Georgia Coastal Ecosystems Long Term Ecological Research Project
Marsh Hammock Research – 2009

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Background

The central paradigm of the Georgia Coastal Ecosystems project is that variability in estuarine ecosystem processes is primarily mediated by the mixture of fresh and salt water flows across the coastal landscape. The GCE project is investigating the underlying mechanisms by which proximity of marshes to upland habitat drives ecosystem change along lateral gradients in the intertidal zone. Our approach to this question involves taking advantage of marsh hammocks as a natural laboratory for evaluating the influence of landscape structure and freshwater input on marsh processes. The hammock research includes basic characterization of groundwater flow as well as physical and biological characteristics at selected sites, experiments designed to understand the effects of manipulating water flow on marsh processes, and modeling. In 2007 we did a survey of 55 hammocks representing a range of sizes and origin, and these data are still being analyzed. Our activities this past year included processing geological samples; collecting data from instrumented hammocks; and continuing archeological studies. We also continued our analysis of the plant community associated with hammocks and initiated field and greenhouse studies to support our modeling efforts. This portion of the project is under the direction of Alber and Alexander, with involvement from co-PIs Pennings, Joye, Burd, Meile, B. Moore (USC), and V. Thompson (Ohio State).

Geology

Geologic characterization of marsh hammocks within the GCE domain, under the direction of Alexander, continued along several fronts in the past year. The Alexander lab completed textural analyses of the hammocks sampled in summer 2007 and showed that there are distinct textural differences between hammocks based on origin. Holocene hammocks contain the greatest amount of sand, followed by Pleistocene hammocks and GCE monitoring sites (as would be expected from their locations on Pleistocene upland bodies), followed by ballast stone hammocks, which accumulate a wide range of materials from the water column, and lastly, dredge spoil hammocks, which are created from an indiscriminant mixture of flocculant muds and sands rapidly deposited in channels over time. During the last year, we also assessed the textural preferences of the focus salt marsh plants in our study. Results indicate that *Borrichia* prefers sandy sediments (75-95% sand) with little mud (4-30%), as is expected from its tendency to grow on the eroding flanks of sandy hammocks and in environments where the texture does not change dramatically with depth. *Juncus* is found in zones of somewhat greater mud content (7-40%) and in a wider range of sand contents (60-95%). *Spartina* grows in more variable settings, with a wide range of sand (5-90%) and mud (7-90%), suggesting that other factors are more important than sediment type for constraining this species.

Coring throughout the region behind Sapelo Island has revealed that stiff, Pleistocene-aged marsh mud discontinuously underlies many of the Pleistocene hammocks and the open marshes surrounding them. This layer, observed from <1 m to >5 m below the surface, is impermeable and widespread and must have significant impact on the hydrologic pathways both from hammocks to marshes and within marshes as well. This linkage between marsh ecosystems, stratigraphy and hydrology will be pursued in the coming year, and the distribution of this impermeable layer will be mapped with greater detail. To start this process, we have collected transects and targeted cores near Marys Hammock (10 cores), Jacks Hammock (1 core) and PNi12 (e.g., Fishing Hammock, 4 cores). These cores have been subsampled for texture and AMS C-14 where material was available; samples will be analyzed in the coming year.

Archeological studies

J. Turck (Ph.D. student, UGA) and Alexander used a vibracorer to take six sediment cores from the marsh near one of our study hammocks (Marys Hammock, a Pleistocene hammock on the west side of the Duplin R.) in an attempt to locate former ground surfaces and understand the depositional history of the marsh surrounding the hammock as related to changes in sea level. The cores were split in half, photographed, X-rayed, and visually inspected. Three sets of sediment samples were taken from the cores at 10-cm intervals for stratigraphic and geochemical analyses. Particle size analysis was performed on one set of samples, to locate buried B soil horizons and stratigraphic discontinuities showing breaks in sedimentation. Loss on ignition was performed on the second set of samples to estimate organic matter, which can be used to locate buried A soil horizons. The third set of samples has been saved for a future pollen study.

Thompson and Turck also published a paper on the response of hunter-gatherer groups to changes in sea level and resource distribution. They suggest that, despite major destabilizing forces in the form of sea level lowering and its concomitant effects on resource distribution, cultural systems rebounded to a structural pattern similar to the one expressed prior to environmental disruption. They propose, in part, that the ability for people to return to similar patterns was the result of the high visibility of previous behaviors inscribed on the landscape in the form of shell middens and rings from the period preceding environmental disruption. Finally, despite a return to similar cultural formulations, hunter-gatherers experienced some fundamental changes resulting in modifications to existing behaviors (e.g., ringed villages) as well as the addition of new ones in the form of burial mound construction. This work was published in the American Antiquity (2009).

Intensive hammock research

In 2008 two hammocks were selected for more detailed study: HNi1 is of Holocene origin and is located west of and adjacent to Blackbeard Island to the north of Sapelo; PCi29 was thought to be of Pleistocene origin and is located adjacent to the south end of Sapelo Island. These two hammocks are of similar size, with similar vegetation zones in the high marsh. We set up transects that run from the nearby upland (Blackbeard and Sapelo Islands, respectively), through the marsh, and up and over each hammock to the marsh adjacent to the Sound (Sapelo and Doboy, respectively) and took cores at each site. Information from the stratigraphic data was used as a guide to install wells across a hydrologically connected sand layer.

The cores from HNi1 generally exhibit profiles consistent with a sand body deposited onto back-barrier marsh by storm processes. A single, continuous marsh deposit, dated by AMS C-14 at about 3500 y BP, underlies HNi1. Sedimentary structures in the cores suggest that energetic forces washed beach sand back onto the marsh, creating a shore-parallel, linear sand body that has been modified over the past few thousand years (see core 5 detail in Figure 1). This Holocene hammock consists of clean medium- to fine-grained sands that contain parallel to cross-bedded laminations. Cores from PCi29, along with

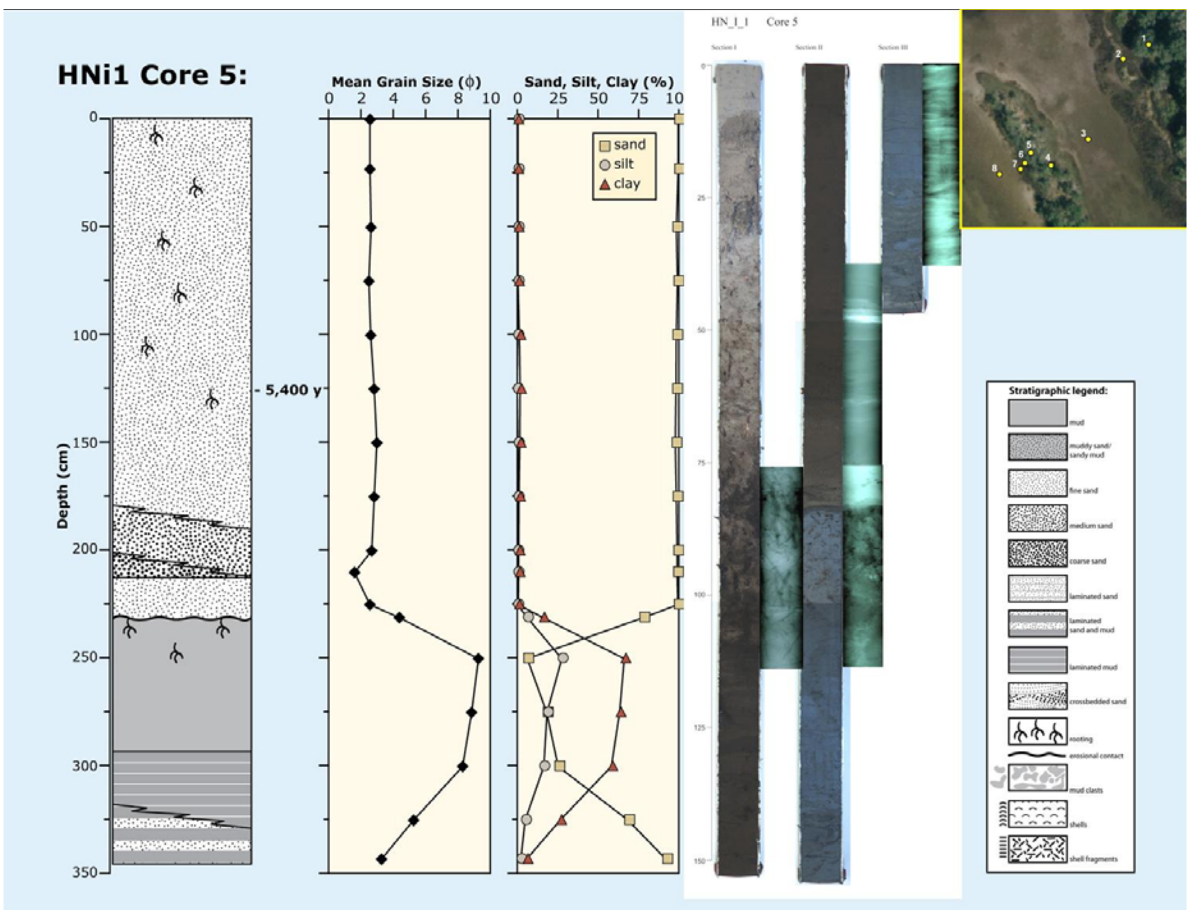

Figure 1. Core 5 from Holocene hammock HNi1 west of Blackbeard Island. Panels show stratigraphic interpretation; average grain size; percent sand, silt and clay; photographs; and core location.

AMS C14 and OSL dating, suggest that this hammock has had a complicated history spanning multiple environments of deposition.

Each hammock has eight wells installed from the upland, across the marsh-upland interface, and into the marsh. Water levels recorded in the wells placed along the transect from Blackbeard over HNi1 and into the marsh show features that suggest significant hydrologic interaction on some timescales and very little at others (Figure 2, top). Tidal signatures are evident in all records; dominant and subordinant tides can be recognized at spring and neap tides for the wells in *Spartina* and *Juncus* zones (wells 2, 3, 7 and 8), whereas both daily tides can be identified only at spring tides in *Borrichia* and upland zones (wells 1, 4, and 5). Large rainfall events are easily recognized in the record, with events on 10, 13 and 25 October creating abrupt increases in well water level.

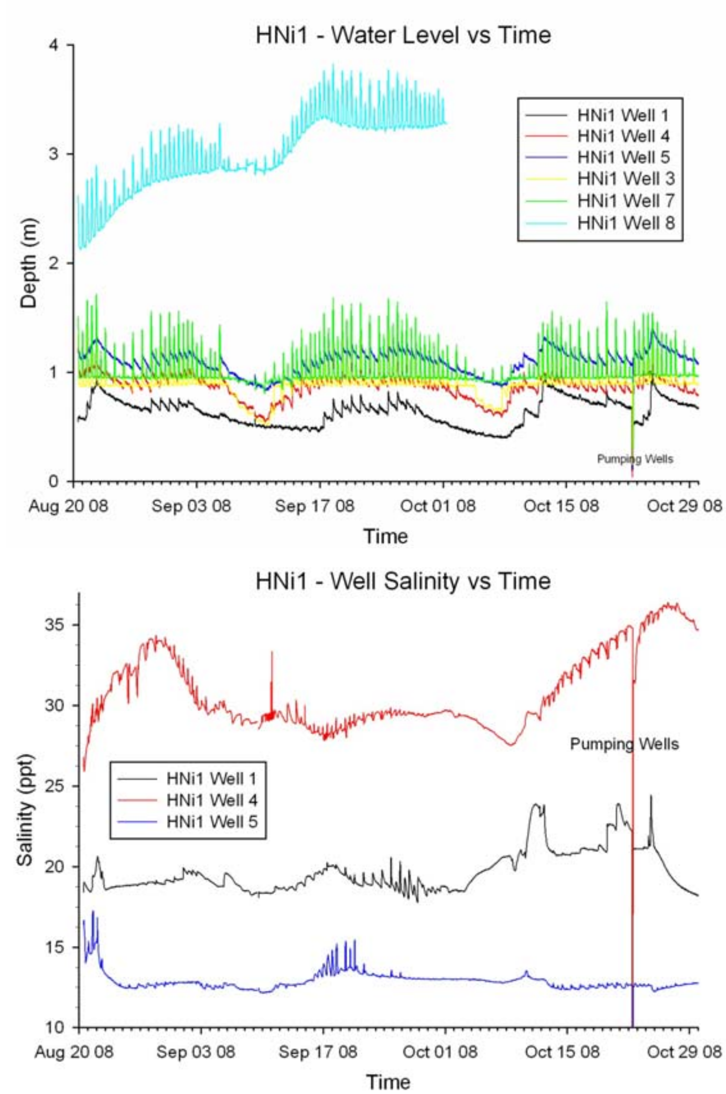

Figure 2. Water levels (top) and salinities (bottom) in wells on hammock HNi1. Water level results for well 8 in the *Spartina* zone are problematic at this time.

Salinity recorders are present in 3 of the wells on HNi1 (Figure 2, bottom). Significant freshening in the hammock well (5), where salinities are 13-15, can be observed in comparison to well 4, in the *Borrichia* zone some tens of meters away and several meters lower in elevation, where salinities are 30-35. Interactions between these closely adjacent wells will form a focus for the coming year.

Monthly monitoring of wells at the two hammocks began in August 2008. It is unclear at this point how hydrologically connected the wells actually are. Chemical constituents are at least an order of magnitude higher in the groundwater than in surface water collected from the sites. Concentrations of dissolved organic carbon (DOC) as high as 15 mM have been observed in the groundwater, and DOC in nearby surface water (~2 mM) exceeds that in open sound water (hundreds of µM). Concentrations of dissolved inorganic nitrogen tend to be dominated by ammonium, which is not surprising since the groundwater is anoxic and sulfidic.

Plant Community

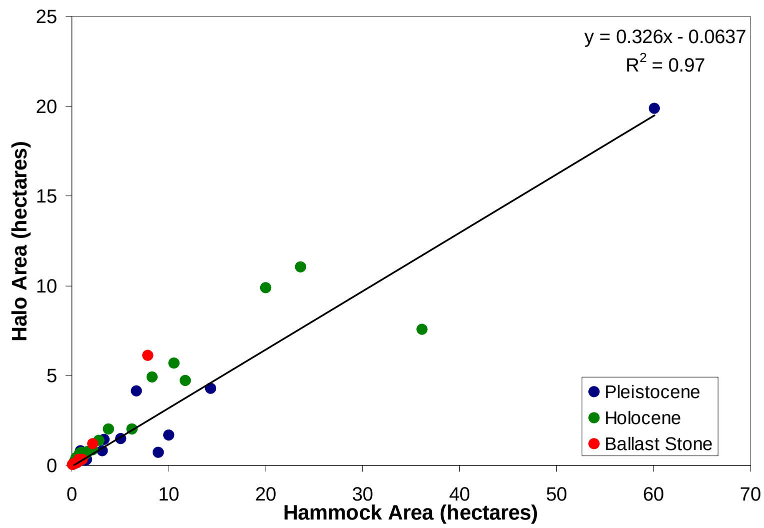

Figure 3. Area of high marsh plant community adjacent to the upland area of hammocks (“halo”) compared with hammock area.

In the hammock survey of 2007, we used sub-meter accuracy GPS units to map the hammock upland border and the extent of the upper marsh (from the hammock border to the upper edge of *Spartina alterniflora*, i.e. the marsh “halo”). Plants within the halo were also characterized. Analyses of these observations by Hladik and Alber showed that the area of the high marsh plant community adjacent to the upland area of the hammocks was positively related to hammock area (Figure 3), and was larger in Holocene and Pleistocene hammocks than those of other origins. *Borrichia frutescens* and *Juncus roemerianus* were most often the dominant plants in these areas, but there were differences related to hammock size and origin. This work will be presented at the LTER ASM and the 2009 CERF meeting.

In order to help parameterize the plant model for Burd, Pennings and Anstead collected data on high marsh plant communities and associated soils. In 2009 we collected light profiles and associated data on plant heights and densities in stands of *S. alterniflora*, *J. roemerianus*, and *B. frutescens*. These data will provide information on how stands of different plant species at different densities affect the light environment for other plants (one mechanism of competition among plants). We also collected data on soil porewater content and porewater salinity from stands of the same three plant species. These data will provide information on how the physical environment experienced by each plant species varies over space and time. To determine if plants are in fact rooting in the soils that we are sampling, we collected pre-dawn xylem pressure potential readings on all three species of plants. (In theory, pre-dawn XPP readings are in equilibrium with soil water potentials).

Pennings and Anstead are also conducting a greenhouse experiment to evaluate the sensitivity of three common salt marsh plants, *S. alterniflora*, *J. roemerianus*, and *B. frutescens*, to varying levels of shade (0 to 80% of light blocked) and salinity (0 to 60). Monthly measurements of plant size and photosynthetic rate over the course of the 2009 growing season will help inform the model about how the three plant species respond to competition for light (as simulated by shade cloth) and salinity. This information will also be used in plant modeling efforts.

Publications and Presentations (2008-2009)

Journal Articles

Thompson, V.D. and Turck, J.A. 2009. Adaptive Cycles of Coastal Hunter-Gatherers. American Antiquity. 74(2):255-278.

Conference Proceedings

Thompson, V.D., Turck, J.A. and DePratter, C. 2009. The Historical Ecology of Islands Large and Small along the Georgia Coast. In: Thompson, V.D. and Waggoner, J. (editors). The Historical Ecology of Hunter-Gatherers. 74th Society for American Archaeology Conference, Atlanta, Georgia.

Turck, J.A. and Thompson, V.D. 2008. Geoarchaeological Analysis of Two Back-Barrier Islands on the Coast of Georgia, U.S.A. In: Reitz, E.J. and Thomas, D.H. (editors). Environmental Archaeology in the Georgia Bight. 65th Southeastern Archaeology Conference, Charlotte, North Carolina.

Related publications which may be of interest

Richards, C.L., White, S.N., McGuire, M.A., Franks, S.J., Donovan, L.A. and Mauricio, R. 2009. Plasticity, Not Adaptation to Salt Level, Explains Variation Along a Salinity Gradient in a Salt Marsh Perennial. Estuaries and Coasts. (DOI: 10.1007/s12237-009-9186-4) (in press)