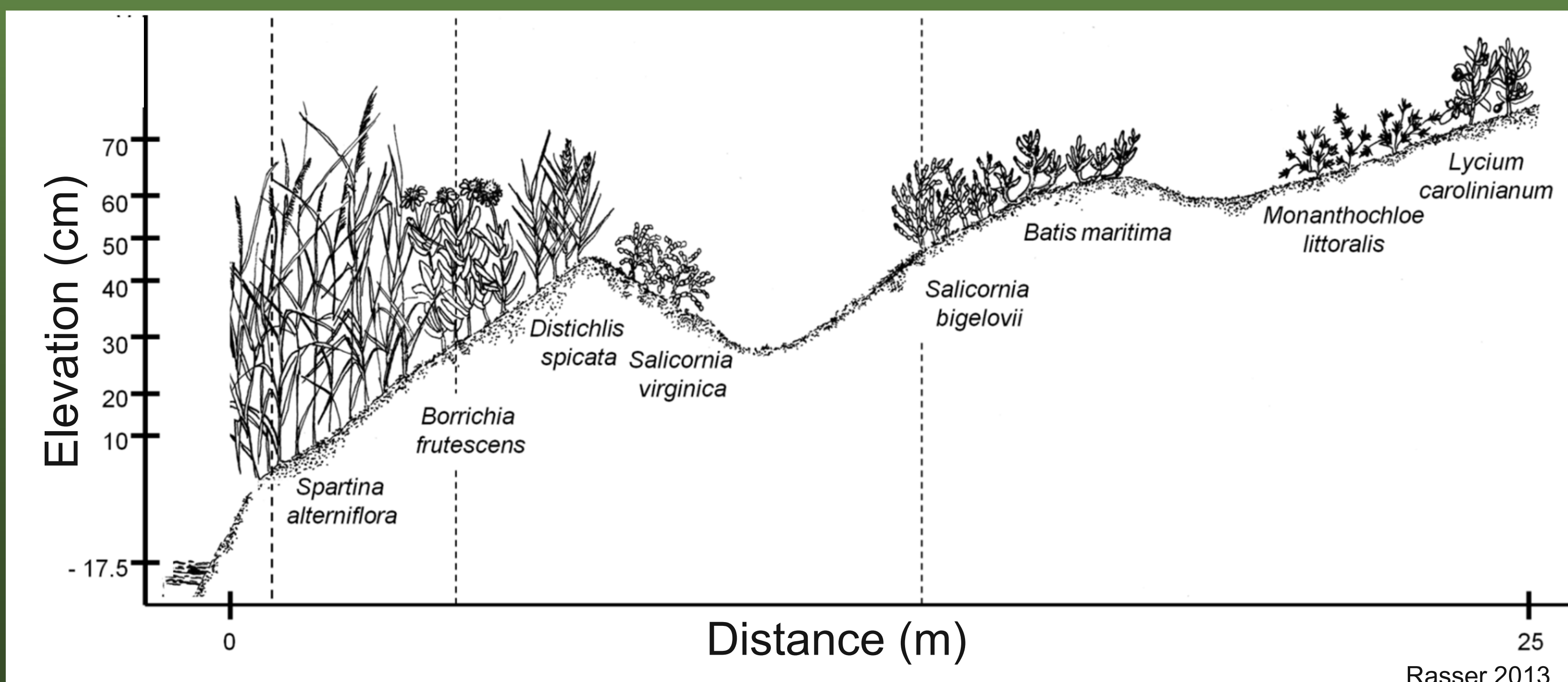
- Detect biologically meaningful change

3. Do fluctuations mirror other indicators?




Creekbank Areas
Porewater Salinity (‰)
Tidal Creek Salinity (‰)
0 5 10 15 20 25 30 35


Interior Marsh Areas
Porewater Salinity (‰)
0 20 40 60 80 100
Tidal Creek Salinity (‰)
0 5 10 15 20 25 30 35


Elevation (cm)
70
60
50
40
30
20
10
- 17.5
Spartina alterniflora
Borrichia frutescens
Distichlis spicata
Salicornia virginica
Salicornia bigelovii
Batis maritima
Monanthochloe littoralis
Lycium carolinianum
Distance (m)
0
25
Rasser 2013

Spartina alterniflora

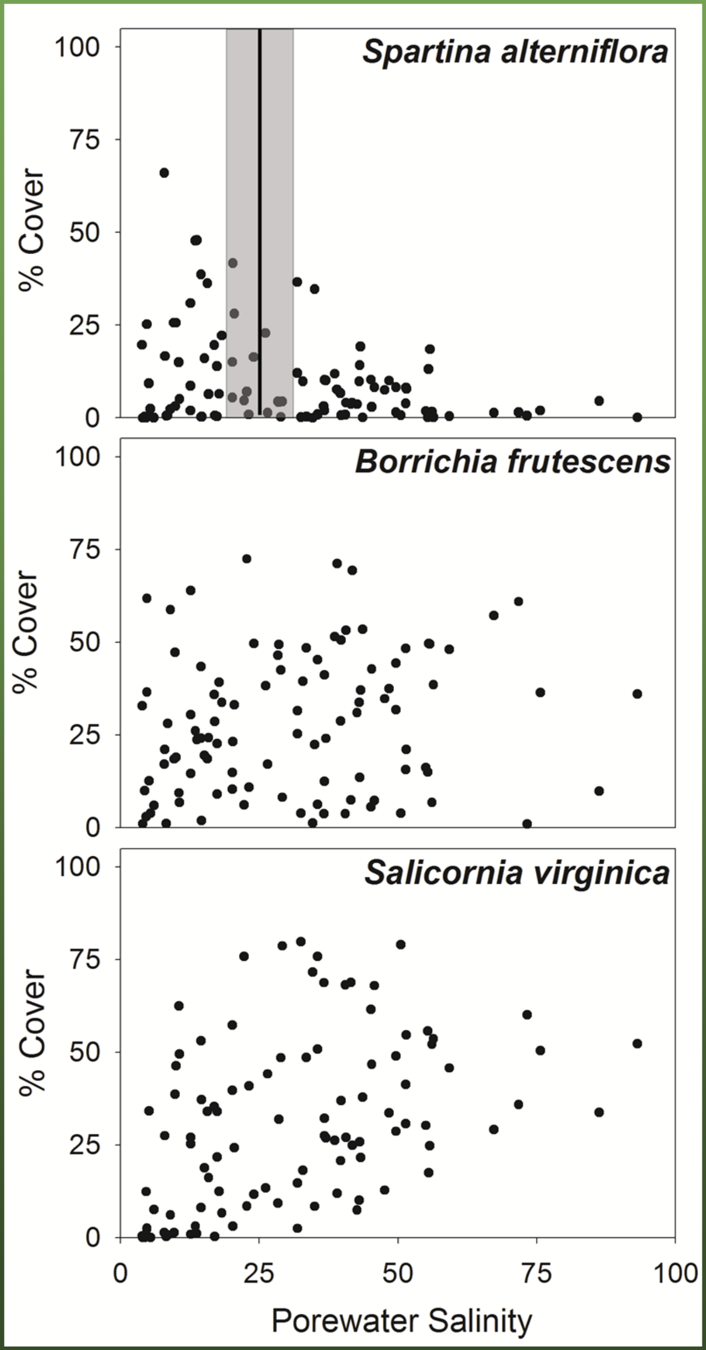
- Found fringing tidal creeks
- Provides important habitat to nekton

Borrichia frutescens

- Occupies creek bank levees
- Most abundant plant in the low marsh

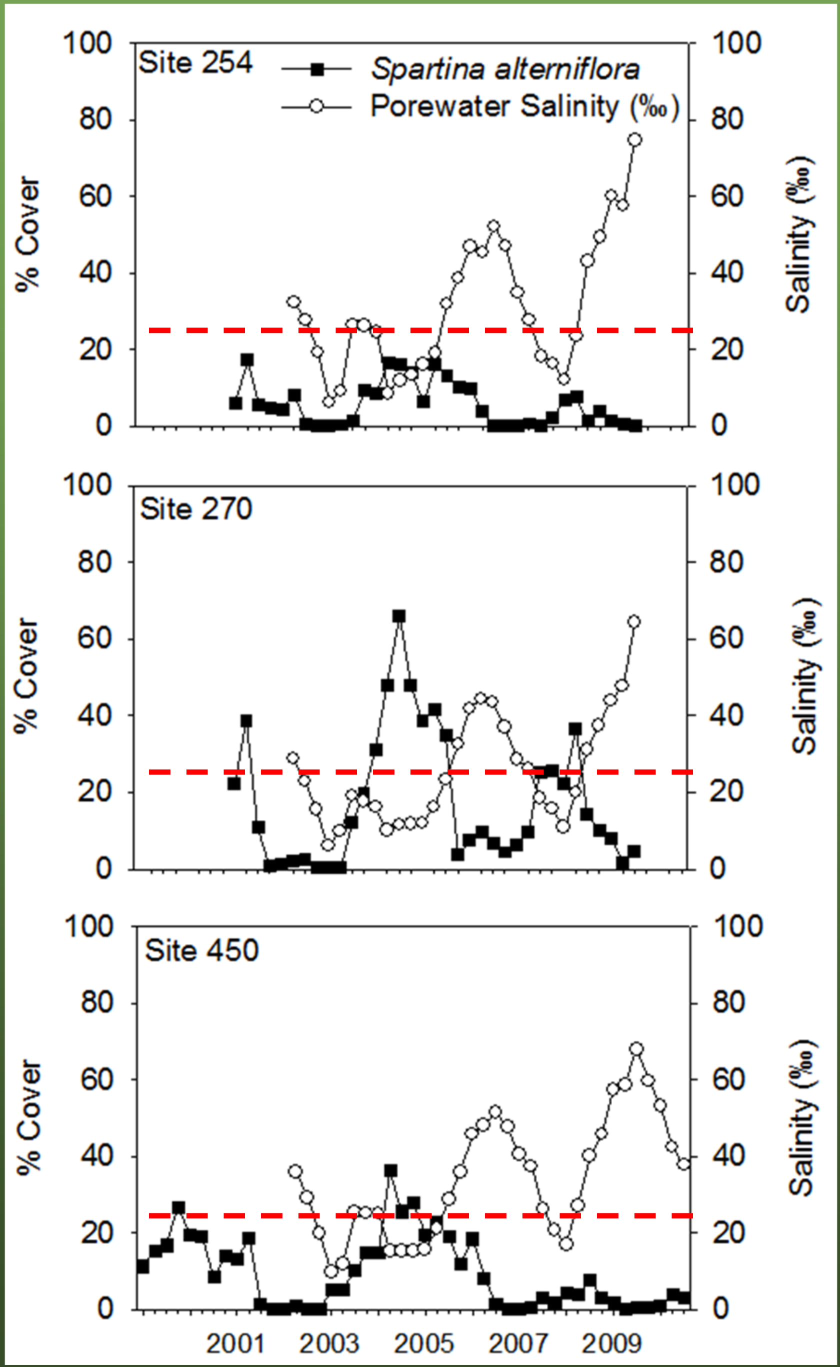
Salinity Tolerance

- Salinity tolerance for *S. alterniflora* estimated at 25 ± 5
- No salinity response detected for *B. frutescens* and *S. virginica*

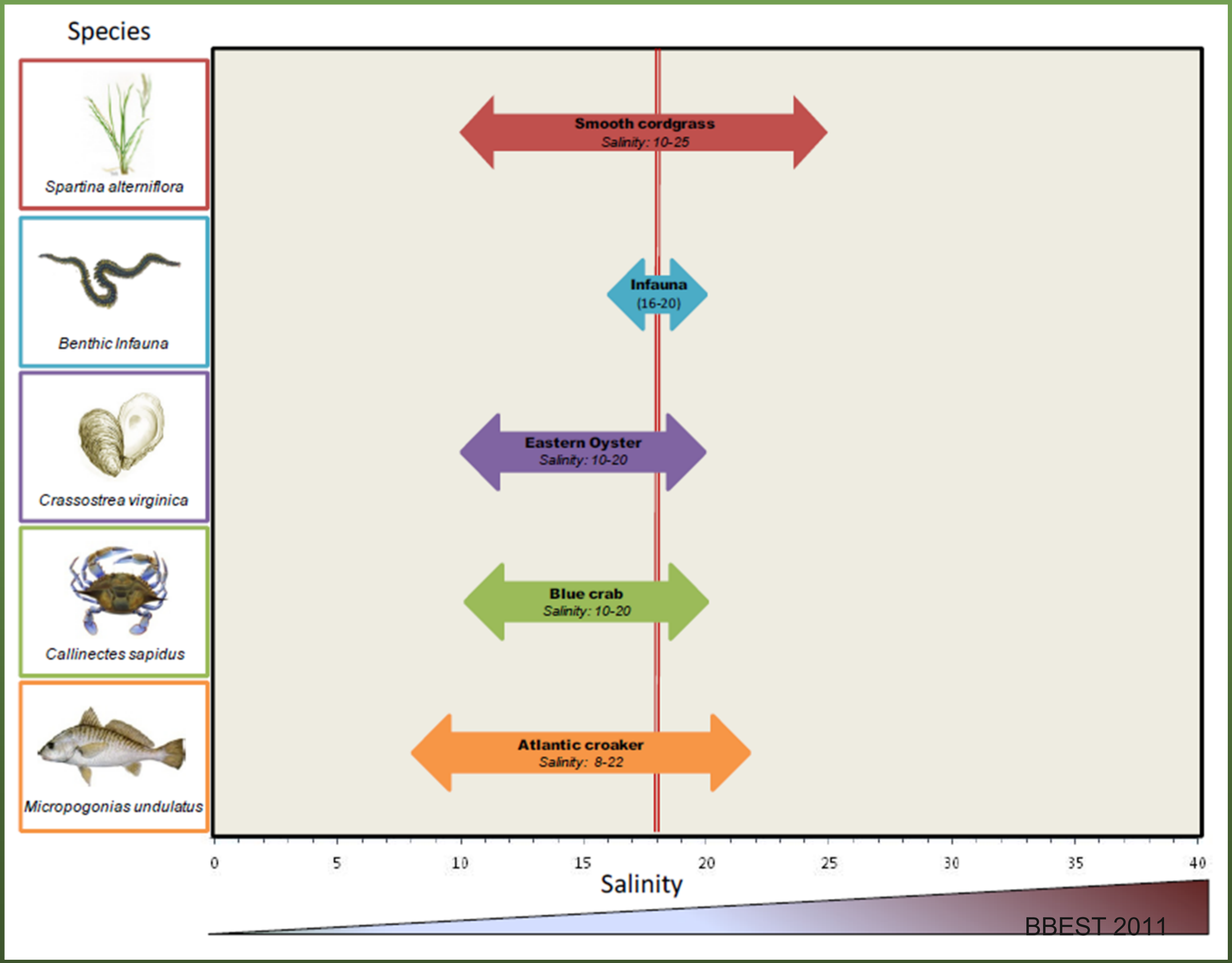


Salinity tolerance cont’

- Porewater salinity exceeding 25 caused consistent decline in *Spartina* abundance

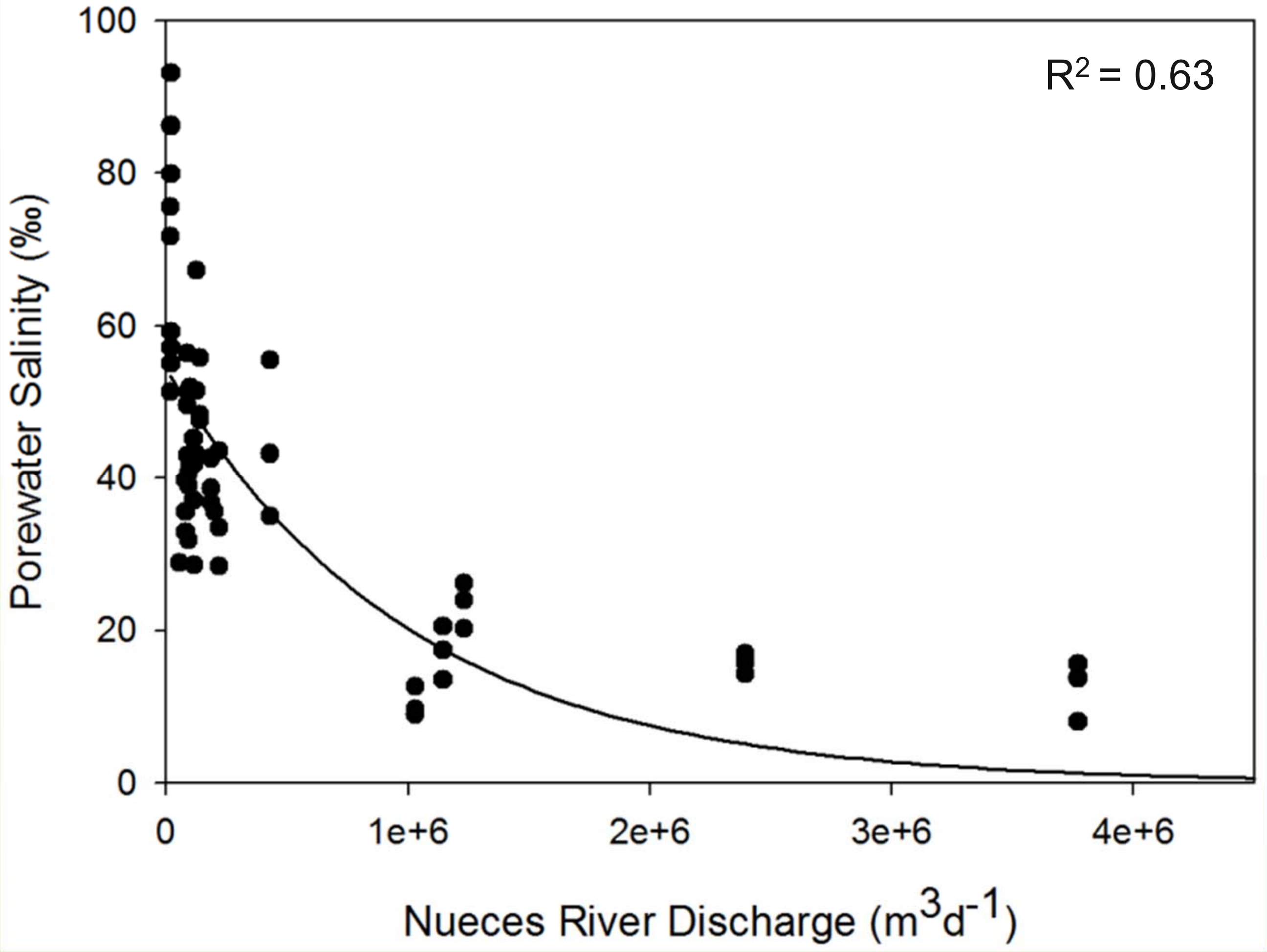


Salinity Tolerance cont'



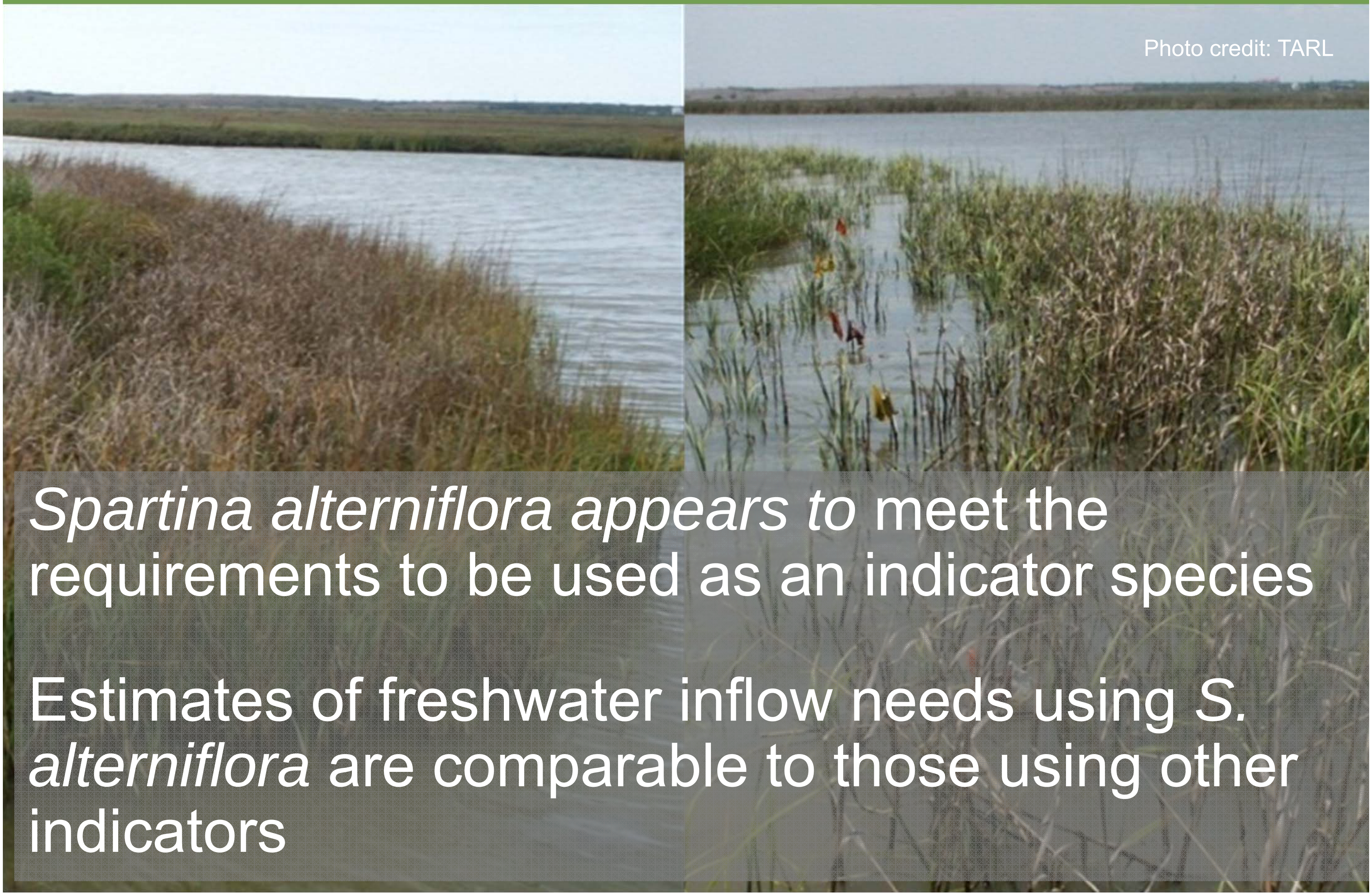
- Salinity tolerance consistent with important faunal species

Salinity Target



- Salinity target of 25 requires Nueces River discharge ~ 1.39×10^7 m^3y^{-1}

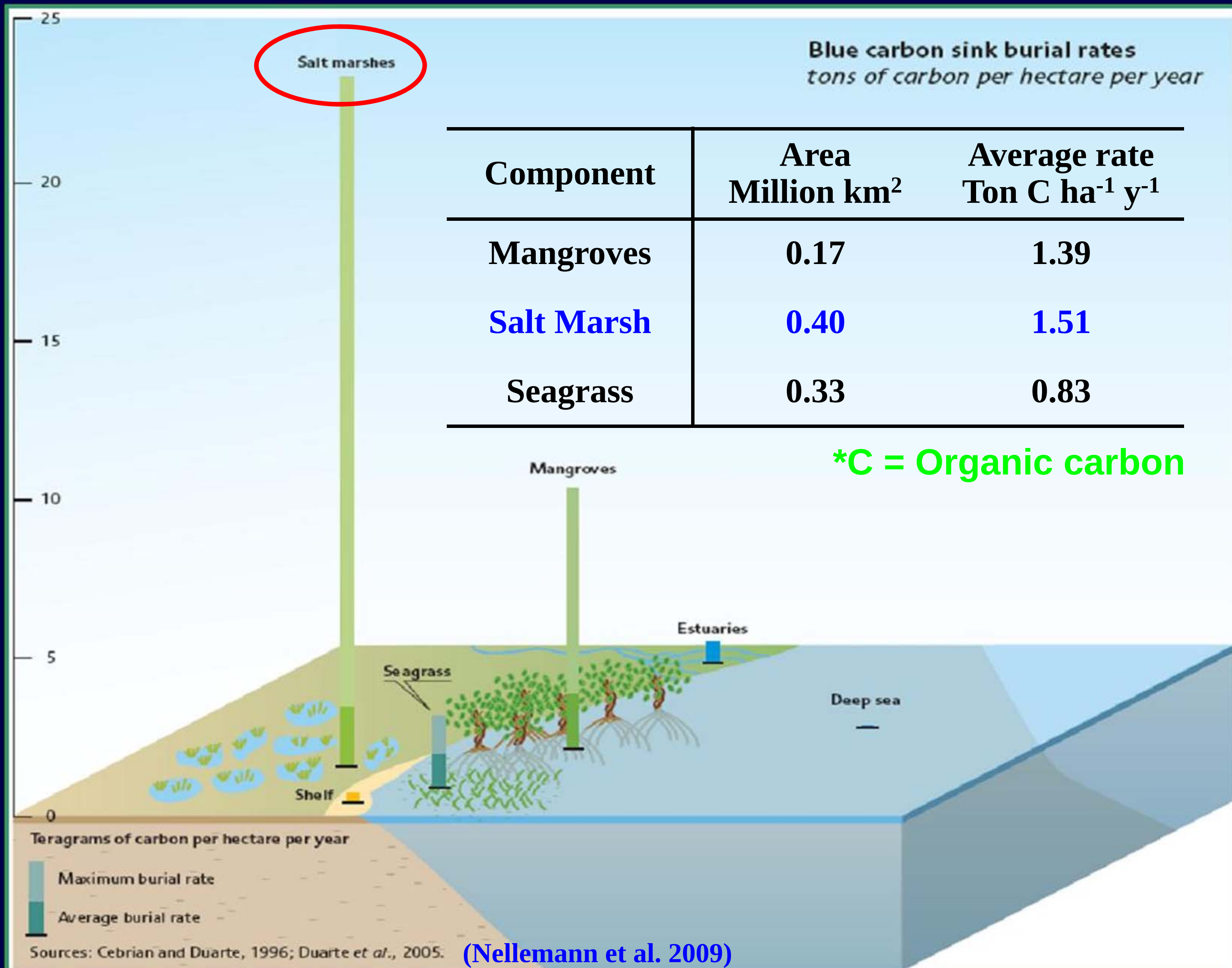
Conclusions



Spartina alterniflora appears to meet the requirements to be used as an indicator species

Estimates of freshwater inflow needs using *S. alterniflora* are comparable to those using other indicators

Carbon sequestration in salt marshes



Component	Area Million km^2	Average rate Ton C ha^{-1} y^{-1}
Mangroves	0.17	1.39
Salt Marsh	0.40	1.51
Seagrass	0.33	0.83

*C = Organic carbon

(Nellemann et al. 2009)

In situ measurements of C-flux

(with Sang-Rul Park)

Photosynthesis and respiration

- Using LI-6400 portable gas exchange system with conifer chamber

- Between 10:00 and 15:00

- For respiration, the chamber was shaded by a black plastic bag

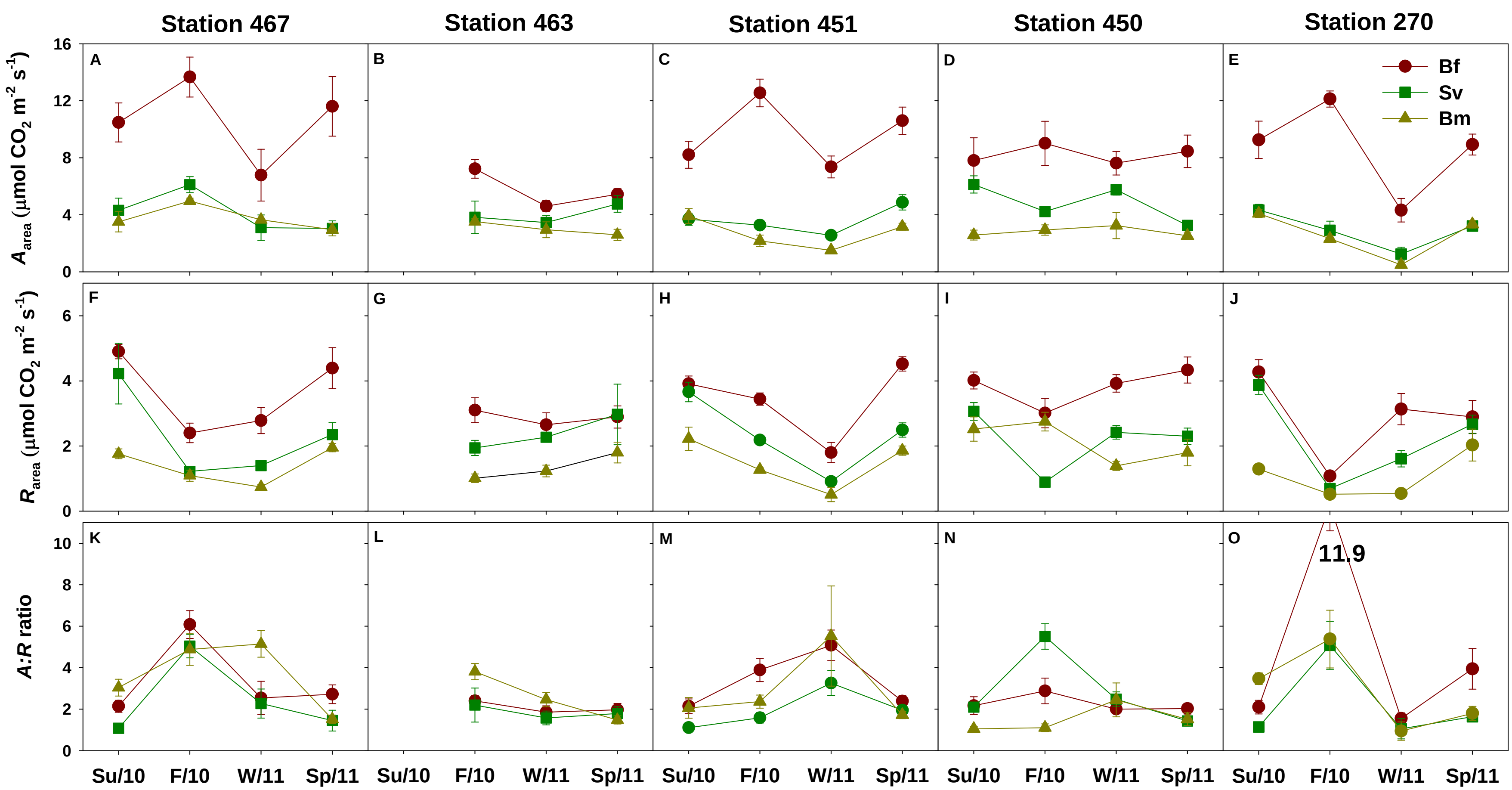
Soil respiration

- Using LI-6400 portable gas exchange system with soil chamber at bare bed and inside canopy

Environmental factors

- Salinity, temperature and precipitation

Photosynthetic characteristics



*A_{area} – net photosynthesis; R_{area} – Respiration; Bf – *B. frutescens*; Sv – *S. virginica*; Bm – *B. maritima.*

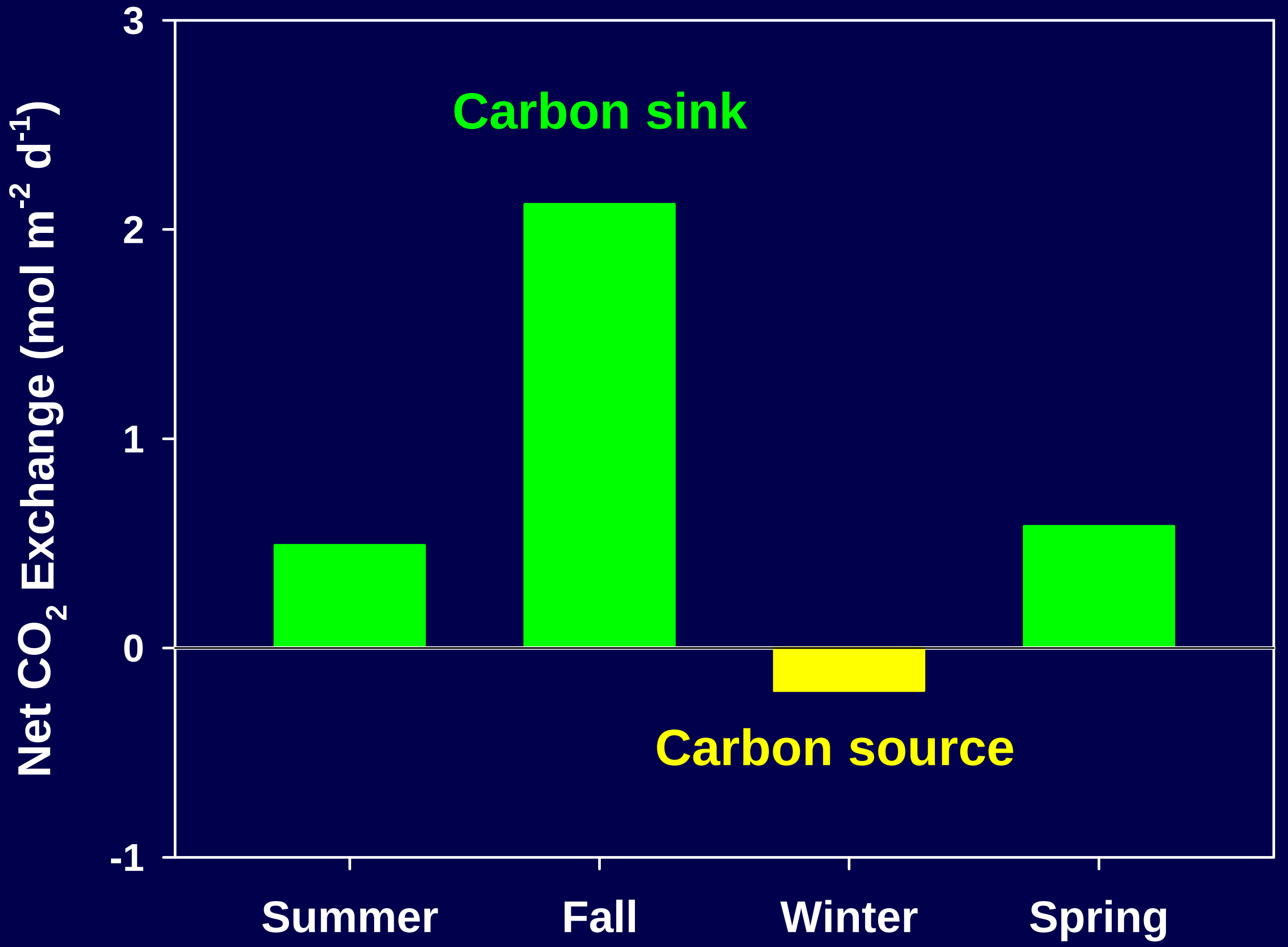
Carbon budget (calculation)

- Vegetation coverage data (P, 2007-2008) and biomass (B, 2010)
- Net photosynthesis (nmol g^{-1} DW s^{-1}, 10 h) and respiration (14 hour),
- Soil respiration (μmol CO^2 m^{-2} s^{-1}, 24 hour)
- Biomass per unit area (BU, g DW) = P (%) X P/B ratio (g DW / %)

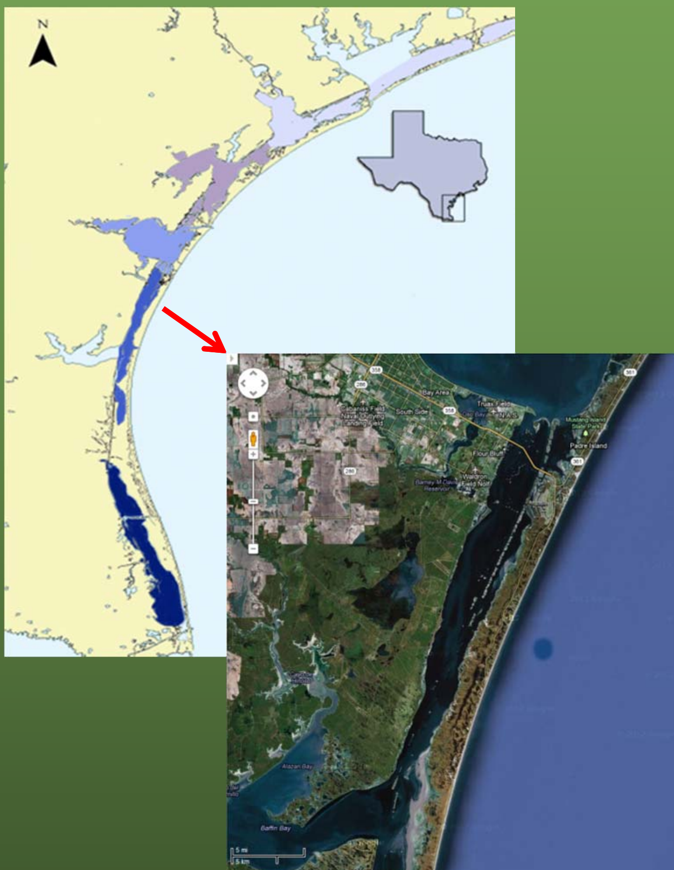
Summer	Net Photo	BU	Mol CO_2 m^{-2} d^{-1}	Res	BU	Area (%)	Mol CO_2 m^{-2} d^{-1}
B. maritima	69.4	43.3	0.108	19.9	43.3		0.043
B. frutescens	54.5	1222.8	2.399	26.5	1222.8		1.633
S. virginica	55.9	64.1	0.129	43.3	64.1		0.140
Soil respiration at bare bed	-	-	-	0.89		9.1	0.007
Soil respiration inside canopy	-	-	-	5.78		64.3	0.321
Total	**2.636**			**2.145**			

Station 270

Carbon budget

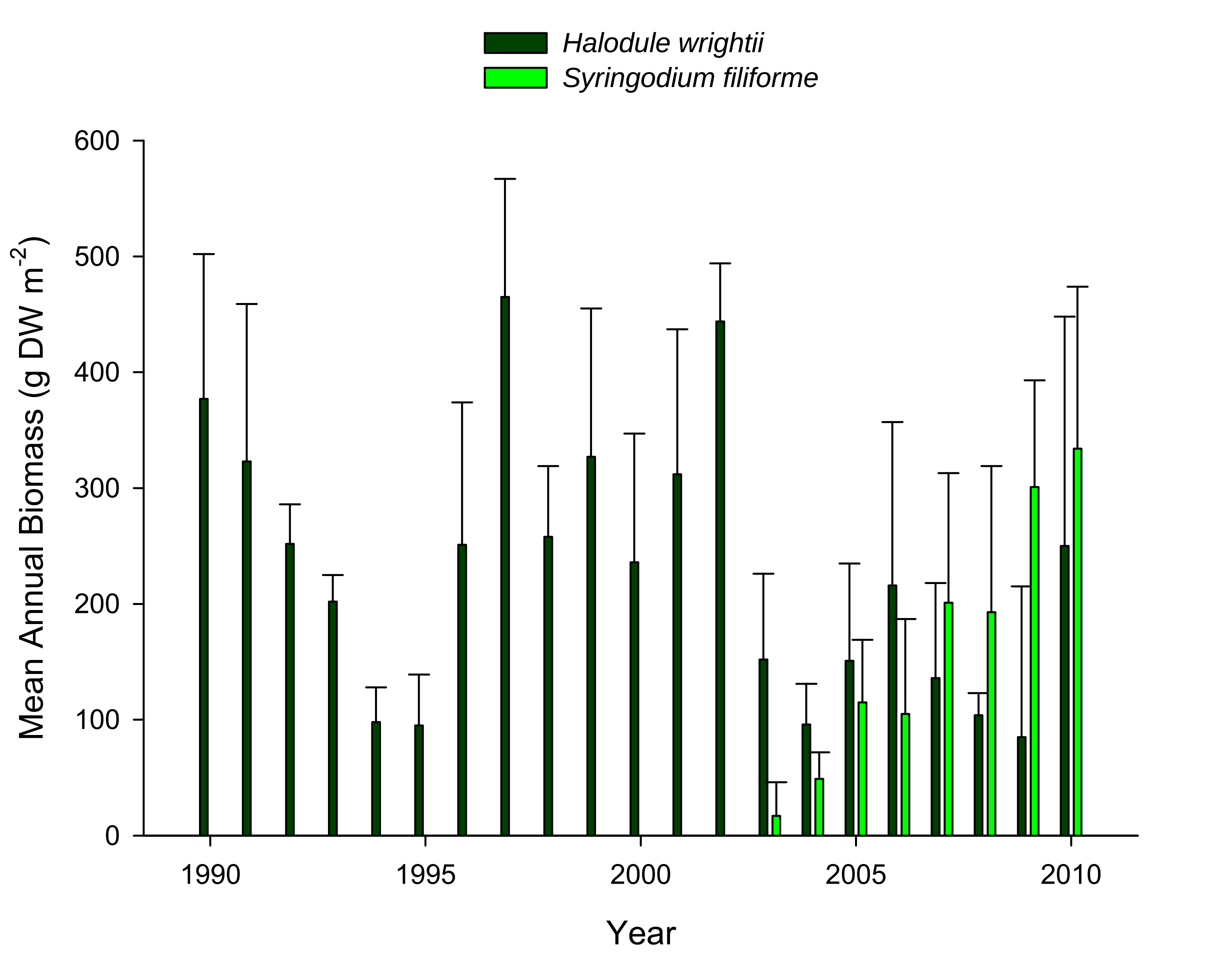


Seagrass Monitoring Site: LM151
(with Chris Wilson)



- Located in upper Laguna Madre between Corpus Christi and Baffin Bays
- Within NPS Boundary of Padre Island National Seashore
- We have collected 20+ years of underwater light, hydrography and seagrass condition data (monthly) starting 1989
- Predominantly hypersaline
- Contains the seagrass species *Halodule wrightii*[*], *Syringodium filiforme*[*], *Ruppia maritima* and *Halophila englemanii*

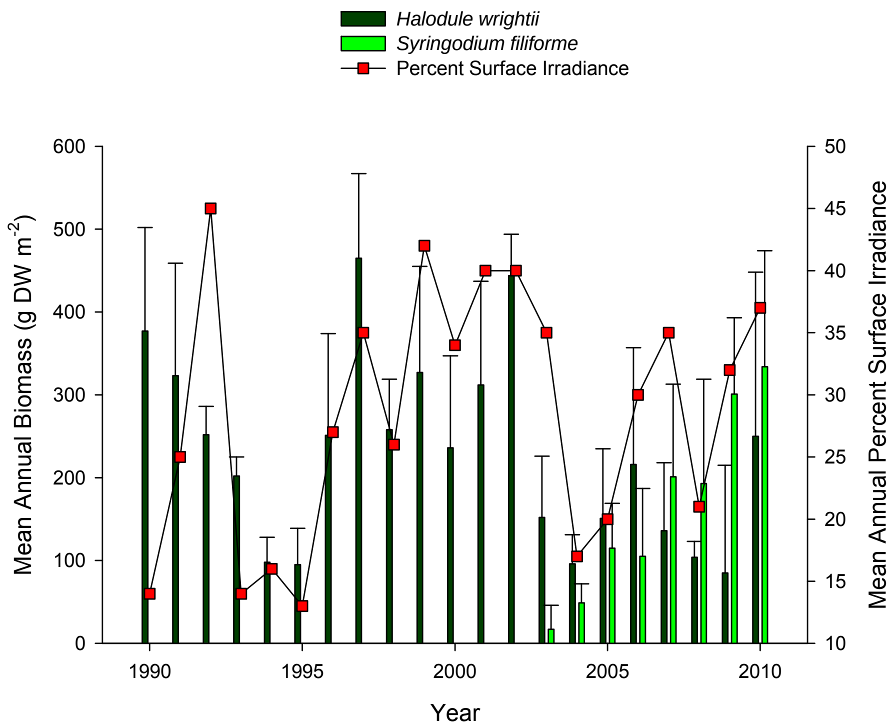
Historical Seagrass Abundance

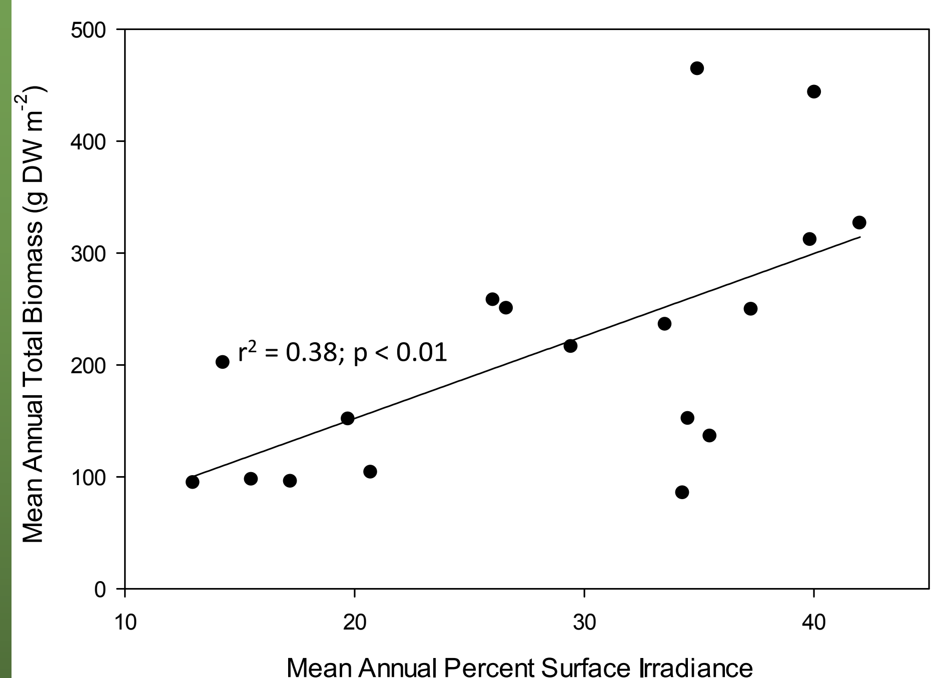


We've observed large variations in seagrass production over time.

What are the environmental mechanisms controlling seagrass production? *(Note: There is no coastal development occurring in direct proximity to this site.)*

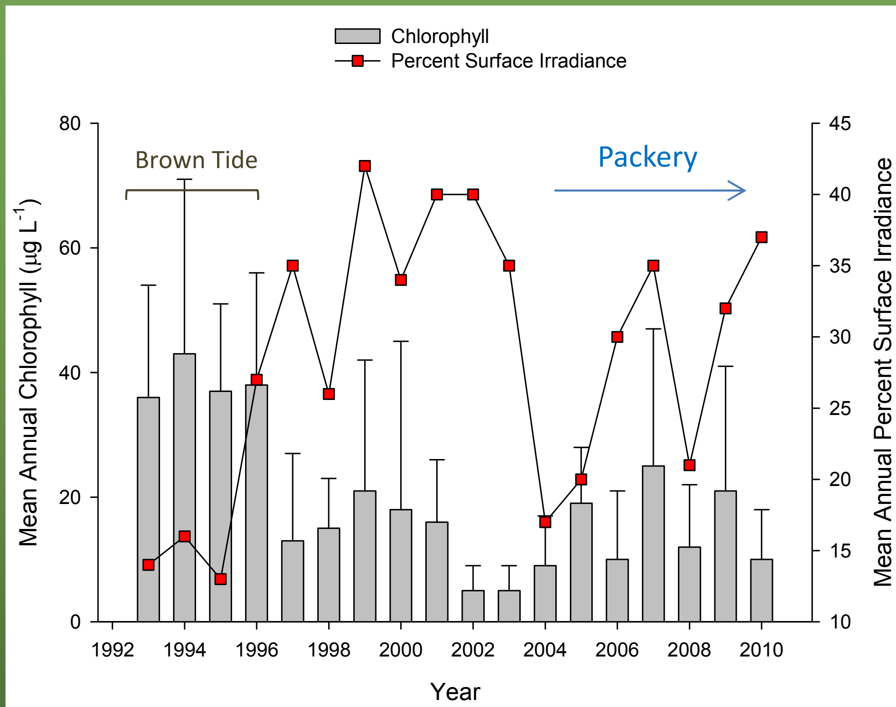
Seagrass and Light Availability

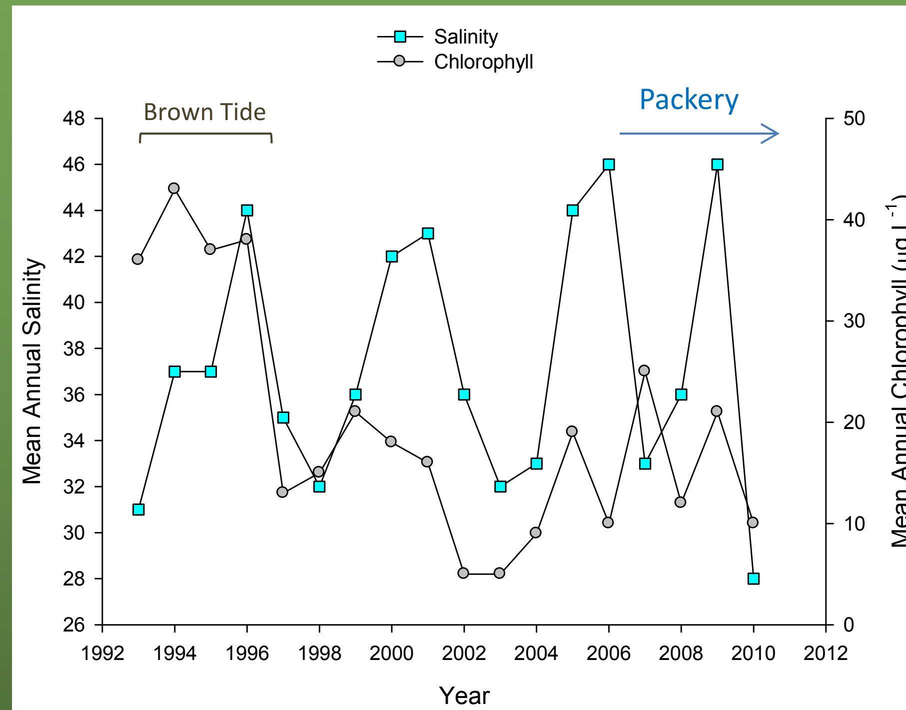




- Seagrass production is correlated to light availability, which is not really surprising.
- What *is surprising* is the large yearly variation in light availability!
- What are the environmental controls on underwater light availability?

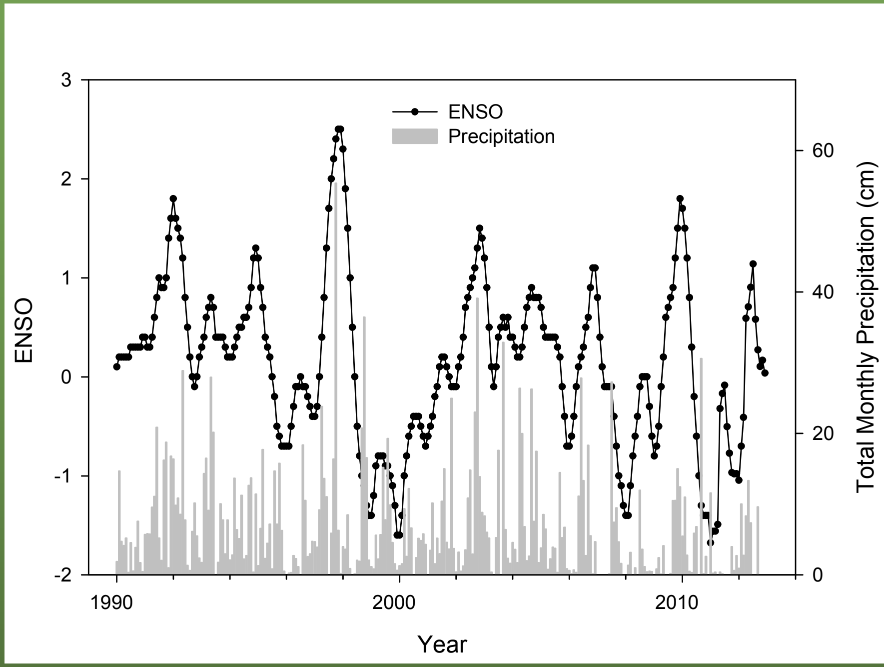
Chlorophyll and Light Availability

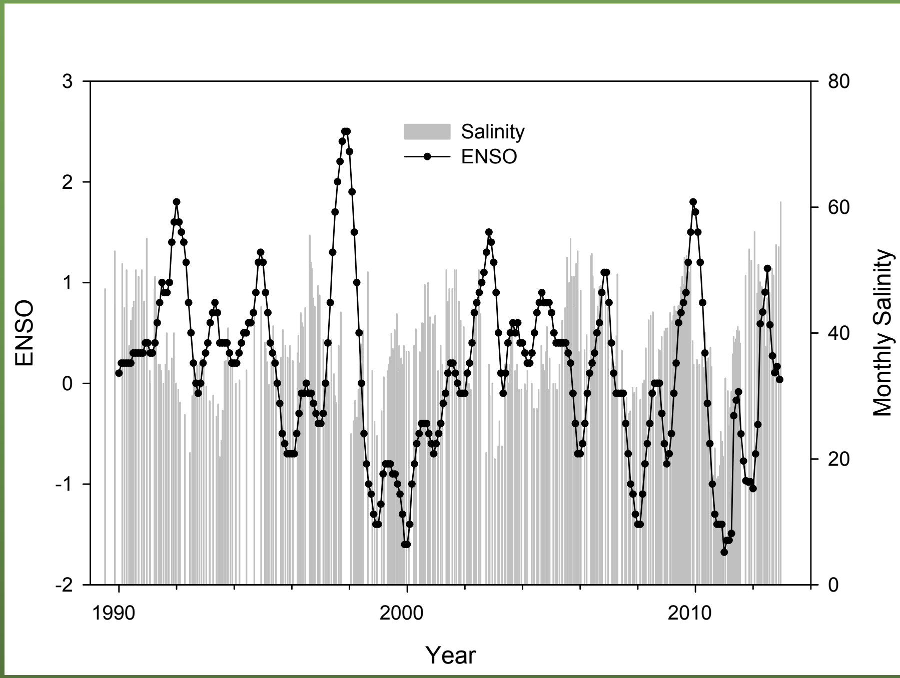




- Very high chlorophyll reduces the light available for seagrass growth.
- Prior to 2006, chlorophyll and salinity are closely correlated.
- Is salinity a driver for the UW light environment? If so, how does this mechanism function?
- **Two notable events are illustrated: 1) Major Brown Tide Bloom and 2) Dredging/Opening of Packery Channel starting in 2004*

Climate and Salinity





- El Niño and negative transition years produce large rain events, which lower salinity.
- La Niña and positive transition years sustain drought conditions, which raise salinity.
- This corroborates with the findings of Jim Tolan
- How does chlorophyll respond to these changes in climate and salinity?

Graphic Summary

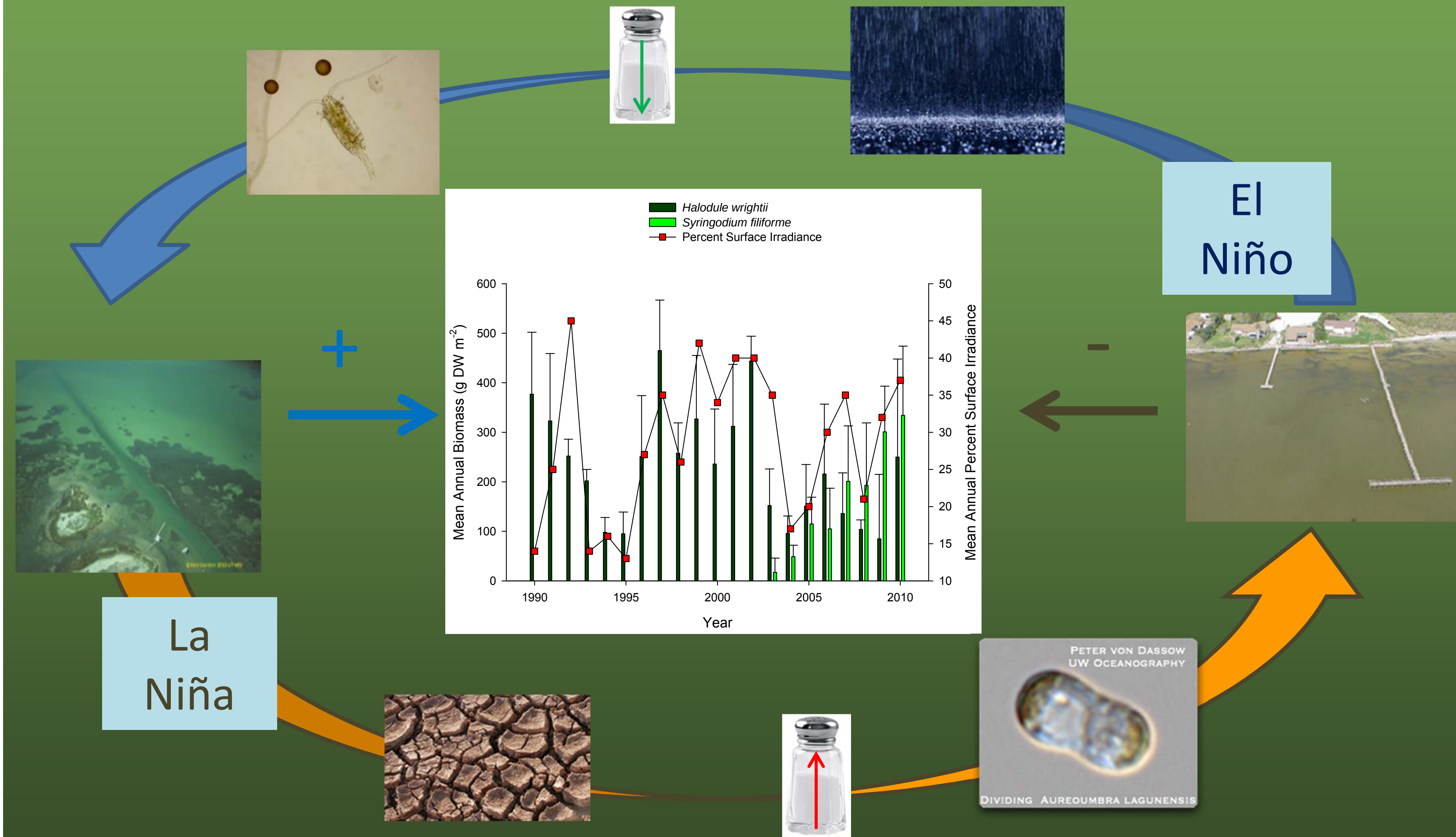


Image Credits: tpwd.state.tx.us; theproducersprospective.com; eoearth.org

Acknowledgments