Modeling Analysis of Florida Bay's Seagrass Community Composition: The Importance of Sediment Characteristics, Water Quality, and Salinity

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Introduction

Florida Bay is a spatially heterogeneous, karstic estuary which receives freshwater inflows from the Everglades ecosystem. A numerical seagrass model was developed to understand the mechanisms controlling seagrass dynamics and the potential effects of water management. Although there are four bed-forming seagrass species found in Florida Bay, the majority of the bay is covered in beds formed by two species: *Thalassia testudinum* and *Halodule wrightii*. Currently, the model simulates these two species.

This model was used to determine salinity effects on seagrass community composition in support of the development of technical criteria for the Minimum Flows and Levels project for Florida Bay. Two calibration basins are presented here: Eagle Key Basin (eastern bay with shallow sediments, low nutrient concentrations, and Thalassia beds) and Whipray Basin (central/ western bay with deeper sediments, higher nutrient concentrations, and mixed seagrass beds).

Model Description

The model is a basin specific description of seagrass dynamics (fig 1) programmed in MATLAB and iterated on a 3hr time-step. Competition between the two seagrass species is implemented through density limitation and sharing of a finite nutrient pool.

Calibration of the model was achieved through least-squares minimization of the summed squared error of the biomass of both species.

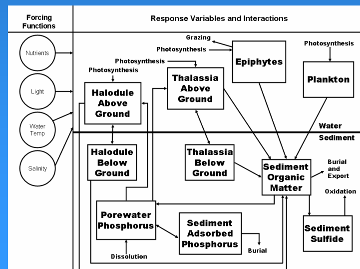


Figure 1: Diagram of the conceptual model underpinning the two-species Florida Bay seagrass model.

Calibration

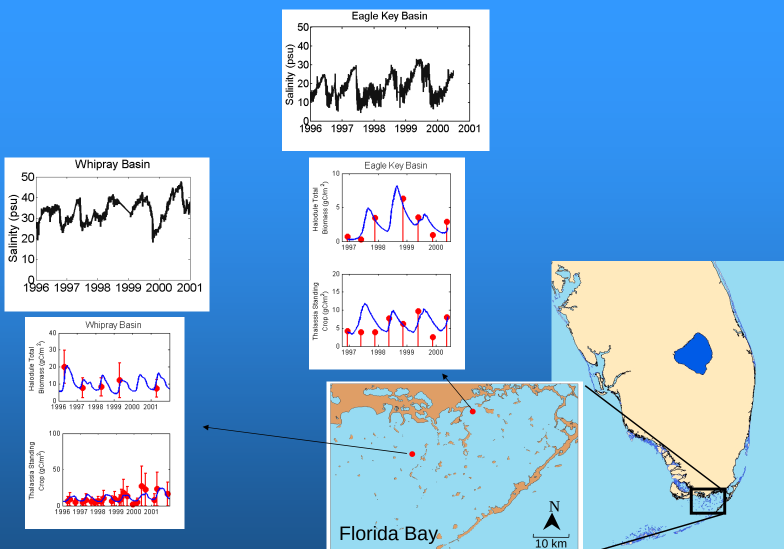


Figure 2: Calibration results are shown along with salinity data for each of the basins. The model (blue lines) was calibrated to monitoring data (red dots) collected by Miami-Dade Department of Environmental Resource Management, Florida Fish and Wildlife Conservation Commission Fish Habitat Assessment Program and University of Virginia. Bars of 1 standard deviation are included on the Whipray data to demonstrate variability found in seagrass biomass data. Salinity data were recorded sub-daily at monitoring platforms by the United States Geological Survey and Everglades National Park.

Salinity Effects By Region

Model output shows that seagrass community composition responds to salinity changes differently in the eastern bay versus the western bay. This indicates that environmental parameters other than salinity (e.g. nutrients, light, sulfide) are important in determining how salinity affects species-specific production and survival across the bay. Base salinity used in these simulations was created by averaging the calibration data for Eagle Key Basin (1996-2000) across years. Simulations indicate that Halodule is better able to compete with Thalassia at high salinities in Whipray Basin than in Eagle Key Basin.

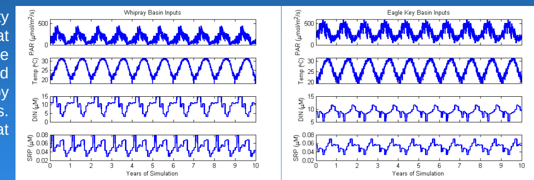


Figure 3. Inputs to the model for simulation are averaged forcing functions. Input data for the calibration period of 1996-2000 were averaged by Julian Day across years. The averaged annual curves are repeated for each simulation year.

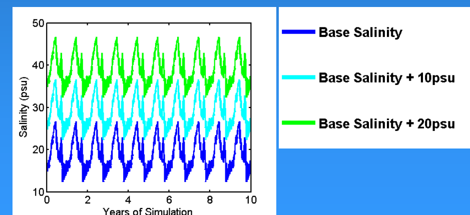


Figure 4. The salinity forcing functions applied to the two basins during the simulations demonstrating that determining appropriate salinity levels to prevent deterioration of Florida Bay seagrass communities is location specific.

Model Differences Between Regions

- **Water column nutrient concentrations (Fig. 3)**
- **Light availability at canopy height (Fig. 3)**
- **Sediment depth/ active root zone (20cm in west, 5cm in east)**
- **Concentration of organic matter in sediment (greater in the west)**

Whipray Basin

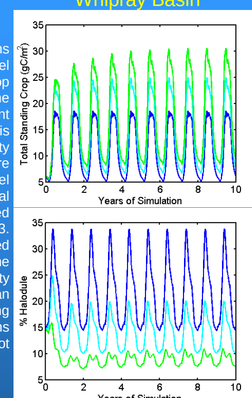
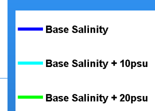


Figure 5. Results of simulations for Whipray Basin. Top panel shows total standing crop (*Halodule* + *Thalassia*) while the bottom panel shows the percent of the total standing crop that is *Halodule* biomass. The salinity regimes depicted in figure 4 were forced through the Whipray model with all other environmental forcings held to the averaged annual curves found in figure 3. The base salinity was simulated for 10yrs to pre-equilibrate the scenarios before the salinity scenarios were applied for an additional 10yrs. Increasing salinity to hypersaline conditions favors *Thalassia*, but does not eliminate *Halodule*.



Eagle Key Basin

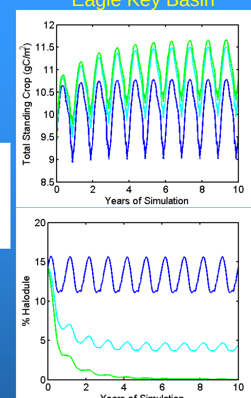


Figure 6. Results of simulations for Eagle Key Basin. Top panel shows total standing crop (*Halodule* + *Thalassia*) while the bottom panel shows the percent of the total standing crop that is *Halodule* biomass. The salinity regimes depicted in figure 4 were forced through the Eagle Key model with all other environmental forcings held to the averaged annual curves found in figure 3. The simulations were stabilized at base salinities for 10yrs before scenarios were begun. Increasing salinity to hypersaline conditions eliminates *Halodule*.

Summary

Simulations suggest that *in situ* salinity tolerance of seagrasses is determined by intrinsic salinity tolerance as well as by the ecological system's capacity to withstand stress as determined by resource availability and environmental conditions. *Halodule wrightii* declines in the eastern bay when salinities are higher than 40 psu. Further away from inflows, in areas routinely hypersaline but richer in nutrient supply and organic matter, *Halodule* survives in salinities greater than 45 psu. Overall seagrass biomass is also higher in the western basins.

Acknowledgements

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