The Role of the Mangrove Ecotone Region in Regulating Nutrient Cycling and Wetland Productivity in South Florida

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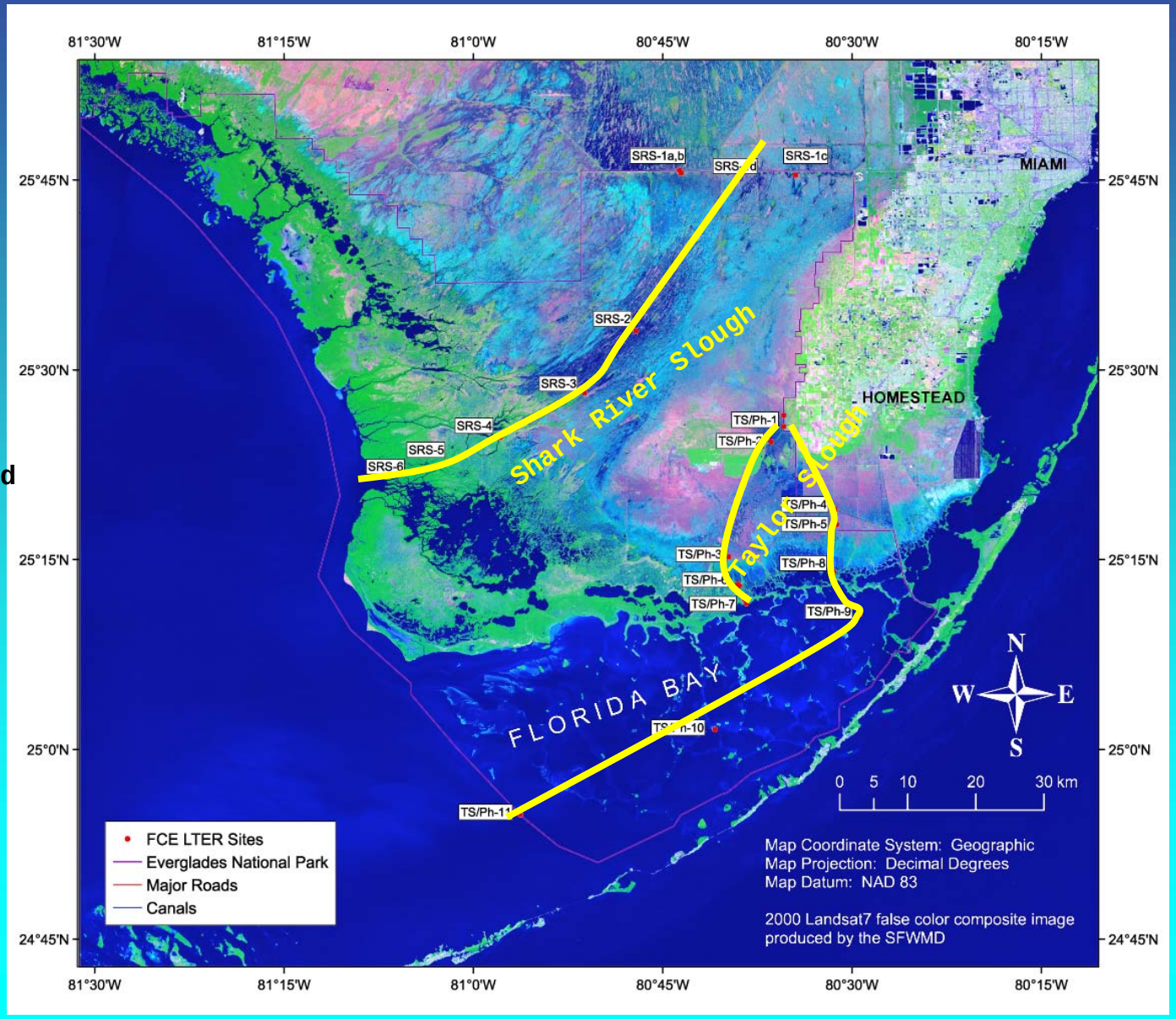
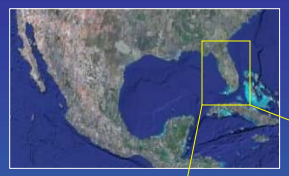
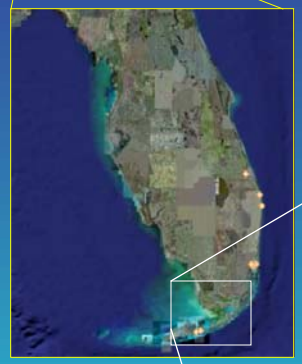
The FCE-LTER Program set up two main transects that intersect Freshwater, Estuarine, and Marine environments

- **Environment is geomorphologically diverse**
- **Presence of diffuse/undefined watersheds**
- **Everglades : Freshwater wetlands and the saline estuaries are phosphorous (P) limited**



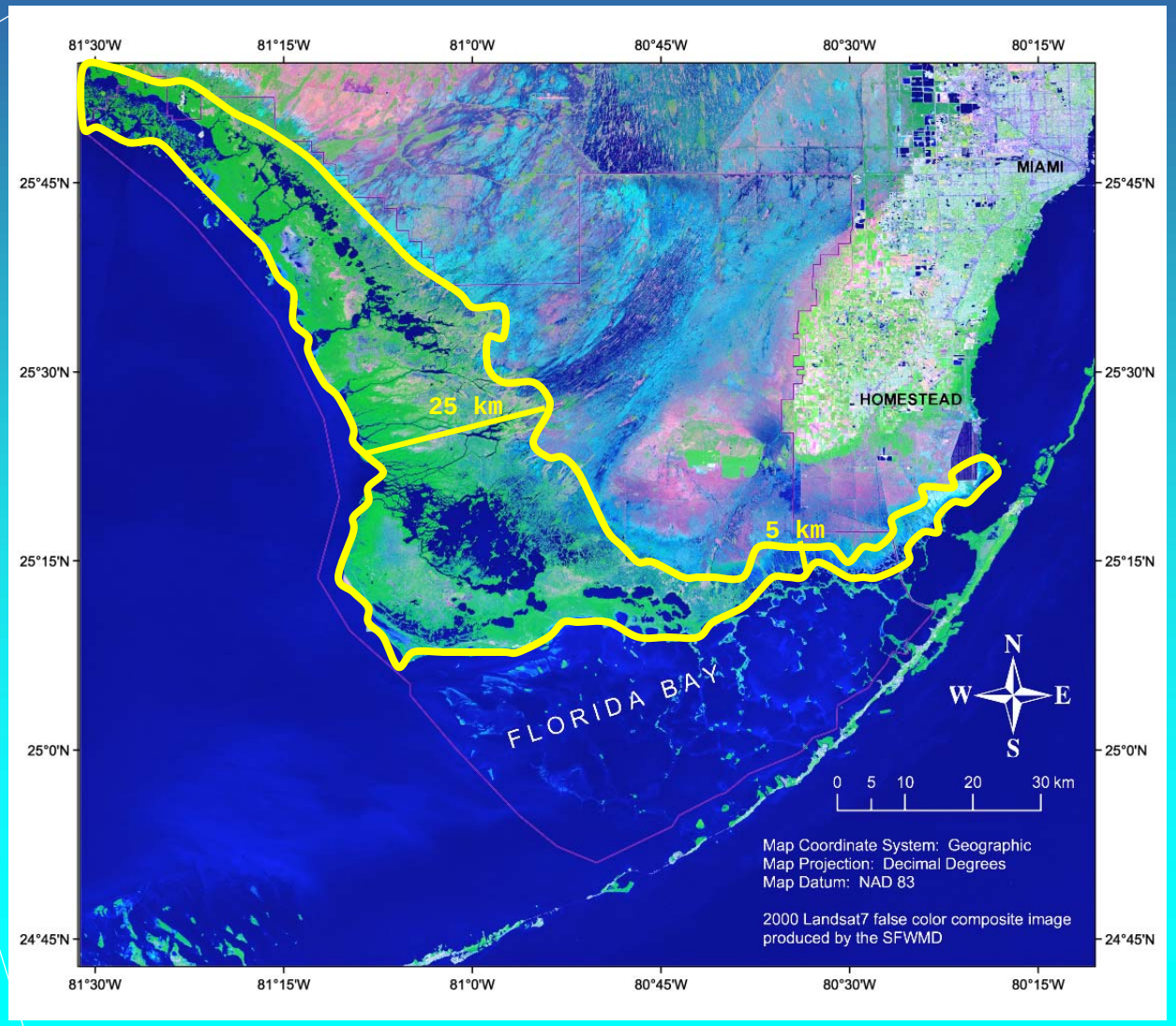
The Mangrove Ecotone Region: Location and definition



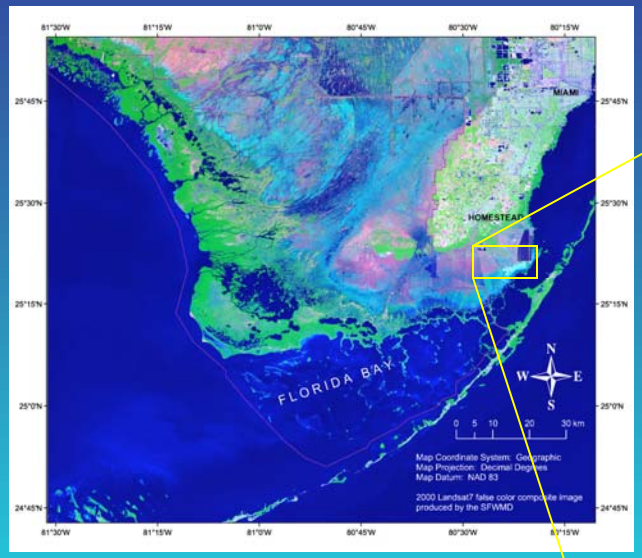


- An extensive region of the Everglades limited by phosphorus availability due to lack of terrigenous sediment input and reduced freshwater flow;

- because of this low terrestrial P and natural flow patterns govern the spatial distribution of vegetation and limits plant productivity, which is dominated by mangrove forests.



The Mangrove Ecotone interact with the “White Zone”, particularly in the Southeast Region



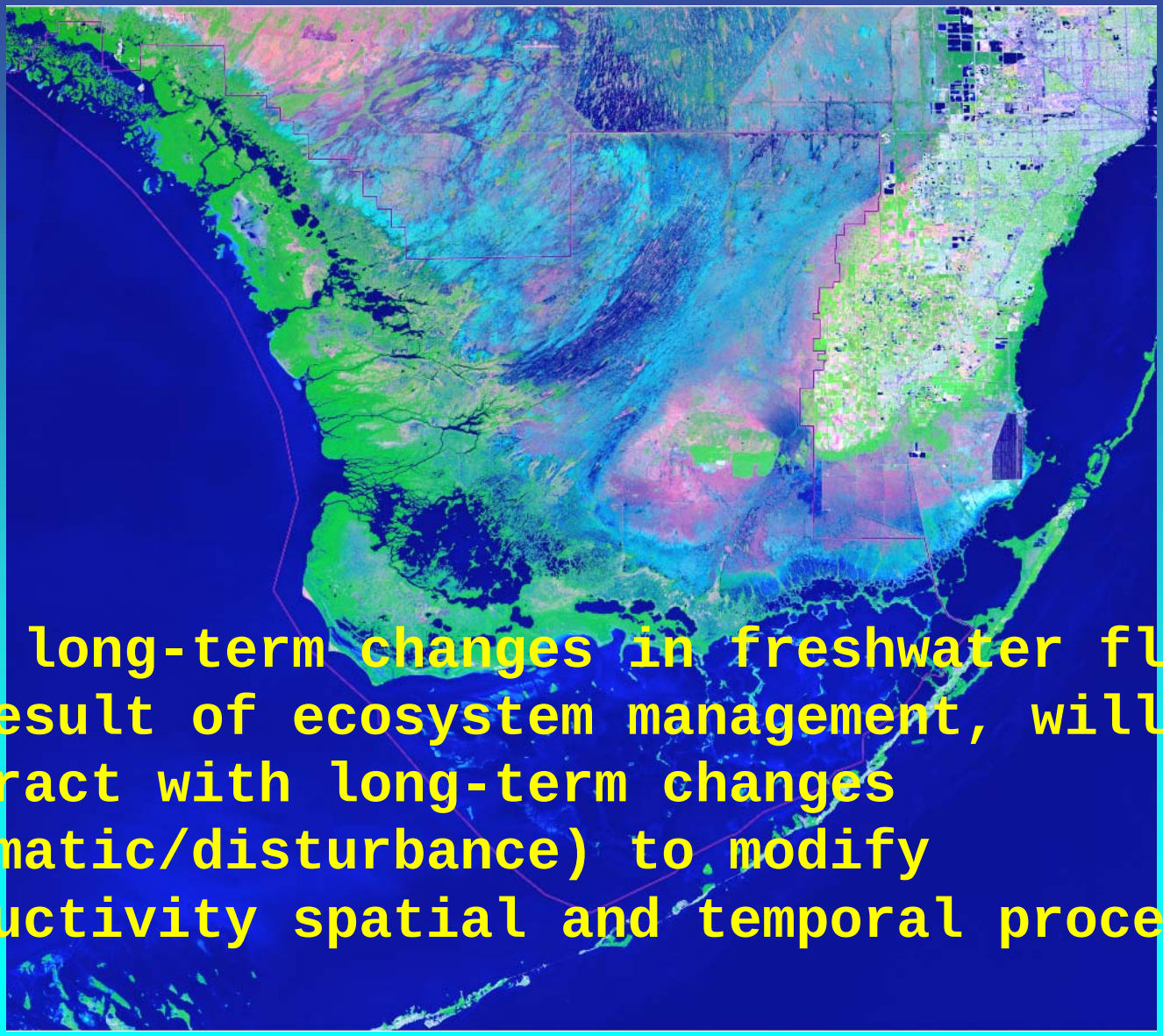
•Closely associated to the mangrove ecotone is the “White Zone”, a region of low productivity characterized by low vegetation cover and canopy height

•Over the past 50 years , the interior boundary of the white zone has encroached inland 1.5 km; maximum shifts occurred in areas cut off by canals from upstream fresh water (1.8 k,-Turkey Point)

•In contrast to other coastal regions in the Neotropics there is a net gain in mangrove area at this boundary

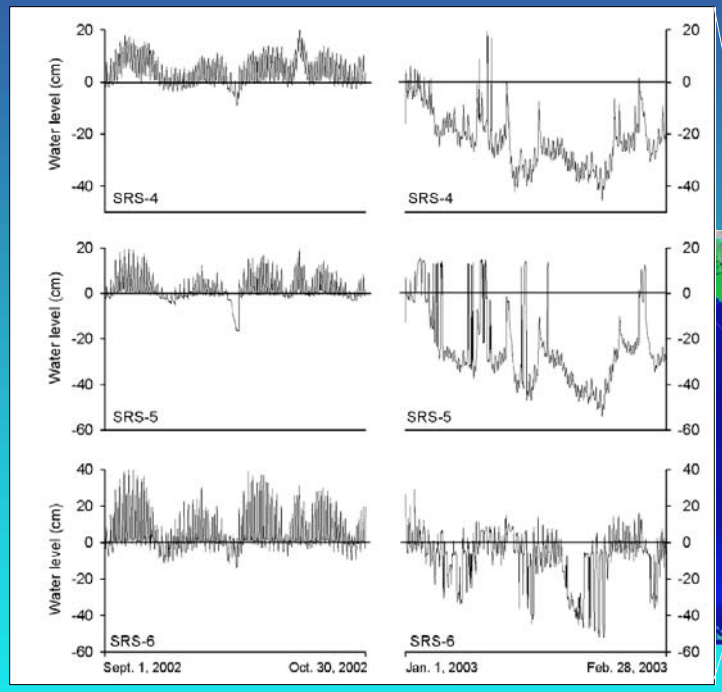
Ross et al 2000, 2001

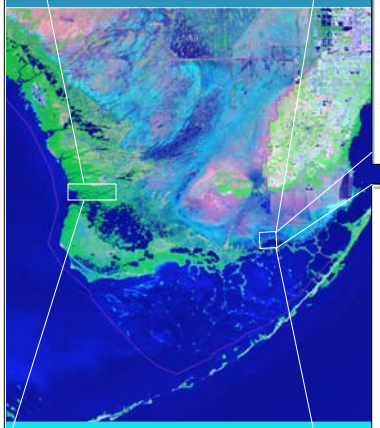
The Mangrove Ecotone Region: Research Question

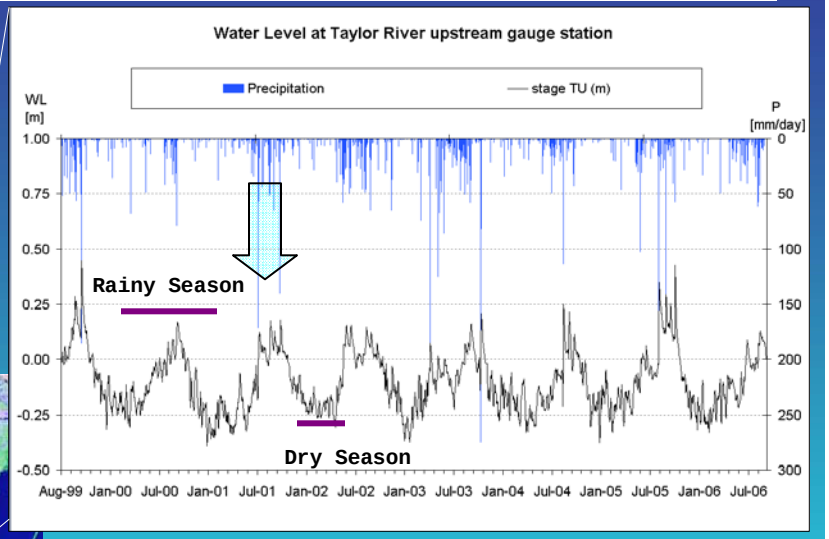


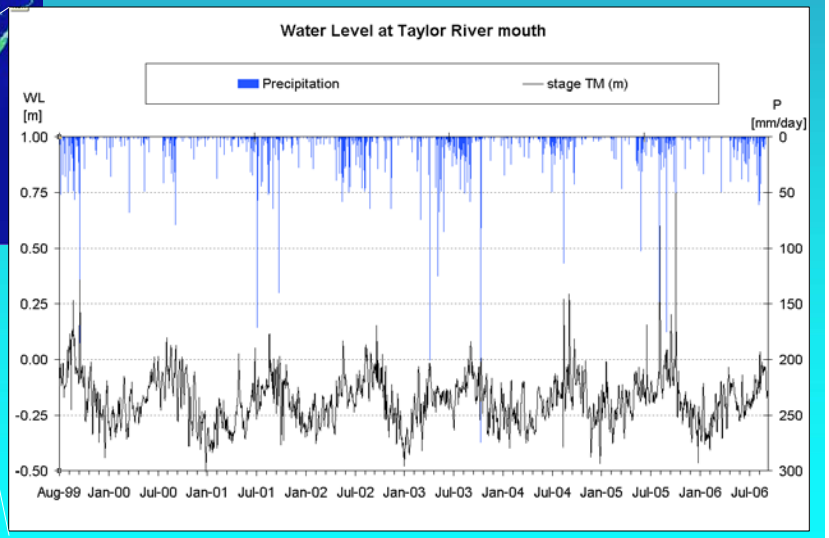
-How long-term changes in freshwater flow, as result of ecosystem management, will interact with long-term changes (climatic/disturbance) to modify productivity spatial and temporal processes?

Significant Spatial variation in Hydroperiod









- **Astronomical tides drive water exchange at shark river Slough**
- **Mangrove wetlands typically flood twice daily**

- **Precipitation influences water levels**
- **Longer Hydroperiod**
- **High wet season water levels influence long duration of inundation events per year; some mangroves are permanently inundated**

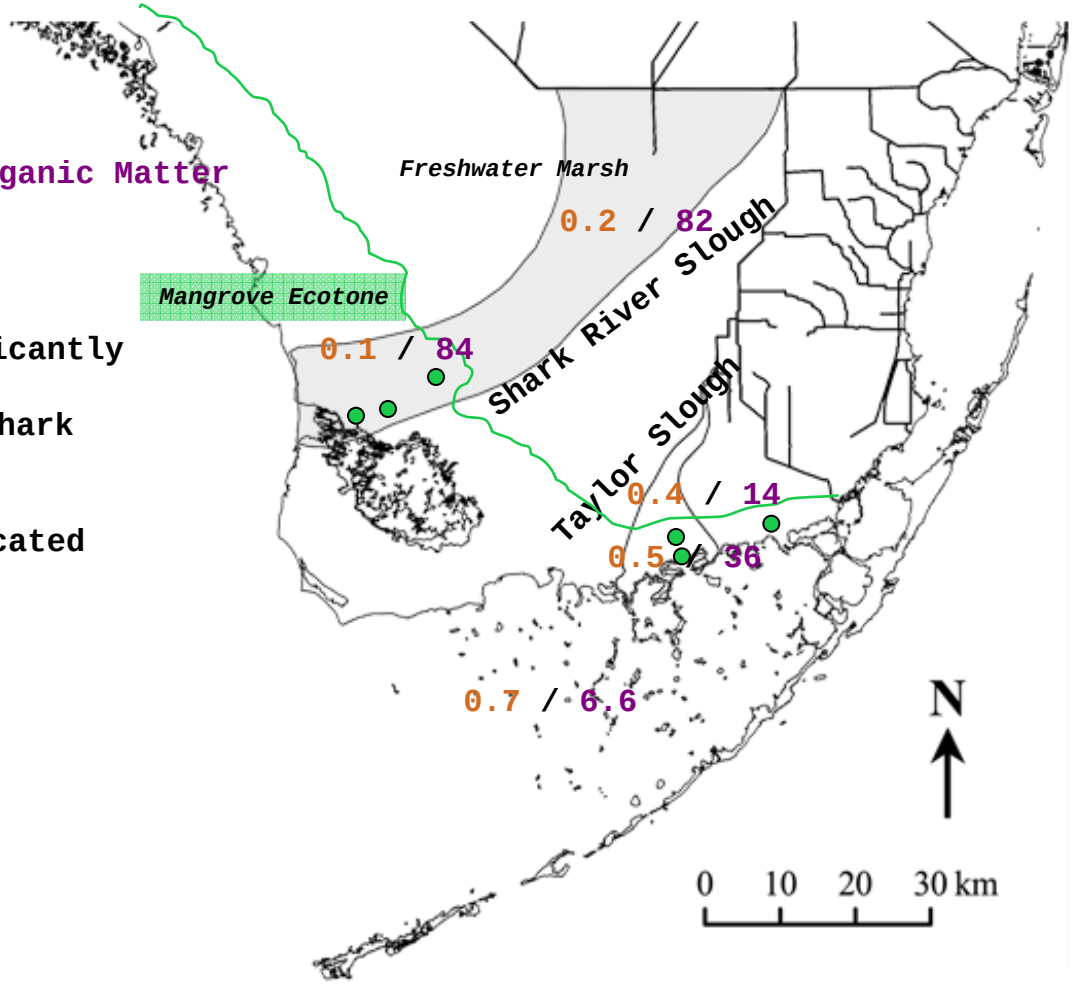
Krauss et al 2006; USGS; Michot, unpublished results

Soils are calcareous along the Sloughs

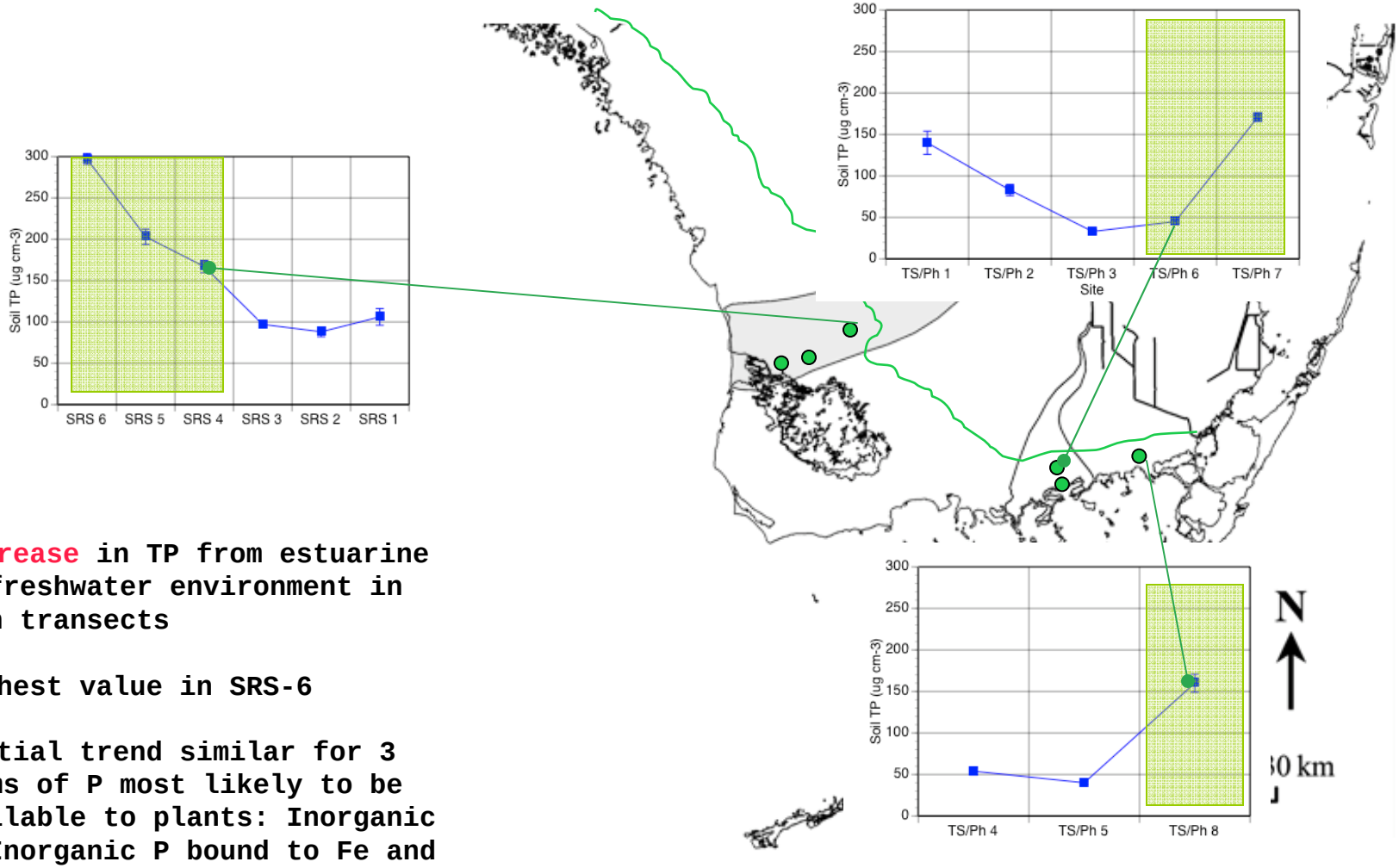
- Bulk Density (g cm^{-3}) / % Organic Matter

•Soil bulk density is significantly lower in freshwater marsh environments and along the Shark River Slough

•The most dense soils are located in Florida Bay.



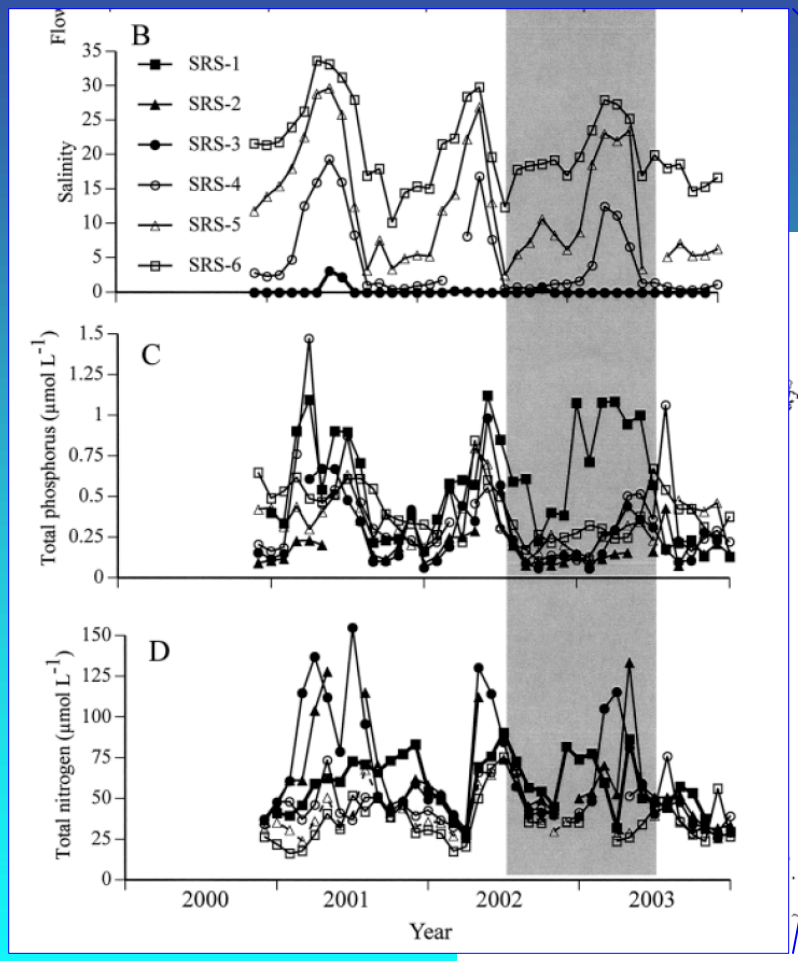
Soil Phosphorous concentration - Spatial Patterns

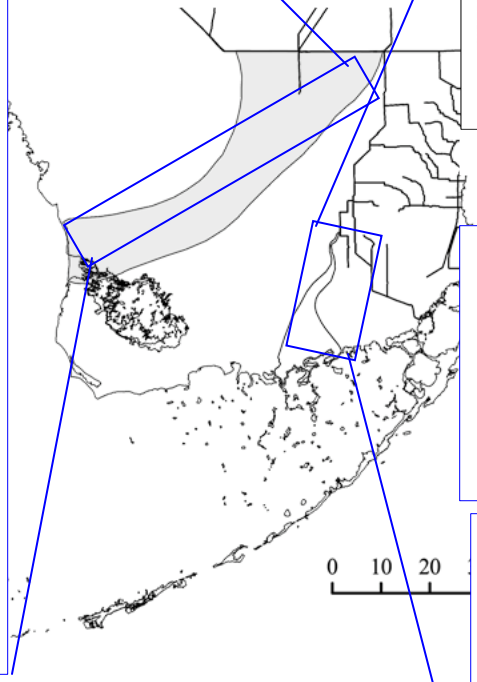


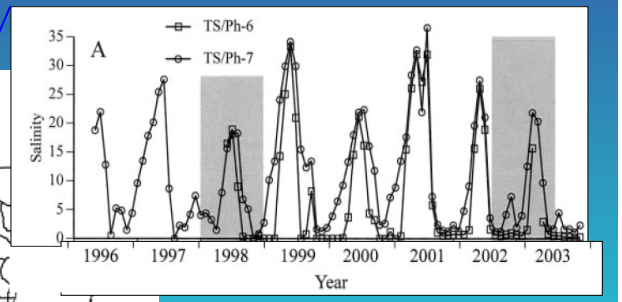
- **Decrease in TP from estuarine to freshwater environment in both transects**
- **Highest value in SRS-6**
- **Spatial trend similar for 3 forms of P most likely to be available to plants: Inorganic P, Inorganic P bound to Fe and Mg minerals, Ca-bound inorganic P**

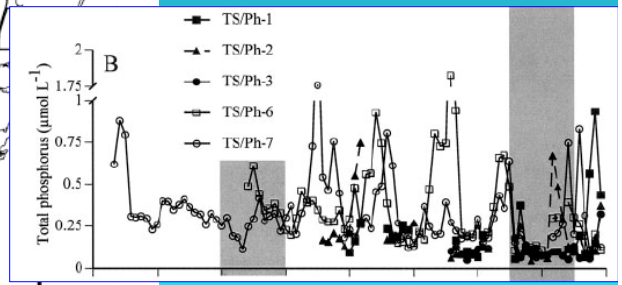
Chambers et al 200

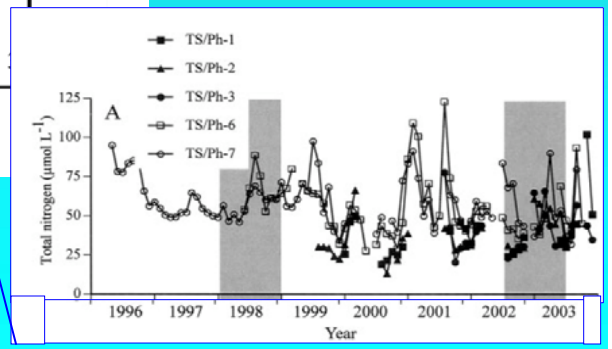
Water column P and N concentration - Spatial Patterns







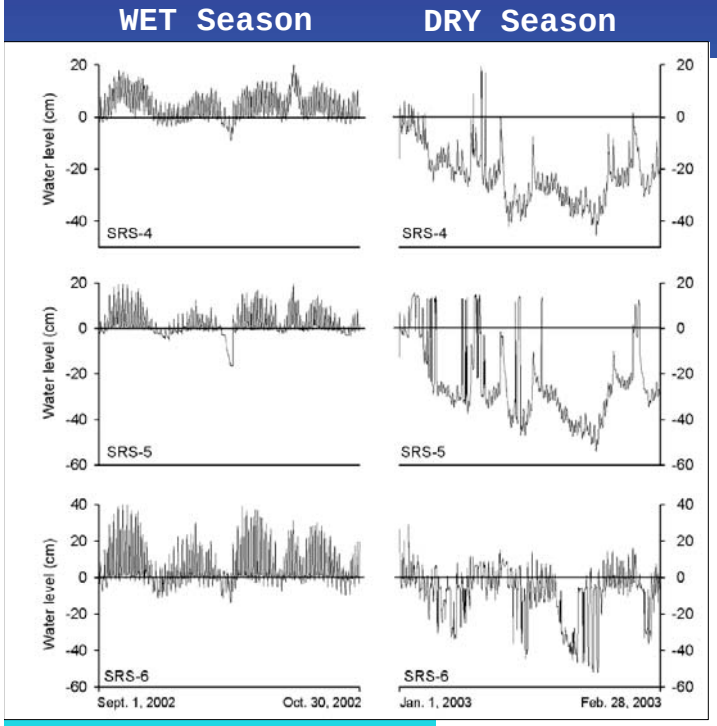


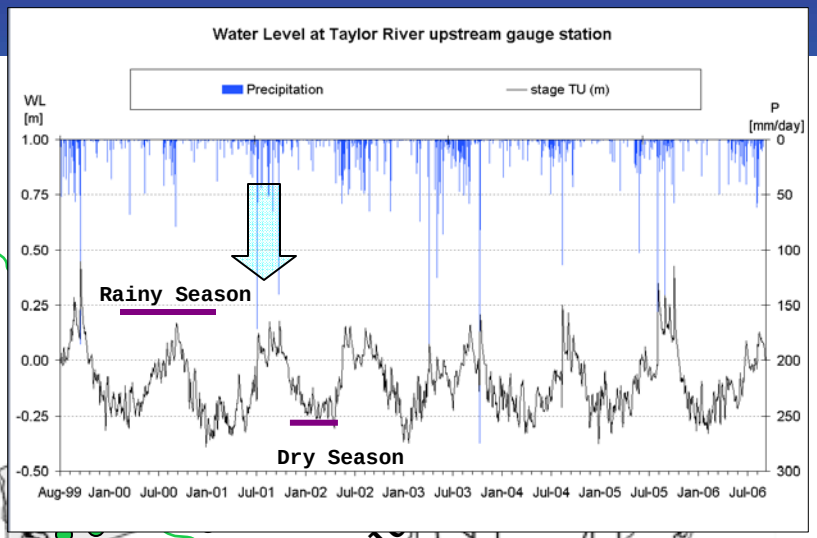


- **Strong seasonality associated to changes in salinity (rainy season)**
- **Interannual variation due to large scale climatic events**
- **Maximum values of TP are low (1.7 uM) in comparison to other coastal regions**

Childers et 2006

Tidal Forcing provides subsides of phosphorus to Southwest Region

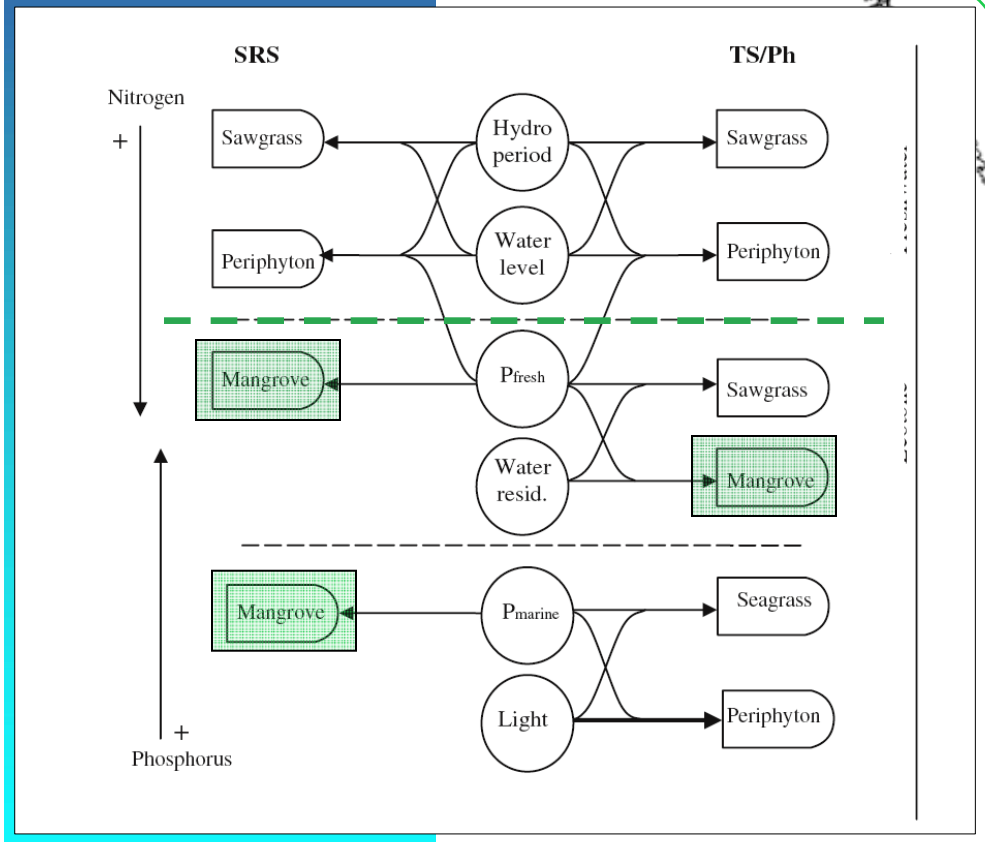


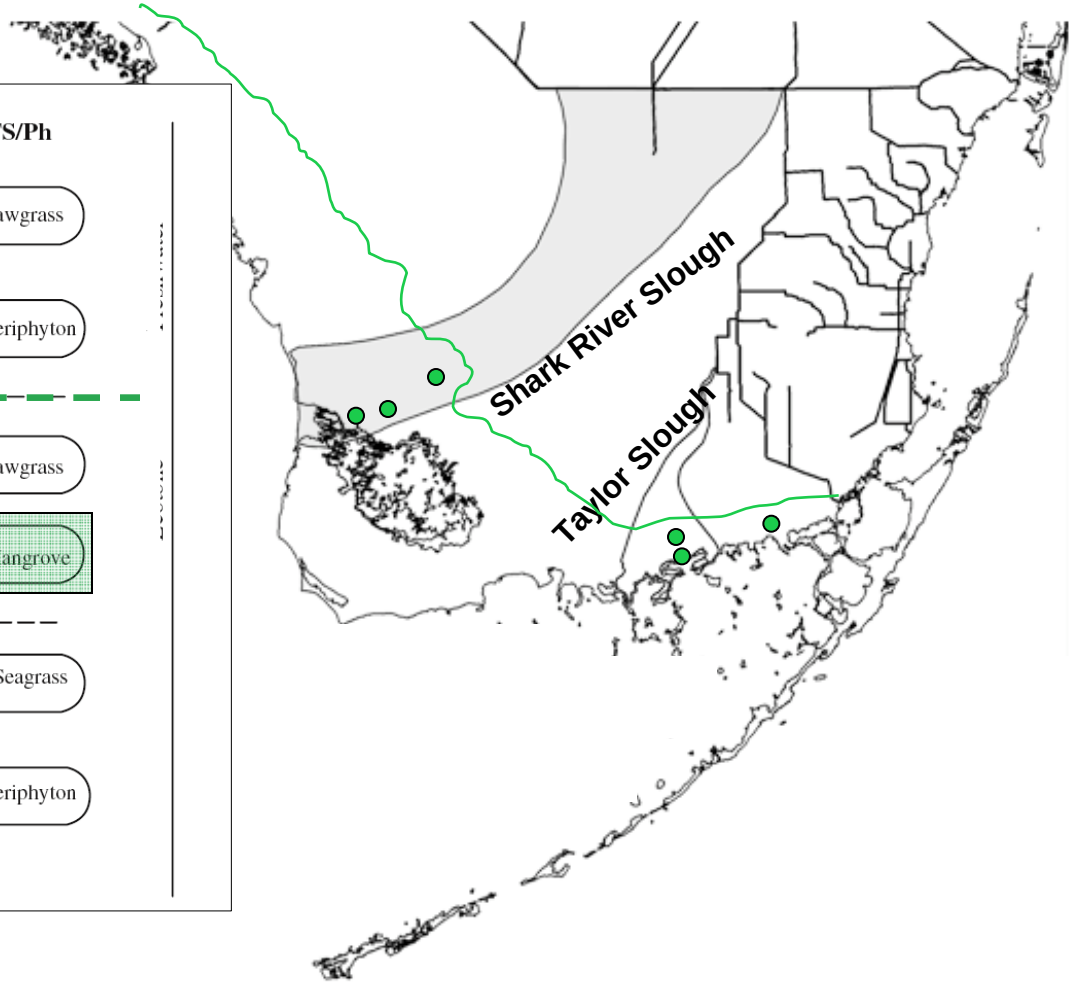


- Shark Transect is influenced by higher P concentrations
- Connectivity to marine source Tidal signature

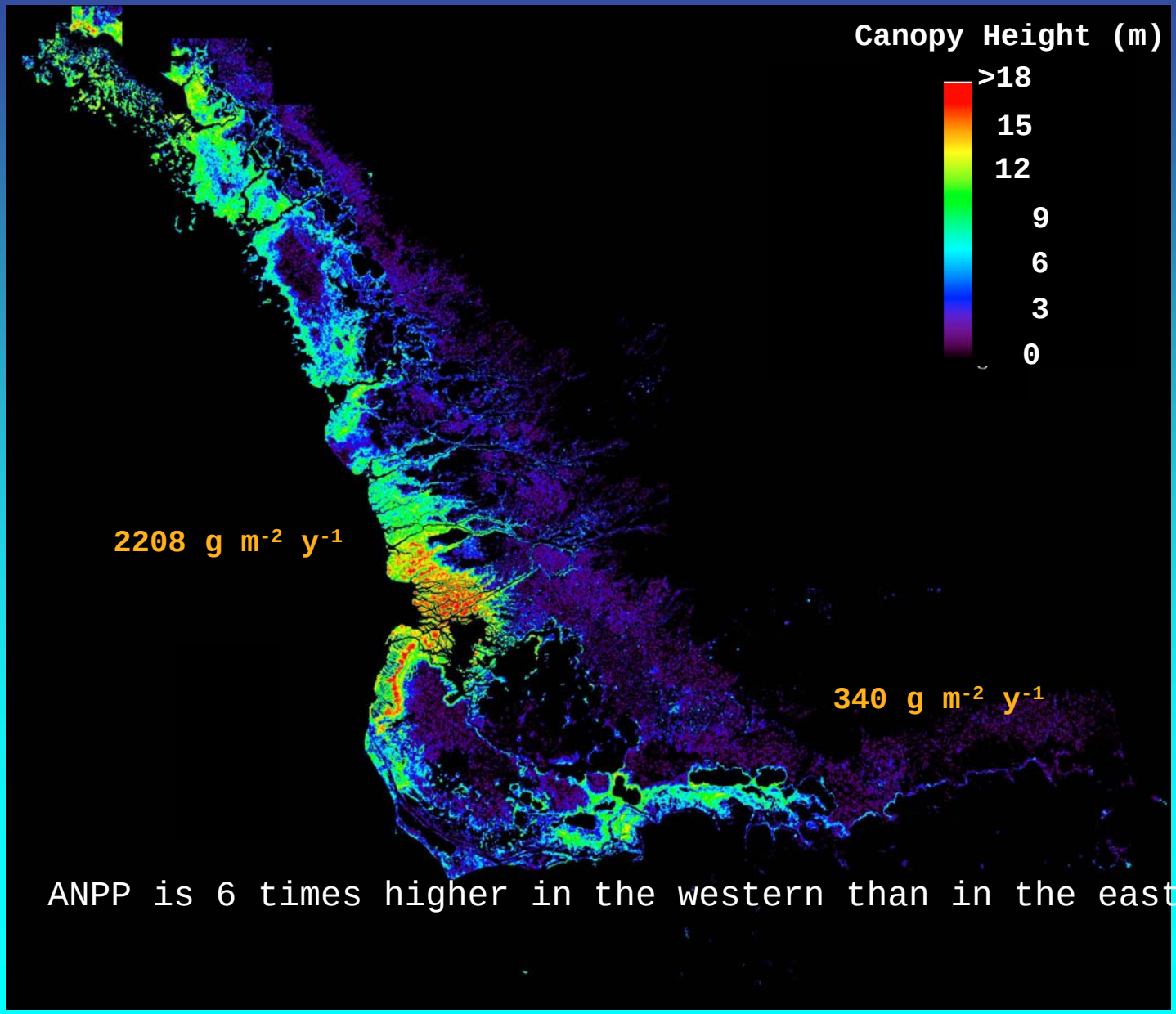
- Taylor Transect has negligible astronomical tidal influence
- It does not have direct connection to marine P

Water Residence and Soil P regulate Plant productivity in the Mangrove Ecotone



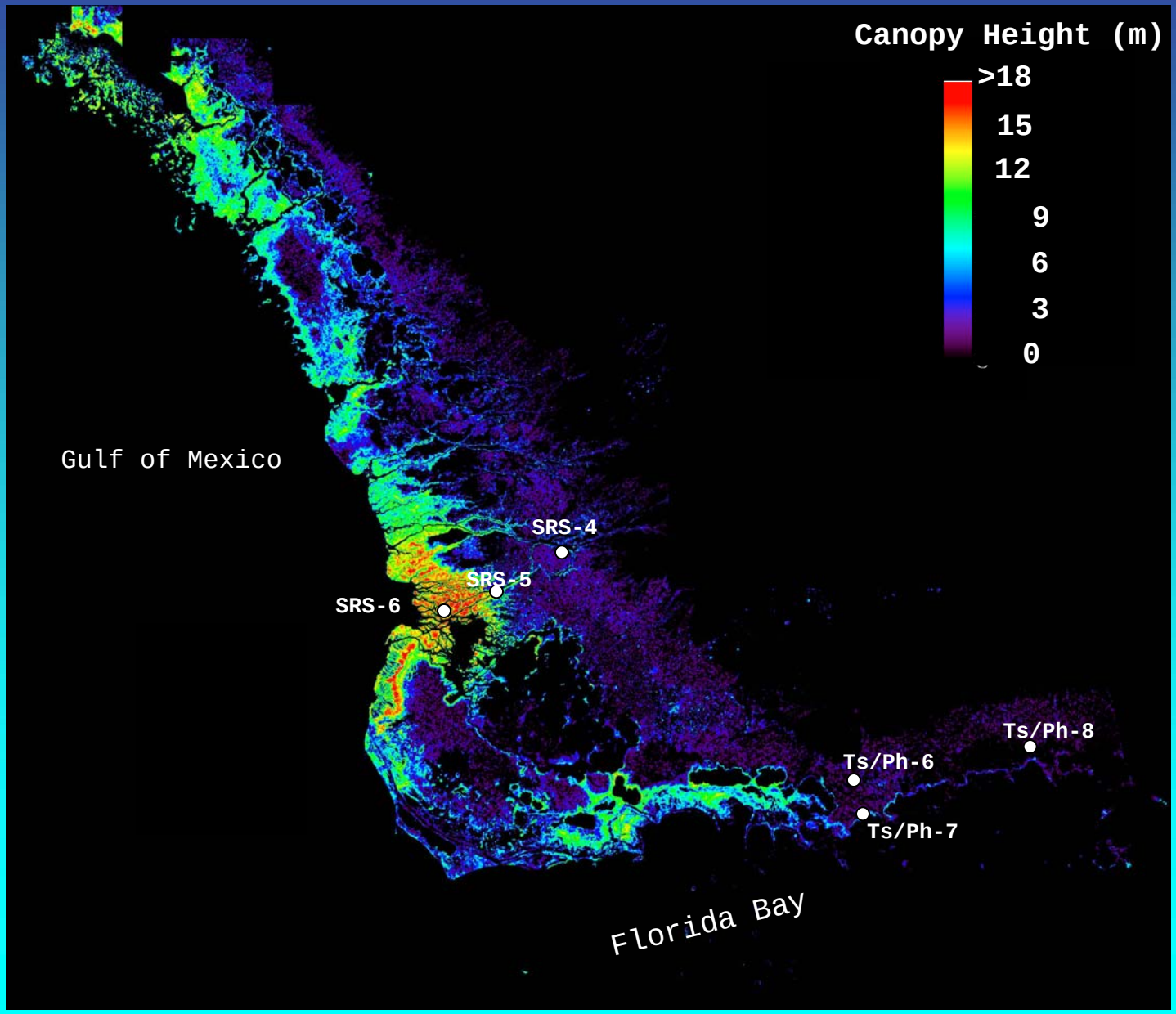


Mangrove tree height correlates with ANPP - Large Spatial Differences



ANPP is 6 times higher in the western than in the eastern reg

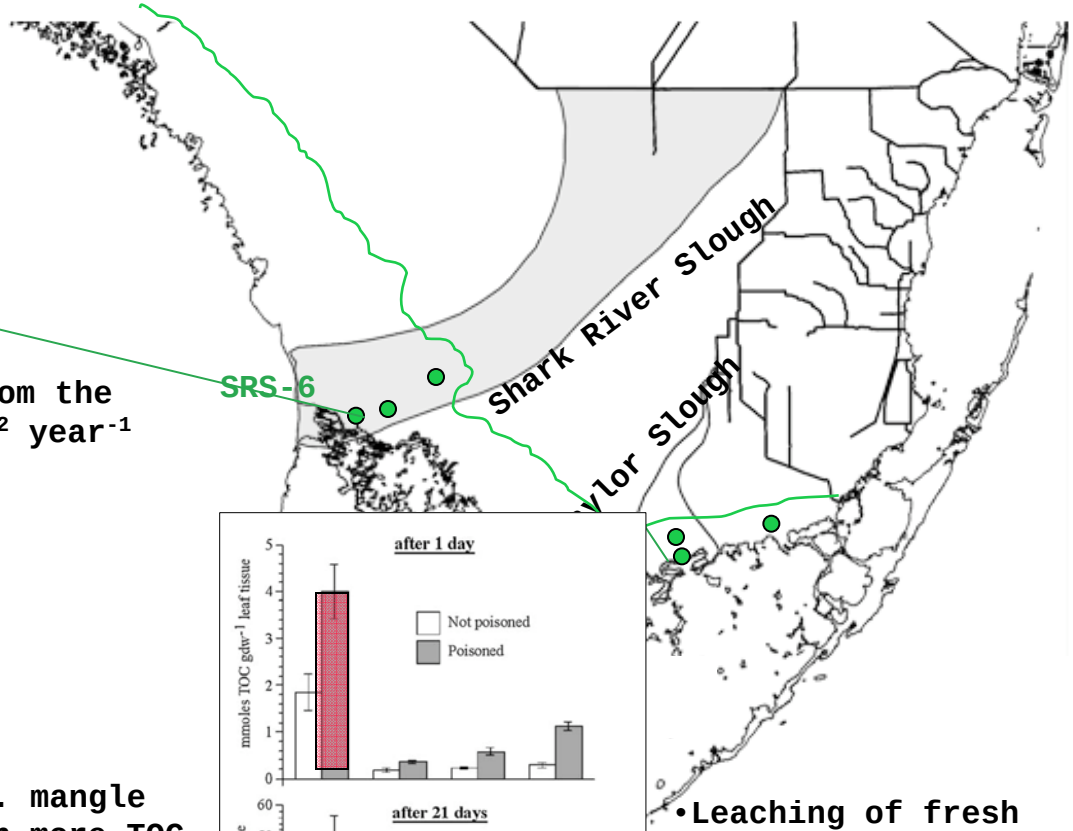
What is the influence of the mangrove ecotone on adjacent waters in South Florida?

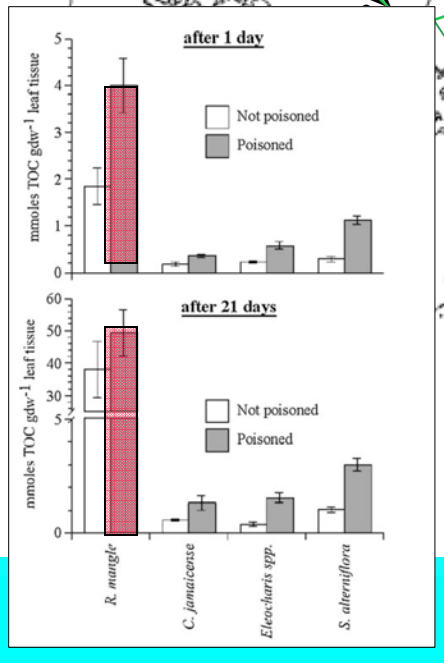


Mangroves export dissolved organic carbon (DOC)
- Flume and Leaching Studies -

MANGROVE-TIDAL CREEK FLUX

•Net annual export of DOC from the fringe mangrove IS 56 g C m^2 $year^{-1}$



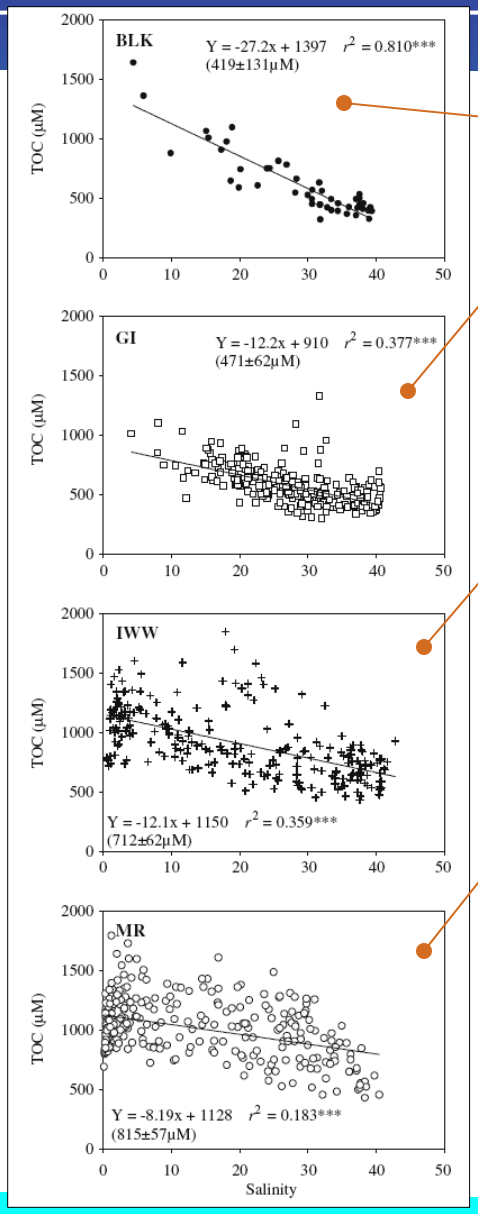


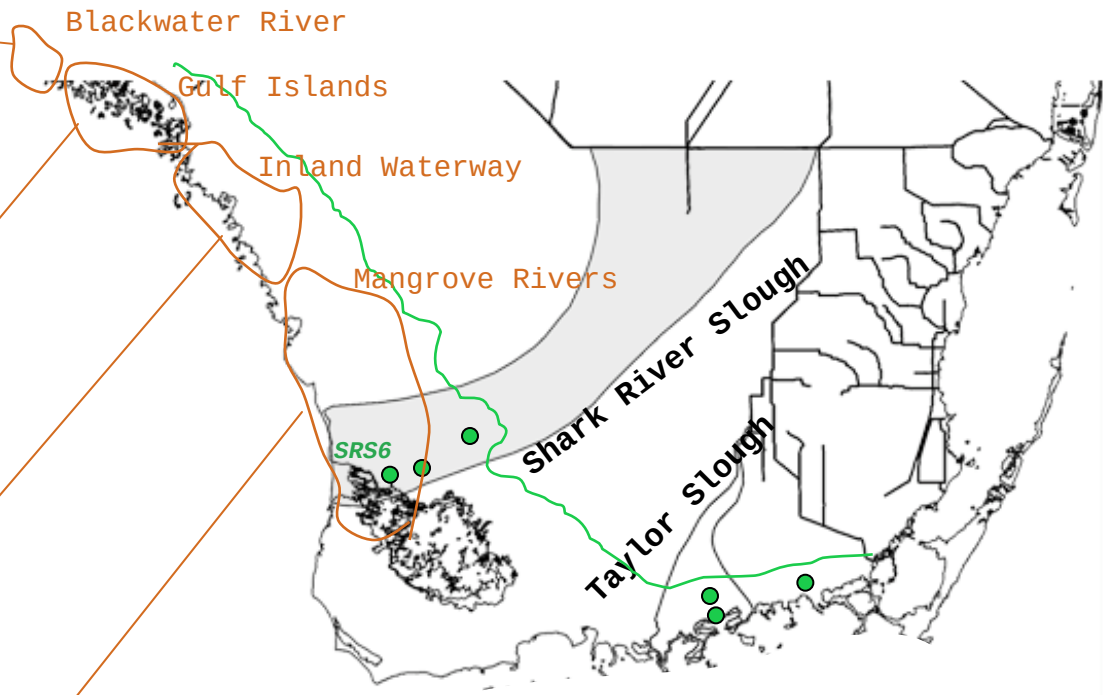
•Leaves of R. mangle released much more TOC per gram of litter than other marsh plant species,

• contributes to the greater waterborne [DOC] observed in the mangrove ecotone

•Leaching of fresh plant litter can be an important autochthonous source of nutrients

Mangrove Ecotone is a source of Total Organic Carbon to Florida Shelf water

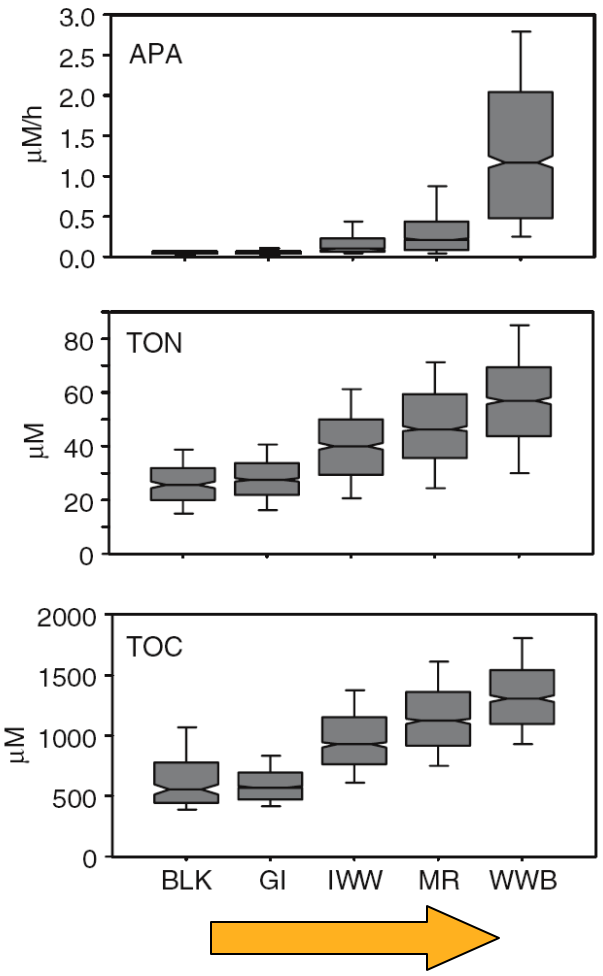


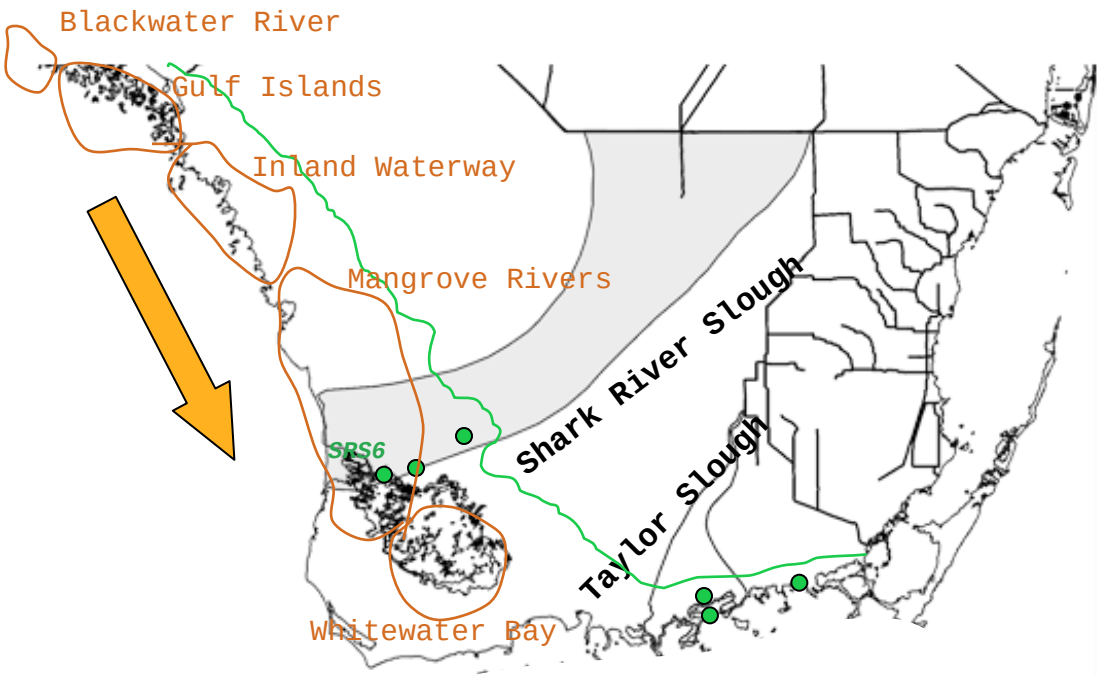


- **There is a hydrological control of TOC & DOM quality**
- **There is a conservative mixing of TOC with Florida Shelf water**
- **Higher variability and low regression in MR is due to seasonal salinity fluctuations in addition to the non-point source nature of DOM in this zone**
- **Mangrove forests work as TOC source**
- **Fluorence index used to characterize DOM indicates that MR and IWW export a considerable amount of mangrove DOM in both Rainy and Dry Season through tidal forcing**

Maie et al 2006; Boyer et 2006

Mangrove Ecotone is a source of Total Organic Carbon and Nitrogen to Florida Shelf water





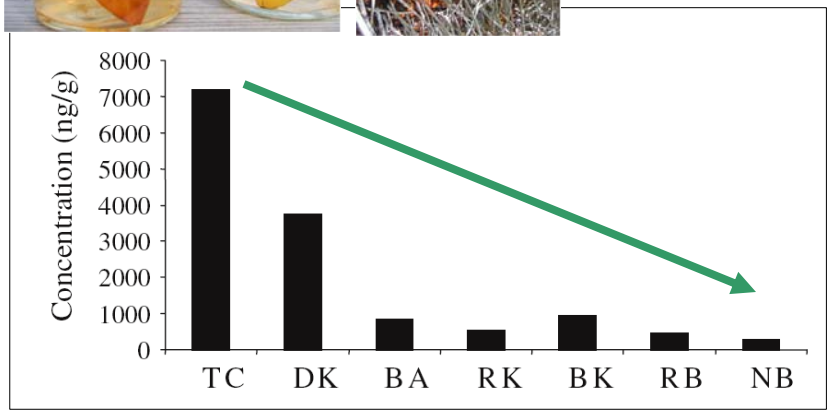
•Most of N (>90%) and P (~90%) are in ORGANIC form in the oligotrophic Florida Coastal Everglades-;

• Total Organic Nitrogen (TON) and Total Organic Carbon (TOC) concentrations increase at the Mangrove Rivers and Whitewater Bay regions by the production of organic matter in the mangrove ecotone

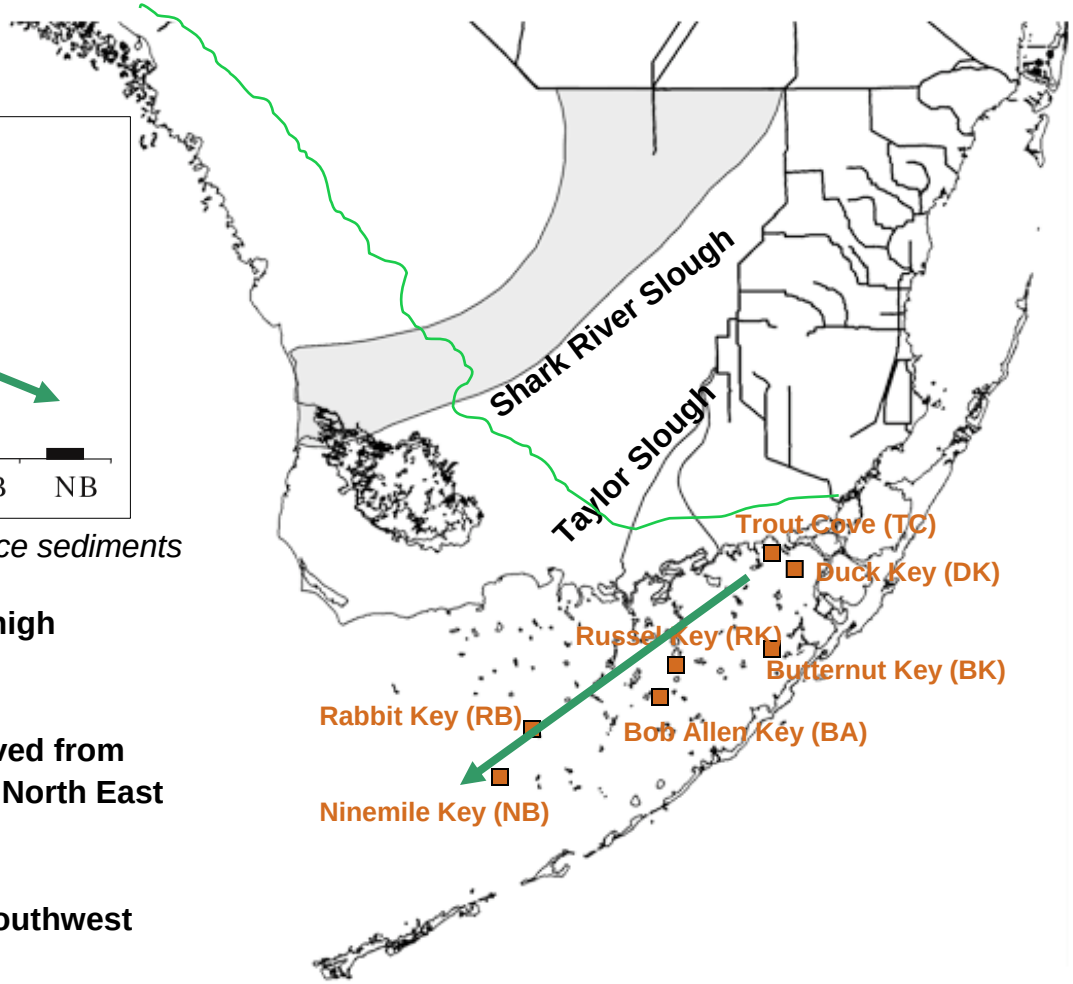
•Alkaline Phosphatase activity measures the amount of enzymatic activity present in the sample; high activity in Whitewater Bay-high water residence times

Boyer et 2006; Maie et al 2006;

Mangrove Organic Matter footprint in Florida Bay: Taraxerol



Taraxerol concentration in Florida Bay surface sediments



- **Mangrove leaves contain exceptionally high abundance of Taraxerol up to 1.4 mg/g**

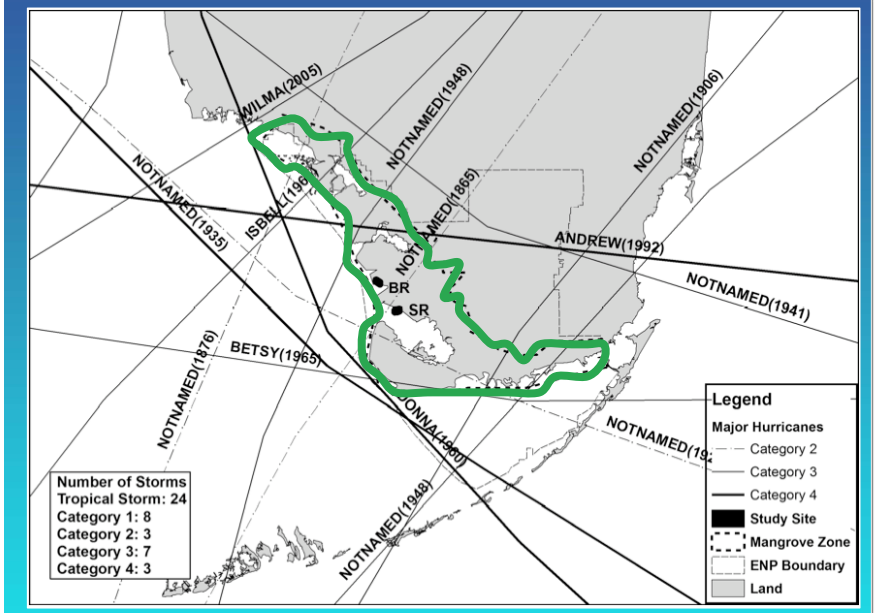
- **More than 60% of Organic Matter is derived from terrestrial mangrove contributions in the North East Section of Florida Bay**

- **Approximately 12% in the Central and Southwest sections**
- **Organic matter from the mangrove ecotone has less influence on Florida Bay than the Western Region**

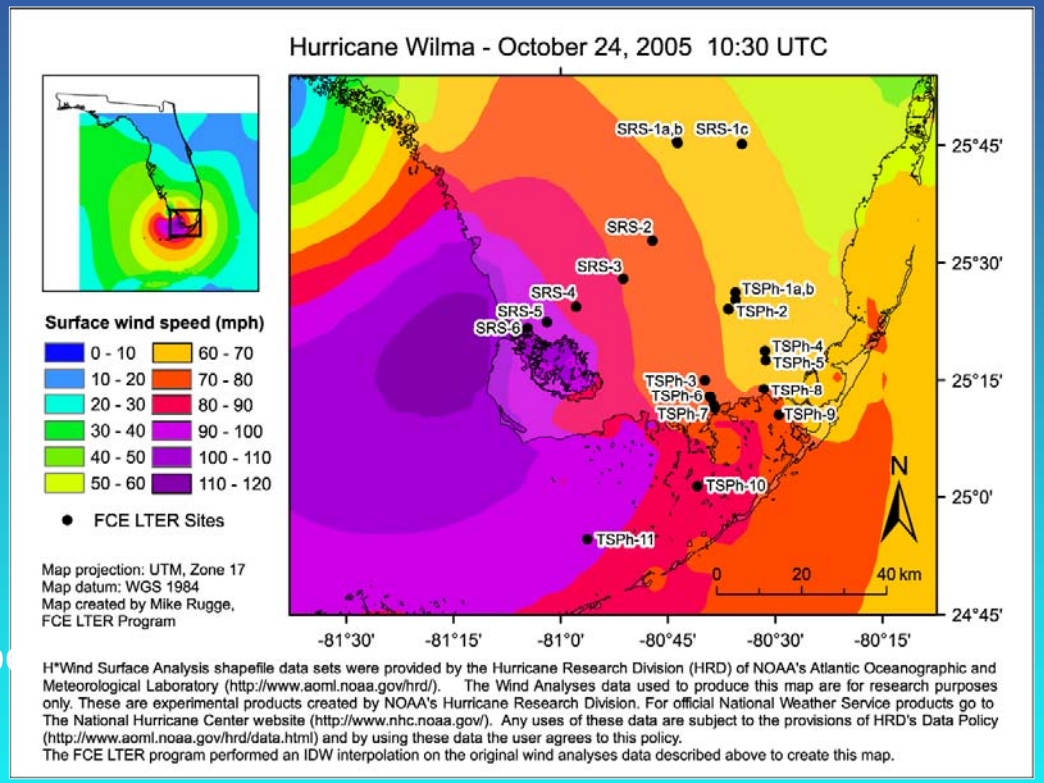
Xu et al 2006

Hurricanes influences the productivity of the mangrove ecotone region

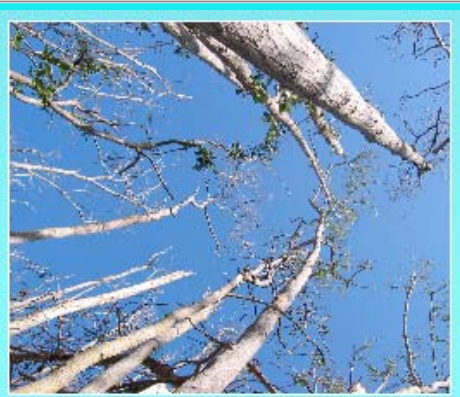
- *Impacts on structure and community dynamics: carbon allocation and nutrient cycling*



Major Storms in the period 1851 - 200



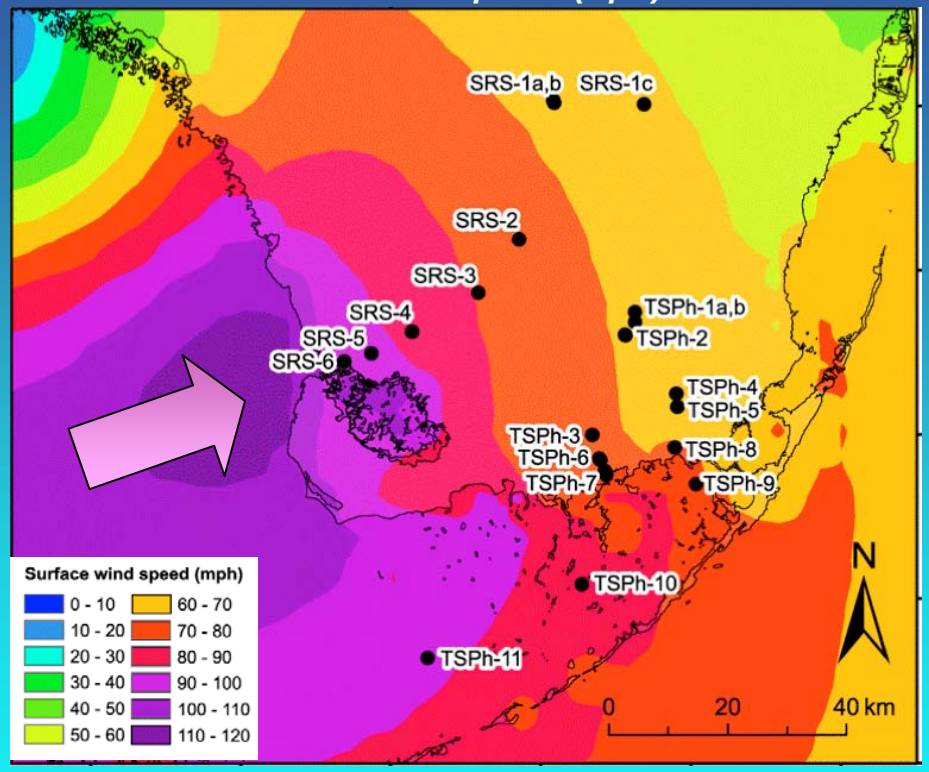
H*Wind Surface Analysis shapefile data sets were provided by the Hurricane Research Division (HRD) of NOAA's Atlantic Oceanographic and Meteorological Laboratory (http://www.aoml.noaa.gov/hrd/). The Wind Analyses data used to produce this map are for research purposes only. These are experimental products created by NOAA's Hurricane Research Division. For official National Weather Service products go to The National Hurricane Center website (http://www.nhc.noaa.gov/). Any uses of these data are subject to the provisions of HRD's Data Policy (http://www.aoml.noaa.gov/hrd/data.html) and by using these data the user agrees to this policy.
The FCE LTER program performed an IDW interpolation on the original wind analyses data described above to create this map.



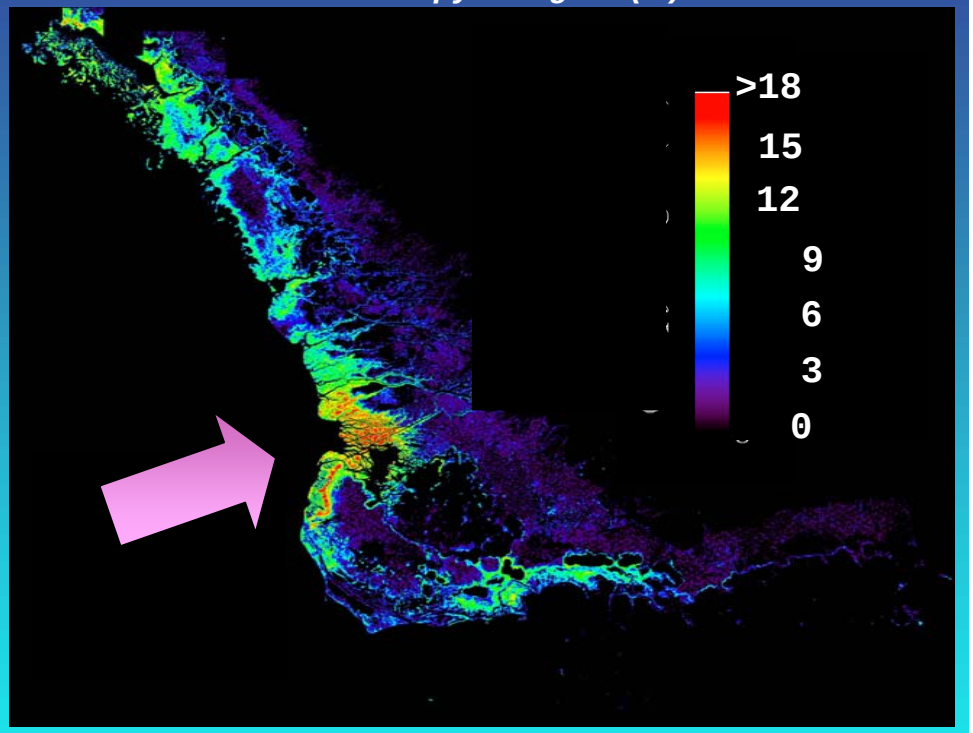
Keqi et al in press; Ru

Hurricanes, as pulsing landscape-level events, add P as result of resuspension and redistribution

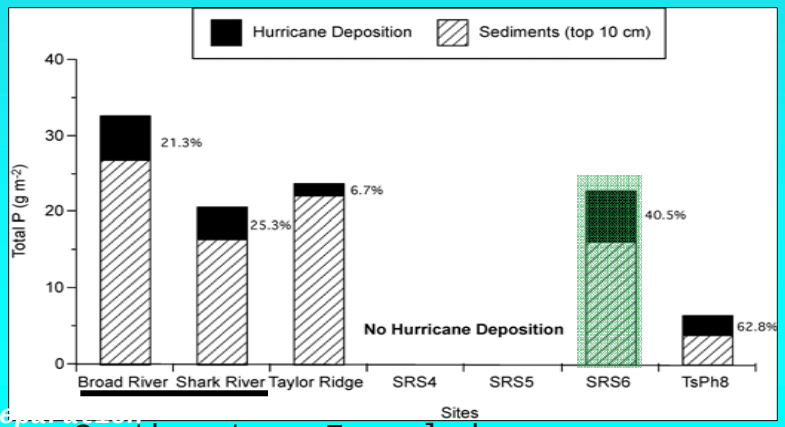
Wind Speed (mph)



Canopy Height (m)



•Total P concentrations in carbonate deposited sediments in southwestern Everglades and Florida Bay areas ranged from 1.5 to 6.5 g m^{-2}



Southwestern Everglades

Rugee, unpublished results ; Simard et al 2006; Castaneda in prep

Conclusions and Research Directions

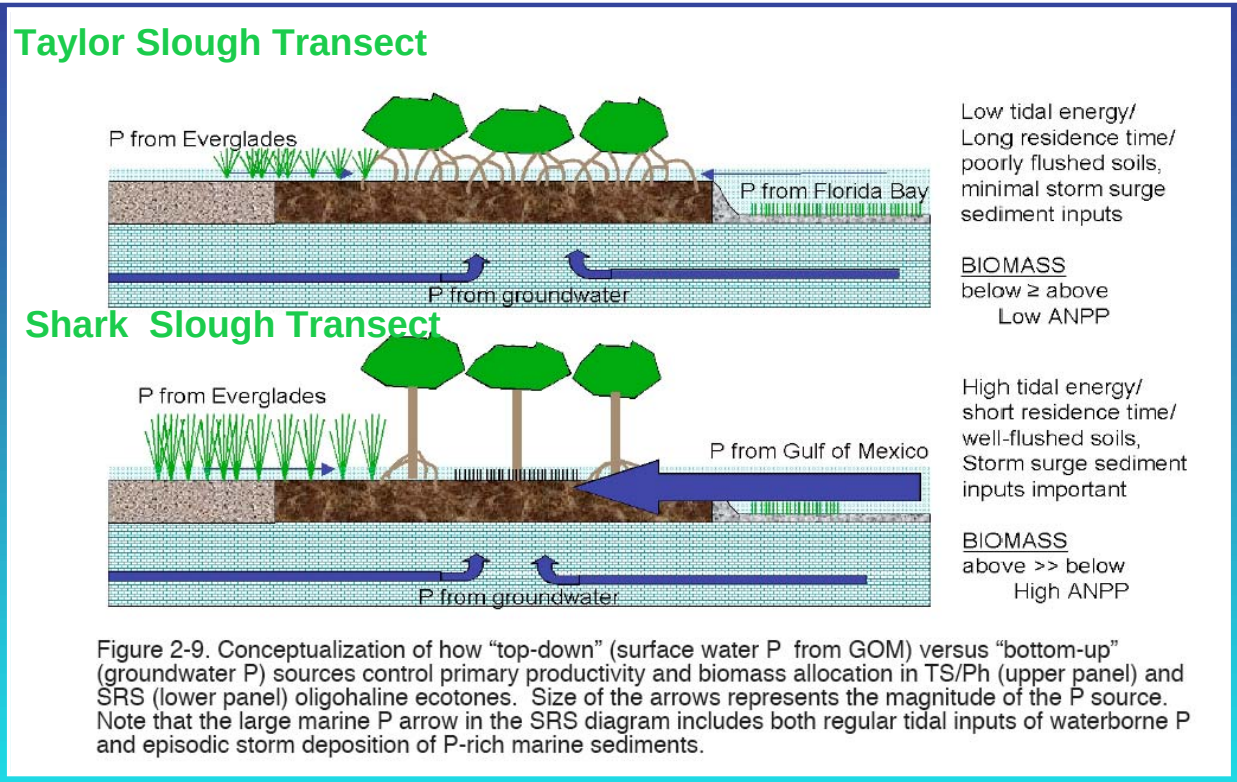


Figure 2-9. Conceptualization of how "top-down" (surface water P from GOM) versus "bottom-up" (groundwater P) sources control primary productivity and biomass allocation in TS/Ph (upper panel) and SRS (lower panel) oligohaline ecotones. Size of the arrows represents the magnitude of the P source. Note that the large marine P arrow in the SRS diagram includes both regular tidal inputs of waterborne P and episodic storm deposition of P-rich marine sediments.

- Ecotone productivity is high and shows significant spatial differences
- Productivity is strongly regulated by marine phosphorus sources and water residence time
- Freshwater management has had and will have major effects on productivity patterns, particularly in the Taylor Region; changes in salinity in the Shark River region as result of freshwater diversion will potentially modify vegetation boundaries
- Need to understand the relative importance of P groundwater sources in controlling productivity