# Seagrass Mortality in Florida Bay: A Tale of Two Die-off Events

Paul Carlson, Laura Yarbro, Sheila Scolaro, Mike Poniatowski, Liz Johnsey, and Vicki Absten.


LOST: Season 1
PEANUTS
featuring "Good ol' Charlie Brown"
by SCHULZ
It was a dark and stormy night.
Suddenly, a shot rang out. A door slammed. The maid screamed.
Suddenly, a pirate ship appeared on the horizon!
While millions of people were starving, the king lived in luxury.
Meanwhile, on a small farm in Kansas, a boy was growing up.
Part II
IN PART TWO I TIE ALL OF THIS TOGETHER..

## Outline:

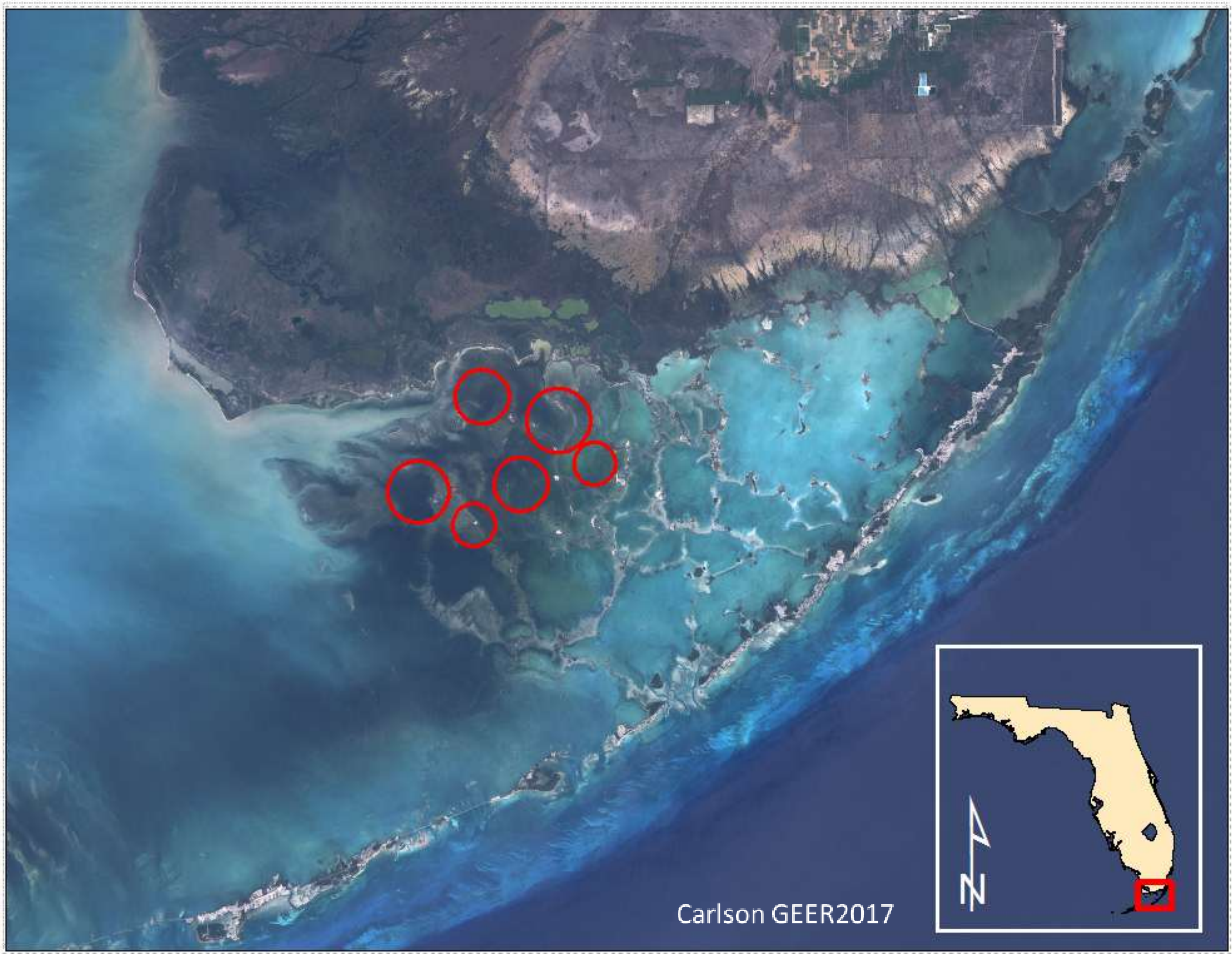
Brief Introduction to Florida Bay

Similarities Between 1987-1991 Die-Off and Current Event

Hypersalinity, Stratification, and Sulfide Intrusion

What else should we watch for?

What else needs to be done?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It was the best of times.  It was the worst of times…
In summer 1987, Florida Bay appeared to be healthy, with extensive, dense beds of *Thalassia testudinum*
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# Mass mortality of the tropical seagrass *Thalassia testudinum* in Florida Bay (USA)

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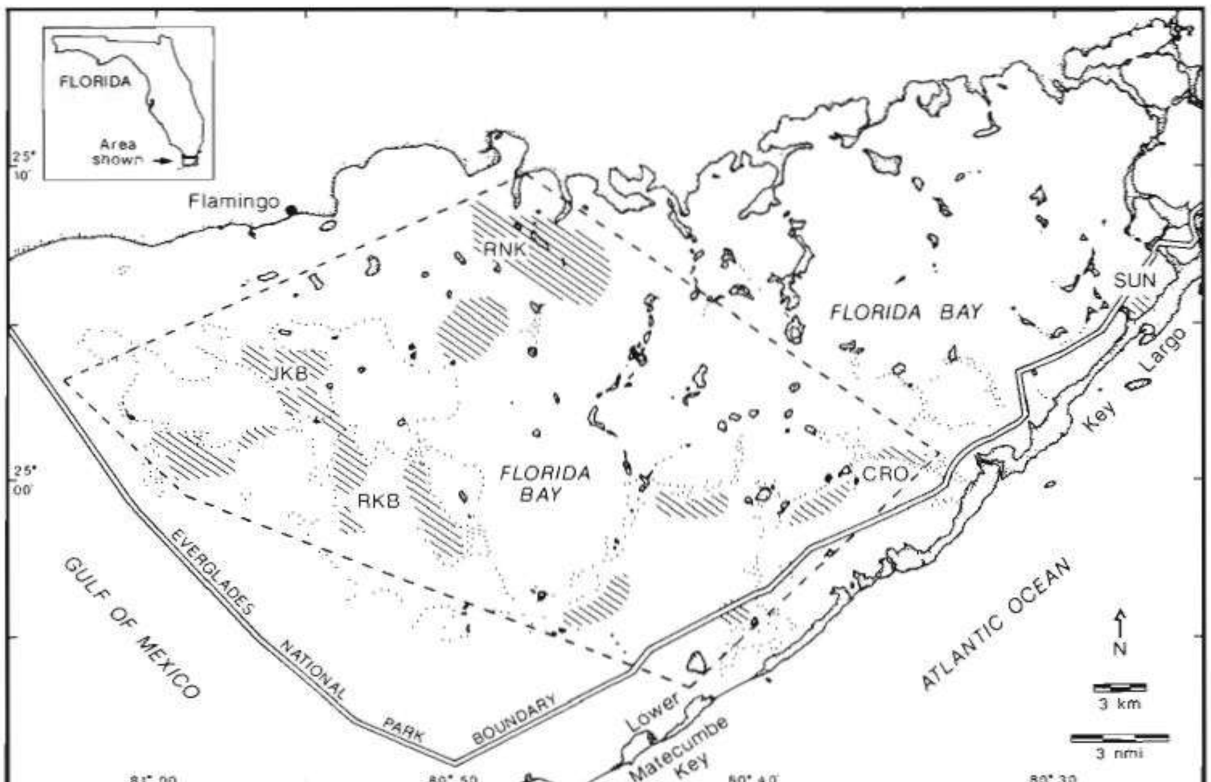



1987- First indications of die-off in dense Thalassia beds western Florida Bay.
1988- Die-off investigation group formed
Die-off continued into 1990 and 1991.
Hypersaline conditions existed.
Elevated porewater sulfide (PWS) concentrations measured and implicated as cause (Bull. Mar. Sci. 54:733).

Estuaries Vol. 22, No. 2B, p. 460–470 June 1999

J. C. Zieman, J. W. Fourqurean, T. A. Frankovich. 1999. Estuaries 22: 460-470.

# Seagrass Die-off in Florida Bay: Long-term Trends in Abundance and Growth of Turtle Grass, *Thalassia testudinum*

Documented hypersalinity associated with die-off episode and effects on productivity, although phytoplankton blooms and turbidity confounded interpretation.

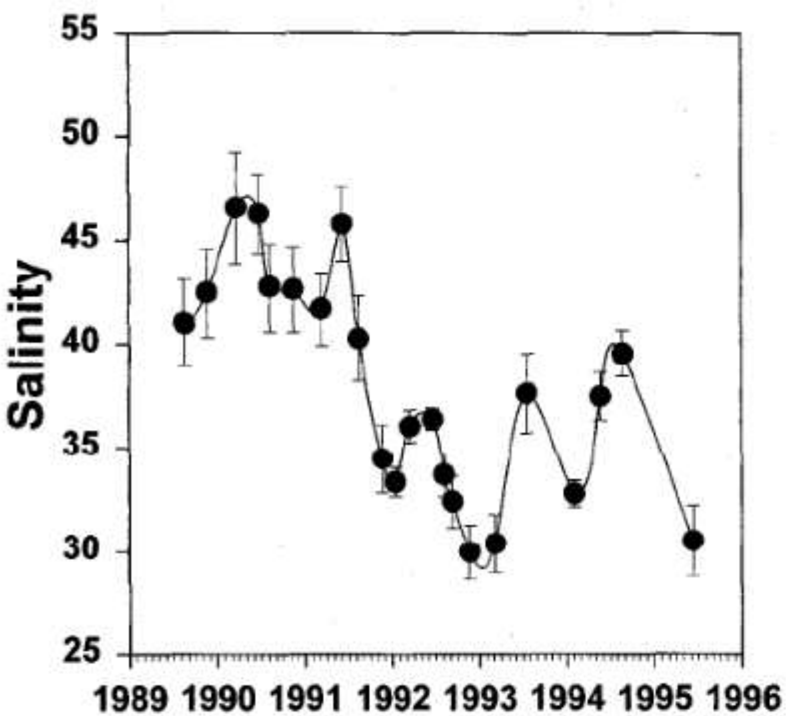
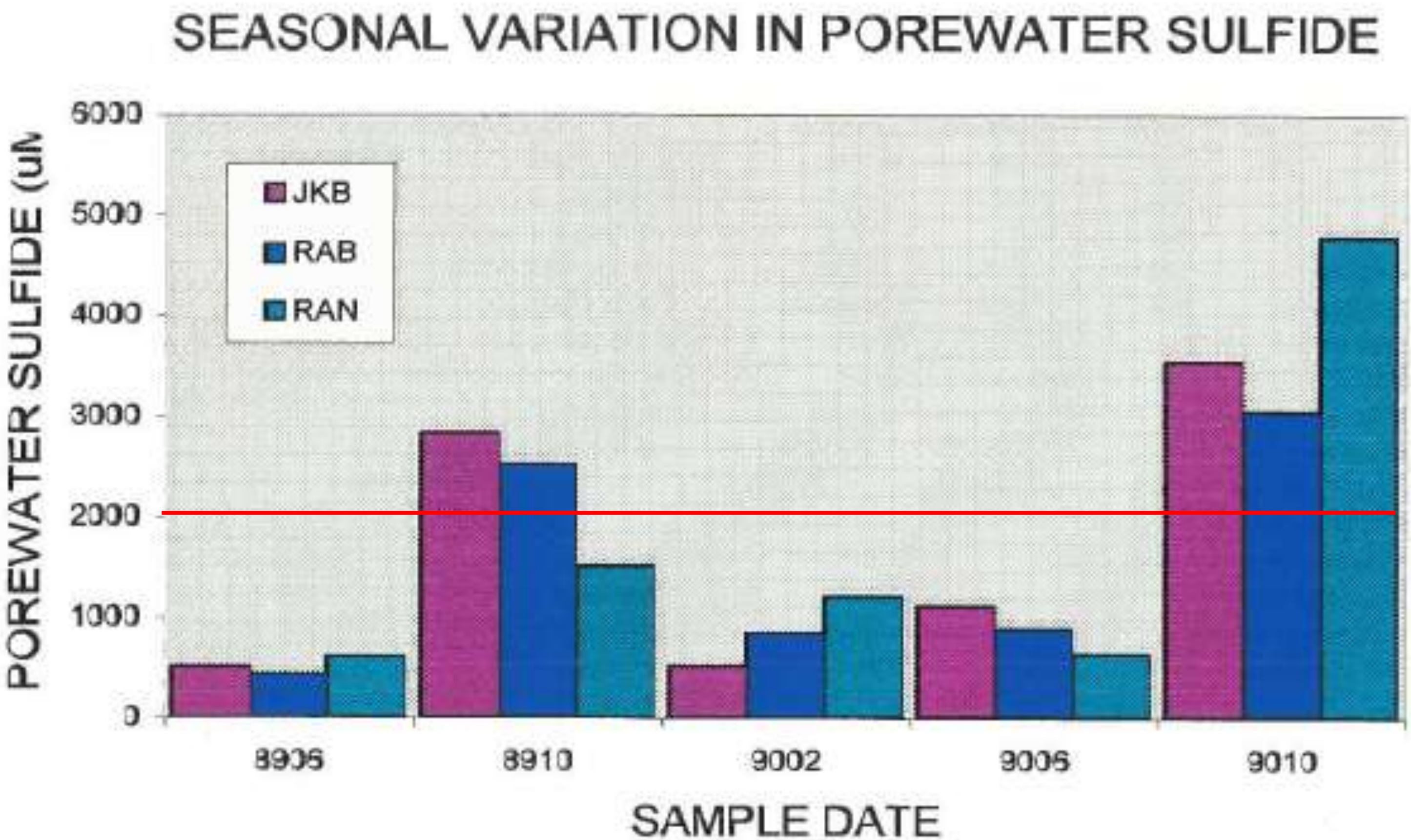



Fig. 2. Average salinity (psu) for all stations in Florida Bay for each sampling date. Error bars are ± 1 SE.

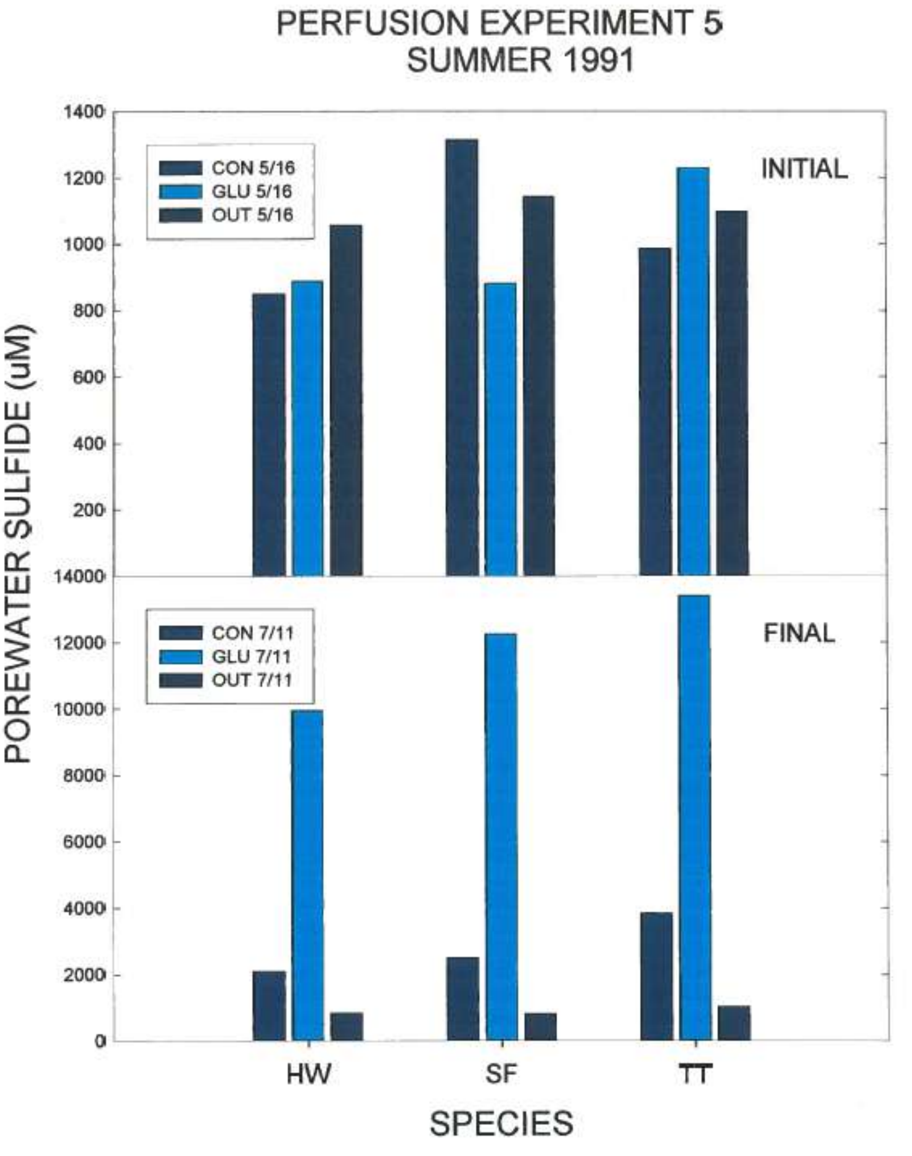
TABLE 1. Comparison of abundance and growth estimates of *Thalassia testudinum* at die-off and unaffected sites. Means of all observations from 1989 to 1995 (±1 SE). Significant differences between die-off and unaffected sites are indicated by different letter superscripts.

| | Die-off Sites | Unaffected Sites |
|---|---|---|
| Standing crop ($g\ m^{-2}$) | 94.2 ± 5.5[a] | 50.2 ± 8.2[b] |
| Short-shoot density ($ss\ m^{-2}$) | 768 ± 33[a] | 518 ± 49[b] |
| Short-shoot mass ($g\ ss^{-1}$) | 117 ± 10[a] | 139 ± 15[a] |
| Shoot-specific productivity ($mg\ ss^{-1}\ d^{-1}$) | 1.74 ± 0.21[a] | 2.47 ± 0.31[b] |
| Mass-specific productivity ($mg\ g^{-1}\ d^{-1}$) | 14.1 ± 0.5[a] | 16.9 ± 0.7[b] |
| Areal productivity ($g\ m^{-2}\ d^{-1}$) | 1.22 ± 0.08[a] | 0.84 ± 0.13[b] |

Field PWS surveys 1989-1990 showed strong seasonal pattern in all three basins studied. Highest concentrations occurred in fall. Assumed acute toxicity threshold of 2.0 mM sulfide marked by red line



Perfusion Experiments: Raise PWS concentrations *in situ* by adding glucose through porous polyethylene tubes

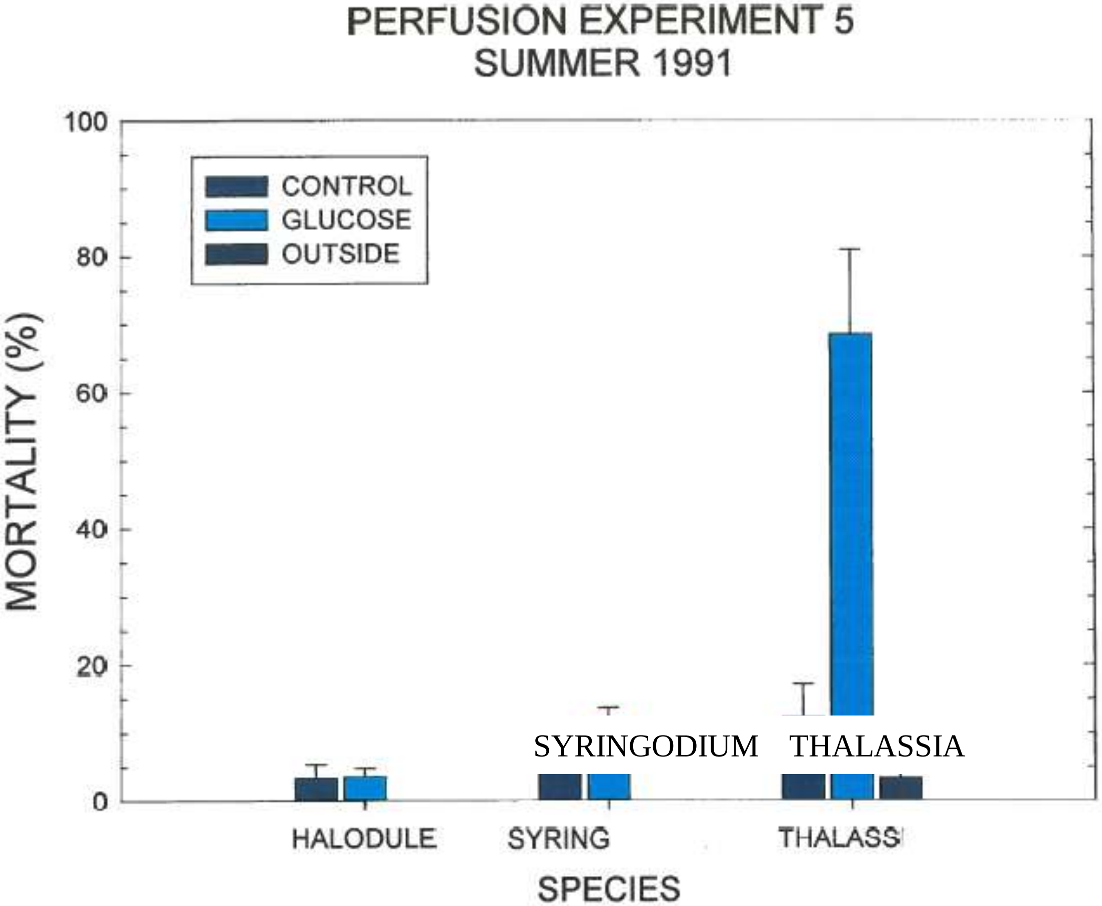



Carlson Yarbro, WA SeaGrant Sulfide Workshop, January 2015

Control (left) and high-glucose treatment (below) buckets after 60 days. Complete mortality of *Thalassia* in glucose-amended sediments

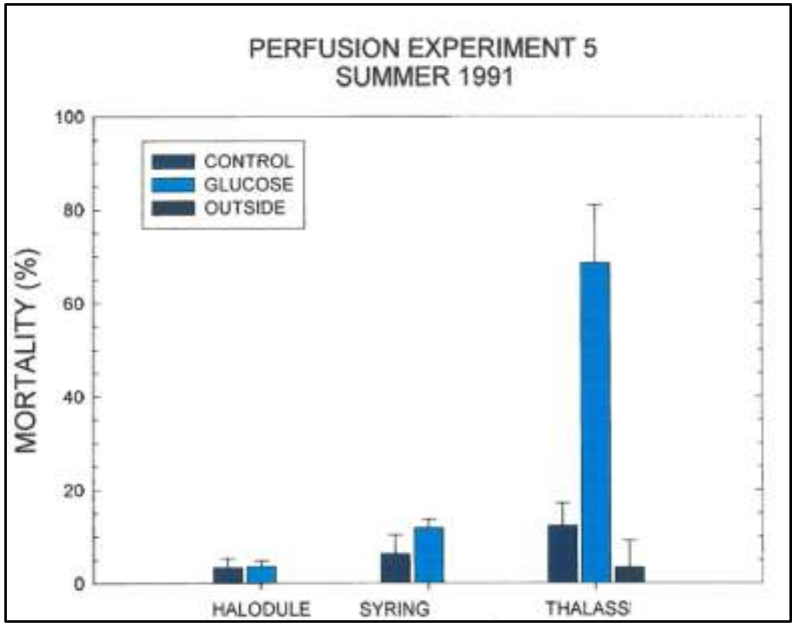
Carlson Yarbro, WA SeaGrant Sulfide Workshop, January 2015

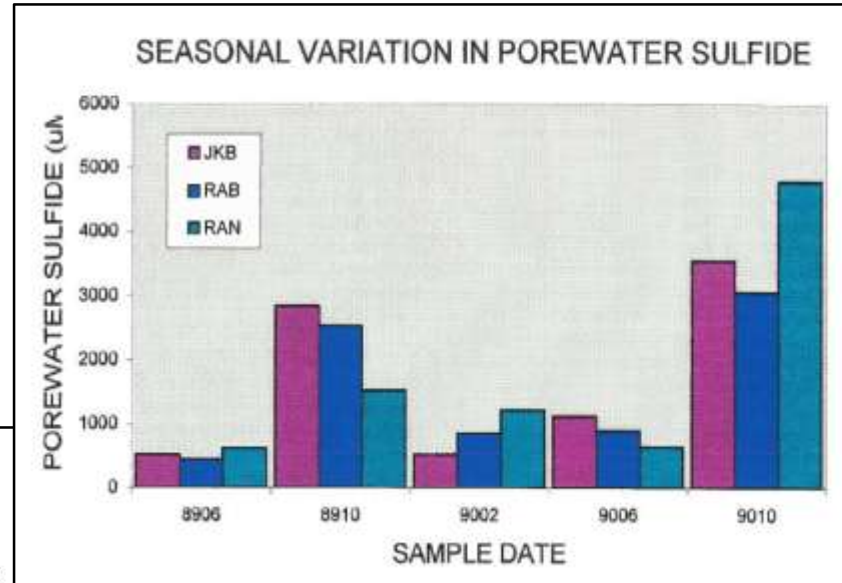
In one perfusion experiment conducted in monospecific stands of three seagrass species, 70-85% of *Thalassia* shoots died in glucose-amended sediments while less than 10% of *Syringodium* and *Halodule* shoots died. These results are consistent with *Thalassia*'s high root:shoot ratio




Carlson Yarbro, WA SeaGrant Sulfide Workshop, January 2015

Seasonal measurements and experiments demonstrated elevated PWS levels, vulnerability of Thalassia to high PWS, and sulfide as the cause of mortality (Carlson et al. 1994)



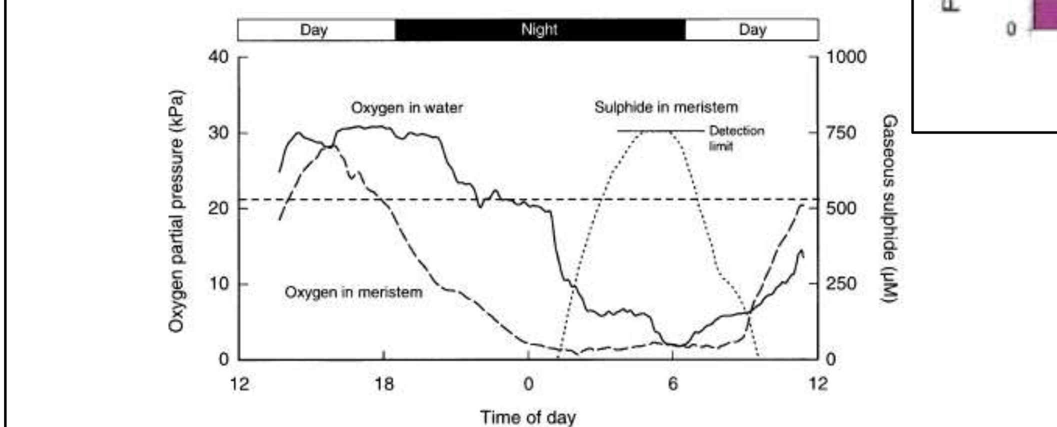
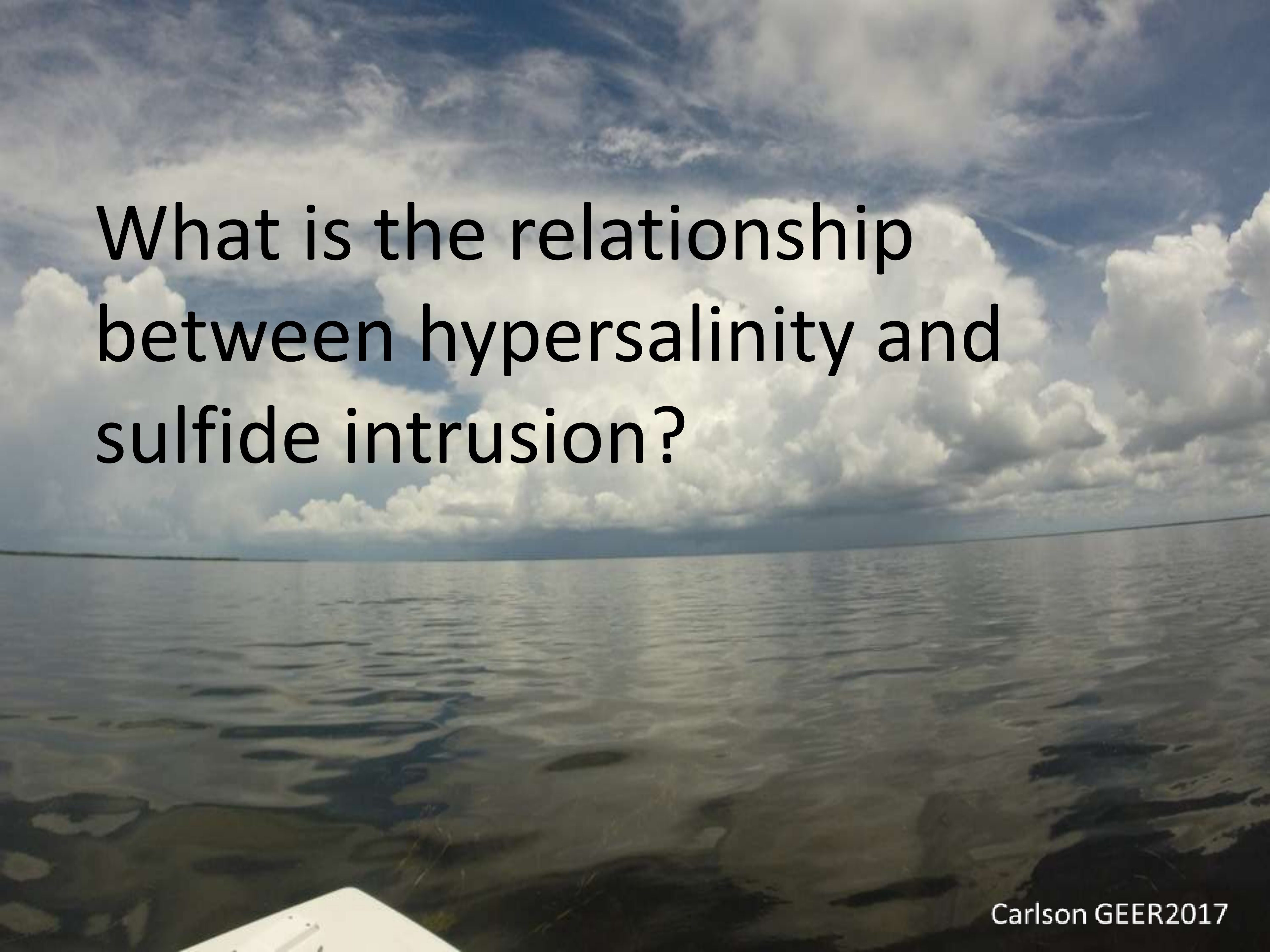




**Fig. 5** *In situ* measurements of diel changes in the oxygen content of the water column and of the oxygen partial pressure and content of gaseous sulphide in the meristematic tissue of *Thalassia testudinum* from a die-off patch at Barnes Key. Upper detection limit (= 750 μM) of the sulphide microelectrode is indicated. The horizontal, dashed line corresponds to the oxygen partial pressure of the atmosphere.

2005- Borum et al demonstrate diel sulfide intrusion into *Thalassia* shoots (J. Ecol. 93:148).


What is the relationship between hypersalinity and sulfide intrusion?
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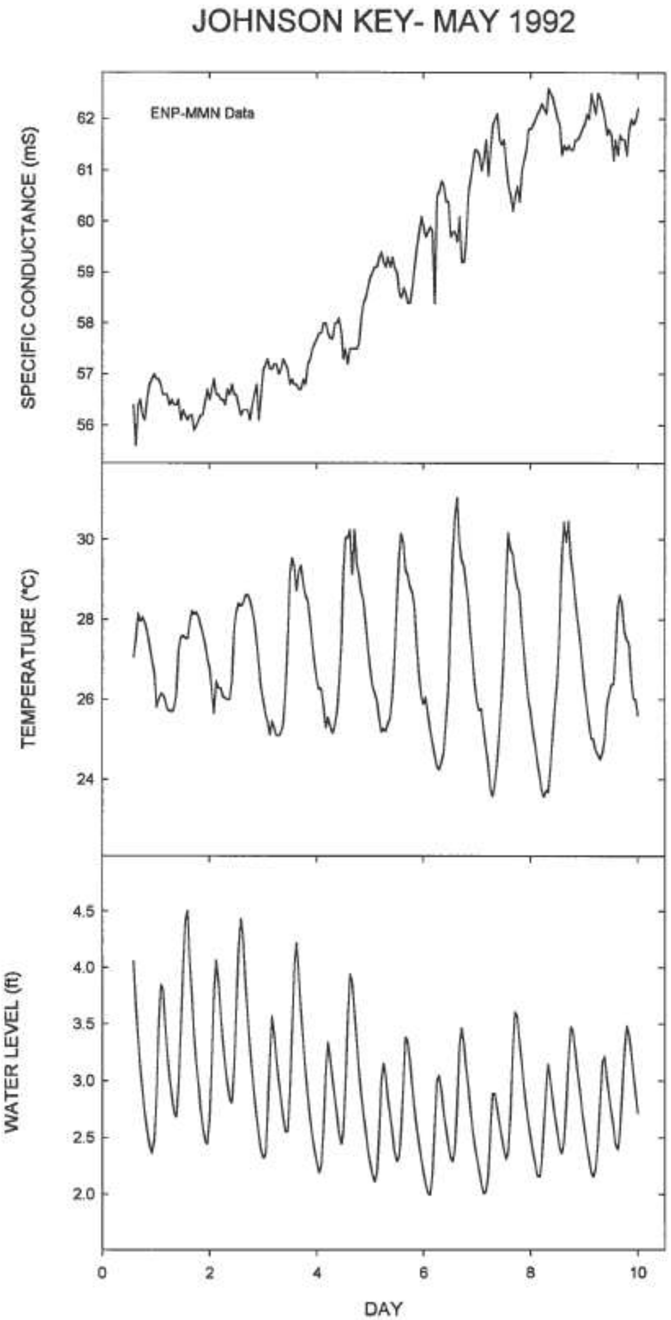
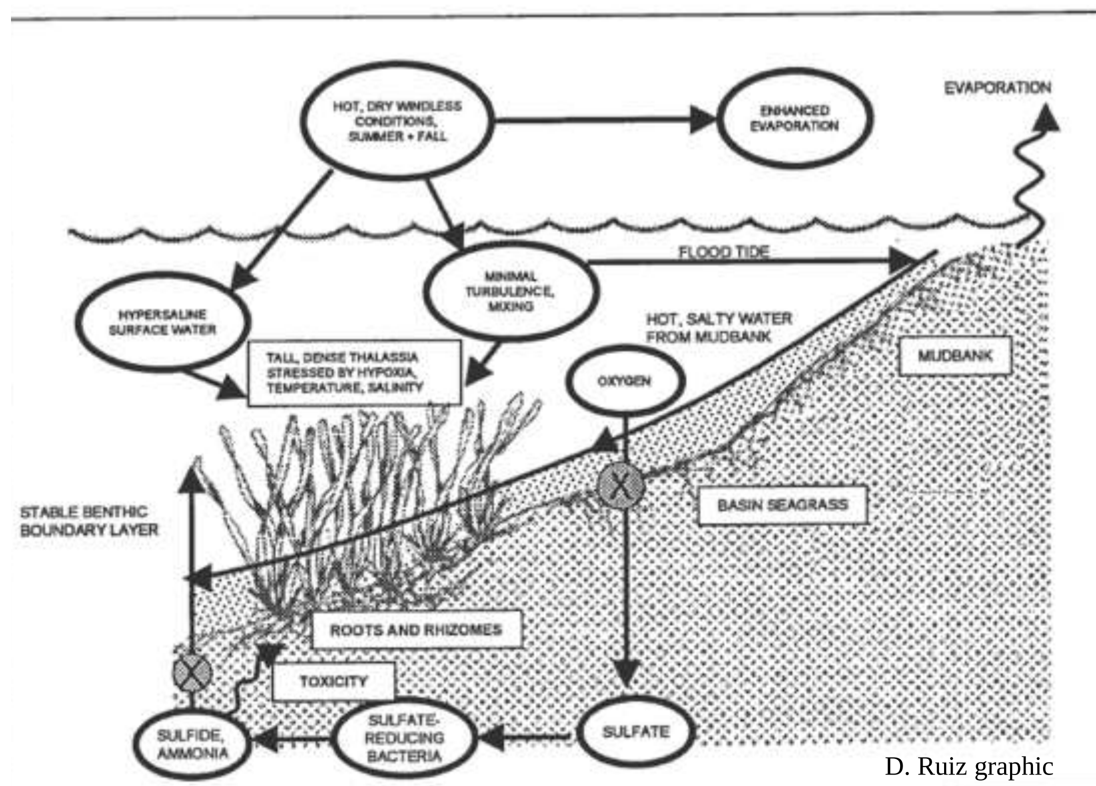



Link between hypersalinity and sulfide intrusion? We proposed that evaporation created a stable boundary layer limiting diffusion of sulfide out of sediments and oxygen diffusion into sediments.

**A Conceptual Model of Florida Bay Seagrass Mortality (1987-1991): Links between Climate, Circulation, and Sediment Toxicity.** Florida Bay Science Conference 1999

*Paul Carlson*, *Laura Yarbro*, and *Tim Barber*, Florida Fish and Wildlife Conservation Commission, Florida Marine Research Institute, St. Petersburg, FL; and *Dewitt Smith*, Everglades National Park.



D. Ruiz graphic

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Summer 2015: Severe drought and hypersalinity (again!)
Die-off recurs in many of the same locations as 1987-91
Dense Thalassia beds in western Florida Bay.
This time, we demonstrate conclusively that evaporation and stratification create a sulfidic bottom water layer.


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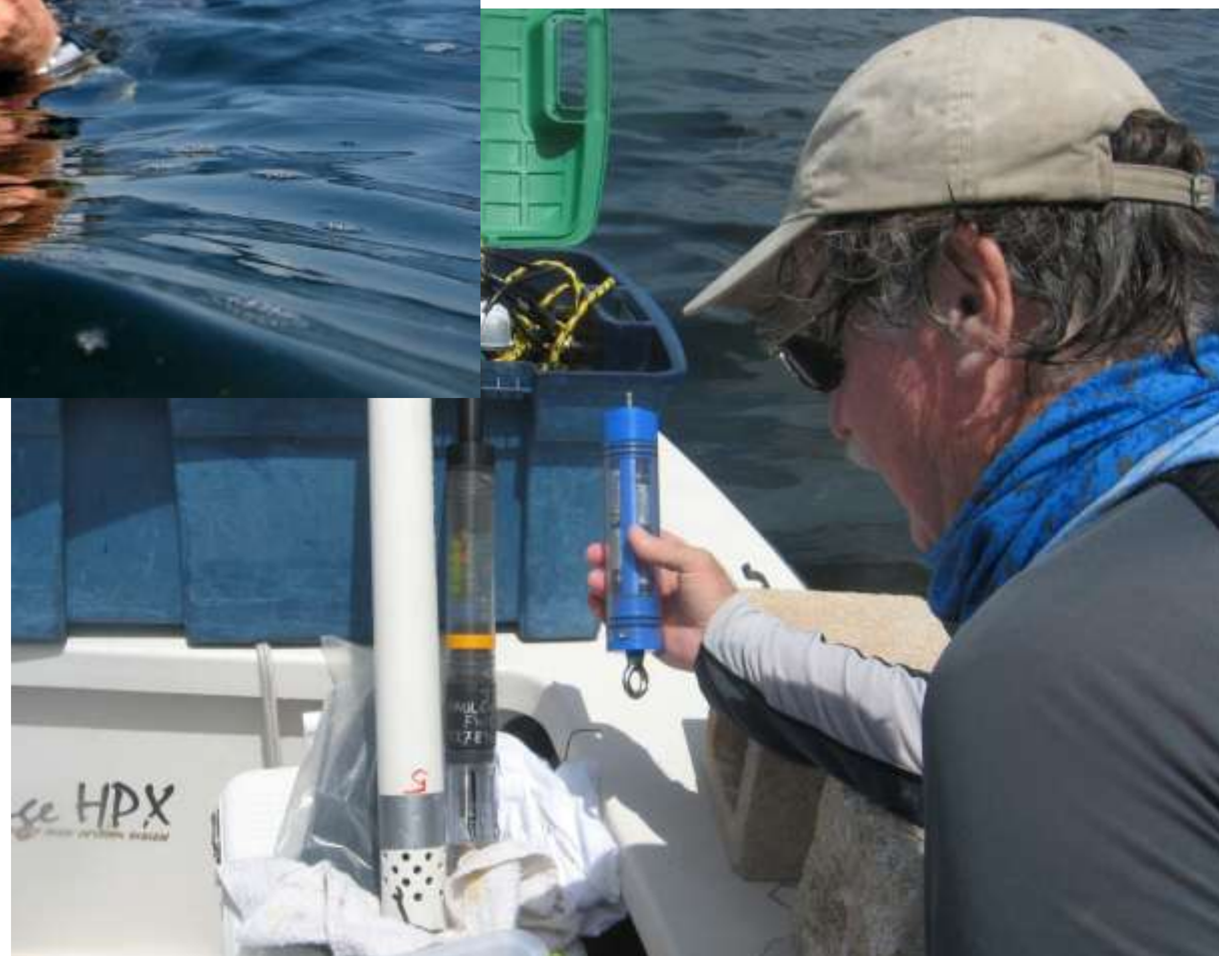
Thanks to Vicki Absten, we were able to deploy dataloggers and sample the sulfidic benthic boundary layer in this event

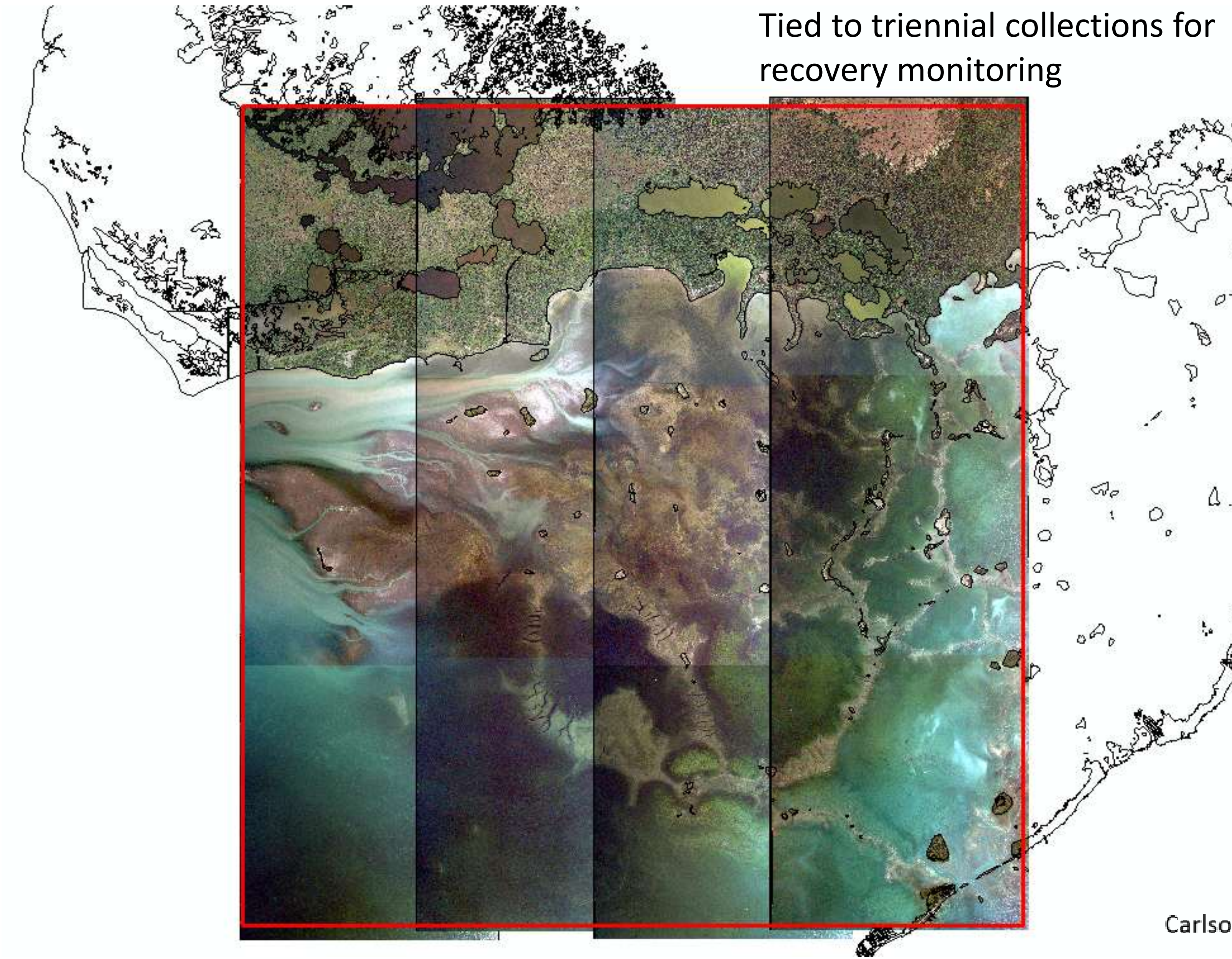



Confirming for both events that sulfide intrusion enhanced by hypersalinity caused seagrass mortality.

| Similarities Between Previous and Current Die-Off Episodes | | |
|---|---|---|
| **Processes / Effects** | **1987-91** | **2015** |
| Regional Drought | Observed | Observed |
| Hypersalinity | Observed | Observed |
| High Water Temperatures | Observed | Observed |
| | | |
| High Sediment Sulfide | Measured | Measured |
| Bottom Layer Formation | Inferred | Measured |
| Dense Thalassia Dies | Observed | Observed |
| Halodule Survives | Observed | Observed |

What lessons from the 1987-1991 event could we apply to this event? Set a baseline.

What have we learned?
Aerial imagery acquired April 2016.
Tied to triennial collections for
recovery monitoring



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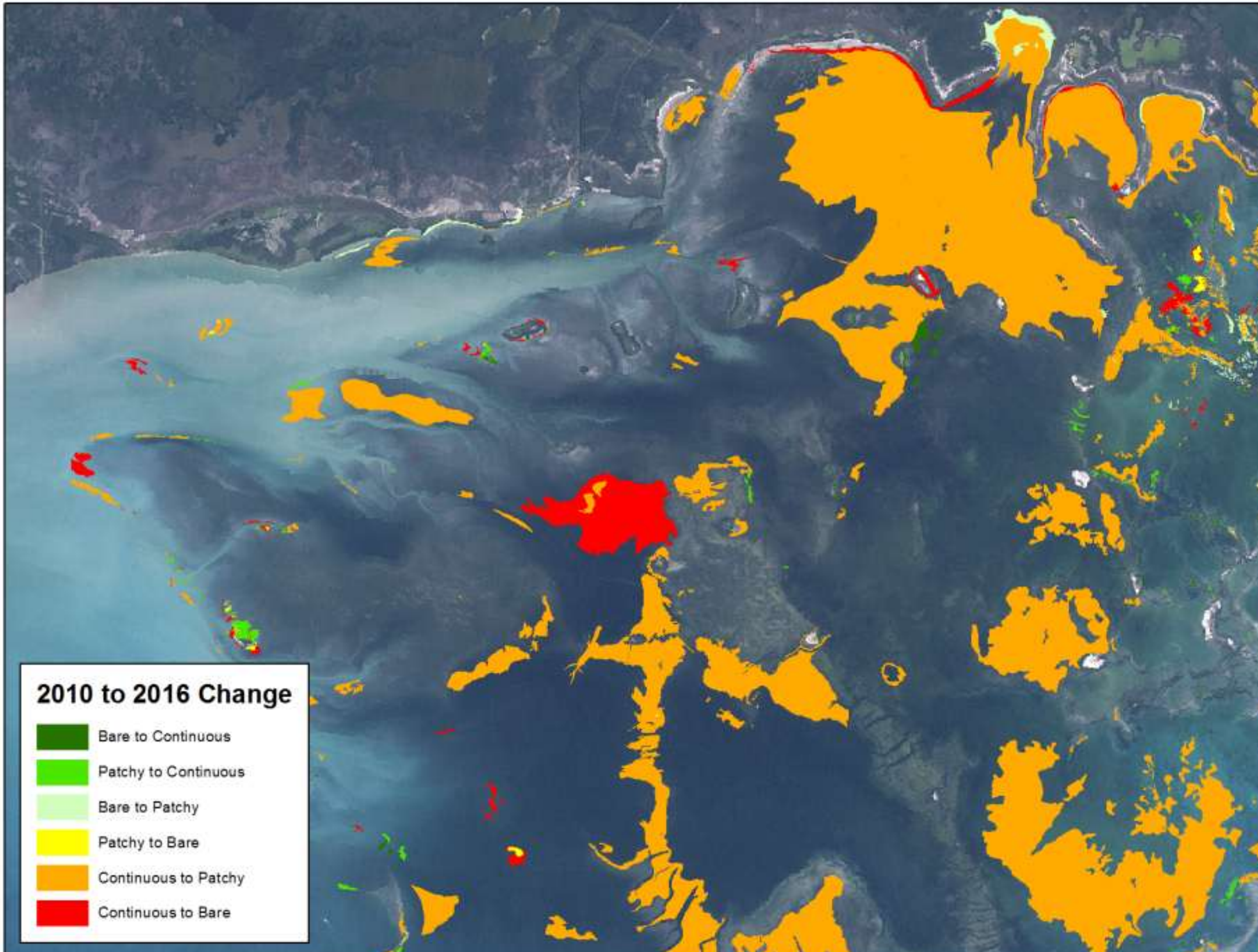
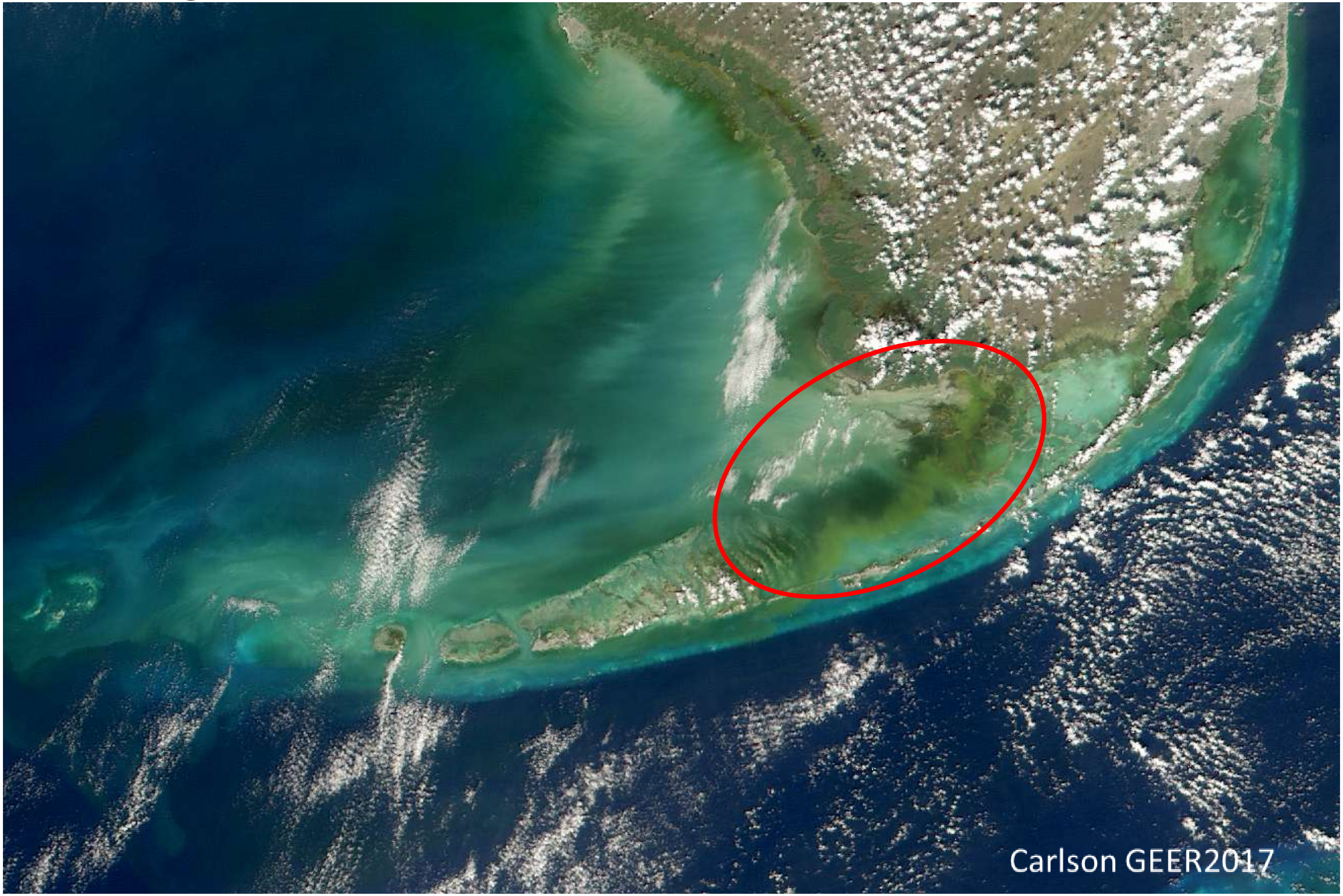

2010 to 2016 Change
Bare to Continuous
Patchy to Continuous
Bare to Patchy
Patchy to Bare
Continuous to Patchy
Continuous to Bare

What else should we be watching for?

Phytoplankton blooms- not as persistent?

Resurgence of *Halodule*, other species

# Intense phytoplankton blooms in fall 2016 and winter 2017, now declining?

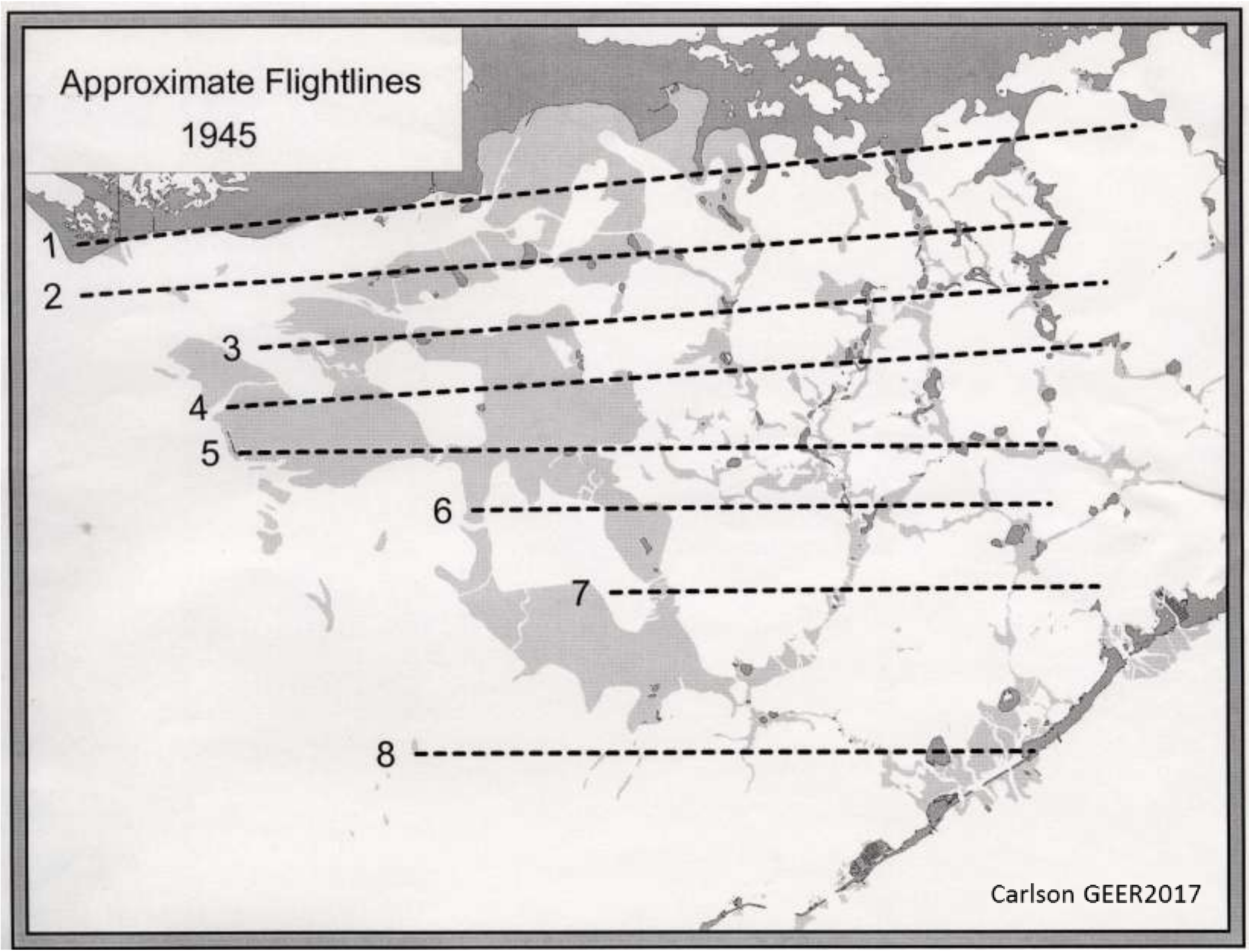


Left- Regional resuspension event, 1/8/2017

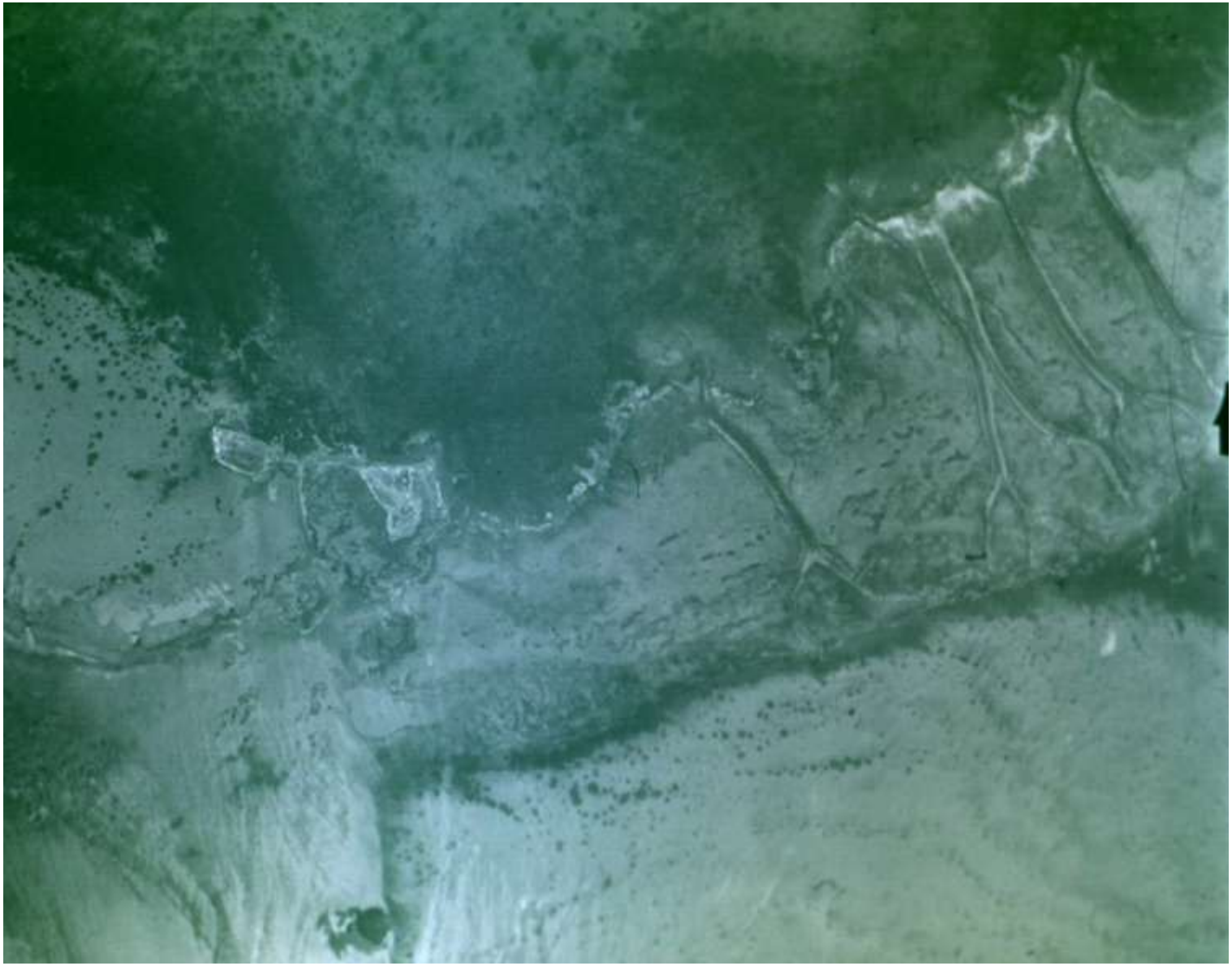
Below- Persistent resuspension and sediment transport within the western Bay

Mangrove mortality,  Crocodile Point, May 1993- Due in part to sediment transport and redeposition on mangrove islands and peninsulas.

# What else should we do?  1. Analyze 1945 aerial photos



# Use 1945 aerial photos to set seagrass restoration targets



Detail of 1945 aerial- Barnes Keys, Twin Basin

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## 2. Analyze time series imagery-in key locations to discern spatial patterns

For additional information on seagrasses in Florida Bay and around the state, please visit the SIMM web page.

**The Seagrass Integrated Mapping and Monitoring (SIMM) Program of Florida:**

Providing information to a broad user community.


Report located at http://myfwc.com/research/habitat/seagrasses/projects/active/simm/simm-reports/