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Coastal Sedimentary Research Examines Critical Issues of National and Global Priority

An international conference was held recently in Honolulu, Hawaii, to examine and plan for coastal sedimentary research in the United States and globally. Participants agreed that sedimentary coastal environments constitute a critical national and global resource that suffers widespread degradation due to human impacts. Moreover, human population growth and inappropriate development in the coastal zone are escalating public asset losses due to coastal hazards and placing large numbers of communities at growing risk (Figure 1).

Consensus was reached on a number of specific scientific priorities, which include better correlation of local relative Holocene sea-level histories, identifying mass balance in littoral sediments, extending the instrumental record with sedimentary archives, understanding the "biolithology" of carbonate reefs on the meter scale, tracking geochemical flux through coastal waters and substrates, and placing more emphasis on why coastal variability exists rather than simply characterizing it. With the understanding that coastal environmental change is a critical national and international research priority, the participants agreed that an international workshop on coastal forecasting should be convened to define a vision for the future of coastal sedimentary research and identify critical areas of enhanced investigation within a research framework.

The Crowded Coast

The U.S. coastal zone is one of the nation's greatest environmental and economic assets [*Ocean Studies Board*, 1999]. A national migration toward coastal towns and villages occurred in the last half of the 20th century and continues today, and now over 80% of the American population lives within 50 miles of the coast. By 2010 population density along ocean shores will be 400 people per square mile compared to less than 100 per square mile for the rest of the nation. Fourteen of the country's 20 largest urban corridors are along the nation's coast and a major portion of U.S. economic infrastructure is near or on the ocean. Globally, the figures in these categories are similar. Over 50%—some 3.2 billion people—live along a coastline today, but this figure is expected to rise to 75% by 2025 [*Hinrichsen*, 1999].

This burgeoning population depends on limited natural resources. Overfishing, mineral depletion, sewage disposal, aquifer deficiencies, vulnerability to coastal hazards, and beach and wetland loss are critical issues throughout the nation and the world. The natural health of the coastal environment is endangered and is a focal point for federal and local policy development. In truth, however, many management policies do not provide adequate solutions, often because they lack a scientific basis.

We live in a time of sea-level highstand with accelerated rises projected ahead. Environmental change —gradual, rapid, and catastrophic—is an integral feature of high sea levels. To understand the history and processes driving coastal environmental changes, research on a range of spatial and temporal scales is needed. High-resolution geologic records of coastal change can extend the instrumental record to the recent past, and former intervals of sea-level highstand can help us understand the present.

Coastal sedimentary research is highly relevant to understanding coastal environments. Most coastal ecosystems depend upon sedimentary substrates and sedimentary transport processes for critical nutrient flux and trophic energy. Sedimentary processes are typically non-linear and highly complex, and hence they are easily disrupted. Our understanding of the structure and function of sediment-dependent environments (that is, reefs, wetlands, estuaries, beaches, etc.) is improving but remains inadequate. The ability to forecast coastal environmental change can be improved with focused research.

No Sponsor for the Academic Community

The academic core of the U.S. coastal sedimentary research community has suffered from a lack of planning for its scientific future. The field has long been characterized by individual research efforts, but there are few unified and system-level research products that cross disciplinary lines. Major aspects of how and why coastal sedimentary processes interact across spatial and temporal scales remain unknown. With the exception of a small number of research efforts (e.g., the National Science Foundation's [NSF] Land Margin Ecosystem Research Program), there is a lack of significant progress in understanding the linkages and interrelationships among and between shoreline environments.

Fig. 1. Aerial photo of North Myrtle Beach, South Carolina. This figure shows the northern end of a 60-mile long stretch of heavily developed shoreline characterized by hotels and private homes on narrow sandy barriers backed by tidal marshes and lagoons. Much of the waterfront development was destroyed in 1989 by Hurricane Hugo, but has since been rebuilt. This figure illustrates one of the major national and global coastal problems—lack of planning or regulation of shoreline development in high-hazard zones. (Photo by D. B. Scott, 1996).

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This situation is now hindering research funding. For instance, within NSF, coastal sedimentary research is left without a clear proponent in either the Earth or Oceans directorates [*FUMAGES*, 1998]. Within the National Oceanic and Atmospheric Administration, the Federal Emergency Management Administration and, to some extent, the Environmental Protection Agency and NASA, funding is available for spatial and temporal analysis of coastal trends, but these efforts typically focus on what environmental tendencies occur and often do not answer why or how coastal change happens.

The Coastal and Marine Geology Program (CMGP) of the U.S. Geological Survey is charged with establishing the geologic framework of the U.S. coastal and marine regions [*Ocean Studies Board*, 1999]. However, the CMGP is not driven by external proposal submission, and instead it responds to requests that originate outside the research sector. Hence, within the national academic community, the true value of coastal sedimentary research is underestimated. At the NSF, programmatic lines typically stop at the coastal zone. As a result, the true nature of coastal sedimentary research as an amphibious discipline cannot easily be accommodated. An important exception to this is the MARGINS "Source to Sink Project" [*Nittrouer and Driscoll*, 1999], which is nascent but promises significant advances in understanding sedimentary flux and partitioning. However, the MARGINS program will primarily focus on only two study sites: New Zealand and New Guinea. Hence, MARGINS does not represent a comprehensive programmatic solution for the U.S. community.

Community Policy Consensus

Coastal environmental value is recognized in the missions of many federal agencies. However, research by the academic core is typically underutilized. The logical source of funding for fundamental research in coastal sedimentary processes and their consequences is NSF. However, NSF's programmatic structure does not promote advances in coastal sedimentology. As a result, the true power of this field lies untapped despite the national and global need. Participants agreed that the community of U.S. coastal sedimentary researchers must develop a vision and a research plan, both fundamentally and in terms of societal relevance. The plan should integrate a spectrum of traditional Earth and Ocean Science fields to effectively mobilize and focus research in coastal change. The plan must provide direction for understanding why and how environmental processes and patterns occur and interact across temporal and spatial scales. The plan should recommend continued support for gifted individual researchers who will lead significant break- throughs in coastal sedimentary research. In addition, a new strategic tool is required. Funding agencies must support integrated multidisciplinary teams of investigators working in specific coastal cells using models and field experiments that utilize observational, mapping, and drilling technologies. International collaboration has been the keystone of important progress in the past, and linkages with overseas investigators must be an integral part of new advances. Conference participants pledged their support for this effort.

Community Science Consensus

A consensus was reached on the following science issues. Instrumental records of sea-level change can be connected to high-resolution geologic archives spanning the last 1–2 k.y. This will improve understanding of sea-level patterns and controlling factors such as El Niño/Southern Oscillation, steric effects, and the dynamic sea surface. PAGES/LOICZ programs in this area should be supported by U.S. efforts.

Regional synthesis and correlation of local relative Holocene sea-level histories is critical. This is fundamental to separating the individual roles of forebulge collapse, neotectonics, and climate effects along the U.S. and global coastline. Isolating these signals will enhance our ability to forecast specific impacts of future sea-level variability. Studies of the timing and variability of last interglacial (and earlier) sea levels should emphasize dated samples lacking open system behavior. Thermally ionized mass spectrometry (TIMS) Th-Pa methodology is useful at critical sites defining sea-level pivot points. Efforts should focus on publication of high-quality examples with high-resolution measurements of indicative sea-level position and chronology.

Mass balance littoral sediment budgets should be emphasized in future studies of coastal change. Little is known of the residence times and exchange rates of coastal sediments in most types of littoral environments. Field experiments must be designed to minimize undefined residual budget components.

The geologic framework of U.S. and global coastal systems must be defined, including siliciclastic, carbonate, and mixed sedimentary systems. This effort should focus on understanding why variability exists and must not stop at defining what that variability is. Improved understanding of framework variability can then be correlated to modern dynamic processes of sediment/water interaction, including sedimentary fluxes, to establish a holistic and systemic understanding of coastal variability. Carbonate reefs are a special global treasure; however, we lack a true understanding of the controls on their structure and evolution. More is known of their morphology on the kilometer scale and their biology on the centimeter scale, but less is known of the biolithology on the meter scale. Workers can unify this disparate understanding by focusing on the meter to dekameter scale of biolithologic, ecologic, and geochemical variability. This approach will help to better understand the impact of increased ocean acidity, shifts in prevailing currents and sea surface temperatures, and changes in the quantity and geochemical character of terrestrial inputs.

Coastal ecologies and water quality depend upon sedimentary environments. Geochemical flux through the water column and sedimentary substrates should be the target of focused field experiments to delineate uptake, diagenesis, sequestration, and release of biogeochemically active chemical constituents. Finally, there was consensus among the community to extend the vision and planning advances made in Honolulu with an international workshop on Coastal Forecasting. The workshop's goal should be to define a vision for the future of coastal sedimentary research and to identify critical areas of enhanced investigation within a national research framework.

The research conference, Non-Steady State of the Inner Shelf and Shoreline: Coastal Change on the Time Scale of Decades to Millennia in the Late Quaternary, was held November 9–12, 1999, at the University of Hawaii in Honolulu. (View the agenda and approximately 90 papers at http://soest.hawaii.edu/Coastal_Conf/).

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