Northeast Coastal and Barrier Network
Protocol Development Summary
(Sept. 2005)

Protocol: Coastal Topography

Parks Where Protocols will be Implemented: ASIS, CACO, COLO, FIIS, GATE, GEWA, SAHI

Justification/Issues Being Addressed:
The problem of land loss/gain and landscape alteration at the marine edge is fundamental to the many issues facing coastal park resource stewards. Shoreline change is a prime geo-indicator of coastal environmental resource threats within parks. Change in shoreline position drives the alteration and replacement of established natural habitats and shoreline retreat may destroy cultural resources, facilities, and other infrastructure where they exist. Geomorphologic change is a basic concern because it also drives change in other natural resource areas of interest within the NPS program: water quality in ground and in estuaries, species and habitats of concern, recreational visitor use, and even resource extraction. Spatial variability is inherent in shoreline change. Early identification of changes in past trends, along with an understanding of normal variability, is key to recognition of 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: 1) the interface of marine and land systems is very dynamic and is driven by multiple forcing mechanisms, 2) it results in alterations to resource patterns and dynamics at habitat and ecosystem level, and 3) it will eventually result in the loss of static resources. Developing an understanding of these effects would benefit from the establishment of local long term monitoring programs.

The primary geomorphologic variables operating in northeastern coastal parks are sea level rise, wave climate, and sediment supply. All eastern coastal parks are adversely affected by a relative rise in sea level (roughly 0.2-0.3 m in the last century). Although slow, this is a chronic driving force. Substantial shoreline retreat is also driven by aperiodic storms (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. Furthermore, almost all-coastal locations have a declining sediment supply that contributes to coastal erosion. In addition to the primary variables, local conditions also control rates and direction of change. These include the geologic framework, offshore topography, orthogonal fetch limitations, and local sediment sources and sinks.

In addition to global, regional, and local natural causes, many cases of coastal erosion are accelerated by human perturbations to the natural system. Specific changes to tides, waves, currents, and availability of sediment have profound morphological and ecosystem feedback. Examples range from stabilized inlets, seawalls, and groins, to hardened shorelines for inland protection, and beach and dune rebuilding with added sand from an external source. Habitat and ecosystem responses to such changes are not well understood by ecologists, and how long these impacts persist are virtually unknown at the local level.

A complete understanding these processes requires 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, which 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.

Monitoring Goals, Questions and Objectives to be addressed by the Protocol:
NCBN Goal:
To improve the understanding of and provide information to park managers on the dynamic nature of coastlines, including the spatial and temporal patterns of change in NCBN parks for use in management decisions and describing the condition of marine and coastal areas.

Monitoring Questions:
What is the spatial and temporal variability in dune/beach topography?
How do offshore topography and fundamental hydrodynamic processes affect changes in the beach/dune system?

Monitoring 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 scales.

Monitoring Objective 2:
Characterize and improve understanding of how long-term trends in marine hydrodynamic processes (tide, current and wave), 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.

Vital Signs:
Coastal topography, offshore topography, marine hydrography, anthropogenic modifications

Measures:
dune, cliff, bank features, shore type, overwash fans/flood plain, landscape pattern, edge of vegetation, bathymetry, location of migrating shoals and bodies, sediment size and type, current patterns, sea level position, tide range, wave characteristics, locations of jetties, shoreline armoring, dredge channels, beach nourishment sites, dune manipulations

Justification of Each Vital Sign:

Vital Sign: coastal topography

Measurements: dune, cliff, bank features, shore type, overwash fans/flood plain, landscape pattern, edge of vegetation

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 resources, buildings and infrastructure, and even to human safety, and are a major management issue in many parks. Overwash fans and flood plains serve as indicators of potential change and can provide early warning to park managers of an impending issue or of a need for additional monitoring and research. Changes in coastal topographic features may also indicate changes in habitat that require management action.

Vital Sign: marine topography

Measurements: bathymetry, location of migrating shoals and bodies, sediment size and type, and geologic framework

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: current patterns, sea level position, tide range, wave characteristics

Functioning on top of the geologic framework, the primary processes influencing the coastal habitat include a suite of natural factors operating at local, regional, and global scales. Natural disturbances consist of the system driving 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, and 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 just what is causing shoreline changes.

Vital Sign: anthropogenic modifications

Measurements: locations of jetties, shoreline armoring, dredge channels, beach nourishment sites, dune manipulations, etc.

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 detail knowledge of the location of shoreline structure and modifications.

Basic Approach:

Both in situ ground surveys using GPS and optical survey equipment, and airborne surveys using LIDAR (LightDistancingAndRanging) equipment will be utilized. Since the mid-1990s, LIDAR technology has emerged as a viable method for collecting beach micro-topography. 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 then be used to extract features identified as important to park managers. Multiple data sets can then be analyzed 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. Acoustic technologies such as radar and sonar do exist and are used in ongoing research studies in several parks. Airborne LIDAR systems such as the NASA EAARL (Experimental Advanced Airborne Research LIDAR) and the Optech Shoals (employed by the US Army Corps of Engineers and others) have potential as both topographic and bathymetric survey instruments and the network is working with these groups at various levels. The NPS must continue to develop and foster these inter-agency partnerships to determine a feasible level of activity and develop appropriate methods for the collection of these features.

Understanding geomorphologic change requires 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, which are currently beyond the capability of the National Park Service to perform. However, there are other agencies (federal, state, and local) which have long term monitoring mandates that provide some of the information needed, albeit less than optimal, 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 network should 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. A baseline survey from available aerial photography will establish the location of anthropogenic structures that already exist.

Principal Investigators and NPS Lead:
Protocol development will be completed through cooperative agreement with Rutgers University.
Principle Investigators: Dr. Norbert Psuty and Jeff Pace
NPS leads: Mark Duffy

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.

As interagency cooperative efforts are developed, additional cooperators from the NPS, USGS, NASA, NOAA, and the USACE are expected to participate in NPS I&M activities.

Development Schedule, Budget, and Expected Interim Products:
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 beach/dune topography protocol is due in October 2006 with the final version expected by August 2007. The interagency agreement with USGS for LIDAR product development was established in FY 2002.
Funding will be obligated to the existing cooperative agreement with Rutgers University in FY 2006 for the development of this protocol.