Georgia Coastal Ecosystems

A New Coastal Site in the Long Term Ecological Research Network

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ABSTRACT

The Georgia Coastal Ecosystems LTER (GCE-LTER) site is a barrier island and marsh complex located on the central Georgia coast in the vicinity of Sapelo Island and the Altamaha River, one of the largest and least developed rivers on the east coast of the US. Our project will use a multidisciplinary approach including environmental monitoring, direct experimentation, mathematical modeling, and GIS to study the ecological linkages between local and distant upland areas mediated by surface and ground water delivery to the coastal zone. A central focus of our research will be the influence of spatial and temporal variability in environmental factors driven by river flow, primarily salinity, on ecosystem processes and structure. Initial field studies will examine: transport and exchange processes in salt-marshes, tidal creeks, and the surficial aquifer; sediment and ground water nutrient dynamics; salt marsh production and trophic structure; bacterial and fungal diversity and productivity; and invertebrate population dynamics. The coastline of Georgia is currently among the least developed in the United States, but is projected to see rapid urbanization over the next few decades. The GCE-LTER project should provide crucial insights needed to predict the impact of water use changes on our coastal ecosystems.

INTRODUCTION

Tidal marsh/estuarine complexes occur at the margin between land and sea, and the ecological processes in this setting are driven by terrestrial, oceanic and atmospheric inputs that vary over many spatial and temporal scales. Terrestrial inputs are relatively predictable over annual scales but unpredictable over days to weeks or longer than annual time scales. Oceanic inputs are highly predictable over tidal time scales. Some of the many scales of variability interact to produce longer time-scale, predictable variation (e.g. seasonal precession of the timing and amplitude of low spring tides, which has important consequences for intertidal organisms), while other longer time scale variations (e.g. storms, upwelling events, blooms, other water quality variations) are less predictable. Atmospheric nutrient deposition varies in unpredictable ways in both space and time, particularly over time scales of days to weeks (Pearl & Fogel, 1994). Superimposed on the scales of natural variability are the consequences of human activities.

Focused study of two general sets of processes is necessary to understand the multiple scales of spatial and temporal variations in coastal processes and to develop predictive models for the impact of these variations on ecosystems at the land-ocean margin:

- How are the effects of spatially and temporally variable patterns of terrestrial, oceanic, and atmospheric inputs propagated through coastal ecosystems?
- How does the resulting variation in nutrients, organic matter, and salinity affect processes in coastal wetlands?

The GCE-LTER study will begin to address these questions by quantifying the existing gradients (mean and variability) of one important variable -- salinity -- over spatial and temporal scales ranging from µm to km and minutes to years. We hypothesize that these gradients will be reflected in ecological variables such as diversity, composition and productivity and in sediment characteristics and associated biogeochemical conditions.

STUDY AREA

The GCE-LTER site is located on the central Georgia coast in the vicinity of Sapelo Island (fig. 1). The upland-estuarine interface of the study area consists of the riverine estuary of the Altamaha River, the lagoonal estuaries bordering the mainland and Sapelo Island, and the tidal marsh complexes fringing small hammocks distributed throughout the coastal area (fig. 2). The salinity regimes of these estuaries result from the interaction of river discharge and ocean tides. The lagoonal estuaries adjacent to upland areas are also influenced, though to a lesser and more localized extent, by local surface runoff and groundwater seepage directly to the marsh.

figure 1. Map of the Southeastern USA, depicting the location of Sapelo Island and the GCE-LTER study area. The pullout image is based on a color-enhanced satellite vegetation map.

The most southerly estuary is Altamaha Sound, which lies at the mouth of the Altamaha River, the largest river in Georgia. Altamaha Sound is strongly river-dominated and constitutes a complex delta made up of low islands, marshes and tributaries. Doboy Sound, located to the north of Altamaha Sound, connects to the coastal ocean via a pass between Sapelo Island and the marsh complexes of Wolf/Queen Islands. Freshwater from the Altamaha River is transported into upper Doboy Sound through the connecting Intracoastal Waterway and marsh channels. Tidal exchange with the Altamaha's plume in the coastal ocean can also deliver low salinity water to Doboy Sound. Thus, mixing with sea water occurs under most conditions, so that water reaching Doboy Sound has low salinity but is not fresh (fig. 3). The third estuary, Sapelo Sound, is at the northern edge of the study area. Like Doboy Sound, it is a lagoonal estuary with no large streams discharging directly into it. Fresh water enters as precipitation, groundwater or as small volumes of surface inflow.

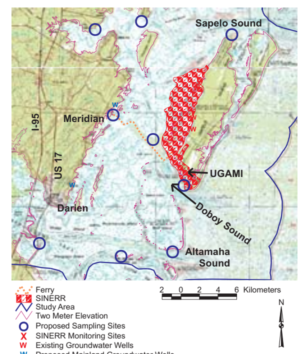


figure 2. Map of the GCE-LTER study area, showing the proposed sampling sites and other geographical features.

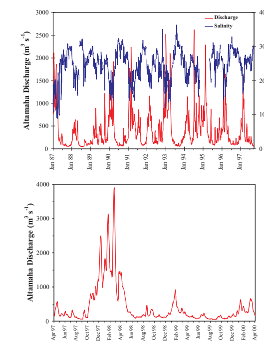
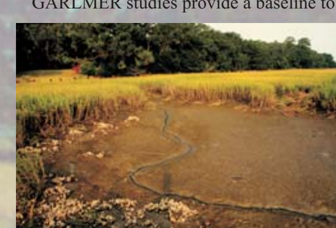


figure 3. Reciprocal trends in Altamaha River discharge (adjusted 7d for time lag) and Sapelo salinity over a ten year period (top), and high inter-annual variability in Altamaha discharge patterns observed during the last three years (bottom; Alber and Sheldon, 1999, and J. Sheldon, pers. Com.).

A unique advantage of the GCE-LTER study area is the long term record of scientific study and ecosystem preservation that have been established by the University of Georgia Marine Institute (UGAMI) on Sapelo Island and the Sapelo Island National Estuarine Research Reserve (SINERR). UGAMI and the SINERR lie close not only to vast tracts of undisturbed marsh, but also to a number of marshes enclosed by breached dikes, settings useful for quantifying marsh use by various organisms or for studying biogeochemical mass balances. UGAMI studies of the Sapelo Island marshes began in 1954 and have resulted in over 800 publications. These publications, LMER data, long-term SINERR monitoring records, and aerial photographs dating back to 1954 provide a perspective on long-term changes in the system and will help in interpreting data collected during the GCE-LTER project.

STUDY PLAN

During its initial funding cycle, the GCE-LTER study will address the questions posed above by focusing primarily on marsh, estuarine, nearshore, and riparian processes that are hypothesized to be affected most directly by variations in freshwater inflow. This focus complements the nearly completed Georgia Rivers LMER project (GARLMER), which focused primarily on water column processes and exchange with the coastal ocean. GARLMER studies provide a baseline to address coupling between estuarine/marsh complexes and the coastal ocean and underscore (Cai et al. in press) the strong influence of marsh processes on estuarine water quality in this region. The proposed LTER will include monitoring across a range of space and time scales to document trajectories of ecosystem processes and ecosystem responses to perturbations.



Low tide view of a Spartina marsh and oyster bed bordering a tidal creek on Sapelo. The 2m tidal amplitudes that occur in the central Georgia Bight produce extensive intertidal zones and cause high sediment resuspension.

The monitoring effort will be complemented by a set of discrete directed studies that will explore specific aspects of ecosystem function.

Three major elements comprise the GCE-LTER study:

Study Element 1: Modeling.

Modeling serves as a predictive, hypothesis-generating device upon which some of the monitoring and experimental studies are based and as a mechanism for data integration, assimilation, and analysis. The GCE-LTER will use and improve four distinct classes of models encompassing the full spectrum of chemical, biological, and physical processes in the system.

(a) Mechanistic ecological model (Richard Wiegert)

(b) Modeling and measuring tidal flows and material exchange between tidal creek channels and marshes (Jack Blanton, Guoqing Lin, Daniela Di Iorio)

(c) Effect of land-use changes on Altamaha River water quality (Alice Chalmers, Merryl Alber, Richard Wiegert, Joan Sheldon)

(d) Biogeochemical modeling (Samantha Joye, Philippe Van Cappellen)

Study Element 2: Monitoring

We will map spatial and temporal variability and mean values of key environmental factors through the study area, using techniques ranging from full-time instrument telemetry to periodic laboratory measurements.

(a) Altamaha River (GCE-LTER management James T. Hollibaugh):
Measure of dissolved and particulate constituents in Altamaha river water entering the study area. Examine water quality in tributaries to relate composite water quality at the head of tide to differences in geology and human activities in different areas of the watershed.

(b) Groundwater (Carolyn Ruppel)
Estimate fluxes of fresh water and dissolved constituents from the surficial aquifer into adjacent marshes and estuarine channels. Compare the quantity and water quality of freshwater emanating from developed versus undeveloped areas. Examine the effects of tidal pumping on groundwater salinity distributions.

Dr. Carolyn Ruppel and GA Tech students removing the casing from a PVC hydrological monitoring well (*Photo courtesy of Carolyn Ruppel*)

(c) Atmospheric (Steven Pennings, Ken Helm)
Collect meteorological data, including pan evaporation and wet and dry deposition data.

(d) Sounds and tidal creeks (James T. Hollibaugh, Steven Pennings, Jack Blanton, Daniela Di Iorio, Wade Sheldon)
Continue routine data collection begun with GARLMER. Establish and maintain continuous records of salinity and temperature at monitoring sites and on routine transects. Data analysis will focus on characterizing the distribution across the study area of mean properties and their variability spectra.

R/V Bluefin, Skidaway Institute of Oceanography

(e) Marshes:
Conduct sediment geochemistry studies and analyses of angiosperms, benthic microalgae, invertebrates, and fungi.

Sediment (Samantha Joye, Christopher Craft)
Angiosperms (Steven Pennings, Christopher Craft)
Benthic Microalgae (Samantha Joye, Wei-Jun Cai)
Fungi (Steven Newell)
Animal Populations (Merryl Alber, T. Dale Bishop)

Orchelimum spp., a tettigoniid grasshopper, is abundant throughout the marsh and feeds heavily on cordgrass, *Spartina alterniflora. (Photo courtesy of Steven Pennings)*

Ascospore of *Phaeosphaeria spartinicola*, one of the principal species of ascomycetes that carry out the decay of standing-dead parts of smooth cordgrass (*Spartina alterniflora*) (*Photo courtesy of Steven Newell*)

Study element 3: Directed Studies of Marsh Structure and Function

In addition to community ecology questions encompassed in the monitoring section (e.g. invertebrate and fungal assemblages), we will conduct additional studies focusing on spatial and temporal variability in angiosperm primary production, community composition, genetic structure and decomposition processes.

(a) Angiosperm Production, Community Structure and Population Genetics (Steven Pennings, Lisa Donovan).

(b) Prokaryotic-Eukaryotic Decomposer Consortia (Steven Newell, Mary Ann Moran, James T. Hollibaugh)

LITERATURE CITED

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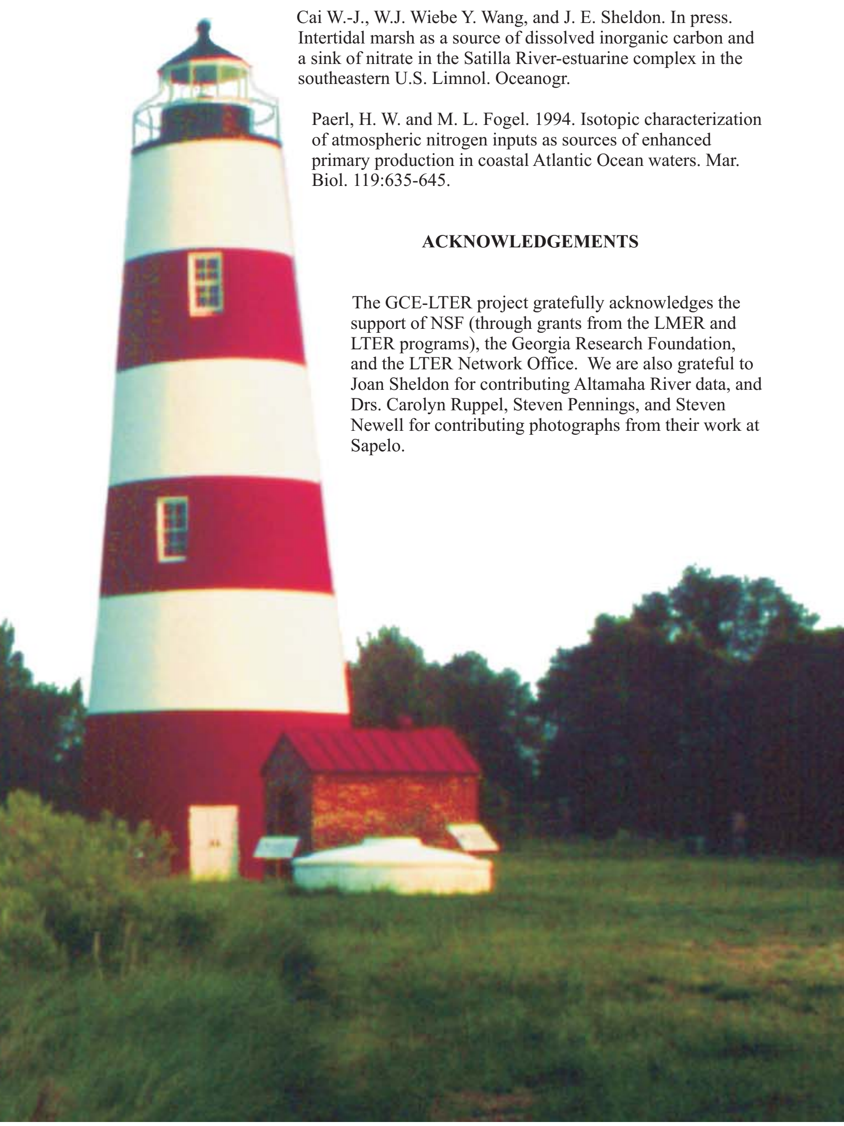

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