Northeast Coastal and Barrier Network
Protocol Development Summary
(May 2009)

Protocol: Northeast Coastal and Barrier Network Geomorphological Monitoring Protocol: Coastal Topography

This protocol has been implemented in the following parks:
- Assateague Island NS
- Cape Cod NS
- Fire Island NS
- Gateway NRA
- Sagamore Hill NHS
- George Washington Birthplace NM
- Thomas Stone NHS
- Colonial NHP

Justification and Issues Addressed:

The problem of sediment loss/gain and landscape alteration at the marine edge is fundamental to many management issues facing coastal park resource stewards, and topographic change is a prime geo-indicator of threats to coastal environmental resources within parks. Change in the width and/or volume of the beach drives the alteration and replacement of established natural habitats and may result in the destruction of cultural resources, facilities, and other infrastructure where they exist. Geomorphologic change to the beach/dune system is a basic concern because it is also directly related to – and in some cases drives – changes in other natural resource areas, such as quality of ground water and surface water in estuaries, abundance and distribution of species and habitats of concern, recreational visitor use, and even resource extraction.

Changes in coastal topography, whether caused by erosion or accretion, vary both spatially and temporally. Understanding historical variations, along with seasonal variability, is key to early recognition of potential ecological problems in coastal parks. For managers, an understanding of the spatial and temporal patterns of geomorphologic change is basic to optimal management of any coastal park because the interface of marine and land systems, 1) is highly dynamic and driven by multiple forcing mechanisms, 2) results in alterations to resource patterns and dynamics at habitat and ecosystem levels, and 3) can eventually result in the loss of static resources. The establishment of local, long-term monitoring programs would provide data to help understand the processes that are driving coastal change within the parks.

The primary factors causing geomorphologic change in Northeastern coastal parks are sea level rise, changes in wave climate (e.g. increased storm frequency and intensity), and changes in sediment supply. Static resources in all eastern coastal parks are adversely affected by a relative rise in sea level. Although slow (roughly 0.2-0.3 m in the last century), sea level rise is a chronic driving force of shoreline retreat, which is further driven by aperiodic storms (i.e., tropical cyclones in summer and mid-latitude nor'easters

in the winter). Storm effects upon the beach may be ameliorated within a week or two, but if the system is degraded, a decade of storm quiescence may be needed for recovery, if it occurs at all. Unfortunately, many coastal locations have a declining sediment supply that contributes to coastal erosion.

Localized conditions – including the geologic framework, offshore topography, orthogonal fetch limitations, and local sediment sources and sinks – may control change rates and trends in sediment supply. However, coastal erosion can be accelerated by human perturbations to the natural system. Engineering structures such as jetties, groins, seawalls, and nourishment and by-passing projects alter wave energy and currents, as well as disrupt sediment transport pathways. These human-induced changes may have profound morphological and ecosystem effects. Habitat and ecosystem responses to such changes are not well understood by ecologists, and how long these impacts persist is virtually unknown at the local level.

A complete understanding of these processes would require an adequate measurement of the hydrodynamic forcing of sediment transport, morphologic change, and ecosystem response at the level of the individual park unit. These are very complex tasks, however, and are beyond the capability of the National Park Service to perform alone. Acquiring some of this information will require concentrated cooperative effort between the NPS and other federal, state, and local agencies with significant coastal mandates. There are however, several measurable indicators and expressions of overall coastal process that can be monitored at the individual park level. Some of these methods are well established and can be implemented quickly, while others involving rapidly emerging technologies will require additional research and testing to develop.

Specific Monitoring Questions and Objectives:

Objective 1: Determine trends and characterize the variability in beach-dune topography of the ocean coastline in network parks over seasonal, annual, and long-term time scales.

- **Question 1:** *What is the spatial and temporal variability in dune/beach topography?*
    - **Vital Sign 1:** Coastal topography

Objective 2: Characterize and improve understanding of how long-term trends in marine hydrodynamic processes (tides, currents, and waves), offshore topography (sediment quality, bathymetry, and location of migrating shoals and bodies), and the location of man-made structures influence NCBN park beach/dune systems.

- **Question 1:** *How do offshore topography and fundamental hydrodynamic processes affect changes in the beach/dune system?*
    - **Vital Sign 1:** Offshore topography
    - **Vital Sign 2:** Marine hydrography
- **Question 2:** *How are anthropogenic modifications to coastal habitats affecting sediment supply and changes in coastal topography?*
    - **Vital Sign 1:** Anthropogenic modifications

Vital Signs, measurements, justifications and basic approach:

Vital Sign: Coastal topography

- **Measurement:** Dune height, dune width, berm height, berm width, cliff height, overwash fan locations, vegetation edge, foreshore slope, cross-shore area change, along-shore area change, cross-shore volume change, along-shore volume change.
- **Justification:** Compared to shoreline position, landscape features and patterns at the inland reach of wave domination are less variable indicators of changes in coastal morphology. As a result, significant changes and trends associated with these features are more easily detected and applied to park management decision making. Dune, cliff, and bluff erosion and migration often involve direct threats to natural and cultural resources, park infrastructure, and even to human safety, and are a major management issue in many parks. The location and extent of overwash fans and flood plains serve as indicators of potential change and can provide early warning to park managers of an impending issue or the need for additional monitoring and research. Changes in coastal topographic features may also indicate changes in habitat that require management action.

Vital Sign: Offshore topography

- **Measurement:** Bathymetry; location of migrating shoals and bodies; sediment size and type; geologic framework.
- **Justification:** Most of the attention of NPS geomorphologic research and monitoring has focused on terrestrial features such as shoreline and dunes. However, the sub-aerial and sub-aqueous beach comprises a single system of sediment transport and exchange. While expressions of the process such as shoreline movement and changes to landscape patterns can be readily measured, a thorough understanding of the controlling processes also requires information about offshore features, such as the nearshore bar, ridge, and channel system; migrating shoals; and other submarine features. The geologic framework – the underlying antecedent geology on which coastal landforms and systems are constructed – has also been identified as a major factor in determining the response of the terrestrial and nearshore environment to the processes of coastal change.

Vital Sign: Marine hydrography

- **Measurements:** Sea level position, tide range, wave characteristics.
- **Justification:** The primary processes influencing coastal systems include the processes of sea level rise, sediment supply, and wave climate. These components combine to influence both physical and hydrologic features that include the nearshore system of bars, ridges, and shoals, as well as the movement of water in the form of currents and waves. Collectively, these features and forces direct and control the movement of sediment through the

nearshore system. Local identification of the rate of relative sea level rise (RSL), tide range, storm surge frequency/magnitude, wave heights, and sediment transport volumes and directions are required to understand the causes of coastal topographic change.

Vital Sign: Anthropogenic modifications

- **Measurements:** Type of anthropogenic shoreline structures, location of anthropogenic shoreline structures, number of anthropogenic shoreline structures.
- **Justification:** Human modification to coastal habitats has a tremendous effect on sediment supply. A complete understanding of the factors that affect shoreline position and coastal topography require detailed knowledge of the location of shoreline structures and modifications.

Basic Approach for all Vital Signs:

Both in situ ground surveys using GPS and optical survey equipment, and airborne surveys using LiDAR (Light Distancing And Ranging) equipment will be utilized to collect coastal topographic data. Since the mid-1990s, LiDAR technology has emerged as a viable method for collecting highly accurate, park-wide elevation datasets. During that time, the NPS has worked closely with research units at NASA and the USGS to collect topographic data and develop LiDAR data applications for coastal monitoring. Network scientific and technical workshops have identified biennial LiDAR surveys as the preferred method for collecting topographic measurements of beach/dune systems in network ocean parks. Once collected, processed, verified, and documented, the topographic data can be used to extract features identified as important to park managers. Multiple data sets can be analyzed within a GIS to detect changes in topographic features and landscape patterns.

Methods for collection of marine geomorphologic features can be highly complex and many of them are beyond the capabilities of the NPS to perform alone at the park, network, or regional level. Technologies such as radar and side-scan sonar do exist and are used in ongoing research studies in several parks. The NCBN will continue to explore opportunities and foster inter-agency partnerships to determine a feasible level of activity and develop appropriate methods for the collection of these data.

Understanding geomorphologic change requires an adequate measurement of the hydrodynamic forcing of sediment transport. Many agencies (federal, state, and local) have long term monitoring mandates that provide some of the information needed for individual parks. Within NOAA, the National Ocean Service provides internet accessible oceanographic data on predicted tides and predicted and observed water levels. NOAA also provides plots of storm surges, and the National Weather Service operates the National Data Buoy Center and its array ringing the US. Some process information gaps can also be filled by temporary data acquisition projects, such as those with the US Army Corps of Engineers coastal programs. The NCBN will identify the appropriate data from

these sites while continuing to work with partner agencies to develop more park specific sources of information.

Data on anthropogenic modifications are ancillary data that will be used to interpret changes to coastal geomorphology. The network will use existing data provided by parks that have completed recent inventories of coastal engineering projects (such as Fire Island National Seashore), and baseline surveys from available aerial photography will be used to establish the number and location of anthropogenic structures at the remaining parks.

Principal Investigators and NPS Lead:
Dr. Norbert Psuty. Protocol development will be completed through cooperative agreement with Rutgers University.

Dr. John Brock of the USGS Geologic Division – Marine and Watershed Studies unit in St. Petersburg, Florida, is cooperating on development of LiDAR products. Wayne Wright of the NASA Wallops Island Flight Facility, Wallops Island, Virginia is cooperating on instrumentation and data acquisition of LiDAR products.

NPS Lead:
NCBN implementation is directed by the NCBN Program Manager, Sara Stevens, NCBN - National Park Service, University of Rhode Island Coastal Institute in Kingston, #105, 1 Greenhouse Road, Kingston, RI 02881. Data and database management is directed by the NCBN Data Manager, Dennis Skidds, NCBN - National Park Service, University of Rhode Island Coastal Institute in Kingston, #105, 1 Greenhouse Road, Kingston, RI 02881.

Protocol Development Status:
A work plan for protocol development that includes a narrative outline, list of SOPs, assignment of tasks, and a timeline has been completed. The draft coastal topography protocol is due in October 2009 with the final version expected by August 2010.