Controls on the Chemical Hydrology and Associated Ecological Structure and Function of Mangroves, Indian River Lagoon, Florida

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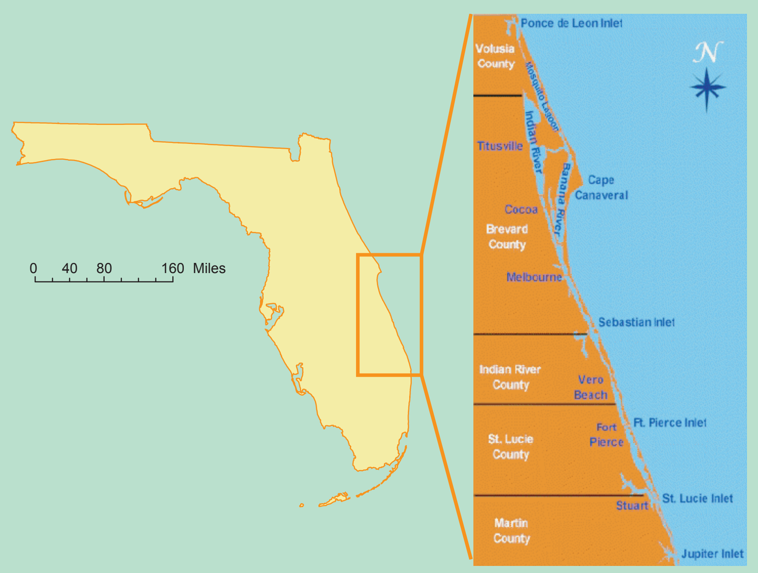
Introduction

It is commonly believed that hydrological processes control ecological functioning in mangroves. To date, however, there have been few studies that fully couple ecological and hydrological processes in mangrove systems.

This study is a fully-coupled ecological-hydrological study of mangroves. Our global hypothesis is that hydrological conditions, in particular the freshwater-saltwater interactions that control porewater salinities, control numberous ecological patterns and processes such as species composition, primary productivity, and nutrient cycling.

Study Site



This study is being conducted on North Hutchinson Island in the Indian River Lagoon, a 250-km estuarine system that supports mangroves on both the mainland and the barrier islands. The study site is just north of the Ft. Pierce Inlet.

Like most mangroves in the Indian River Lagoon, the study site has been impounded and internally ditched in attempts to control mosquito populations. Surface water inflow and outflow are through four 24-in corrugated metal pipes interspersed around teh perimeter levee surrounding the impoundment. Groundwater inflow and outflow presumably occurs under this levee.

Methods

There are 20 sample points at which the coupled ecological-hydrological studies are being conducted. At each sample point, there are permanent vegetation plots in which species composition, primary productivity, and nutrient cycling are studied adjacent to piezometer nests with piezometers screened at 0.6, 1.2, and 1.8 m below the ground surface. Water samples are collected in the wet and dry seasons, with water samples being analyzed for dissolved constituents and deuterium and oxygen-18. Additionally, a 400-m resistivity survey was conducted from the Indian River Lagoon to near the dune crest of the island.

Results

Community Types

Five community types were identified based upon species composition and stand structure: (1) salt pan, (2) sparse black mangrove (*Avicennia germinans*), (3) dense black mangrove (*Avicennia germinans*) (4) red mangrove (*Rhizophora mangle*), and (5) woody upland. Sample points are distributed in each of the five community types, with emphasis placed on the transitional areas between the salt pan, sparse black, and dense black mangrove community types.

5. Woody Upland

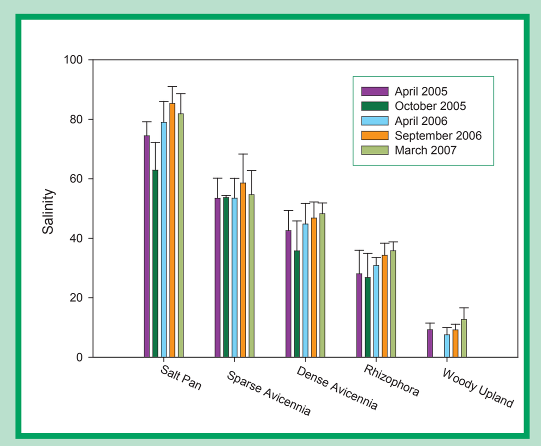
4. Red Mangrove

1. Salt Pan

2. Sparse Black Mangrove

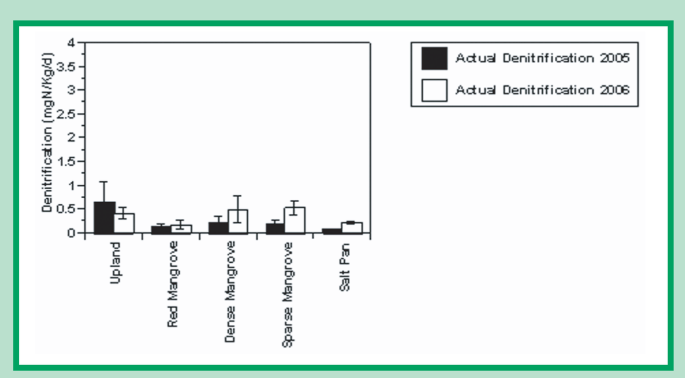
3. Dense Black Mangrove

Porewater Salinities

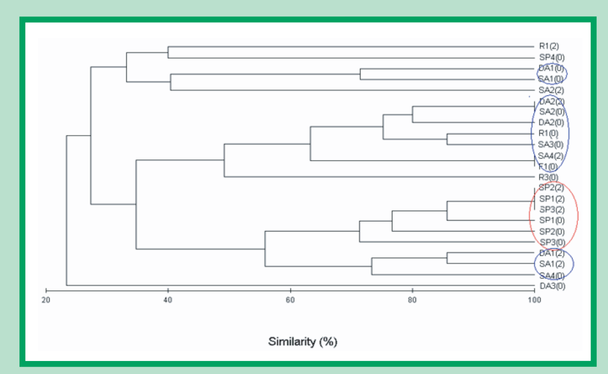


Salinities vary spatially, with surface water and groundwater salinities ranging from ~10 in the upland, to ~30 in the regularly-flushed mangroves, to ~75 in the irregularly-flushed mangroves and salt pan. There are no significant seasonal differences within each of the five community types.

Nutrient Cycling and Microbial Activity

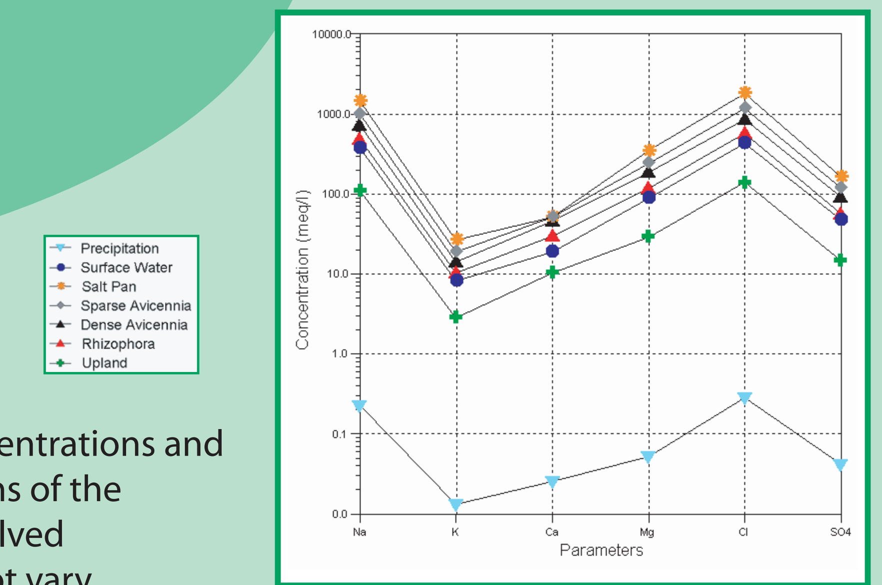


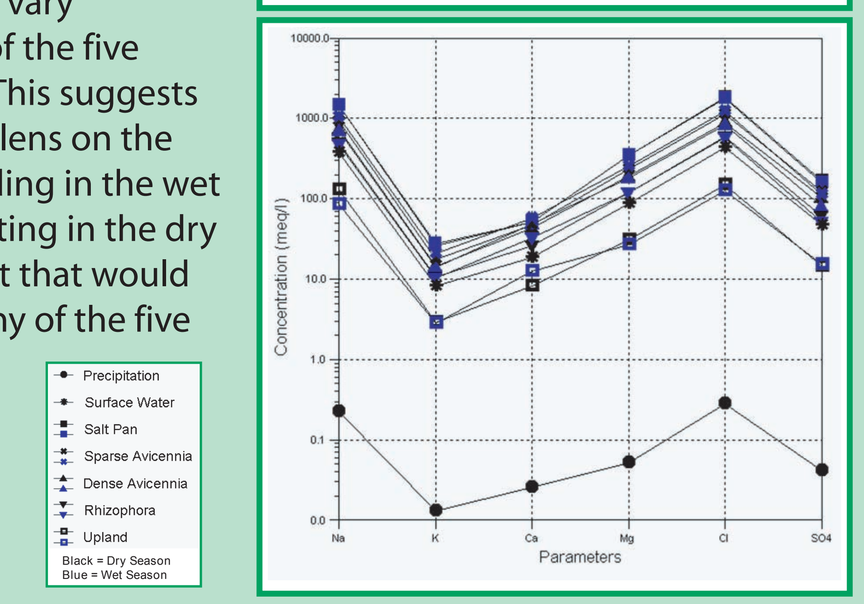
Actual denitrification varied among the five community types in 2005 and 2006. Values are means ± 1 standard error. Actual denitrification is significantly higher in the sparse black mangrove, dense black mangrove and woody upland community types.



Microbial species composition varies among the five community types. Data are for t=0 and fertilized subplots at t=2. The results of t=0 and t=2 are shown in one dendrogram to indicate a possible fertilization caused clustering. SP: saltpan; DA: dense Avicennia; SA: sparse Avicennia; R: red mangrove; F: woody upland. The circles indicate branches in the dendrogram with a similarity of >60%.

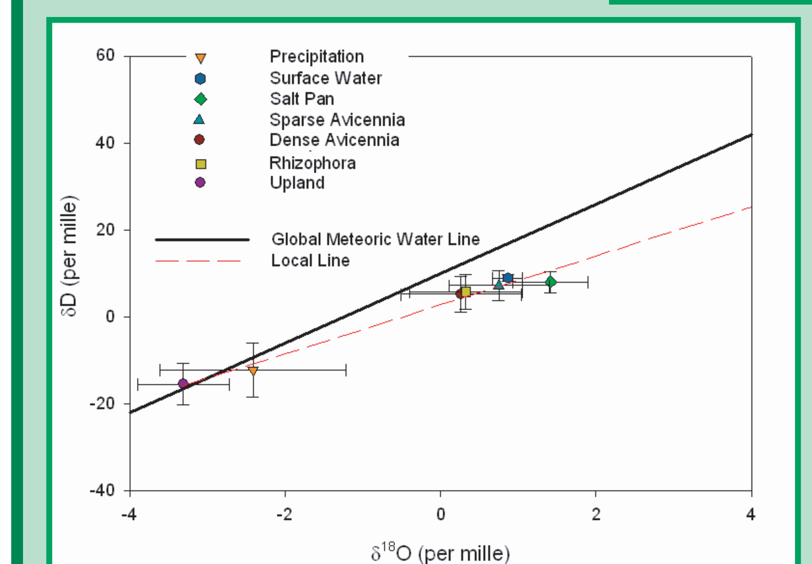
Groundwater Geochemistry: Evapoconcentration





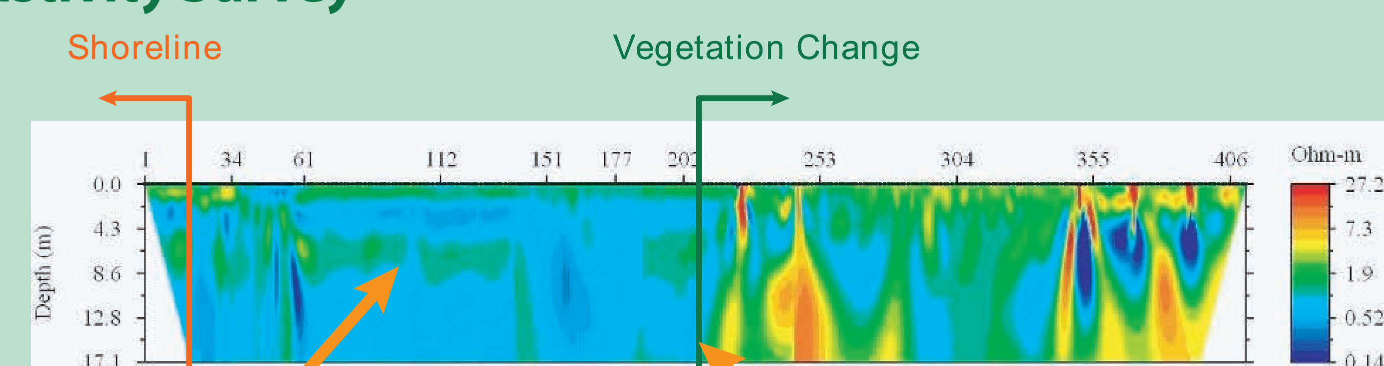
There are substantial differences in the absolute concentrations of the dissolved constituents in each of the five community types. Source waters are precipitation and surface water (i.e., inflowing Indian River Lagoon water). The woody upland water has intermediate concentrations and therefore could be a mix of these end members. However, the salt pan, sparse black mangrove, dense black mangrove, and red mangrove water have higher concentrations and therefore cannot be a simple mix of precipitation and surface water. There are no substantial differences in the relative proportions of the dissolved constituents in each of the five community types. This suggests that the differences in absolute concentrations are largely a function of evapoconcentration.

The absolute concentrations and relative proportions of the conservative dissolved constituents do not vary seasonally in each of the five community types. This suggests that the freshwater lens on the island is not expanding in the wet season and contracting in the dry season to the extent that would be measurable in any of the five community types.



Deuterium and oxygen-18 data further support the theory that absolute concentrations of dissolved constituents are largely controlled by evapoconcentration. Precipitation and woody upland water plot on the meteoric water line, while salt pan, sparse black mangrove, dense black mangrove, and red mangrove waters plot on an evaporative trend line.

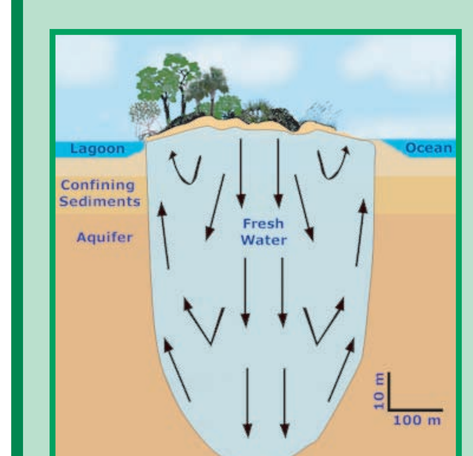
Resistivity Survey



The subsurface below the mangroves is dominated by layering of saline waters of varying conductivities.

No freshwater is present shoreward of the transition from mangrove to woody upland occurs.

Conclusions



There are strong correlations between porewater salinity and species composition, primary productivity, and nutrient cycling. The traditional conceptual model for the hydrology of carbonate islands is that porewater salinities are at least partly controlled by a freshwater lens that floats on underlying saline waters and expands and contracts seasonally. Our results, however, indicate that there is a brackish lens only under the uplands and that this brackish lens does not expand and contract seasonally. Instead, porewater salinities in the mangrove are largely controlled by evaporative enrichment of mixed precipitation and surface water. These porewater salinities, which exceed sea-water salinities, extend to depths of many meters below the ground surface under the mangrove.