occur elsewhere in the coming century. Sustained operation of the GSN will ensure that ground motion recordings are available for scientific analysis and emergency response applications.

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Author Information

Jeffrey Park, Yale University, New Haven, Conn.; Kent Anderson, IRIS Consortium, Washington, D.C.; Richard Aster, New Mexico Institute of Mining and Technology, Socorro; Rhett Butler, IRIS Consortium, Washington, D.C.; Thorne Lay, University of California, Santa Cruz; and David Simpson, IRIS Consortium, Washington, D.C.

For additional information, contact J. Park; E-mail: jeffrey.park@yale.edu.

MEETINGS

Salt Marsh Geomorphology: Physical and Ecological Effects on Landform

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Salt marshes are among the most productive ecosystems on the planet, producing more organic matter per unit area than forests, grasslands, and cultivated fields. Marsh landscapes typically fringe low-energy coastal environments, but in places they may extend inland tens to hundreds of kilometers.

As a consequence of their high productivity and interactions with the coastal ocean, salt marshes provide numerous benefits to society. For example, salt marshes are critical habitats for commercially harvested marine and estuarine biota; they filter nutrients and sediment from the water column; and they provide recreational opportunities. In addition, salt marshes help dissipate erosive tide and wave energy, and they have intrinsic aesthetic values. All of these societal benefits have a quantifiable economic value, and salt marsh impairment and degradation have associated costs.

The high productivity and resulting societal benefits of salt marshes are sustained by recurrent interactions between physical and biological processes. These processes operate within the context of human modification of the landscape, including changes imparted to mechanical and biological energy flows (e.g., land use).

In the last two centuries, coastal urbanization has destroyed extensive areas of salt marsh, forcing a dependence on the few remaining salt marsh ecosystems to maintain key ecosystem functions, such as organic matter production and the interception and transformation of terrestrial nutrients.

Likewise, salt marsh processes continue to function under a regime of eustatic sea level rise. As a consequence, some of the extant salt marsh landscapes are subject to greater instability, whereas new salt marsh areas are likely to develop in different coastal locations. Hence these unique and biologically essential landscapes are subject to degradation, transformation, and regeneration in response to natural and anthropogenic forcing.

A recent Chapman Conference entitled "Salt Marsh Geomorphology: Physical and Ecological Effects on Landform," organized by AGU, focused on the integration of physical and ecological sciences to enhance understanding of the interactions between salt marsh geomorphology and intertidal sedimentary processes (see the conference Web site at http://www.geol.sc.edu/chapman/index.htm, and the Bay of Fundy photos at http://www.gly.fsu.edu/~fagherazzi/halifax/index.htm).

The major scientific goals of the conference were (1) to present a comprehensive synthesis on the feedbacks between salt marsh ecology and geomorphology; (2) to determine research questions of key importance for the coupling of ecological and geomorphological processes in salt marshes; and (3) to develop a common language that can be used by scientists from different disciplines to exchange information.

Scientists from North America, Europe, Asia, and Australia attended the meeting along with consultants involved in salt marsh restoration projects around the world.

Biosedimentary and Biogeochemical Processes

The influence of biophysical processes on sediment transport is a key component of the ecomorphological evolution of salt marshes. For example, the vegetation canopy modifies marsh hydrodynamics, thus enhancing sediment deposition and erosion on the marsh platform. Benthic mats and biological films also modify the physical characteristics of sediments, considerably increasing resistance to erosion. Furthermore, microbial assemblages enhance sediment capture and retention among the marsh plants.

Conference presentations underlined the complexity of biosedimentary processes and the future research needs in this area. Similarly, biogeochemical processes and nutrient cycling have an important role in controlling plant development, with evident consequences for landscape evolution. New approaches linking biogeochemical processes to marsh morphology and plant distribution were outlined in the conference. For example, it has been proven that the most rapid rates of carbon and nitrogen cycling are observed in sediments vegetated by the tall form of *Spartina alterniflora* near the creek banks.

Coupled Biological and Morphological Models of Salt Marsh Evolution

A session of the conference was devoted to conceptual and quantitative models of salt marsh evolution. Coupled biological and physical models are only recently coming to light, and enable a comprehensive description and quantification of salt marsh interactions. It was clear from the conference that numerical models rely on the description of physical and biological processes by mathematical relationships parameterized with field investigations and laboratory experiments.

Given the novelty of this research field, some expressions utilized in the models still need scientific testing. For example, still lacking is a quantitative relationship for below-ground organic production and the processes that control it. Despite this limitation, numerical models of salt marsh evolution are highly effective at describing the complex interactions between biota and sediment transport processes, and can drive field investigations on specific processes fundamental for the co-evolution of the salt marsh landscape.

The conference session also stressed the importance of a precise characterization of equilibrium states in salt marshes. In fact, the final goal of the modeling approach is the determination of the rates at which the coupled biological and physical system moves toward equilibrium or switches between two different equilibrium configurations.

Integrated Approaches and Scientific Dissemination

Morphological and ecological attributes of salt marshes are highly dependent on geographic location and their unique physical and biological processes. As a result, the relative magnitude of forcing functions (e.g., suspended sediment concentration (SSC), tidal range, vegetation, morphology, climate, and wave action) will also vary between marshes in different geographical settings, requiring both site-specific and broad-scale research to place these marshes within a global framework. However, in order to compare the evolution of salt marshes in different areas of the globe, it is necessary to adopt standard measurement techniques and comparative analysis of the obtained results.

A successful example of a research network based on a standardized research methodology is represented by researchers utilizing the surface elevation table (SET) (http://www.pwrc.usgs.gov/set/), which is a leveling device for measuring the relative elevation of salt marsh sediments. The combined occurrence of a standardized method for the measurement of specific marsh attributes and the network for the dissemination of the results provides a scientific basis for comparative studies. More initiatives like this are deemed necessary for a global assessment of salt marsh processes and forms.

A holistic approach to salt marsh geomorphology and ecology requires extensive funding to sponsor large-scale interdisciplinary, comparative, multi-scale projects. A successful example, presented during the conference, is the European Community project TIDE (Tidal Inlets Dynamics and Environment, Research and Technological Development Fifth Framework Programme: TIDE - EVK3-CT-2001-00064, 2001-2004, http://www.istitutoveneto.it/tide/project/tide.php).

Salt Marsh Restoration and Science

Recognition of the ecological and economical value of wetlands has led to a flourishing of tidal marsh restoration projects. Results from restoration projects in the United States and Europe were presented at the conference, among them those undertaken in the San Francisco Bay, California; the Bay of Fundy, Canada; the Venice Lagoon, Italy; and the Florida and Louisiana coastal marshes. A deeper understanding of the processes that connect the different components of the tidal marsh landscape is then necessary for the correct planning of interventions and restoration practice.

A related discussion focused on the importance of a closer cooperation between restoration practice and scientific research. Restoration projects are often driving research in salt marshes, providing continuous monitoring and high-quality data sets. On the other hand, there is a need to keep the science ahead of the practice, with the ultimate goal of providing efficient tools for proper management of these environments.

An effective way to disseminate scientific results is through research forums. The Chapman Conference on Salt Marsh Geomorphology can therefore be viewed as a template for future meetings.

Future Research Needs

The conference highlighted the need to focus on the correct description and quantification of key biological processes and their role as geomorphic agents. Key research areas are the quantification of belowground production of organic material; the relative role of vegetation and marsh morphology on tidal hydrodynamics and resultant deposition and erosion processes; the feedbacks between marsh morphology and vegetation biomass and zonation; and the influence of biogeochemical processes on marsh ecosystems and morphology.

From the summary conference discussions, it also emerged that both the role of fauna on landscape forms and the genetic biodiversity of marsh vegetation are important components of salt marsh ecogeomorphology that are relatively understudied. Animals can easily disrupt the equilibrium between vegetation and landscape, thus becoming an active element of marsh evolution (and sometimes deterioration). The link between genetic variance of dominant plants and marsh morphology is also a research field of increasing importance. Genotypic variations both on small and large spatial scales change the type and structure of the marsh plants, with an impact on hydrodynamic parameters related to stem density and dimensions, and sedimentary processes.

The Salt Marsh Geomorphology: Physical and Ecological Effects on Landform Chapman Conference was held 9–13 October 2004, in Halifax, Nova Scotia, Canada.

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—SERGIO FAGHERAZZI, Florida State University, Tallahassee; RAYMOND TORRES, University of South Carolina, Columbia; CHARLES HOPKINSON, Marine Biological Laboratory, Woods Hole, Mass.; and DANIKA VAN PROOSDIJ, Saint Mary's University, Halifax, Nova Scotia, Canada.