National Park Service
U.S. Department of the Interior

Park Coastal Geology

Geologic Resources Division, Coastal Geology Program
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Interagency Collaboration Helps Locate Hurricane Isabel Impacts

Overwash fans along Cape Hatteras National Seashore cover the road and backbarrier vegetation.

Several agencies collaborated in the aftermath of Hurricane Isabel to assess the storm's impacts to Cape Hatteras and Cape Lookout National Seashores on the North Carolina Outer Banks. Once the storm had made landfall in North Carolina, the National Oceanic and Atmospheric Administration (NOAA) flew the coast and deployed a new research digital aerial photography system. The tool recorded coordinates associated with 1.2-foot-resolution digital images and aircraft positional and attitude data. In response to the need for rapid assessment of hurricane impacts, the USGS Rocky Mountain Mapping Center is developing a rapid method to process post-storm imagery and make it available to land managers. Their technique uses the aircraft positional and attitude data to ortho-rectify or correct the aerial imagery through a batch process, saving many hours of processing time. The imagery will be made available to the public over the Internet. Users will be able to call up the images in mosaics corresponding to regions of interest.

The USGS Center for Coastal and Watershed Studies and NASA also collected pre- and post-storm EAARL (Experimental Advanced Airborne Research Lidar) data to analyze the impacts of the hurricane. The high level of detail in these topographic and ocean floor data provide a way to quantify amounts of sediment moved by the storm and understand the geologic impacts in the national seashores. Maps produced for a new inlet area at Cape Hatteras in the days following the storm helped natural resource managers visualize the new shape of the park.

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Hurricane Isabel: A case study in restoration response at three Mid-Atlantic national seashores

Hurricane Isabel made landfall at Cape Lookout National Seashore along the North Carolina coast on September 18, 2003. The powerful northeast quadrant of the storm also struck Cape Hatteras National Seashore, opening a 1,700-foot-wide breach in the narrow barrier island park. Additionally, storm waves washed over the lower portions of Assateague Island National Seashore in Maryland and Virginia, piling sand on parking lots and roads. Although these three barrier island parks were affected by the storm, Cape Hatteras faced the greatest restoration effort. The only road to give island residents access to their homes within this national seashore was damaged and required immediate attention. The need to restore public access influenced the park's decisions related to natural resource management.

Hurricanes and other storms are vital for maintaining the barrier islands along the Atlantic Coast. Storm waves wash over the islands, depositing sand that stretches across the islands in fanlike shapes and adds elevation. As the beach on the ocean side erodes, the corresponding buildup of sand toward the more protected sound side preserves the island by allowing it to remain above rising sea level. If this process did not

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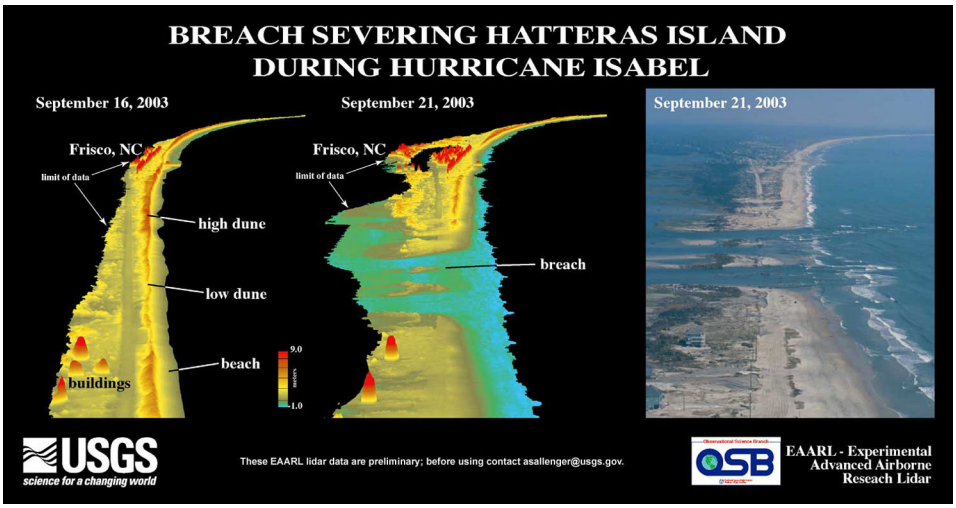
A 1,700-foot passage between the Atlantic Ocean and Pamlico Sound at Cape Hatteras National Seashore, North Carolina, was created on September 18, 2003, when 25-foot waves and a storm surge caused by Hurricane Isabel slammed into the Outer Banks (above). Damage to State Highway 12 (below) required immediate attention to restore access to Hatteras Village, which could only be reached by road through the park. NPS photos.



Pre and post storm lidar coverage showing elevation changes at the breach severing Hatteras Island during Hurricane Isabel. Figure provided by Abby Sallenger, USGS.

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occur, barrier islands would break apart very quickly and be inundated.

At Cape Lookout and Assateague Island National Seashores the NPS is able to maintain natural barrier island processes because infrastructure such as roads and homes is minimal. The fans of sand resulting from Hurricane Isabel are being preserved for detailed geologic study and are playing out their natural role of island preservation. Indeed, at Assateague, a prestorm shoreline restoration project to mitigate the impacts of jetties constructed at Ocean City was designed to allow the natural storm process to continue. Nevertheless, the National Park Service facilitates visitor use at these national seashores. Cape Lookout is repairing the docks to restore boat access to the barrier island. Additionally, the interdunal sand road—a transitory, unpaved driving route—has been relocated and meanders across the new sand deposits. On the south end of Assateague Island, portable visitor-use facilities that were demobilized in preparation for the storm are being reinstalled on the new sand deposits. At these national seashores, requests for NPS protection of private and state infrastructure are minimal.

The situation at Cape Hatteras is different. The State of North Carolina has the right to maintain State Highway 12 running through the park. Moreover, the presence of six villages within the park result in private and state "restoration" actions that alter many of the park's natural resources, including barrier island dynamics. The breach or inlet opened by Hurricane Isabel severed Highway 12 northeast of Hatteras Village, cutting off residents from their prestorm mode of travel along asphalt roads. The situation was considered an emergency because no other means of access, such as bridge, causeway, or ferry, is available to the village. Accordingly, the U.S. Department of Homeland Security directed the Army Corps of Engineers to fill the new inlet. Once the inlet was filled, the state transportation department reconstructed the broken segment of highway.

Private property owners in the park also tried to restore prestorm conditions by reconstructing berms between their homes and the park beach, using the 2–4 feet of sand that had washed onto their property. Unlike the case at many barrier islands, large berms are not natural to Cape Hatteras. In an effort to maintain barrier island dynamics on park lands, the park did not allow residents to use park beaches as a sand source for the berms, and required the berms to be built as far onto private property as possible.

The effects on the infrastructure along the barrier islands has heightened awareness of state agencies and local communities of the need for environmentally sound, long-term transportation planning. Cape Hatteras National Seashore has long been involved with the Outer Banks Task Force, an interagency panel that has studied Highway 12 problems for 10 years. Spurred by the storm, the panel is finalizing its recommendations to guide the interagency response to any future inlets created by storms on the Outer Banks. If the results of these collaborative planning efforts can be implemented after future storms, community restoration actions may become more consistent with natural coastal processes.

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Geologic Resources Evaluation Update

Rebecca Beavers, Bruce Heise, Dave Sherrod (USGS), Tim Connors and Joe Gregson evaluate NEW geologic resources at Hawaii Volcanoes National Park. NPS photo.

Parks are using geologic products provided by the Geologic Resources Evaluation (GRE) program in three basic ways. First, parks are using the information to add to their understanding of the park's geology for scientific, educational, or interpretive purposes. Next, parks are using the information in traditional geologic applications, such as dealing with landslides, rockfalls, or human health and safety issues. Finally, parks are integrating geologic map data with other, non-geologic, information to assist in management decisions. Some examples of how parks utilize this type of evaluation information are briefly summarized below.

Geologic Resource Evaluation for Coastal Parks – In 2002, the GRE team coordinated and funded a Coastal Mapping Protocols workshop at Canaveral National Seashore to address coastal park mapping needs and coastal management issues related to low relief and barrier island coastal systems. Workshop participants identified coastal landform and bathymetric features that should be incorporated into coastal geology mapping products. With the increased funding available in 2003, coastal park mapping projects were initiated or continued for seven parks. By leveraging funds with a unique consortium of the USGS, North Carolina Geologic Survey, and Eastern Carolina University, work has continued on mapping the four North Carolina coastal parks. Completion is expected in 2004. Leveraging funds with the USGS Western Division of Coastal and Marine Geology has made possible the mapping of submerged resources of the three west coast parks on the big island of Hawaii and the integration of these maps with onshore mapping awaiting digitization. In a first for the GRE, a private contractor has been hired for coastal mapping at Canaveral National Seashore.

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These groups will establish protocols for future coastal mapping efforts in NPS shoreline units.

Integrating the Inventories at Padre Island – In 1980, the Texas Bureau of Economic Geology (TBEG) conducted shoreline mapping of Padre Island National Seashore and published it in a technical publication. This was an exceptionally well done document for its time and was used as one of the models for the Coastal Mapping Protocols workshop. Subsequent work on vegetation and soil mapping at the park relied heavily on this map. To update the existing map to reflect physical changes and technological advances, GRE is funding in part the TBEG to remap the park's coastal features and integrate the new map with data on soils and vegetation.

Preliminary meetings for mapping in Alaska – Geologic mapping in Alaska, like most natural resource related work, presents enormous logistical, scientific, and map scale problems. Yet most Alaska parks have been requesting GRE participation for several years. A preliminary meeting in Anchorage with most of the NPS geoscientists working in Alaska parks indicates a strong continuing interest. The GRE team, working with Alaska Regional Office staff and the USGS, will conduct a pilot scoping meeting for park staff from the three parks in the Central Alaska Network in 2004 to evaluate what geologic information is already available and identify what new work needs to be done.

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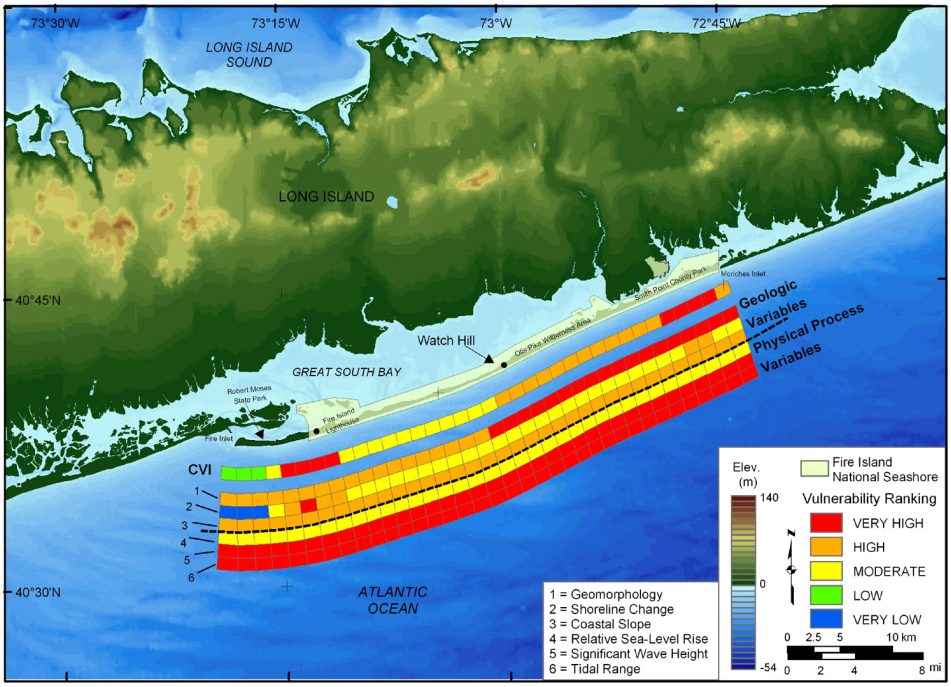
NPS Geologic Resources Division, Texas Bureau of Economic Geology, Baylor University, US Geological Survey, and USDA-Natural Resources Conservation Service staff evaluate geologic features and processes with Darrell Echols, Chief of Resource Management at Padre Island National Seashore.



Relative coastal vulnerability assessment for Fire Island National Seashore. The innermost color bar is the relative coastal vulnerability index (CVI). The remaining color bars are separated into the geologic variables (1-3) and physical process variables (4 - 6). The very high vulnerability shoreline is near Moriches inlet and the Fire Island lighthouse where the shoreline change rates are highest. High vulnerability shoreline is concentrated east of Watch Hill where overwash occurence is most frequent. Moderate vulnerability shoreline is along the community section of Fire Island, and the low vulnerability portion of the shore lies within Robert Moses State Park where shoreline accretion rates are high because of spit progradation. Large-scale (10-15 km) coastal vulnerability is controlled by the geologic framework differences that exist east and west of Watch Hill. Smaller-scale (2-5 km) variations in vulnerability reflect the rates of historic shoreline change in the area.

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Coastal Vulnerability to Sea-Level Rise

In 2001, the U.S. Geological Survey (USGS), in partnership with the NPS, began conducting hazard assessments to determine the vulnerability of twenty-five national park units to sea-level and lake-level changes. This project was designed to assist NPS in managing its nearly 7,000 miles of shoreline that may be vulnerable to coastal change in the next 50-100 years as sea level continues to rise. Data for six variables (geomorphology, shoreline change, coastal slope, relative sea-level change, significant wave height, and tidal range), which are important in determining how a shoreline will respond to sea-level change, were collected from numerous federal, state, and local agencies. A numerical-based methodology, used to score these variables and calculate a coastal vulnerability index (CVI), was developed to highlight areas that are likely to be most affected by future sea-level change. NPS staff are using the CVI data and products for long-term resource management plans, and assessing future threats to resources. This cooperative project has mapped coastal vulnerability during 2003 within Kenai Fjords NP, Glacier Bay NPP, Fire Island NS, Cape Hatteras NS, Cumberland Island NS, Desoto NMEM, and Padre Island NS.

The final products for each park unit selected for coastal vulnerability assessment will include an online publication in USGS open file format, all of the shapefiles and associated spatial datasets used in the assessment, as well as a large map displaying coastal vulnerability within the park. The application of CVI studies for cultural resource management within Olympic NP, Cape Cod NS, Gulf Islands NS, and NP of American Samoa was presented at the George Wright Society meeting in San Diego in April. A presentation on the GIS methodology used in coastal vulnerability assessment was given at the Spatial Odyssey Conference in December 2003.

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Assateague Island National Seashore Welcomes new Coastal Geologist

Assateague Island National Seashore is pleased to announce the addition of Courtney A. Schupp to the park's Division of Resource Management. Courtney has been selected for a recently created Coastal Geologist position and comes to the National Park Service from the Virginia Institute of Marine Science, where she is currently completing her Masters Degree in Marine Science/Coastal Geology. For her thesis, Courtney has been investigating spatial relationships between nearshore bathymetry, sediment distribution, and short-term shoreline change in North Carolina's Outer Banks. Prior to graduate school, she worked with the USGS Coastal and Marine Geology Program at Woods Hole, the Maryland Geological Survey, and the state of North Carolina.

Horse grazing in the marsh at Assateague Island National Seashore. NPS photo.

Coutney's primary responsibility at Assateague will be to oversee implementation of the North End restoration program, a 25 year collaborative effort with the Corps of Engineers to mitigate impacts of an adjacent stabilized inlet on northern Assateague Island. She will also manage the park's geophysical monitoring programs and assist in the development of coastal change monitoring programs for the Northeast Coastal and Barrier Network. Courtney will be on-board by mid-January 2004 and duty stationed at park headquarters in Berlin, Maryland. If the opportunity presents itself, please join me in welcoming Courtney to the National Park Service.

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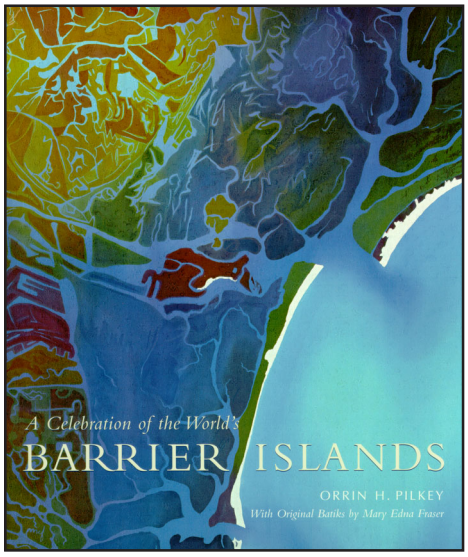
Book Review-
A Celebration of the World´s Barrier Islands

By: Orrin H. Pilkey with original batiks by Mary Edna Fraser



"Through its eloquent characterization of the condition of barrier islands worldwide with photos, charts and exquisite original batiks, *A Celebration of the World's Barrier Islands* has the potential to arouse widespread public concern for these islands, just as Rachel Carson's *Silent Spring* motivated the public on the subject of pesticides. For those development and engineering forces at work rearranging the earth's barrier islands, look out! *A Celebration of the World's Barrier Islands* is a compelling, informative and explosive missive that could mobilize public opinion against further short-sighted abuse of these dynamic islands."

–Brent Blackwelder, president, Friends of the Earth

"Delicate renderings of the islands by artist Mary Edna Fraser look like vivd aerial-view paintings but are actually batik prints of the coasts, counterbalancing Pilkey's careful study of the 'restless ribbons of sand.'"
– *New Yorker*

"Pilkey has written a highly engaging and intelligent book on the fragile beauty of the barrier islands."
– *Library Journal*

"It's a wonderful tour, richly illustrated with colour and black and white photos. Mary Edna Fraser's silk batiks deserve special mention. They capture the sense of the islands remarkably well, giving us a keen birdseye view of the land."
– *New Scientist*

"Pilkey provides an informative guide to the wheres and wherefores of barrier islands - from the vacation meccas off the east coast of North America, to the exotic carbonate archipelagos of Mozambique, to the ice-battered slivers of tundra that line the Arctic Ocean. Aerial and satellite photographs illustrate each geological peculiarity that the text brings into focus, but the most remarkable images in the book are the batiks created by Mary Edna Fraser."
– *Natural History*

From the Carolina Outer Banks to New York's Fire Island, from Iceland to the Netherlands and Colombia to Vietnam, barrier islands protect much of the world's coastlines from the ravages of the sea.

Although these islands are vastly different in many ways, they also share many common features. Most dramatic among these is their dynamism -barrier islands are in almost constant motion, their advances and retreats powerful testimony to the force and beauty of nature -and their vulnerability in the face of a different kind of force, commercial and residential development.

This first-of-its-kind survey of barrier islands around the globe had its genesis in 1993, when geologist Orrin Pilkey met artist Mary Edna Fraser at Cape Lookout National Seashore in North Carolina. They soon realized they shared a passion for the barriers, one heightened by the many threats the islands face from development and global warming. These fragile and irreplaceable jewels, Pilkey and Fraser determined, needed to be better understood, and, as important, to be seen in a new way, if they were to be saved.

Every bit as dynamic as the islands they depict, Mary Edna Fraser's spectacular original batik artwork (silk cloth colored by hand using a modern variation of an ancient dyeing technique) has been exhibited in both science and art museums. Combined with Orrin Pilkey's engaging and informative text, they create a treasure of a book that is at once beautiful and rigorously scientific. Pilkey identifies three major types of barriers - coastal plains, Arctic, and delta -each with its own geological characteristics and particular morphologies, which are themselves shaped by several factors, including the absence or presence of underlying rock formations, tidal patterns, and vegetation. Employing the

latest advances in geological mapping, Pilkey also identifies traces of ancient barriers marking long-lost shorelines -a further reminder that in the geological dance of land and sea, change is the only constant.

Praise for Mary Edna Fraser and her art:

"Pilot with a palette . . . as much of an artist in the midst of the creative process as Picasso laboring over his easel." -Michael Kilian, *Chicago Tribune*

"Fraser´s works depict an organization and sensuousness in the land that is visible only from the air." -Susan Lawson-Bell, National Air & Space Museum

"Exhibited and collected around the world, her batiks have a common theme: promoting the awareness of environmental beauty and change on the planet as seen from the air. " -Carolyn Russo, *Women and Flight*

About the Author

Orrin H. Pilkey is James B. Duke Professor Emeritus of Geology and director of the Program for the Study of Developed Shorelines at Duke University. He is the recipient of many awards, including the Francis Shepard Award for Excellence in Marine Geology, and the author or editor of many books, including *The Beaches Are Moving: The Drowning of America's Shoreline*, *Living by the Rules of the Sea*, and *The Corps and the Shore*. Mary Edna Fraser is a renowned artist specializing in the production of large-scale batiks, many based on aerial photographs. Her work has been exhibited at the Smithsonian National Air and Space Museum, the Duke University Museum of Art, the National Science Foundation, and the National Academy of Sciences.

Review from Columbia University Press Website. It can be accessed through http://www.columbia.edu/

Ocean Strategy

Americans expect their National Park System to contain unimpaired resources and values that represent the nation's ocean heritage in superlative natural, historic, and recreation areas in every region. Ocean parks currently fail to meet these expectations. Ocean resources in national parks are largely managed the same as those outside the parks. General state laws and regulations govern fishing in parks. Federal and state laws and regulations that apply to lands and waters around the parks also afford most of the environmental protection in ocean parks. Consequently, increasing fishing pressure has collapsed fish populations in parks. Parks have lost fishing and other recreational opportunities dependent on living ocean resources. Ecological effects of overfishing have cascaded through ocean parks, dramatically altering entire ecosystems. Diverse and productive giant kelp forests, coral reefs, and sea grass meadows in parks have been replaced by degraded, collapsed, disturbance-adapted sea urchin barrens, algae-dominated reefs, and other altered communities.

A sea turtle with a new antenna to record her travels returns to the Gulf of Mexico at Padre Island National Seashore. NPS photo.

Ocean park managers are currently exploring how to increase National Park Service capacity for ocean stewardship. They are looking for ways to improve partnerships to better restore impaired ocean wild life, natural processes, cultural resources, and recreational opportunities in the national park system, and to preserve them for the enjoyment of future generations. Human-driven global forces that alter climate and sea level complicate ocean stewardship and render concepts of *natural* and *unimpaired* difficult to grasp. The critical keys to improved ocean conservation in the National Park System are partnerships to facilitate cooperation, collaboration and communication. To be a credible and effective partner, the National Park Service needs to increase its capacity for ocean conservation. This plan presents the major issues and recommendations identified by ocean park superintendents, other park professionals, and their partners during 2002-2003.

The four pillars of park stewardship were used to organize the recommendations: *Know*, *Restore*, *Protect* and *Connect*. Managers need to better know and understand ocean park ecosystems and resources. They need better resource inventories and monitoring programs. They need to define ocean boundaries and jurisdictions, and to increase their capacity to explore and understand the ocean realms of parks and to revitalize the National Park Service's scientific and public safety diving program. They need to understand how parks relate to other marine protected areas and what roles parks play in national ocean conservation strategy and policy. Ocean parks need to restore impaired resources. They need to assess performance of new reserves in parks, to develop joint fishery management plans with states, to prevent extirpation of species, and to establish ocean damage assessment teams. A *Restore Impaired Ocean Park Resources* initiative is proposed to address critical issues. Protecting parks and mitigating threats is a core capability for the National Park Service that needs to be enhanced by developing more formal agreements with state and federal partners. Ocean park boundaries need to be effectively marked. Perhaps the most important task ahead is to better connect people to ocean parks. An ocean park task force is needed to coordinate these activities. It would help resolve misperceptions about the need to change ocean conservation strategies, improve communication among ocean park professionals and with the public, engage artists, Park Fellows, and more volunteers in parks, and raise National Park Service awareness about its ocean responsibilities and opportunities.

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Northeast Coastal and Barrier Network Moves Toward Implementation of Long Term Geomorphologic Monitoring

Dune scarping (above) on north end of Assateague Island and overwash fan (below) with dune scarping following Presidents Day Storm, Assateague Island National Seashore, February 2003. Mark Duffy for scale. NPS photo.

The National Park Service Northeast Coastal and Barrier Network (CBN) consists of eight bio-geographically similar parks. The parks in the network are Assateague Island, Cape Cod, and Fire Island National Seashores, Colonial National Historical Park, Gateway National Recreation Area, George Washington Birthplace National Historic Site, and Sagamore Hill and Thomas Stone National Historic Sites.

Over the past three years, the network has made significant progress toward developing and implementing a long-term geomorphologic monitoring program. Recent accomplishments include: the reconvening of the programs scientific advisory committee, the creation of a conceptual model and identification of potential monitoring variables, continued development and testing of proposed protocols using emerging technologies, continued building and formalization of partnerships, and the acquisition of surveying equipment essential to high-precision data collection.

Planning and scoping has been identified as an essential precursor to protocol development. With the sudden death of Dr. Jim Allen in July 2002, the CBN lost its chief scientific advisor for coastal geomorphology. Jim served as chair of the networks planning and scoping workshops and his death created a major need within the network for scientific expertise. Building on previous workshops at Gateway National Recreation Area in April 2000 and USGS Woods Hole in January 2001, the network reconstituted and reconvened a scientific and technical advisory panel with a two day meeting at the University of Rhode Island in October 2002.

In addition to vigorous and wide-ranging discussions on a variety of coastal issues, the workgroups primary purpose was to create a conceptual model and to generate a detailed list of potential monitoring variables. The conceptual model is a graphic representation of the processes that influence coastal morphology and serves as the underpinnings for the selection of monitoring variables. The indicators list consists of twenty-nine potential candidate variables or mapping units that could be used to analyze and understand the processes that affect park resources. Indicators range from global scale processes such as sea level change to local scale phenomenon like shoreline position and beach topography. The workshop report, including the conceptual model and list of indicators, is currently undergoing internal review. Upon completion of the review process, it will be available at the NPS Northeast Coastal and Barrier Network website.

http://www1.nature.nps.gov/im/units/ncbn

Network activity went well beyond conceptual and planning activity. Prior to the formal establishment of the Northeast Coastal and Barrier Network, a variety of monitoring and data collection efforts were underway at several network parks. By building on existing activity, the network could accelerate its protocol development while simultaneously involving parks in the process. Consequently, activities like GPS shoreline and beach topographic surveys were continued and exported to network parks. Continuation of existing activity provided an opportunity for testing of protocol techniques and methods while at the same time supplying high-quality geospatial data for park and network data libraries.

Coincident with the planning and pilot sampling activities, is the development of inter and intra agency partnerships. These partnerships, besides being congressionally mandated, represent a common sense approach to monitoring and are an essential component of the networks overall strategy. The Coastal and Barrier Network is using a variety of collaborative efforts to develop and implement its geomorphologic program. The Coastal Geology section of the NPS Geologic Resources Division (GRD) provides regular and ongoing guidance and feedback on coastal science issues. GRD along with the Cooperative Ecosystems Studies unit at the University of Rhode Island, is also providing technical assistance with data management issues that include database design and the creation of GIS tools to develop park level capabilities for basic data analysis.

Partnerships are also playing a major role in field data collection. An important element of the CBN geomorphologic program is a three way collaborative effort between the NPS, USGS, and NASA to conduct aerial laser surveys (LIDAR) of topographic features in network parks. Initiated at Assateague Island National Seashore (ASIS) in the mid 1990s, the program has evolved to include all of the eight network parks. Multiple surveys have been flown at four ocean parks while four estuarine parks are tentatively scheduled for survey in winter 2004. By combining the research missions and capabilities of NASA and USGS with the

Underwater data collection using GPS rover receiver on site at USS Arizona Memorial, Pearl Harbor, Hawaii in November 2003. NPS photo.

information needs of parks, the CBN is able to economically collect valuable data while riding the leading edge of geospatial research and innovation.

While data collection and management issues have dominated CBN partnerships, several agencies and organizations have provided ongoing support to the networks steady development. Besides the various NPS units, seven federal agencies and academic institutions formally participated in the planning and scoping workshops. In addition to participating in scoping workshops, the Rutgers University Institute of Marine and Coastal Sciences, is providing major assistance and guidance in composing and editing workshop reports and related documents. Individual parks, especially Assateague Island, Cape Cod, and Gateway's Sandy Hook unit have provided invaluable scientific and technical guidance as well as logistical and financial support to network activity.

Finally and most recently, in acknowledgement of the fact that reliable monitoring requires high precision measuring capability, the network and Assateague Island jointly purchased survey grade GPS equipment for use in network, park, and other NPS activity. Several uses are already planned for the first of its kind in the NPS equipment including ground control for LIDAR surveys, high precision three dimensional shoreline and beach mapping, and a cooperative effort between NCBN and NPS GIS Branch to inventory and assess the status of ground control networks in parks. In its first field operation, the GPS Total Station was used by the NPS Submerged Resources Center to re-establish ground control and to perform real time measurements of control points on the USS Arizona Memorial.

In conclusion, the Coastal and Barrier Network has made significant progress towards implementing a geomorphologic monitoring program. Many of the accomplishments to date provide a foundation to continue to build and operate the program until its goal of providing quality data that can be used in the management of park resources is achieved. With continued support from a variety of partners both within and outside the NPS, the network looks forward to reaching operational capacity in the next one to two years.

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Interesting Websites for your review

http://resources.ca.gov/ocean/CORSA/CORSA_index.html

www.lib.berkeley.edu/WRCA/coastal_intro.html

http://www.longislandsoundstudy.net/habitat/

http://www.sam.usace.army.mil/hottopics.htm

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