

## **GCE-III Annual Report – Year Three (2015)**

### **What are the major goals of the project?**

The primary goal of GCE-III is to understand how variation in salinity and inundation, driven by climate change and anthropogenic factors, affect biotic and ecosystem responses at different spatial and temporal scales, and to predict the consequences of these changes for habitat provisioning and C sequestration across the coastal landscape. We divide our research into 4 inter-related programmatic areas: Climate and Human Drivers of Change (Area 1); Long-term Patterns within the Domain (Area 2); Response of Marsh Habitats to Changes in Salinity and Inundation (Area 3); and Integration and Forecasting (Area 4). Our major goals within these areas are as follows:

Area 1: To track long-term changes in climate (average conditions and extreme events like storms) and human actions (in the watershed and adjacent uplands), and to evaluate the effects of climate and human drivers on domain boundary conditions (riverine input, runoff and infiltration from adjacent uplands, sea surface height).

Area 2: To describe temporal and spatial variability in physical (stratification strength, estuarine salt intrusion length, residence time), chemical (salinity, nutrient concentration and speciation, organic matter lability), geological (accretion) and biological (organism abundance and productivity, microbial processes) properties within the domain and to evaluate how they are affected by variations in river inflow and other boundary conditions.

Area 3: To characterize the responses of the marsh habitats in the domain (Spartina marsh, fresh/brackish marsh, high marsh) to pulses and presses in salinity and inundation that might be expected in the coming decades.

Area 4: To describe current patterns of habitat provisioning and C sequestration and export in the GCE domain, and to evaluate how these might be affected by changes in salinity and inundation.

### **What was accomplished under these goals?**

The specific objectives associated with each of our main goals are listed below, along with the years over the 6-year course of the project during which we plan to address them. The initials of the primary PIs involved in each activity are also listed. AB: Burd, BS: Silliman, CA: Alexander, CC: Craft, CH: Hopkinson, CM: Meile, DD: Di Iorio, JB: Byers, JH: Hollibaugh, JS: Schalles, MA: Alber, MG: Garbey, ML: Leclerc, PM: Medeiros, RC: Castelao, RP: Peterson, RV: Viso, SJ: Joye, SP: Pennings, VT: Thompson, WC: Cai, WS: Sheldon

Under the objectives that were targeted for year 3 of the project we summarize our activities and, where applicable, include significant results and plans for the next reporting period.

**Area 1: Drivers of Change** – We collect long-term measurements of A) climate, water chemistry, oceanic exchange, and B) human activities on the landscape in order to document how boundary conditions that affect the domain vary over time.

#### Area 1A Objectives

1. Install and maintain an eddy covariance flux tower in the Duplin River (yr 1-6) DD, ML, WS

Year Three Activities: GCE continues to operate an eddy covariance tower in the Duplin River that measures CO<sub>2</sub> and H<sub>2</sub>O fluxes along with atmospheric, soil and water properties. We have established a data processing routine that involves signal processing (de-spiking, planar fit, de-trending) and 30-minute averaging.

Significant Results: The footprint of the flux tower varies with time of day and season. Our analyses show that 70% of the signal is from *S. alterniflora*-dominated areas of the salt marsh. ([Results Fig. 1](#))

2. Collect ongoing information on climate and oceanographic conditions, sea level, and river discharge (yr 1-6) WS, DD, MA, ML

Year Three Activities: A series of meteorological stations are used to characterize the GCE domain ([Activities Fig. 1](#)). The station at Marsh Landing serves as our primary station for ClimDB. We continue to operate a ceilometer (purchased with Supplemental equipment funds) and a sodar to evaluate boundary layer conditions as an aid to interpretation of flux tower data.

Significant Results: Ceilometer and sodar data were used to characterize nocturnal low-level jets. We have found that periods with low-level jets are associated with smaller jet speed, weaker turbulence, stronger atmospheric stability, and smaller turbulent kinetic energy and fluxes. These results are being written up for publication.

3. Collect monthly samples of Altamaha River water entering the GCE domain, and analyze it for dissolved inorganic nutrients, DIC, alkalinity and pH (yr 1-6) MA, WC, SJ

Year Three Activities: We collect monthly samples of the river water entering the GCE domain via the Altamaha River for analysis of dissolved inorganic nutrients, DIC, alkalinity and pH.

4. Measure exchange between the mouths of the estuary and the coastal ocean (yr 2-4) DD, RC

Year Three Activities: The GCE led 4 oceanographic cruises on the R/V Savannah in 2014, and also participated in an additional 3 cruises in the GCE domain (led by J.T. Hollibaugh for a separate NSF project). Instruments were deployed within each of the three sounds in the GCE domain and data are being used along with ship based measurements to provide information on along and cross shelf flows during each season. In addition, cruises involved measurements of inorganic C (pCO<sub>2</sub>, pH, DIC, and Total Alkalinity); organic carbon (DOC, POC, CDOM, C composition); nutrients (DIN); DNA; chlorophyll; and sediment (texture, composition). A final cruise is scheduled for 2016.

Significant Results: Cruise observations provide information on seasonal salinity variability on the shelf ([Activities Fig. 2](#))

5. Measure exchange between the Duplin River and Doboy Sound (yr 1-6) DD

Year Three Activities: We have concluded that we cannot attach a horizontal ADCP to an existing structure as originally planned and will instead need to install a piling, which requires permits from

both the State DNR and the USACE. However, we have started to evaluate exchange with the FVCOM model (see Objective 2C1).

Next Reporting Period: We will proceed with permitting and deployment.

#### Area 1B Objectives

1. Conduct structured interviews of McIntosh County residents about environmental change (yr 1) MA

Year Three Activities: This objective was completed in yr 1.

2. Evaluate market and non-market values of natural resources in McIntosh County (yr 1) MA

Year Three Activities: This objective was completed in yr 1.

3. Incorporate information on human activities in the GCE database (yr 1-6) CA, VT, WS

Year Three Activities: We developed an armored shoreline GIS database based on 2013 imagery. This is being compared to a similar 2006 database to examine rates of armoring and preferential areas of armoring in the GCE domain.

4. Assess changes in Native American economic systems over time and their impact on the coastal Georgia landscape (yr 1-4) VT

Year Three Activities: We continued our investigations of human population growth in the domain (both Native Americans and historic EuroAmericans) in the context of ecological change. This past year we excavated materials from 3800 BP to provide insight into an observed large-scale decline in the radiocarbon record that occurred at that time. We are also using dendrochronology as the basis for paleoclimate reconstruction of sea level rise and drought events.

**Area 2: Patterns within the Domain** - We collect data documenting key ecosystem variables within the GCE domain. Major activities in this area consist of A) field monitoring of water and marsh attributes at our core monitoring sites, B) remote sensing of productivity and habitat shifts, and C) hydrodynamic modeling of water and salt transport.

#### Area 2A Objectives

1. Continue the GCE core monitoring program in the water column, which consists of continuous measurements of salinity, temperature and pressure at 9 sites, and quarterly or monthly CTD profiles and measurements of nutrients, chlorophyll and suspended sediment at 11 sites (see [Activities Table 1](#)) (yr 1-6) This will be augmented to include Secchi depth, pH, DIC and total alkalinity (starting yr 1); an additional sonde in the Duplin (installed yr 2); and documenting salinity intrusion in the Altamaha (starting yr 1) WS, DD, MA, SJ

Year Three Activities: We maintain sondes at 9 GCE sites ([Activities Fig. 2](#)). We also take CTD measurements and water samples according to the schedule in [Table 1](#). This past year we added a SeapHOx instrument (purchased with supplemental funds), which provides continuous, highly accurate measurements of pH. The instrument is being tested at the mouth of the Duplin River.

Significant Results: Although the Altamaha river estuary is slightly stratified during both low and high flow, our initial assessment suggests that upstream saltwater intrusion shifts approximately 15 km seaward during high discharge conditions.

2. Continue the core monitoring program in the marsh, which consists of annual measurements of soil accretion, accumulation, compaction and decomposition; disturbance to plant communities; and plant and animal biomass, densities, and community composition in the marsh associated with each core site (yr 1-6). This will be augmented to include monitoring mixed plant communities; brackish/salt plant distributions; and barnacle recruitment (starting yr 1) SP,CC, BS

Year Three Activities: We monitor plants, invertebrates, and sediment elevation at each core site ([Activities Fig. 2](#)) as well as plant mixtures and barnacle recruitment at sites established in Yr 1. We also continued monitoring recovery from a wrack disturbance experiment.

Significant Results: An analysis of disturbances observed in our long-term monitoring data shows that different disturbances are important in different habitats. On creekbanks, wrack disturbance is common and reduces plant biomass by ~50%. Creekbanks also slump into the subtidal area, causing total vegetation loss. Neither of these processes is important in the mid-marsh, but snails occasionally are associated with loss of vegetation. A manuscript detailing these results is in preparation.

3. Add a core monitoring station in tidal fresh water (yr 1-2) CC

Year Three Activities: We are measuring plant productivity at the new core monitoring tidal forest site using dendrometer bands and litterfall traps. We made baseline RSET measurements and will make our first post-baseline measurements in 2016.

Significant Results Annual litterfall based on our first year of data is  $572 \pm 37 \text{ g m}^{-2}$ . These values are comparable to those in published studies of tidal forests in the southeastern US.

4. Characterize groundwater flow into the Duplin River (yr 1-3) RP, RV, CM

Year Three Activities: In summer 2015 we collected continuous radon and water level data over a period of 3 weeks that is being used to constrain groundwater inputs to the Duplin River. We also collected high resolution electrical resistivity data to examine details of tidal pumping.

Significant Results: A manuscript is now in preparation in which we compare groundwater inputs to the Duplin River across multiple years, spanning high/low tides across the spring/neap variations.

5. Assess seasonal dynamics of ammonium oxidizing archaea (yr 1-2) JH

Year Three Activities: We continue to collect weekly water samples at Marsh Landing on Sapelo Island for measurements of AOA, ammonia and nitrite oxidizing bacteria, and DIN.

Significant Results: Tolar et al. (submitted) analyzed data on the population dynamics of AOA collected since 2008 and found pronounced mid-summer blooms that affect the composition of DIN and coincide with a variety of factors (temperature, dissolved oxygen, pH) associated with the summer increase in net ecosystem heterotrophy.

6. Assess seasonal dynamics of blue crabs (yr 3-6) SP, BS

Year Three Activities: We ended the blue crab monitoring in the marsh in 2015 because it was too labor intensive to justify the limited data collected.

Significant Results: We analyzed long term fishery-independent data collected by the Georgia Department of Natural Resources and found that the number of crabs per trawl was reduced at high salinities. A manuscript is now in preparation.

7. Characterize DOM composition and predominant sources of estuarine water (yr 1-3) PM

Year Three Activities: We collected DOM samples from the GCE domain (Altamaha River, Doboy and Sapelo Sounds) and analyzed their organic composition using ultrahigh resolution mass spectrometry. Dark incubations spanning from 24 hours to 70 days were conducted to assess lability of organic matter at those sites.

Significant Results: Medeiros et al. (2015) describes our findings that interannual variability in river discharge plays a dominant role in controlling DOM composition variability. During drought conditions, the influence of marsh-derived organic matter imprinted a clear signature on the riverine DOM. ([Results Fig. 3](#))

## Area 2B Objectives

1. Create high resolution maps of site bathymetry and habitat distribution (yr 1-6) CA, MA, RV, DD

Year Three Activities: We collected new high-resolution imagery of a portion of the domain that can be compared with Dec 2012 and 2013 flyovers by the Georgia coastal imagery consortium and the GCE. We also completed sampling the tidal creeks of the Duplin River with a high resolution echo sounder and have merged these data with swath multi beam and LIDAR data to provide a high resolution DEM for our modeling efforts.

Significant Results: Multibeam bathymetry data were analyzed for bedform asymmetry and elevation change. Bedform asymmetry indicates ebb dominated sediment transport from the river mouth up to a highly sinuous river channel reach where bed forms switch to flood dominated.

2. Assess patterns of marsh productivity using satellite imagery (yr 1-6) JS, SP, AB, MA, WS

Year Three Activities: We used Landsat 5 TM images to evaluate patterns in *S. alterniflora* productivity over the last 3 decades. We developed filters for tidal stage and atmospheric conditions, and used an NDVI-based algorithm to extract information from a set of 294 images spanning 1984-2011.

Significant Results: An underlying annual phenological cycle of *Spartina* biomass was observed, along with substantial size class dependent, seasonal and inter-annual variations. *Spartina* biomass was correlated with river discharge, tide stage, and Palmer Drought Index. These results are consistent with, and extend back in time, similar analyses based on sampling permanent plots.

## Area 2C Objectives

1. Implement FVCOM in the Duplin River (yr 1-6) DD, RC

Year Three Activities: We have the 3D hydrodynamic FVCOM 3.2.2 model running for the Duplin River. This past year we have added groundwater discharge and begun to calculate transport processes, residence time, and the effects that groundwater discharge will have on these parameters

Significant Results: Groundwater discharge introduces freshwater into the upper section of the Duplin, resulting in a decrease in salinity of approximately 1 compared to model runs without groundwater ([Results Fig. 4](#)). This freshwater contributes to the net outflow of the Duplin.

2. Implement FVCOM in the larger GCE domain (yr 1-6) RC, DD

Year Three Activities: FVCOM has also been implemented in the GCE domain. The past year we completed an extensive validation using the LTER salinity time series and implemented computer

codes to compute residence time and connectivity between the multiple channels in the estuarine complex.

Significant Results Model runs from 2012-2014 capture the transition from a severe drought to a high discharge condition. We are currently investigating the estuarine response to this shift.

**Area 3: Responses to Salinity and Inundation** - We work in each of our key marsh habitats to assess how they will respond to changes in salinity and inundation. A) In the Spartina marsh we will assess marsh-atmosphere and marsh-creek exchange; monitor and model Spartina primary production; assess organism interactions; and evaluate ecosystem metabolism. B) In the fresh/brackish marsh our work involves long-term observations along the transect of the Altamaha River, and a large-scale field manipulation to evaluate how pulses and presses of salt water affect a tidal freshwater marsh. C) In the high marsh our work involves a field survey of high marsh areas, an experimental manipulation of runoff to the high marsh, and modeling of plant communities.

#### Area 3A Objectives

1. Characterize temporal variability in marsh-atmosphere exchange of CO<sub>2</sub> (yr 2-6) ML, DD, CH, WS

Year Three Activities: We have begun analyzing the data collected by the flux tower to characterize the effect of tidal inundation on CO<sub>2</sub> exchange.

Significant Results: Our analyses show that light response curves vary as a function of the ratio between plant height and inundation ([Results Fig. 5](#)), and suggest that flooding reduces CO<sub>2</sub> flux by approximately 20%. A poster on this work was recognized as a runner-up in the student poster competition at the LTER All Scientist's Meeting.

2. Evaluate Spartina plant phenology (yr 1-6) MA, JS, WS and above- and below-ground production (yr 1-4) SP

Year Three Activities: The phenocam camera collects images every 30 min and contributes data to the national phenocam network. We continue to sample plants in permanent plots on a monthly basis for above and below-ground production, timed to correspond with Landsat overpasses so that our findings can ultimately be scaled up.

Significant Results: We have developed a smart classifier for automatically extracting information from the phenocam images. This is being written up for publication.

3. Quantify lateral C exchange through a small tidal creek (yr 1-3) CH, WC, DD, RC, MA

Year Three Activities: We analyzed field samples collected over the course of Year Two to evaluate DIC exchange between the small creek adjacent to the flux tower and the Duplin River. We also developed hypsometric curves ([Activities Fig. 3](#)) to characterize water flow.

Significant Results: The creek imports water that is low in DIC concentration during flood tide, and exports water high in DIC during ebb ([Results Fig. 6](#)). This suggests that the marsh platform and creek banks are the apparent source of this C.

4. Evaluate net ecosystem metabolism and quantify net C exchange in the Duplin R (yr 1-4) CH, WC, MA

- Year Three Activities: We used the in situ diurnal technique to estimate metabolism from our Year 2 field measurements. Water masses were matched using a Lagrangian particle tracer model, and the rates of change of DO and DIC were used to calculate GPP, R, and NEP after correcting for air-water exchange and dispersion mixing. We also continued to collect DIC, pH and TA samples on a bimonthly basis.

Significant Results: We found that the Duplin estuary is highly productive and heterotrophic, with overall levels increasing up-estuary where the ratio of marsh/water and tidal creek drainage density are highest. The dispersion and air-sea fluxes were a significant component of the overall diel changes in DO and DIC.

5. Conduct a blue crab removal manipulation (yr 4-6) BS, SP

Year Three Activities: This begins yr. 4. However, we did some initial tests and found that our proposed predator exclusion design was not effective. Our current plan is to use replicated 10 m diameter cages with different mesh sizes to tease out the effects of blue crabs, mud minnows, and larger nekton.

Planned Activities: We will have a planning meeting at the GCE annual meeting in January 2016 and then deploy cages in the spring.

6. Monitor headward erosion in tidal creeks (yr 1-4) SP

Year Three Activities: We continued this activity in 2014-5.

7. Develop a Spartina physiological model (yr 1-3) AB

Year Three Activities: We have completed data analysis of a year's worth of above and below ground biomass and non-structural carbohydrate data, which is being used to develop model formulations for the translocation of material between above and below ground plant components.

Significant Results: Although there is a significant seasonality in above and below-ground non-structural carbohydrates, there appears to be no obvious environmental cue for the allocation of this material.

8. Develop a model to predict porewater salinity (yr 1-3) CM

Year Three Activities: We have finalized the soil model, and begun to compare model results to measured porewater salinities. The independent estimates of freshwater inputs agree well, suggesting that the flow modeling and ET estimates are consistent.

Significant Results: One outcome of this effort is to constrain freshwater input to the upper Duplin. This work was presented at the 2014 AGU meeting and the 2015 LTER ASM.

Area 3B Objectives

1. Assess changes in community composition along the salinity gradient of the Altamaha (yr 1-6) MA, CC

Year Three Activities: We continued our annual survey to document the transition in bankside vegetation from *S. cynosuroides* to *S. alterniflora* along the salinity gradient of the Altamaha.

2. Conduct field manipulation of salt water intrusion in a low-salinity tidal marsh (yr 1-6) CC, SP, BS

Year Three Activities: We have been dosing the SALTE<sub>x</sub> plots for almost 2 years and are continuing monitoring of porewater, soil surface elevation, and gas exchange. We have begun monitoring surface algae and extracellular enzyme activity in the plots also. We are collecting soils for future analysis of microbial communities. This past year we also harvested the greenhouse mesocosm experiment in which we exposed mixtures of plants from tidal fresh and brackish marshes to water of differing salinity and for different lengths of time.

Significant Results: Seawater additions resulted in increased sulfate and chloride immediately,

and porewater nitrogen and phosphorus increased 2-4 months after initial seawater application. Most of the freshwater plants have died in the press plots, which are continually exposed to brackish water ([Results Fig. 7](#)). Ecosystem respiration and methane emissions are also significantly lower and we are seeing a measurable decline in elevation and an increase in soil surface temperature. In the pulse treatments, the most sensitive plant species died back temporarily but recovered in the following year. In the mesocosms, plant community responses were a function of both salinity and the duration of exposure to saline water.

### 3. Apply SLAMM to the GCE domain (yr 1-3) CC, CA, MA

Year Three Activities: In the Altamaha River we have run the SLAMM model with the new inputs and are also working with Jim Morris (Univ. South Carolina) to run his point-based model (Marsh Equilibrium Model). In the larger domain, we have mapped the distribution of salt, brackish and tidal fresh marsh in the GCE domain using both the GCE new high-resolution imagery, LiDAR and regression tree models. These distributions will provide better initial conditions to better inform future SLAMM modeling.

Significant Results: Hauer et al. (2015) ran the SLAMM model as part of a coast-wide study of GA designed to improve population projections at sub-county scales. In McIntosh County, where the GCE is located, the projected population at risk to the threat of sea-level rise varied from 291 to 2,887, depending on the increase in sea level (1 or 2 m) and the year considered (2050 or 2100).

## Area 3C Objectives

### 1. Continue to monitor groundwater salinity, temperature and pressure on instrumented hammocks (yr 1-2) CA, CM, WS

Year Three Activities: Sensors have been removed from hammock wells because of high failure rate. We have worked with Schlumberger (the sensor company) to redesign the sensors to be more resistant to the harsh conditions in the wells.

Significant Results: Ledoux (2015) used the sensor data to quantify the role of upland / precipitation driven groundwater flow. He found that it exceeds the impact of tidal forcing on net groundwater flow from the upland to the marsh.

Next Reporting Period: New sensors have been developed and will be deployed for testing at GCE sites.

### 2. Survey high marsh characteristics in sites with different land-use categories

(yr 1-2) MA, JB, CA, SP

Year Three Activities: We conducted further analysis on the plant and animal distributions, sediment, porewater nutrients, parasite loads, and microbial community from samples collected during the yr 1 high marsh survey. We also continued working with a cross- LTER group to evaluate the ecological impacts of coastal armoring.

Significant Results: Freshwater input from the upland structures the high marsh community in our study sites. *Spartina* dominates near developed uplands with bulkheads; *Juncus* dominates near developed, but unarmored shorelines. We also found that movement across the ecotone by the land crab *Armases cinerum* varied with upland structure. This latter observation is especially interesting given that Hubner et al. (2015) found evidence for differences in both dietary and habitat preferences of *Armases* that can move freely between high marsh and coastal forests.

### 3. Conduct upland manipulation of water flow to high marsh areas (yr 3-6) SP, MA, JB, CA

Year Three Activities: We have identified a potential site for this experiment. We have surveyed

and taken cores along three transect across the marsh-upland boundary to characterize the stratigraphy at the site and have requested permission from DNR to conduct the experiment. Significant Results: The site proposed for the upland manipulation has a well-developed, clean, sandy, porous layer at ~1.0 m depth that serves as a conduit for freshwater from the uplands to influence the marsh.

4. Develop a clonal plant model to explore vegetation dynamics (yr 3-5) MG

Year Three Activities: We measured the clonal architecture of 4 species of plants to parameterize the model.

Significant Results: We have established a web site ([ScalingUpMarshScience.cs.uh.edu](http://ScalingUpMarshScience.cs.uh.edu)) that allows volunteers to help us align thousands of photographs into a mosaic of the marsh. A second web site under development will use volunteers to score plant and animal abundance in the images. This information will be used to compare with model predictions.

**Area 4: Integration and Forecasting** - We use a combination of integrative modeling, empirical observations, and remote sensing to produce an integrated picture of habitat provisioning and carbon flow across the landscape, and evaluate how changes in salinity and inundation may change these services in the future. Major activities include A) develop an integrative model that uses a hydrodynamic model (FVCOM), a soil model, and 3 different semi-empirical plant models to predict salinity and inundation patterns, porewater salinities, and plant responses over different time scales, and B) use combined model output to evaluate habitat provisioning and C flow under different scenarios.

#### Area 4A Objectives

1. Run FVCOM to predict salinity and inundation (yr 3-4) DD, RC

Year Three Activities: Maps of residence time and connectivity have been produced, and we are investigating how those vary with forcing. Changes in salinity in the estuary in response to sea level rise and storms are also being investigated.

2. Run the soil model to predict porewater salinity (yr 4-5) CM

Year Three Activities: Model simulations have been performed to assess seasonal patterns and inter-annual variations. We also performed a sensitivity analysis to quantify the role of different external forcings (e.g. precipitation), or model parameters (e.g. soil hydraulic conductivity).

3. Run the plant models to predict vegetation response yr (2-6) AB, MG

Year Three Activities: The Spartina model is currently being validated against biomass data that was collected in the field as part of the GCE LTER and also against literature data from other locations.

#### Area 4B Objectives

1. Develop scenarios (yr 3) MA, AB, CA, VT

Year Three Activities: Calendar year daily statistics of Altamaha River discharge over the period 1932-2014 were calculated and binned into 3 levels of discharge in order to define periods of wet, dry, normal and variable years for use in modeling efforts ([Activities Fig. 4](#)).

Next Reporting Period: We plan to develop further scenarios that can be used in model runs.

2. Evaluate C flow (yr 3-6) WC, CH, ML, MA, CC

Year Three Activities: To better understand the factors controlling seasonal CO<sub>2</sub> fluxes and the extent of autotrophy/respiration in the coastal South Atlantic Bight (SAB), we measured pCO<sub>2</sub> from the GCE domain in each season (April, July, Sept., Dec.) as part of the series of oceanographic cruises conducted this past year. Underway pCO<sub>2</sub> was measured in cross-shelf

transects, and discrete samples were also collected for DIC, Total Alkalinity (TA), and pH measurements. These samples are currently being processed. We also collected and dated 4 cores at GCE monitoring sites to examine carbon sequestration rates.

Significant Results: High resolution maps of sea surface pCO<sub>2</sub> over the region suggest that while the estuarine zones are a strong source of CO<sub>2</sub> to the atmosphere, the SAB shelf is a net sink of atmospheric CO<sub>2</sub> during all seasons ([Results Fig. 8](#)). These data will also be used to evaluate the extent of in-situ DIC generation and export from estuarine zones to the coastal ocean.

### 3. Evaluate habitat provisioning (yr 3-6) MA, RC, DD, CA

Year Three Activities: We are starting to use FVCOM to evaluate how salinity ranges (and hence dynamic habitat) will vary with sea level rise ([Activities Fig. 5](#)).

Significant Results: McFarlin et al. (2015) evaluated the effects of the loss of *Spartina alterniflora* on habitat provisioning for benthic epifauna, macroinfauna and meiofauna. In the GCE domain, abundances of all invertebrate groups and the diversity of macroinfauna were lower in bare plots, with clear separation between infaunal assemblages in bare and reference (=vegetated) plots ([Results Fig. 9](#)). In contrast, there was overlap between the assemblages and the abundance of some groups (i.e. meiofauna) increased in bare plots in Louisiana, suggesting that the role of *S. alterniflora* is context-dependent.

### What were the Key Outcomes and Accomplishments?

**Plant Community Structure** Community similarity is thought to decay with distance; however, this view may be complicated by the relative roles of different ecological processes at different geographical scales, and by the compositional perspective (e.g. species, functional group and phylogenetic lineage) used. Kunza and Pennings (2008) found that plant diversity was greater in Texas than in Georgia marshes. Guo et al. (2015) built on these results by examining similarity as a function of distance among samples. Based on studies in other ecosystems, they hypothesized that community turnover in salt marshes would be more rapid at local versus larger geographical scales; and that community turnover patterns would diverge among compositional perspectives, with a greater distance decay at the species level than at the functional or phylogenetic levels. They examined the characteristics of plant community composition at a series of salt marsh sites being studied in the GCE domain in comparison to sites located on the Gulf Coast in TX, and found that there was strong variation in community composition within individual salt marsh sites across elevation; in contrast, community similarity decayed with distance four to five orders of magnitude more slowly across sites within each region. Overall, community dissimilarity of salt marshes was lowest in the GA sites, intermediate in TX, and highest between the two regions ([Outcomes Fig. 1](#)). These results indicate that local gradients are relatively more important than regional processes in structuring coastal salt marsh communities. The results from the three compositional perspectives generally showed similar patterns, suggesting that in ecosystems with low species diversity, functional and phylogenetic approaches may not provide additional insight over a species-based approach.

**Wetland salinization.** Wetland salinization alters the soil-water environment, increasing ionic concentrations and altering chemical equilibria and mineral solubility. The effects of these changes typically include decreased inorganic nitrogen removal, decreased carbon storage, and increased generation of toxic sulfides. In a review of wetland salinization, Herbert et al. (in press) reviewed documented cases of salinization in the literature, most of which are concentrated in Australia, Europe, and the Atlantic coast of the US ([Outcomes Fig. 2](#)). They identified five mechanisms that contribute to the secondary salinization of inland freshwater wetlands: 1) vegetation clearance; 2) intensive irrigation;

3) river regulation; 4) mining and extraction and 5) de-icing salts, and five mechanisms that apply in coastal wetlands: 1) seawater intrusion linked to sea level rise; 2) reductions in freshwater flow; 3) alterations of subsurface flow; 4) anthropogenic alteration of coastal geomorphology and 5) storm surges. We are studying all of the latter mechanisms in the GCE-LTER program. The paper points out that salinization represents a growing widespread threat to inland and coastal wetlands especially given the fact that almost all of these mechanisms may be intensified by global climate change. The factors identified here can be used to identify wetlands currently undergoing salinization and those at potential risk in the future.

**Apex predators.** Large-bodied top predators are often highly mobile, with the potential to provide important linkages between spatially distinct food webs. In a series of studies of the American Alligator, Nifong found evidence that alligators can be an important consumer of blue crabs (Nifong et al. 2012), and that their presence can result in non-consumptive effects in crab behavior that indirectly affect blue crab consumption of ribbed mussels and periwinkle snails (Nifong and Silliman 2013). They also demonstrated that gut contents of alligators included numerous salt marsh species. More recently, Nifong et al. (2015) found that alligators in marine/estuarine habitats were significantly larger than those captured in freshwater and intermediate habitats, with clear differences in the stable isotope signatures among size classes ([Outcomes Fig. 3](#)). Rosenblatt et al. (2015) examined the implications of these findings for individual niche specialization. This series of studies demonstrates that apex predators can exert strong top-down effects in ecological communities, and that cross-ecosystem foraging behavior is influenced by intrapopulation characteristics (body size, sex, individual specialization).

## GCE Activities 2015

### Area 1: Drivers of Change

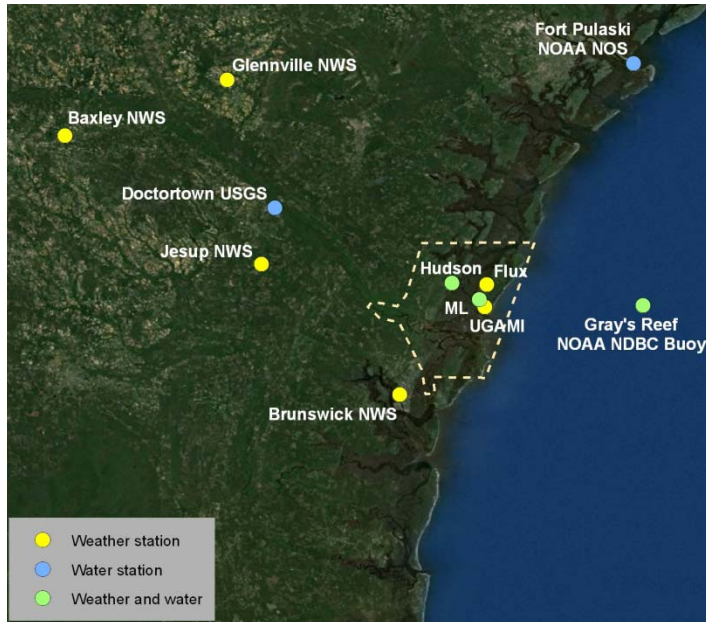


Fig. 1. Locations of observing stations used for boundary conditions (ML is Marsh Landing; UGAMI is UGA Marine Institute). Corresponds to Objective 1A.2: Collect ongoing information on climate and oceanographic conditions, sea level, and river discharge.

### Area 2: Patterns within the Domain

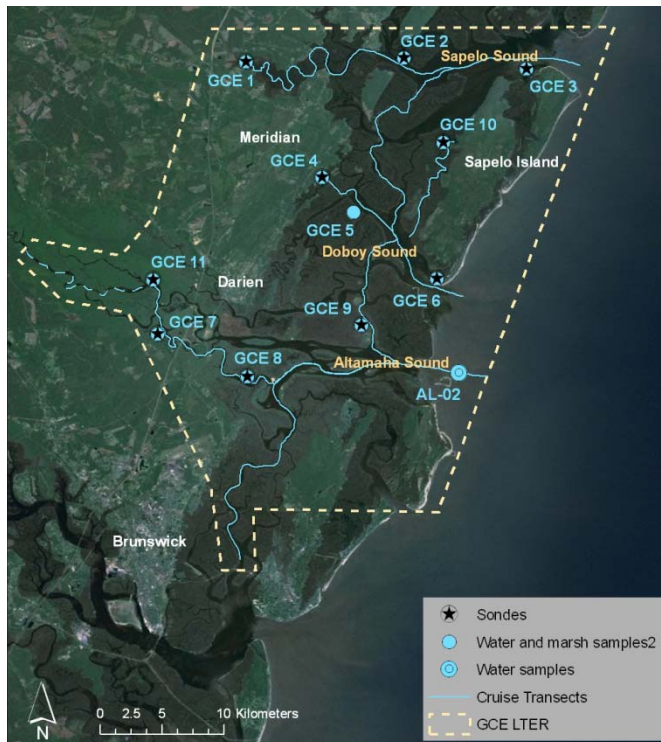


Fig. 2. GCE domain showing core monitoring stations. Corresponds to Objective 2A.1: Continue the GCE core monitoring program in the water column and Objective 2A.2: Continue the core monitoring program in the marsh.

## GCE Activities 2015

Table 1. Monitoring program for GCE-III. Initials of PIs responsible for supervising each aspect of the monitoring program are indicated in parentheses. LTER core areas are 1: primary production, 2: populations, 3: organic matter cycling, 4: inorganic nutrients, 5: disturbance. GCE PIs: AB: Burd, BS: Silliman, CA: Alexander, CC: Craft, CH: Hopkinson, CM: Meile, DD: Di Iorio, JB: Byers, JH: Hollibaugh, JS: Schalles, MA: Alber, MG: Garbey, ML: Leclerc, PM: Medeiros, RC: Castelao, RP: Peterson, RV: Viso, SJ: Joye, SP: Pennings, VT: Thompson, WC: Cai, WS: Sheldon. Corresponds to Objectives 2A.1 and 2A.2: Continue the GCE core monitoring programs.

Type	Location	Frequency	Core Area & Variables Measured
<b>Area 1 Atmospheric</b>			
Weather stations, with SINERR, USGS (DD)	Sites 4, 6, flux tower	Every 15 min	Abiotic driver of 1-5. > level 2 stations: PAR, temp, rH, precip, wind speed and direction, barometric pressure, total solar and long wave radiation; flux tower also measures CO <sub>2</sub> , humidity and heat fluxes
Wet deposition, with SINERR, NADP (MA)	Site 6	Weekly	4. Hydrogen (acidity as pH), sulfate, nitrate, ammonium, chloride, base cations (such as calcium, magnesium, potassium, sodium)
<b>Area 1 Water</b>			
Altamaha River chemistry (MA, WC)	Head of tide	Monthly	3, 4. Dissolved inorganic nutrients (NO <sub>x</sub> , NH <sub>4</sub> <sup>+</sup> , HPO <sub>4</sub> <sup>2-</sup> , H <sub>2</sub> SiO <sub>4</sub> <sup>2-</sup> ) and organics (DOC, TDN, DON, TDP, DOP), particulate CN, DIC, alkalinity, pH
<b>Area 2 Water</b>			
Sound chemistry (MA, WC)	Sites 1-5; 8-11, AL-2	Quarterly	1, 3, 4. Dissolved inorganic nutrients (NO <sub>x</sub> , HPO <sub>4</sub> <sup>2-</sup> ) and organics (DOC, TDN, DON), particulate CN, DIC, alkalinity, pH, Secchi depth, chlorophyll a
	Sites 6-7	Monthly	1, 3, 4. Dissolved inorganic nutrients (NO <sub>2</sub> <sup>-</sup> , NO <sub>3</sub> <sup>-</sup> , NH <sub>4</sub> <sup>+</sup> , HPO <sub>4</sub> <sup>2-</sup> , H <sub>2</sub> SiO <sub>4</sub> <sup>2-</sup> ) and organics (DOC, TDN, DON, TDP, DOP), particulate CN, DIC, alkalinity, pH, Secchi depth, chlorophyll a, total suspended sediment
Sound hydrography (DD)	Sites 1-4, 6-11	Every 30 min	Abiotic driver of 1-5. Salinity, temperature, pressure at moorings; CTD profiles at all stations in conjunction with sound chemistry; sea level station at GCE4
Duplin-domain exchange (DD)	Mouth of Duplin R.	Every 15 min	Abiotic driver of 1-5. Continuous horizontal ADCP measurements of water flux
<b>Area 2 Marshes</b>			
Soil accretion (CC)	Sites 1-11	Annual	3. Sediment accretion, elevation, compaction
Plant productivity (SP)	Sites 1-11, 2 zones	Annual	1. Stem density, height, flowering status, calculated biomass, in 2 marsh zones
	Flux tower	Monthly	1. Monthly measurements of biomass in short, med, tall <i>Spartina</i> using Jim Morris's methods (cite)
Disturbance (SP)	Sites 1-11	Annual	5. Wrack and biotic disturbance in permanent vegetation plots
Plant composition (SP)	Site 3, 6, 7, 8, Altamaha	Annual	2. Community composition in 4 types of salt marsh, 2 types of low-salinity and 2 types of high marsh vegetation mixtures
Marsh Invertebrates (SP BS)	Sites 1-11, 2 zones	Annual	2. Density and size of benthic macroinvertebrates in 2 marsh zones
Recruitment (BS)	Sites 1-11	Quarterly	2. Recruitment of barnacles to standard substrates

## GCE Activities 2015

### Area 3: Responses to Salinity and Inundation

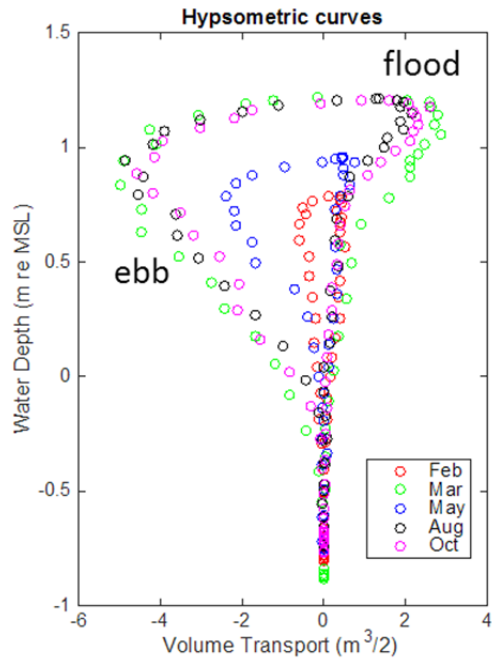


Fig. 3. Hypsometric curves for a small tidal creek on the Duplin River. The flood and ebb tides are asymmetric due to internal storage of water on the marsh, resulting in an ebb-dominated estuary. Corresponds to Objective 3A.3: Quantify lateral C exchange through a small tidal creek.

### Area 4: Integration and Forecasting

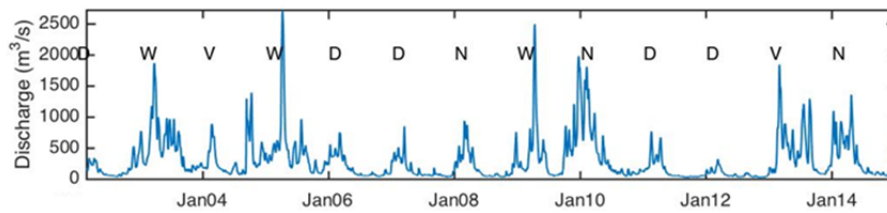


Fig. 4. River discharge showing years that are determined to be D=dry, W=wet, N=normal and V= variable. These statistical attributes are used to define model year runs. Corresponds to Objective 4B.1: Develop scenarios.

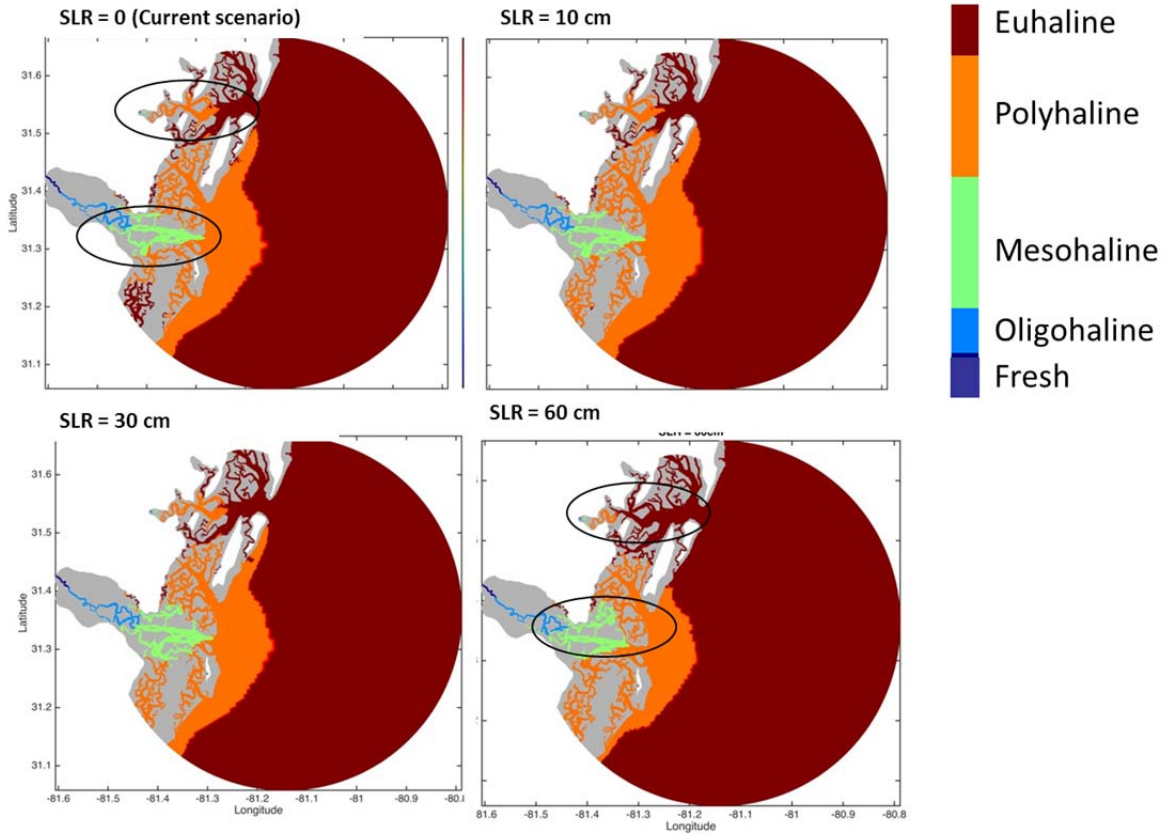


Fig. 5. Potential changes in dynamic habitat as a consequence of sea level rise. Circled areas show places of greatest change. Corresponds to Objective 4B.3: Evaluate habitat provisioning.

# GCE Significant Results 2015

## Area 1: Drivers of Change

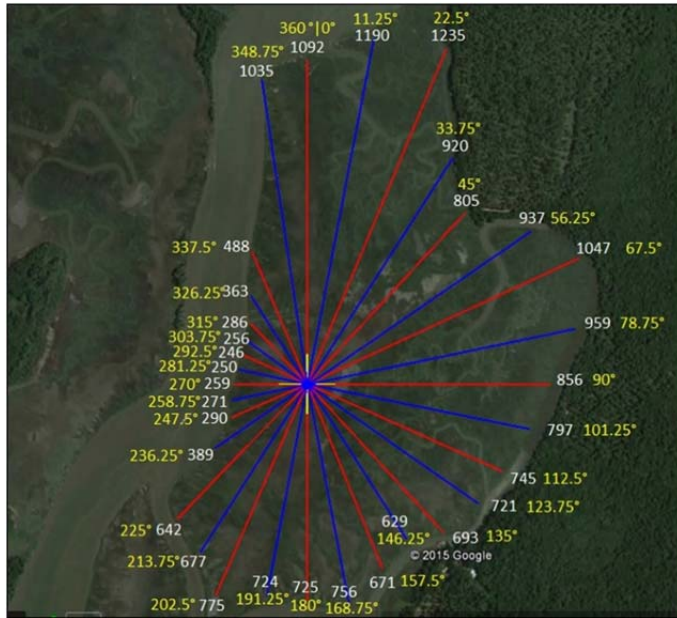


Fig. 1. Direction (degrees, in yellow) and distance (m, in white) of fetch at the GCE flux tower that falls within the *Spartina* zone. The tower is located at the blue dot. Corresponds to Objective 1A.1: Install and maintain an eddy covariance flux tower in the Duplin River.

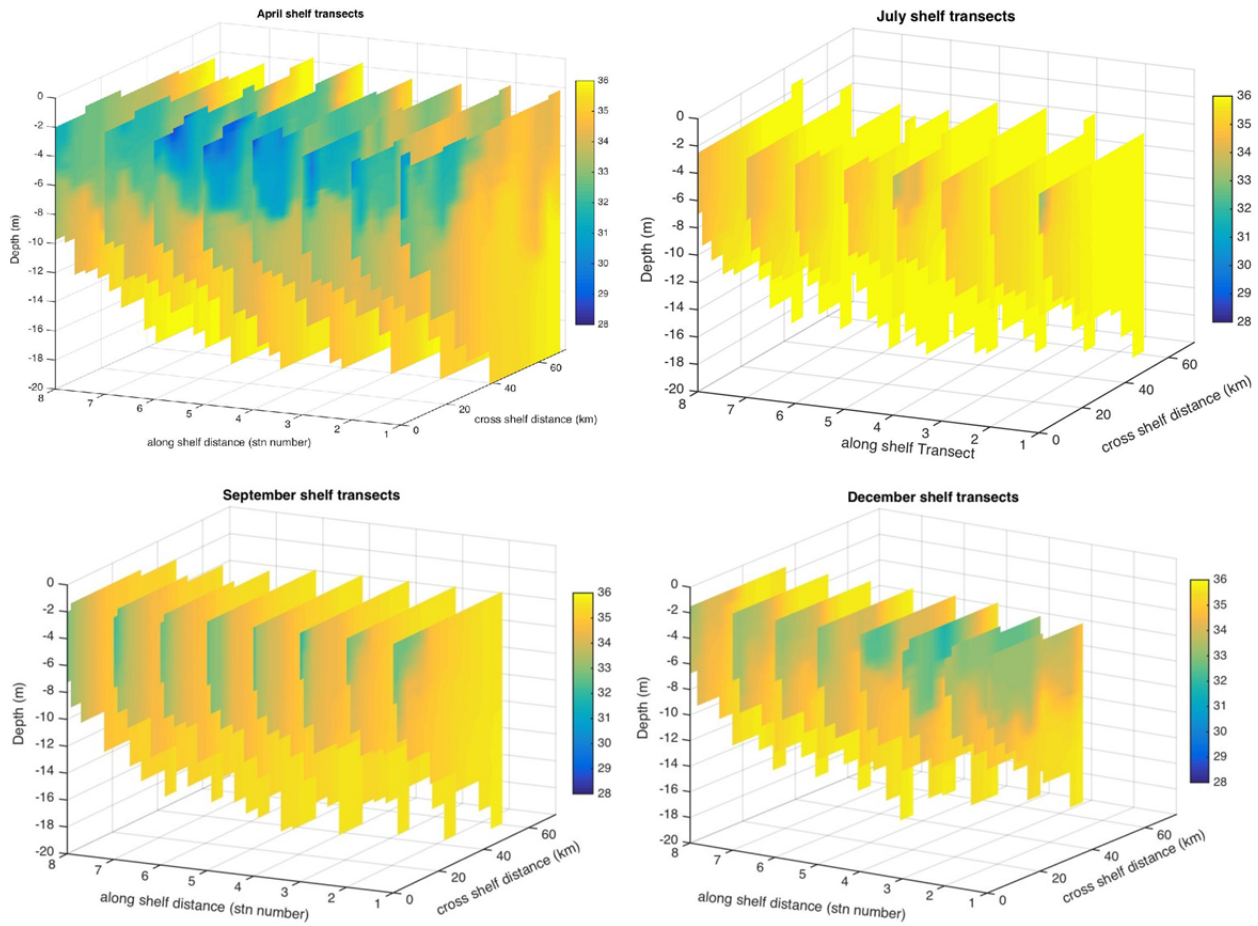


Fig. 2. Seasonal salinity patterns in the South Atlantic Bight. Corresponds to Objective 1A.4: Measure exchange between the mouths of the estuary and the coastal ocean.

# GCE Significant Results 2015

## Area 2: Patterns within the Domain

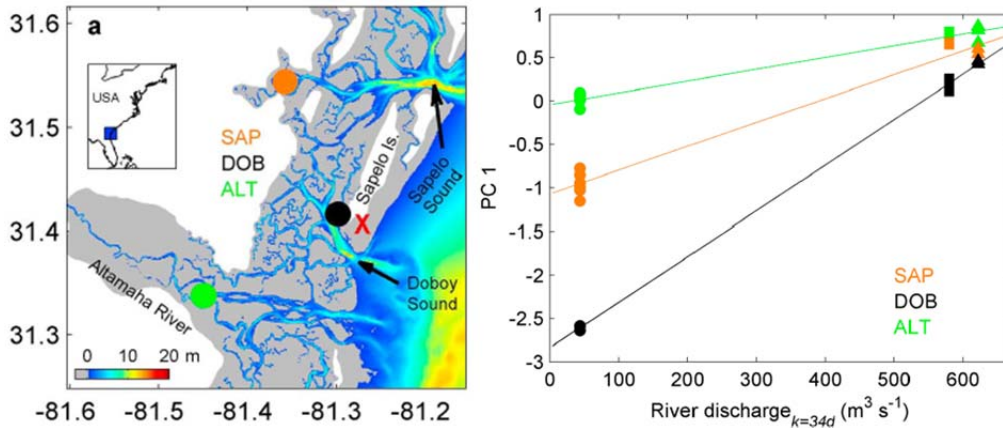


Fig. 3. (left) Sampling locations (circles) at Sapelo (SAP) and Doboy (DOB) Sounds and the Altamaha River (ALT). (right) Relationship between Altamaha River discharge and PC1 of DOM composition at the locations listed at left. Solid lines are least squares fits to observations. Samples were collected in Nov 2012 (circles), May 2013 (squares), and Sep 2013 (triangles). From Medeiros et al. 2015. Corresponds to Objective 2A.7: Characterize DOM composition and predominant sources of estuarine water.

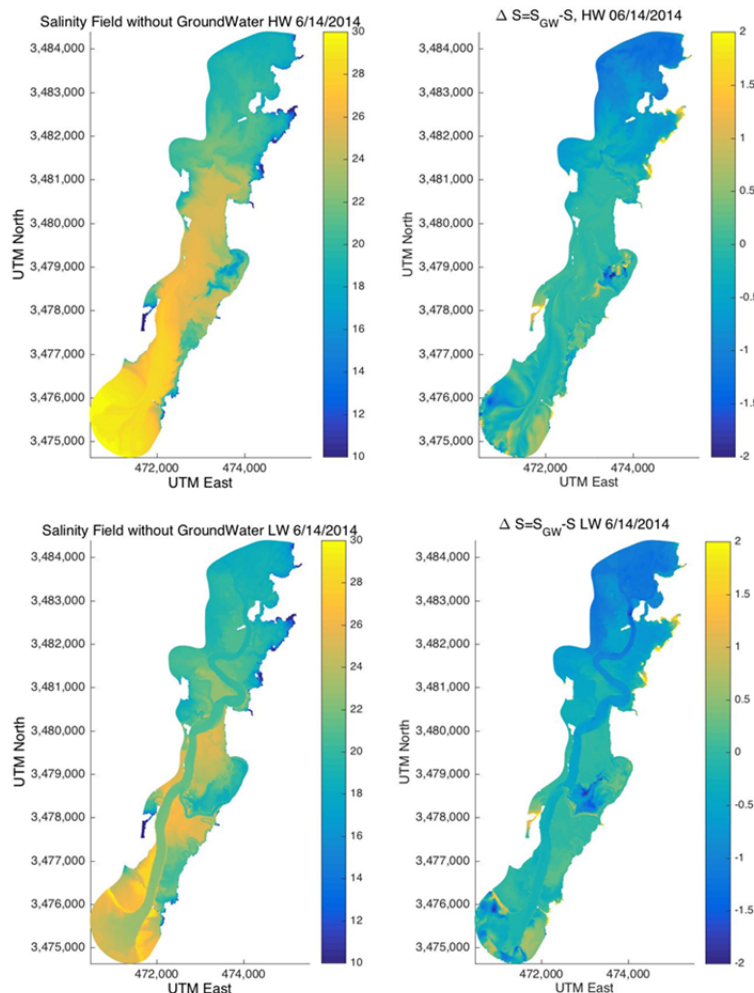


Fig. 4. Results of FVCOM model runs in the Duplin River showing changes in salinity as the result of groundwater at high (top) and low (bottom) tide. Corresponds to Objective 2C.1: Implement FVCOM in the Duplin River.

# GCE Significant Results 2015

## Area 3: Responses to Salinity and Inundation

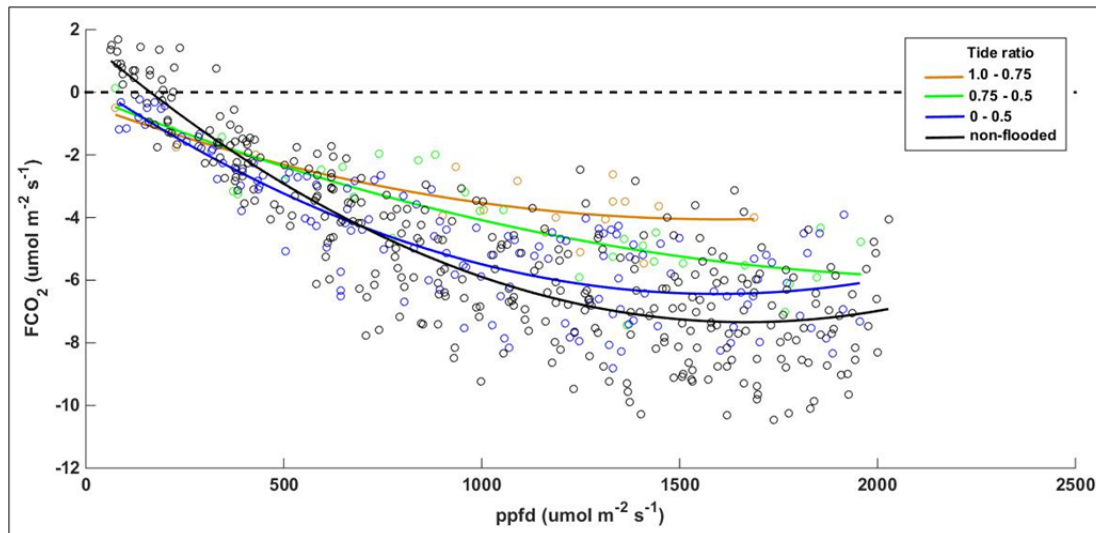


Fig. 5. Light response curve of CO<sub>2</sub> exchange with different levels of flooding (3 tide ratios) and non-flooded conditions in August 2014. Tide ratios calculated as tide height/plant height. ppfd = photosynthetic photon flux density. Corresponds to Objective 3A.1: Characterize temporal variability in marsh-atmosphere exchange of CO<sub>2</sub>.

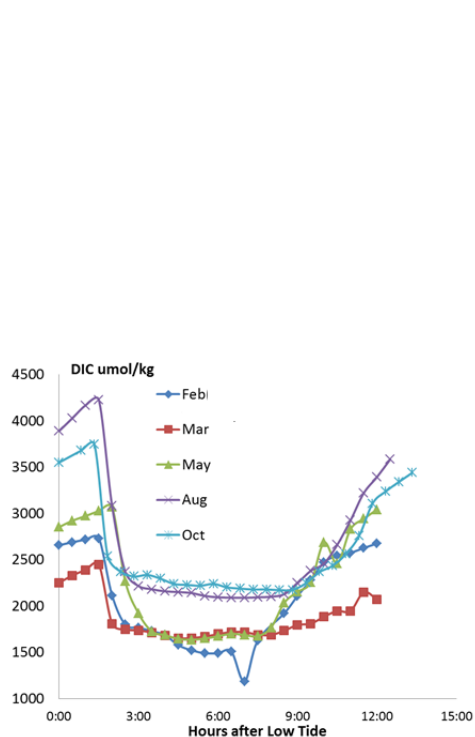


Fig. 6. DIC concentrations in a tidal creek over a tidal cycle, measured in different seasons. The marsh platform was not flooded in February. Corresponds to Objective 3A.3: Quantify lateral C exchange through a small tidal creek.

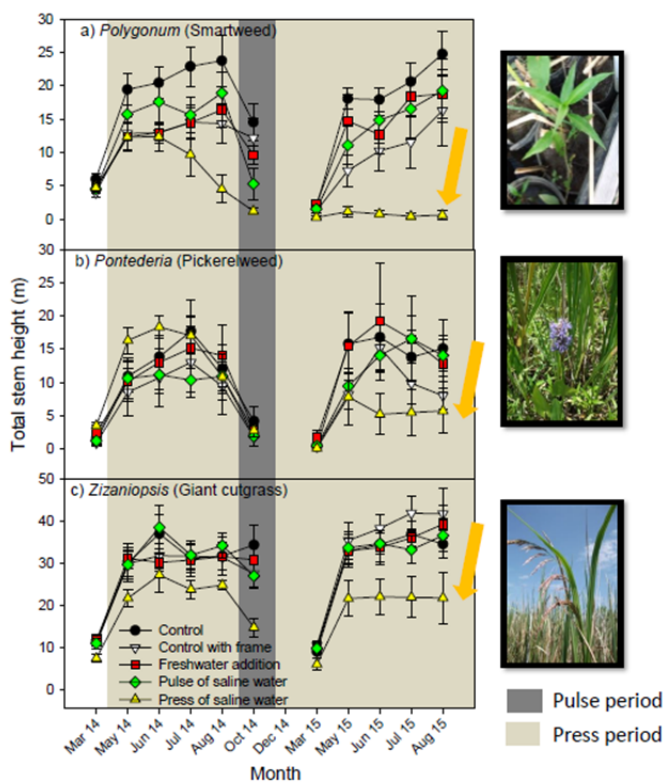


Fig. 7. Plant response in the SALTEx experiment. Arrows indicate current condition in press plots. Corresponds to Objective 3B.2: Conduct field manipulation of salt water intrusion in a low-salinity tidal marsh.

## GCE Significant Results 2015

### Area 4: Integration and Forecasting

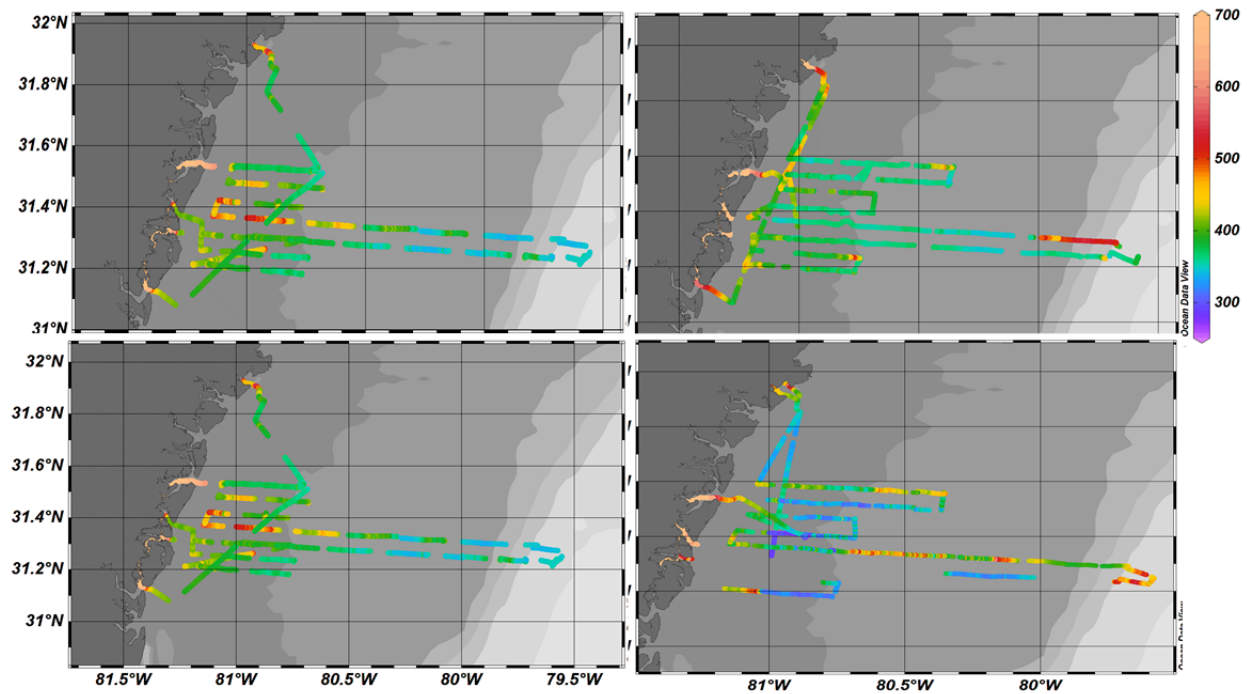


Fig. 8. pCO<sub>2</sub> concentrations in the GCE domain. Corresponds to Objective 4B.2: Evaluate C flow.

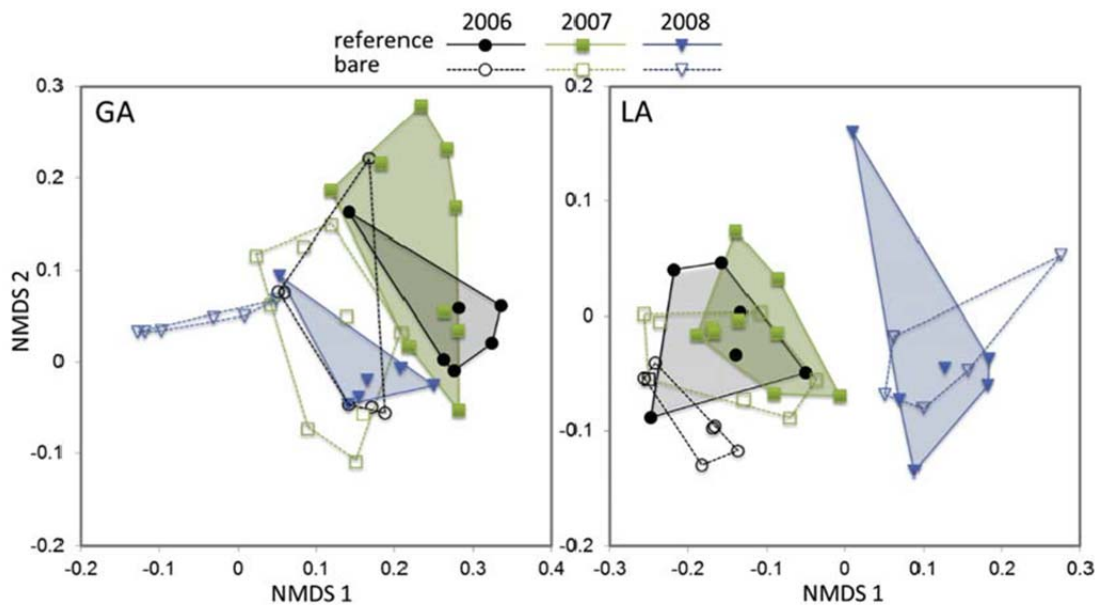


Fig. 9. Composition of infaunal assemblages in bare (open symbols, dashed lines) versus reference plots (closed symbols, solid lines) across sample years 2006-2008 in GA (left, 2-D stress=0.14) and LA (right, 2-D stress=0.11). The NMDS ordination of 4<sup>th</sup>-root transformed abundances is a representation of dissimilarity between treatment and sample year based on a Bray-Curtis similarity matrix. From McFarlin et al. 2015. Corresponds to Objective 4B.3: Evaluate habitat provisioning.

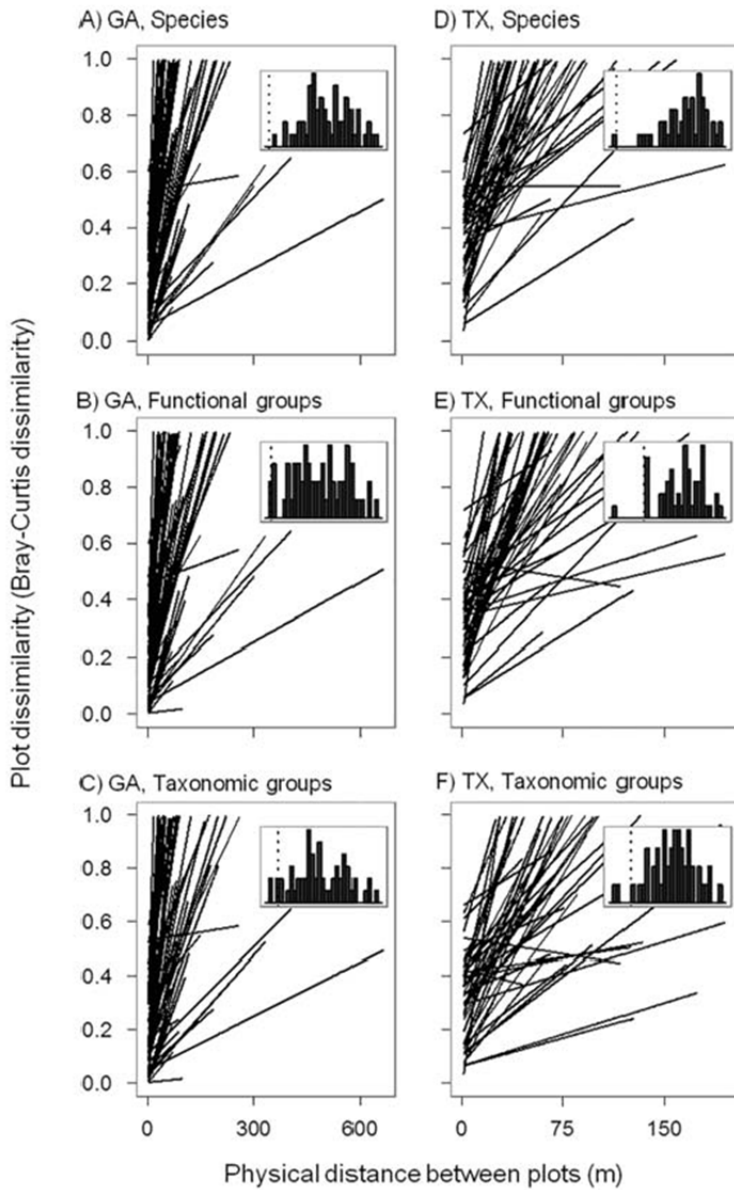


Fig. 1. Relationship between plot distance and plot dissimilarity (Bray-Curtis) for each of 59 transects in GA and 49 transects in TX based on species (panels A and D), functional groups (panels B and E), and taxonomic groups (panels C and F). Lines represent linear regression fit to the data for each transect. Histograms of Mantel  $r$  values (range 0 to 1) for each transect are shown; significant values are to the right of the dashed lines. From Guo et al. 2015.

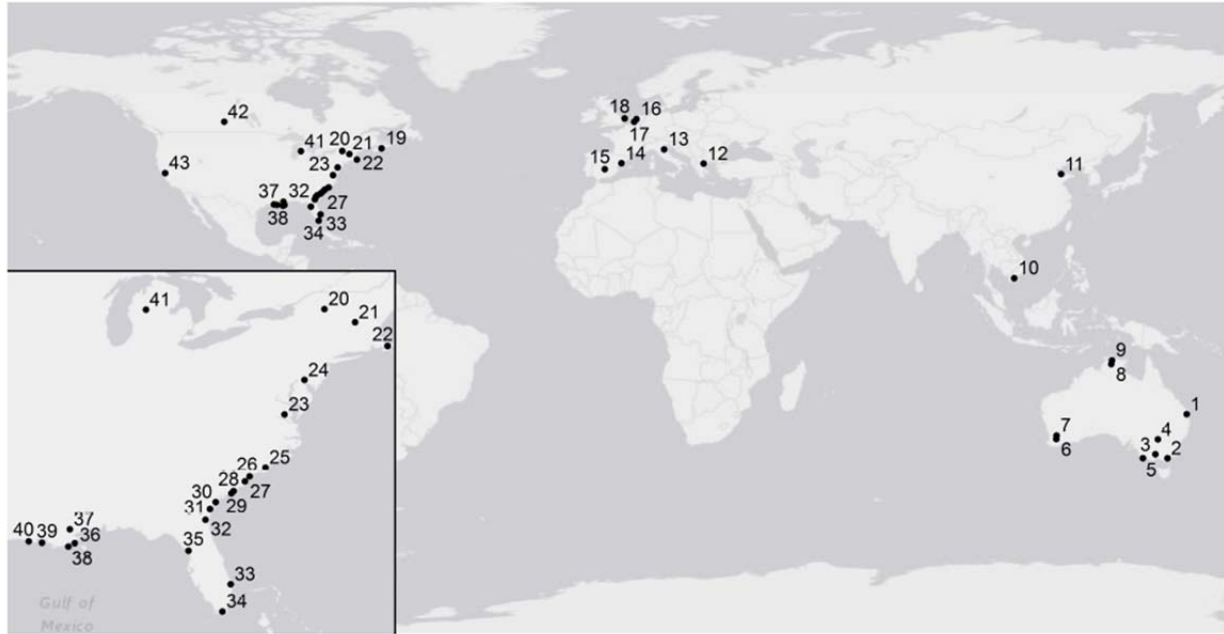


Fig. 2. Distribution of documented cases of freshwater wetland salinization. The absence of data from large geographic areas of the world does not imply the absence of wetland salinization. From Herbert et al. (in press).

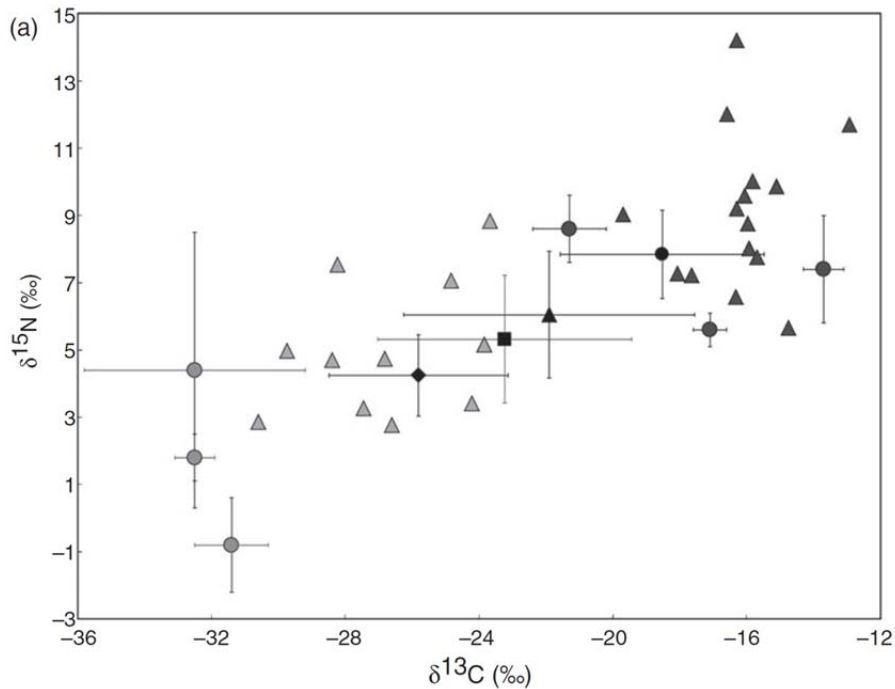


Fig. 3.  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values of *Alligator mississippiensis* subpopulation groups [black diamond is small juvenile (TL<79 cm), black square is large juvenile (TL=79-100 cm), black triangle is subadult (TL=100-183 cm), and black circle is adult (TL>183 cm)], marine/estuarine primary producers (dark grey circles), marine/estuarine prey species (dark grey triangles), freshwater/upland primary producers (light grey circles), and freshwater/upland prey species (light grey triangles). Error bars are not included for prey species. From Nifong et al. 2015.

## What opportunities for training and professional development has the project provided?

The GCE provides training and professional opportunities to K-12 educators, to undergraduate students, and to graduate students. GCE personnel are also involved in LTER network activities.

### GCE Schoolyard Program

The GCE Schoolyard immerses science and math teachers (K-12) in hands-on research activities alongside GCE scientists and graduate students. Teachers participate in field research, attend lectures, and develop ways to use this experience in the classroom. In July 2015, V. Butler (GCE Schoolyard Coordinator) and J. Crawford (UGA Marine Extension Service) ran our summer workshop, which included 9 new and 4 returning participants, at the GCE field site on Sapelo Island. The teachers worked on projects ranging from elevation surveys to plant monitoring to harvesting a greenhouse experiment. Participants reported an increase in their knowledge of both coastal systems and the scientific process. One of the participants wrote in their evaluation, "I have decided after my time here that I can easily base my zoology/botany class on labs instead of the textbook" and another "Most of the time when we go to a workshop, we listen to others talk and we don't participate in a meaningful way. This 'workshop' requires us to 'work' as we learn."

### Undergraduate education

10 undergraduate students worked with GCE LTER scientists on projects this past year:

- Several student interns were in residence at the field site on Sapelo Island over the summer: Two students from UH worked with S. Pennings assisting with wrack disturbance, vegetation monitoring and plant-herbivore studies; a student from Duke worked with B Silliman on consumer interactions; 3 UF students worked with C. Angilini on salt marsh community experiments.
- A student from UGA worked as a summer intern for C. Reddy, helping the GCE field crew in both the field and the lab and collecting samples to help calibrate the SeapHOx instrument.
- Five students from College of Coastal Georgia helped with quarterly monitoring at the SALTE<sub>x</sub> site in October.
- Undergraduates also worked in the labs of GCE investigators: A student from Savannah State Univ in C. Alexander's lab to analyze shelf sediment samples collected during cruises; a student at CCU worked with R. Viso to analyze multibeam data. Students from UGA worked with J.T. Hollibaugh processing microbial ecology samples; with P. Medeiros working on organic matter composition; and with J. Byers screening organisms for parasites.
- One of our undergraduates, identified as part of our partnership with the Peach State Louis Stokes Alliance for Minority Participation (LSAMP), was honored this past year as one of the top 100 student workers from UGA by the UGA Career Center.
- A. Burd uses GCE-LTER results in his freshman seminar, in particular when discussing the effects of sea level rise on coastal ecosystems.

### Graduate education

Graduate students are an integral part of the research at the GCE LTER. There are currently 27 students from 8 institutions engaged in LTER activities. Graduate students have also been authors on numerous publications that have resulted from this work. Other graduate activities include:

- S. Pennings (UH) began a distributed graduate class on "Sea level rise and saline intrusion in coastal habitats" in fall 2015. The course, which is being taught live over the internet, is offered

for credit at 20 universities across the country and has over 45 faculty, 25 managers, and 120 graduate students participating. Scientists from PIE, VCR and FCE helped organize the course.

- F. Li and W-T. Lin (UH Ph.D. students, Pennings) organized a weekly brown bag seminar series for all GCE-LTER personnel at the UGA Marine Institute during summer 2015. Speakers included faculty, students, and DNR personnel. Topics ranged from marsh plant community ecology to archaeological investigations to sea turtle nest monitoring.
- Several investigators use GCE data in their graduate courses: C. Angelini (Coastal Systems), A. Burd (Quantitative Methods in Marine Science), R. Castelao (Estuarine and Coastal Oceanography), C. Craft (Wetlands Ecology), P. Medeiros (Chemical Oceanography), R. Peterson (Application of Isotope Geochemistry), and R. Viso (Applied Geophysical Field Methods).

### International education

GCE investigators worked with students and scientists from several institutions this past year:

- C. Angelini (UF) hosted 1 PhD student from Radboud University and 1 post-doctoral associate from the Univ. of Groningen, the Netherlands, both of whom spent time at the UGA Marine Institute working on a salt marsh carbon experiment.
- We also have active collaborations with international students and scientists in Netherlands (Radboud University Nijmegen, University of Groningen), China (East China Normal University), India (Central Rice Research Institute), Czech Republic (Czech University of Life Sciences), and United Kingdom (Swansea University).
- The GCE has graduate students and post-doctoral associates from a variety of countries, including China, Vietnam, South Korea, Malaysia, and Moldova.

### Network activities

As detailed below, GCE scientists are actively collaborating on cross-site comparisons and are involved in network planning and governance, both within the LTER and with other groups.

- M. Alber and J.T. Hollibaugh attended the LTER Science Council Meeting at Harvard Forest in May 2014.
- S. Pennings began a term on the LTER National Executive Board in 2015.
- M. Alber, J. Byers, and C. Alexander are members of an LTER cross-site group examining the ecological effects of coastal armoring on soft-sediment environments; C. Alexander is a member of a group examining ecological and physical effects of major storms; M. Alber and S. Pennings are participating in a cross-site synthesis of temporal and spatial variation in primary production
- M. Alber and C. Alexander are PIs on a cross-site coastal SEES grant to evaluate the vulnerability of salt marshes to rising sea levels being conducted at GCE, VCR, and PIE.
- C. Reddy (GCE field crew) conducts amphibian surveys as part of the North American Amphibian Monitoring Program.
- The high-resolution digital camera on the GCE flux tower is part of the Phenocam network.
- GCE actively contributes content to the LTER Network Office for inclusion on the LTER website and newsletters.

We also have a strong network presence in terms of information management, through the activities of W. Sheldon and A. Sapp (UGA). Over the past year, GCE IM staff served the network in the

following capacities:

- Collaborated with other informatics professionals inside and outside LTER to found the ESIP EnviroSensing Cluster ([http://wiki.esipfed.org/index.php/EnviroSensing\\_Cluster](http://wiki.esipfed.org/index.php/EnviroSensing_Cluster)) to document and train scientists on best practices for sensor networks and sensor data management
- Participated in a CUAHSI virtual workshop on field data management solutions, providing training on using the GCE Data Toolbox software for data processing, quality control, synthesis and archiving
- Collaborated with other OCE-funded LTER sites and BCO-DMO personnel to begin cross-listing relevant LTER data sets in BCO-DMO on LTER site profile pages to enhance discovery
- Helped the CWT LTER site complete the migration of their legacy data holdings to a new LTER Data Catalog that leverages GCE-IMS technology, allowing CWT to register hundreds of data sets in PASTA this year
- Leveraged GCE-IMS components and protocols to establish a data catalog and bibliographic, taxonomic and geographic databases for the Savannah River Ecology Laboratory
- Provided reference code and documentation to the PHENOCAM program at UNH for capturing sequential IR and RGB images from a camera connected to a Campbell Scientific logger
- GCE continues to host the USGS Data Harvesting Service for HydroDB, in which data from 85 USGS stream flow gauging stations are automatically harvested on a weekly basis for 12 LTER sites (AND, BES, CAP, CWT, FCE, GCE, KBS, KNZ, LUQ, NTL, PIE, SBC) and 1 USFS site.

## How have the results been disseminated to communities of interest?

The GCE disseminates information to multiple audiences: we share information within the project itself; we distribute data and metadata; we provide information to the general public via our website; we reach schoolchildren through our children's book; we work with coastal managers through the Georgia Coastal Research Council; and we conduct various specialized activities.

### Project personnel

We use a wide variety of approaches for disseminating information internally. We continue to maintain multiple email lists and a password-protected project website, which provides GCE participants with role-based access to provisional data and private documents as well as web forms for submitting data, metadata, files, announcements, calendar events and other content for sharing publicly or only within GCE. We also maintain private email lists and file exchange services to facilitate collaboration on specific projects (SALTE<sub>x</sub>, Flux Tower, High Marsh), and publish a weekly newsletter to inform GCE participants, advisors and other interested parties about upcoming events, new data and file postings, field site news and research highlights.

This year we finished linking our research request and permitting web application and project management database to GCE-III objectives to simplify reporting and data submission tracking. We also revised our data submission system to ensure that metadata for new data sets are immediately registered and original data files are securely archived. A new data submission report web page provides contributors with status updates on processing of their data sets, as well as downloadable reports listing formal citations and DOIs ([Dissemination Fig.1](#)).

We continued our training program on data and metadata submission. Training is conducted in at annual project meetings and is required for all new participants. We also redesigned our data submission template with drop-down menus ([Dissemination Fig. 2](#)) and developed a relational database system for tracking and managing sample information for our water quality management program.

### Data and Metadata

We continue to operate an integrated information management system (GCE-IMS) at UGA based on relational database and dynamic web application technology to manage, archive and distribute data, metadata and other research products. We also operate an enterprise-class GIS system for managing geospatial data and maintain software to link the GIS to the GCE-IMS to support unified metadata generation.

In 2015 we undertook a major effort to finalize and publish all pending monitoring and study data, adding 112 new data sets and additional years of observations to many existing long-term data sets. We also began providing online access to both near-real-time and processed data from our eddy covariance flux tower.

As of October 2015, all 489 public data sets in the GCE Data Catalog have been uploaded to the LTER Data Portal with comprehensive EML metadata. New and updated data sets are uploaded monthly as they reach their public access date (i.e. within 2 years of collection), since PASTA does not support uploading metadata unless the data files are downloadable. However, metadata and data set summaries continue to be provided for all public and private GCE data sets through the GCE Data Catalog.

GCE research data are downloaded by a diverse group of web visitors, including academic researchers, educators, and personnel from other LTER programs ([Dissemination Table 1](#)). We also actively collaborated with staff of the Biological and Chemical Oceanography Data Management Office

(BCO-DMO) at Woods Hole to include dynamic data links on the GCE project page at BCO-DMO and we will continue to refine this approach to enhance discovery. To date, over 970,000 data files have been downloaded by the public since our data catalog was put online in 2001.

#### General public

We continue to maintain a website and public data portal for disseminating information and products from GCE research including publications, reports, research data, photographs and remote sensing imagery. We also actively contribute content to the LTER Network Office. Use of the GCE website has increased steadily since 2001, with over 407,000 page views from 164,000 visitors between October 2014 and September 2015. Over 1.1 million distinct web visits have been recorded since 2001.

We also maintain a dedicated education program website, providing information on the GCE Schoolyard program, children's book ("And the Tide Comes In..." by M. Alber) and other GCE education activities, with content geared towards K-12 educators and students. In addition we continue to host a support website for the GCE Data Toolbox for MATLAB software, an open source data management tool used for data processing and analysis at GCE and many other LTER sites. This year W. Sheldon provided training on use of this software at a CUAHSI virtual workshop and LTER All Scientists Meeting working group session; video recordings and materials from these and other training events are available on the website.

#### Children's Book

The GCE children's book, "And the Tide Comes In", published in Nov 2012, is part of the LTER book series. This past year we distributed more than 2000 books through our partners at 4H, Sapelo Island National Research Reserve, UGA Marine Extension, and others. This past year the book was adopted by Athens-Clarke County, GA as a read aloud text to integrate the science curriculum and we provided copies for all second grade classrooms in the district. We also donated a copy of the book to each of the public libraries in Georgia. A new edition geared for audiences beyond Georgia is now in preparation.

#### Georgia Coastal Research Council

The GCE continues to provide outreach to coastal managers through partial support of the Georgia Coastal Research Council (GCRC). Core activities of the GCRC include communicating via the GCRC listserv to representatives of academic units and state and federal agencies interested in coastal Georgia (the GCRC currently has 159 affiliates representing 19 universities, seven federal agencies, and nine state/regional organizations). The GCRC website ([www.gcrc.uga.edu](http://www.gcrc.uga.edu)) has more than 1100 pages and documents (including member biographies, project summaries, and research needs) and serves an important role as a conduit of coastal research information: during the past year the website logged more than 26,000 visitors and 39 different documents were downloaded more than 50.

In 2014 the GCRC completed several technical synthesis documents at the request of Georgia DNR, including a report reviewing relevant scientific research on vegetated buffers adjacent to coastal wetlands and produced an update on research relevant to the occurrence of marsh dieback in Georgia. In March 2015 we organized the first GCRC Coastal Symposium for the general public. There were approximately 80 people in attendance representing federal and state agencies, academia, NGO's, city and county government, community groups, and citizens.

#### Additional Activities

- GCE hosted PBS NewsHour in August 2015 for a story highlighting the SALTE<sub>x</sub> experiment and the flux tower. The story is part of a series, [The Wild Side of Sea Level Rise](#), which explores the basic research behind ocean expansion and its impacts on coastal ecology.
- The Pennings lab established a web site ([ScalingUpMarshScience.cs.uh.edu](http://ScalingUpMarshScience.cs.uh.edu)) that allows volunteers to help us align thousands of photographs into a mosaic of the marsh
- C. Angelini ran a day-long outreach activity with UF's Women in Science and Engineering group for 40 underprivileged girls that attend Girls Place, an after school program in Gainesville, FL
- The GCE field crew gave a tour to students from Ivy Academy in Chattanooga, and provided support for researchers evaluating shore birds.
- GCE continues to provide web hosting for the Georgia Coastal Research Council, as well as a searchable bibliographic database for the UGA Marine Institute.

## GCE Dissemination of Results 2015

Table 1. Total public data file downloads for 2012-2015 and 2001-2015 by data set theme and user affiliation, excluding GCE participants, metadata and GCE-to-LNO file transfers. Note that data distribution through the LTER Network Information System (NIS) just began in September 2013.

<b>Downloads by Data Set Theme</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>	<b>2015</b>	<b>2001-2015</b>
Algal Productivity	3	49	430	281	801
Anthropology	0	60	492	244	796
Aquatic Invertebrate Ecology	74	445	9164	4676	15061
Bacterial Productivity	1	293	4269	1906	6707
Botany	0	0	0	41	41
Chemistry	0	33	444	361	863
Fungal Productivity	0	49	748	319	1145
General Nutrient Chemistry	17	77	487	315	1082
Geology	3	32	440	344	858
Geospatial Analysis	0	47	1064	562	1683
Hydrography/Hydrology	1	27	221	415	700
Meteorology	12	157	1499	1111	2972
Multi-Disciplinary Study	29	41	764	493	1335
Organic Matter/Decomposition	0	201	1707	1061	3140
Physical Oceanography	66	1631	18972	16211	38045
Phytoplankton Productivity	0	107	2297	977	3548
Plant Ecology	54	348	7117	4622	12486
Population Ecology	0	8	186	164	358
Pore-water Chemistry	11	44	518	428	1028
Real-time Climate	142	79	125	106	894
Terrestrial Insect Ecology	63	155	2498	1128	4183
Various (custom file)	3	7	0	0	58
<b>Downloads by Affiliation</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>	<b>2015</b>	<b>2001-2015</b>
Academic Research Program	151	42	185	87	1884
Educational Program (K-12)	4	7	10	26	139
Educational Program (Post-secondary)	126	26	78	42	863
Environmental Advocacy Group	1	0	0	0	8
Government Agency	4	3	1	13	410
International LTER Site	11	1	2	0	46
LTER Network Office (Metacat)	51	9	4	38	1235
LTER NIS	0	3641	53045	35460	92146
Other LTER Site	29	29	3	4	259
Other/Unspecified	102	132	114	95	794
<b>Total Data Downloads</b>	<b>479</b>	<b>3890</b>	<b>53442</b>	<b>35765</b>	<b>97784</b>

# GCE Dissemination of Results 2015

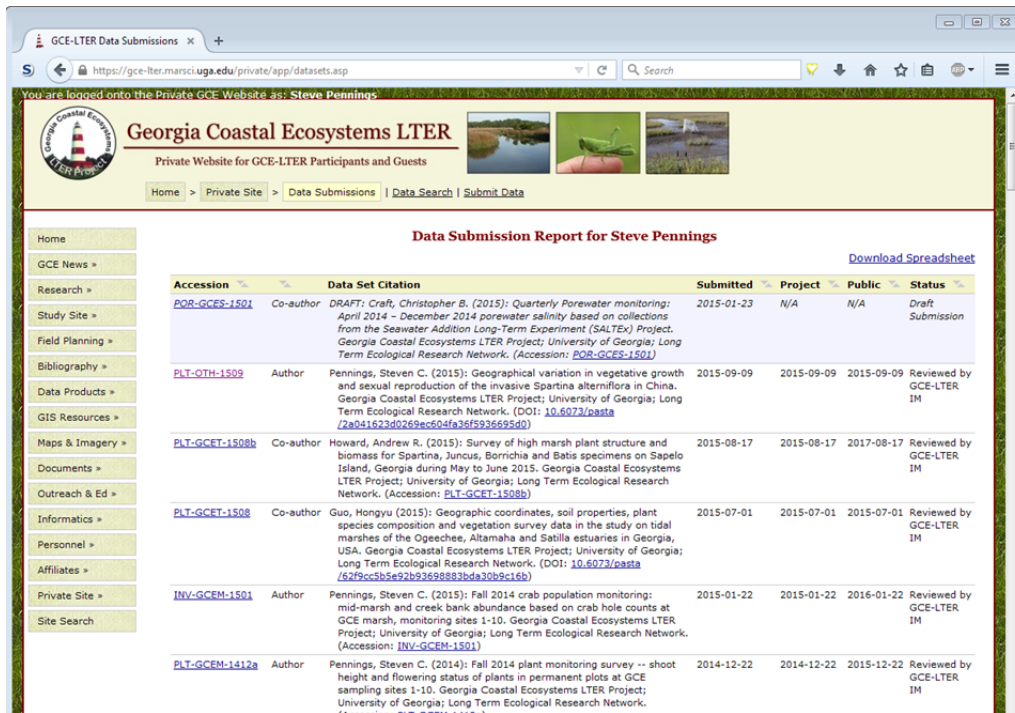


Fig. 1. Dynamic data submission report, providing data contributors with information about the status of pending data submissions as well as links, citations and DOIs for all finalized data sets.

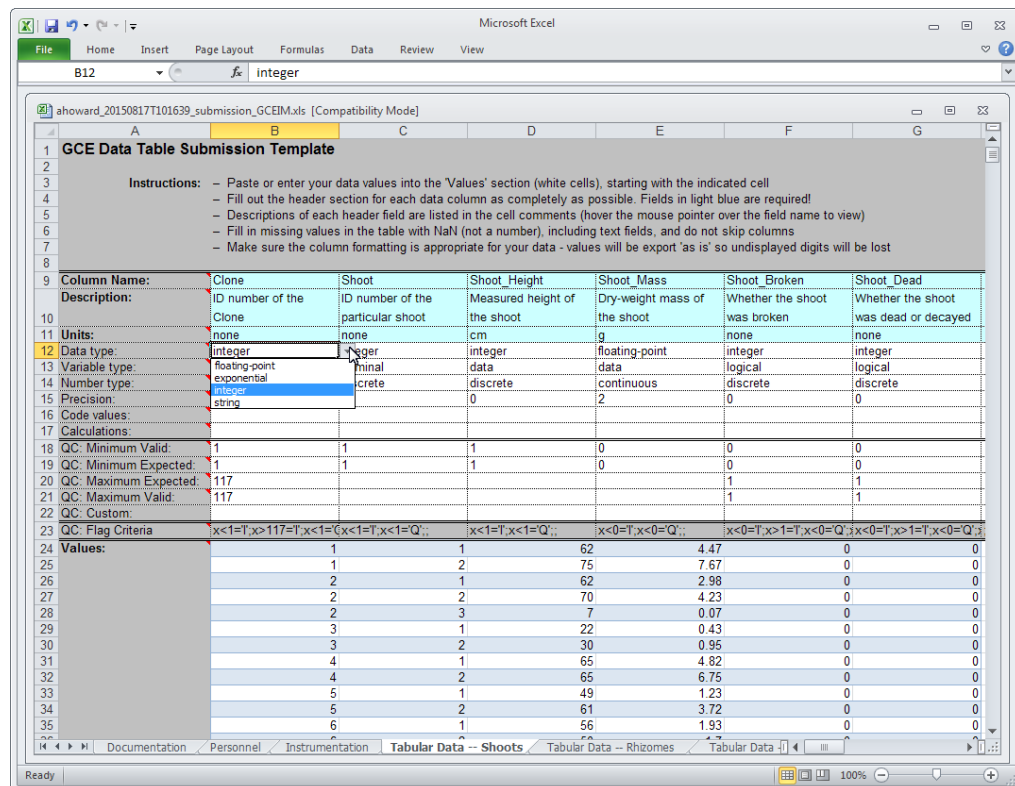


Fig. 2. Data submission template with drop-down menus to simplify content entry for required fields.

### What is the impact on the development of the principal discipline(s) of the project?

GCE scientists have published 34 journal articles and 6 book chapters and other one-time publications in 2014-15. Papers published this past year cover a broad range of ecological topics, including plant distribution (e.g. Guo et al. 2014), biodiversity (e.g. Angelini et al. 2015), disturbance (e.g. McFarlin et al. 2015), and nutrient cycling (e.g. Schutte et al. 2015). We have also made contributions in microbiology (e.g. Givens et al. 2015), biogeochemistry (e.g. Medeiros et al. 2015), remote sensing (e.g. Andrade et al. 2014), and physical oceanography (e.g. Sullivan et al. 2015). A complete list of publications can be found at [http://gce-nas.marsci.uga.edu/public/app/biblio\\_query.asp](http://gce-nas.marsci.uga.edu/public/app/biblio_query.asp). Key accomplishments this past year include research on plant community structure, wetland salinization, and apex predators.

### What is the impact on other disciplines?

The GCE is an interdisciplinary program, with biologists, geologists, chemists, physicists, and anthropologists engaged as PIs on the project.

### What is the impact on the development of human resources?

There are currently 10 undergraduate students, 27 graduate students and 9 post-doctoral scientists associated with the project. We had 2 REU participants this past year. We also have active collaborations with international students and scientists in Netherlands (Radboud University Nijmegen, University of Groningen), China (East China Normal University), India (Central Rice Research Institute), Czech Republic (Czech University of Life Sciences), and United Kingdom (Swansea University). Finally, we are leading a cross-institution graduate course on sea level rise and saline intrusion that is being offered at 20 universities, and has >150 participants.

### What is the impact on physical resources that form infrastructure?

The GCE has installed an extensive boardwalk system that provide access to plots associated with our long-term salinity addition experiment (SALTEx). We also installed boardwalks and photovoltaic cells in support of our eddy covariance flux tower, which is a 30 foot tall tower located in a salt marsh adjacent to Sapelo Island. We maintain sondes that continuously measure conductivity, temperature and salinity at 11 water quality monitoring sites in Altamaha, Sapelo, and Doboy Sound, and in the adjacent marshes we have RSETs that measure sediment elevation (there are also RSETs in the SALTEx plots). We also have groundwater wells installed along 2 transects that run from the uplands to the marsh. We partner with the Sapelo Island National Estuarine Research Reserve to run our weather station and to provide support for both an NADP station and a USGS water quality monitoring station. We also operate a wireless, outdoor data server on Sapelo to acquire, store and relay real-time data from the flux tower and other field instruments to servers at UGA.

### What is the impact on institutional resources that form infrastructure?

The UGA Marine Institute (UGAMI) on Sapelo Island provides the base of field operations for the GCE LTER. The project has 3 technicians who work at UGAMI, and all of our scientists use the facility while in the field. Two GCE labs (Pennings, Alber) maintain year-round housing and operations at UGAMI and at

any given time there are students, technicians and other personnel at the facility. We maintain two 22' small boats, two Kawasaki mules and two trucks at the field station to access sampling sites. We also operate a GIS lab at UGAMI in collaboration with the Sapelo Island National Estuarine Research Reserve.

#### What is the impact on information resources that form infrastructure?

The GCE Information Management program has developed a number of software products, database systems and web applications that have been released as open source software. These tools, including the GCE Data Toolbox for MATLAB, our Metabase Metadata Management System, our bibliographic database, our file archive and our geospatial library, are widely used across the LTER Network and in other environmental informatics programs. The GCE Data Toolbox software has been downloaded by over 3600 registered users (705 since 2012) and is actively used at 9 other LTER sites for sensor data harvesting, data analysis or general data processing tasks. Notably, both the CWT and AND LTER programs have standardized on the GCE Data Toolbox for all environmental sensor data processing. Also, the Metabase metadata management system was adopted by 3 other LTER sites (CWT, MCR and SBC) and the Savannah River Ecology Lab.

#### What is the impact on technology transfer?

We provide user training and other support resources for the GCE Data Toolbox for MATLAB software. This past year we updated the API Guide and QA/QC Flagging Reference on the toolbox support website, conducted a training session in the CUAHSI Virtual Workshop on Field Data Management Solutions, ran a training workshop at the LTER All Scientists Meeting and participated in the ESIP EnviroSensing Cluster working group, which included the GCE Data Toolbox application for sensor data as part of the Best Practices Guide released in 2014. ([http://wiki.esipfed.org/index.php/EnviroSensing\\_Cluster](http://wiki.esipfed.org/index.php/EnviroSensing_Cluster))

#### What is the impact on society beyond science and technology?

The GCE website and public data portal is used to disseminate publications, reports, research data, photographs and remote sensing imagery. Over 1.1 million distinct web visits have been recorded since 2001, with over 407,000 page views from 164,000 visitors this past year. In addition, GCE scientists regularly give seminars and public presentations, contribute articles to newsletters and other popular publications, and talk to the media about coastal issues. Our Schoolyard program brings K-12 teachers to the field site, and this past year our children's book and accompanying lesson plans were distributed to approximately 2000 grade school teachers and environmental educators. GCE outreach is served by partial support of the Georgia Coastal Research Council (GCRC, [www.gcrc.uga.edu](http://www.gcrc.uga.edu)), which works to promote science-based management of Georgia coastal resources by facilitating information transfer between scientists and managers. PBS NewsHour highlighted GCE research this past year as part of their "Wild Side of Sea Level Rise" series.

## **Products and Publications**

### **Books**

Craft, Christopher B. (2016). *Creating and Restoring Wetlands: From Theory to Practice*. Elsevier. Amsterdam, The Netherlands. Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes

Vepraskas, M.J. and Craft, Christopher B. (2016). *Wetland Soils: Genesis, Hydrology, Landscapes, and Classification 2nd*. Vepraskas, M.J. and Craft, C.B.. CRC Press. Boca Raton, FL. Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes

### **Book Chapters**

Andrade, Francisco and Blanton, Jackson O. and Ferreira, M. Adelaide and Amft, Julie (2014). Developments in Salt Marsh Topography Analysis Using Airborne Infrared Photography. *Remote Sensing and Modeling* 9. Finkl, Charles W. and Makowski, Christopher. Springer International Publishing. 317-331. Status = PUBLISHED; Acknowledgement of Federal Support = Yes ; Peer Reviewed = Yes

Langman, Owen and Craft, Christopher B. (). Carbon and nutrient cycling of created and restored wetlands. *Encyclopedia of Wetlands. Volume 3. Wetland Management* . Status = AWAITING\_PUBLICATION; Acknowledgement of Federal Support = No ; Peer Reviewed = Yes

Sharitz, Rebecca R. and Batzer, Darold and Pennings, Steven C. (2014). Ecology of Freshwater and Estuarine Wetlands: An Introduction. *Ecology of Freshwater and Estuarine Wetlands Second edi*. University of California Press. 1-22. Status = PUBLISHED; Acknowledgement of Federal Support = Yes ; Peer Reviewed = Yes

Sharitz, Rebecca R. and Pennings, Steven C. (2014). Development of wetland plant communities. *Ecology of Freshwater and Estuarine Wetlands Second edi*. University of California Press. 133-150. Status = PUBLISHED; Acknowledgement of Federal Support = Yes ; Peer Reviewed = Yes

### **Conference Papers and Presentations**

O'Donnell, J.P. and Schalles, John F. (2015). *28 Years of Landsat5 TM and external forcing data for analysis of Spartina biomass on the Central Georgia coast*.. Coastal and Estuarine Research Federation Biennial Meeting.. Portland, OR.. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Dugan, J. and Alber, Merryl and Alexander, Jr., Clark R. and Byers, James and Emery, K. and Gehman, Alyssa and Lawson, S. and McLenaghan, Natalie Ann (2015). *A conceptual model for predicting the ecological effects of coastal armoring in soft-sediment environments*.. Coastal and Estuarine Research Federation Biennial Meeting. Estes Park, CO. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Dugan, J. and Alber, Merryl and Alexander, Jr., Clark R. and Byers, James and Emery, K. and Gehman, Alyssa and Lawson, S. and McLenaghan, Natalie Ann (2015). *A conceptual model for predicting the ecological effects of coastal armoring in soft-sediment environments*.. Coastal and Estuarine Research Federation Biennial Meeting. Portland, OR. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Alexander, Jr., Clark R. and Jackson, C. and Jaeger, J.M. and Corbett, D.R. and Howard, S. and Walsh, J.P. (2015). *AMBUR-HVA: A New Hazard Vulnerability Assessment Tool for Regional Coastal Resiliency Planning*.. SURA Coastal Resilience Workshop. Fort Lauderdale, FL. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Bulski, K. and Alexander, Jr., Clark R. and Venherm, Claudia and Robinson, Michael and DeLeo, LeeAnn (2015). *Armored Estuarine Shorelines of Coastal Georgia - Patterns, Trends and Projections*.. Coastal and Estuarine Research Federation Biennial Meeting. Portland, OR. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Roberts Thompson, Amanda D. and Tucker, Bryan and Bedell, Jennifer and Tucker, Megan T. and Golsch, Matthew and Ritchison, Brandon Tyler and Colvin, Matthew H. and Napora, Katherine and Black, Rachel and Bouzigard, Aimee and Thompson, Victor D. (2014). *Articulating Management and Research on Ossabaw Island, Georgia*. Southeastern Archaeological Conference. Greenville, SC. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Ritchison, Brandon Tyler (2014). *Changing Communities: Mississippi Period Transitions on the Georgia Coast*. Southeastern Archaeological Conference. Greenville, SC. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Schalles, John F. and Hart, Alissa C. and Altrichter, Adam E. and Carpenter, Eryn J. and Vichienwanitchkul, Prem (2015). *Coastal systems in a time of climate change: The mangroves are coming*. Climate Change Actions - Sustainable Solutions for a Living Earth. Loyola University - Chicago, IL. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Miklesh, David Michael and McKnight, Charles Jared and Di Iorio, Daniela and Meile, Christof (2015). *Controls on porewater salinity distributions in a southeastern salt marsh*. LTER All Scientists Meeting. Estes Park, CO. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Ledoux, Jonathan G. and Alexander, Jr., Clark R. and Meile, Christof (2014). *Delineating groundwater flow along a marsh transect at a back barrier island on the coast of Georgia*. Southeastern Estuarine Research Society Fall meeting. Carolina Beach, NC. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Gehman, Alyssa and McLenaghan, Natalie Ann and Byers, James and Alexander, Jr., Clark R. and Pennings, Steven C. and Alber, Merryl (2015). *Effects of development and shoreline armoring on the high marsh ecosystem*. Benthic Society Ecology Meeting 2015. Quebec City, CN. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Sheldon, Jr., Wade M. (2014). *Example Workflows for Sensor Data Processing and QA/QC*. Federation of Earth Science Information Partners Summer Meeting 2014. Copper Mountain, Colorado. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

DeLeo, LeeAnn and Alexander, Jr., Clark R. and Robinson, Michael and Bulski, K. and Venherm, Claudia (2015). *Geospatial analysis of the distribution and variability of Spartina wrack in Georgia marshes*. Coastal and Estuarine Research Federation Biennial Meeting. Portland, OR. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Ledoux, Jonathan G. and Alexander, Jr., Clark R. and Meile, Christof (2015). *Groundwater flow at the Georgia coast: Magnitude and drivers across a back barrier island - marsh transect*. LTER All Scientists Meeting. Estes Park, CO. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Nahrawi, Hafsah Binti and Leclerc, Monique Y. and Zhang, Gengsheng and Pahari, R. and Di Iorio, Daniela and Alber, Merryl and Sheldon, Jr., Wade M. and Shalack, Jacob (2015). *Influence of Daytime Tide Events on CO2 Exchange between Salt Marshes and the Atmosphere*. Long-term Ecological Research All Scientist Meeting (LTER ASM). Estes Park, CO. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Robinson, Michael and Alexander, Jr., Clark R. and Venherm, Claudia and DeLeo, LeeAnn (2015). *Integrated survey methods document estuarine bathymetry and benthic habitats for research and management: Coastal Georgia*. Coastal and Estuarine Research Federation Biennial Meeting. Portland, OR. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Addes, Danyel (2014). *Listening to and learning from local ecological knowledge: A social science pilot study in McIntosh County, GA*. Social Coast Forum 2014. Charleston, South Carolina. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Miklesh, David Michael and McKnight, Charles Jared and McLenaghan, Natalie Ann and Di Iorio, Daniela and Meile, Christof (2014). *Modeling the Effects of Changes to Physical, Hydrological, and Biological Processes on Porewater Salinity Distributions in a Southeastern Salt Marsh*. 2014 AGU Fall Meeting. San Francisco. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Ritchison, Brandon Tyler (2015). *Regional Abandonment and Community Organization: Regional and Community Perspectives on the North Georgia Coast*. Society for Georgia Archaeology meeting. Valdosta, GA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Schalles, John F. and Smith, Elizabeth and Chaves=Rameriz, Felipe and Davis, Nicole and Altrichter, Adam E. and Hart, Alissa C. and Carpenter, Eryn J. and Seminara, D.N. and Vichienwanitchkul, Prem (2015). *Replacement of marsh with mangrove communities in Coastal Texas and potential impact to Whooping Cranes*.. Coastal & Estuarine Research Federation Meetings.. Portland, OR.. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Venherm, Claudia and Alexander, Jr., Clark R. and DeLeo, LeeAnn and Robinson, Michael (2015). *Shoreline Characterization in Coastal Georgia Using a Geospatial Video Mapping System*.. Coastal and Estuarine Research Federation Biennial Meeting. Portland, OR. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Golsch, Matthew and Ritchison, Brandon Tyler and Colvin, Matthew H. and Tucker, Bryan and Thompson, Victor D. (2014). *Utilizing Complementary Techniques to Understand Formation Processes at the Ossabaw Island Shell Ring (9CH203)*. Southeastern Archaeological Conference. Greenville, SC. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

## Inventions

### Journals

Alicia M. Wilson · Tyler B. Evans · Willard S. Moore · Charles A. Schutte · Samantha B. Joye (2015). What time scales are important for monitoring tidally influenced submarine groundwater discharge? Insights from a salt marsh. *Water Resources Research*. 51 (6), . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1002/2014WR015984

Alicia M. Wilson · Tyler Evans · Willard Moore · Charles A. Schutte · Samantha B. Joye · Andrea H. Hughes · Joseph L. Anderson (2015). Groundwater controls ecological zonation of salt marsh macrophytes. *Ecology*. 96 (3), 840. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1890/13-2183.1

Angelini, Christine and van der Heide, J. and Griffin, John N. and Derksen-Hooijberg, M. and Lamers, L.P.M. and Smolders, Alfons J. P. and Silliman, Brian R. (2015). Foundation species' overlap enhances biodiversity and ecosystem multifunctionality from the patch to landscape scale.. *Proceedings of the Royal Society B*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1098/rspb.2015.0421

Atkins, Rebecca and Griffin, John N. and Angelini, Christine and O'Connor, M.I. and Silliman, Brian R. (2015). Consumer- plant interaction strength: importance of body size, density and metabolic biomass.. *OIKOS*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1111/oik.01966

Charles A Schutte, Samantha B Joye, Alicia M Wilson, Tyler Evans, Willard S Moore, Karen Casciotti (2015). Intense nitrogen cycling in permeable intertidal sediment revealed by a nitrous oxide hotspot. *Global Biogeochemical Cycles*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1002/2014GB005052

Davidson, Andrew and Griffin, John N. and Atkins, Rebecca and Angelini, Christine and Coleman, F. and Silliman, Brian R. (.). The spatial dimension of trait-mediated indirect interactions: Predators intensify grazer-plant interactions by driving vertical, not horizontal, grazer habitat shifts. *Marine Ecology Progress Series*. . Status = AWAITING\_PUBLICATION; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Drake, Katherine and Halifax, H and Adamowicz, Susan C. and Craft, Christopher B. (2015). Carbon sequestration in tidal salt marshes of the Northeast United States. *Environmental Management*. 56 (4), 998-1008. Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes

Freita, R. and Schrack, L. and Sieg, R. D. and Silliman, Brian R. and Costa, C. (2014). Grazing scar characteristics impact degree of fungal facilitation in *Spartina alterniflora*/ leaves in a South American Salt Marsh.. *Brazilian Archives of Biology and Technology*. 58 (1), 103-108. Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes ; DOI: 10.1590/S1516-8913201400030

Givens, Carrie and Ransom, Briana and Bano, Nasreen and Hollibaugh, James T. (2015). Comparison of the Gut Microbiomes of 12 Bony Fish and 3 Shark Species. *Marine Ecology Progress Series*. 518 209-223. Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes ; DOI: 10.3354/meps11034

Gries, Corinna and Henshaw, Donald L. and Brown, Renee F. and Cary, Richard and Downing, Jason and Jones, Christopher and Kennedy, Adam and Laney, Christine and Martin, Mary and Morse, Jennifer and Porter, John and Read, Jordan and Rettig, Andrew and Sheldon, Jr., Wade M. and Strachan, Scotty and Zdravkovic, Branko (2014). Sensor and sensor data management best practices released. *ILTER Databits - Information Management Newsletter of the Long Term Ecological Research Network*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = No

Griffin, John N. and Toscano, B.D. and Griffen, B.D. and Silliman, Brian R. (). Does relative abundance modify multiple predator effects?. *Basic and Applied Ecology*. . Status = AWAITING\_PUBLICATION; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Guo, Hongyu and Chamberlain, Scott A and Elhaik, Eran and Jalli, Inder and Lynes, Alana R. and Marczak, Laurie and Sabath, Niv and Vargas, Amy and Wieski, Kazimierz and Zelig, Emily and Pennings, Steven C. (2015). Geographic Variation in Plant Community Structure of Salt Marshes: Species, Functional and Phylogenetic Perspectives. *PLOS ONE*. 10 (5), . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1371/journal.pone.0127781

Guo, Hongyu and Wieski, Kazimierz and Lan, Zhenjiang and Pennings, Steven C. (2014). Relative influence of deterministic processes on structuring marsh plant communities varies across an abiotic gradient. *Oikos*. 123 (2), 173- 178. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1111/j.1600- 0706.2013.00425.x

Hauer, M. and Evans, J and Alexander, Jr., Clark R. (2015). Sea-Level Rise and Sub-County Population Projections in Coastal Georgia.. *Population and the Environment*.. 37 44-62. Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes ; DOI: 10.1007/s11111-015-0233-8

He, Qiang and Silliman, Brian R. (2015). Biogeographic consequences of nutrient enrichment for plant-herbivore interactions in coastal wetlands.. *Ecology Letters*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Herbert, Ellen and Boon, Paul and Burgin, Amy J. and Neubauer, S. C. and Franklin, Rima B and Ardon, Marcelo and Hopfensperger, Kristine N. and Lamers, L.P.M. and Gell, Peter (). A global perspective on wetland salinization: Ecological consequences of a growing threat to freshwater wetlands. *Ecosphere*. . Status = ACCEPTED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Hopkinson, Charles S. and Cai, Wei-Jun and Hu, Xinping (2012). Carbon sequestration in wetland dominated coastal systems - a global sink of rapidly diminishing magnitude. *Current Opinions in Environmental Sustainability*. 4 186 - 194. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1016/j.cosust.2012.03.005

Hunter, E.A. and Nibbelink, N.P. and Alexander, Jr., Clark R. and Barrett, K. and Mengak, L.F. and Guy, R.K. and Moore, C.T. and Cooper, R.J. (2015). Coastal vertebrate exposure to predicted habitat changes due to sea level rise.. *Environmental Management*. 1-10. Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes ; DOI: 10.1007/s00267-015-0580-3

Hubner, L. and Pennings, Steven C. and Zimmer, Martin (2015). Sex- and habitat-specific movement of an omnivorous semi-terrestrial crab controls habitat connectivity and subsidies: A multi-parameter approach. *Oecologia*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1007/s00442-015-3271-0

Liu, Qian and Lu, Xinxin and Tolar, Bradley and Mou, Xiaozhen and Hollibaugh, James T. (2015). Concentrations, turnover rates and fluxes of polyamines in coastal waters of the South Atlantic Bight.. *Biogeochemistry*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: DOI 10.1007/s10533-014-0056-1

Liu, Wenwen and Maung-Douglass, Keith and Strong, Donald R. and Pennings, Steven C. and Zhang, Yihui (). Geographical variation in vegetative growth and sexual reproduction of the invasive *Spartina alterniflora* in China. *Journal of Ecology*. . Status = AWAITING\_PUBLICATION; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Loftis, Kathy and Meile, Christof (2014). Isotopes and elemental ratios in multi-parameter mixing models. *Limnology and Oceanography: Methods*. 12 694-702. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Marczak, Laurie and Wieski, Kazimierz and Denno, Robert and Pennings, Steven C. (2013). Importance of local vs. geographic variation in salt marsh plant quality for arthropod herbivore communities. *Journal of Ecology*. 101 1169- 1182. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1111/1365-2745.12137

McFarlin, Caroline R. and Bishop, Thomas Dale and Hester, Mark and Alber, Merryll (2015). Context-dependent effects of the loss of *Spartina alterniflora* on salt marsh invertebrate communities. *Estuarine, Coastal and Shelf Science*. 163 218-230. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: <http://dx.doi.org/10.1016/j.ecss.2015.05.045>

Medeiros, Patricia M. and Seidel, Michael and Dittmar, Thorsten and Whitman, William B. and Moran, Mary Ann (2015). Drought-induced variability in dissolved organic matter composition in a marsh-dominated estuary. *Geophysical Research Letters*. 42 6446-6453. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1002/2015GL064653

Nifong, James C. and Layman, C. and Silliman, Brian R. (2015). Size, sex, and individual-level behavior drive intra-population variation in cross-ecosystem foraging of a top-predator.. *Journal of Animal Ecology*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1111/1365-2656.12306

Rosenblatt, A. E. and Nifong, James C. and Heithaus, M.R. and Mazzotti, Frank J. and Cherkiss, M.S. and Jeffery, B.M. and Elsey, Ruth M. and Decker, R.A. and Silliman, Brian R. and Guillette, L.J. and Lowers, R.H. and Larson, J.C. (2015). Factors affecting individual foraging specialization and temporal diet stability across the range of a large *generalist* apex predator. *Oecologia*. 178 5-16. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1007/s00442-014-3201-6

Runfola, Dan and Pontius, Robert G. (2013). Quantifying spatial and temporal instability of land change. *International Journal of Geographical Information Science*. 27 (9), 1696 - 1716. Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes

Sheldon, Jr., Wade M. (2014). Using the GCE Data Toolbox as an EML-compatible workflow engine for PASTA. *LTERR Databits - Information management Newsletter of the Long Term Ecological Research Network*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = No

Sheldon, Jr., Wade M. and Chamblee, John F. and Cary, Richard (2013). Automating Data Harvests with the GCE Data Toolbox. *LTERR Databits - Information Management Newsletter of the Long Term Ecological Research Network*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = No

Silliman, Brian R. and Schrack, Elizabeth and He, Qiang and Santoni, A. and Jacobi, R. and Jacobi, M. and van der Heide, J. and van de Koppel, Johan (). Facilitation shifts paradigms and can increase success of coastal restoration.. *Proceedings of The National Academy of Sciences*.. . Status = AWAITING\_PUBLICATION; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes

Sullivan, Jessica C. and Torres, R. and Garrett, A. and Blanton, Jackson O. and Alexander, Jr., Clark R. and Robinson, Michael and Moore, Trent C. and Amft, Julie and Hayes, D. (2015). Complexity in Salt Marsh Circulation for a Semi-enclosed Basin. *Journal of Geophysical Research - Earth Surface*. . Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes ; DOI: 10.1002/2014JF003365

Tellez, M. and Nifong, James C. (2014). Gastric nematode diversity between estuarine and inland freshwater populations of the American alligator (*Alligator mississippiensis*, daudin 1802), and the prediction of intermediate hosts. *International Journal for Parasitology: Parasites and Wildlife*. 3 227-235. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1016/j.ijppaw.2014.07.001

von de Koppel, J. and van der Heide, J. and Alteiri, A. and Eriksson, B. and Bouma, H. and Olf, Han and Silliman, Brian R. (2014). Long-distance interactions regulate the structure and resilience of coastal ecosystems.. *Annual Review of Marine Science*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

## Licenses

### Other Products

#### Databases.

GCE Bibliographic Database, for managing, searching and distributing GCE and UGAMI publications ([http://gce-iter.marsci.uga.edu/public/app/biblio\\_query.asp](http://gce-iter.marsci.uga.edu/public/app/biblio_query.asp))

#### Databases.

GCE File Archive, for managing, search and distributing documents, imagery and other file-based resources ([http://gce-iter.marsci.uga.edu/public/app/resource\\_search.asp](http://gce-iter.marsci.uga.edu/public/app/resource_search.asp))

#### Databases.

The Metabase Metadata Management System, a generalized relational database and associated middleware for managing metadata content, data file distribution, and EML metadata generation ([http://gce-iter.marsci.uga.edu/public/app/data\\_search.asp](http://gce-iter.marsci.uga.edu/public/app/data_search.asp))

#### Databases.

GCE Data Portal is a browseable web-based catalog of data sets and plots from federal and GCE-affiliated monitoring programs operating near Sapelo Island, Georgia (<http://gce-iter.marsci.uga.edu/portal/>)

#### Databases.

GCE Taxonomic Databases is a web accessible database for managing taxonomic information, generating themed species lists, and providing taxonomic coverage metadata for GCE-LTER data sets ([http://gce-iter.marsci.uga.edu/public/app/all\\_species\\_lists.asp](http://gce-iter.marsci.uga.edu/public/app/all_species_lists.asp)).

#### Software or Netware.

PyGIS geospatial library for ArcGIS (<https://gce-svn.marsci.uga.edu/trac/Python-GIS>)

#### Software or Netware.

The GCE Data Toolbox for MATLAB, a comprehensive software framework for metadata-based processing, quality control and analysis of environmental data ([https://gce-svn.marsci.uga.edu/trac/GCE\\_Toolbox](https://gce-svn.marsci.uga.edu/trac/GCE_Toolbox))

## Other Publications

## Patents

## Technologies or Techniques

## Thesis/Dissertations

Givens, Carrie. *A fish tale: comparison of the gut microbiome of 15 fish species and the influence of diet and temperature on its composition*. (2012). University of Georgia. Acknowledgement of Federal Support = Yes

Hensel, Marc Simon. *Cross-kingdom consumer diversity enhances multifunctionality of a coastal ecosystem*. (2013). University of Florida. Acknowledgement of Federal Support = Yes

Ledoux, Jonathan G.. *Drivers of groundwater flow at a back barrier island - marsh transect in coastal Georgia*. (2015). The University of Georgia. Acknowledgement of Federal Support = Yes

Marton, John M.. *Ecosystem services of restored wetlands and riparian buffers---USDA conservation practices in the glaciated interior plains*. (2012). Indiana University. Acknowledgement of Federal Support = Yes

Schutte, Charles. *Nitrogen cycling and trace gas dynamics in shallow coastal aquifers*.. (2014). University of Georgia. Acknowledgement of Federal Support = Yes

Herbert, Ellen. *The effects of global change on the fate of soil organic matter in tidal freshwater wetlands*. (2015). Indiana University. Acknowledgement of Federal Support = Yes

Tolar, Bradley. *The influence of environmental factors including reactive oxygen species on the spatial and temporal distribution of marine Thaumarchaeota*. (2014). University of Georgia. Acknowledgement of Federal Support = Yes

Nifong, James C.. *Use of marine habitat and food resources by coastal inhabiting Alligator Mississipiensis (American Alligator): implications for food webs and community dynamics*. (2014). University of Florida. Acknowledgement of Federal Support = Yes

## Websites

*GCE Data Toolbox Wiki*

<http://gce-svn.marsci.uga.edu>

The GCE Data Toolbox Wiki is the web-based project management and bug tracking system for the GCE Data Toolbox.

*Georgia Coastal Ecosystems LTER*

<http://gce-lter.marsci.uga.edu>

This is the main site for the Georgia Coastal Ecosystems LTER project, with information about all aspects of the project and a public data portal (<http://gce-lter.marsci.uga.edu/portal/>) for disseminating information and products from GCE research including publications, reports, research data, photographs and remote sensing imagery. There is also a password-protected portion of the site, which provides project investigators with access to provisional data and private documents as well as web forms for submitting data, metadata, files, announcements, calendar events and other content.

*Georgia Coastal Ecosystems LTER Education Program*

<http://gce-schoolyard.uga.edu>

This is the main site for the GCE LTER Education program. It includes information about the children's book "And the Tide Comes In...: Exploring a Georgia Salt Marsh" by Merryl Alber (Author) and Joyce Mihran Turley (Illustrator), which is part of the LTER Children's Book Series. The website also provides information on the GCE Schoolyard program (in-service training for K-12 teachers in field ecology), as well as other educational and outreach opportunities.

*Image Matching Game: Scaling Up Marsh Science*

<http://ScalingUpMarshScience.cs.uh.edu>

Scaling Up Marsh Science allows volunteers to help us align thousands of photographs into a mosaic image of the marsh.