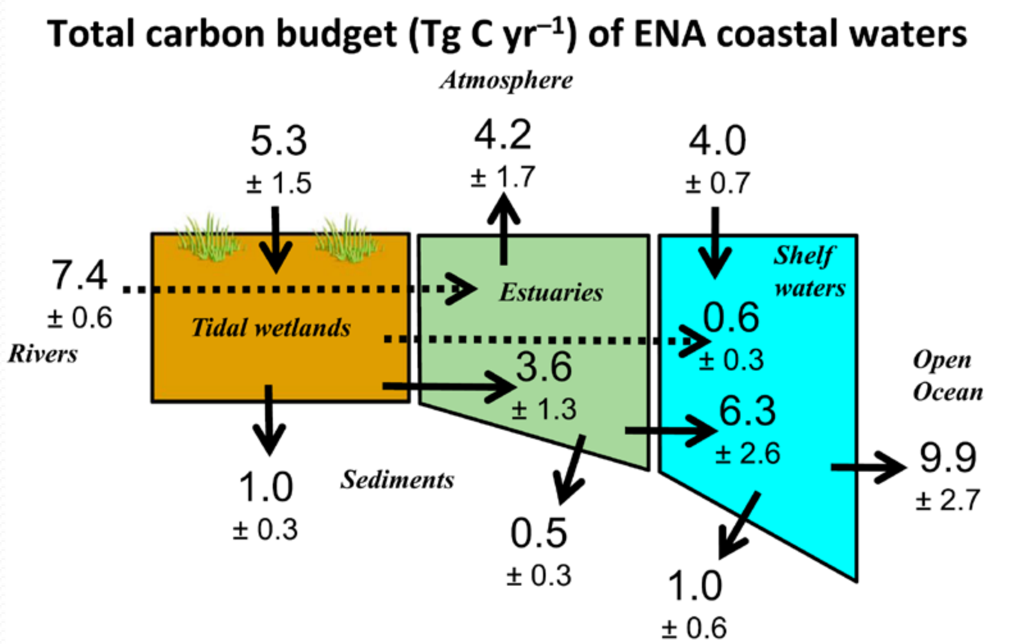
Toward an Improved Understanding of Blue Carbon: The Role of Seagrasses in Sequestering CO_2

Richard C. Zimmerman, Victoria J. Hill, David Burdige
Department of Ocean, Earth & Atmospheric Sciences
Old Dominion University
Norfolk VA

Matthew Long
Woods Hole Oceanographic Institute
Woods Hole, MA

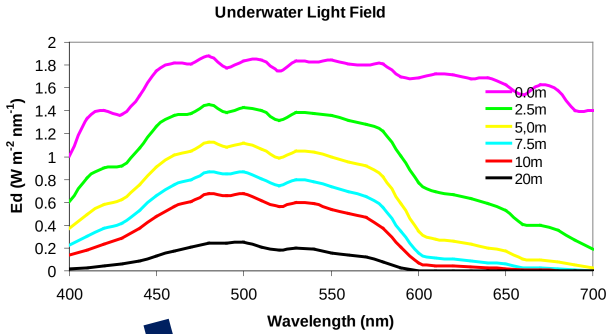
What is the role of seagrasses in C sequestration in the coastal Eastern North America?

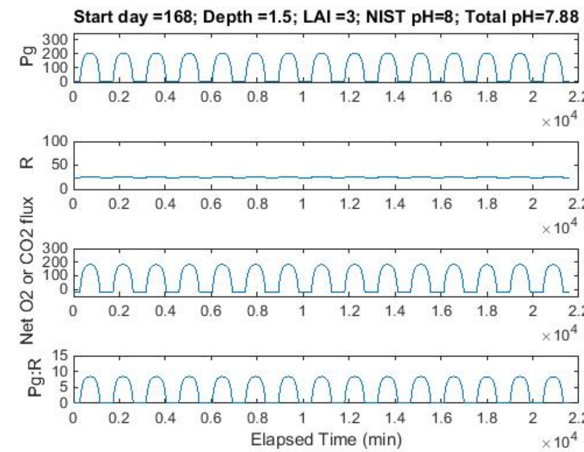
- Seagrasses occupy <5% of total estuarine area
- But are a dominant source of carbon burial



Najjar, R., M. Hermann, R. Alexander, E. Boyer, D. Burdige, D. Butman, W. Cai, E. Canuel, R. Chen, A. Firedrichs, R. Feagin, P. Griffith, A. Hinson, J. Holmquist, X. Hu, W. Kemp, K. Kroeger, A. Mannino, S. McCallister, W. McGillis, M. Mulholland, C. Pilskan, J. Salisbury, S. Signorini, P. St-Laurent, H. Tian, M. Tzortziou, P. Vlahoss, Z. Wang, and R. Zimmerman. 2018. Carbon budget of tidal wetlands, estuaries and shelf waters of Eastern North America. Global Biogeochem. Cycles **32:389-416.**

Using *GrassLight* to Predict Seagrass Impacts on Carbon Flux



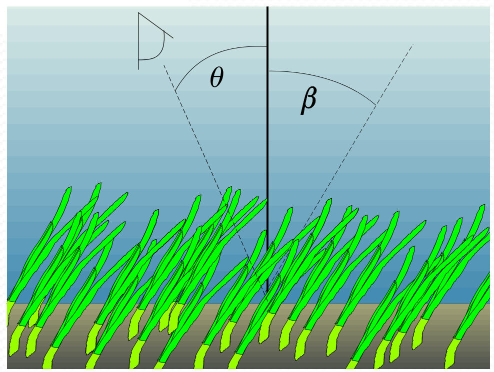


Summer

[CO_2]

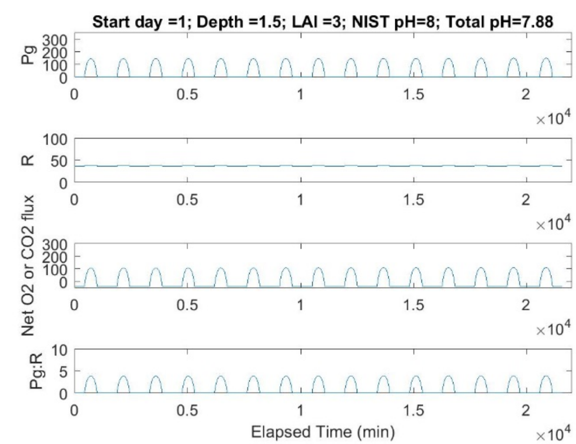
Temperature

Flow



GrassLight Bio-Optical Model

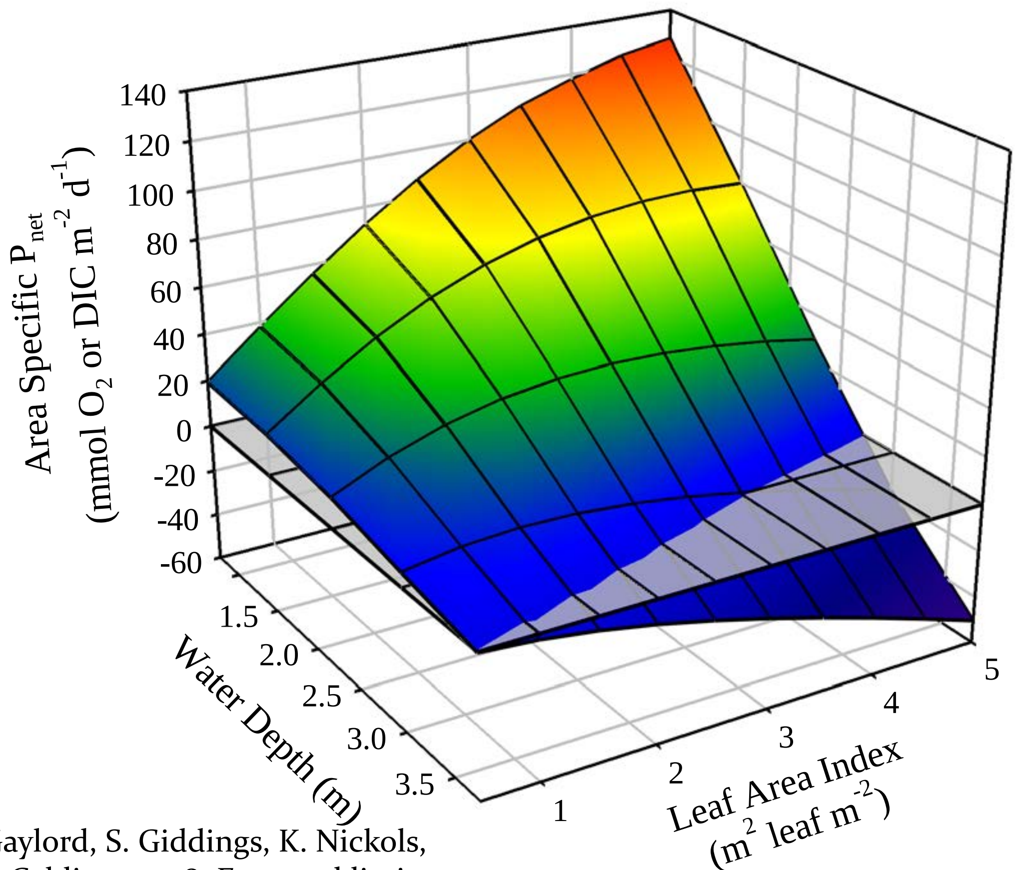
Winter



Koweek, D., R. Zimmerman, K. Hewett, B. Gaylord, S. Giddings, K. Nickols, J. Ruesink, J. Stachowiz, Y. Takeshita, and K. Caldiera. 2018. Expected limits on the ocean acidification buffering potential of a temperate seagrass meadow. Ecol. Appl. **In Press.**

Area-specific P_{net} of the meadow

- Increases with LAI in shallow water
- Decreases with depth



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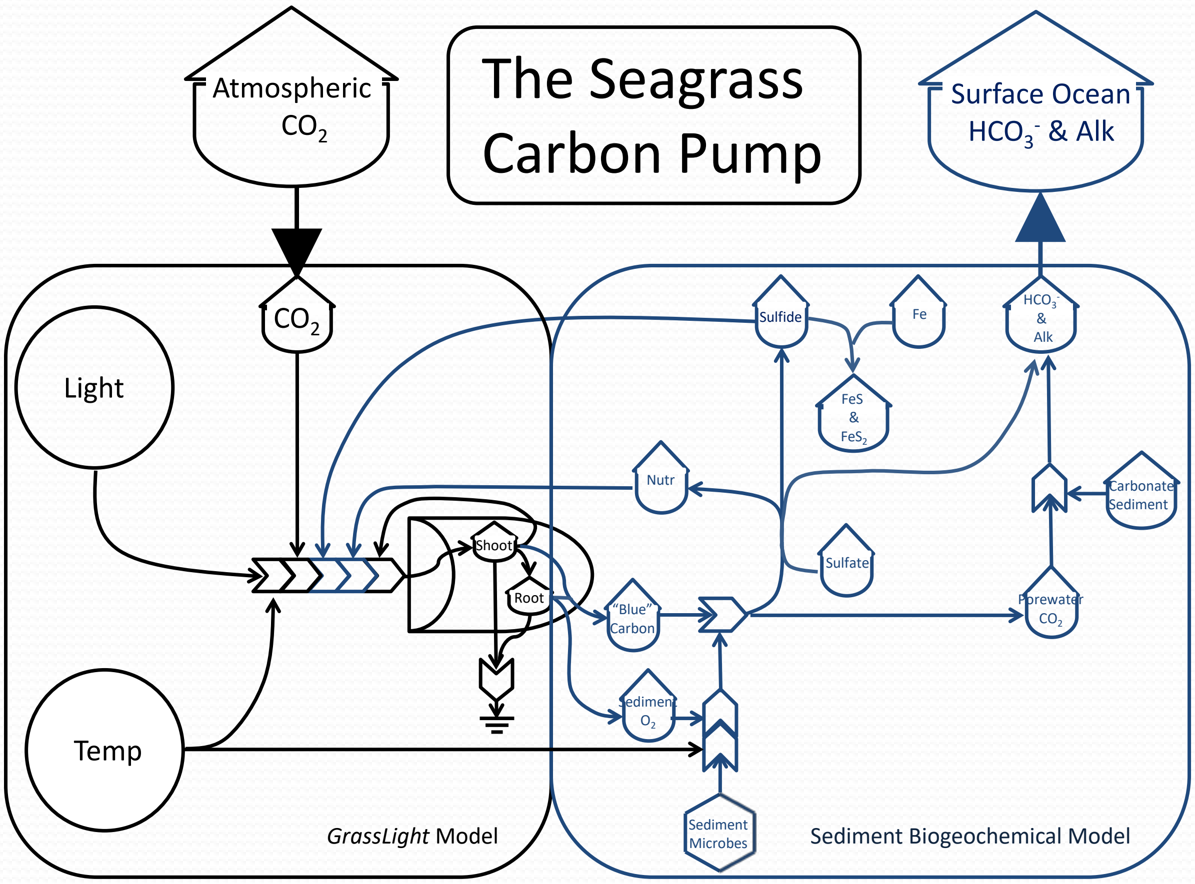
So, seagrasses can influence local water chemistry

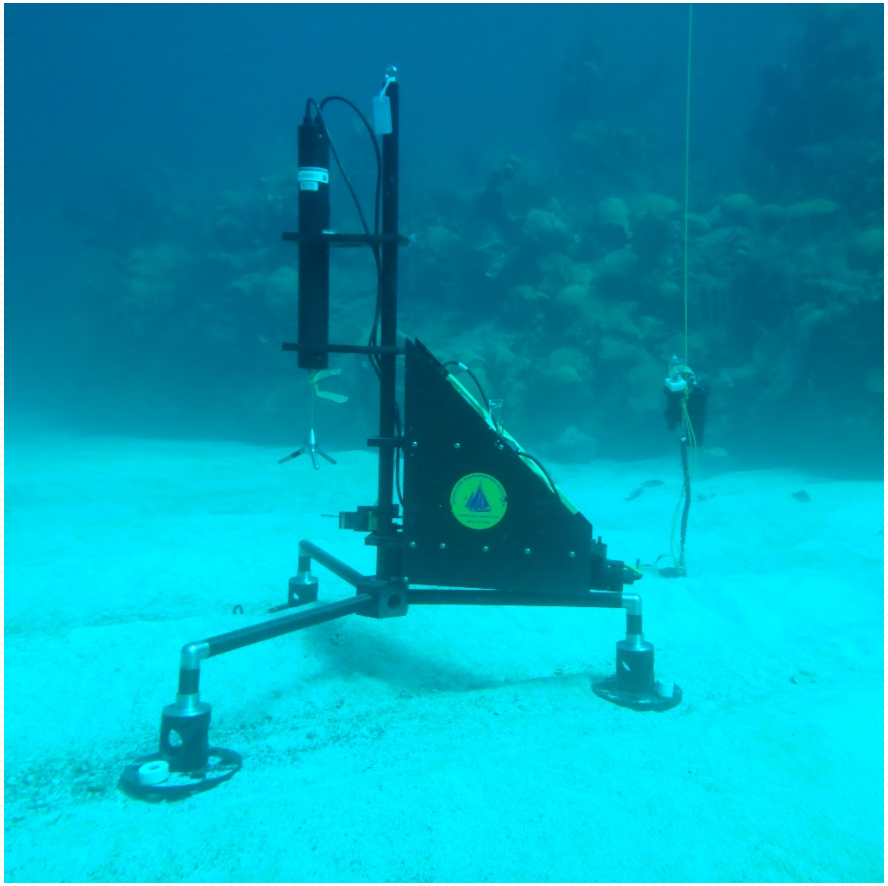
- Impacts are greatest in shallow water with moderate shoot density
- Self-shading limits effect of plant density on water chemistry
- Eelgrass impacts decrease with water depth
- Greatest impacts
  - 0.4 ΔpH
  - 4 $\Delta\Omega_{Ca}$
  - 2.5 $\Delta\Omega_{Ar}$
- These daily integrals assume
  - Instantaneous and complete vertical mixing
  - No dilution (advection)
  - No air-sea gas exchange
  - No contributions from benthos or plankton

- Need to incorporate:
  - Sediment geochemistry - Carbonate dissolution & porewater exchange
  - Advection/residence time of overlying water

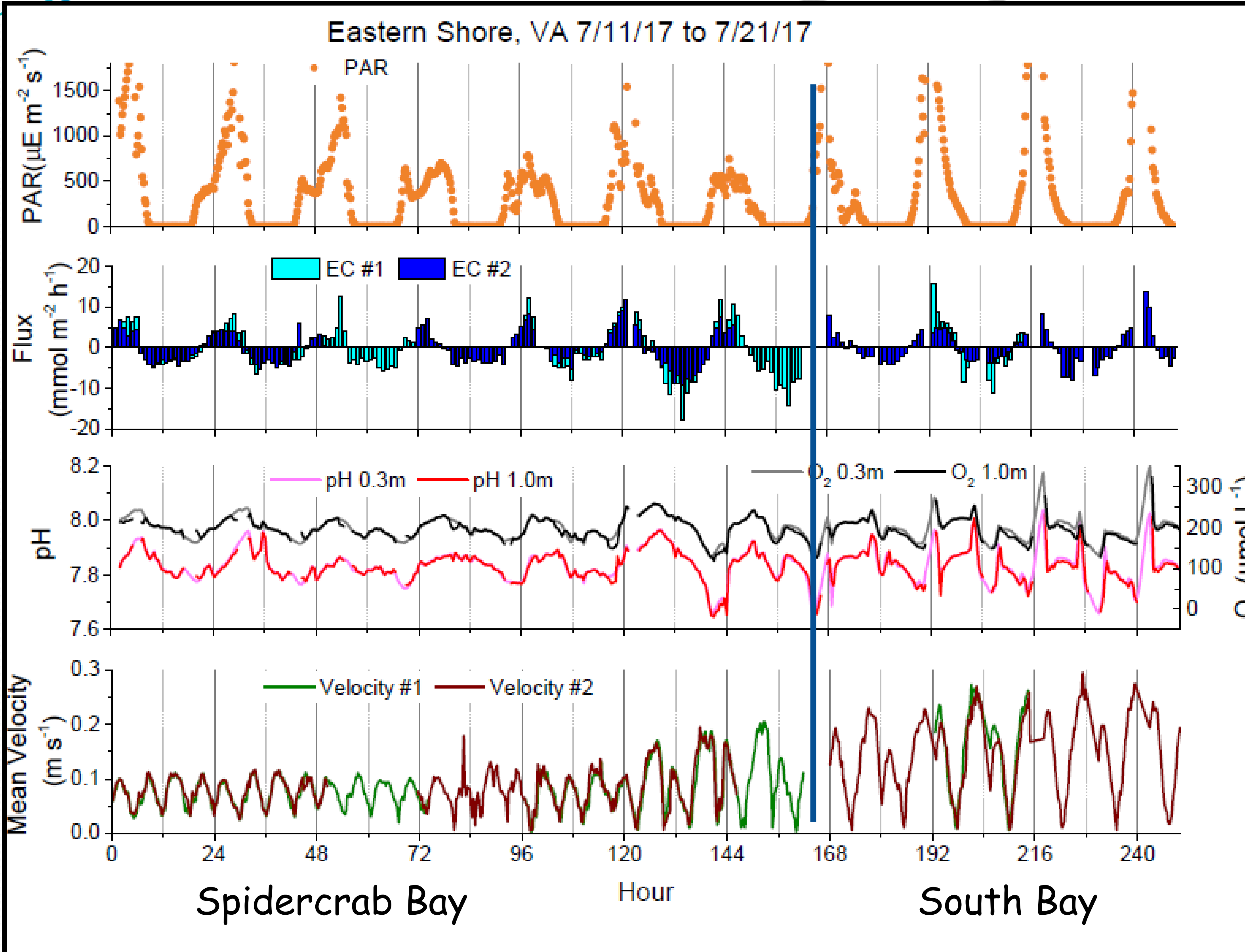


Validating *GrassLight* Model with Eddy Covariance Hydrogen Ion and Oxygen Exchange System (ECHOES)

- Net Community Metabolism
- High temporal resolution
- No enclosures




13
600
Spidercrab Bay
LAI 1.7
EC1
EC2
South Bay
LAI 3.0

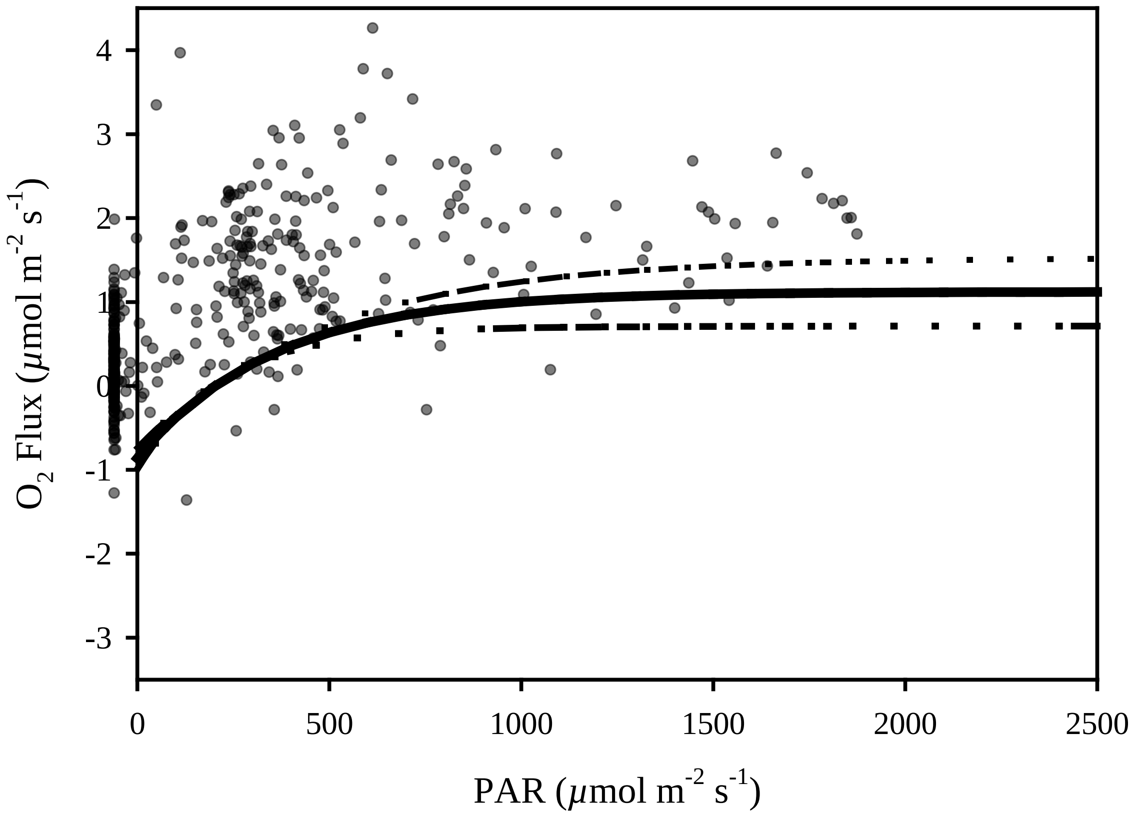


Eastern Shore, VA 7/11/17 to 7/21/17
PAR
PAR(μE m-2 s-1)
1500
1000
500
0
EC #1
EC #2
Flux (mmol m-2 h-1)
20
10
0
-10
-20
pH 0.3m
pH 1.0m
O2 0.3m
O2 1.0m
pH
8.2
8.0
7.8
7.6
300
200
100
0
O2 (umol L-1)
Velocity #1
Velocity #2
Mean Velocity (m s-1)
0.3
0.2
0.1
0.0
0
24
48
72
96
120
144
168
192
216
240
Hour
Spidercrab Bay
South Bay

ECHOES Flux vs E

- **General model:** O_2 **Flux** = P_E*(1-exp(-E/E_k))+ R

- **Spidercrab Bay LAI = 1.7**
- Coefficients (95% CI):
- E_k = 354 (228 ,482)
- P_E = 2.0 (1.7, 2.3)
- R = -0.9 (-1.0, -0.7)
- r^2: 0.47



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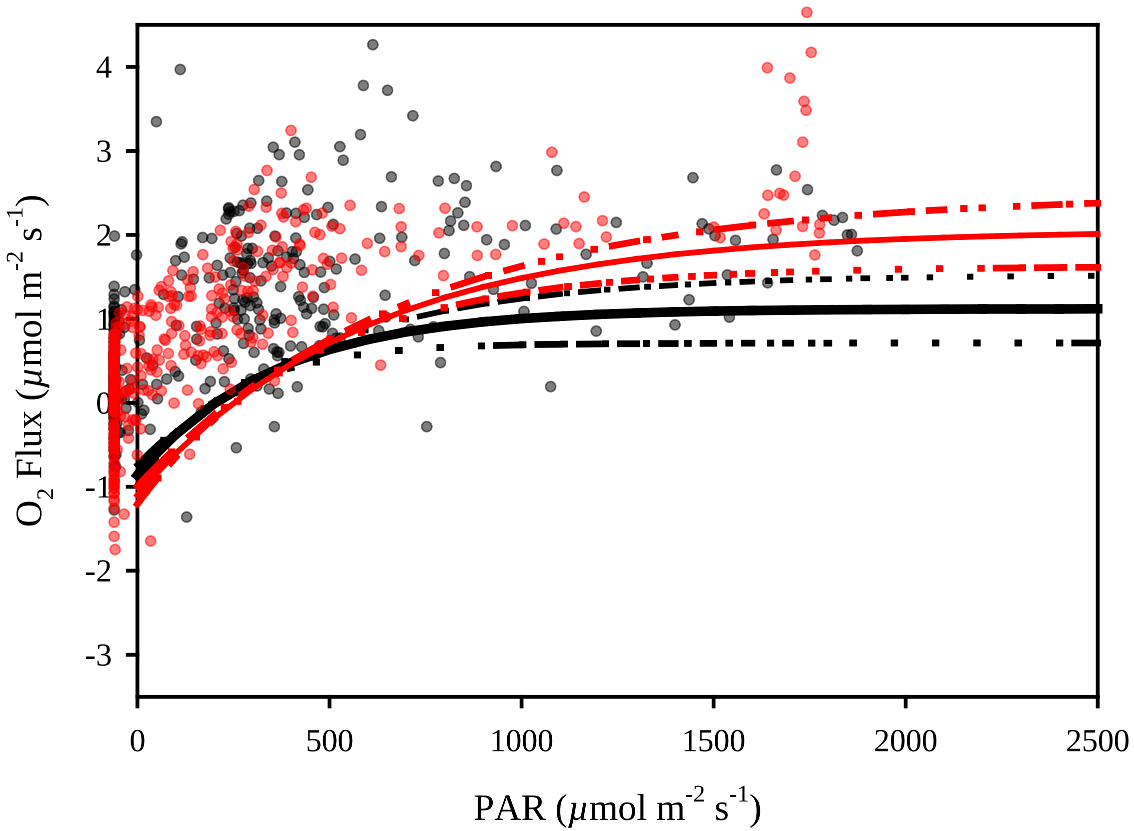
- **South Bay LAI = 3.0**
- Coefficients (95% CI):
- E_k = 583 (455, 711)
- P_E = 3.2 (2.8, 3.5)
- R = -1.1 (-1.2, -1)
- r^2 = 0.66



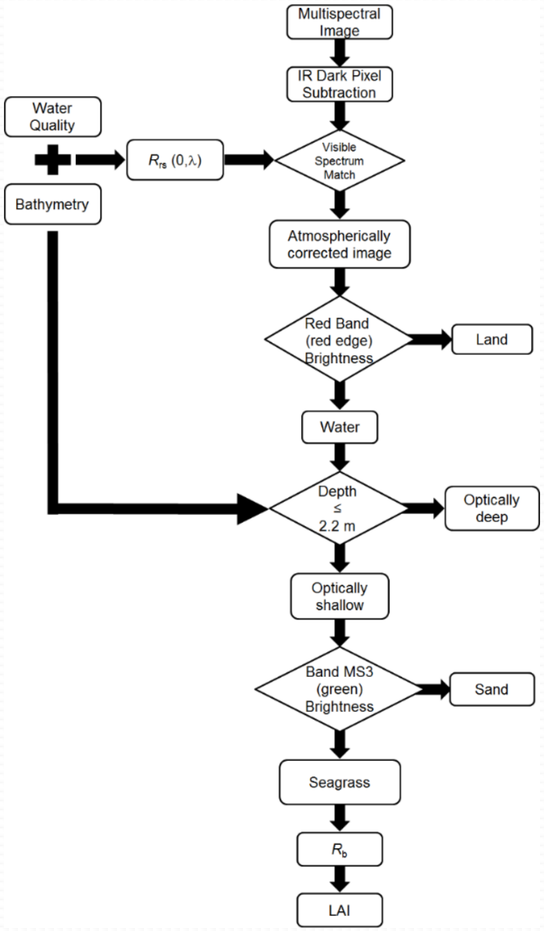
Quantifying Blue Carbon Burial in Seagrass Ecosystems and the Impact of Projected Climate Change

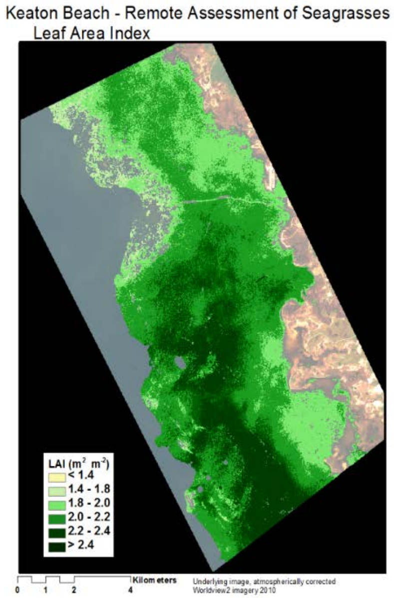
Richard C. Zimmerman, Victoria J. Hill, Jiang Li

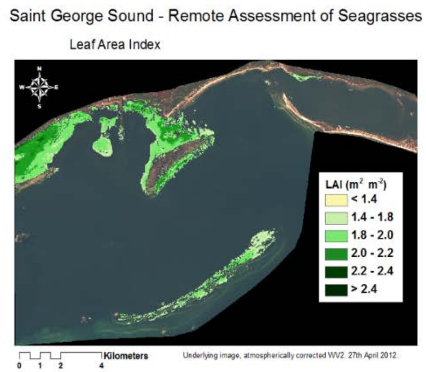
Department of Ocean, Earth & Atmospheric Sciences
Department Electrical & Computer Engineering
Old Dominion University
Norfolk VA

Blake Schaeffer
US EPA

Algorithm based on our remote sensing work in the Gulf of Mexico & Bahamas





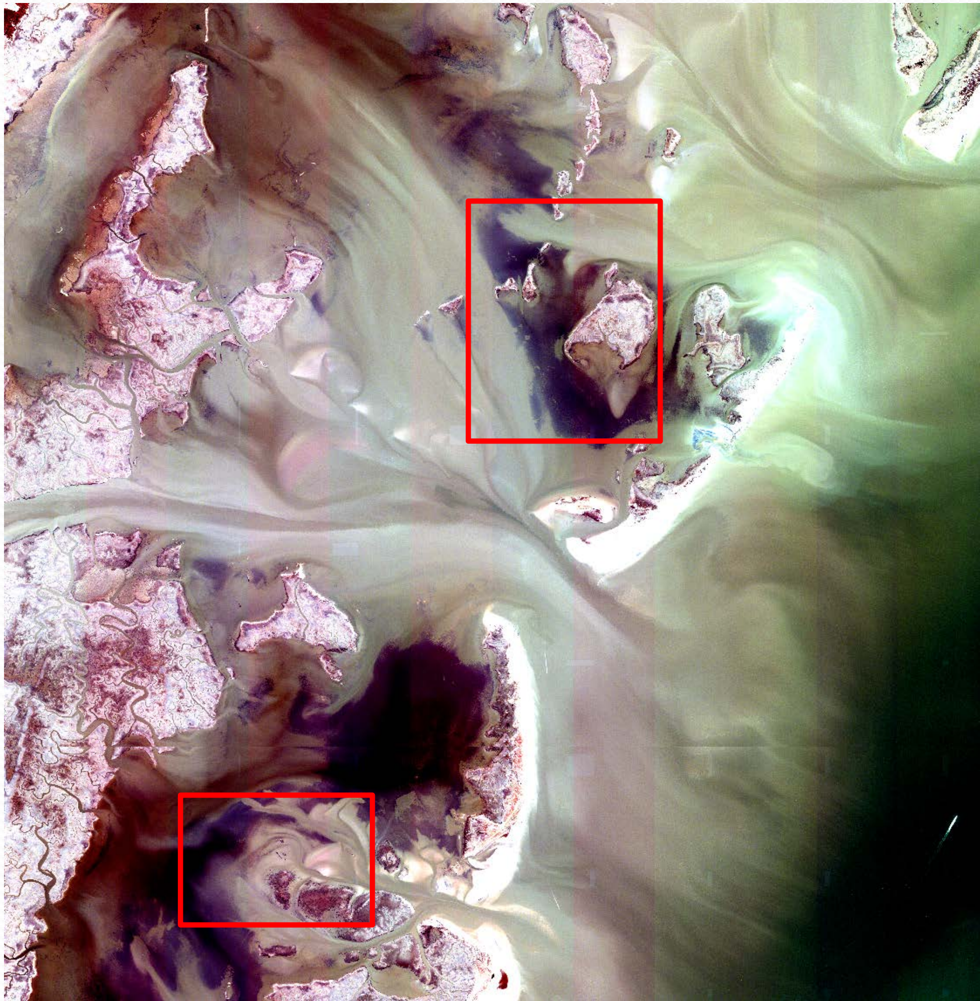


Dierssen, H., R. Zimmerman, R. Leathers, T. Downes, and C. Davis. 2003. Remote sensing of seagrass and bathymetry in the Bahamas Banks using high resolution airborne imagery. Limnol. Oceangr. **48:444-455.**

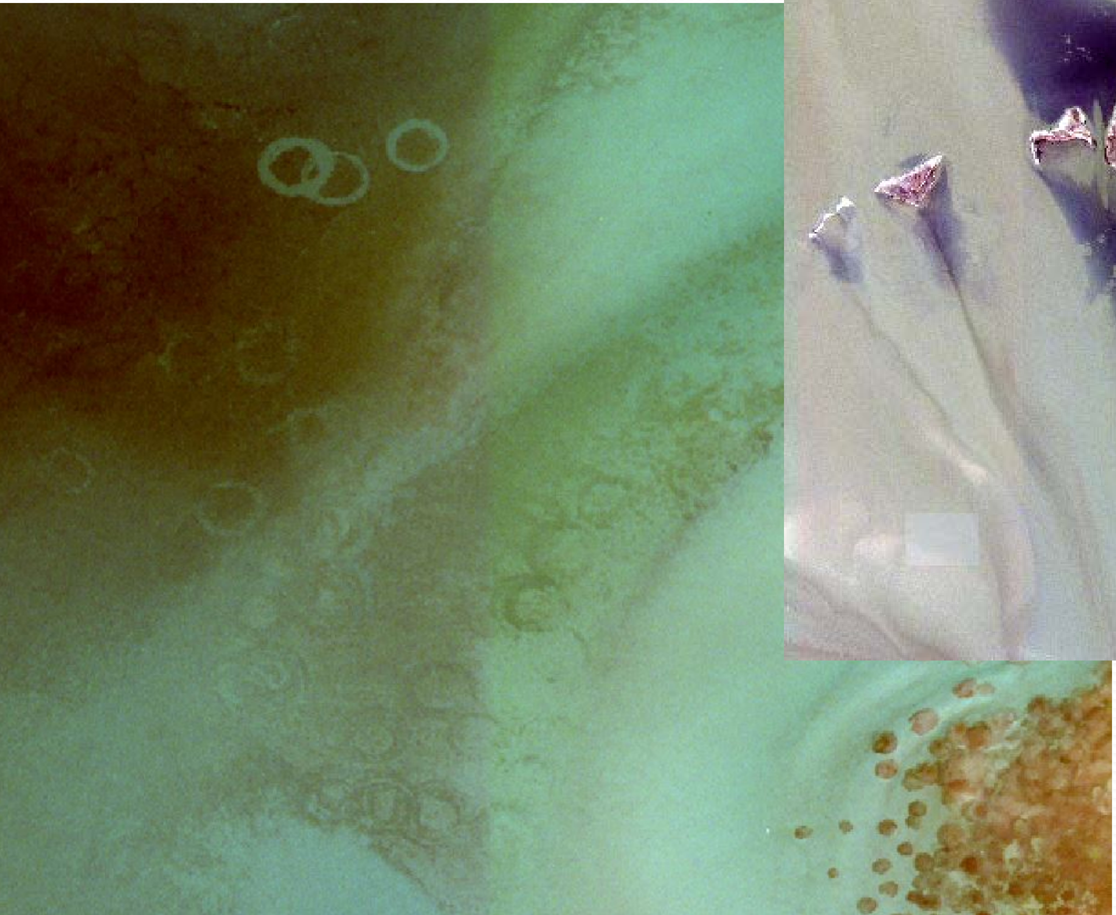
Hill, V. J., R. C. Zimmerman, W. P. Bissett, H. Dierssen, and D. D. R. Kohler. 2014. Evaluating Light Availability, Seagrass Biomass, and Productivity Using Hyperspectral Airborne Remote Sensing in Saint Joseph's Bay, Florida. Estuaries and Coasts **37:1467-1489.**

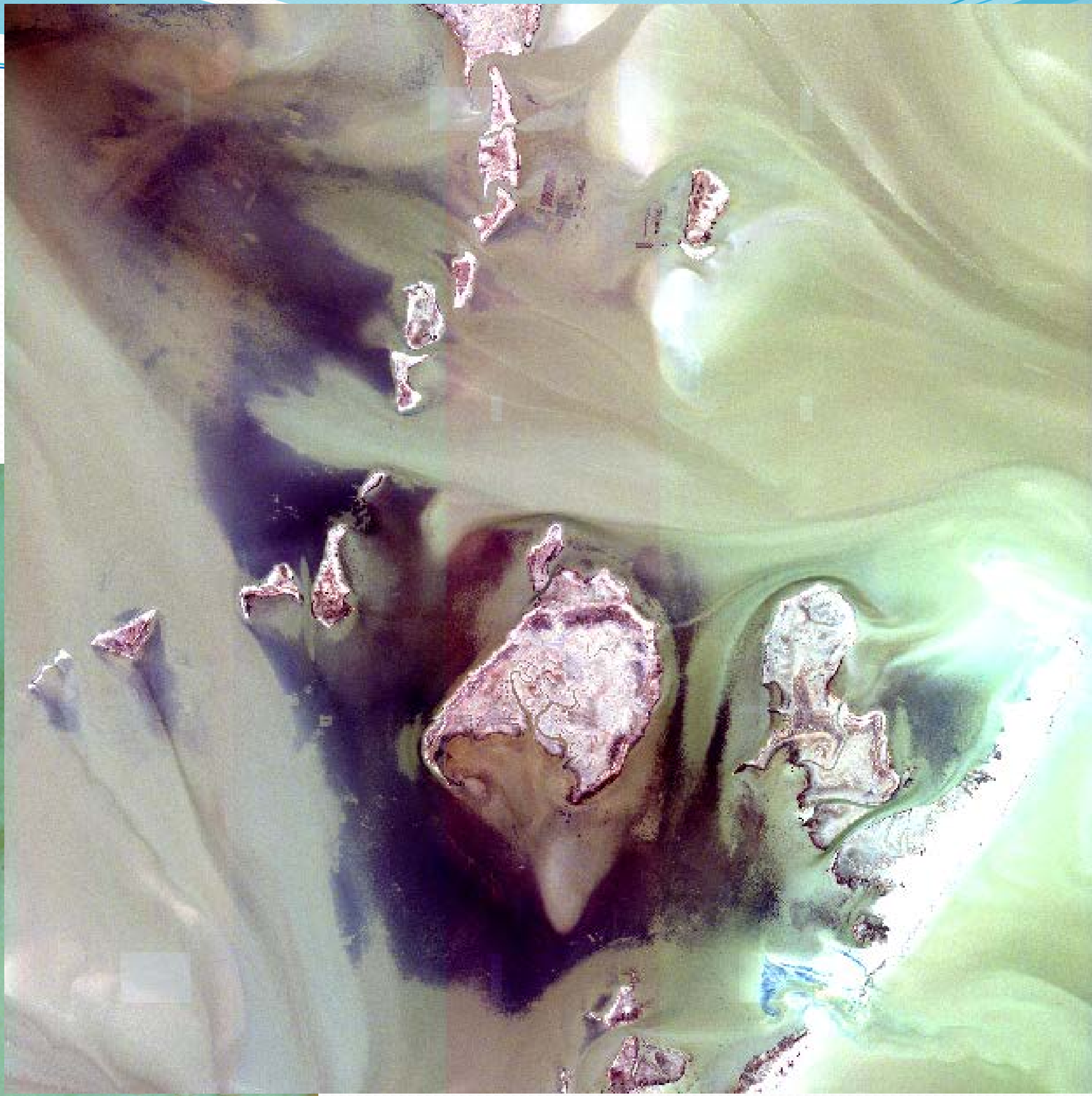
Quantifying SAV & Blue Carbon Abundance from Space

- WorldView-2 image of Spidercrab Bay & South Bay
- Obtained 1 May 2018
- 32° off nadir
- Spatial resolution ~1.3 m
- 12:20 hrs, +2 ft tide
- Low water was at 16:00

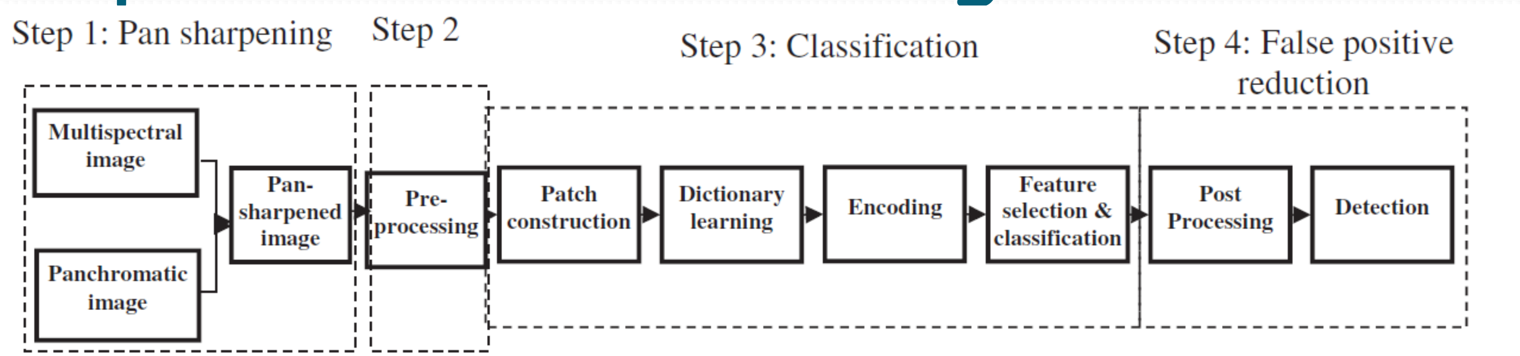


Disturbed patches evident

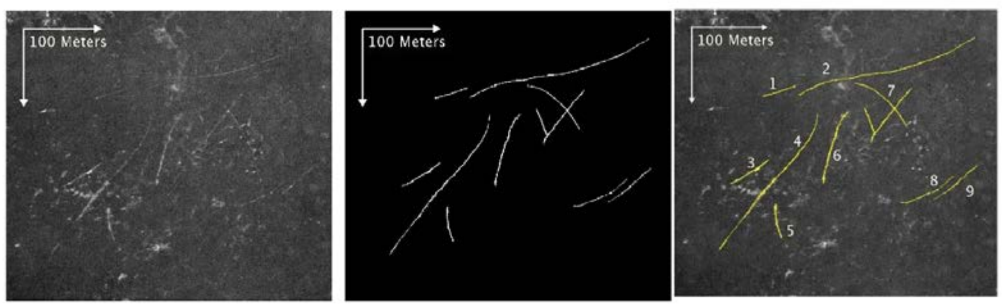




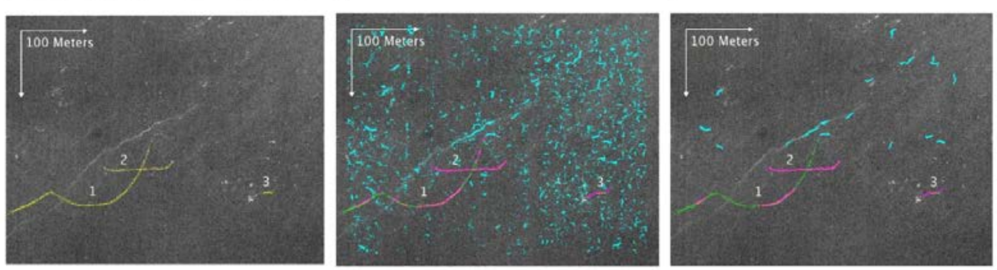
Machine Learning Algorithm to Detect Propeller Scars in Seagrass Meadows



Training Data:



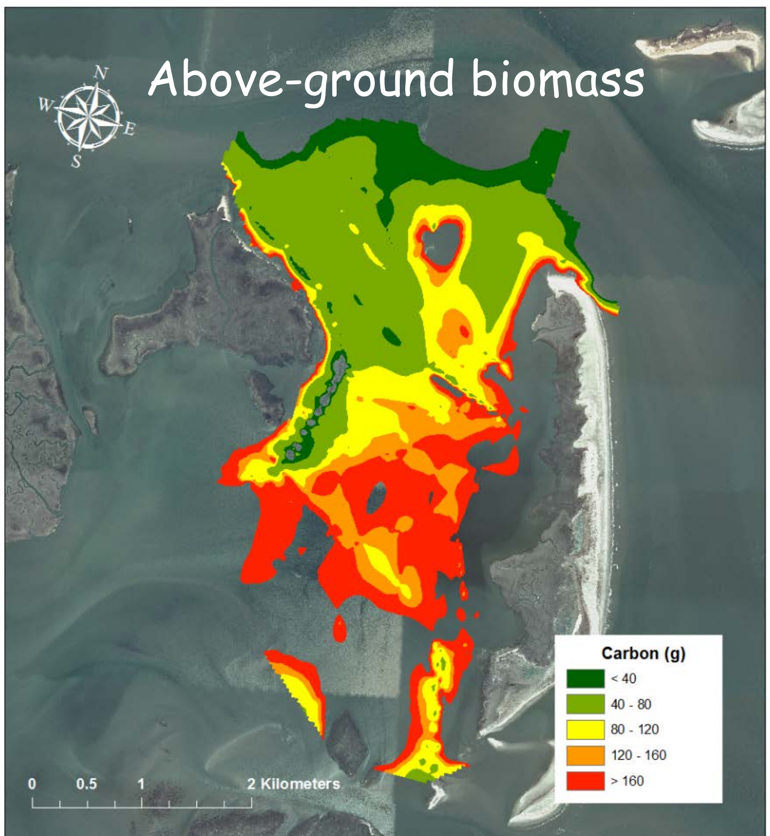
Testing Data:

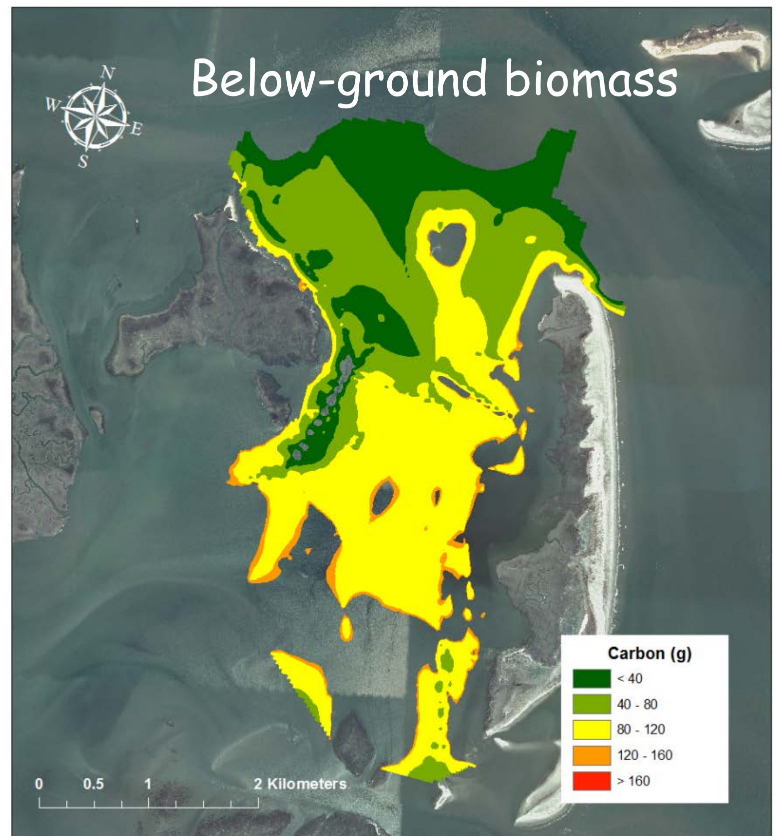


Oguslu, E., K. Islam, D. Perez, V. Hill, W. Bissett, R. Zimmerman, and J. Li. 2018. Detection of seagrass scars using sparse coding and morphological filter. Remote Sens. Env. **213:92-103.**

Morphological differences affect carbon burial

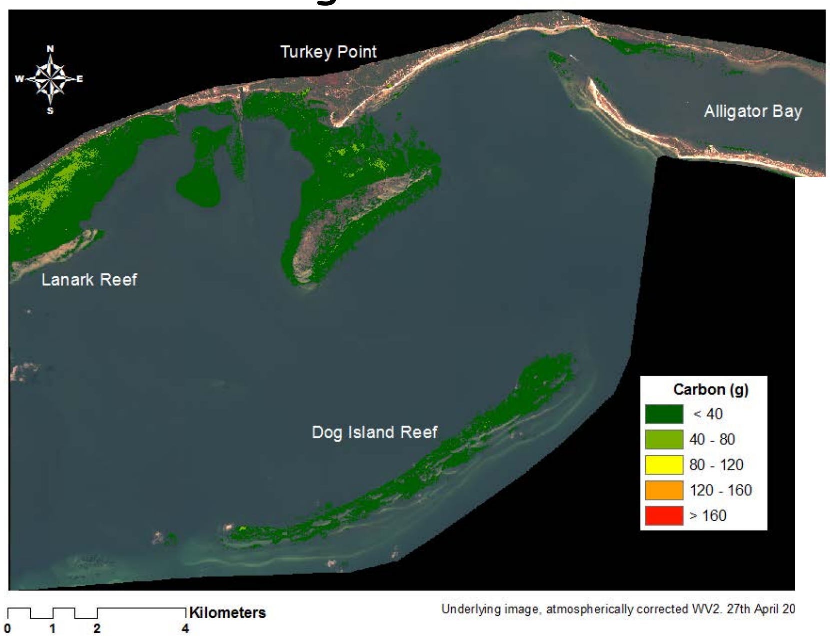
Eelgrass biomass in South Bay VA mostly above-ground



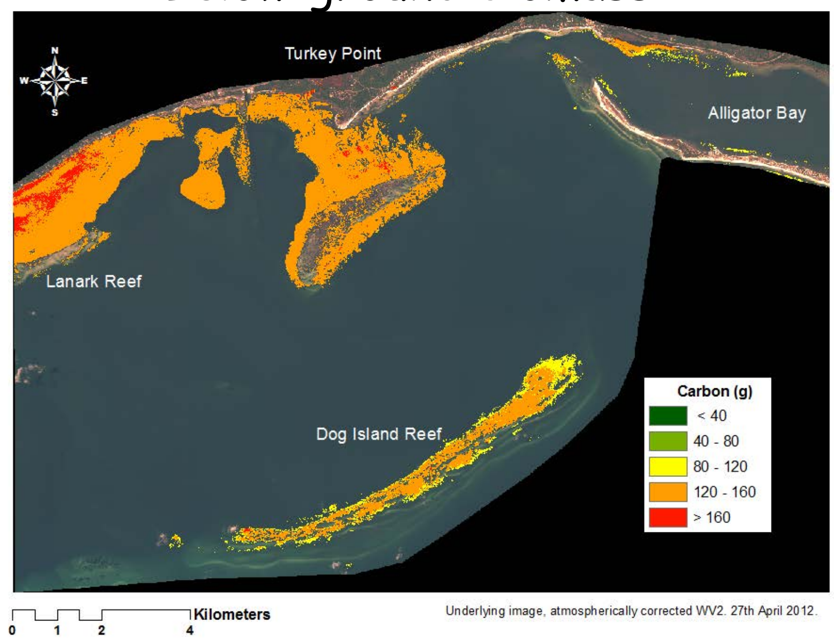


Turtlegrass biomass in FL mostly below-ground

Above-ground biomass



Below-ground biomass



- Tropical seagrasses, esp turtlegrass
  - Invest more C in below ground that eelgrass
  - Retains senescent leaves, enhance burial and nutrient retention

	St. George Sound, FL	South Bay VA
	Mostly turtlegrass	Eelgrass
Total Area (ha)	1700	650
Seagrass Carbon		
Above Ground C (Mg)	540	390
Below Ground C (Mg)	2132	230
Total C (Mg)	2672	620
Above Ground NPP (Mg)	2700	1950
Leaf Burial (Mg)	1350	195
Blue Carbon Potential (Mg)	3482	425
Area normalized Blue Carbon Potential (Mg ha^{-1})	2.0	0.7

Can Seagrass Meadows Mitigate Ocean Acidification Thresholds for Eastern Oysters in the Chesapeake Bay?

Emily Rivest, Mark Brush

Virginia Institute of Marine Science

Gloucester Pt. VA

Richard C. Zimmerman, Victoria J. Hill

Department of Ocean, Earth & Atmospheric Sciences

Old Dominion University

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Coupling *Eco-Oyster* and *GrassLight* to predict ecosystem-level responses to climate change