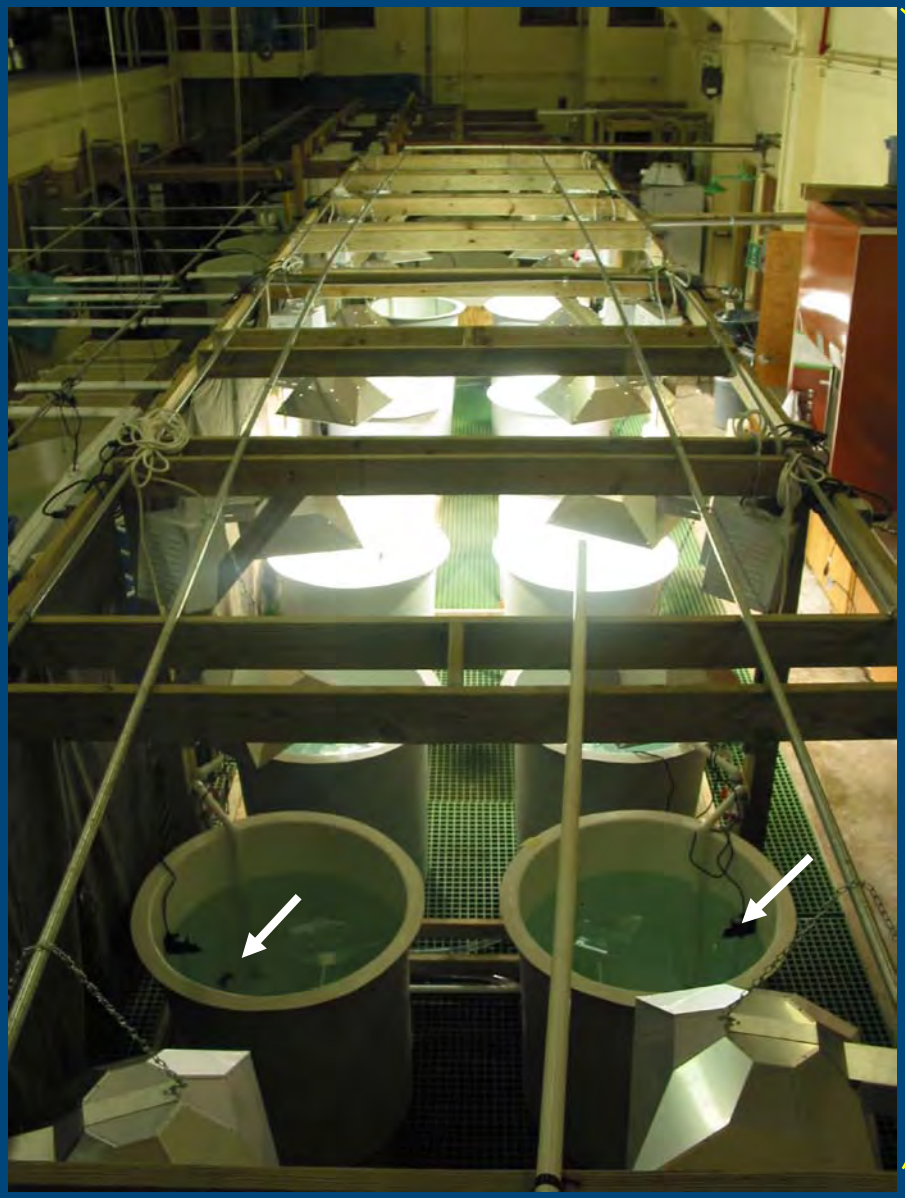
Coastal Marine Habitat Sustainability

- Multiple Stressor Effects Seagrass/Macroalgae Communities
- Nutrient Cycling –Seagrass, Sediments & Phytoplankton (blooms) FL Bay
- Resilience Tropical Marine Habitats Climate Change

Marguerite Koch
Biological Sciences Department
FAU

Overhead View Mesocosms



FAU Marine Laboratory
Gumbo Limbo Environmental Complex

- Controlled Temperatures
- Power sweeps
- 1000 Watt MH Lights
- Open or Closed Systems

Summary Mesocosm Experiments (5)
(*Thalassia testudinum*)

Results

•**Thermal tolerance threshold ~ 34ºC (2-Temp Threshold Experiments)**
•**Hypersalinity tolerance threshold ~ 60 PSU (3-Hypersalinity Experiments)**

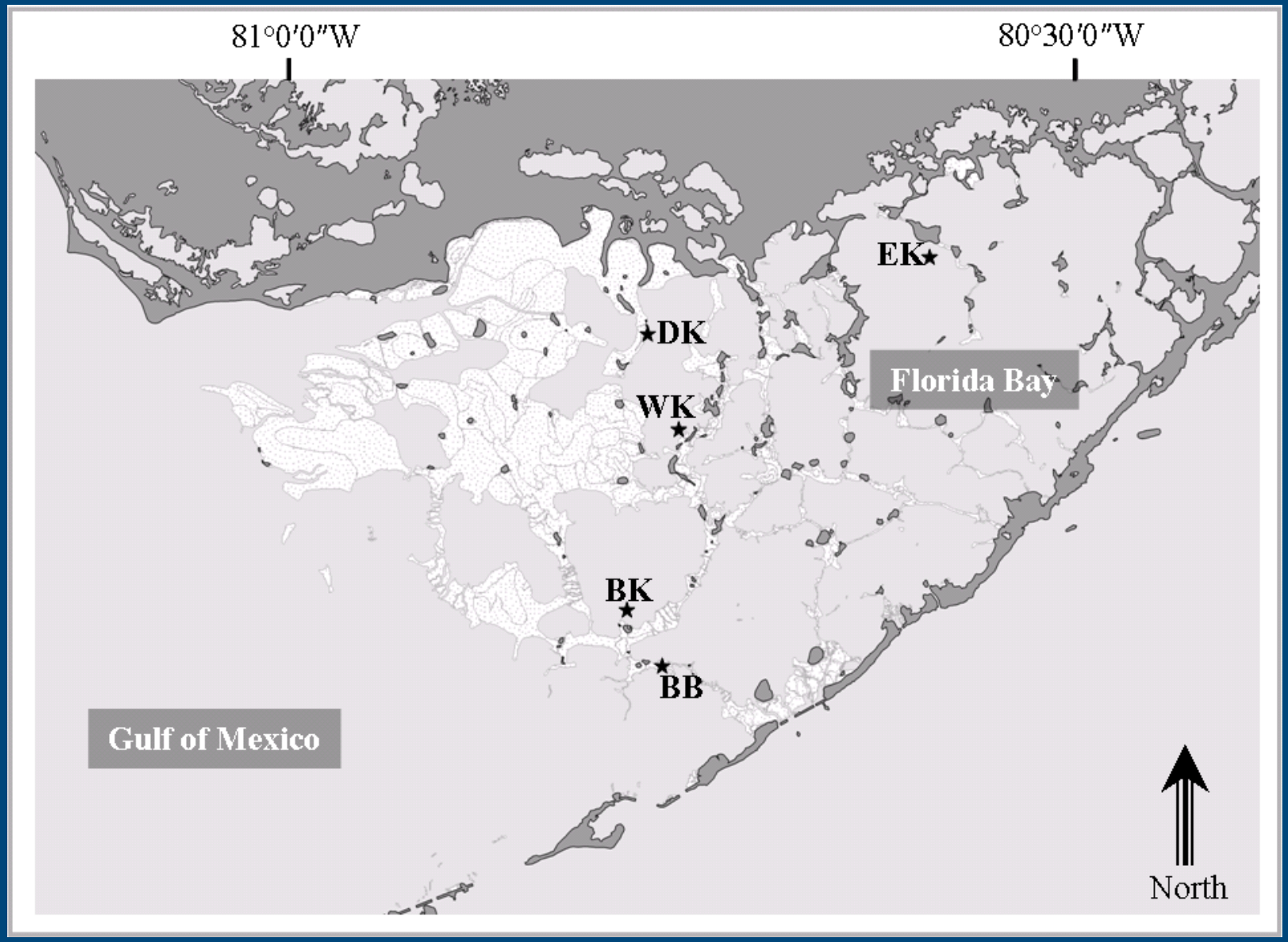
•***Thalassia* has a high capacity to oxidize porewater sulfide (Sulfide Injection Exp)**
•**> threshold salinity levels (65 PSU) affect sulfide oxidation (Sulfide Injection Exp)**
•**DOC and temperature increase sediment sulfate reduction (Glucose Experiment)**
•**Plants survive porewater sulfide levels of 16 mM (Glucose Experiment)**

Conclusion

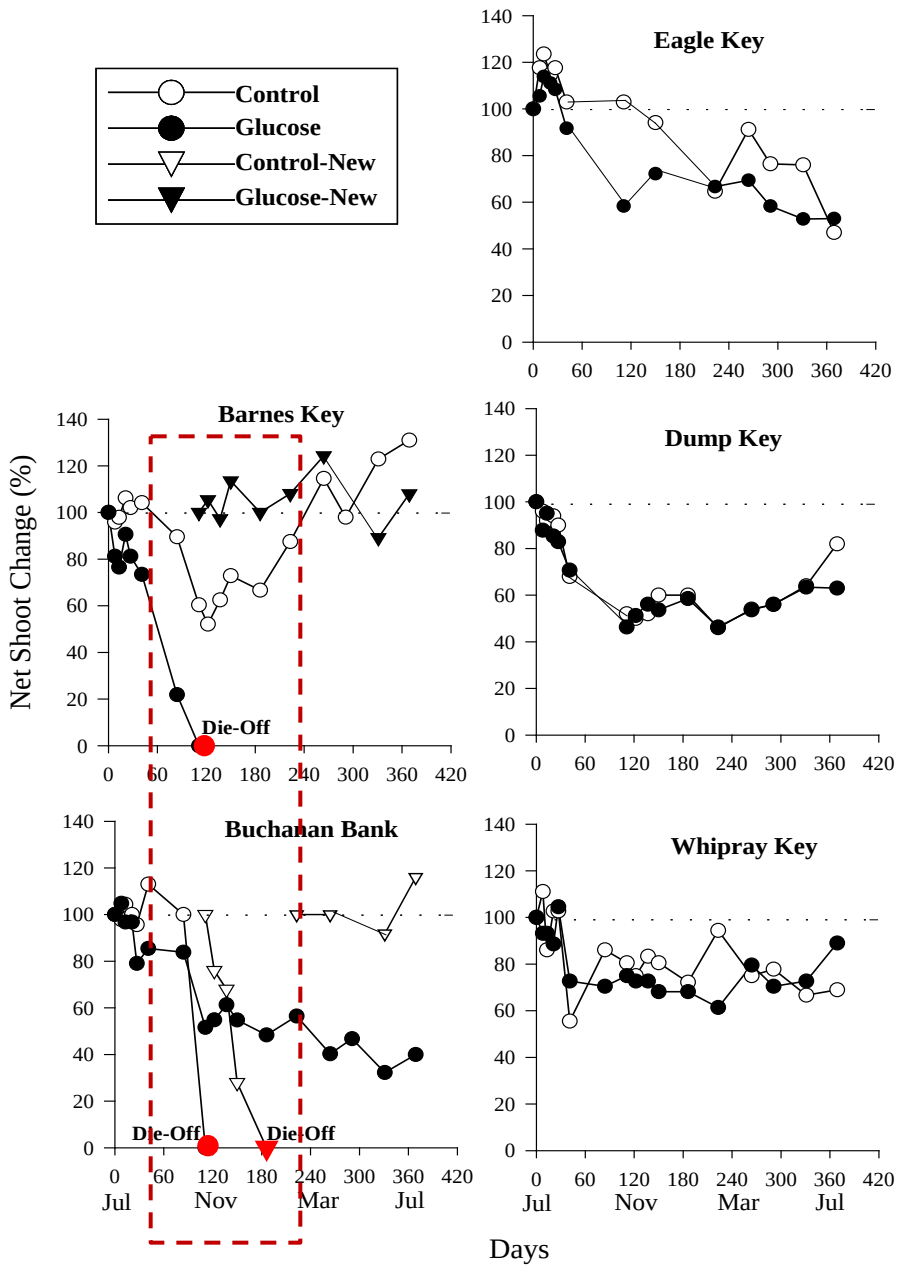
•**Salinity, Temperature, and Sulfide not directly initiating seagrass die-off events**
•**Stressors influence plant O_2 balance**

Field Validation Experiment

Florida Bay Sites
Glucose Field Experiment June 2004-July 2005

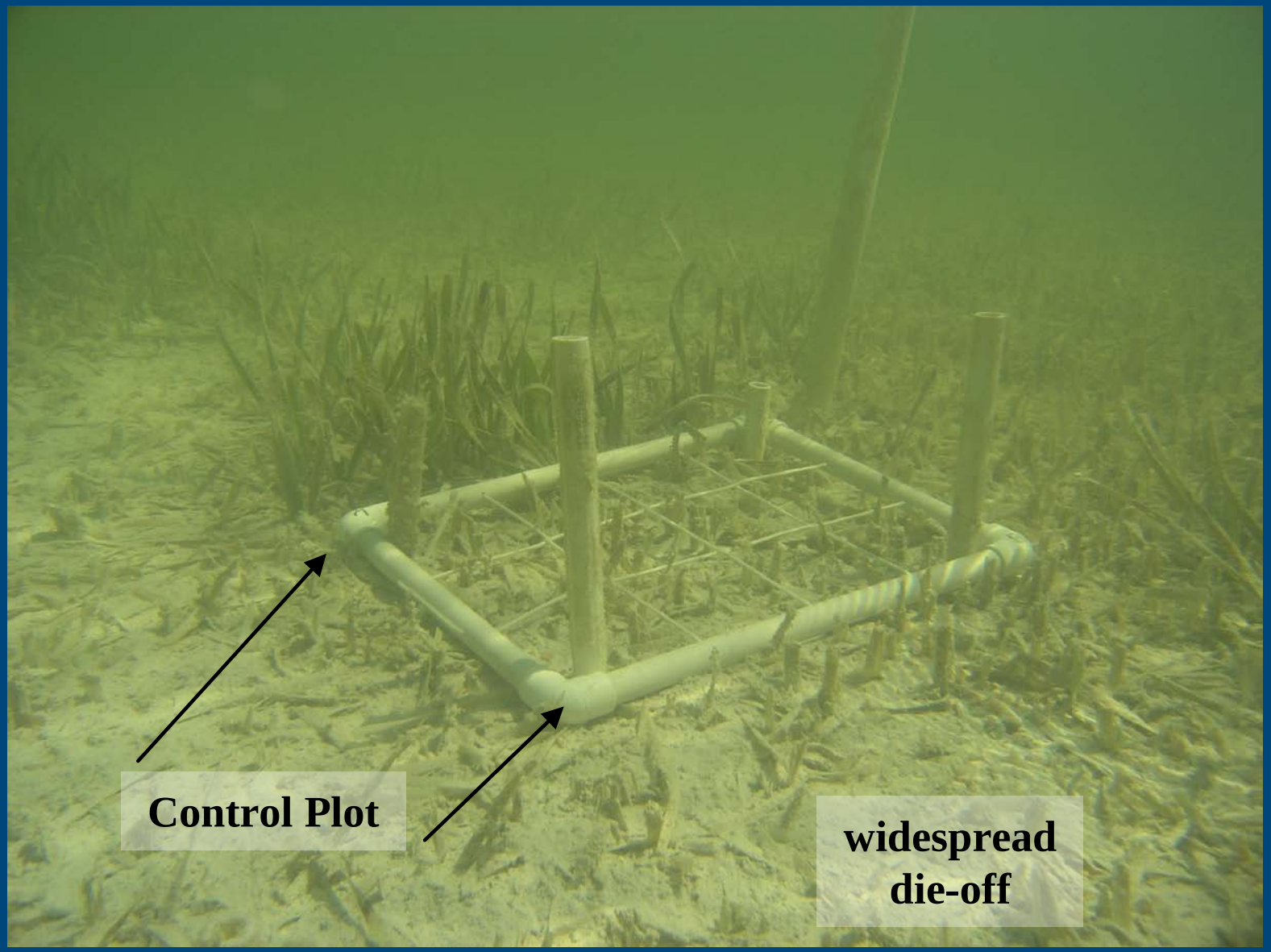


Thalassia Change Shoot Density

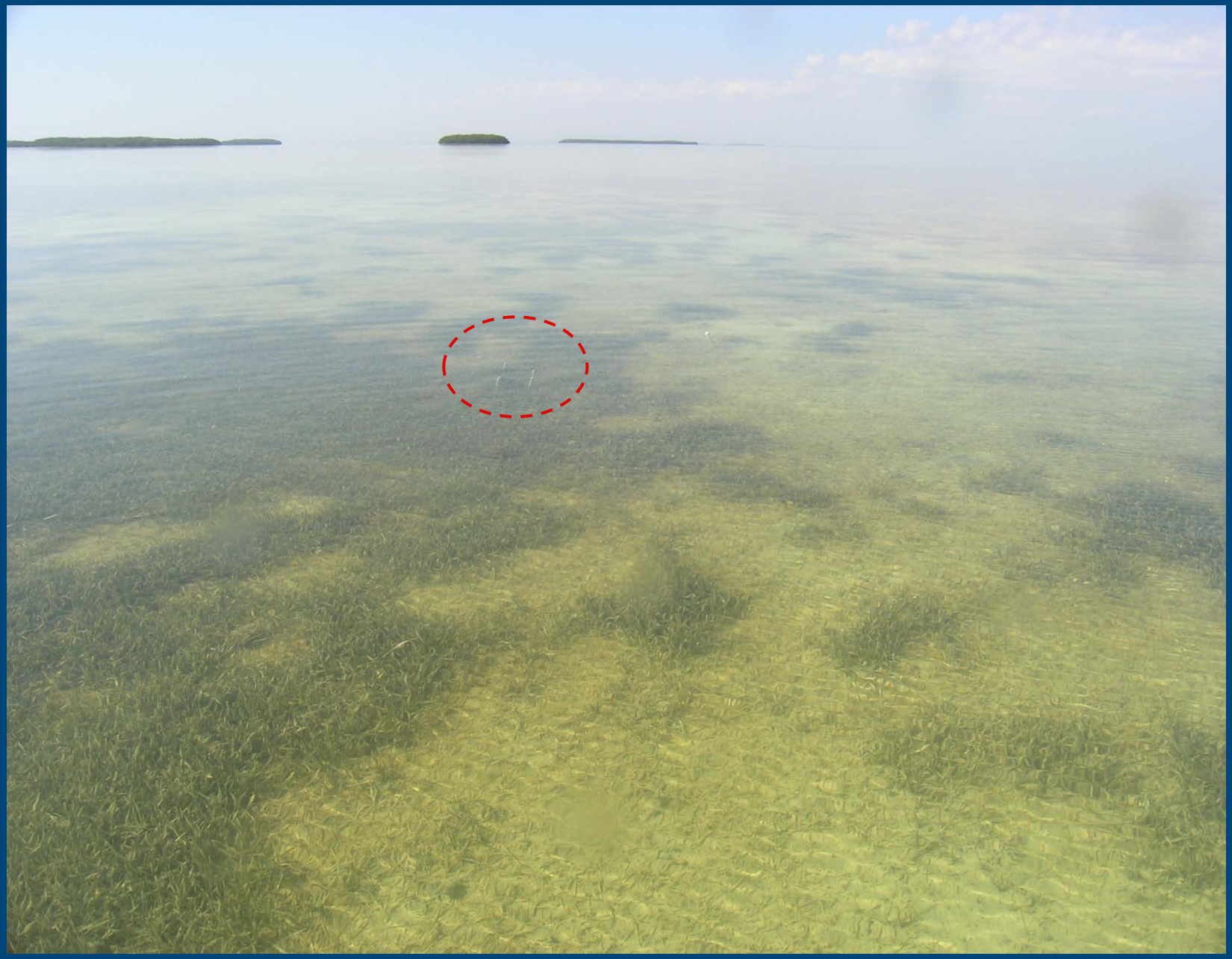


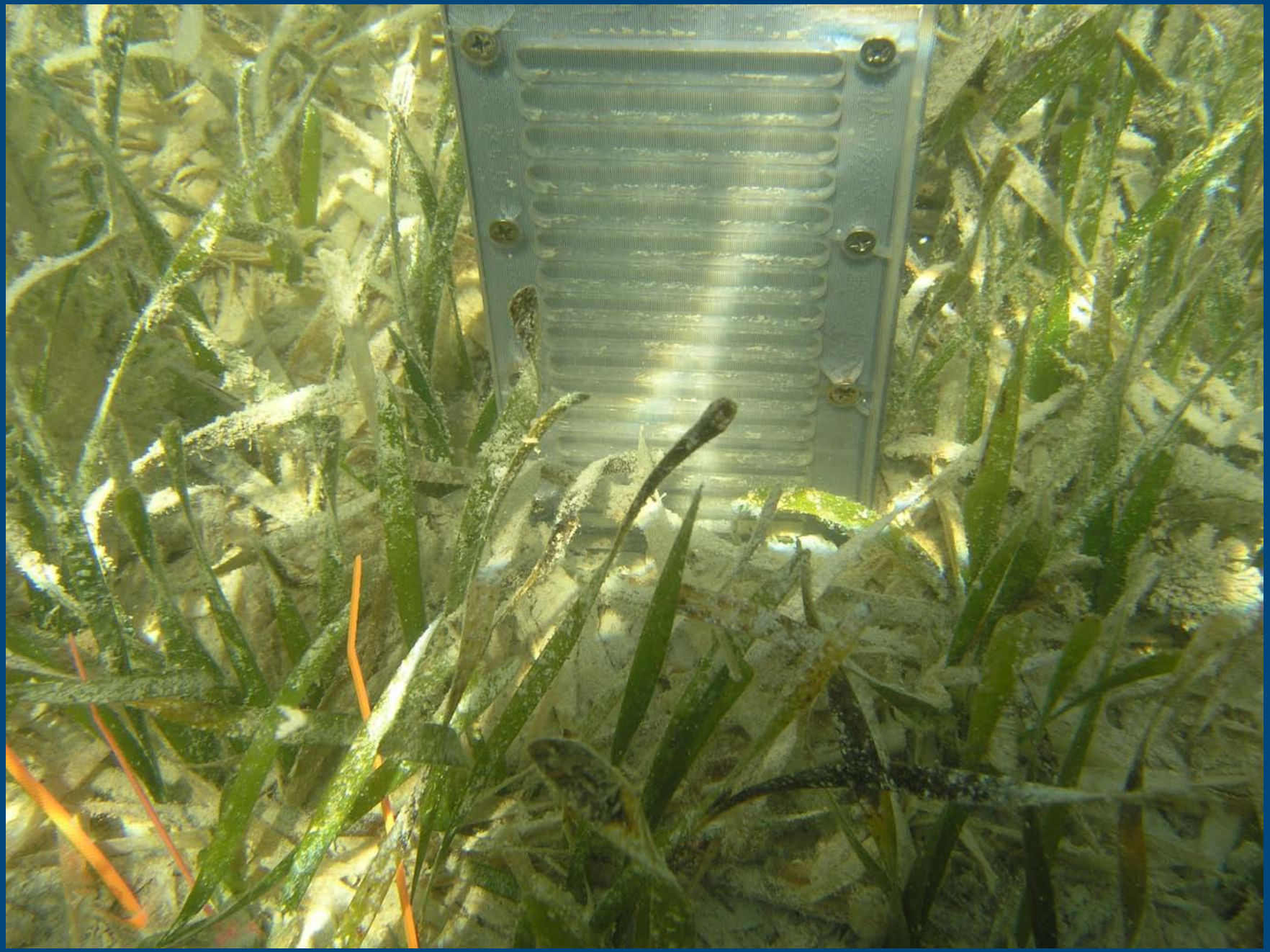
Koch, M.S., Schopmeyer, S.A., Nielsen, O.I., Kyhn-Hansen, C., Madden, C.J (2007) Conceptual model of seagrass die-off in Florida Bay: Links to biogeochemical processes. 350:73-88. Journal of Experimental Marine Biology and Ecology.

Buchanan Bank Die-Off (Sept-Oct 2004)

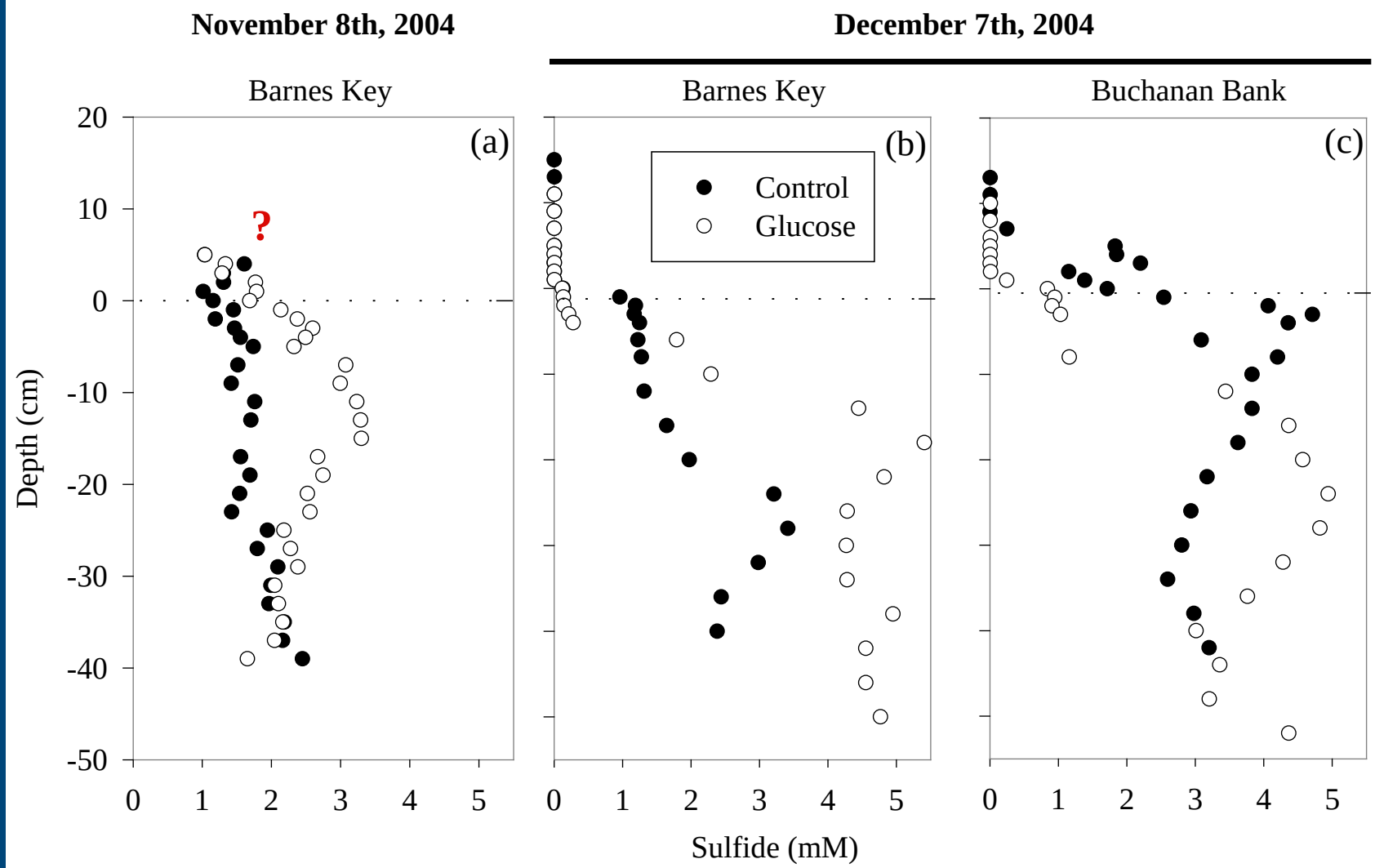


Buchanan Bank Die-Off (Glucose Site)



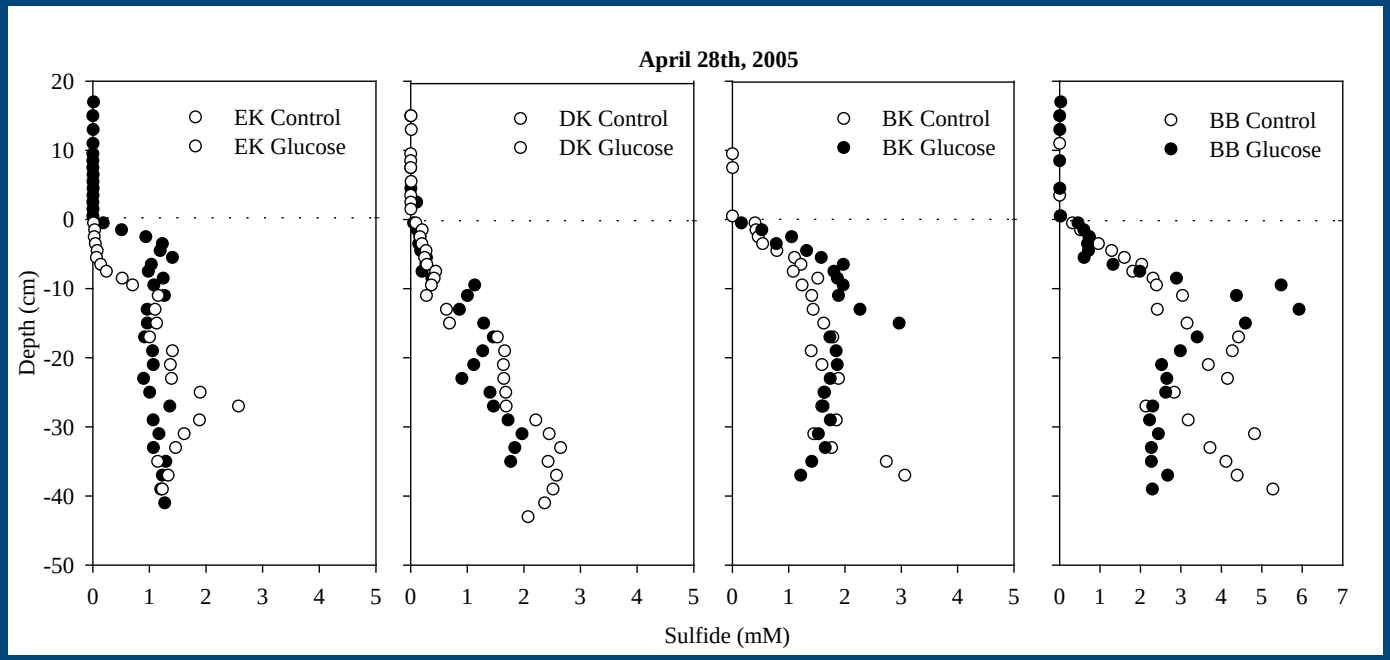


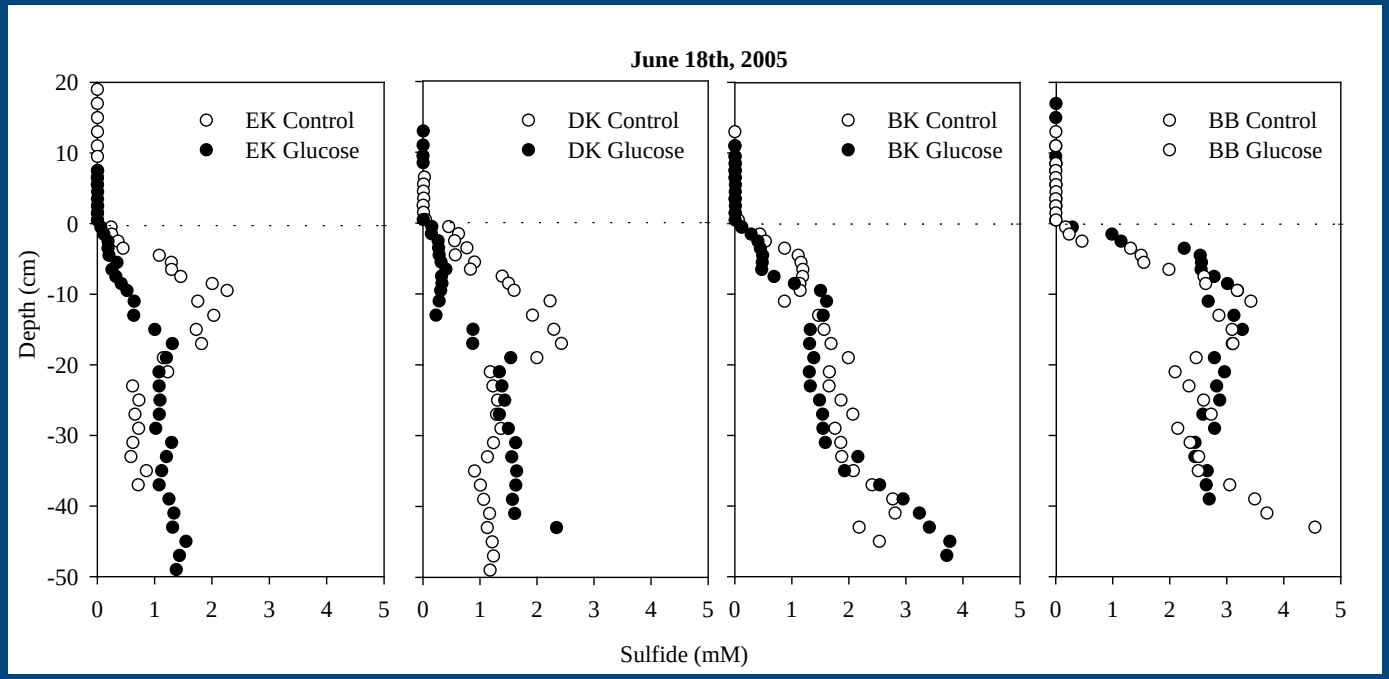
Total Sulfide Profiles During Die-Off Events



Koch et al. 2007

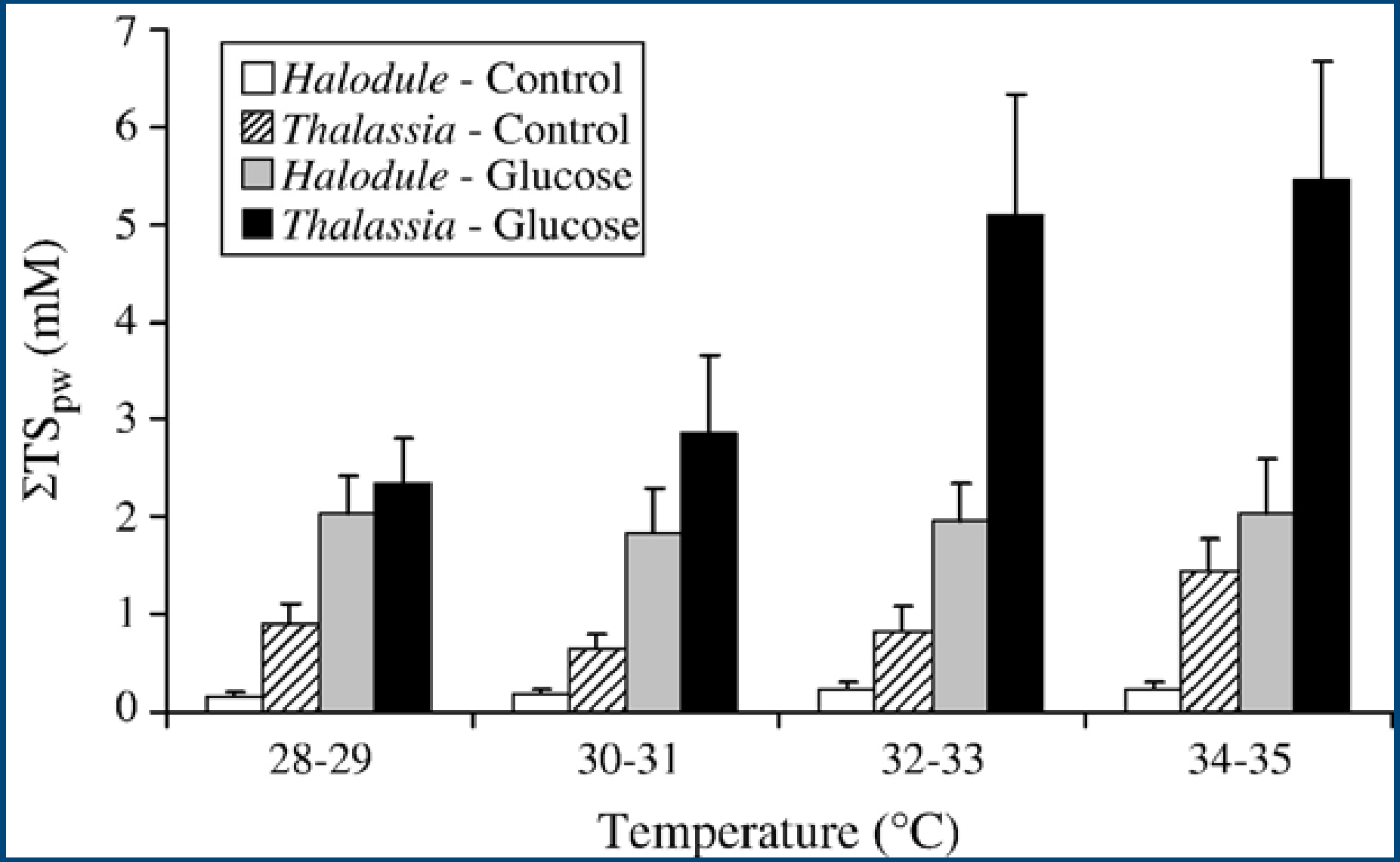
Porewater Sulfide Profiles Spring/Summer





Koch et al. 2007

Temperature and Glucose Effects Porewater Sulfides



Koch et al. 2007

Cascade of Stressors in Florida Bay Western Basins

- High Nutrients (P)
  - GOM Influence

Plant

- High Plant Biomass-July/August
  - High Plant Productivity Rates
  - High Plant Respiratory O_2 Demand

Sediment

- High Decomposition Rates->DOC
  - High sediment O_2 demand
  - Increase sulfate reduction rate

- Hypersalinity/High Temperatures-July/August
  - Accelerate Plant Respiratory O_2 Demand

- Hypersalinity/ High Temperature
  - Accelerate sediment O_2 demand
  - Accelerate sulfate reduction rates

- Shorter Day length-Sept/October
- Lower Temperatures
  - Shift in P:R ratios
  - Increased epiphyte load

- Sulfide oxidation consumes O_2

- Shoot density decline
  - Release >DOC

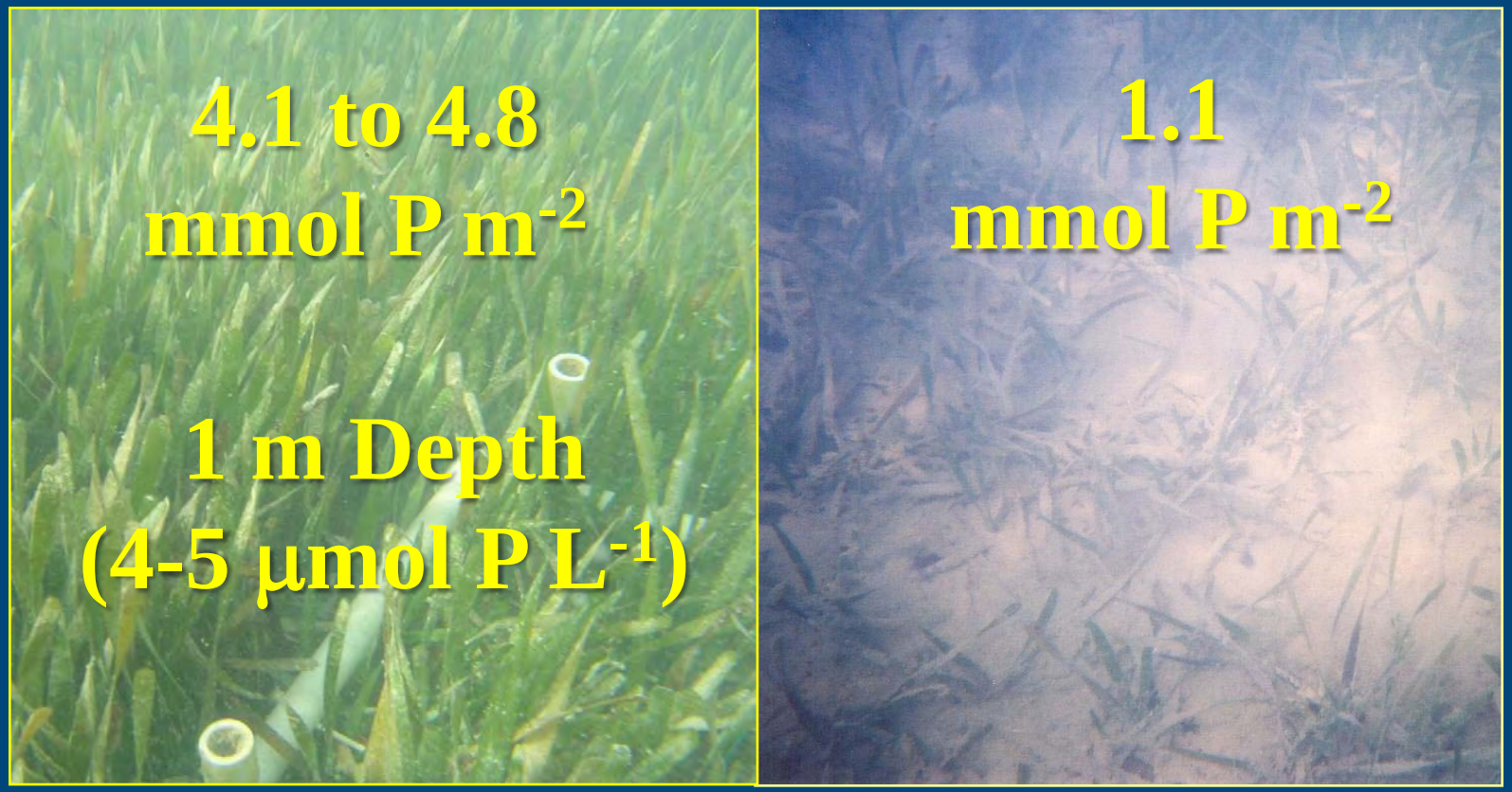
- Accelerate sulfate reduction rates
- Reduced O_2 rhizosphere

- Nighttime Watercolumn/Plant Hypoxia
- Seagrass Asphyxiation "Die-off" Event

Koch et al. 2007

Large Scale Seagrass Mortality Events
Nutrient Pulses to Water Column Florida Bay

Western/Central Bay | **Eastern Bay**



- **Pulsed Event (4,000 ha major die-off ~6,000 kg P)**

Current Working Hypotheses FL Bay Seagrass Die-Off Research (Nov. 2009)

Hypothesis #1: Seagrass die-off in Florida Bay during the fall and winter is a result of plants down-regulating due to shorter day lengths and a P:R imbalance that results in meristimatic hypoxia/anoxia and potential sulfide toxicity if overlying waters are also hypoxic.

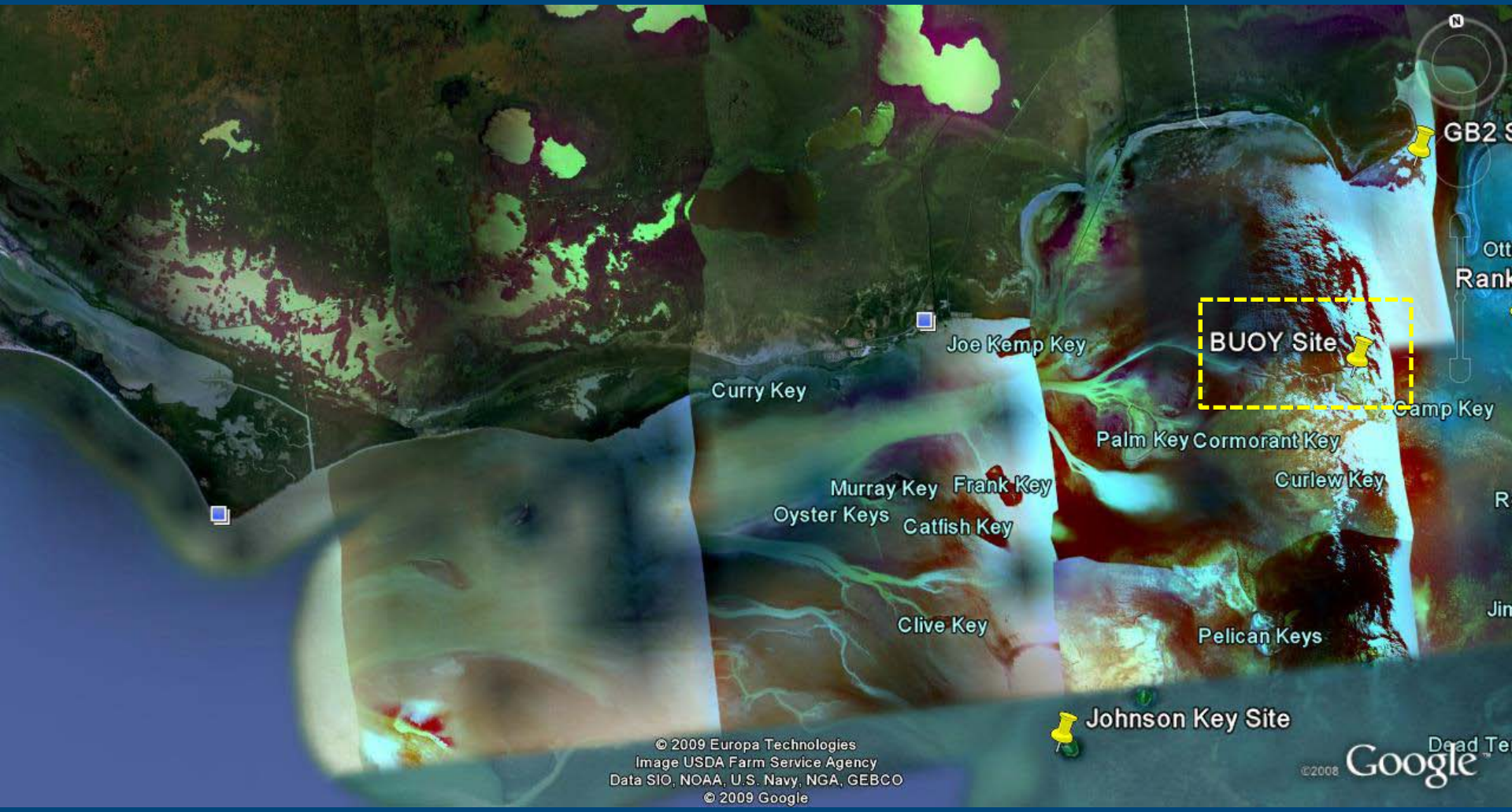
Hypothesis #2: This hypoxia in the overlying water is exacerbated by hypersaline and high temperature conditions.

Hypothesis #3: Water column hypoxia is a factor in controlling *Thalassia* dominance, over *Halodule* and *Syringodium*, in areas with repetitive die-off conditions in the Bay.

Hypothesis #4: Resilience of seagrass species is a function of genetic diversity, morphology, and/or biochemical production of heat shock proteins or metabolites that aid in hypoxic stress.

Project Initiation: July, 2009 during Major Seagrass Die-Off Western Bay Buoy Key Region

FAU Western Bay Stressor Research Sites (Garfield, Buoy, and Johnson)

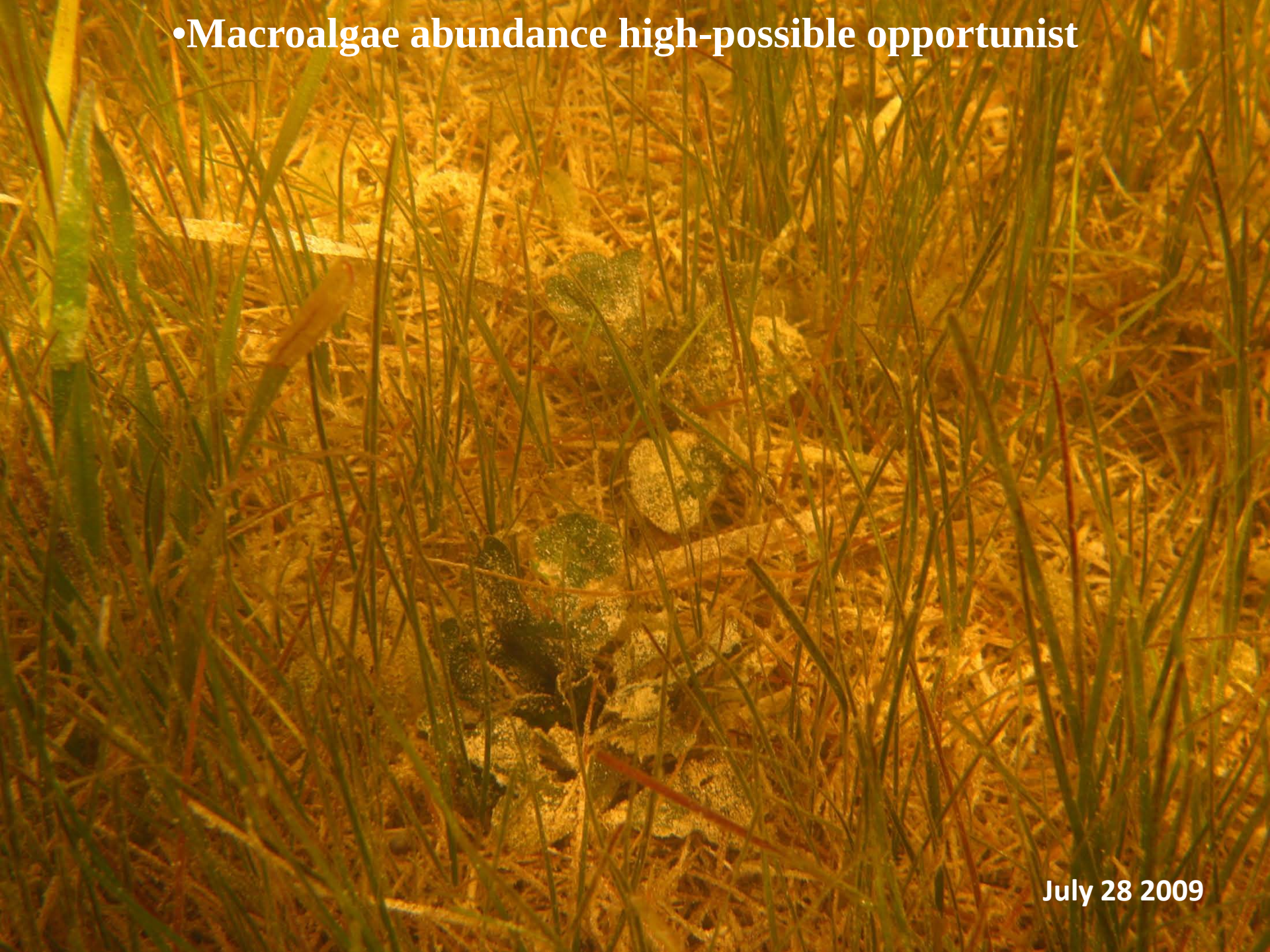


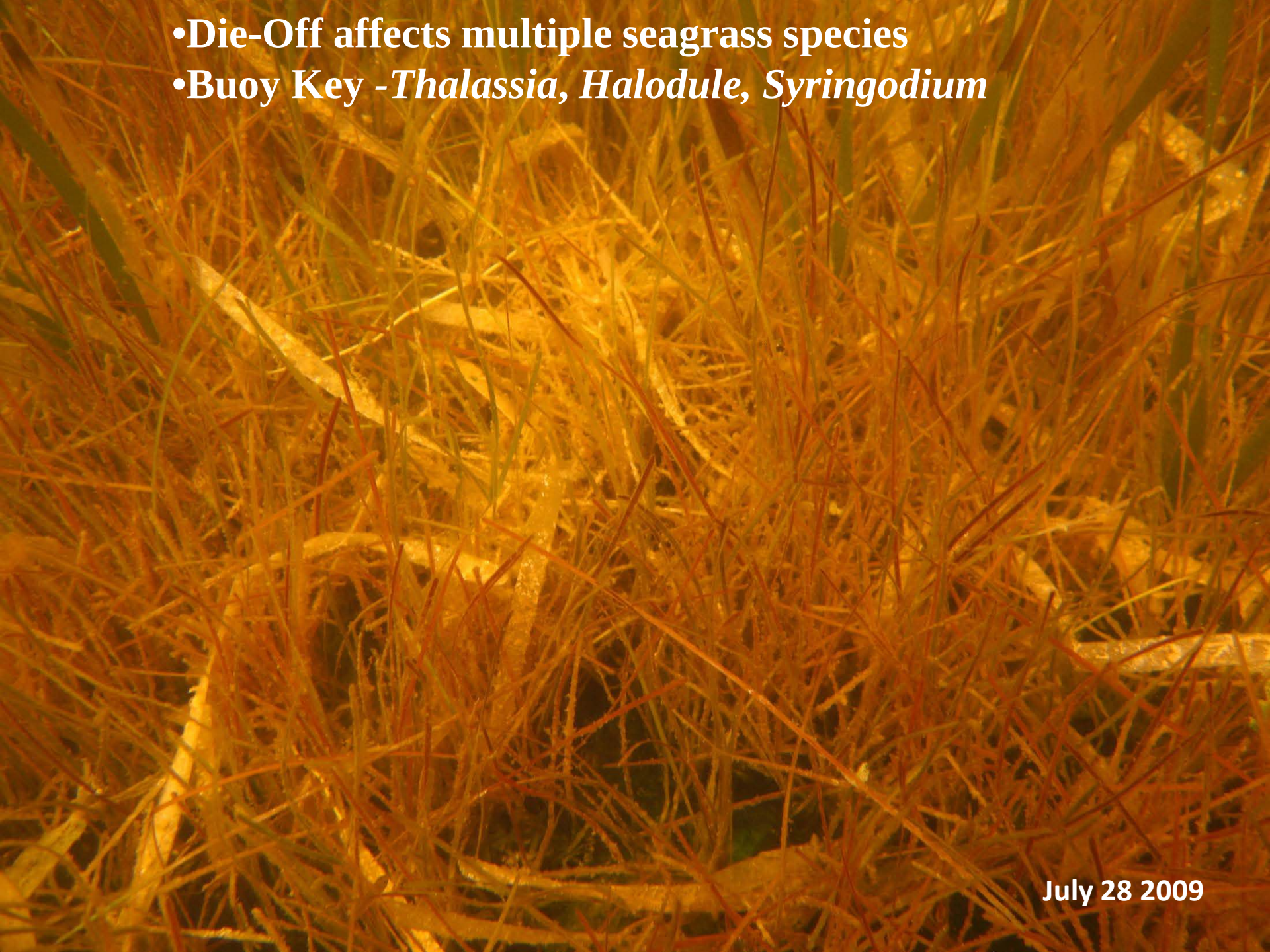
•Patchy Die-Off Pattern
•Floating blades-Halodule
July 28 2009

•Brown tips Thalassia
•*Batophora* macroalgae
July 28 2009

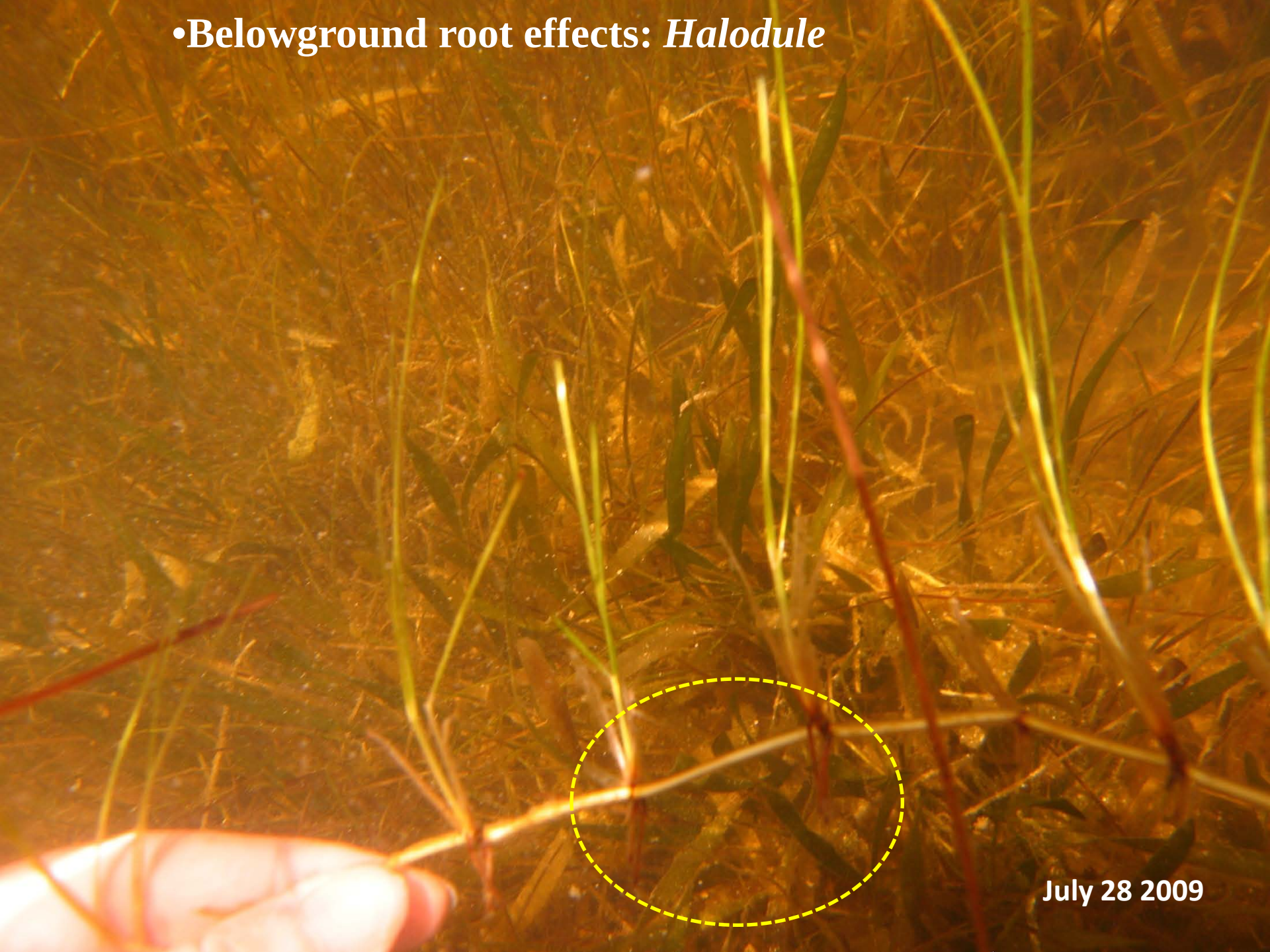
•Leaf wrack *Thalassia* supporting filamentous algae

•Filamentous algae on sediment surface


•Macroalgae abundance high-possible opportunist
July 28 2009


•Die-Off affects multiple seagrass species
•Buoy Key -*Thalassia, Halodule, Syringodium*
July 28 2009

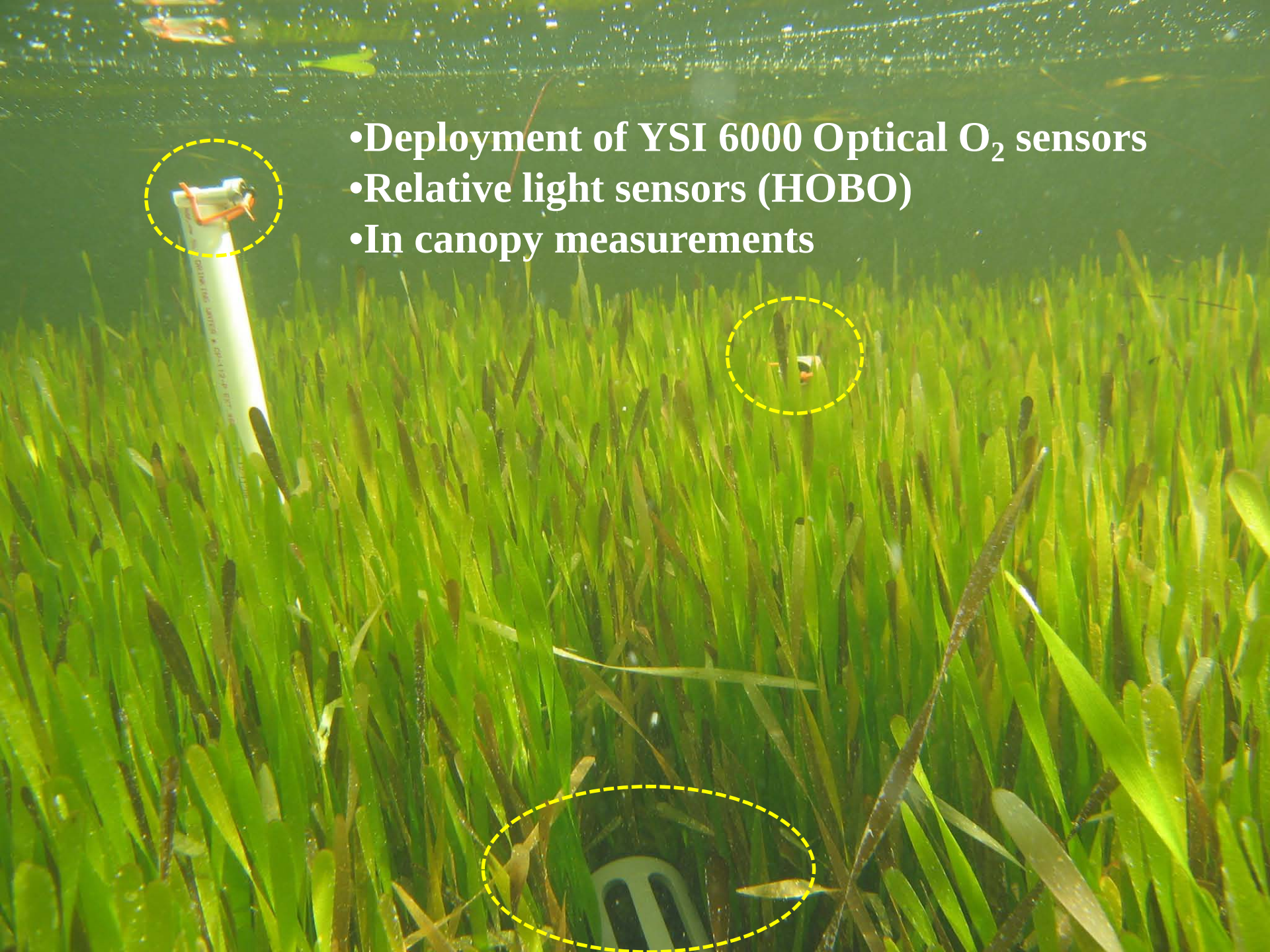
•**Belowground root effects: *Halodule***

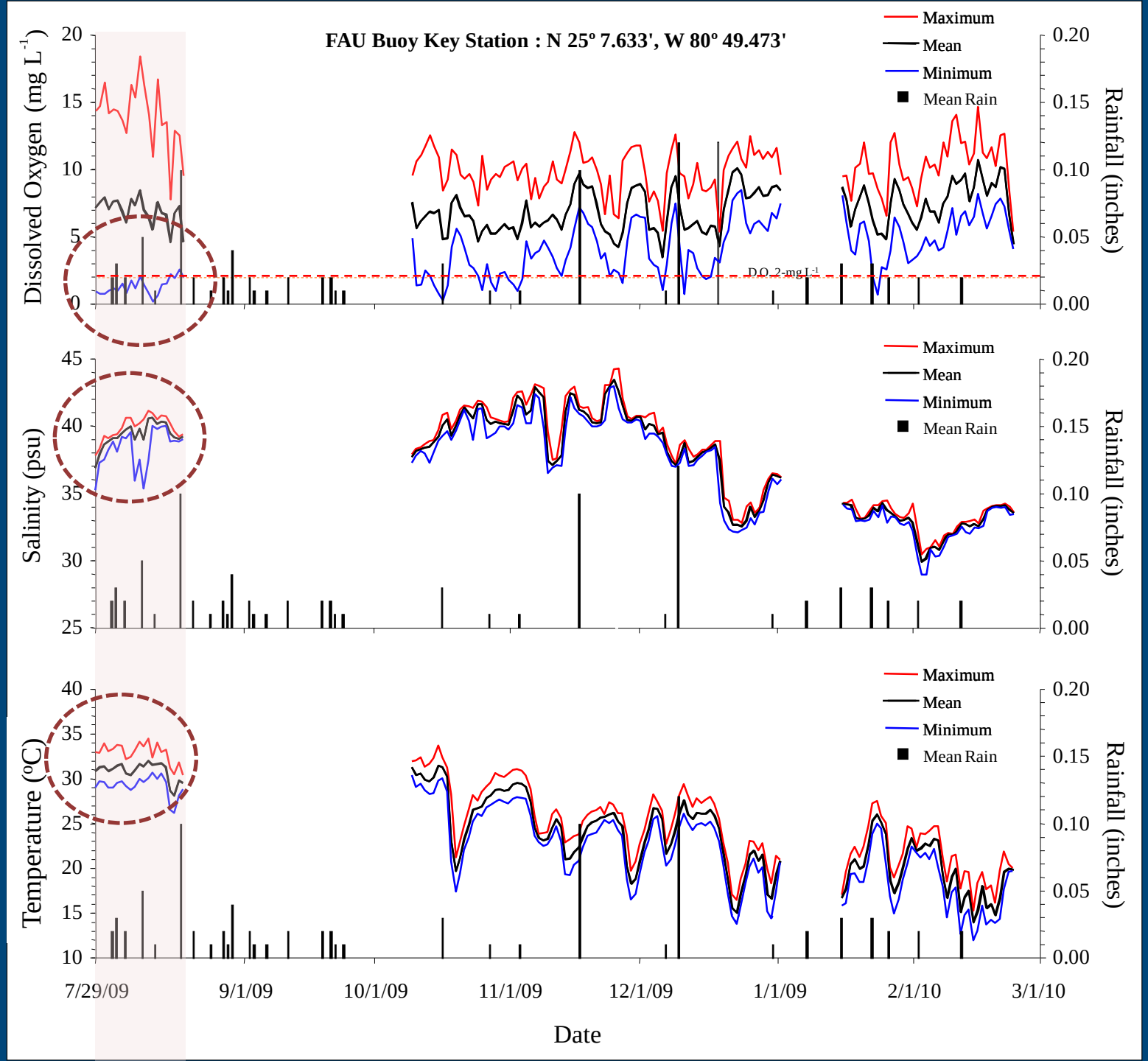


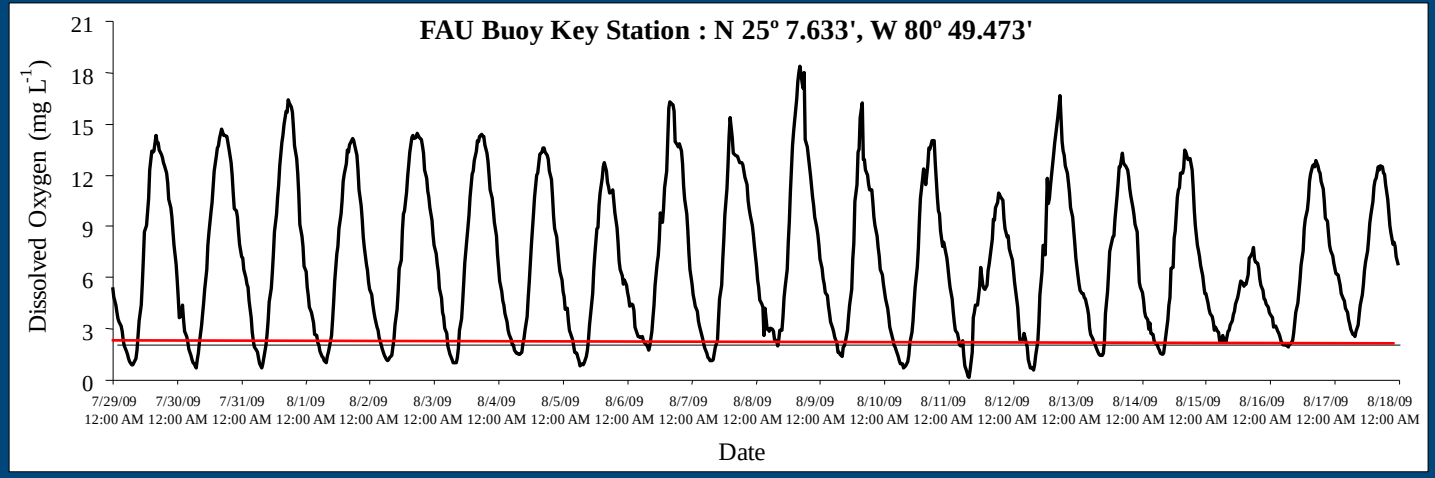
•Belowground root effects: *Syringodium*
•Flaccid/brittle rhizomes
July 28 2009

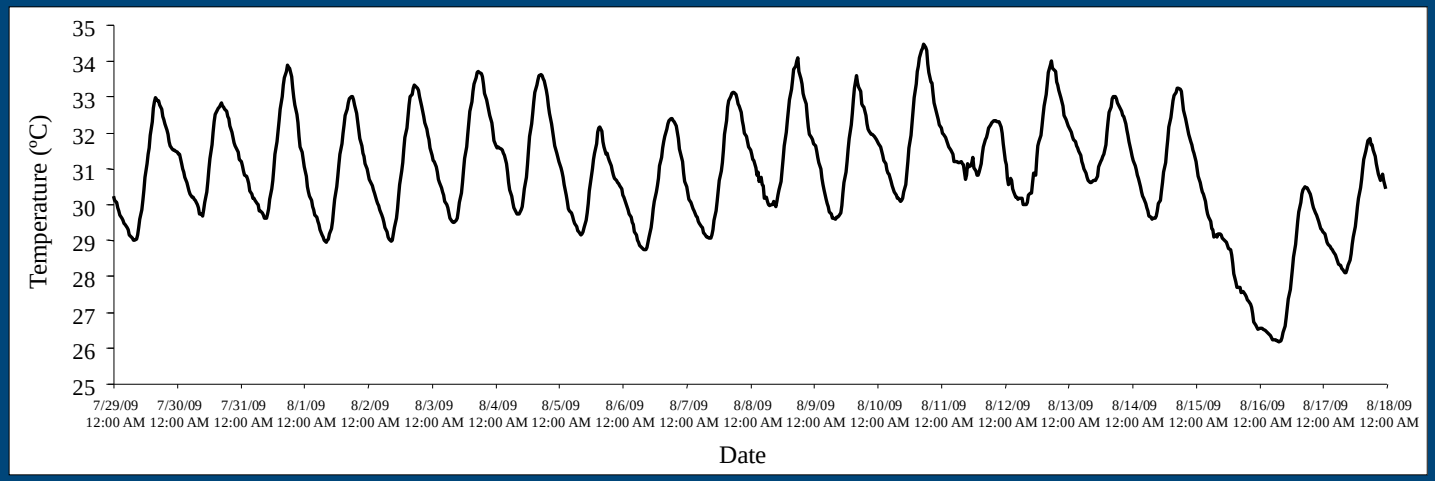
•Plants detaching from sediment: *Halodule*
July 28 2009

•**Plants detaching from sediment: *Halodule***


•Deployment of YSI 6000 Optical O_2 sensors
•Relative light sensors (HOBO)
•In canopy measurements


FAU Buoy Key Station : N 25º 7.633', W 80º 49.473'
Maximum
Mean
Minimum
Mean Rain
Dissolved Oxygen (mg L-1)
Rainfall (inches)
D.O. 2-mg L-1
Salinity (psu)
Temperature (ºC)
7/29/09
9/1/09
10/1/09
11/1/09
12/1/09
1/1/09
2/1/10
3/1/10
Date


FAU Buoy Key Station : N 25º 7.633', W 80º 49.473'
Dissolved Oxygen (mg L-1)
21
18
15
12
9
6
3
0
7/29/09 12:00 AM
7/30/09 12:00 AM
7/31/09 12:00 AM
8/1/09 12:00 AM
8/2/09 12:00 AM
8/3/09 12:00 AM
8/4/09 12:00 AM
8/5/09 12:00 AM
8/6/09 12:00 AM
8/7/09 12:00 AM
8/8/09 12:00 AM
8/9/09 12:00 AM
8/10/09 12:00 AM
8/11/09 12:00 AM
8/12/09 12:00 AM
8/13/09 12:00 AM
8/14/09 12:00 AM
8/15/09 12:00 AM
8/16/09 12:00 AM
8/17/09 12:00 AM
8/18/09 12:00 AM
Date


Temperature (ºC)
35
34
33
32
31
30
29
28
27
26
25
7/29/09 12:00 AM
7/30/09 12:00 AM
7/31/09 12:00 AM
8/1/09 12:00 AM
8/2/09 12:00 AM
8/3/09 12:00 AM
8/4/09 12:00 AM
8/5/09 12:00 AM
8/6/09 12:00 AM
8/7/09 12:00 AM
8/8/09 12:00 AM
8/9/09 12:00 AM
8/10/09 12:00 AM
8/11/09 12:00 AM
8/12/09 12:00 AM
8/13/09 12:00 AM
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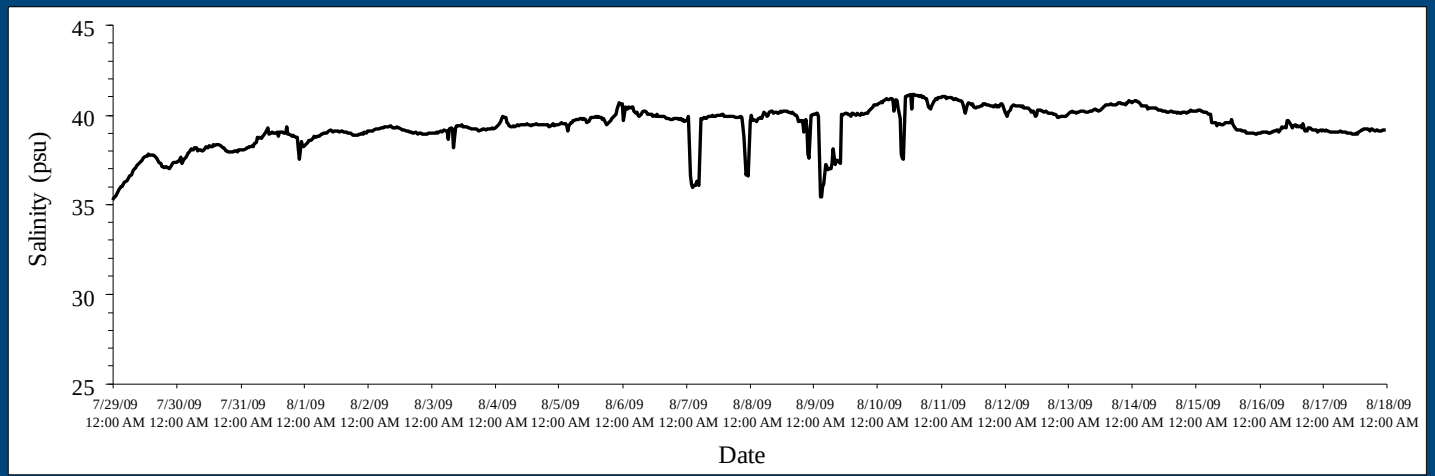
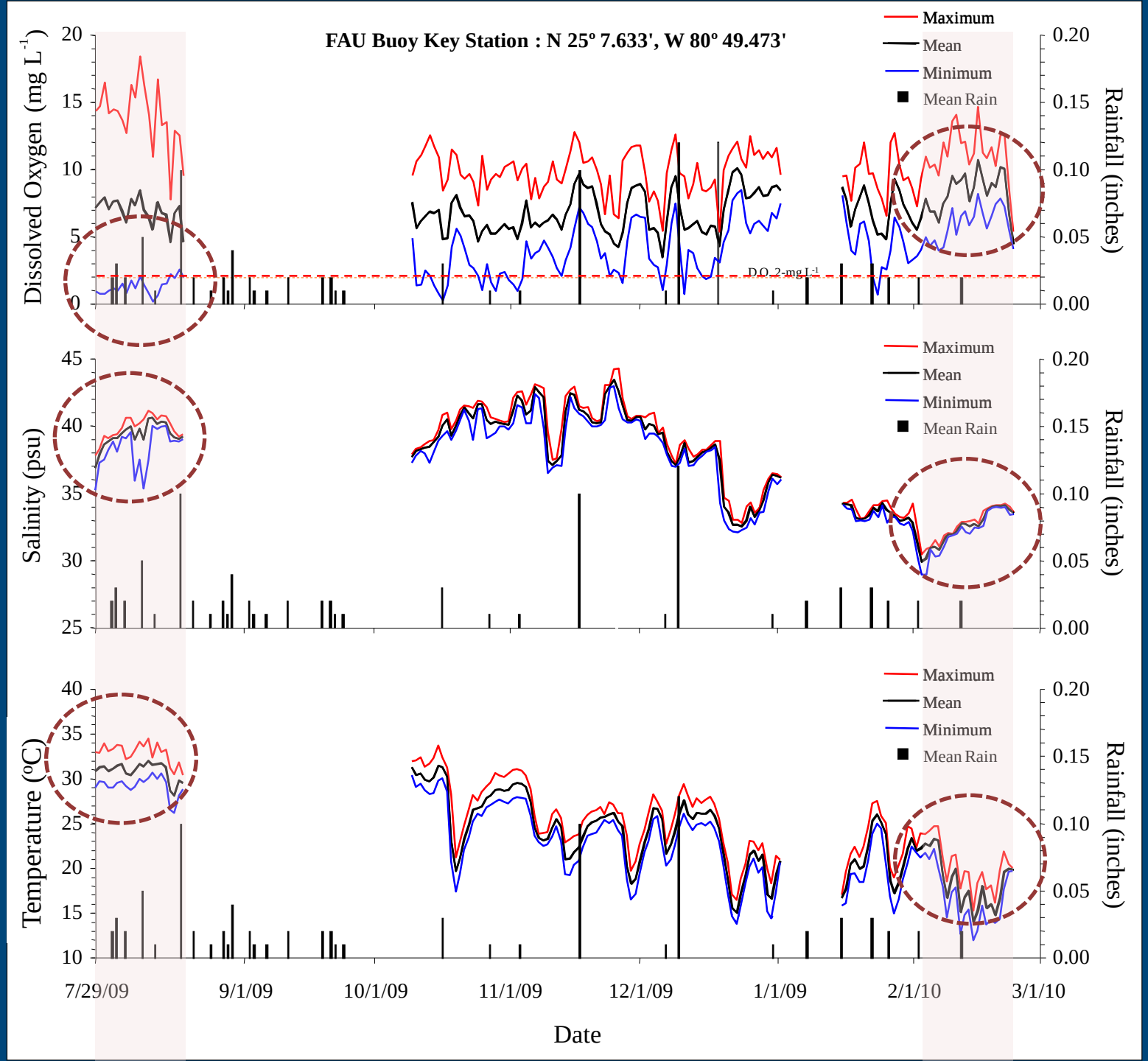
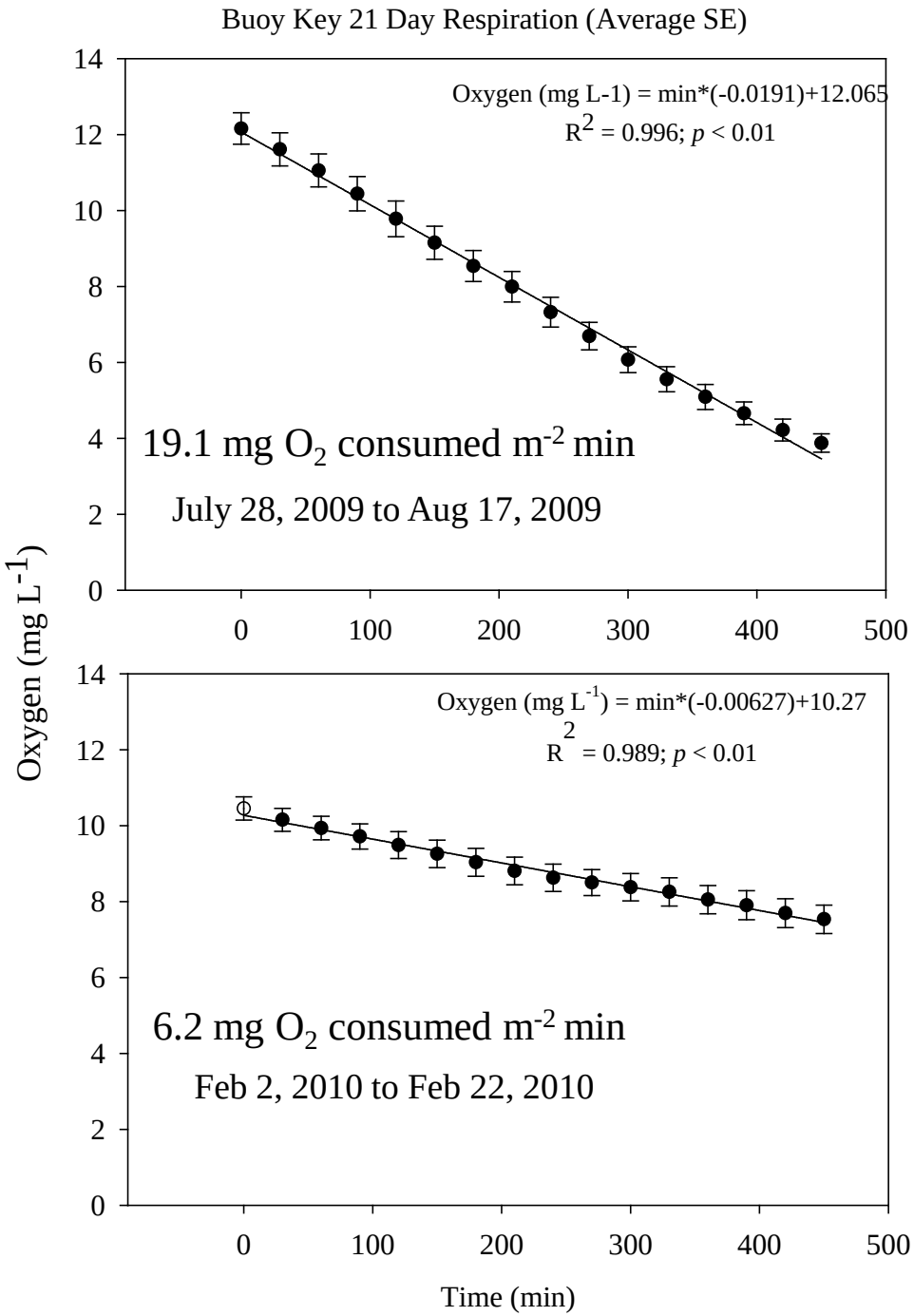
8/17/09 12:00 AM
8/18/09 12:00 AM
Date

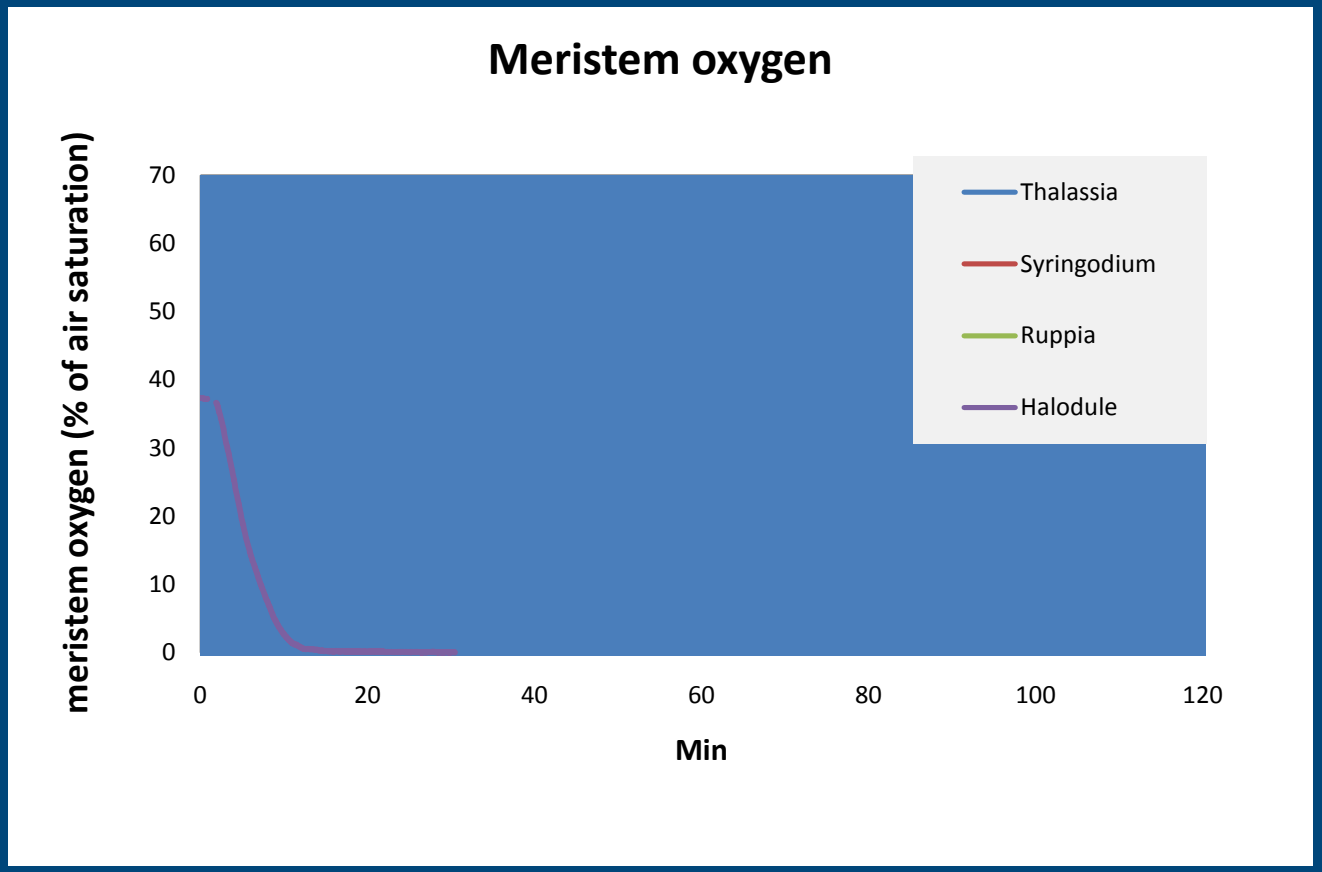

Salinity (psu)
45
40
35
30
25
7/29/09 12:00 AM
7/30/09 12:00 AM
7/31/09 12:00 AM
8/1/09 12:00 AM
8/2/09 12:00 AM
8/3/09 12:00 AM
8/4/09 12:00 AM
8/5/09 12:00 AM
8/6/09 12:00 AM
8/7/09 12:00 AM
8/8/09 12:00 AM
8/9/09 12:00 AM
8/10/09 12:00 AM
8/11/09 12:00 AM
8/12/09 12:00 AM
8/13/09 12:00 AM
8/14/09 12:00 AM
8/15/09 12:00 AM
8/16/09 12:00 AM
8/17/09 12:00 AM
8/18/09 12:00 AM
Date


FAU Buoy Key Station : N 25º 7.633', W 80º 49.473'
Maximum
Mean
Minimum
Mean Rain
Dissolved Oxygen (mg L-1)
Rainfall (inches)
D.O. 2-mg L-1
Salinity (psu)
Temperature (ºC)
7/29/09
9/1/09
10/1/09
11/1/09
12/1/09
1/1/09
2/1/10
3/1/10
Date


Buoy Key 21 Day Respiration (Average SE)
Oxygen (mg L-1) = min*(-0.0191)+12.065
R2 = 0.996; p < 0.01
19.1 mg O2 consumed m-2 min
July 28, 2009 to Aug 17, 2009
Oxygen (mg L-1) = min*(-0.00627)+10.27
R2 = 0.989; p < 0.01
6.2 mg O2 consumed m-2 min
Feb 2, 2010 to Feb 22, 2010
Oxygen (mg L-1)
Time (min)
0
2
4
6
8
10
12
14
0
100
200
300
400
500

Oxygen Concentrations (mg/L) at 100% O_2 Saturation as Function Salinity and Temperature

Temperature (°C)	Salinity (psu)						
	25	**30**	**35**	**40**	**45**	**50**	**55**
10	9.62	9.32	9.02	8.74	8.47	8.20	7.94
15	8.65	8.39	8.14	7.89	7.65	7.42	7.20
20	7.85	7.62	7.40	7.18	6.97	6.77	6.57
25	7.17	6.97	6.77	6.58	6.40	6.22	6.04
30	6.59	6.41	6.24	6.07	5.90	5.74	5.59
35	6.08	5.92	5.77	5.62	5.47	5.33	5.19
40	5.64	5.49	5.35	5.22	5.08	4.95	4.83



minutes until 95% anoxic in meristem:

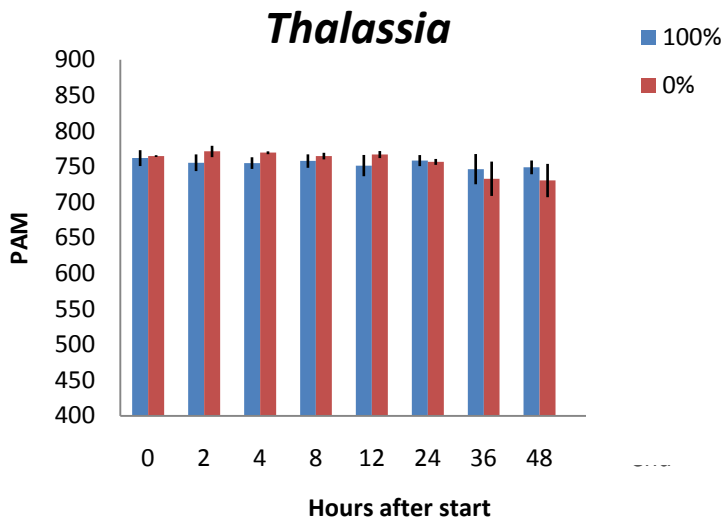
Species	Minutes
Thalassia	109 ± 47
Syringodium	47 ± 10
Ruppia	24 ± 9.5
Halodule	11 ± 1.5

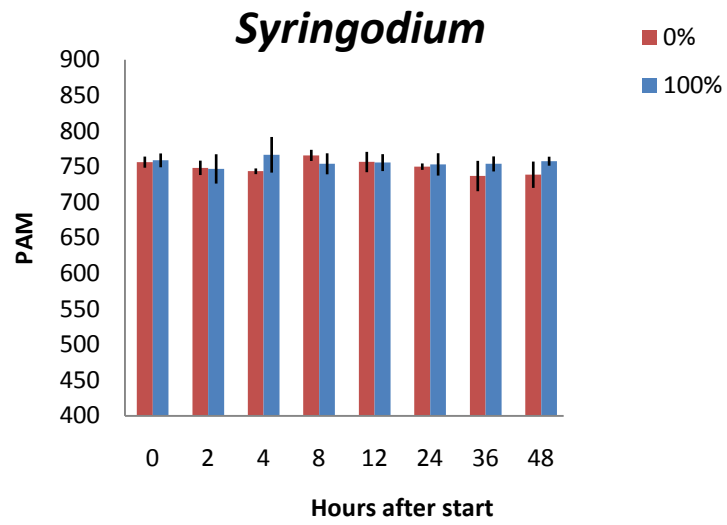
Mean SD, n=3

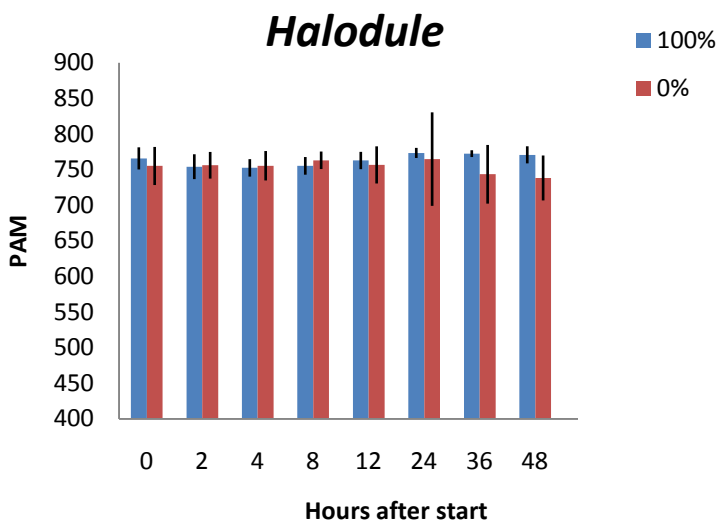
Raun, Borum, Koch
(In prep. 03/2010)

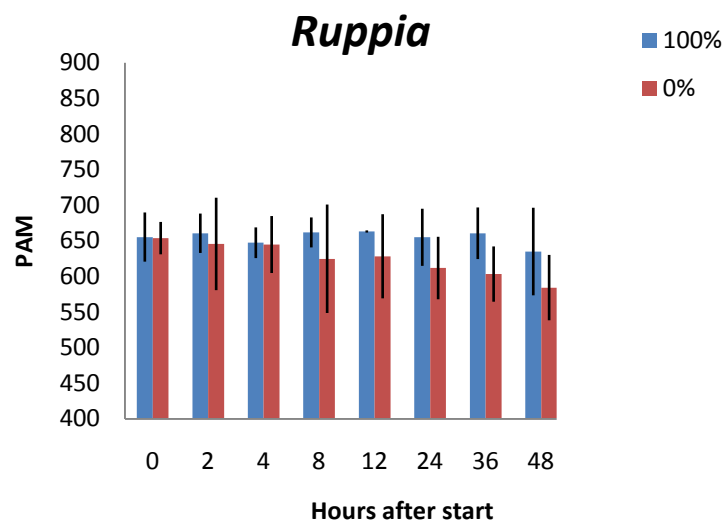
Raun, Borum, Koch
(In prep. 03/2010)

PAM









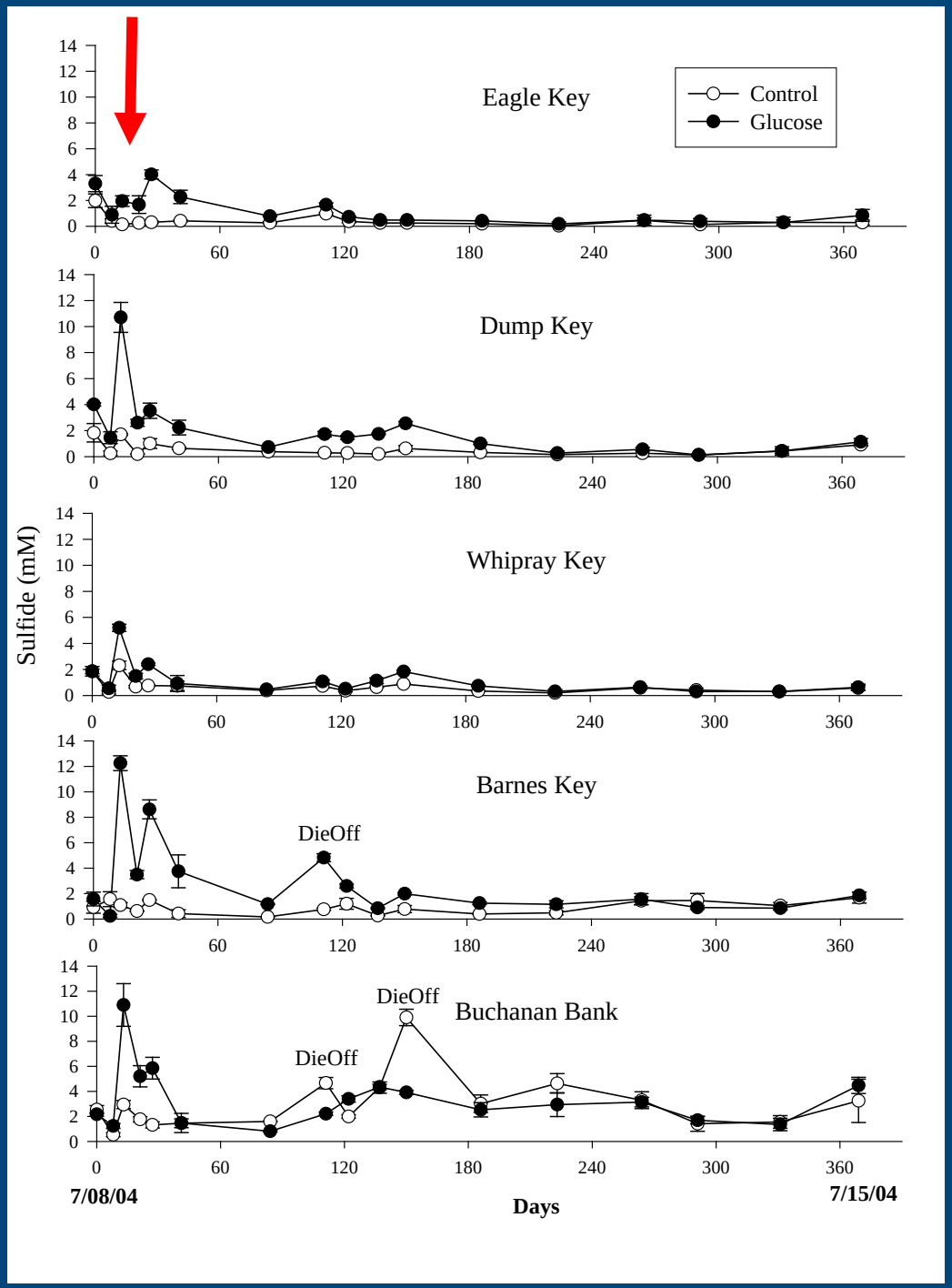
Seagrass Research Needs Florida Bay

- Mechanistic Understanding of seagrass die-off
- Oxygen dynamics and drivers at canopy and overlying water
- Resilience mechanisms to hypoxia
- Tipping points seagrass ecosystem to high temperature

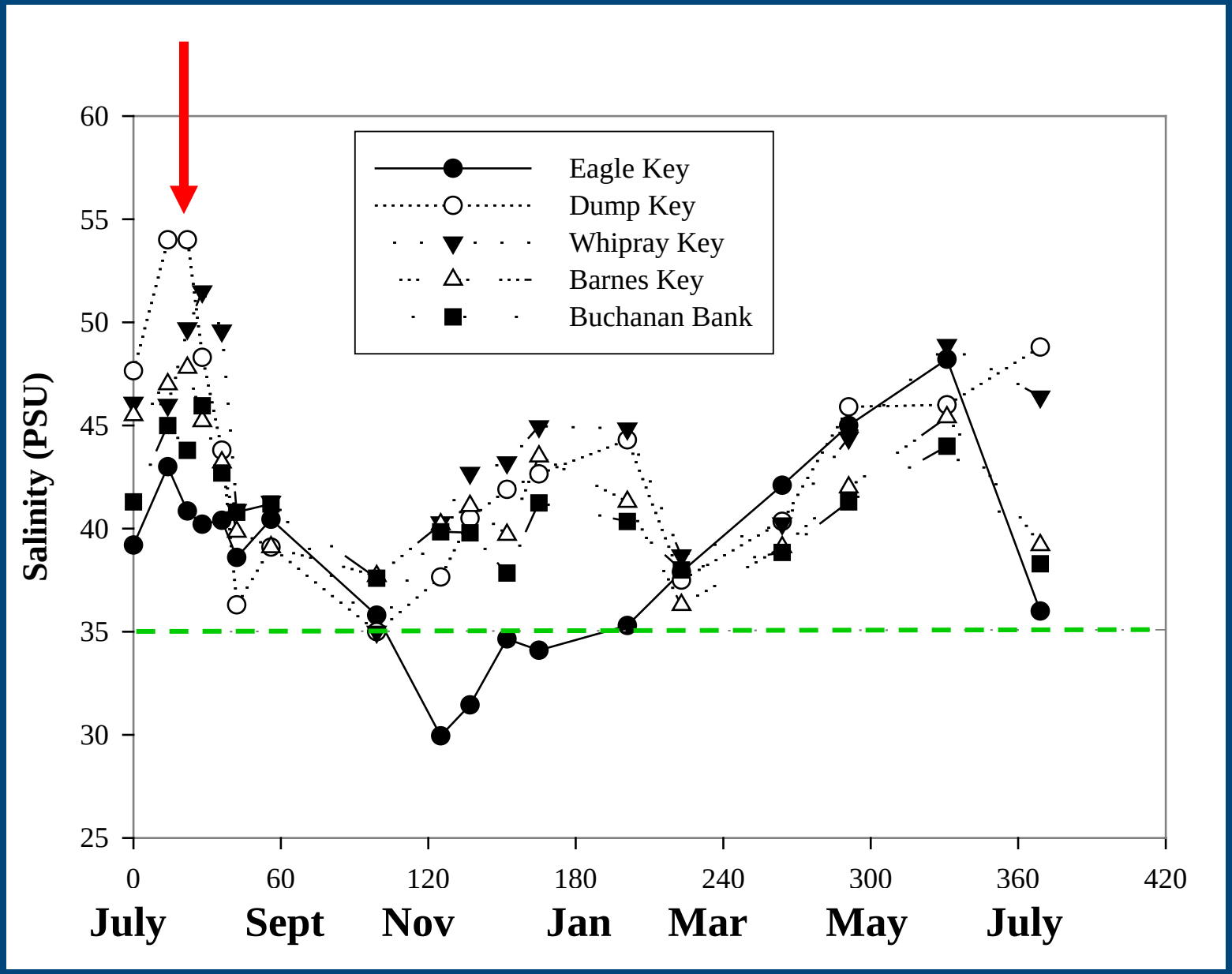
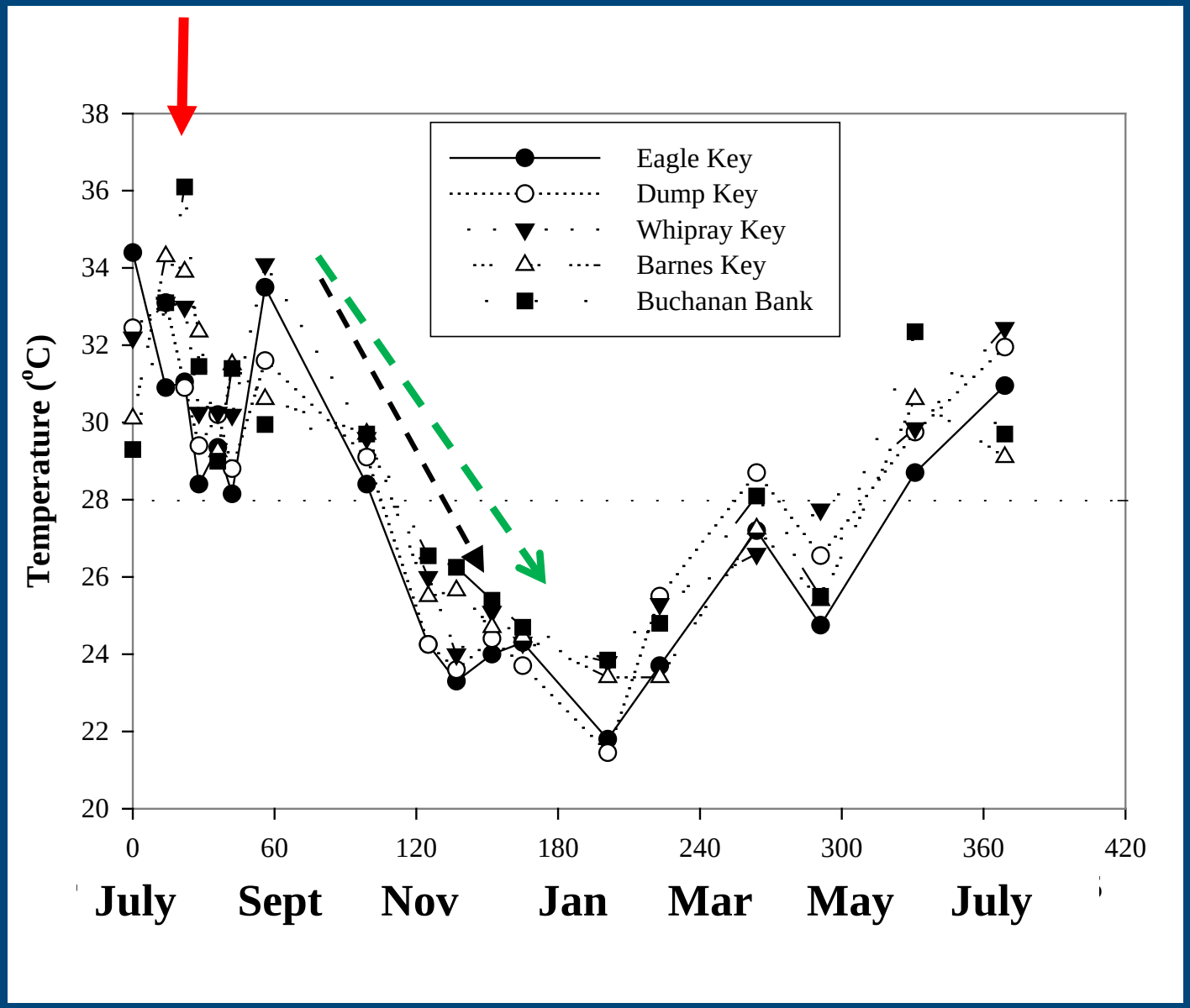
- Linkages between water column and benthic dynamics
- Nutrient transformations and fate
- Biogeochemical processes across nutrient gradient

- Recruitment potential for seagrass in the bay & ecotone
- Needs for restoration-now or in future? Methodologies?

- Rates of seagrass bank accretion vs sea level rise


Eagle Key
Control
Glucose
Dump Key
Whipray Key
Barnes Key
DieOff
Buchanan Bank
DieOff
DieOff
Sulfide (mM)
Days
7/08/04
7/15/04

Salinity June 2004-July 2005



Temperatures June 2004 – July 2005