



FCE ASM 2008

BIOGEOCHEMICAL CYCLING

WORKING GROUP PARTICIPANTS

Joseph Boyer, Len Scinto, Jeff Absten, Edward Castaneda, Susan Dailey, Stephen Davis, Jeana Drake, Jack Fell, James Fourqurean, Rafael Guevara, Anne Hartley, Kelly Henry, Darrell Herbert, Rudolf Jaffe, Krish Jayachandaran, Kristine Jimenez, Greg Koch, Laurel Larsen, Kung-Jen Liu, Greg Losada, Philip Matich, Vickie McGee, Jay Munyon, Greg Noe, Oliva Pisani, Amanda Quillen, Mark Rains, Damon Rondeau, Katherine Segarra, Suresh Subedi, Ania Wachnicka



CENTRAL QUESTIONS

GENERAL QUESTION 4: How do water residence time and the magnitude of nutrient inputs, primarily from freshwater inflows, marine inputs, and groundwater, control local nutrient concentrations and cycling rates in the oligohaline ecotone?



GENERAL APPROACH

The overall effect (measured as phytoplankton productivity and biomass) of nutrient loading is strongly controlled by estuarine water residence time.



STATUS (PARTIALLY COMPLETED)

We presented this comparison last year for Florida Bay. Need to analyze Shark River Estuary.



SPECIFIC RESEARCH QUESTION 4-1

What are the mechanisms by which P availability acts to regulate N cycling rates in marshes and mangroves of the southern Everglades?



APPROACH 1

Measurement of P-amended nutrient fluxes along lower Taylor River and Little Madeira Bay.

Steve Davis and Victor Rivera-Monroy



STATUS (ACTIVE)

Goal: to understand the role of season and increased P on the exchange of C, N and P between the soil/sediment and water column
Benthic fluxes of DO, DIN, DIP, and DOC measured at four stations from 2006-2008.





Florida Coastal Everglades Long Term Ecological Research



1. Experiments run during early wet season (August), dry season (May), and transition from wet to dry season (January) for 3 years
2. Peat soil cores collected from TS 7b and sediment cores from pond 1 in lower Taylor River, eastern Little Madeira Bay, and western Little Madeira Bay (the latter two chosen to understand prevailing wind effects on sediment characteristics).
3. Cores incubated w/ controls in ambient water and enriched in DIP for four hours. Cores mixed without re-suspension. Difference between initial and final used to calculate fluxes.
4. This approach is powerful because it provides us with information on
 - a) Seasonal effects on benthic fluxes
 - b) Effect of P enrichment
 - c) ...especially when coupled with process-specific fluxes (denitrification, nitrification, etc.) and upstream-downstream/landscape-level

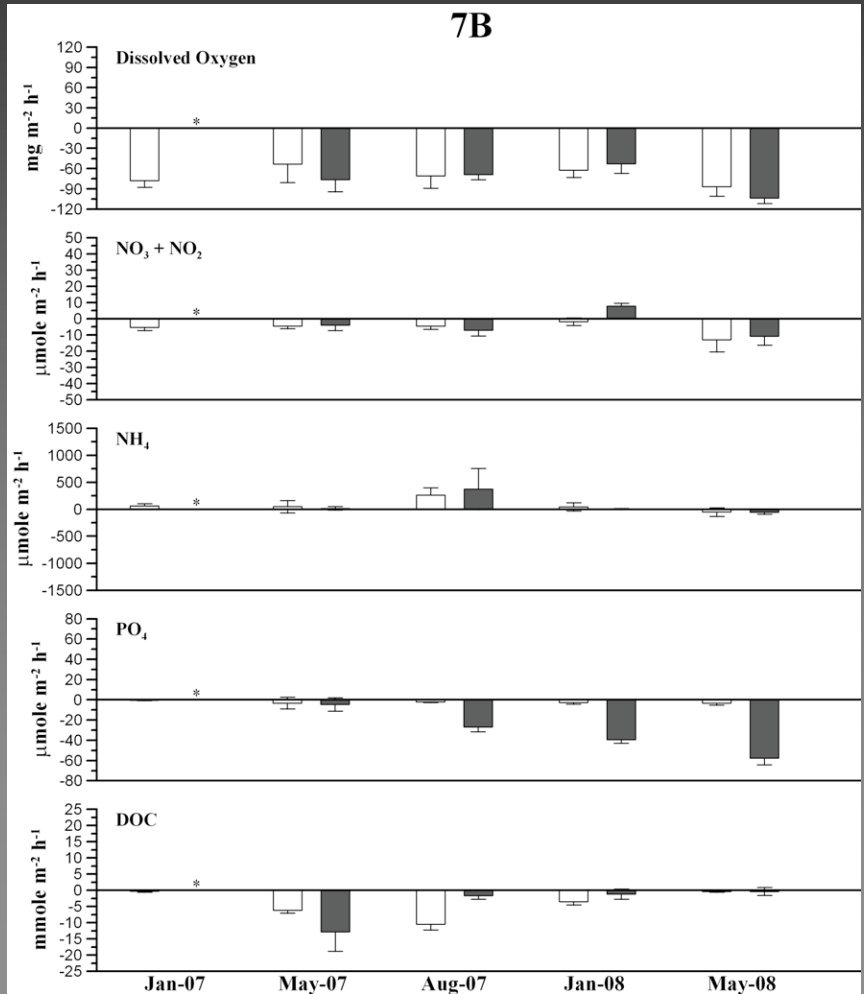
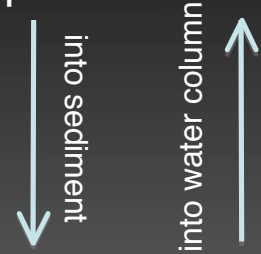


Florida Coastal Everglades Long Term Ecological Research



Benthic fluxes measured on mangrove peat soil cores from TSPH 7b

n = 5 for each
open bars = control
shaded bars = P added to water column



DO uptake, no effect of P addition

NO_x⁻ uptake regardless of P addition (denitrification?)

NH₄⁺ flux shifted, no P effect

PO₄ uptake enhanced with of P addition

mostly DOC uptake, variable interaction with P flux



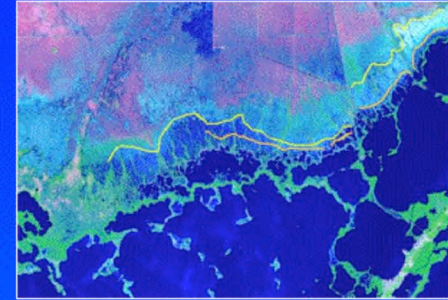
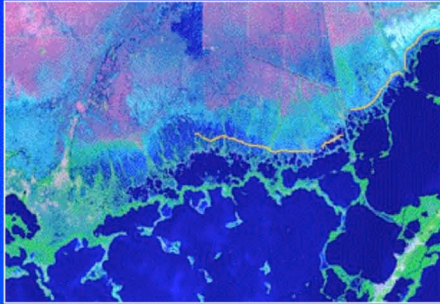
APPROACH 2

**Nitrogen cycling of estuarine wetlands of Taylor River,
Florida, USA**

**Victor H. Rivera-Monroy, Robert R. Twilley, Edward
Castañeda-Moya, Peter Lenaker, Daniel Childers**

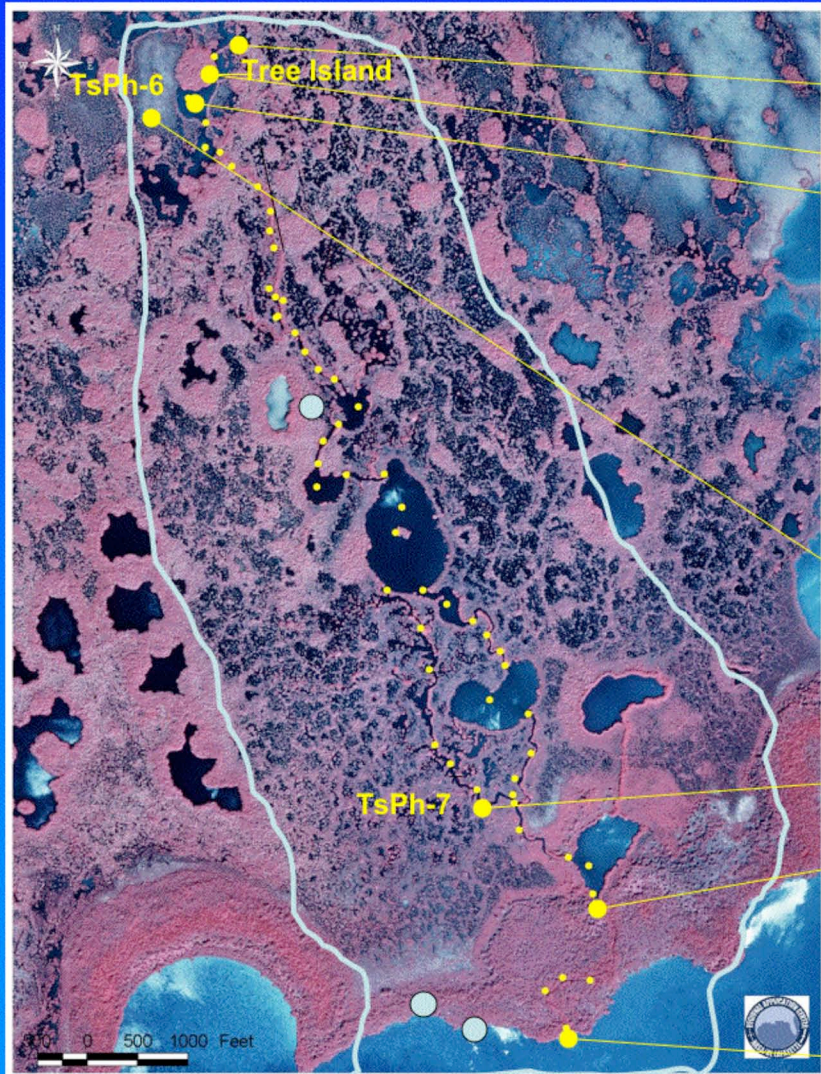


STATUS (ACTIVE)



- How do nutrient concentrations in the water column and sediment pore water control denitrification rates?
- Are there significant differences in denitrification rates among different vegetation units (mangrove, tree island) and water bodies (“Ponds”) ?

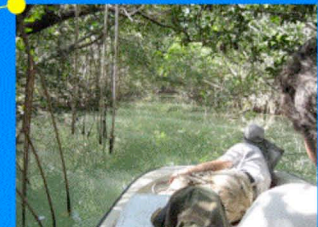
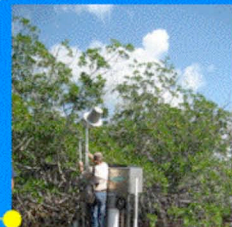
Study Area- Taylor Slough / Taylor River Sites



- ~4 Km long small channel (10-20 m width; 1-2 m depth)

- Connects a number of shallow ponds

- TsPh-6 & TsPh7 are FCE LTER sites





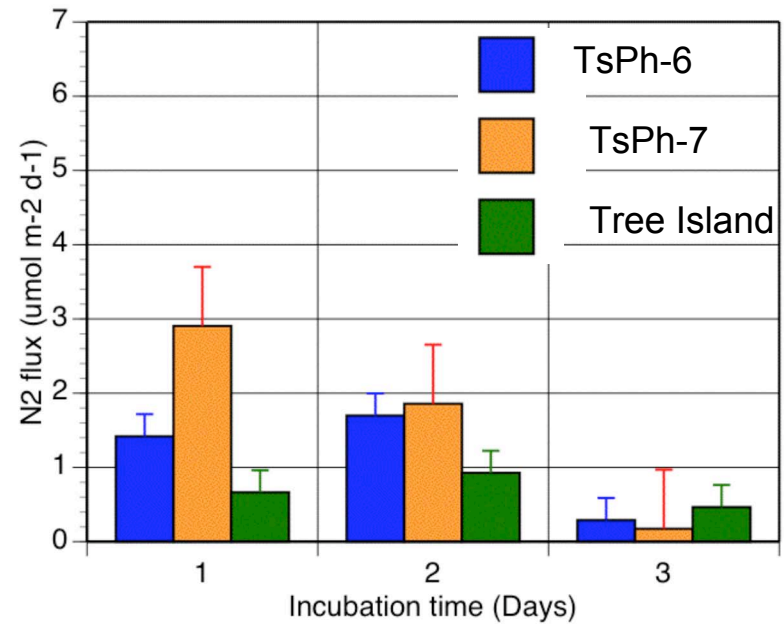
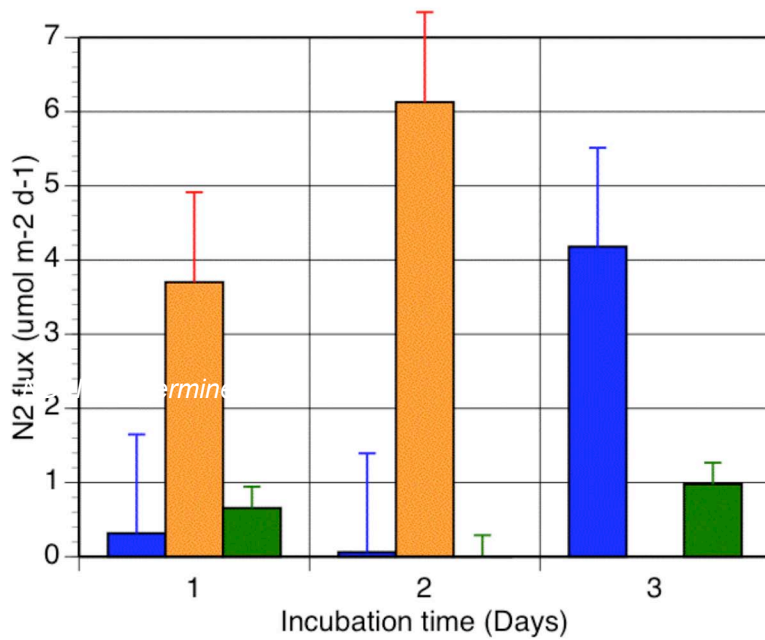
Direct denitrification rates

¹⁵N Incubation chamber technique
(¹⁵KNO₃ enrichment; 200 μmol core⁻¹)



May 2007

August 2007

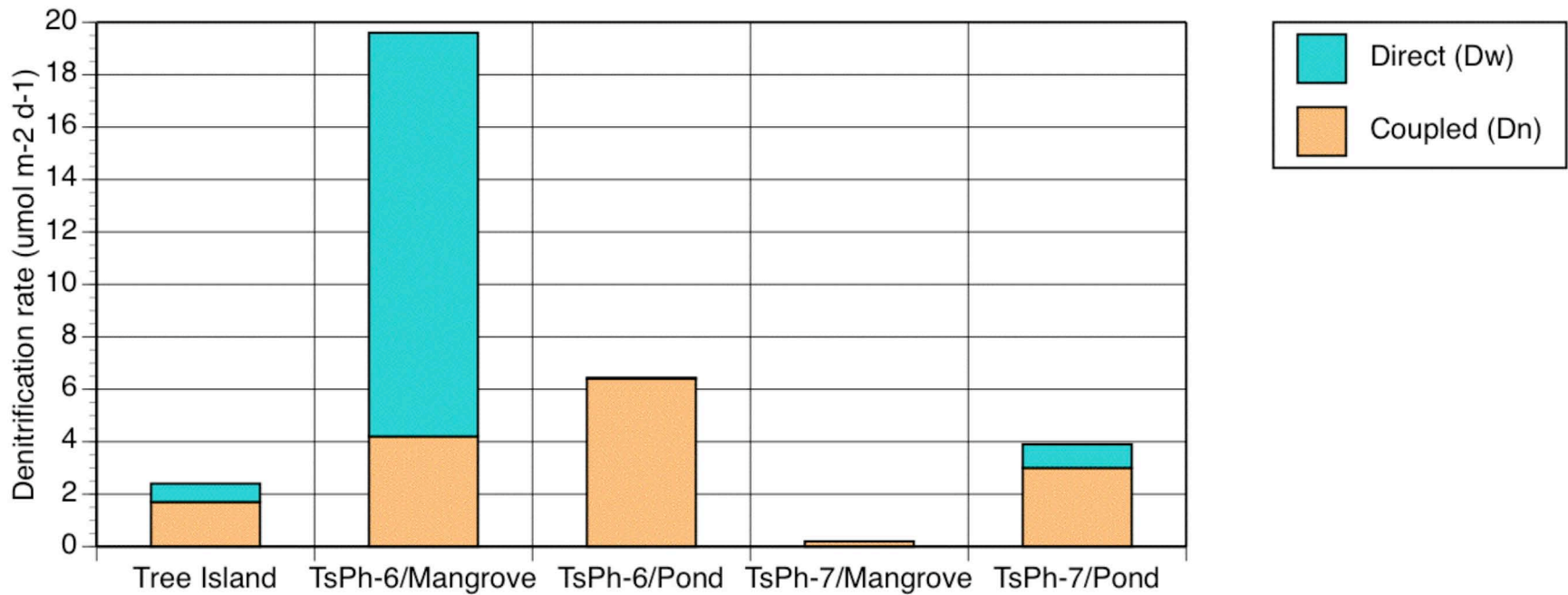




Denitrification Rates

Isotope Pairing Technique

January 2007





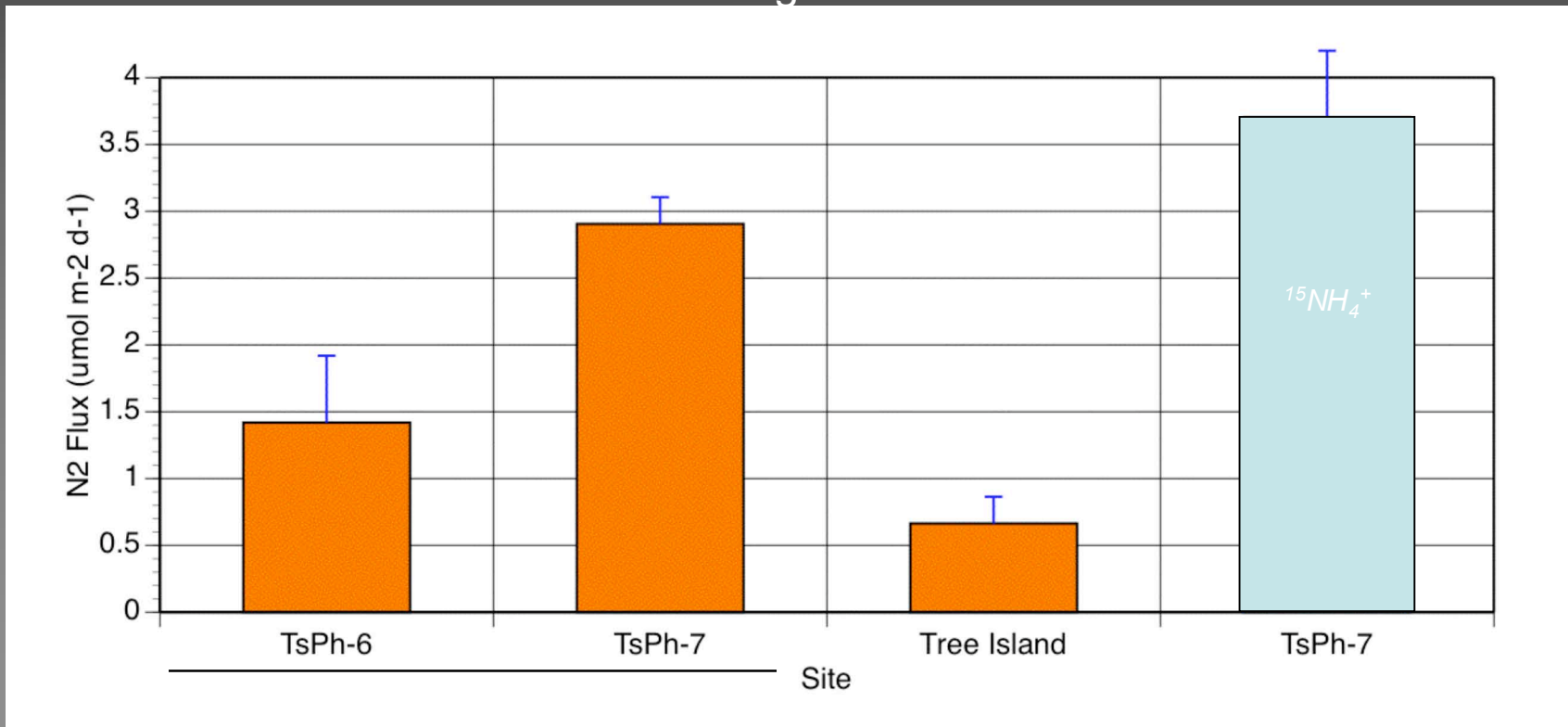
Direct denitrification rates

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August 2007

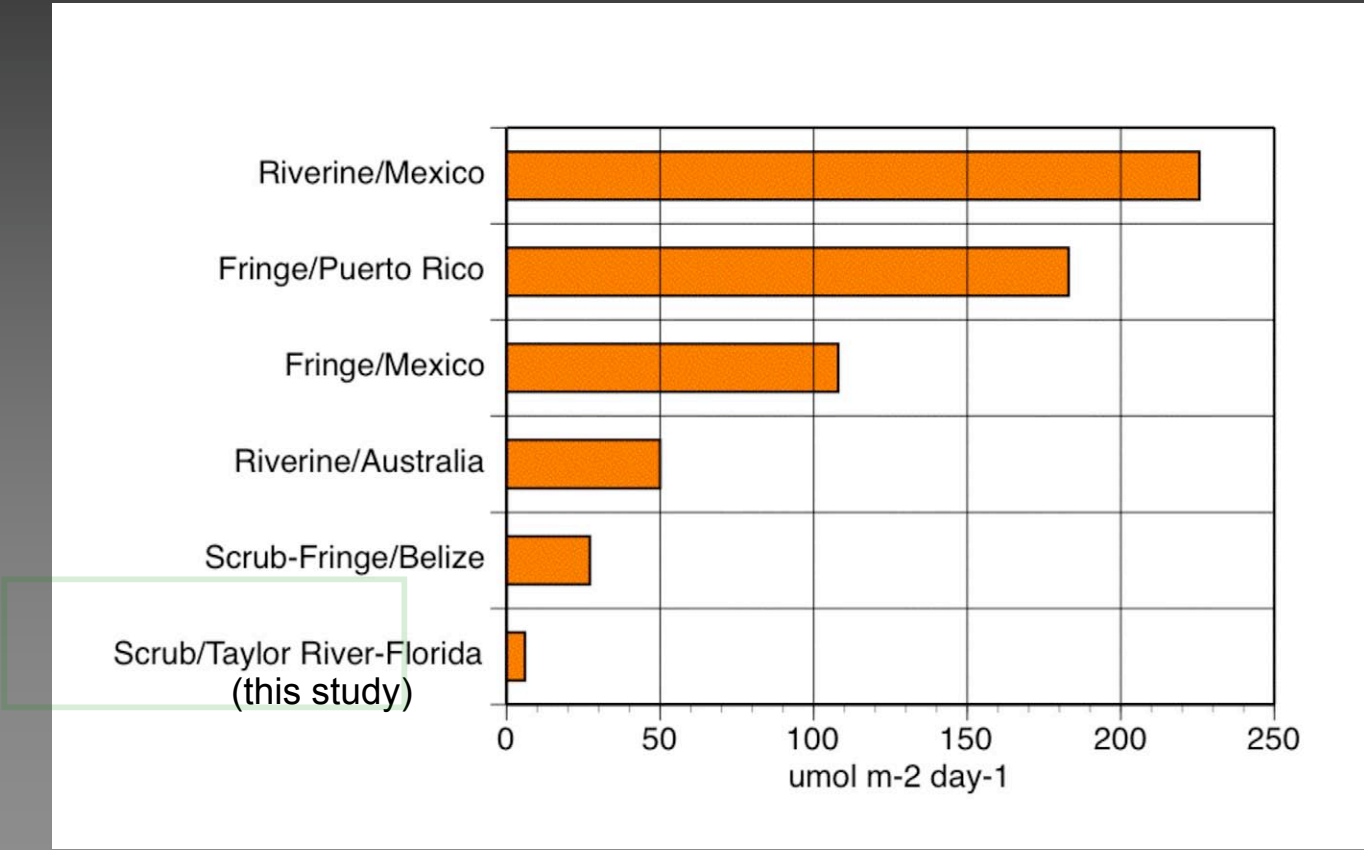
Comparison with coupled denitrification rate



Scrub mangroves



Direct denitrification rates (total) in several types of mangrove forests





CONCLUSIONS

- Low NO_3^- concentrations in the water column limit direct denitrification in ponds, mangrove and tree island sediments,
- Denitrification rates obtained with the IPT and ^{15}N chamber incubation techniques were within the same order of magnitude and ranged from 1-19 $\mu\text{mol m}^2 \text{d}^{-1}$; average total denitrification rate for the region was 4 $\mu\text{mol m}^2 \text{d}^{-1}$; a low rate in comparison to other systems



SUPPLEMENTAL RESEARCH QUESTION

Soil organic carbon dynamics in tropical peatlands are a product of interacting effects among hydrological, chemical and biological factors. Anthropogenic drivers such as climate change, nutrient inputs and hydrologic modifications act synergistically to shift the SOC balance from C sink to C source in tropical peatlands.

(LTER Supplement to Troxler)



APPROACH 3

Measure CO₂ flux as function of tidal inundation.

Also new proposal to NSF - Synergistic effects of multiple anthropogenic stressors in coastal peatlands.

-to determine the relative influence of plant and microbial community structure and metabolism on C storage in tropical peatlands

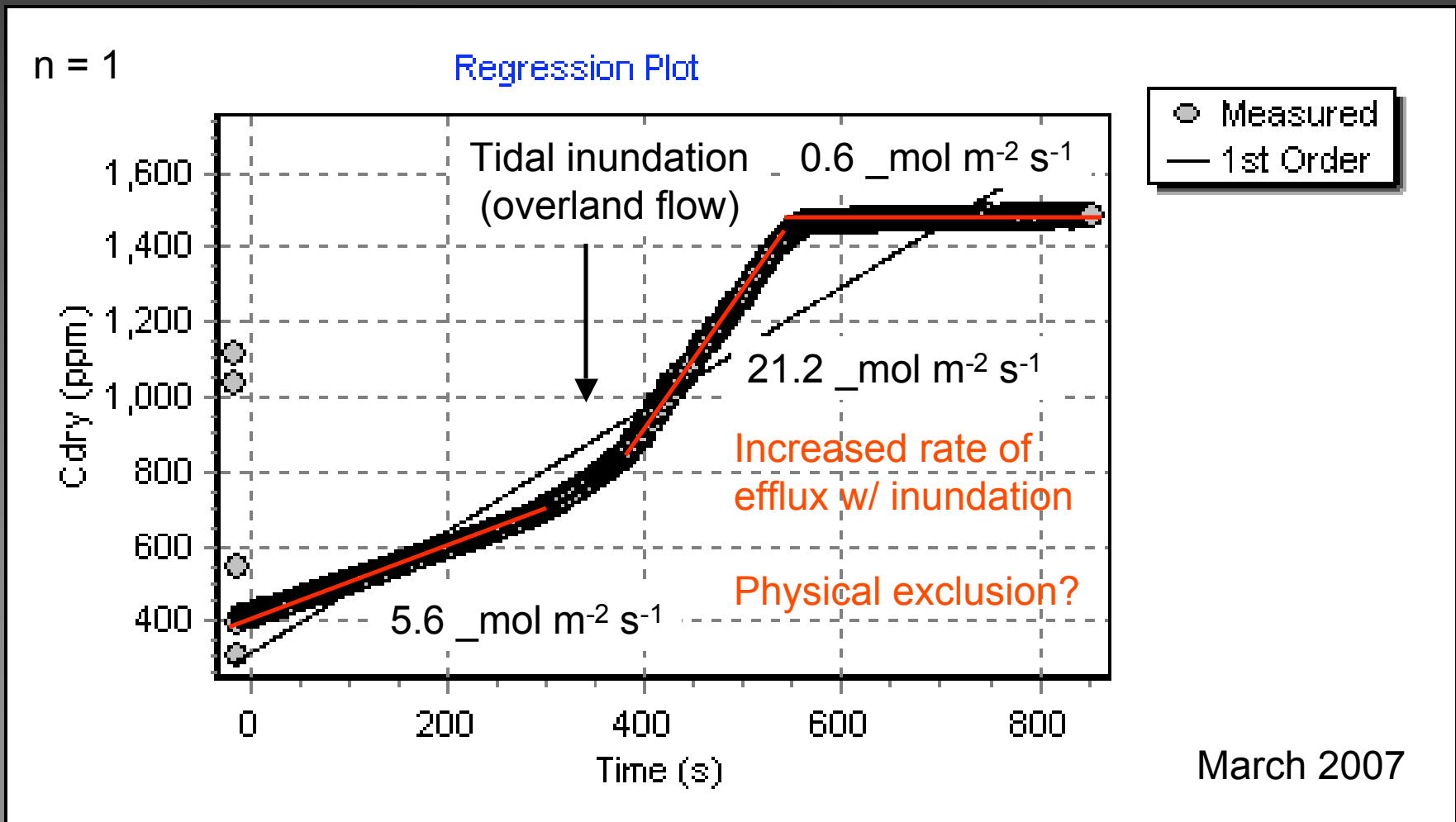
-framework for evaluating the relative influence of drivers of plant production and microbial respiration on C storage because of differential controls on carbon dynamics that occur along natural nutrient gradients

Troxler et al.



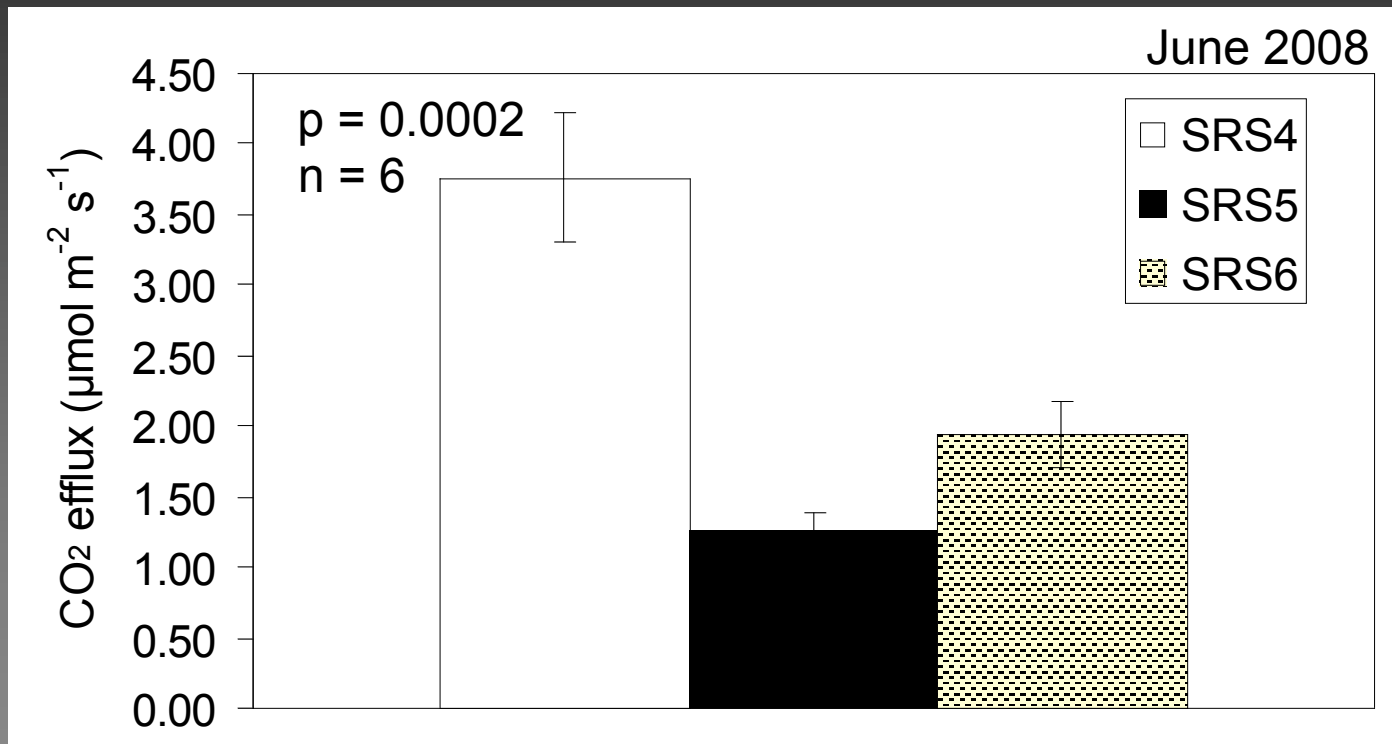
STATUS (ACTIVE)

Temporal variability in carbon dioxide efflux with tidal inundation at SRS 6





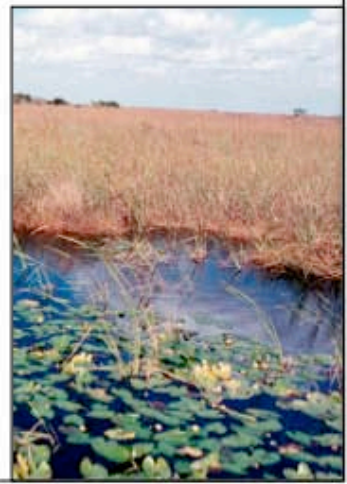
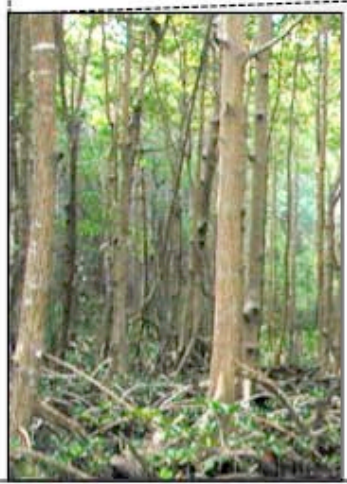
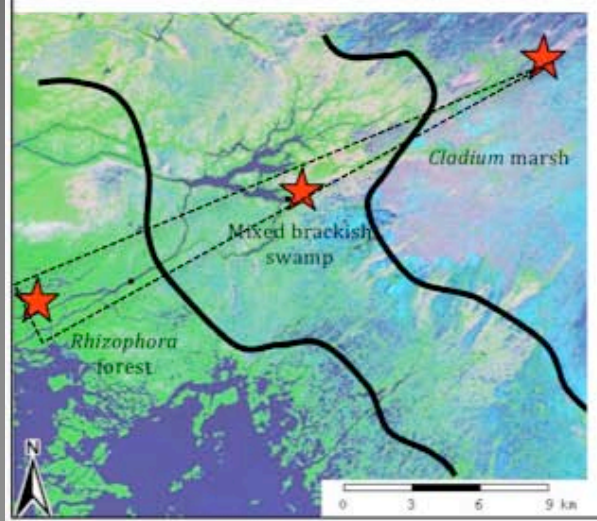
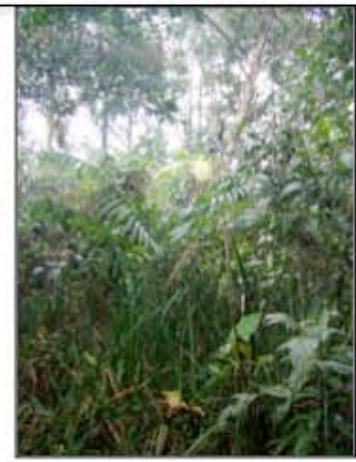
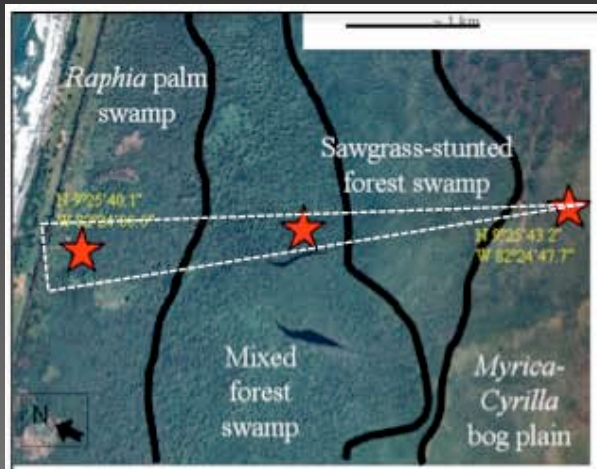
Carbon dioxide efflux at SRS 4, 5 & 6



- Tidal inundation contributes to high temporal variability in flux rates
- SRS 4 among highest reported efflux rates for mangrove systems (see Lovelock 2008); SRS 5 & 6 within range of other systems



Proposal: Synergistic effects of multiple stressors in coastal peatlands



Nutrient availability



SPECIFIC RESEARCH QUESTION 4-2

How is the bacterial community influenced by temporal changes in water source in the oligohaline ecotone, and how are these community shifts reflected in ecosystem processes, such as those of the N cycle?



APPROACH

- **Bacterial Metagenomics** - T-RFLP analysis
- **Yeast/Fungi Community Structure** – Luminex xMAP
- **Pyrosequencing** - 454 Sequencing is a massively-parallel pyrosequencing system capable of sequencing roughly 100 megabases of **raw** DNA per 7-hour run (no amplification).
- **Anammox measurements**



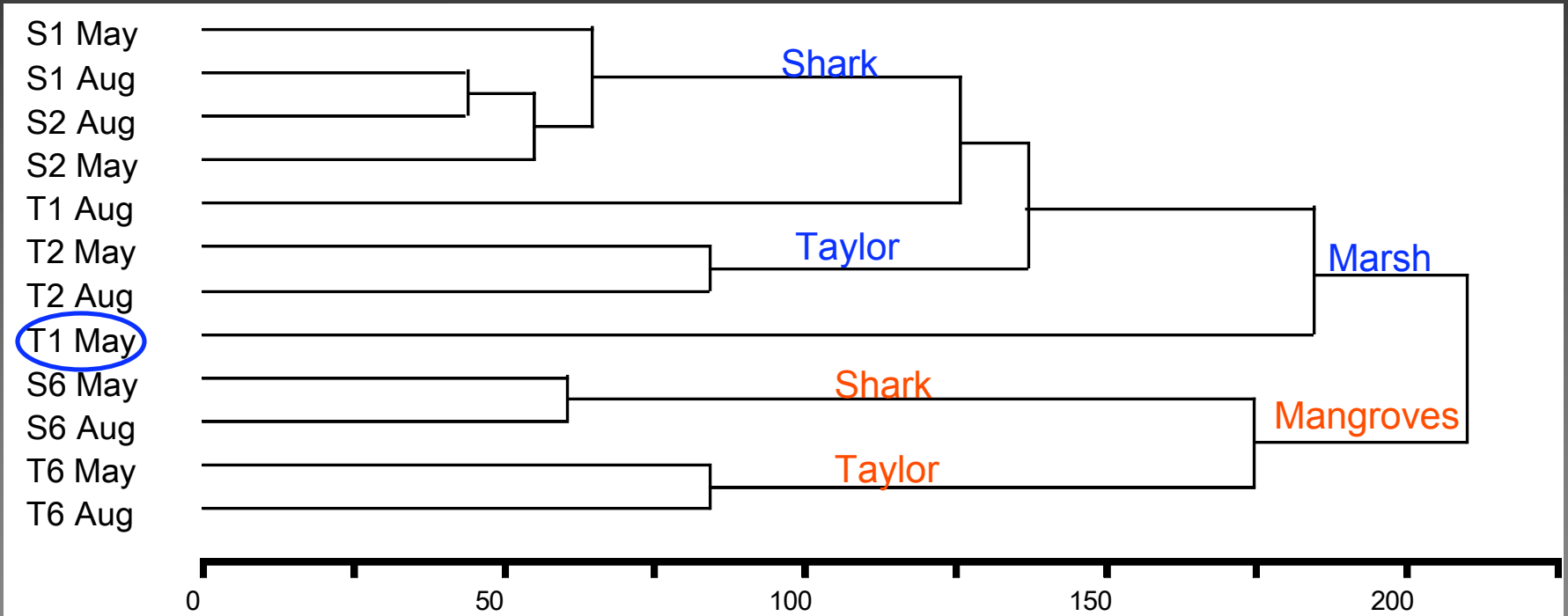
STATUS (ACTIVE AND COMPLETED)

Bacterial Metagenomics of Soils and Sediments – Much work already done, but see poster for water column bacterial community structure comparison.

Bacterial Metagenomics of Floc – Dr. Rafa Guevara has joined my lab and is continuing previous work.



Floc Bacteria Cluster Analysis



In Mangroves, major difference is at level of watershed, not season.
In Marsh, watershed still dominates but season has more pronounced effect.



Pyrosequencing

454 Sequencing is a massively-parallel pyrosequencing system capable of sequencing roughly 100 megabases of raw DNA per 7-hour run (no amplification).

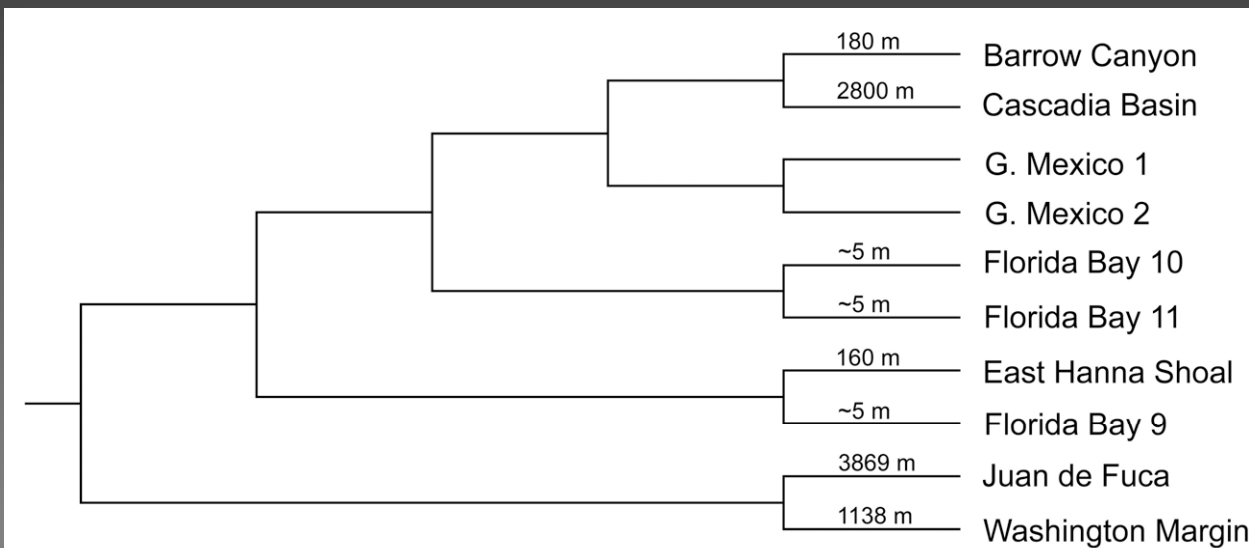
- **Linda Amaral-Zettler, MIRADA Project - NSF funded through ICOMM @ WHOI (water column bacteria, archaea, and eukaryotes)**
- **Ryan Penton & Jim Tiedje, Center for Microbial Ecology @Michigan State (marine sediments for bacteria)**



Florida Coastal Everglades Long Term Ecological Research



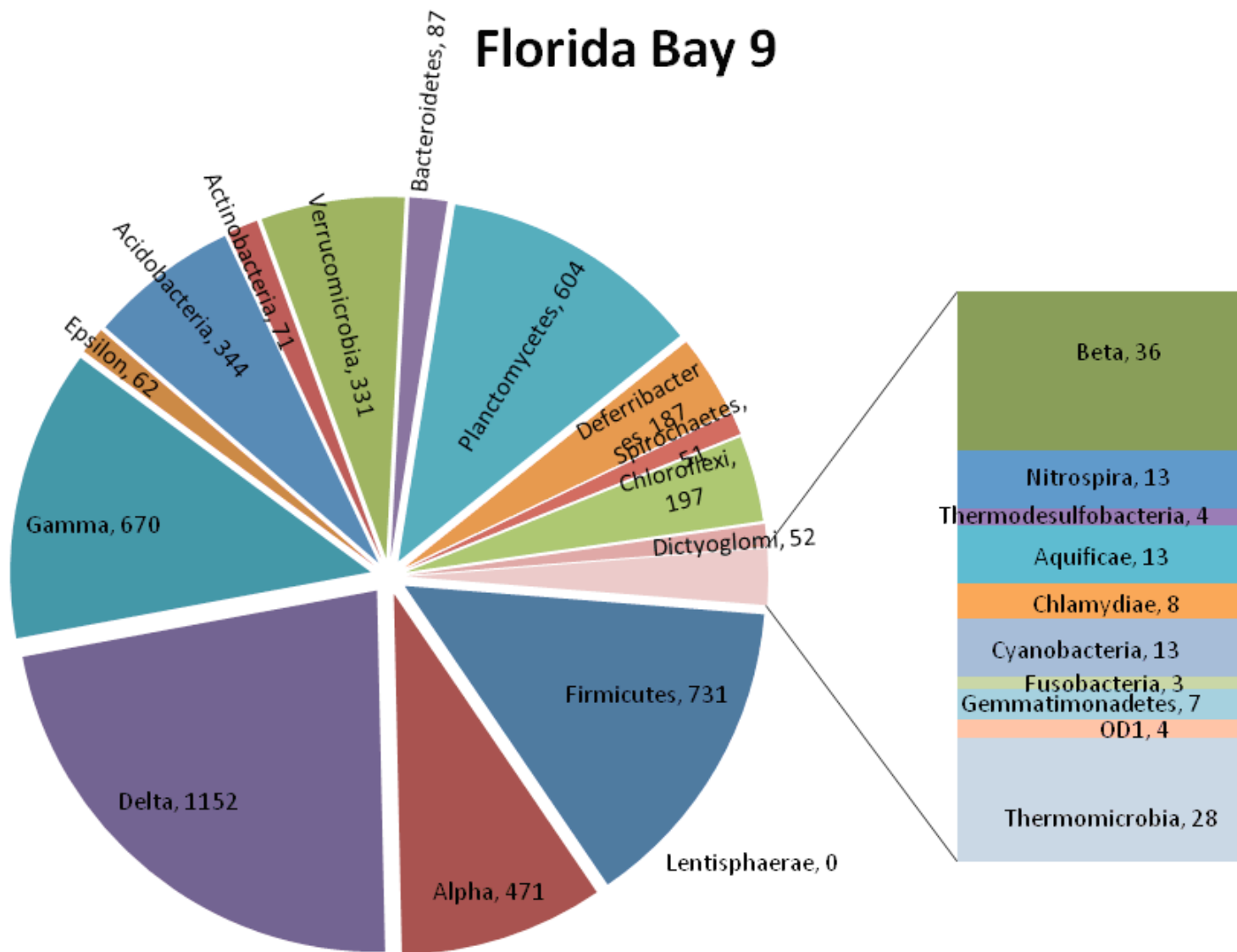
Florida Bay 11 has highest Shannon diversity with 10 and 9 following.
than others



Chao-Sorenson based UPGMA tree based on 0.05% cluster dissimilarity (7615" genus
The same relationship exists at the 0.01% dissimilarity level (15,195 "species" level

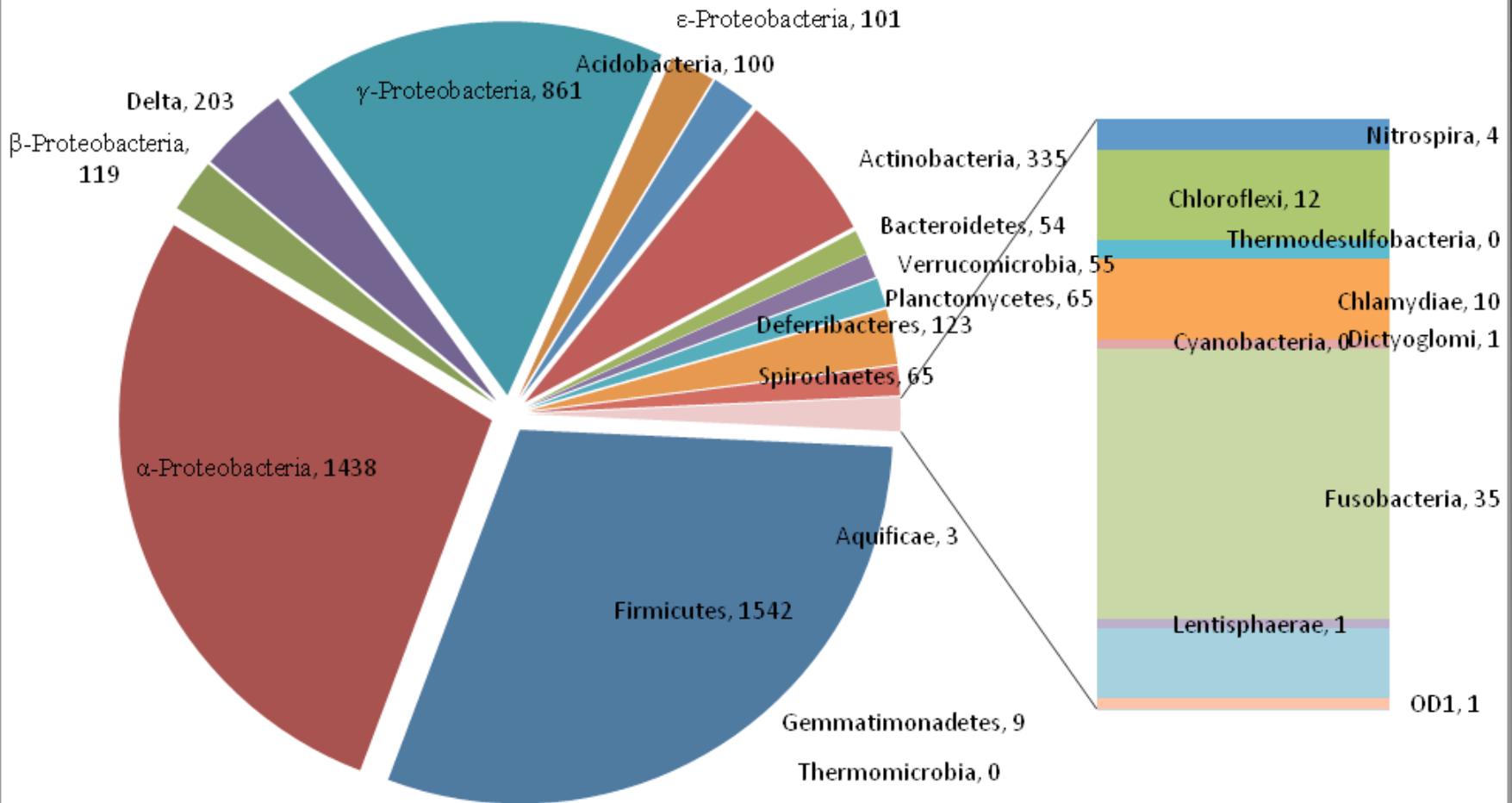


Florida Bay 9



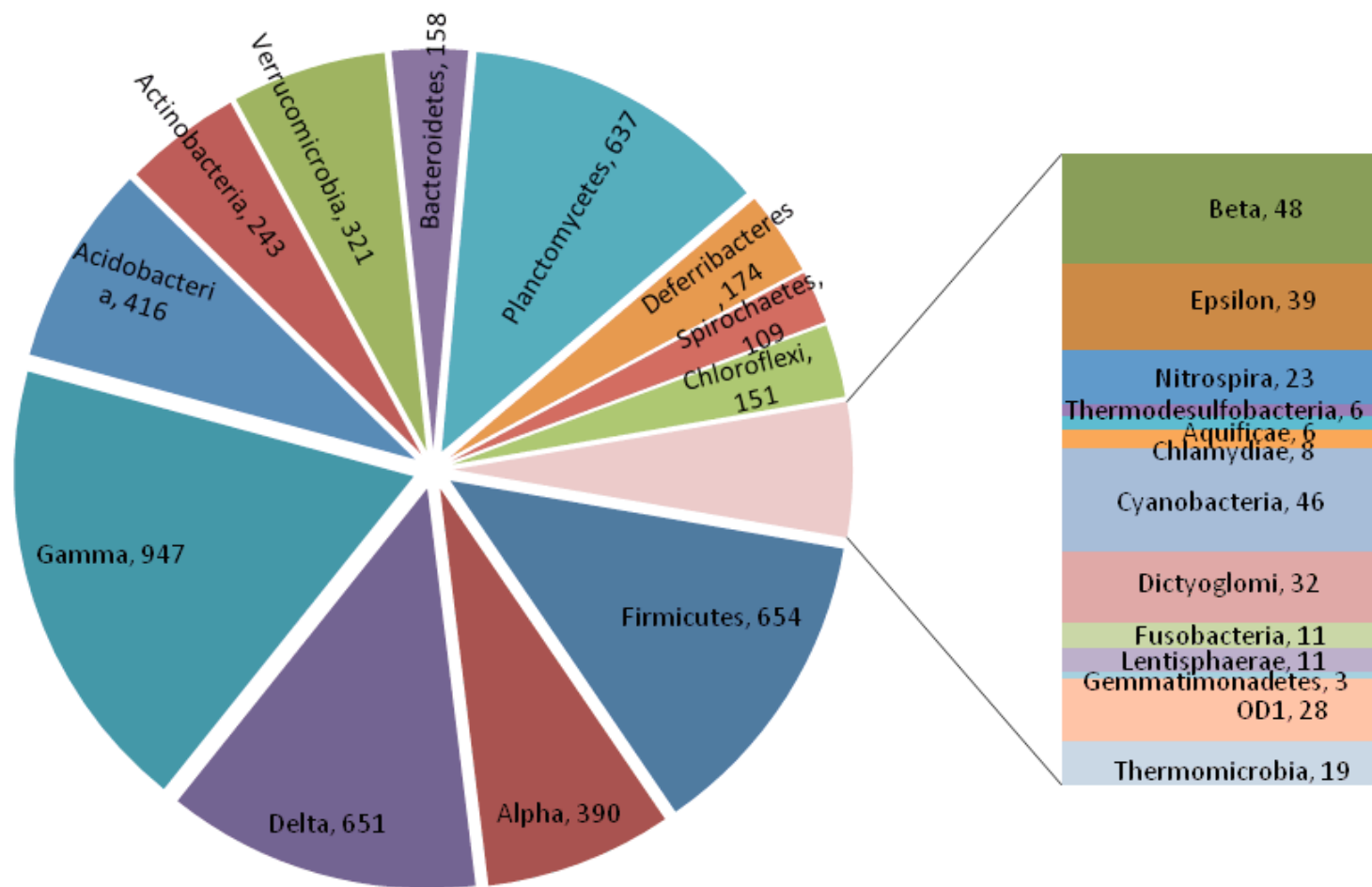


Florida Bay 10





Florida Bay 11

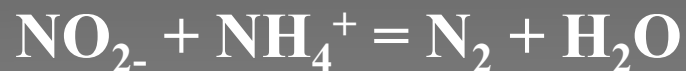




Anammox

Recently described **AN**aerobic **AMM**monia **OX**idation process.

Analogous to denitrification



Plan to collaborate with Jim Heffernan's MIMS to address rates across the LTER as function of P availability.

Koop-Jakobsen & Giblin 2009



CRITICAL DATA NEEDS

Group data: N cycling rates, bioavailability of floc, floc fungal community, etc.

FCE data: Mass flows to the estuaries, soil chemistry, ISCO data synthesis, etc.



WHERE WE ARE

- Beginning to unravel residence time/productivity issue
- On the way towards better understanding of N cycle
- Defining microbial community structure dynamics
- Not there yet with functional attributes of metagenomics (gene expression, etc.)



PRODUCTS TO DATE

Lots of presentations

Some proposals submitted

Few manuscripts in review

Couple pubs out



PRESENTATIONS

1. Kelble, C. R., J. N. Boyer, D. Rudnick, and P. B. Ortner. 2008. Water quality monitoring in the southern estuaries. GEERS – Orlando, FL.
2. Rivera-Monroy, V. H., S. E. Davis III, R. R. Twilley, D. L. Childers, M. Simard, R. Chambers, R. Jaffe, J. Boyer, D. Rudnick, E. Castañeda-Moya, T. Troxler, C. Coronado-Molina, and G. B. Noe. 2008. The Role of the Mangrove Ecotone Region in Regulating Nutrient Cycling and Wetland Productivity in South Florida. GEERS – Orlando, FL.
3. Kelble, C. R., J. N. Boyer, C. Mitchell, and P. B. Ortner. 2008. Marine and Estuarine Goal Setting for South Florida (MARES). Florida Bay Conference – Naples, FL.
4. Boyer, J. N., M. Ikenaga, A. Dean, and C. Pisani. Species Composition of Cyanobacterial Blooms in Florida Bay. Florida Bay Conference – Naples, FL.
5. Briceño, H. O. and J. N. Boyer. 2008. Storm Strength, Proximity, and Water Residence Time Differentially Affect the Magnitude of Impact and Recovery Time of Phytoplankton Biomass in Separate Zones of Florida Bay. Florida Bay Conference – Naples, FL.
6. Jaffé, R., M. Chen, Y. Yamashita, N. Maie, K. Parish, R. M. Price, J. N. Boyer, and L. Scinto. 2008. Characterizing the Dynamics of Dissolved Organic Matter in the Florida Coastal Everglades. Florida Bay Conference – Naples, FL.
7. Cosby, B. J., J. N. Boyer, H. Briceno, F. Marshall, and W. Nuttle. 2008. Advection and Exchange in Florida Bay Inferred from Long-term Water Quality Data. Florida Bay Conference – Naples, FL.
8. Boyer, J. N. 2009. Compound Interest: The Value of Long-Term Coastal Water Quality Monitoring in South Florida. Everglades Coalition Meeting – Miami, FL.
9. Briceño, H. O., and J. N. Boyer. 2009. Impact and Recovery Time of Phytoplankton Biomass After Major Storm in Separate Zones of Florida Bay, USA. 2009 ASLO Annual Meeting – Nice, France.
10. Guevara, R., M. Ikenaga, C. Pisani and J. N. Boyer. 2009. Bacterial community structure in sediment and water samples from freshwater marsh, mangrove and seagrass, in the Florida Everglades. Florida Coastal Everglades LTER All Scientists Meeting – Miami, FL.



PROPOSALS SUBMITTED

1. NOAA/CSCOR – Marine and estuarine goal setting for South Florida (MARES). \$1,471,157 (\$597,787 FIU) – pending.
2. FDEP - Evaluating nutrient loading in coastal waters around Florida using a Coastal Ocean Observing System (COOS). \$143,000 (sub-contract to FSU) - declined.
3. NSF - Dissolved Organic Matter (DOM) Quality: Linking Sources and Molecular Composition to Photoreactivity and Bioavailability. \$443,111 - declined.
4. NSF – Collaborative Research: Synergistic effects of multiple anthropogenic stressors on coastal peatlands under projected climate change (SEAS). \$757,498 - pending.
5. NSF-PIRE – Interrelationships among hydro-ecological and socio-economical features of large wetland ecosystems: The Everglades (US), the Pantanal (Brazil) and the Okavango Delta (Botswana) - pending.
6. NPS – Increased water delivery and dissolved organic matter (DOM) dynamics: assessing the photo- and bio-reactivity of DOM in the greater Everglades. \$162,805 - pending.
7. NPS – Effects of climate variability and water management operations on Everglades National Park waters. \$149,990 - pending.
8. NPS – Development of Cyanobacterial Bloom Observation & Tracking System (CYBOTS) to Assess of Environmental Triggers and Species Composition of Cyanobacterial Blooms in Florida Bay. \$270,239 - pending.



Publications

1. Rivera-Monroy, V. H., R. R. Twilley, S. E. Davis III, D. L. Childers, M. Simard, R. Chambers, R. Jaffe, J. N. Boyer, D. Rudnick, K. Zhang, E. Castañeda-Moya, S. Ewe, C. Coronado-Molina, M. Ross, T. J. Smith III, B. Michot, E. Meselhe, W. Nuttle, T. Troxler, G. B. Noe. (submitted). The role of the Everglades mangrove ecotone region (EMER) in regulating nutrient cycling and wetland productivity in South Florida. *Critical Reviews in Environmental Science and Technology*.
2. Glibert, P. M., J. N. Boyer, C. A. Heil, C. Madden, B. Sturgis, and C.S. Wazniak. (submitted) Blooms in lagoons: Fundamentally different from those of riverine-dominated estuaries.
3. Ikenaga, M., R. Guevara, and J. N. Boyer. (submitted). Changes in sediment bacterial community structure along the Florida Coastal Everglades marsh-mangrove-seagrass gradient. *Microbial Ecology*.
4. Troxler, T. G., M. Ikenaga, L. Scinto, J. N. Boyer, R. Condit, R. Perez, G. Gann, D. L. Childers. (submitted). Divergence of plant and bacterial community structure and soil CO₂ flux along a resource gradient in a coastal peatland of Panama. *Ecosystems*.
5. Wachnicka, A., E. Gaiser, T. Frankovich, L. Collins, and J. N. Boyer. (submitted). Developing diatom-based inferences of environmental change in Florida Bay and adjacent coastal wetlands of South Florida. *Estuarine, Coastal and Shelf Science*.
6. Briceño, H. O., and J. N. Boyer. (submitted). Climactic controls on nutrients and phytoplankton biomass in a sub-tropical estuary, Florida Bay, USA. *Estuaries and Coasts*.
7. Boyer, J. N., C. R. Kelble, P. B. Ortner, and D. T. Rudnick. 2009. Phytoplankton bloom status: An indicator of water quality condition in the southern estuaries of Florida, USA. *Ecological Indicators*.
8. Clayton J. Williams, C. J., J. N. Boyer, and F. J. Jochem. 2009. Microbial activity and carbon, nitrogen, and phosphorus content in a subtropical seagrass estuary (Florida Bay): evidence for limited bacterial use of seagrass production. *Marine Biology* 156: 341-353.
9. Williams, C. J., J. N. Boyer, and F. J. Jochem. 2008. Indirect hurricane effects on resource availability and microbial communities in a subtropical wetland - estuary transition zone. *Estuaries and Coasts* 31: 204-214.



WHERE WE WANT TO BE IN 2009 MID-TERM REVIEW

**More organized and better integrated with
both central questions and models.**



OUR VISION FOR DECADAL PLAN

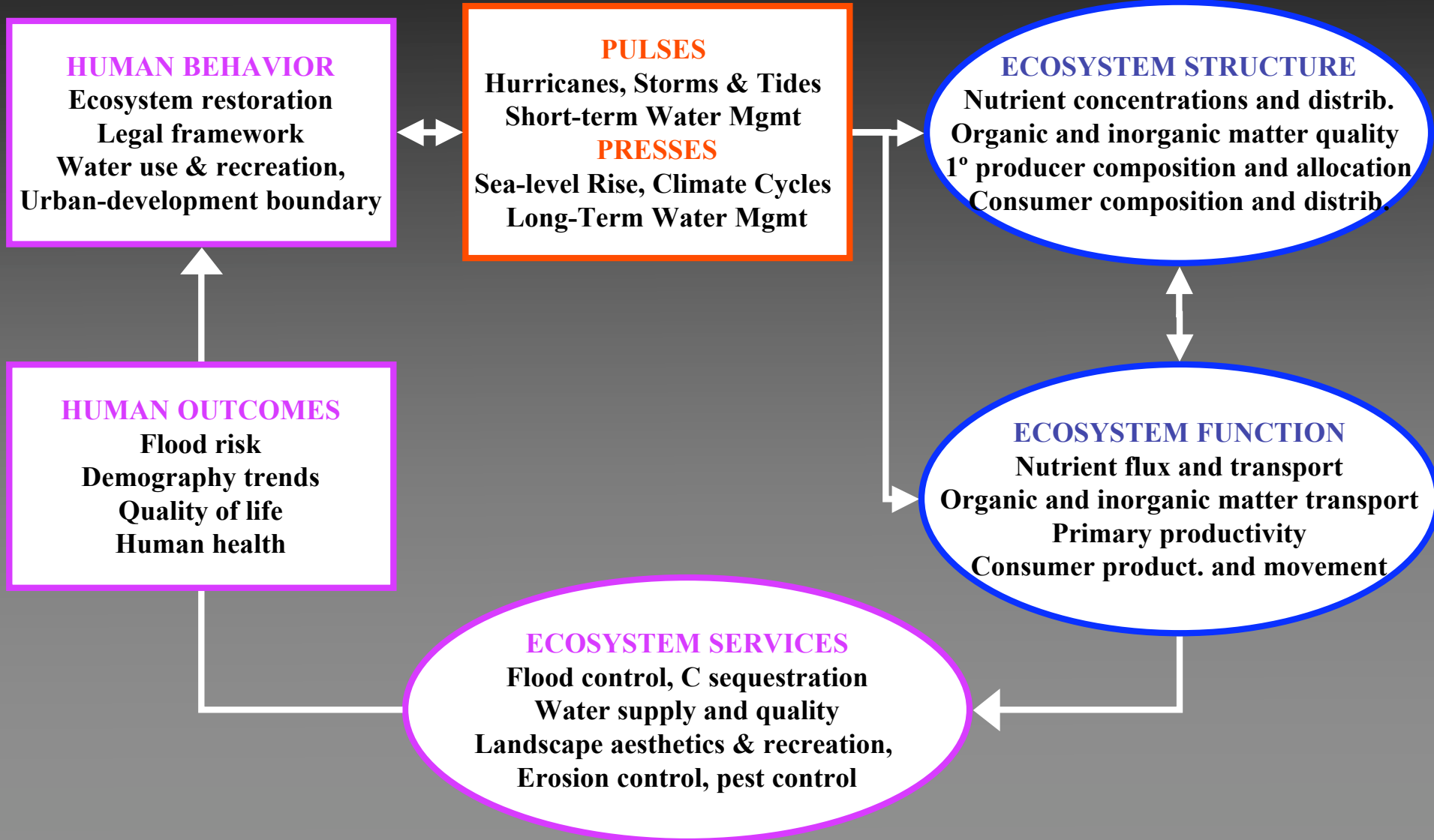
**X-site comparisons of soil/sediment/water
column bacterial metagenomics**

**X-site comparisons of DOM quality as it
relates to bioavailability/mineralization**

FCE in ISSE Context

Socio-cultural-economic Template

Geophysical Template





OUR CONTRIBUTION TO CENTRAL HYPOTHESES BY RENEWAL TIME

- 1. Increasing inputs of freshwater will enhance oligotrophy in nutrient-poor coastal systems, as long as the inflowing water has low nutrient content; this dynamic will be most pronounced in the oligohaline ecotone.**

List expected form and mechanism of contribution toward this hypothesis

Any concerns or suggestions for movement toward this goal



OUR CONTRIBUTION TO CENTRAL HYPOTHESES BY RENEWAL TIME

- 2. An increase in freshwater inflow will increase the physical transport of detrital organic matter to the oligohaline ecotone, which will enhance estuarine productivity. The quality of these allochthonous detrital inputs will be controlled by upstream ecological processes.**

List expected form and mechanism of contribution toward this hypothesis

Any concerns or suggestions for movement toward this goal



OUR CONTRIBUTION TO CENTRAL HYPOTHESES BY RENEWAL TIME

- 3. Water residence time, groundwater inputs, and tidal energy interact with climatic and disturbance regimes to modify ecological pattern and process in oligotrophic estuaries; this dynamic will be most pronounced in the oligohaline ecotone.**

List expected form and mechanism of contribution toward this hypothesis

Any concerns or suggestions for movement toward this goal