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FCE II Year Six Annual Report For NSF Award DBI-0620409

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FCE II YEAR SIX
ANNUAL REPORT FOR NSF AWARD DBI-0620409

FLORIDA COASTAL EVERGLADES LTER

Florida International University

Submitted November 2012

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B. Partner Organizations

- College of William & Mary: Collaborative Research; Personnel Exchanges
- Ecology and Environment, Inc.: Collaborative Research; Personnel Exchanges
- Everglades Foundation: Collaborative Research; Personnel Exchanges
- Everglades National Park: Collaborative Research; Personnel Exchanges
- Florida Atlantic University: Collaborative Research; Personnel Exchanges
- Florida Gulf Coast University: Collaborative Research; Personnel Exchanges
- Florida State University: Collaborative Research; Personnel Exchanges
- Harbor Branch Oceanographic Institute: Collaborative Research
- Indiana University: Collaborative Research
- Louisiana State University: Collaborative Research; Personnel Exchanges
- Miami-Dade County Public Schools: Collaborative Research; Personnel Exchanges
  Two of our Education and Outreach coordinators (Susan Dailey and Nick Oehm) have taught and given FCE LTER presentations at Miami-Dade County Public Schools. Our Research Experience for Teachers (RET) and Research Experience for Secondary Students (RESSt) programs have included teachers and students from Miami-Dade County Public schools.
- National Aeronautics and Space Administration: Collaborative Research; Personnel Exchanges
- National Audubon Society: Collaborative Research; Personnel Exchanges
- The Pennsylvania State University: Collaborative Research; Personnel Exchanges
- Portland State University: Collaborative Research; Personnel Exchanges
- South Florida Water Management District: Financial Support; In-kind Support; Collaborative Research
- Sam Houston State University: Collaborative Research
- Texas A&M University at Galveston: Collaborative Research; Personnel Exchanges
- U.S. Department of the Interior: In-kind Support; Facilities; Collaborative Research

- Department of Interior U.S. Geological Survey: In-kind Support; Collaborative Research
- University of Alabama: Collaborative Research; Personnel Exchanges
- University of California, Berkeley: Collaborative Research; Personnel Exchanges
- University of California, Los Angeles: Collaborative Research; Personnel Exchanges
- University of Colorado: Collaborative Research; Personnel Exchanges
- University of Florida: Collaborative Research; Personnel Exchanges
- University of Georgia: Collaborative Research; Personnel Exchanges
- University of Miami: Collaborative Research; Personnel Exchanges
- University of Miami Rosenstiel School of Marine & Atmospheric Science: Collaborative Research; Personnel Exchanges
  Jack Fell through a separately funded NSF grant.
- University of North Carolina at Chapel Hill: Collaborative Research; Personnel Exchanges
- University of North Carolina at Wilmington: Collaborative Research; Personnel Exchanges
- University of South Florida: Collaborative Research; Personnel Exchanges
- University of Virginia: Collaborative Research; Personnel Exchanges
- Miami-Dade County, Department of Planning and Zoning: Collaborative Research

C. Other collaborators

We have maintained important collaborative partnerships with 5 federal agencies (Everglades National Park, USGS, NOAA, EPA, and NASA-JPL) during the sixth year of the FCE II LTER Program. We also partner with 1 state agency (South Florida Water Management District), 2 NGOs (Everglades Foundation and the National Audubon Society), and 24 other universities (Louisiana State University, College of William & Mary, Texas A&M University, and University of South Florida through subcontracts).

Through our Education and Outreach program, we have developed strong working relationships with: Felix Varela Senior High School; Miami Dade County Public Schools; Miami Dade College Department of Biology, Health, and Wellness; Miami Dade College School of Education; Deering Estate at Cutler; Science Approach, LLC; and the Everglades Digital Library. We also work closely with CEMEX USA aggregate mining corporation and the Ft. Lauderdale Museum of Discovery and Science as our primary community partners.

II. ACTIVITIES AND FINDINGS

A. Research Activities

New and ongoing research activities and findings relevant to the goals of the FCE II proposal are reported separately by working group, below.

1. Primary Production

Observational studies of long-term trends in primary production and plant community structure continue in the major community types of the FCE domain: freshwater marsh, mangrove forests and seagrass meadows.

- *Freshwater Marsh:* Long-term trends in periphyton biomass and composition at the FCE sites were combined with large-scale landscape data to produce models that predict changes in periphyton biomass, composition and nutrient content from alternative water management scenarios. Comparative international investigations continue in karstic wetlands elsewhere, including the Caribbean wetlands and Canadian alvars, and a special issue on the topic is being prepared for the *Journal of Cave and Karst Science*.
- *Mangrove Forests:* The response of carbon storage and net primary production of mangrove forests to hurricane disturbances was assessed through long-term observations and gas flux studies. We also investigated how carbon storage in mangrove forests responds to temperature and cold-air disturbances. We began collaborations with Tom O'Halloran (Sweet Briar College) to understand how different plant functional groups' productivity responds to diffuse irradiance. Our carbon dynamics work involves high-resolution eddy covariance datasets, so we participated in the LTER workshop, Software tools for sensor networks (http://sensor-workshop.ecoinformatics.org/) held in May 2012. We continue to deploy sulfur hexafluoride (SF6) inert tracers to understand water and carbon flow patterns in the Shark River.
- *Seagrass Meadows:* Experimental studies in seagrass meadows explored the response of these systems to changes in pCO_2, with a goal of predicting the response of seagrass meadows to environmental change. The role of seagrasses as global carbon sinks was established.

2. Trophic Dynamics

Extensive long-term datasets of spatial and temporal variation in the abundance and community composition of fishes and alligators are being analyzed from marshes to coastal estuaries, with a focus on connectivity throughout the landscape mediated by detrital food webs.

- *Large Predators:* We continue extended studies of the drivers of population dynamics, movements and trophic interactions of freshwater communities, bull sharks, alligators, snook, and bottlenose dolphins including investigations of individual specialization. This included completing a laboratory study of isotopic turnover rates in American alligators.
- *Fish Communities:* A 20-yr recreational fishery dataset and related angler catches has been related to hydrological parameters at SRS. The variation in prey quality (caloric density and stoichiometry) was examined among freshwater and estuarine prey. Data were provided to

the National Park Service and the Florida Wildlife and Fish Commission (FWC) on the status of the snook fishery at study sites for consideration of whether the recreational fishery should be opened or remained closed after a 2010 cold snap that resulted in a massive mortality event. Studies of the impacts of introduced fishes on native fish populations were extended.

- *Detrital Pathways:* We established the importance of biomarkers (e.g. fatty acids) for investigating the importance of detrital, and other, pathways in food webs of marshes and the estuary.
- *Comparative Research:* We completed extensive comparisons of Florida Bay and Shark Bay, Australia in 23 manuscripts in a forthcoming special issue of *Marine and Freshwater Research.*

3. Organic Matter Dynamics

We continue to document changes in DOC dynamics and optical properties throughout the freshwater to marine gradient.

- *DOC Dynamics:* Monthly observations of of DOC and optical properties of DOM continue. More intensive analyses were completed along a salinity transect and during the tidal cycle at SRS. These studies generated first data on $\delta^{13}C$ values for DOC in SRS estuary. We initiated molecular characterizations of DOM using advanced analytical tools, and expanded the scope of our research on dissolved black carbon. We also initiated studies on the formation of methyl halides from periphyton assemblages and the photolysis of DOM.
- *Soil and Detritus:* We completed our annual survey of bulk soil properties and analyses are ongoing. A comprehensive analysis of inter-annual variation (2006-2010) in soil properties (Taylor Slough and Panhandle basins) is being undertaken. Litterfall production was monitored monthly at the SRS mangrove sites.

4. Biogeochemical Cycling

The Biogeochemical Cycling group continues baseline water quality observations, studies of microbial and cyanobacterial dynamics and experimental research to disentangle biogeochemical consequences of salinity and inundation changes associated with sea level rise.

- *Baseline Water Quality:* Dissolved and total nutrient analyses were carried out at all LTER sites in conjunction with SERC Water Quality Monitoring Network and ENP Taylor Slough studies.
- *Microbial Dynamics:* Three procedures were performed each month for all FCE sites: bacterial production, bacterial enumeration, and the measurement of pigment, quantum yield, and excitation characteristics of phytoplankton using Phyto-PAM.
- *Cyanobacterial Bloom Dynamics:* An experimental approach has been undertaken to determine if the cyanobacterial community structure in Florida Bay might be responding to differential P sources, including organic P additions.
- *Sea Level Rise Experiments:* We conducted initial experiments to determine how sea level rise and changes in the balance of fresh and saltwater might affect soil biogeochemistry in lower Shark River. In August 2011, 24 peat monoliths were collected from a mature mangrove forest adjacent to lower Shark River (SRS-6) and transported to our outdoor tidal mesocosm. A randomized split-plot design was used to test the effects of ambient (15-20 ppt) and elevated salinity (30-35 ppt), and water level/hydroperiod (control and inundated, or

-8 cm elevation relative to control), and the combination of salinity and water level on soil C flux (CO2, CH4, and porewater DOC) and porewater dissolved nutrients. We also extracted DNA from soil samples using an UltraClean Soil DNA Isolation Kit (MoBio laboratories). 16S rRNA genes were amplified using eubacterial universal primers 27f. PCR products were analyzed by T-RFLP.

5. Hydrology

The Hydrology group continues to measure major water balance parameters including freshwater inflow from the upstream Everglades, marine water intrusion, groundwater, precipitation and evapotranspiration in both Shark and Taylor Sloughs. We also evaluate the role of water management and sea level rise on water levels and residence times using spatial (satellite) analyses and ground-based calculations.

- *Hydrologic Variables:* Precipitation, evapotranspiration, and surface water levels and flow continued to be collected across FCE for water budget estimates. Groundwater and surface water levels and chemistry were monitored in the mangrove ecotone of both Shark and Taylor Sloughs for evidence of groundwater-surface water exchange as well as for identification of the extent of saltwater intrusion.
- *Estimating Groundwater Discharge:* We calibrated and validated a variable-density groundwater flow model of groundwater exchange in the mangrove ecotone as a function of hydraulic head, water salinity, and water temperature data. The next steps in developing the variable-density groundwater flow model were conceptualized, including (a) refining and extending the spatial and temporal domains of the model in the ecotone, (b) modeling the liberation and subsequent transport of phosphorous through the underlying bedrock into the ecotone, and (c) modeling flow and transport processes in the ecotone.
- *Spatial Analyses:* Evapotranspiration (ET) was also modeled across the FCE LTER landscape by applying an energy balance equation to Landsat 5TM datasets collected between 1993 and 2006. The Landsat 5TM satellite data (collected between 1993 and 2006) was also used to establish relationships between spectral data, modeled ET and water chemistry within the coastal mangrove ecotone.
- *Water Residence Times:* Water flushing times were estimated as the quotient of volume of surface water to total water output (including evapotranspiration, surface water outflow, and groundwater recharge) for southern Taylor Slough and Shark Slough from 2001 – 2011 using a water budget equation, and hydrologic data collected by the FCE LTER, Everglades National Park (ENP) and the US Geological Survey (USGS). We analyzed major ion and total nutrient data (FCE LTER core data sets) for Taylor Slough from 2008 – 2012 in relation to estimated water flushing times, and analyzed monthly grab samples of groundwater and surface water, collected from the FCE Taylor Slough sites from 2011 – 2012 for the stable isotope of oxygen and hydrogen in order to identify the sources of water in Taylor Slough.

6. Human Dimensions

FCE Human Dimensions research continues to develop our understanding of the human dimensions of land use change as it affects local ecological dynamics in south Florida. In year 6, we made progress in: (1) developing spatial models of land use decision-making, (2) connecting

FCE ecological research to regional land use/cover dynamics, and (3) adopting a methodology that facilitates cross-LTER site comparisons.

- *Spatial Patterns of (Sub)urban Landscapes:* Land cover data derived from high-resolution GeoEye imagery were used to characterize the types and greenness of land covers using categorical data (classified cover) and continuous/quantitative data (e.g., indices of vegetation greenness such as NDVI). Progress was made on developing specifications for high-resolution remote sensing land cover in southern Miami-Dade County, updating and recalibrating water demand estimates for various land uses.
- *Social/Structural/Institutional Determinants:* We continue to analyze the land cover data using spatially explicit GIS approaches that integrate high-resolution land cover with municipal zoning data, and with neighborhood-scale socio-demographic characteristics derived from Claritas PRIZM market segmentation data. We analyzed the relationships between residential environmental attitudes ("sense of place"), yard stewardship practices, and social demographics (age, ethnicity, neighborhood characteristics). Graduate student Rebecca Garvoille carried out ethnographic and archival fieldwork in the southern Everglades to determine how south Florida's successive environmental restoration projects, including its national parks, have shaped the politics of identity, land and nation for Native Americans and rural glades peoples in the southern Everglades and how the legacies of these struggles inform contemporary Everglades restoration politics. She completed an article examining how suburban development in communities adjacent to Everglades National Park is shaped by local ecologies and the broader political economies of agriculture and real estate in Florida.
- *Homogenizing Residential Landscapes in America:* We continue the analysis of cross-site data land cover and neighborhood-scale socio-demographic (PRIZM) data at four urban LTER sites (FCE, BES, PIE and CAP). Specifically, we are analyzing the relation between socio-demographic groups common to residential neighborhoods in all four sites, and their associated land covers, landscape structure and spatial autocorrelation, and developing preliminary spatial econometric models. Ogden extended household survey-interview instruments and protocol fieldwork as part of FCE-related cross-site research funded by a series of collaborative grants from NSF Macrosystems Biology Program (DBI-1065785, 1065548, 1065741, 1065740, 1065760, 1065737, 1065831, 1065772).

7. Climate and Disturbance

We have continued research to track the course and effects of climate change and disturbance on the Everglades ecosystem through our observational, paleoecological, carbon cycling and tracer study initiatives.

- *Observational Studies:* Through conversations with USGS partners, the FCE LTER program will acquire two long-term staff gauges in the Shark River Slough estuary that record meteorological data and measure tidal cycles, salt-water intrusion and storm surge in the estuary. We also expanded our network of study sites in the northern areas of Shark River Slough to examine upstream ecological responses to modifications of water flow along the Tamiami Trail. Continued long-term collections along the SRS and TS transects have quantified effects of salt-water encroachment and disturbance (particularly the active 2005 tropical storm season) on the location and movement of the oligohaline ecotone.

- *Paleoecology:* We completed the special issue of the *Journal of Paleolimnology* focused on Everglades paleoclimate. Diatom-based studies were completed to document historic ecological regime shifts in the South Florida estuaries. Continued collaborations with Utrecht University were fostered through site exchanges to develop multi-proxy interpretations of past sea level rise rates. Similar collaborative work with the Swiss Federal Institute for Forest, Snow and Landscape Research has fostered the progress in dendrochronologically-(tree ring width, isotope)-based hydrological interpretations.
- *Carbon Dynamics:* FIU, Everglades National Park and the University of Hawaii organized a C-cycling workshop in October, 2012 to further our understanding of the role of freshwater discharge and tidal exchange in the large mangrove forest of the southern Everglades. The team reviewed and receive external feedback on recent carbon cycle investigations in the coastal mangrove forests of Everglades National Park, developed methods for integrating on-going CO_2 eddy covariance measurements, primary production, and soil carbon accumulation within a functional carbon budget, formulated proposal ideas to advance the science of coastal carbon cycle studies in south Florida and in other systems, and generated hypotheses to predict how the carbon budgets of the mangrove forests will respond to sea level rise and altered freshwater discharge due to climate change and hydrologic management.
- *Tracer Studies:* A second SF6 tracer study was conducted in November 2011 in the Shark and Harney Rivers to measure carbon export through the system. Graduate student Annie Palya refined the approach used for our new CRDS system to measure the isotopic composition of the DIC and DOC during this study (compared to last year), as carbon isotopes may help to resolve different sources of carbon. Saline samples present a unique challenge when using the TOC-CRDS system, but this work shows that high-precision measurements of ^{13}C of DOC are possible at marine-estuarine C concentrations. This analytical approach is relatively new, and is important for understanding the C-dynamics within the FCE.

8. Modeling and Synthesis

FCE continues to develop hydrologic, geochemical, biological and social systems models, and drives synthesis through their integration.

- *Hydrologic and Geochemical Models:* We continue to develop models of the water budget of Shark Slough to understand all components of the water budget, including the specific contribution of groundwater discharge**.** We model groundwater discharge in select locations in Taylor and Shark Sloughs to quantify the magnitude and timing of groundwater discharge at specific locations along the ecotone**.** We built conceptual models linking hydrodynamics and P dissolution and transport from the carbonate rock to the ecotone.
- *Biogeochemical and Biological Modeling:* We modeled the N and P budgets of Taylor Slough to understand seasonal variations in nutrient flux and storage terms, and N and P loading to Biscayne Bay to understand and predict nutrient loading as a function of current and predicted future land use/land cover**.** Multidecadal OM and P accumulation measurements are now being used to inform OM- and P-accumulation models
- *Social Modeling:* Land-use/land-cover in Miami-Dade County is being modeled to understand how policy (e.g., floodplain mapping, zoning) affects development patterns,

including quantifying how cultural controls create fine-scale homogeneity and coarse-scale heterogeneity in suburban landscapes.

- *Integrated Modeling:* We refined the overarching Conceptual Heuristic Model for FCE to provide a framework and roadmap for model integration**.** We developed an approach to apply the Everglades Landscape Model (ELM) to understand how different restoration scenarios in the central Everglades might affect water flows and phosphorus loading to the southern Everglades and drafted a synthesis paper focused on integrated modeling to document lessons learned and future strategies to overcome remaining barriers.

9. Information Management

Overview

The Florida Coastal Everglades (FCE) Information Management System (IMS) continues to facilitate the site's scientific work and to ensure the integrity of the information and databases resulting from the site's coastal Everglades ecosystem research. The major focus of the FCE Information Management team (Linda Powell, Information Manager and Mike Rugge, FCE Project Manager) has been the implementation phase for a FCE IMS physical hardware restructure and improving its network-wide standardization to facilitate increasing use of site data in synthesis projects. In addition to Linda Powell attending the LTER ASM in Estes Park, Colorado in September, the FCE IMS information manager made the following contributions to the LTER network:

- Member of the LTER Network Information Management Advisory Committee (NISAC)
- Chair of the LTER IM Unit Registry working group
- FCE IMS data contributions to ClimDB, SiteDB, All Site Bibliography, PersonnelDB and Metacat XML database.
- Participation in LTER SensorNIS workshop at Hubbard Brook LTER

IT Infrastructure

The FCE IMS team manages two Windows servers and three Linux servers with a total storage capacity of 2.9 Gigabytes and an additional 1.1 Gigabytes of storage between two desktop workstations. The servers housing the development and production versions of the FCE Oracle10g database are equipped with RAID5 technology (Redundant Array of Independent Disks). The FCE information management system (IMS) team is nearly finished with the migration of FCE information and data from its physical servers housed in the FCE LTER office to five (5) virtual servers housed on Florida International University Division of Information Technology's (UTS) equipment.

Support for EML Metadata

The FCE IMS received NSF supplemental IM funding in 2012 and work has been started on improving the quality and availability of LTER Data and EML Metadata. Existing FCE 2.0 EML metadata (currently 516 FCE EML XML files and 516 FCE Excel templates) is being upgraded to EML 2.1 and modified to incorporate the LTER Controlled Vocabulary Key wording according to the LTER EML Best Practices. Intensive work is in progress to make FCE data and metadata fully compliant with the LTER NIS and PASTA import ready.

FCE Website and Data Statistics
Currently, the FCE archive contains 516 FCE datasets, of which a total of 463 are publically available online at http://fcelter.fiu.edu/data/FCE/. Public downloads of FCE datasets from January 2001 to September 25, 2012, broken down by dataset type and user affiliation, show that the University community continues to be the largest user group and the FCE nutrient data is most popular download.

B. Findings

1. Primary Production

We address our central question: "How does seasonal and inter-annual variability in water source (surface water, groundwater, rainfall, and marine inputs) and associated P availability control primary productivity and biomass allocation in the oligohaline ecotone?" using a combination of long-term observations and experimental work in the freshwater marsh, mangrove forest and seagrass meadows along the two FCE transects.

- *Freshwater Marsh:* Variability in periphyton production along the FCE LTER transects over the 12-year period of record is negatively correlated with water depth and phosphorus (Gaiser et al. 2011), facilitating development of a multi-parameter model to predict periphyton abundance and composition from a range of water quality and hydrologic scenarios. The periphyton models are were incorporated into the system-wide ecosystem assessment reported to the U.S. Congress (SFETF 2012). Long-term compositional data also show how nutrient availability enhances, rather than reduces, spatial beta-diversity likely owing to resource homogeneity and high disturbance in the Everglades interior (Gaiser et al. In Press). Research on the impact of periphyton on rates of aquatic metabolism continues to show conflicting results, from highly regulatory (Gaiser et al. 2011) to minimal in comparison with contributions of aquatic macrophytes (Schedlbauer et al. 2012), so a series of experimental manipulations are being planned for 2013 to resolve issues of scale that likely underlie these differences. Intercontinental comparisons of karstic wetland periphyton are showing high comparability between the Everglades diatom flora (formerly considered endemic) and that of Caribbean wetlands (La Hee et al. 2012) and even Canadian counterparts (Gaiser, unpubl. data).

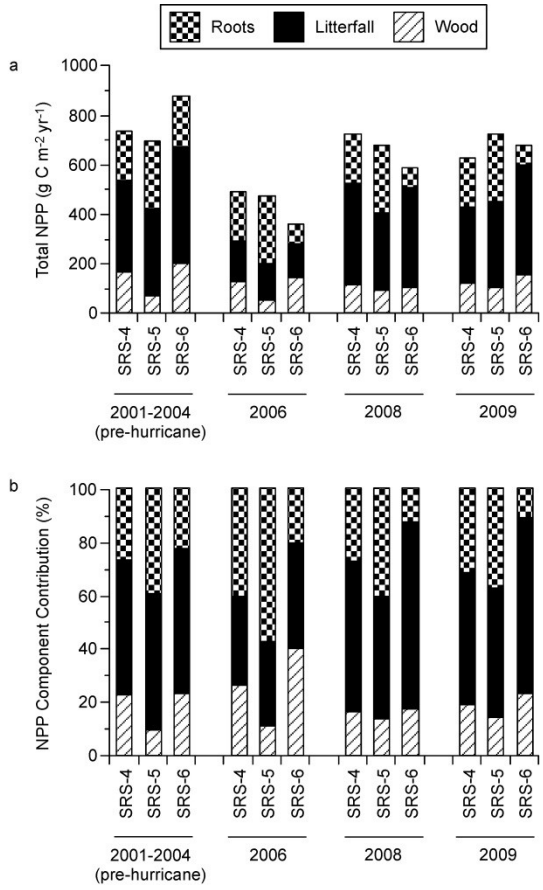

Figure 1: Variation in total carbon net primary production (NPP) including roots, litterfall, and wood (a) and NPP component contribution (b) in mangrove forests of the Florida Coastal Everglades before and after the passage of Hurricane Wilma

- *Mangrove Forests:* We found that the amount of C stored in mangrove forests increased downstream in the Shark River (Castañeda-Moya 2010) and after the passage of Hurricane Wilma there was a reduction in ca. 11% in C storage at our downstream site, but upstream there was a slight increase in C storage following the storm. Different plant parts responded differently to the passage of the storm, causing changes in the relative C storage in different plant structures. In particular, root C storage increased after the storm (Castañeda-Moya et al. 2011). These results indicate how mangrove trees responded physiologically to defoliation as greater energy was allocated to root production and storage and associated nutrient uptake. The storm also changed the pattern of carbon production within sites (Figure 1). At the monthly time scale, net ecosystem carbon exchange (NEE) occurring across the mangrove forest-atmosphere interface is controlled by air and soil temperature, integrated solar irradiance, surface water salinity, duration of tidal inundation, and rainfall. Green vegetation mostly recovered within a year of the passage of Hurricane Wilma, as evidenced in the time series of enhanced vegetation index (EVI) centered on the mangrove forest flux tower at SRS6 (Barr et al. 2012). Our results underscore the resilience of mangrove forests to hurricane disturbance. Cold weather events can be significant disturbances to the tropical ecosystem of the FCE; we found that following a cold spell in January 2010, ecosystem function was modified to the point that the mangrove forest became a source of carbon. Such cold periods likely limit the northward extent of mangrove forests, and as climate warms in North America so that air temperatures below the freezing point become less frequent, we expect mangrove forests to invade the salt marshes of the intertidal zone north of the current mangrove range.

- *Seagrass Meadows:* Seagrasses were shown to be a major overlooked part of the global carbon cycle (Fourqurean et al 2012). The global seagrass ecosystem organic carbon pool could be as high as 19.9 Pg C; a more conservative approach using more plentiful surface soil data and patterns in change in with depth estimate the pool to be between 4.2 and 8.4 Pg C. Current rates of seagrass loss may result in the potential loss of up to 299.3 TgC y^{-1}, if all of the organic carbon in the biomass and the top meter of soils were remineralized. The importance of seagrasses as primary producers and carbon sinks is likely to change in the future as pCO_2 and temperature continue to rise. The dominant seagrass species of the FCE domain all exhibit C-limited rates of photosynthesis at current pCO_2 , but the species have

different mechanisms for acquiring CO2 for photosynthesis (Campbell and Fourqurean, in review a). Given that seagrasses carbon limited photosynthetic rates, increases in atmospheric pCO_2, and consequentially oceanic $CO_{2(aq)}$ concentrations, may prove beneficial to seagrasses (Campbell and Fourqurean in review b). We found that seagrass growth responses to $CO_{2(aq)}$ enrichment were relatively weak, while plant nitrogen (N) and phosphorus (P) content strongly responded, increasing leaf C:N and C:P ratios. Elevated $CO_{2(aq)}$ additionally increased soluble carbohydrate allocation towards belowground storage organs. Nutrient availability interacts with photosynthetic rate in seagrasses to determine the carbohydrate allocation to belowground storage organs, however. Nutrient-limited plants store more carbohydrates in their rhizomes as soluble sugars than do nutrient-replete plants (Campbell et al 2012). In the oligotrophic ecotone of the FCE, we found that light availability on the bottom is at least as an important a driver of the community structure of benthic plant communities as salinity (Frankovich et al. in press).

2. Trophic Dynamics

We explore our central questions: "How does variation abiotic conditions (e.g. waterflow) influence the quality and transport of organic matter?, How does variation in abiotic conditions influence the trophospatial dynamics of consumer communities from the marsh to Florida Bay?, and ultimately, How do organic matter dynamics influence consumer communities and feedbacks to the rest of the ecosystem?" through research on large predators and fish, detrital food web studies.

- *Large Predators:* The past year has seen the culmination of several years of work on fish dispersal in the freshwater Everglades with documentation of pulsed immigration to and emigration from short-hydroperiod marshes as water floods and recedes in these habitats (Goss et al, in review; Hoch et al., manuscript in revision). Also, we used path analytical modeling to document landscape-scale impacts of top-down effects, supporting results from experimental studies conducted at a relatively small number of local sites. The ability to scale-up these results is an important dimension of our research in this area. We are finding there is a high degree of individual specialization in movements and trophic interactions within top predator populations that result in differing ecological roles and responsiveness and vulnerability to changes in the physical environment. Work in wetlands on eastern mosquitofish as well as long-term studies on bull sharks and alligators in the ecotone region provided support for the Niche Variation Hypothesis, which predicts that among-individual variation in niche use will increase in the presence of intra-specific competition.
- *Fish Communities:* We discovered two pulses of small fish dispersal in Everglades wetlands each year, once when water floods the marsh and a second when marshes dry. Two and three dimensional Brownian diffusion models best describe dispersal of four species examined. Since 2004, we have examined spatiotemporal dynamics in the Everglades fish community at the marsh-mangrove ecotone. Our focus has been in understanding how both freshwater and estuarine fishes, including species of important recreational value, respond to variation in hydrological conditions, primarily driven by upstream freshwater inflows. The increase in freshwater taxa with marsh dry-down, both small-bodied prey and larger predatory taxa, is accompanied by increases in the abundance of estuarine predators including snook and bull sharks. Long-term monitoring of dynamics at these sites has allowed us to detect the structuring effects of other drivers, such as extreme climatic events. The 2010 cold event

caused significant mortality across Everglades fauna and flora, and at our sites species affected included estuarine and nonnative fishes, both of tropical origin (Figure 2). While estuarine prey appear to have recovered from the cold snap, snook and nonnatives show no recovery, which has led to the continued closure of the snook fishery for 2012, a multimillion dollar industry in Florida. Our monitoring provided the only fisheries-independent population estimates for snook in ENP. With projected increases in extreme temperature events as a result of climate change, subtropical regions may undergo drastic community shifts and diversity loss, with implications for the provisioning of ecosystem services. Invasive species work has shown that high density of a non-native fish, the Mayan cichlid, is correlated with changes in the relative abundance of native fish in oligohaline areas of the Taylor Slough. Three species, particularly sheepshead minnows, decreased in density when Mayan cichlids increased in density, which occurred in periods of years without strong cold fronts.

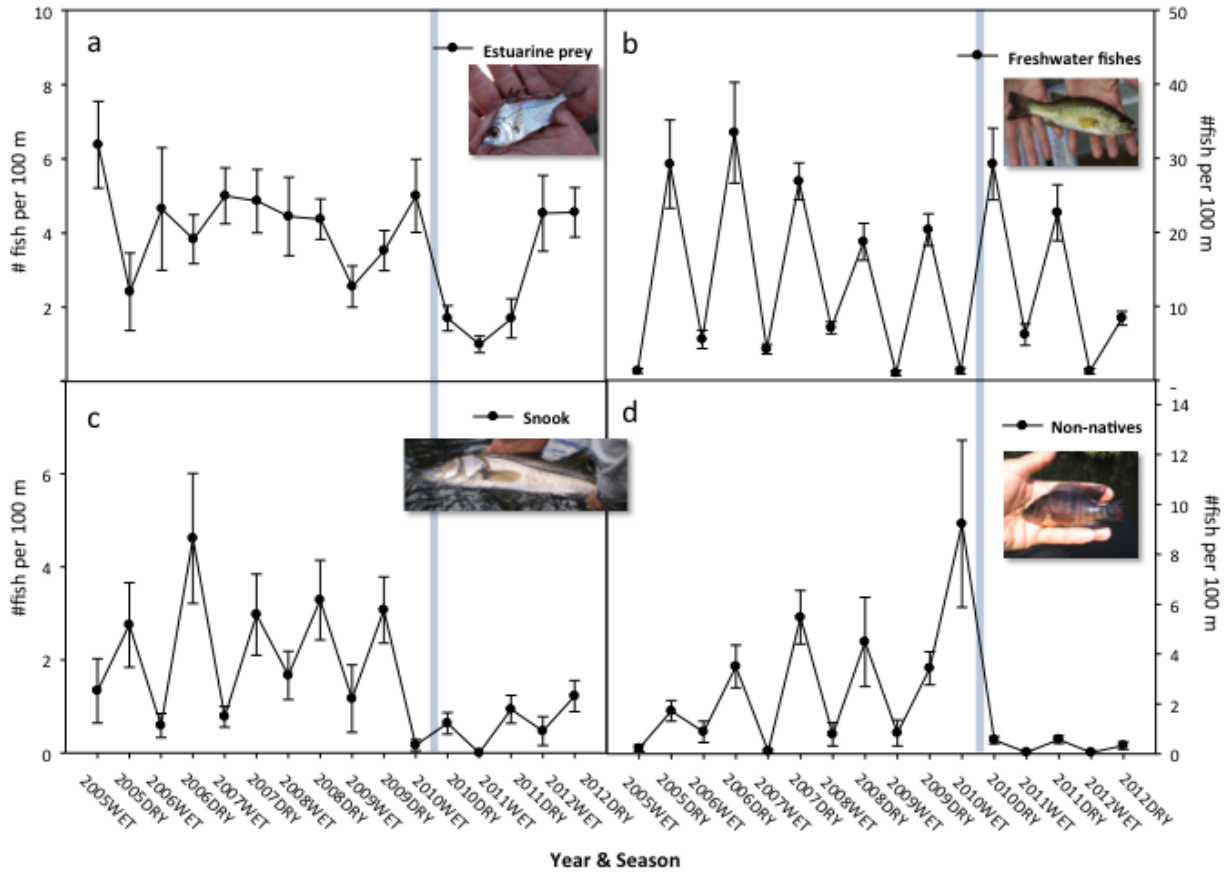

Figure 2: Seasonal and yearly abundance of (a) estuarine prey, (b) freshwater marsh fishes (both predators and prey), (c) snook, and (d) nonnative taxa across all sampled creeks. Wet season samples correspond to Nov-Dec, while dry season samples aggregate early (Feb-Mar) and late dry (Apr-May) samples. The timing of the 2010 cold snap is shown by the blue line.

- *Detrital Pathways:* Detrital contributions are typically cited as important for supporting wetland food webs, but few papers have documented directly as is done in our study. Our use of fatty acid profiles and stable isotopes to analyze freshwater marsh and estuarine food webs (Belicka et al. 2011, in prep) provides rare direct documentation of detrital inputs to wetland and estuarine food webs and represents a new, and critical, line of research for the consumer group entailing direct tracking the microbial base of the food web in our FCE

study area. We are using this work as a springboard to future studies on detrital and microbial routes of energy flow.

3. Organic Matter Dynamics

This group advances research addressing: "How are organic matter dynamics (DOM, "floc", and soils) in the oligohaline ecotone controlled by local processes versus allochthonous freshwater, marine, and groundwater sources?" via studies characterizing DOM, detrital material and soils across the oligohaline ecotone.

- *DOC Dynamics:* We completed 9 years of monthly determinations of optical properties at representative sampling stations in the FCE. In particular excitation emission matrix fluorescence with parallel factor analysis (EEM-PARAFAC) has proven to be ideally suited to study the origin, transport and fate of DOM. We are now extending the molecular characterization work by aiming to develop a cross-linking between the EEM-PARAFAC data and ultra high resolution mass spectrometry data (FT-ICR/MS 14t) and including 2D H-NMR determinations through collaborations with the Max Planck Institution and the Helmholtz Center, Germany. Preliminary data on size fractionated DOM suggest that this material covers a large MW range, but the relatively consistent composition suggests that the DOM structure consists of macromolecular assemblies with similar composition. Size fractionated photo-decomposition studies are underway to assess effects on bioavailability.

  We have now added ^{13}C measurements of DOC (and DIC) to our suite of analytical techniques, and have now generated the first data of this kind for the FCE, focusing specifically on estuarine DOC from SRS and Florida Bay. However, we have also started generating ^{13}C-DOC data for the freshwater marsh sites. Preliminary findings clearly show the large contribution of degraded mangrove detritus as a source of DOC and DIC at SRS. ^{13}C-DOC in Florida Bay confirms spatial and seasonal variability in the relative contributions of freshwater/mangrove vs. seagrass-derived DOC inputs.

  As an integral part of the DOM characterization work we have over the past 2 years also included the analytical determination of dissolved black carbon (DBC), a decomposition product derived from soil charcoal. A spatial and temporal DBC variability study shows that DBC is closely coupled to DOC dynamics. Collaborative efforts with another 6 LTER sites and others, has allowed us to perform a global study on stream DBC, indicating that the previously observed linear correlation between DBC and DOC is ubiquitous, and at an average of ca. 11% DOC-C the total export of riverine DBC to the ocean was estimated at 26Mt/yr.

  Assessing the contribution of mangroves to the DOC and POC pool has been an important activity for FCE2. From our salinity transect study on optical properties of DOM, we determined that some components showed non-conservative behavior indicative of mangrove-derived DOM inputs, while other DOM components, in particular those associated with soil inputs from the Northern Everglades, behaved conservatively. During the dry season a protein-like component behaved conservatively until reaching the mid-salinity range when its behavior changed to non-conservative due to degradation and/or loss. The tidal study data suggests that porewater (or groundwater) inputs following low tide contribute to the transport of mangrove-derived DOM into the rivers. Based on this study, up to 30% of the DOC in the rivers is mangrove-derived and is flushed into the rivers due to tidal pumping.

Regarding methylhalide formation on the FCE, preliminary irradiation experiments for freshwater and estuarine DOM yielded net production rates for both CH_3Cl and CH_3Br. Initial experiments with periphyton indicate that with salt intrusion, periphyton may produce significant quantities of CH_3Cl. The incubation of periphyton in artificial wetland under a 12:12 light dark cycle yielded net production of CH_3Cl and increased significantly with the addition of Cl. The concentration of CH_3Cl increased by approximately 3.4 and 65 pM over a 0 to 72 hour range for 1‰ and 10 ‰ treatments, respectively and reached a steady state concentration after 24 hours.

- *Soils and Detritus:* Soil bulk density from the Taylor Slough basin ranged from 0.15 to 0.5 gm-cm^{-3}, was higher than from the Panhandle basin every year, and generally increased throughout the study period. The %OM LOI ranged from 7-12% from freshwater marshes and from 13-56% from estuarine mangroves. Extractable iron in soils was similar among drainage basins and wetland types, typically ranging from 0.6 to 2.0 g Fe kg^{-1}. In contrast, inorganic sulfur was on average over four times higher from estuarine soils relative to freshwater, and was positively correlated with soil organic matter. Finally total soil phosphorus (P) was lower in freshwater soils relative to estuarine soils (84 ± 5 versus 326 ± 32 mg P kg^{-1}). Total P from the freshwater marshes in the Panhandle basin (but not in Taylor Slough) rose throughout the study period from 54.7 ± 8.4 to 107 ± 17 mg P kg^{-1}, a possible outcome of increased delivery of P concomitant with increased, managed flows through the basin. There was a consistent seasonal pattern of total litterfall among mangrove sites (Figure 3a).

  Total litterfall (cumulative values) was significantly higher during the wet season (June-November) compared to the dry season (December-May) for all sites, with the highest rates at SRS-6. Annual total litterfall was significantly ($F_{2, 27} = 11.7$, $P < 0.05$) higher at SRS-6 (1296 ± 149 g m^{-2} yr^{-1}) compared to SRS-4 (656 ± 32 g m^{-2} yr^{-1}) and SRS-5 (848 ± 67 g m^{-2} yr^{-1}; Figure 3a). There was no significant site and season interaction for total litterfall indicating that the trends for season are similar for all sites. Standing litter crop also showed a significant seasonal trend among mangrove sites that paralleled to that of litterfall production (Figure 3b). There was a significant site and season interaction with higher values during the wet season compared to the dry season for all sites, except for SRS-5 (Figure 3b). SRS-4 (978 ± 96 g m^{-2}) showed the highest cumulative values during the wet season, while SRS-6 (331 ± 10 g m^{-2}) had the lowest in the dry season (Figure 3b). Overall, mean standing litter crop ranged from 66.8 ± 9.3 g m^{-2} (SRS-5) to 124.2 ± 16.1 g m^{-2} (SRS-4) among mangrove sites. Total annual standing litter crop was significantly ($F_{2, 9} = 6.4$, $P < 0.05$) higher at SRS-4 (1490 ± 108 g m^{-2}) relative to SRS-5 (802 ± 180 g m^{-2}) and SRS-6 (940 ± 76 g m^{-2}; Figure 3b).

  Litter turnover rates were significantly different among sites with the lowest k_t values at SRS-4 (0.019 ± 0.001 d^{-1}) and the highest values at SRS-5 (0.054 ± 0.007 d^{-1}) and SRS-6 (0.064 ± 0.006 d^{-1}). Overall, there were not significant differences in k_t values between seasons for each of the three sites, or a significant site and season interaction. Mean residence times of litter did differ significantly among sites, with higher values at SRS-4 (75 ± 3 d) compared to SRS-5 (39 ± 14 d) and SRS-6 (23 ± 3 d). Seasonal differences in residence time of litter were not evident for any of the sites, nor a significant interaction between sites and seasons. These results suggest the strong coupling between hydroperiod and fertility gradients along Shark River. The low tidal exchange in combination with lower leaf decomposition (previous studies) and litter turnover rates in SRS-4 account for the higher

accumulation of litter at this site compared to SRS-6. This difference in standing litter crop and residence times of litter also underline the relative importance of frequency and duration of inundation in regulating both decomposition and litter accumulation in the forest floor along Shark River.

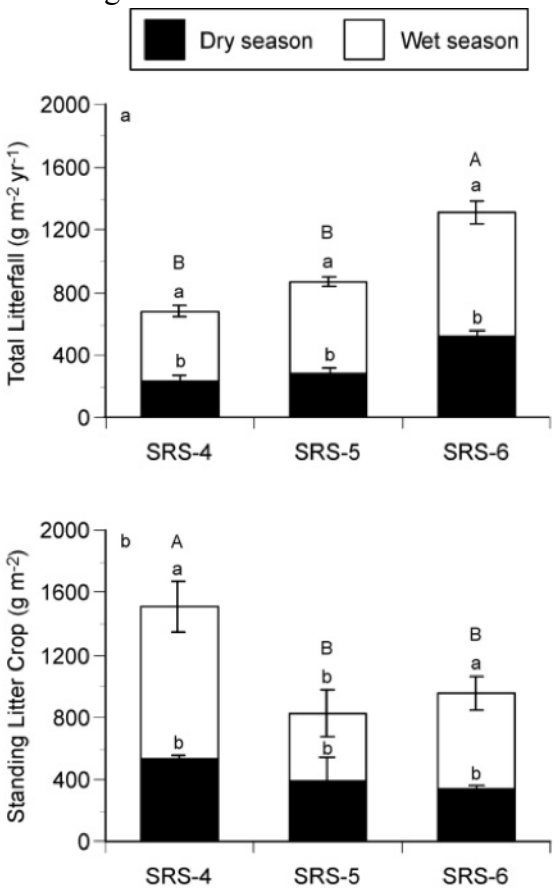

Figure 3a & b: Annual and seasonal rates of total litterfall (a) and standing litter crop (b) in mangrove forests along Shark River estuary, southwestern Florida Coastal Everglades during the period January-December 2011. Means (± 1 SE) with different small letters are significantly different ($P < 0.05$) within each site. Means (± 1 SE) with different capital letters are significantly different ($P < 0.05$) among sites.

4. Biogeochemical Cycling

We continue research to discover: "How 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," through our baseline water quality observations, studies of microbial and algal community dynamics and experimental manipulations of salinity and inundation mimicking the effects of sea-level rise.

- *Baseline Water Quality:* Efforts this year have concentrated on using our long-term observational datasets to develop nutrient criteria for Florida state waters.
- *Microbial Dynamics:* Principal Components Analysis showed that BP and Abundance was related to biomass of cyanobacteria and dinoflagellates/greens while diatom bionass had two main determinants: inorganic N and TP or organic N and TP in more turbid environments.
- *Cyanobacterial Bloom Dynamics:* Findings suggest that, under P-limitation, growth of cyanobacteria is favored by organophosphonate additions, especially some *Synechococcus* strains which have also been observed as a dominant strain in cyanobacterial blooms occurred in Florida Bay. It is possible that natural or anthropogenic inputs of

organophosphonate compounds estuaries and marine waters may be the trigger which shifts phytoplankton community structure to that of cyanobacteria and promotes bloom formation.

- *Sea Level Rise Experiments:* Results indicated that daytime CO2 flux rate was significantly lower in the inundated treatments compared to the control water level, but the main effect of salinity was not significant during the day. There was, however, a significant interaction between salinity and inundation, such that the control water level-elevated salinity treatment had higher rates of soil respiration than the inundated-elevated salinity treatment (Figure 4). In addition to the treatment effects, temperature also influenced soil respiration rates. Methane flux was significantly lower in the control water level-ambient salinity treatment than all other treatments and porewater DOC increased significantly with greater inundation. Among the three pathways of soil C loss measured (CO2 flux, CH4 flux and DOC production) 95% of all soil C lost from mangrove peat soils was lost through CO2 flux. Increasing tidal inundation by 8 cm significantly decreased the rate of CO2 flux by 35-37 %. Increasing salinity from ambient (15-20 ppt) to 30-35 ppt increased the rate of CO2 flux by an average of 17-21 %. The combination of these two variables (increased inundation and elevated salinity) resulted in a synergistic decline in the rate of CO2 flux, 19-26 % less than in the control treatment. Preliminary metagenomics results indicate that soil bacterial community structure responded differently to the treatments. While an increase in salinity did not produce observable changes, an increase in water level produced a decrease in richness and a increase in relative abundance of several OTUs (T-RFs).

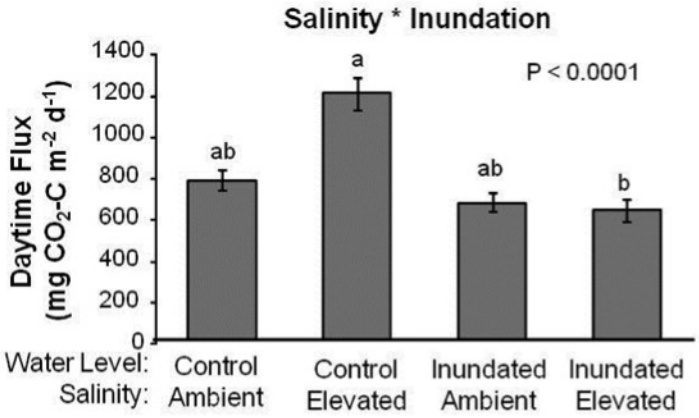

Figure 4: Average soil respiration rate according to treatment condition. Different letters represent significantly different means ($p<0.05$).

5. Hydrology

Research of the Hydrology group was driven by the question: "How will the interaction of surface and groundwater inflows, tidal energy and seawater intrusion, local rainfall, and evapotranspiration control [physical and chemical] hydrologic conditions in the oligohaline ecotone under conditions of increasing freshwater inflows (or sea level rise) from the Everglades?"

- *Hydrologic Variables:* Water budget studies confirmed that groundwater inputs constituted a significant contribution to the surface water in both Taylor (27 %); and Shark Sloughs (19 %), and were more significant closer to the coastline (Saha et al., 2012; Zapata-Rios and Price, 2012; Minochet et al., 2011; Figure 5.1).
- *Estimating Groundwater Discharge:* Groundwater discharge to the surface water of the coastal Everglades resulted in a release of phosphorus to the surface water stimulating primary production (Koch et al., 2012).
- *Spatial Analyses:* Our long-term spatial studies show that salinity continues to increase in the groundwater of the ecotones of both Shark and Taylor Sloughs as freshwater releases are minimal and sea level continues to rise (Saha et al., 2011a; Figure 5.2).
- *Water Residence Times:* Residence times in Shark Slough decreased in a downstream direction from >90 days to about 14 days between SRS-1 and SRS-4 (Saha et al., 2011b). Between January 2001 through December 2011 water flushing times varied on average from 11 to 54 days in Taylor Slough, and were inversely correlated with evapotranspiration (Sandoval et al., 2012; Figure 5.3).

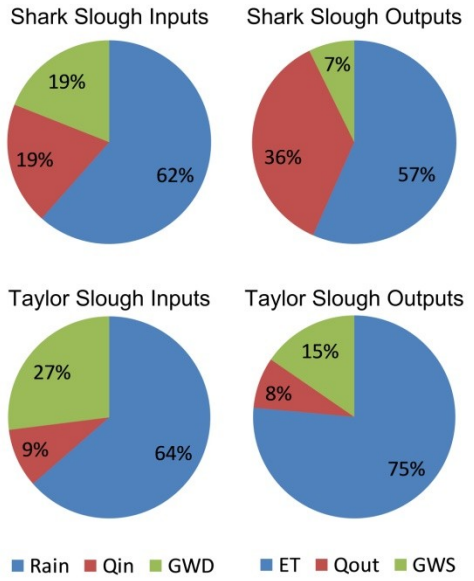

Figure 5.1: Pie charts of water budget components in Shark and Taylor Sloughs. Inputs include rain (blue), surface water inflow (Qin, red), and groundwater discharge (GWD, green). Outputs consist of evapotranspiration (ET, blue), surface water outflow (Qout, red), and groundwater seepage (GWS, green).

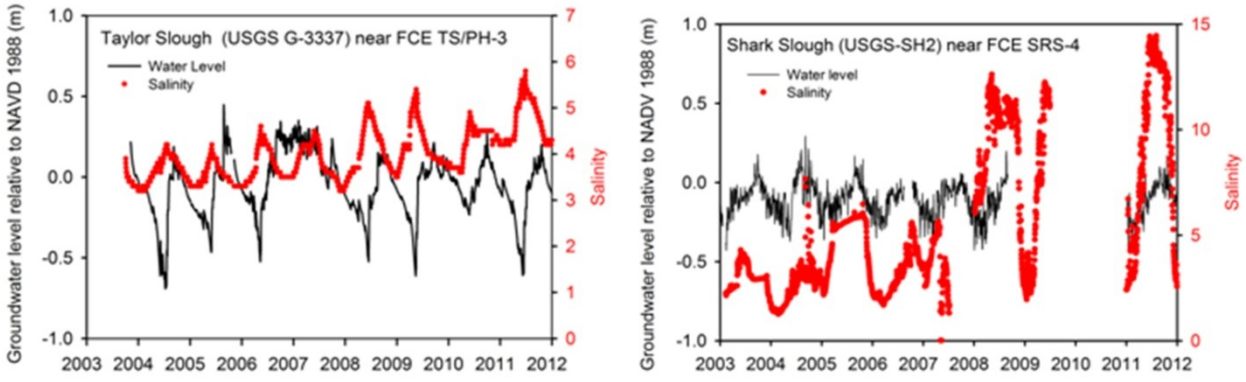

Figure 5.2: Groundwater salinity (red) and groundwater level (black) in the ecotones of both Taylor (left graph) and Shark (right graph) sloughs (Saha et al., 2011).

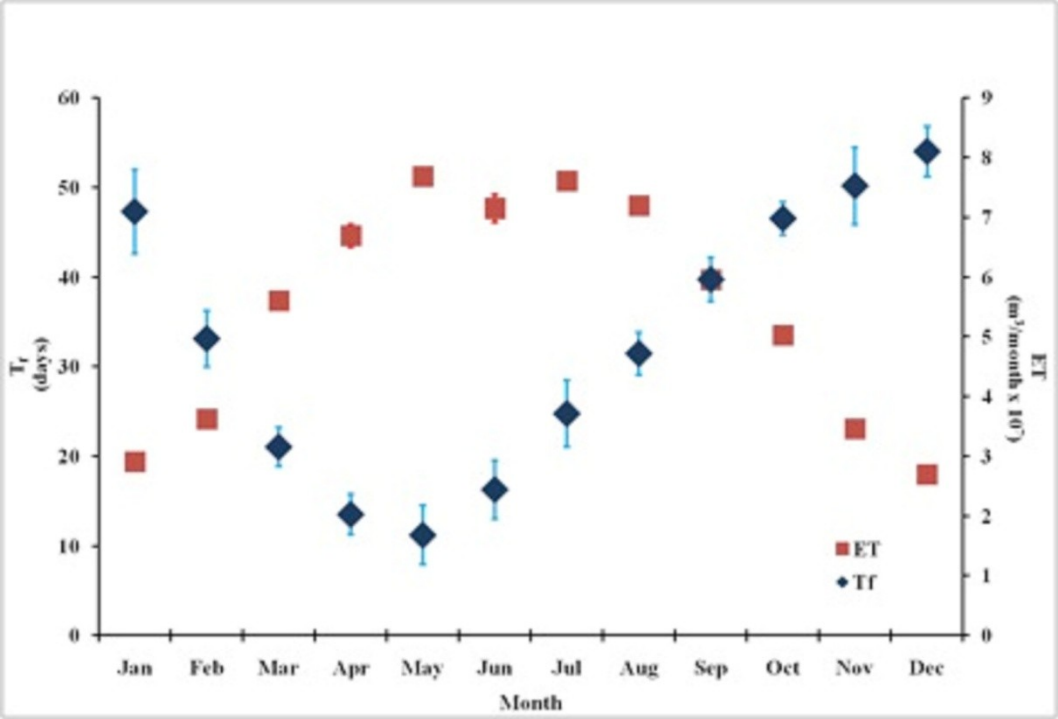

Figure 5.3: Average monthly flushing times (left axis) and evapotranspiration (right axis) of Taylor Slough between 2001-2011.

6. Human Dimensions

Human Dimensions research in FCE focuses on the central question: "What social and economic processes drive land use change in areas adjacent to FCE and how do these changes affect the quantity and quality of water flowing along FCE transects."

- *Spatial Patterns of (Sub)urban Landscapes:* We mapped four main land cover categories (tree, grass, impervious and other) at high resolution from Geoeye imagery, followed by deriving neighborhood-level statistics of absolute and relative proportions of land in the various covers. Analysis of 5 different types of neighborhoods ranging from high affluence, urban to low-affluence exurban indicates that (1) all the five groups have a lot of turfgrass, (2) Distinct social groups appear to be producing some distinctive landscapes, but (3) Urban/affluent and exurban/poor groups appear to be converging with similar proportional land covers in tree/grass. Among the five groups demonstrated here, the intermediate urbanicity and affluence groups (21, 46 and 63) are the ones that display the highest levels of spatial autocorrelation in terms of percent grass or percent tree cover in individual parcels. Informal norms of post-Andrew development phasing may play a role here in explaining the degree of contiguity of land cover behavior. Neighboring parcels in the high affluence, high

urbanicity group (07) are least likely to display similarities in terms of proportions tree or grass cover maintained in parcels.

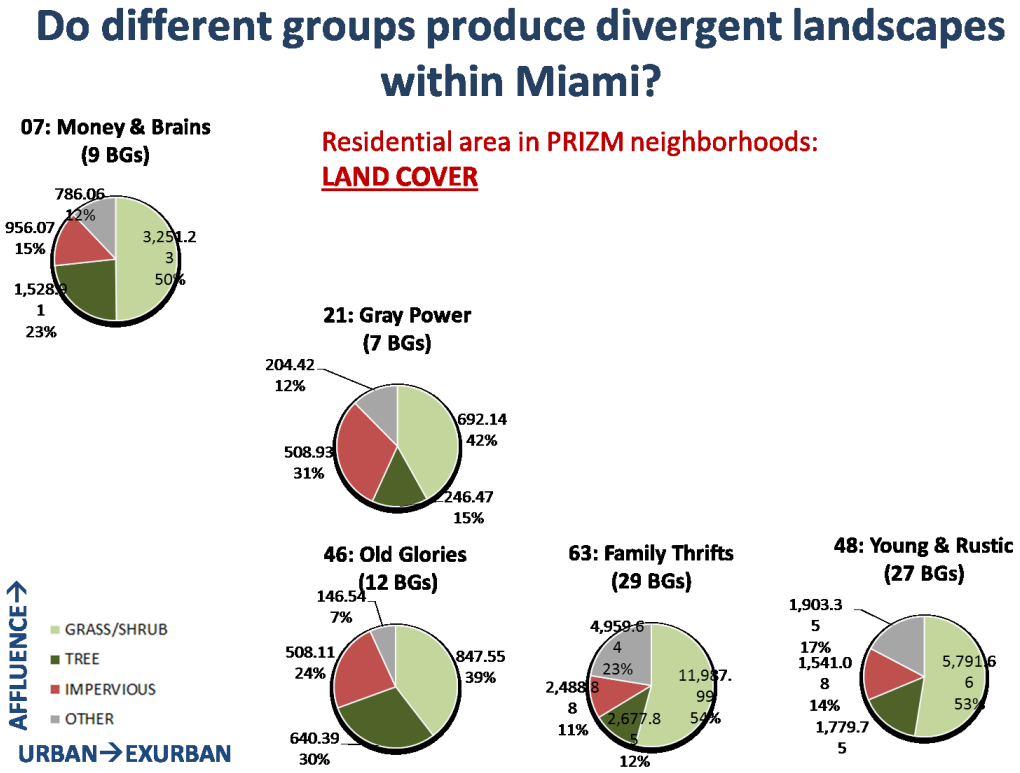

Figure 6.1: Example results with 5 social groups (neighborhoods) in Miami-Dade, ranging from high affluence, urban ("07") to low affluence, exurban ("48").

In related work, Onsted and Roy Chowdhury examine the specific role that zoning and flood hazards have played in the urban growth of the Redlands area of Miami-Dade County. The results indicate that agricultural zoning has indeed retarded urban growth. Furthermore, these results of past analysis of zoning's specific effect can be integrated into the architecture of an urban growth model employing cellular automata that allows for a more accurate assessment of future growth scenarios. We found that the average annual consumption rate of available land (G) can be explained by: $G = (X/Y) / Z * 100$, where X = Total Urban Growth upon a designated land category (from 2001 to 2011), Y = Available land for development in 2001 (Y=A+B, where A = Agricultural land and B = Undeveloped, Unprotected Land), and Z = Number of Years of Growth (10 years).

Table 6.1: Urban growth (in hectares) in each land designation (2001 to 2011)

	X	A	B	Y	Z	G
All Redland	1337	14,108	1728	15836	10	0.84%
High Flood Risk	739	8476	1048	9525	10	0.78%
Low Flood Risk	598	5632	694	6326	10	0.95%
Lands Zoned for Agriculture	505	7991	725	8715	10	0.58%
Lands Zoned as Interim	409	5759	626	6386	10	0.64%
Lands zoned for development	418	357	374	731	10	5.71%

*A and B columns do not always equal Y due to rounding.

7. Climate and Disturbance

We are addressing our central question "How is the location and the spatial extent of the oligohaline ecotone controlled by changes in climate (precipitation, temperature, wet vs. dry years), freshwater inflow (management, restoration, and the "Grand Experiment"), and disturbance (sea level rise, hurricanes, fire)?" using observational and paleoecological approaches, together with focal work on carbon dynamics and tracer studies of water and material fluxes.

- *Observational Studies:* Hurricane Wilma (October 2005) delivered 3-4 cm of P-rich marine sediment into the fringing mangrove forest in SRS (Castañeda-Moya et al. 2010), which increased soil elevation relative to sea level rise (SLR), stimulated mangrove belowground production (Whelan et al. 2009), and eventually leached into the river water column to cause phytoplankton blooms across Florida Bay (Briceño & Boyer 2010). Data from our mangrove eddy covariance tower enabled us to document recovery of this nearly completely defoliated forest (Smith et al. 2009), to one that sequesters CO2 at rates exceeding temperate and many tropical forests (Barr et al. 2011). Delays in rehabilitating freshwater flows to the Everglades have created a system where biogeochemistry and productivity in the coastal transition zone are largely driven by marine water supplies to the ecotone, confirming extraordinary sensitivity to saltwater encroachment associated with SLR and storm activity.
- *Paleoecology:* Preliminary results of the study on the impact of sea level rise on the coastal salt marsh ecosystem in the Shark River Slough revealed distinct changes in diatom assemblages in the upper level of the core (Wachnicka and Smoak, unpubl.). The youngest sediments were dominated by both, marine and brackish water taxa, reflecting the dynamic nature of this area, where salt water from the Gulf of Mexico mixes with freshwater flowing from the Everglades wetlands. The most common taxa included marine species such *as Paralia sulcata*, *Thalassiosira* spp. and brackish

water species such as *Tryblionella granulata* and *Achnanthes* spp. Multi-proxy studies on the ecological regime shifts caused by climate variability, and extreme climate and weather events on coastal embayments along the southeastern portion of Florida revealed significant shifts in the magnitude and timing of restructuring in diatom, ostracode and foraminifera assemblages after 1950s. The major assemblage restructurings often coincided with the occurrence of severe drought periods in the South Florida region. The timing of the increase in magnitude of the assemblage restructurings coincides with major alterations of the South Florida hydroscape. Similar work in the upper Everglades watershed (Nodine and Gaiser, unpubl.) is showing that tropical storms alter diatom community dynamics in ways that should be recognizable in sediment cores, suggesting capacity for high-resolution reconstructions of storm frequency.

Dendrochronological studies show two periods of extreme stress (1935 and 2005) attributed to the effects of the Hurricane of 1935 and Hurricane Wilma, two storms that caused significant damage in the Florida Keys (Rebenack and Anderson, unpubl.). In addition, the tree located closest to the periphery of the freshwater lens showed an overall more enriched isotopic signature compared to the three trees growing over a deeper part of the lens (Figure 7). This may indicate that these slash pine on Big Pine Key are susceptible to freshwater stress. The difference in the trends of the carbon isotope chronologies of both sets of trees over time is still being investigated. Currently, the carbon isotope chronologies from Big Pine Key are being refined to ensure that only false rings were removed from the dataset so that correlations may be investigated for various climate variables. Oxygen isotope analysis on the same slash pine samples will be completed within the next few months. Ongoing work also includes the development of a corresponding Lower Florida Keys climatology using data supplied by the NCDC, ring-width measurements for each sample and a seasonal isotopic analysis of stem water from living *P. elliottii* trees near the disk collection site. Additionally, *Taxodium ascendens* cores from the C-111 Basin are being prepared for carbon and oxygen analysis.

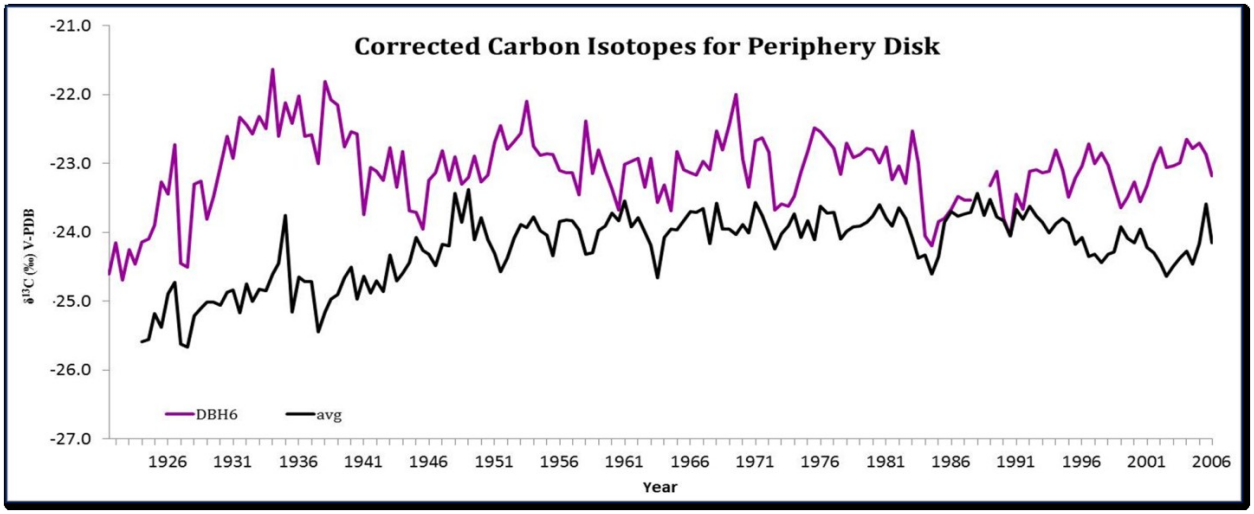

Figure 7: Carbon isotope chronologies for DBH6 (the tree located closer to the edge of the freshwater lens) and the average of the trees in Figure 1. DBH6 shows an overall more enriched carbon isotope signature over time indicating that this tree has been under more stressful conditions compared to the other three trees located over a deeper part of the freshwater lens.

- *Carbon Dynamics:* Much progress was made in a Carbon Dynamics-focused workshop, which refined work planned for FCE III as well as a successful WSC proposal focused on linking C-dynamics to hydrologic change in South Florida (Sukop et al.). Each participant gave presentations about present work at or relevant to the SRS study area and efforts were discussed on how to integrate on going research projects within the region (pCO_2, OM mineralization, mangrove biomass, and future tracer experiments). Resultant recommendations included: increased temporal and spatial sampling; getting C and CO_2 into similar flux units; further experiments & monitoring at smaller tidal creek scales; complex nature of land surface & tidal variability (with regard to soil CO_2 flux). Further recommendations focused on recommendations for monitoring pH, which is important for proper pCO_2 fluxes from sediment (soil) water interface to the water column (and to the atmosphere). Dr. Goni also recommended ^{14}C AMS dating of DOM, in order to asses the actual age of "background" C moving through the system. The FIU group has previous dated DIC from Florida Bay, and further recommended doing both analyses in tandem.
- *Tracer Studies:* Results from Harney River tracer studies indicate that the DOC is composed of mangrove and/or other C3 derived terrestrial material and not seagrass. Additionally the isotopic composition of DIC compared with salinity indicates that near the mangrove zone mineralization of the OM (perhaps mangrove derived) is contributing to dissolved form of carbon. These results were similar to the previous work in Shark River from last year.

8. Modeling and Synthesis

Integration and synthesis were a top priority in Year 6. During this time, we focused on a "dynamic budget" modeling approach of the ecotones and added hydrologic and hydrodynamic modeling of the FCE and land-use/land-cover modeling of the land directly adjacent to the FCE. Selected major findings from this year's activities include: (1) Groundwater discharge plays an important role in the water budgets of the ecotone, but it is spatially and temporally variable, (2) Nutrient budgets of the ecotone are strongly seasonal, (3) Flood mapping and agricultural zoning retard urban growth along the boundaries of the FCE, and (4) In seven scenarios modeled, proposed hydrological restoration in the central Everglades did not adversely affect water quality in the southern Everglades.

- *Hydrologic and Geochemical Models:* In recent years, a great deal of our focus has been on the role that groundwater discharge might play in the water and nutrient budgets of the ecotone. Previously, Zapata-Rios (2009), Michot et al. (2011), and Spence (2011) showed that both groundwater discharge and recharge occur in the ecotone, though the magnitude varies spatially and temporally, with the latter having both within- and between-year dimensions. Saha et al. (2012) added to this understanding, modeling the water budget for Shark River for calendar years 2002-2008, and finding that net groundwater exchange, especially groundwater discharge, are important components of the water budget, though there is substantial inter- and intra-annual variation. This line of inquiry continues, as we continue to constrain the conditions under which groundwater discharge occurs to better enable us to predict what might happen to that groundwater discharge under restoration and

climate-change scenarios. For example, the model calibrated by Spence (2011) is now being expanded upon to be applied to a spatially and temporally larger model domain to improve the estimates of groundwater discharge over a larger area and over a longer period of time. All of these findings are important in the context of previous findings by Price et al. (2006), who hypothesized that groundwater discharge to the ecotone could be an additional source of P to these P-limited environments.

We are now beginning to link these findings on groundwater discharge to nutrient budgets in the ecotone. N and P budgets based upon the results of Michot et al. (2011) coupled with unpublished direct estimates of nitrification, denitrification, nitrogen fixation, and burial rates indicate seasonally varying N and P deficits in the lower Taylor River, with N deficits of -3,653 mg m^{-2} y^{-1} and -11,527 mg m^{-2} y^{-1} for the dry and wet seasons in 2002, respectively, and P deficits of 64 mg m^{-2} y^{-1} and -36 mg m^{-2} y^{-1} for the dry and wet seasons in 2002, respectively. Doubling the P concentration in the groundwater to simulate the differences reported by Price et al. (unpublished reports) increases the budget closure term, which is reflected in higher burial rates. However, these increased burial rates are still lower than burial rates found by elsewhere on Taylor River by Rivera-Monroy (unpublished results), exceeding even the total through flow per square meter in the area. This landscape-level nutrient budget strongly suggests the importance of performing both water and nutrient budgets on a seasonal basis and not relying on integrated annual estimates.

- *Biogeochemical and Biological Modeling:* We have just completed a synthesis of multidecadal changes and spatial gradients in radiometric-based soil and nutrient accretion along the Taylor River ecotone. This included comparisons with spatial variation of elevation change and temporal variation in hydrology, with historical flows estimated from historical and paleoecological data. Spatial and temporal variation in OM accumulation indicate that a southward shift in peak OM accumulation occurred over the 20th Century, with OM accumulation highest at the freshwater end in the early 1900s and in the northern mangrove zone in the late 1900s. Similarly, P accumulation is highest in the northern mangrove zone in the late 1900s, suggesting a link between OM and P accumulation during this time. This data set is now available to help calibrate existing models of OM and P accumulation, i.e., the Spatially Explicit Carbon Accumulation and Transport (SCAT) model, which simulates the accumulation and transport of OM in the sawgrass ridge and wet prairie slough habitats of Shark River Slough, and Ribbon models, which are being used to simulate water TP and ecosystem P stocks (e.g., vegetation, consumers, detritus, floc, and soil) and fluxes (e.g., retention, transport, and cycling rates) for the landscape units sawgrass, wet prairie and moderately P-enriched sawgrass, and wet prairie habitats.

  We have an ongoing effort to use nutrient loading estimates to model long-term, average nutrient concentrations in Biscayne Bay. The study consists of a series of steps to (a) review an existing nutrient loading study, (b) estimate nutrient loads to Biscayne Bay for all water budget components, (c) extend an existing hydrology/salinity model to utilize the nutrient loads for mass balance calculations, and (d) use the nutrient box model with estimated loads for future land use scenarios. This mass-balance approach is simple to implement compared to more costly alternatives (e.g., coupled hydrodynamic-water quality models) and lends itself to the analysis of uncertainty through sensitivity analyses. However, the mass-balance approach works on long time steps and therefore is not able to predict the short-term responses of nutrient concentrations to short-term changes in nutrient loads, such as occurs during episodic events (e.g., hurricanes). Feedback received at a workshop convened to

review the results recommended that further work be undertaken to better refine the mass-balance calculations, particularly with respect to these episodic events. Such work is now underway.

- *Social Modeling:* In recent years, we have added social science modeling, to better understand and predict future development pressure that will be exerted on the FCE. Social-science modeling in the past year has been focused on the controls on changes in land use/land cover on the boundaries of the FCE. Aldwaik et al. (in review) shows that the results of land use/land cover modeling are sensitive to category creation; Garvoille et al. (in review) shows that cultural controls create fine-scale homogeneity and coarse-scale heterogeneity in suburban landscapes; and Onsted and Roy Chowdhury (in review) examines the specific role that flood-hazard mapping and zoning have played in the urban growth of the Redlands area of Miami-Dade County, along the eastern boundary of the FCE. All of these results are being integrated into the architecture of urban growth models employing cellular automata to facilitate a more accurate assessment of future growth scenarios (e.g., Onsted and Clarke 2011; Onsted and Clarke 2012).
- *Integrated Modeling:* The Everglades Landscape Model (ELM; latest version 2.8.4, Fitz and Paudel 2011) is a regional-scale, integrated ecological assessment model designed to help us understand Everglades hydro-ecological dynamics and to predict the relative responses of the landscape to alternate water management scenarios. An important use of this ELM simulation framework is to evaluate the relative ecological benefits of alternative scenarios in the greater Everglades region. In the central Everglades, restoration will ultimately include reconnecting multiple impoundments that have altered the water flows and depths (i.e., the Decompartmentalization Project, commonly known as the Decomp Project). Recently, we participated on a review team evaluating alternative restoration scenarios for Phase 1 of the Decomp Project. In a prolonged, stakeholder-based process, ELM was used to simulate two baseline and seven alternative management scenarios, indicating that proposed hydrologic restoration plans did not adversely impact water quality in the southern Everglades (Fitz et al. 2011, which was the precursor to the separate interagency reporting in 2012). During this time, we also developed a sulfate module for the ELM, for both general research throughout greater Everglades and application to decision-making in planning Aquifer Storage and Recovery Projects.

  This also was a year of transition, as we changed leadership and refocused our efforts for FCE III, with a greater emphasis on integrated modeling in a scenarios framework. We have been working on a synthesis paper, focused on integrated modeling in the context of the FCE, in which we are describing the lessons learned, the technical and cultural obstacles that remain, and the framework we're using to overcome these obstacles and improve integrated modeling in FCE III and beyond. This paper has been a challenge. The paper has been drafted many times over, and continues to be a work in progress, with the main authors holding a formal, all-day writing workshop in Fall 2012. Though the paper remains a work in progress, much has been learned to date, which is already being applied toward the visioning of integrated modeling for FCE III. Part of this visioning is placing FCE III modeling in a scenarios context, in which common storylines will be adopted, with the degree to which modeling efforts are linked to these storylines helping to define the ways in which the modeling efforts proceed and interact. We are combining this scenarios framework with bottom-up decision scaling that includes an initial extraction of signals of land-use and climate change from long-term socio-ecological datasets and obtaining stakeholder feedback

on the outcomes of water-management decisions and climate change. This allows sensitive ecosystem attributes and thresholds for undesirable impacts to be identified at the outset, constraining the modeling efforts to drivers and response variables that are likely to provide the most informative outcomes. Planning for climate change can then build on an understanding of ways in which ecosystem and societal risks are enhanced or mitigated by ecosystem feedbacks or social infrastructure and influence decisions in a way that facilitates investments that maximize chances for a sustainable future.

9. Products of Supplemental Funding

- R.E. Boucek (PhD student), J.S. Rehage & M. Heithaus received supplement funding to incorporate mesoconsumers in studies of animal movement in SRE. In Spring 2012, we tagged a total of 44 common snook (*Centropomus undecimalis*), all of which have been detected in the acoustic array in two data downloads (May & August 2012). We presented preliminary results of the movement data at the 2012 INTECOL meeting, Orlando, FL, and the 2012 ASM meeting, Estes Park, CO.

- J.S. Rehage and R.E. Boucek received funding for an REU project to compare prey quality among freshwater and estuarine taxa in SRE. Large numbers of freshwater prey enter the upper estuary upon marsh drying, but their quality compared to resident prey (both fish and invertebrate) is unknown. We compared the caloric content and stoichiometry of common prey found in the upper SRE, both freshwater and estuarine. The project was led by Maria Jesus Soula (undergraduate student, FIU Biology), and involved Steve Santos, high school student at Varela SH, Miami, FL. Maria Jesus presented preliminary results of the prey quality data at the 2012 ASM meeting, Estes Park, CO.

- Adam Rosenblatt received supplemental funding from the ICUN crocodile specialist group to study isotopic turnover rates and discrimination factors in alligators (Rosenblatt and Heithaus in press). Philip Matich received grants from PADI Foundation, SERC, and Zoo Miami to study the long-term impacts of the 2010 cold snap on movements, trophic interactions, and ecological roles of juvenile bull sharks in the Shark River Estuary. Studies are ongoing.

- International NSF supplemental funding was provided to compare and contrast the hydrologic and ecological systems of Florida Bay (FCE LTER) with Shark Bay in Western Australia. That supplement allowed for Dr. Jim Fourqurean to organize a workshop on 3 March 2011 in Perth, Australia, as well as for Drs. Rene Price, Jim Fourqurean, and Mike Heithaus, graduate students of FCE LTER to collect hydrologic, geochemical, and ecological data from Shark Bay Australia, between March-July 2011. The results of the workshop and the additional samples collected resulted in a special issue in the CSIRO journal of Marine and Freshwater Research. There are 23 number of papers in this special issue. One paper produced from the hydrology working group includes: Price, R.M., Skrzypek, G., Grierson, P.F., Swart, P.K., and Fourqurean, J.W. 2012, The use of stable isotopes of oxygen and hydrogen to identify water sources in two hypersaline estuaries with different hydrologic regimes, Marine and Freshwater Research, 63(10), MF12042, in press.

C. Training and Development

The FCE LTER Education & Outreach program is designed to address the goals and objectives outlined in the *2011 Strategic and Implementation Plan: LTER Research and Education (SIP)*.

The FCE Education & Outreach (EO) team has developed and continues to tailor our programs for our key constituents and under-represented groups including K-12 students, teachers and administrators; undergraduate and graduate students; professors; policy makers; and citizens. Over the last year FCE research has been presented to over 2200 K-20 students including 1145 high school students, 835 undergraduates, and 236 graduate students. These students can be found in 92 different classrooms from seven different institutions.

FCE scientists are also busy presenting our work outside of the classroom. Our researchers have delivered 37 presentations, in 17 venues within our community, 4 beyond our community, and have been heard by more than 810 audience members.

Our partnerships have also allowed us to broaden the scope of our outreach and reach a different constituency. Specifically, our relationship with the Tropical Botanic Artists has allowed us to educate our community on macroalgae. Tropical Botanic Artists and the FCE Marine Macroalgae Research Lab have presented the watercolors exhibit *Macroalgae: Hidden Colors of the Sea* at six venues across South Florida.

In another partnership with local wildlife filmmaker, Richard Kern, FCE research has been incorporated into his current film *Surviving the Everglades*. Mr. Kern's film/lecture series, *Encounters in Excellence,* is presented to over 50,000 K-12 students annually in Miami Dade County Public Schools (MDCPS). Some of this footage will be developed into 3-5 minute videos and posted the companion website *OdysseyEarth.com*.

FCE researchers are active throughout our community. The current FCE Student Group (SG) President, David Lagomasino, hosted and coordinated the NASA International Space Apps Challenge, and the NASA Waterscapes program on behalf of FCE LTER. Many of our scientists have also been visible throughout our community as judges in the South Florida Regional Science and Engineering Fair, the Intel International Science and Engineering Fair selection committee for MDCPS, South Florida Regional Science Bowl, and the Fairchild Environmental Challenge.

FCE is also working through our SG to increase training opportunities for undergraduate and graduate students to engage in interdisciplinary science. The current SG consists of 58 students that include 40 Ph.D. candidates, 11 masters students, and 7 undergraduates. The SG is composed of 26 life science students, 24 studying earth sciences, 4 in chemistry, 2 engineering and 2 within the social sciences. FCE students earned 4 MS theses and 3 Ph.D. dissertations from December 2011 to September 2012.

FCE continues to work with K-12 students through a near peer mentoring in our Research Experience for Secondary Students (RESSt) and Research Assistantships for High School Students (RAHSS) programs. Over the last year, FCE scientists have provided internship

opportunities for 14 high school students. These internships promote collaboration and integrate curricula across biophysical and social science disciplines

In 2012, RAHSS intern Jamie Odzer received 3rd Place at the Intel International Science and Engineering Fair for her project researching blue crabs. Mentored by Ph.D. student, Adam Rosenblatt, Jamie received a total of nine awards and a $1000 cash prize. Our second RAHSS student, Cindy Saenz, who was mentored by Tiffany Troxler received two awards for her poster.

Increasing the diversity of our educational programs remains a consistent priority and we are working throughout our educational programs to develop environmental literacy materials that meet the needs of diverse communities, traditionally under-represented groups across settings, political, socioeconomic, ethnic and cultural, age, and gender groups. FCE is currently hosting 64 undergraduates in our labs, 50 of which are underrepresented minorities, including 36 females, and 24 Hispanic students. Our formal high school mentoring programs are working with students in 5 high schools and of the 14 students 93% are underrepresented minorities (13 Hispanic, 5 female).

In 2012, FCE made significant strides in the REU program. Former RAHSS recipient, Christopher Sanchez, continued working with mentors Drs. Evelyn Gaiser and Colin Saunders in publishing a manuscript of his RAHSS results in the *Journal of Paleolimnology*. Chris is the first RAHSS to continue as a formal REU and our first student to publish the results of their science fair project. Christopher has continued working through 2012 as an REU under the direction of Tiffany Troxler studying the relationship between water quality and carbon dioxide efflux in Everglades mangrove forests. He is also in a second year REU studying similar processes with Dr. Daniel Childers at CAP LTER. Christopher presented the results of his FCE research at the 2012 FCE LTER All Scientists Meeting (ASM). Christopher is also being recognized for his outstanding work beyond FCE LTER and has been named a *2012 Barry M Goldwater Scholarship* for excellence in education and his work with LTER was a major contributing factor.

REU Alex Perez presented the poster "*Nutrient Dynamics of Benthic Flora in Florida Bay*" at the *21st Biennial Conference of the Coastal and Estuarine Research Federation* and the *2012 FCE LTER ASM*. He presented a second poster and gave an oral presentation as part of the *ESA 2012 Nutrient Additions Alter Community and Ecosystem Processes: Lessons Learned from the Long-Term Ecological Research (LTER) Network* session.

Our third, formal REU, Michelle Prats was mentored by Dr. Kevin Whelan while learning the SET sampling technique, conducted sampling and established one SET sampling site in Biscayne National Park. Michelle presented her results in a poster at the *9th INTERCOL International Wetlands Conference*.

FCE LTER is also working with both professional and pre-service teachers in programs that provide the knowledge, skills and materials needed for taking advantage of LTER resources by working directly with LTER scientists. In 2012, we mentored three teachers through our RET program.

Our first RET, Paul Rehage, has collected and identified macroalgae from the near shore mangrove and seagrass habitats with his classes at Miami Beach Senior High Academy of Marine and Environmental Science. Mr. Rehage and his students have been working with Dr. Ligia Collado-Vides in order to determine the relative abundance, species richness, and percent cover of rhizophytic algae on red mangrove prop roots, and epiphytic algae on seagrass blades. Upon completion, Mr. Rehage and his students will conduct a Simpson's Diversity Index in order to compare macroalgae and seagrass diversity between sites and present those results in a poster at our annual ASM.

Our returning RETs Teresa Casal & Catherine Laroche have been working with Dr. Victor Rivera-Monroy on a project studying the relationship between salinity and its effects on the establishment and productivity of mangroves. Ms. Casal has collected soil pore-water and surface water samples from SRS and is working with Ms. Laroche to develop similar protocols in our Research Experience (RE) and citizen science programs at the Deering Estate.

Our RETs provide the driving force behind our development of environmental literacy materials. Ms. Casal has produced two new lessons, two power point lectures, and given four FCE related oral presentations. Ms. Casal continues to include FCE LTER data analysis in all of the classes that she teaches in the School of Education at Miami Dade College and both she and Laroche present FCE curriculum in the Global Studies MAGNET at Felix Varela Senior High School.

Over the last year, FCE has been working with the Everglades Digital Library, and our partners, in developing a prototype for sharing our curriculum materials. The new Everglades Discovery System will not only house our materials, but will also coordinate those materials with FCE datasets.

As part of the FCE Communication Plan, we launched our newsletter "News from the Sloughs" in October 2011 and have since posted 4 quarterly editions boasting a total of 24 articles http://fcelter.fiu.edu/about_us/news/. The content has included a variety of topics ranging from student highlights to key findings in research publications to interviews with FCE researchers and field stories. FCE LTER continues to expand our participation throughout social media and is largely due to the efforts of our SG. In June 2012, our graduate students introduced their blog *Wading Through Research* http://floridacoastaleverglades.blogspot.com/ and have since posted 31 entries. FCE continues to maintain a Facebook page and Twitter, and recently created a Flickr account to share photos and plans to begin posting to Tumblr. We are currently working towards coordinating our communication outlets and social media through our new FCE Communications Committee, led by Susan Dailey.

The FCE Citizen Science program currently consists of an Everglades predator-tracking kiosk in the EcoDiscovery Center at the Ft. Lauderdale Museum of Discovery and Science (MODS). The display enables the MODS to bring real-world research to their patrons while educating them on the effects of environmental changes such as rising sea level and restoring the Everglades affect predator behavior. Predators can also be tracked over the internet through Predator Tracker (http://tracking.fiu.edu). Dr. Heithaus also discusses his research in the episode *Coastal Carnivores,* a 26 minute documentary that he produced and broadcast as part of the PBS series *Changing Seas*.

Dr. Gaiser led the "LTER Readings" graduate student workshop at FIU in Fall 2011. Twelve students enrolled. The readings group discussed the FCE III renewal proposal and students contributed to the development of proposal materials. The group also learned about the NSF proposal review process and staged a mock panel to evaluate example proposals.

Dr. Gaiser served as a dissertation defense opponent for graduate students Julio Ibarra (Twente University, Netherlands) and Emmy Lammertsma (Utrecht University, Netherlands). Dr. Ibarra successfully defended his thesis on how developments in cyberinfrastructure have changed long-term ecological research, and Dr. Lammertsma successfully defended her thesis on long-term drivers of climate fluctuations from paleoecological records in South Florida.

Dr. Gaiser is mentoring a new RAHSS student, Sara Osorio, a junior at Felix Varela High School. Sara is comparing diatom community assembly along the freshwater to marine gradient in the restored slough at Deering Estate at Cutler with the FCE LTER research sites in Taylor Slough.

Dr. Gaiser led a workshop at the Organization for Biological Field Stations meeting at Archbold Biological Station, Venus, FL (Sept. 2012) on aquatic sensor development and deployment.

D. Outreach Activities

There are many ways in which FCE scientists, students, and staff interact with the greater public. Outreach often takes the form of presentations at forums such as community group meetings, publicized events, and secondary schools, or of specific training activities for students, teachers, or others. If a FCE scientist discusses their LTER research in such a presentation, we record that presentation as FCE outreach. The FCE Education and Outreach staff (including FCE high school interns) gave numerous presentations to schools in South Florida. FCE researchers also gave 171 presentations from September 2011 - October 2012. We include some examples of FCE outreach activities during the past year below.

- Dr. Gaiser spoke about the FCE LTER program at the FIU School FIU School of the Environment, Arts and Society Ocean Sciences Lecture Series in Key Largo, FL.

- Dr. Gaiser speaks about karstic wetland algae and provides tours of algal habitat on an annual basis at Misery Bay Provincial Park in Ontario, Canada.

- Dr. Gaiser contributes as Water Quality Working Group Lead to the "Synthesis for Everglades Research and Ecosystem Services" program, a FCE LTER partner project operated through Everglades Foundation and Everglades National Park. The project involves communication with policy-makers and stakeholders in establishing alternate scenarios for a sustainable future for South Florida.

- Dr. Gaiser contributes to the development of "System-Wide Indicators of Everglades Restoration," a report to U.S. Congress by FCE partners in the South Florida Ecosystem Restoration Task Force.

- Dr. Gaiser encouraged K-24 participation in the FCE LTER program by speaking at the annual Fairchild Challenge at Fairchild Tropical Botanic Garden, Miami, FL.

- Emily Nodine spoke to a school group from the University of Mary Washington about FCE and Everglades research when they were visiting for a field trip in March 2012. The course was Everglades Environmental Exploration (EESC/GEOL 421).

- Breithaupt, J. L., Smoak, J.M., Smith III, T.J., & Sanders, C.J. (2012, April). Carbon, Climate & Mangrove Sediments: Context & Preliminary Results in the Coastal Everglades. 3-Hour Lecture to Freshwater Ecosystems class at New College of Florida.

- Rebecca Garvoille - Invited Lecturer. The Culture and Peoples of the Everglades. The Gathering: Everglades. A Cultural Tourism and Educational Weekend put on by the Florida Humanities Council. Everglades City, FL. March 2012.

- The LSU group is currently participating in developing proposals to expand long term ecological studies in several regions in Latin America, including: La Ceiba, Honduras; Bahia Honda, Panama, and the Yucatan Peninsula, Mexico.

- J.S. Rehage presented at the "Meet the Scientists Symposium at Terra High School in March 2012.

- J.S. Rehage was a guest speaker at the 2012 Summer High School Research Internship Program,' Why do science?' in May 2012 at Florida International University.

- J.S. Rehage served as an Ecological Society of American Mentor for the Aquatic Ecology Section at the 2012 annual meeting in Portland, Oregon.

- Colin Saunders participated as science and technical expert at public meetings with Army Corps of Engineers and local stakeholders (e.g., SAFER--South Florida bass fishermen's association) to discuss status and plans of CERP-funded projects about sheetflow enhancement.

- Norm Scully's "Sources and Sinks of Methyl Halides in the Florida Everglades and Coastal Waters" project involved a high school student through the Apprenticeships in Science and Engineering program.

- During 2011-2012, Adam Rosenblatt interned with Miami PBS affiliate and co-produced an episode of Changing Seas entitled "Coastal Carnivores" about predator behaviors in the FCE. He also conducted interviews with Dr. Tyrone Hayes, Dr. Michael Heithaus, and Dr. Mireya Mayor for FIU's Confluence series.

- In 2011, Adam Rosenblatt was featured in and co-produced an educational video and interactive display about the Everglades for use in the Ft. Lauderdale Museum of Discovery and Science (MODS). He also presented two talks about Everglades research at MODS.

- Ligia Collado-Vides performed outreach and public education about local primary producers and how they are vital to coastal ecosystems at the Deering Estate Seafood Festival in March 2012.

- David Lagomasino spearheaded outreach about FCE research at the Target Wednesday After Hours: Art and the Environment Opening Reception. Frost Art Museum, Florida International University. January 25, 2012.

- Elizabeth Lacey (working with Ligia Collado-Vides) helped organize an exciting art exhibit at Biscayne National Park called Macroalgae: Hidden Colors of the Sea. This 2011 exhibit showcased 30 high quality watercolor paintings and 3 herbarium display frames of macro-algae in all of its biological splendor. This innovative collaboration was sparked as part of Bioblitz 2010, and involved FIU's Marine Macroalgae Research Center, Biscayne National Park and Miami's Tropical Botanic Artists.

The FCE LTER Program reaches out to the public is through our web site (http://fcelter.fiu.edu/) and our web statistics show a steadily growing number of new web clients since the inception of the web site in 2001, suggesting a strong positive trajectory for our web-based public outreach. We've had 141,129 'Data' page visits made in 2011, up from 84,273 visits in 2010. We continue to receive general questions from our visitors and requests for schoolyard visits and presentations. Additionally, visitors to the data section of our website downloaded 284 datasets from August 13, 2011 through September 25, 2012.

III. PUBLICATIONS AND OTHER SPECIFIC PRODUCTS

A. Publications

Books

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Book chapters

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B. Other Specific Products

Presentations at Professional Conferences

The FCE LTER Program has not generated any tangible economically-valuable products to date. However, we view the dissemination of our results at professional scientific conferences as a tangible intellectual product. FCE scientists and students have made 171 such presentations during the sixth year of FCE II.

We continue to dedicate FCE resources to provide travel support for FCE scientists, students, and educators to attend professional conferences. This is important for their professional development, but is also important as a mechanism for disseminating products of FCE LTER research. Disseminating this intellectual product is critical to helping guide the science of Everglades Restoration.

Data or databases

We have 516 FCE and historical Everglades datasets available for public download at http://fcelter.fiu.edu/data. Datasets include climate, consumer, primary production, water quality,

soils, and microbial data as well as other types of data. We are collaborating with Dr. Colby Leider at the Music Engineering (MuE) Program at the University of Miami to develop a custom iOS application to facilitate exploration, manipulation, and annotation of long-term ecological data signals on a mobile platform. NSF supplemental support is being used to develop a web-based data-processing visualization tool.

The FCE IM team lends its expertise to site and network researchers when necessary by providing application support for its Excel2EML tool, available to the community via the FCE website (http://fcelter.fiu.edu/research/information_management/tools/).

C. Internet Dissemination

The url of the main FCE LTER Program website is http://fcelter.fiu.edu. Detailed discussion of FCE's data management and website management is available in this report.

IV. CONTRIBUTIONS

A. Contributions within Discipline

Several FCE scientists participate in large-scale high-density monitoring programs in the Everglades compliment FCE-LTER research. This includes the RECOVER program of the Comprehensive Everglades Restoration Monitoring and Assessment Program funded through the South Florida Water Management District, which collects and analyzes periphyton, vegetation and consumer data from 125 sites throughout South Florida every year in conjunction with abiotic and other biotic data. Gaiser and Trexler are collecting periphyton, consumers and plants from >400 sites per year, distributed throughout the Everglades, and analyzing patterns relative to water quality and hydrology gradients. Monitoring in Biscayne Bay, Florida Bay and the Florida Keys continues through support from the Southeast Environmental Research Center, University of Virginia and South Florida Water Management District.

Dr. Gaiser serves on the advisory board of the southeastern NEON domain. This requires regular meetings that focus on methods of coordinating SE Domain NEON science with other science in the region, including that of the FCE LTER, as well as national NEON activities.

Dr. Gaiser serves on the LTER Executive Board and the 2013 LTER Minisymposium planning committee.

FCE LTER Education & Outreach is represented at the Network level by Nick Oehm and Susan Dailey, who serve as Co-chair of Executive Board for Education Committee; LNO Communication Committee; Communication Newsletter and Website subcommittees; and ASM 2012 Planning Committee; ASM 2012 Program, Poster, Outreach, and Entertainment subcommittees.

J.S. Rehage & colleagues continued to track fish dynamics at the marsh-mangrove ecotone in SRS in relation to environmental variables, particularly marsh hydrological conditions. They also analyzed a 20-yr recreational fishery dataset and related angler catches to hydrological parameters at SRS.

Jeff Onsted was a panelist for: "SLEUTH Symposium III: After 15 years with the SLEUTH model, what we've learned and where we're headed." at the Annual Meeting of the Association of American Geographers in New York, NY from February 24-28, 2012.

Carl Fitz finalized a project funded by the U.S. Army Corps of Engineers to apply the Everglades Landscape Model (ELM) to evaluate water quality constraints on a critical CERP project that represented the first steps to "decompartmentalize" the central Everglades - i.e., to remove barriers to water flow into the southern Everglades. In a prolonged, stakeholder-based process, we simulated a total of 2 Baseline and 7 Alternative management scenarios, concluding that the proposed hydrologic restoration plans did not adversely impact water quality in the Everglades. As the technical lead of the Decomp Physical Model (DPM), Colin Saunders coordinates a multi-agency, multi-university team of researchers and participate in the execution the science plan of the Decomp Physical Model, a landscape-scale experiment located north of Everglades National Park. The DPM will experimentally re-introduce historic rates of sheetflow in an oligotrophic portion of Everglades to determine ecological benefits of sheetflow and determine the impacts of different canal-backfilling options. In coordination with the Army Corps of Engineers and Florida Department of Environmental Protection, he also developed a set of triggers, based on an analysis of historic hydrologic and water quality data, which will be used to guide operations of the culvert structure used to discharge water across the L67A levee and experimentally recreate high rates of sheetflow downstream. The first high-flow treatment of this 5-year, BACI-design experiment will occur in 2013.

Norm Scully's research group at Portland State University has been able to successfully apply a stable isotope tracer technique to measure and calculate the gross photochemical production rate for CH_3Cl and CH_3Br from natural waters. This technique will also prove invaluable in our measuring production and decay rates of CH_3Cl and CH_3Br from periphyton assemblages.

Ligia Collado-Vides has been working on a macroalgal bloom in Biscayne Bay with the support and collaboration of the Biscayne Bay Aquatic Preserve and RER (Previous DERM). The green macroalgae bloom in Biscayne Bay is an important study for the land/water management in south Florida, since it is a bloom that might signaling a high level of nutrient availability in the Bay.

Rinku Roy Chowdhury has served as the Chair of the Human Dimensions of Global Change (HDGC) Specialty Group, Association of American Geographers since 2010.

Laura A. Ogden served on the Executive Board of the Anthropology and Environment Section, American Anthropological Association.

Drs. Rene Price and James Fourqurean were invited to attend the Land-Ocean Connectivity Workshop- a Gordon-like workshop in Brest, France, September 2012.

Dr. Rene Price moderated a special session entitled Self-organized Landscapes: Coastal Wetlands at the 9th INTECOL International Wetlands Conference; June 3-8, 2012. Orlando, Florida. She also organized a special session entitled "Groundwater-Surface Water Exchange of Water and Constituents along Coastlines" for the Coastal and Estuarine Research Federation (CERF) Conference schedule for Nov. 2011 in Daytona, FL.

Dr. Price is a Florida Professional Geologist, and is an active member of the following professional organizations: American Geophysical Union; Geological Society of America; International Association of Geochemistry; and International Association of Hydrogeologists. She is an Associate Editor of Applied Geochemistry.

B. Contributions to Other Disciplines

Several FCE scientists participate as advisors to the South Florida Ecosystem Restoration Task Force for establishing Vital Sign Indicators of Everglades restoration. This team is using FCE LTER and other large, long-term datasets to assess and evaluate the trajectory of Everglades restoration projects. This includes participation in bi-monthly workshops, modeling efforts and synthesis of long-term datasets. This group published their findings in a special issue of the journal Ecological Indicators in 2009 and continues to report their findings to the U.S. congress annually. In 2012, they contributed to the 2012 System-wide Ecological Indicators for Everglades Restoration Report.

Several FCE scientists participate as advisors to the REstoration COordination and VERification (RECOVER) team for the Comprehensive Everglades Restoration program. This includes participation in quarterly workshops, reading and evaluating annual reports and proposals and synthesizing data for use in Everglades monitoring and protection.

J.S. Rehage contributed data to the 2012 System Status Report (SSR) to Congress detailing the progress of Everglades Restoration efforts.

J.S. Rehage and R.E. Boucek provided data to the National Park Service and the Florida Wildlife and Fish Commission (FWC) on the status of the snook fishery at study sites for consideration of whether the recreational fishery should be opened or remained closed after a 2010 cold snap that resulted in a massive mortality event.

Drs. Rene Price, Mike Ross and Len Scinto served as technical advisors to the Loxahatchee Impoundment Landscape Assessment LILA Coordination Committee, which meet 4 times a year.

Gaiser is a steering committee member of the Global Lakes Ecological Observatory Network. This is a grassroots network of limnologists, engineers and information specialists who aim to equip lakes and wetlands with high-resolution sensors and real-time global conveyance to evaluate large-scale patterns in ecological change in aquatic ecosystems. Participation in

GLEON will facilitate future high-resolution sensor data collection and communication within the FCE LTER and a site at the head of the FCE watershed at Archbold Biological Station.

The purge and trap GS-MS and GC-ECD, GC-IRMS systems Norm Scully's research group built can be used for volatile organic compound analyses across disciplines at Portland State University, including the Department of Chemistry and Environmental Science and Management.

Laura Ogden serves as social science, subject editor for the *Journal of Wetlands Ecology and Management*.

C. Contributions to Human Resource Development

Professional Service Teachers:
FCE LTER is working with both professional and pre-service teachers in programs that provide the knowledge, skills and materials needed for taking advantage of LTER resources by working directly with LTER scientists. In 2012, we mentored three teachers (Teresa Casal, Catherine Laroche, and Paul Rehage) through our RET program.

Undergraduate Students:
FCE is currently hosting 64 undergraduates in our labs, 50 of which are underrepresented minorities, including 36 females, and 24 Hispanic students. Five FCE REUs (Alex Perez, Michelle Prats, Mari Soula, Jerry Alvarez, Jonathan Hernandez) were funded with 2011 and 2012 supplemental funds.

Mentoring High School Students:
FCE continues to work with K-12 students through a near peer mentoring in our Research Experience for Secondary Students (RESSt) and Research Assistantships for High School Students (RAHSS) programs. Over the last year, FCE scientists have provided internship opportunities for 14 high school students. These internships promote collaboration and integrate curricula across biophysical and social science disciplines

In 2012, RAHSS intern Jamie Odzer received 3rd Place at the Intel International Science and Engineering Fair for her project researching blue crabs. Mentored by Ph.D. student, Adam Rosenblatt, Jamie received a total of nine awards and a $1000 cash prize. Our second RAHSS student, Cindy Saenz, who was mentored by Tiffany Troxler received two awards for her poster.

D. Contributions to Resources for Research and Education

FCE Children's Book
Our FCE children's book, One Night in the Everglades, has been published in English and Spanish and is being distributed widely.

Dr. Randy Chambers teaches an undergraduate Wetland Ecosystems course at the College of William and Mary that uses FCE LTER research in units on Everglades and biogeochemistry.

Rebecca Garvoille served as a judge for the Miami-Dade County Public Schools' 2012 Intel International Science and Engineering Fair Review Committee.

Norm Scully's research group developed a new GC-MS system with pre-concentration unit for use with spiked $^{13}CH_3Cl$ and $^{13}CH_3Br$ tracer experiments. This new GC-MS system with quadrupole detection has allowed us to make measures of the photochemical consumption of CH_3Cl and CH_3Br and the calculation of the gross photochemical production. New GC-ECD and GC-IRMS pre-concentration systems were also built that are capable of methyl halide measurements in natural waters at pM concentrations. The new systems have significantly enhanced our capacity for data collection for the photochemical and periphyton flux experiments and the instrumental capacity of our laboratories and Portland State University.

Colin Saunders developed a sediment trap for measuring sediment transport, adapted from coastal sediment traps, and employed in the Decomp Physical Model (DPM) experiment.

The FCE LTER website (http://fcelter.fiu.edu/) provides a variety of information, including data, educational activities, maps, project information, site information, publications, presentations, and photos. Visitors to the data section of our website downloaded 284 datasets from August 13, 2011 thru September 25, 2012.

F. Leveraged Funding

A table of leveraged funding for year 6 FCE II (2012) is available to FCE personnel through the FCE LTER Intranet at https://fcelter.fiu.edu/intranet/funding/?year=2012.

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