Relationship of Seagrass and Physical Trends in Southern Biscayne Bay and Northeastern Florida Bay and the Role of Density in *Thalassia testudinum* Responses to Stressors

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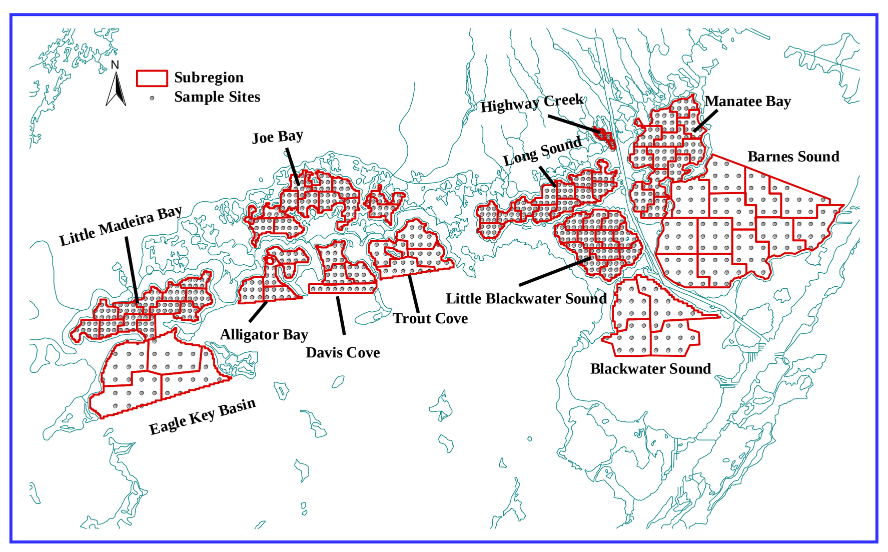
Introduction

Water availability and delivery to the Taylor River Slough/C-111 basin effects the southern Biscayne Bay and northeastern Florida Bay ecotone regions and estuarine habitat . This watershed and the downstream estuarine basins have been the focus of regional restoration efforts and water management initiatives. Restoration efforts of the Comprehensive Everglades Restoration Program (CERP), and water management initiatives, such as the Minimum Flows and Levels (MFLs) have identified the submerged aquatic vegetation (SAV) community of this region as a key measure of gauging the success of these programs. In June 1993 Federal and State water managers began to increase the amount of fresh water delivered to the Taylor River Slough. A requirement of the program was assessment of the effects of the additional water on downstream SAV communities. In response to this the South Florida Water Management District (SFWMD) contracted with the Miami-Dade County Department of Environmental Resources Management (DERM) to perform water quality and SAV monitoring in the receiving northeastern embayments of Florida Bay.

Methods

In October of 1995 sampling methodologies were revised to include stratified random assessments, based on the EPA "EMAP" sampling design protocols. This methodology was similar to that being used by other SAV monitoring efforts within Florida Bay (Fourqurean et al., 2002). Monitoring was expanded, in October 1997, east of US 1 to include the two southern most basins of Biscayne Bay, Manatee Bay and Barnes Sound, which directly receive discharges from the C-111.



Study Area

The study area includes sampling sites within 12 basins. 96 sites are randomly selected for each sampling event. The frequency has changed over the program's history, monthly sampling from 1995-1999, bi-monthly sampling 2000-2006, and quarterly 2007-present.

The seagrass community in this region is dominated by three species *Thalassia testudinum*, *Halodule wrightii*, and *Ruppia maritima*. Data collected to date has shown that each species has a characteristic distribution associated with water depth, proximity to freshwater inputs, and extent of exchange with open bay waters.

SAV Metrics

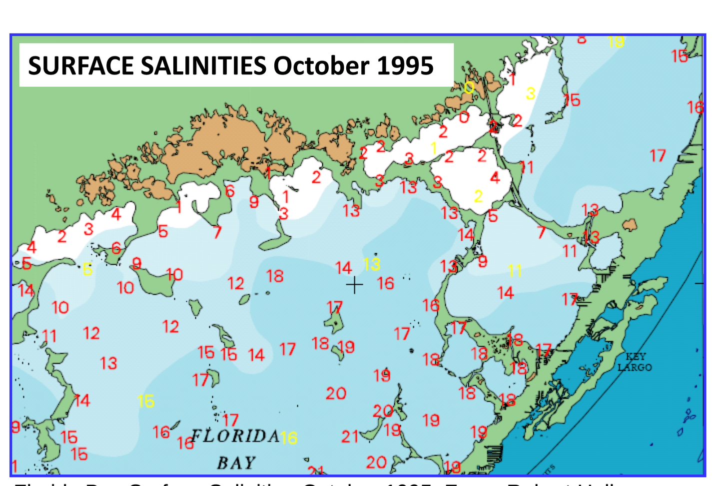
- SAV is sampled with a 0.25m² grid.
- Visual percent cover is estimated using the Braun-Blanquet scale (BBCA) for both seagrass and macro algae.
- Seagrass shoot counts are performed in a 0.0625m² sub-grid to calculate density.

Physical Parameters

- A multi parameter sonde, Hydrolab or YSI, are used to collect physical measurements: Temperature, Dissolved Oxygen (DO), pH, Oxidation Reduction Potential (ORP or Redox)

Program History

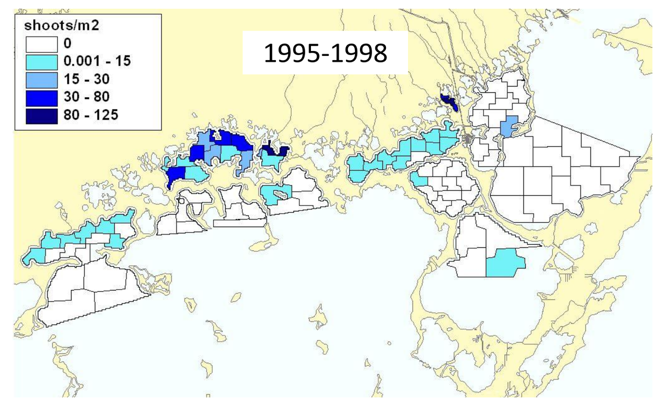
- The early part of this program's data history is strongly characterized by what was considered a very wet spring and summer in 1995. With low to moderate salinity conditions persisting through 1998.
- Salinity has continually increased during this study period, with a changes occurring to the seagrass community,
  - Loss of *Ruppia* in the primary receiving basins
  - Long term gradual declines and pronounced losses of *Thalassia*
- A known associated dynamic appears to be active in this region – with increases in salinity and losses of seagrass, dissolved oxygen decreases have also been documented. In addition Oxidation-Reduction Potential has decreased which would be an indicator of increased hydrogen sulfide consumption of oxygen, something that has been documented in other studies (Carlson et. Al 1994).



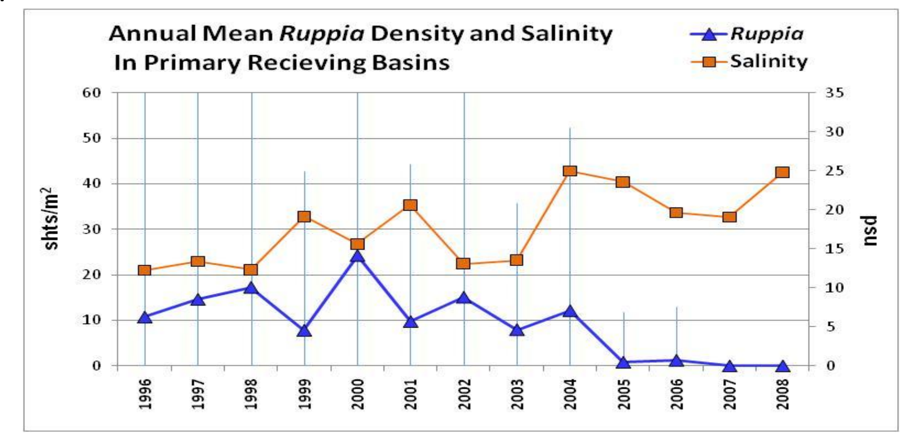
Florida Bay Surface Salinities-October 1995. From: Robert Halley, Dewitt Smith, and Mark Hansen USGS & ENP OPEN-FILE REPORT #95-634 and #98-142 FLORIDA BAY SALINITY MAP - 6A

Ruppia maritima

This salt tolerant freshwater grass, is considered an important indicator species for restoration and regulatory requirements (i.e., Florida Bay and Florida Keys Feasibility Study (FBFKFS); Minimum Flows and Levels (MFL) criteria for Florida Bay). Within the study this grass is found in the primary receiving basins (Joe Bay, Highway Creek, Little Madeira Bay, Long Sound).



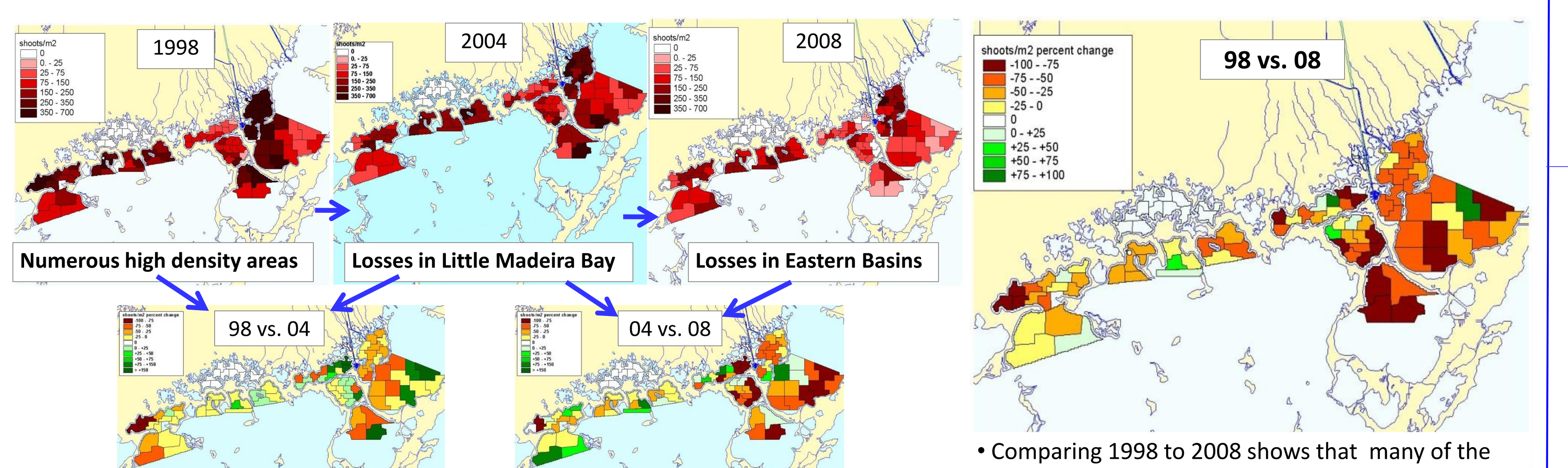
- During the period of lower salinity that persisted from 1995-1998, *Ruppia* had moderate to high densities in Joe Bay and Highway Creek.
- Lower densities were maintained in Little Madeira and Long Sound.
- Sporadic presence extended the range into Trout Cove as well as the more marine basins Manatee Bay and Blackwater Sound



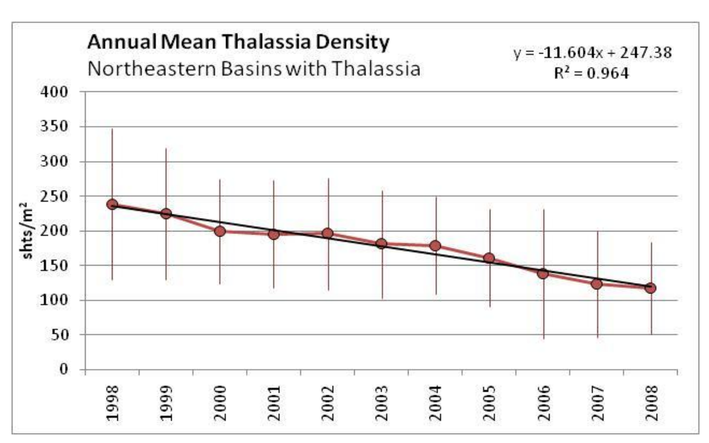
- In the primary receiving basins, *Ruppia* shows variable responses to annual mean salinity, but persisted near or above 10shoots/ m²
- Following the elevated salinity of 2004-2005 , *Ruppia* had not been recorded in the study area through 2009

Thalassia testudinum

The dominant macrophyte in the region, *Thalasssia* is present in all but two basins within the study area (Joe Bay and Highway Creek). Long term declines documented during this study occur during a period of increasing salinity and accompanied with lower dissolved oxygen.



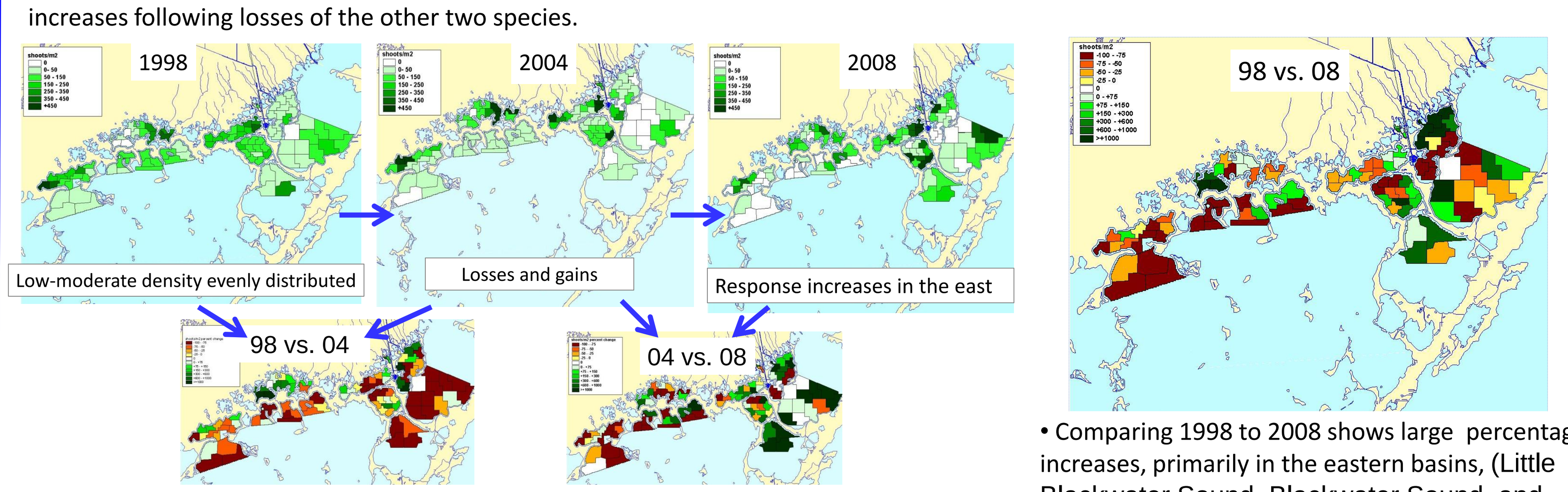
- Dense *Thalassia* in western Little Madeira Bay under goes losses of 75-100%
- Salinity begins to trend up and some of the Eastern basins (Long Sound, Little Blackwater Sound) show some areas gains
- *Thalassia* is lost in the Eastern basins (Long Sound, Little Blackwater Sound, Blackwater Sound, and Manatee Bay).
- Multiple conditions are associated with this loss: 2004-2005 high salinity, a series of hurricanes – the most impacting was Katrina, and the subsequent prolonged algal bloom.
- Comparing 1998 to 2008 shows that many of the basins have had large areas with losses of fifty percent or more.



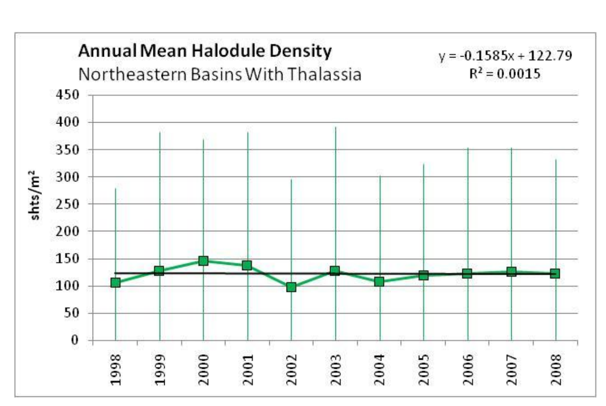
- Net long term decline in *Thalassia* shoot density for the study area during the period of record.
- While the long term trend is mostly linear, a number of areas have had periods of stability and cycles of increases within the 1998-2008 time frame.
- The extent of loss shown is influenced greatly by event losses in specific areas
  - 1999 Little Madeira Bay
  - 2005 Eastern Basins
- Coinciding with the overall decline in *Thalassia* has been the increase in salinity, and decrease in DO and Redox

Halodule wrightii

This species of seagrass has a wide range of salinity tolerance and is known to be a rapid colonizer of areas that have undergone change. Both of these characteristics are evident in this program's period of record, *Halodule* has maintained the widest distribution and has responded with localized increases following losses of the other two species.

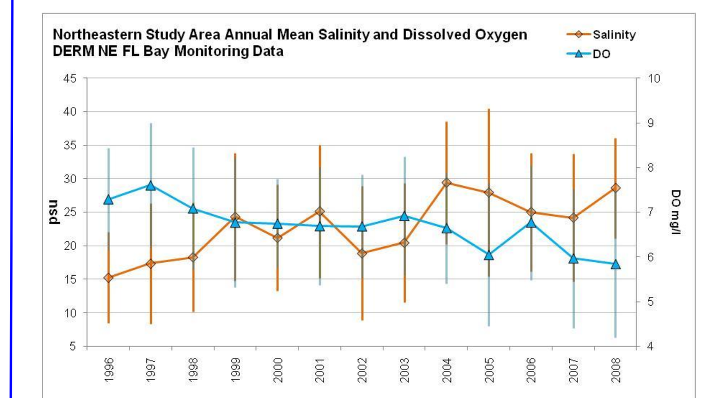


- Being mostly in low density small increases or decreases show as high percentage changes
- Notable increases in areas where *Thalassia* was losses following the culmination of events in t 2005
- Comparing 1998 to 2008 shows large percentage increases, primarily in the eastern basins, (Little Blackwater Sound, Blackwater Sound, and Manatee Bay).

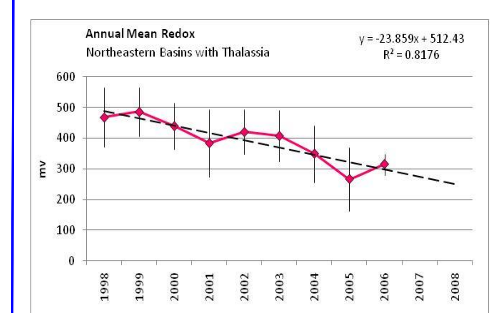


- Overall, mean *Halodule* shoot density for the study area has remained constant
- However, distributions have changed, from evenly distributed in a lower density, following the low salinity years, to concentrations of higher densities in areas of *Thalassia* and *Ruppia* losses.

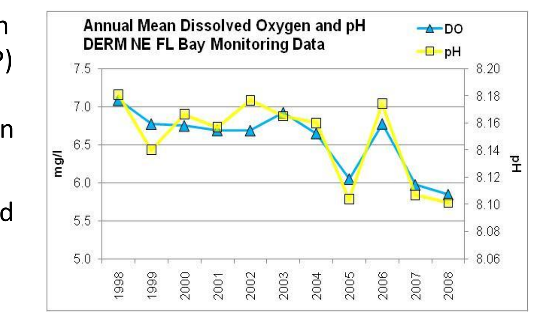
Physical Parameters Trends



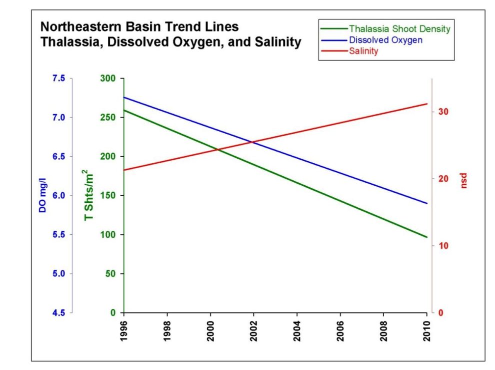
- Salinity has trended up since the program's inception in 1996
  - 2008 mean almost double that of 1996
  - 2004 & 2005 were peak years
  - 2008 distinctive year - high mean with low deviation
- Dissolved oxygen trended lower during this time period as well
  - 2008 annual mean almost 2mg/l lower than 1996



- Oxidation-Reduction Potential (Redox/ORP) can provide an indication of hydrogen sulfide activity
- The trend is expected with reduction in Thalassia and DO



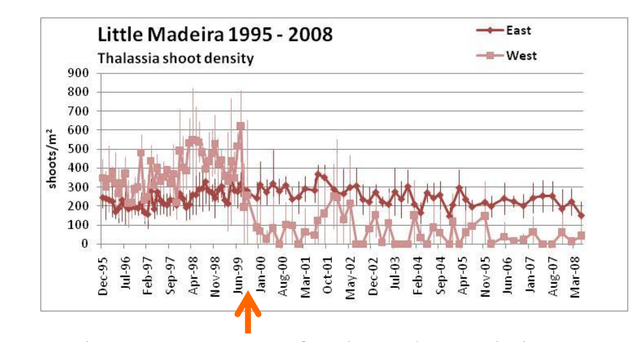
- Not a large swing in pH – but does track DO closely
- Increased CO2 accompanying lower DO???



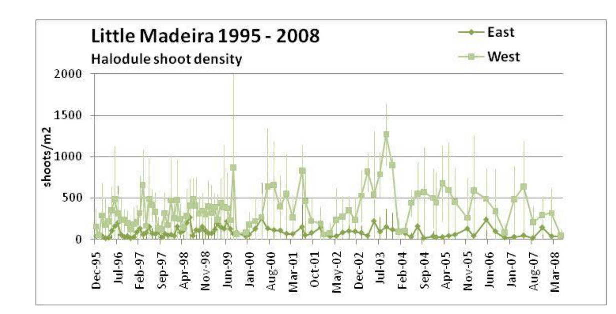
Potential feedback & dynamics with *Thalassia*

- Increased salinity :
  - Increases *Thalassia 's* metabolic demands for oxygen
- Less *Thalassia*:
  - Less O2 production
  - Lower redox: increased hydrogen sulfide consumption of oxygen
    - Further stressing & additional loss of *Thalassia*

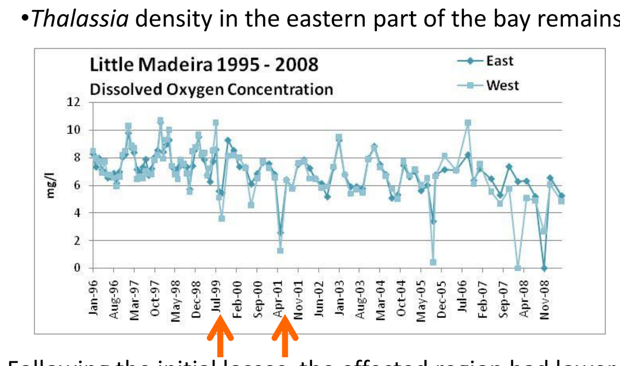
Little Maderia Bay - 1999 Western Region *Thalassia* Losses: Potential Example of Density Dependent Change



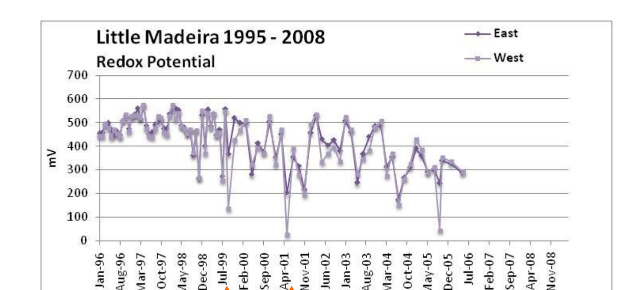
- In the western region of Little Madeira, *Thalassia* increases in density through 1998.
- Mid 1999 - many of the western stations have 0 *Thalassia*
- *Thalassia* density in the eastern part of the bay remains constant



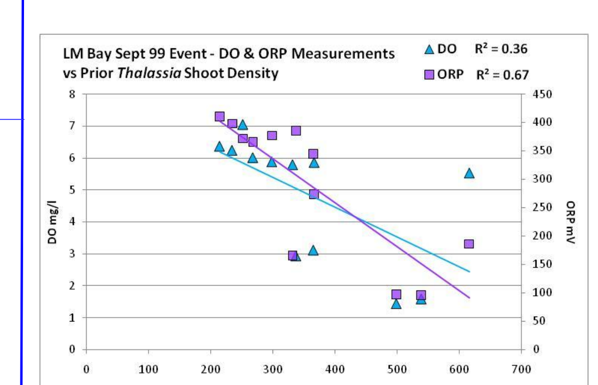
- *Halodule* increased following in the western areas following the loss of Thalassia



- Following the initial losses, the effected region had lower dissolved oxygen measurements for some of the samplings



- Lower Redox readings are likely an indication of increased hydrogen sulfide oxygen consumption.
- During the same samplings low dissolved oxygen was measured, redox potential was much lower in the areas experiencing loss of *Thalassia*



- The regressions are based on the first distinct low redox and DO measurements , September 1999, using these against the mean *Thalassia* shoot density of the prior three samplings
- This gives some indication that the severity of low Redox and DO has some relationship with the preexisting *Thalassia* density.
- In contrast the less dense eastern part of the bay , which did not experience a loss of Thalassia, also did not have the same extent of low DO or Redox

Summary

- This program initiated during a period of low salinity in the northeastern region of Florida Bay. There are some key features of that period that are worth noting:
  - ***Ruppia*** maintained a moderate presence in the primary receiving basins and ranged into the secondary basins
  - ***Thalassia*** was throughout the study area, with the except the primary receiving basins, in moderate to high densities
  - ***Halodule*** was evenly distributed in low density throughout the study are
  - **Dissolved oxygen** annual mean values were 7.0 – 7.5 mg/l
- During this program's history as salinity has trended up, *Ruppia* has been lost from the receiving basins
- Long term gradual declines and punctuated losses have occurred with *Thalassia*
  - The loss in western Little Madeira may be an example of density dependent reaction with DO and Redox dynamics
- Salinity has trended up and dissolved oxygen has trended down in this program's period of record