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Everglades National Park

Submerged Aquatic Vegetation and Physico-Chemical Monitoring in the Florida Bay Mangrove Zone, Everglades National Park

Background

Ecosystem restoration in the mangrove zone of Everglades National Park aims to reduce salinity levels to historical conditions and to consequently restore submerged aquatic vegetation (SAV) to previously higher abundances. The mangrove zone is considered to be the mangrove estuaries and brackish "lakes" located along the ecotone between freshwater Florida Everglades and saltwater Florida Bay (Fig. 1). Extensive SAV beds, supporting large populations of wading birds and wintering waterfowl, once characterized these areas. Present SAV, waterfowl, and wading bird abundances are all greatly reduced from historical (1931–46) levels. These reductions are coincident with a 20–30 practical salinity units (psu) increase in salinity in this region caused by diminished freshwater inflows due to upstream water management practices. Prolonged periods of elevated salinity in the mangrove zone are hypothesized to have reduced the seasonal duration and spatial extent of SAV. The decline in waterfowl abundance in the mangrove zone lakes is thought to be at least partially due to this reduction in SAV. During high rainfall years, and thus increased freshwater inputs, SAV and waterfowl abundances increased in the mangrove lakes. Because of the coincidence of increasing salinities with the decline of the dominant *Chara hornemannii* Wallman alga cover in the mangrove lakes and the lack of other historical water quality data, the temporal and spatial loss of *Chara* cover was attributed mostly to the assumed inability of the brackish *Chara* populations to tolerate elevated salinities.

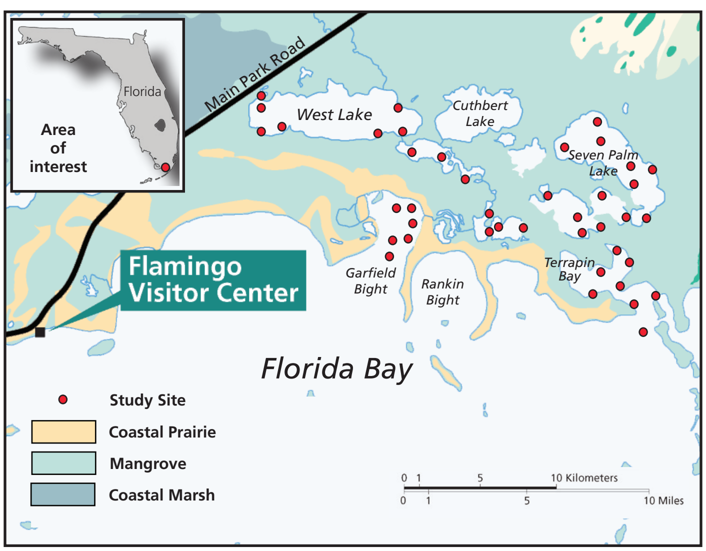

Figure 1. Location map of study sites.

Project Objectives

Successful restoration will be assessed by comparison of future SAV patterns with established benchmarks. Establishing these benchmarks will require quantifying the spatial and temporal patterns of SAV abundance and an increased understanding of the processes governing the relationships between water quality and SAV abundances; therefore, the focus of this investigation was to describe SAV spatial and temporal distribution and abundance and their relationships with sediment depth and water quality parameters. Water temperature, salinity, light availability, water level, water column total nitrogen and phosphorus concentration, and phytoplankton chlorophyll-a (chl *a*) concentration were measured in the mangrove zone from May 2006 through April 2009. This study also compares and contrasts the local geographies between the two adjacent sub-estuaries in the mangrove lakes region and evaluates how these inherent system attributes may have structured the ecosystem responses to reduced freshwater deliveries in both systems. The results of this study contribute toward predicting how the SAV communities will respond to proposed restoration of freshwater flow.

Key Findings & Management Implications

Spatially, annual mean salinity, light availability, and sediment depth to bedrock structure the SAV communities in the mangrove sub-estuaries of Florida Bay. Three distinct SAV communities (*Chara hornemannii* alga group, *Halodule* wrightii seagrass group, and a Low SAV coverage group) were identified along the Everglades–Florida Bay ecotone. These communities were differentiated along salinity and nutrient availability gradients. *Chara* communities were located in the lower salinity (mean annual salinity <25 psu) upstream "lakes," while *Halodule* communities were located in the more marine coastal embayments. SAV cover, particularly in the *Chara* communities, varied according to water quality differences observed between two adjacent sub-estuaries (West Lake to Garfield Bight sub-estuary and the Seven Palm Lake to Terrapin Bay sub-estuary). These sub-estuaries were characterized by alternate states of water quality and SAV abundance. The West Lake sub-estuary was turbid, dominated by persistent algal blooms and high nutrient concentrations, and suffered from low SAV abundance.

In contrast, the Seven Palm Lake sub-estuary was characterized by clear water and higher-SAV cover that persisted throughout the year, and low nutrient and phytoplankton concentrations. The SAV community groups were related to water quality by using a discriminant function model that predicted the type of plant community at a given site from salinity, light availability, and sediment depth to bedrock. Mean salinity alone was able to correctly classify 78% of the sites and reliably separated the *Chara* group from the *Halodule* group. Light availability was uniquely valuable in separating the *Chara* group from the Low SAV coverage group. Regression analyses identified significant relationships between phosphorus (P) concentration, phytoplankton abundance, and light availability, and suggest that a decline in water transparency, associated with increasing salinity, also may have contributed to the historical decline of *Chara* communities in the group.

The clear relationships between P availability, phytoplankton abundance, and light availability indicate that historic SAV communities will not be restored in the freshwater end of these estuarine systems unless water column total phosphorus (TP) concentrations are reduced, especially in the West Lake system. Though increased freshwater flow will decrease salinity and also may decrease P loading, the re-establishment of flourishing *Chara* communities in the estuaries of the southern Everglades may be inhibited by the long-term retention of P in P-limited carbonate ecosystems (Herbert and Fourqurean 2008). Because 75% of the sites characterized by *Chara* dominance exhibited median light at bottom exceeding 5% of surface light, and all sites characterized with Low SAV coverage were below this level of light availability, 5% light at bottom is a reasonable estimate for the maintenance of *Chara* communities. Using a light availability target of 5% of surface light at bottom and the regression equations relating light availability to chl *a*, and chl *a* to TP, we estimate that annual mean water column TP concentrations should be maintained at or below 2.2 ± 1.1 µM (mean ± 95% confidence interval) to limit phytoplankton abundance and allow for the shift back to the *Chara*-dominated regime in the upstream "lakes." However, if the *Chara*-dominated and the phytoplankton-dominated regimes are distinct stable states characterized by hysteresis (Scheffer et al. 1993), a much lower TP concentration may be required to restore a presently turbid, phytoplankton-dominated mangrove lake to a clear-water, *Chara*-dominated lake.

Repeatable seasonal patterns were not evident in most SAV communities with the exception of light-limited brackish alga *Chara hornemannii* Wallman communities that experienced seasonal changes in light availability in a turbid environment. In contrast, *Chara* cover in clear-water, SAV-dominated environments was temporally negatively correlated with salinity and water depth. These observations suggest that water clarity may determine the importance of the salinity driver in these *Chara* communities. Cover of the more marine seagrass *Halodule wrightii* exhibited some temporal variation that was positively correlated with water temperature. This study demonstrates the differential importance of water quality and environmental drivers in estuaries distinguished by alternate regimes of phytoplankton and SAV dominance, and explains how differences in local estuarine geography may filter the response of SAV communities to environmental stressors.

Restoring higher levels of freshwater flow to the mangrove estuaries of Florida Bay may promote the spatial and temporal expansion of SAV communities if the quality of the freshwater, as indicated by low nutrient and phytoplankton content, is sufficient. Increased freshwater flow will decrease salinities and possibly decrease water column nutrient concentrations by displacing relatively P-rich marine water. Decreased nutrient concentrations should increase light availability to benthic macrophytes by alleviating persistent algal blooms that currently affect much of the mangrove lake estuaries.

Recommendations for Future Studies

The full range of pre-restoration water quality conditions and SAV abundance patterns have yet to be determined, and the relationships among SAV, water quality, and nutrient pools are not fully understood. Restoration goals will be assessed in the future by comparison of salinity and SAV patterns with established benchmarks. The baseline data collected by this project will be the benchmark against which the success of restoration efforts will be judged. These data also are used to produce statistical modeling tools that can be used to predict change from proposed management actions.

Aerial view of mangrove lakes region along northern Florida Bay. Photo by Bill Perry, NPS.

References

Herbert, D.A., and J.W. Fourqurean. 2008. Ecosystem structure and function still altered two decades after short-term fertilization of a seagrass meadow. Ecosystems 11:688–700.

Frankovich, T.A., and J.W. Fourqurean. 2010. Submerged aquatic vegetation and physico-chemical monitoring in the Florida Bay mangrove zone for CERP assessments and targets refinement. Final report to Everglades National Park, Cooperative Agreement #H5297-05-0041, October 2010.

Scheffer, M., S.H. Hosper, M-L. Meijer, B. Moss, and E. Jeppesen. 1993. Alternative equilibria in shallow lakes. Trends in Ecology and Evolution 8:275–2

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www.nps.gov/ever/naturescience/cesimon10-3.htm

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