

**ANNUAL ADMINISTRATIVE REPORT (FY2007) AND WORK  
PLAN (FY2008) FOR THE CAPE COD NATIONAL SEASHORE  
PROTOTYPE MONITORING PROGRAM**

**PART OF THE NORTHEAST COASTAL AND BARRIER NETWORK AND THE  
ATLANTIC AND GULF COAST BIOGEOGRAPHIC REGION**

**FY2007-FY2008**



In April 2007, a powerful northeast storm created a breach of the coastal barrier dune that forms the seaward boundary of Pleasant Bay in Chatham at the southern extent of CACO. The monitoring program captured the effects of this breach on water quality and tidal dynamics of Pleasant Bay.  
Photo: Stephen Smith, NPS

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Northeast Region Approval Signature:

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Elizabeth Johnson, Regional Inventory and Monitoring Coordinator,      Date  
Northeast Region

Cape Cod National Seashore Approval Signatures:

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George Price, Superintendent      Date

Prepared by:

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Carrie Phillips, Chief, Natural Resource Management      Date

## AARWP Checklist

<b>Budget program (MS Access, aarwp_budget.mdb)</b>	
X	The income amounts entered for Biological Inventories, Vital Signs Monitoring, Prototype \$\$ - Annual Transfer, Water Quality Monitoring and other sources matches the dollar amounts from the memos sent to the regions/networks by WASO (have you used the correct income amounts?).
X	In the Add/Edit Budget Records form, the amount shown for Total Expenses matches that for Total Income. (If it doesn't, enter a record under Expenses in the 7_Other category to make it balance; use an entry such as 'Unexpended funds' or 'Overspent Funds' in the Description column to explain the amount.)
X	For all Expense records, the Description field includes the name of the university, agency, company, or other vendor to help us document our outsourcing efforts. (If this expense involved a contract, cooperative agreement, interagency agreement, or other partnership, is it clear where the money went?)
X	For all Expense records, the correct item from the picklist for 'Where \$\$ Went' has been entered. [Think about who the check was written to; e.g., enter 'Other Non-Federal' for funding that went directly to the private sector, such as for purchases (computers, supplies, etc.), travel (airlines, rental cars, hotels).]
NA	On the Status of Biological Inventories form, there is one record for each inventory that is described in the text section of the AARWP or in the budget program. Be sure to list each park that was involved in the particular inventory.
X	Each year's budget has been exported as an .rtf file (one for FY 2007 and one for FY 2008), and both files have been inserted into MS Word at the end of the AARWP document.
X	The file aarwp_budget.mdb has been renamed to include the 4-character network alpha code and the years, as shown in this example: NCCN_FY0708_aarwp.mdb
<b>Annual Report and Work Plan (MS Word)</b>	
X	I have carefully read the guidance for the AARWP and followed it.
X	A header or footer with the date that the aarwp was last revised has been included.
X	I followed the new guidance for Executive Summaries.
none this year	Photographs that might be included in one of the reports to Congress, brochures, websites, or other materials that help the program have been submitted by the network. (See the photo database and guidelines for submitting photographs.)
X	The aarwp file has been renamed using the network's 4-character alpha code and the years (FY0708) as in the example NCCN_FY0708_aarwp.doc
X	The annual report has been approved by the appropriate individuals, per my region's procedures. (If you cannot get electronic signatures, it is okay to submit a hard copy with signatures after November 2.)
X	I have followed my region's procedures for submitting the two files (e.g., NCCN_FY0708_aarwp.doc and NCCN_FY0708_aarwp.mdb). (Most regions require you to submit the files through the regional office. The files may be zipped into a zip file if desired, and then submitted to Steven Fancy via either email or ftp).
<b>Review of FY 2008 Work Plan by WASO</b>	
X	[Enter Yes or No]: Has the FY 2008 work plan been approved by the network Board of Directors and the Regional I&M Coordinator, and therefore ready for the full WASO review? (If you enter No, the WASO I&M and WRD offices will not review the work plan until it is finalized by January 31, 2008).

## **Executive Summary**

### **Cape Cod National Seashore Prototype Monitoring Program FY2007 Annual Administrative Report**

In 1996, CACO was identified as a prototype park for long-term ecosystem monitoring within the Atlantic and Gulf Coast biogeographic region. As a prototype park and in partnership with U.S. Geological Survey (USGS), CACO was charged with developing and refining long-term monitoring protocols that would support management of Cape Cod's natural resources and that could be of utility to other Atlantic and Gulf Coast parks. With the advent of the network approach to inventory and monitoring, our mission expanded to include focused technical support to the Northeast and Coastal Barrier Network (NCBN). The CACO Prototype Monitoring Program also emphasizes partnership and integration with the Atlantic Research Center (ARC), another element of the Natural Resource Challenge located at Cape Cod National Seashore. We have already seen substantial benefits from an integrated approach to management of these two highly related programs.

Cape Cod is a large glacial peninsula that extends 60 miles into the Atlantic Ocean from the coast of Massachusetts. Cape Cod National Seashore (CACO) encompasses 44,600 acres of marine, estuarine, fresh water, and terrestrial ecosystems. Marine and estuarine ecosystems include barrier islands, beaches, spits, tidal flats, salt marshes, salt ponds, and soft-bottom benthos. Freshwater ecosystems include kettle ponds, vernal pools, sphagnum bogs, forested swamps, and dune slack wetlands. Terrestrial systems include pitch pine and scrub oak barrens, pitch pine forests, oak forests, heathlands, dunes, and grasslands. Many of these habitats are globally uncommon and the species that occupy them are correspondingly rare.

During the past three centuries Cape Cod ecosystems have been altered profoundly by human occupation. For example, construction of dikes and ditches in estuaries has changed natural tidal regimes resulting in water quality degradation and loss of native plant and animal species. Beach and dune stabilization efforts have interfered with natural processes shaping shorelines. Discharges from non-point sources of pollution such as landfills, septic systems, and golf courses have adversely affected surface and ground-water quality. Fire suppression has altered the distribution and volume of the heathland and pitch pine communities that predominated before European settlement. Some of the highest ozone levels in the northeast have been recorded at CACO. The park includes many municipal and private in-holdings and is surrounded by varying densities of residential and commercial development. Add the over 5 million visitors that come to CACO each year, and the significance of the challenges facing CACO managers becomes apparent.

The CACO Prototype Monitoring Program uses an ecosystem approach based on the *Conceptual Framework for the Development of Long-term Monitoring Protocols at Cape Cod National Seashore* (Roman and Barrett 1999) and its 2002 Update (Boland *et al.*

2002). These documents also describe the conceptual models used to select specific monitoring components, provide justification for each monitoring project, enumerate the specific monitoring questions being addressed, and identify the parameters being measured. Selection of the specific activities planned under these objectives has been guided by the project prioritization and implementation scheme described in *2003 Cape Cod National Seashore LTEM Project Prioritization Report* (Phillips 2003). The program's \$702,400 annual budget supports staff and cooperators, and in partnership with the ARC, supports laboratory operations and acquisition of instrumentation and field equipment. Currently, our activities are focused on implementation of completed long-term monitoring protocols and related studies, and completion of protocols that have been in development for the past several years. We also continue to build a comprehensive data management program.

### **Program Accomplishments**

#### Inventories:

- Dune slack wetland inventory and monitoring data were used to prepare a manuscript accepted by a peer-reviewed journal.
- Completed the second year of a two year survey for four-toed salamanders.
- Continued technical support to a cooperator from the University of Rhode Island conducting an inventory of near-shore marine fish.
- Continued to provide technical expertise and assistance to amphibian and reptile inventory projects at NCBN and NETN parks.

#### Monitoring:

- Continued monitoring sediment elevation, nekton, and vegetation in CACO's estuarine systems. Monitoring results were used to plan and document response to tidal restoration. Monitoring data were used to prepare two manuscripts on estuarine restoration that have been accepted in peer-reviewed journals.
- Used sediment elevation, hydrology, vegetation, and other monitoring methods to further investigations into saltmarsh dieback on Cape Cod.
- Shoreline change data was integrated into a paper prepared in collaboration with the Provincetown Center for Coastal Studies and presented at a Coastal Sediment conference.
- Continued monitoring shoreline change. Monitoring methods were used to document and intensively monitor formation of a new inlet to Pleasant Bay; these data and maps have been used by the Town of Chatham, the Pleasant Bay Alliance, and the Center for Coastal Studies.
- Continued amphibian monitoring and participation in the USGS Amphibian Research and Monitoring Initiative. Two graduate student research projects continued on spadefoot toads. In previous years, amphibian monitoring indicated that CACO supports the most significant population of spadefoot toads in the northeast, and that significant mortality is occurring along park roads. These two research projects will expand our understanding of spadefoot movements and road mortality, and will help the park better implement protective measures.

- Continued monitoring air quality through participation in the National Atmospheric Deposition Program, the Mercury Deposition Network, the Interagency Monitoring of Protected Visual Environments program, and an ozone monitoring partnership with the Commonwealth of Massachusetts.
- Continued monitoring ground water hydrology. USGS completed a protocol for monitoring ground-water quality.
- Continued to communicate the results of monitoring and related studies through interpreter training, interpretive programs, provision of content to the park newspaper and website, presentations at community conferences and workshops, and participation in school programs.

#### Water Quality Monitoring:

- Initiated implementation of the estuarine nutrient enrichment protocol. This effort included partnership with the NCBN and the Atlantic Research Center to provide chlorophyll analysis for other network parks.
- Continued monitoring water quality in 20 kettle ponds. In collaboration with USGS, work continued on development of custom data analysis tools for kettle pond water quality data.

#### **Public Interest Highlights**

**Fifty years of kettle pond water quality data reveal impact of degradation of water quality** - In 1957, a study by Woods Hole scientists, including Jacques Cousteau's son, discovered aquatic moss flourishing at the bottom (60 feet) of Duck Pond in Wellfleet MA. It is not found there any longer. Work in the 1980's indicated that the moss was not found below 43 feet. In 2007, the kettle pond water quality project discovered that the moss is now not found below 39 feet. This loss of moss is related to the amount of light available to the plant to permit photosynthesis. Monitoring data shows that there has been a decrease in depth that the light is able to penetrate. It is suspected that an increase in recreational use since the fifties has led to an increase in water column productivity, with water chemistry data pointing to nutrient loading as the cause.

**Estuarine nutrient enrichment monitoring captures effects of coastal barrier beach breach** - In April 2007, a powerful northeast storm created a breach of the coastal barrier dune that forms the seaward boundary of Pleasant Bay in Chatham at the southern extent of CACO. The estuarine nutrient enrichment monitoring project captured the effects of this breach on water quality and tidal dynamics of Pleasant Bay. The increased flushing of Pleasant Bay by cold, nutrient poor Atlantic Ocean water resulted in increased tide heights and dramatic improvements to water clarity and the health of submerged aquatic vegetation. Tide heights increased by approximately two meters immediately following the breach as measured by pressure transducers at the northernmost extent of the system. Water clarity measurements in August 2007, as compared to August 2006, from continuous PAR sensors placed in Pleasant Bay northwest of the breach at a submerged aquatic vegetation monitoring site indicate an approximate 30% increase in light penetration. The estuarine nutrient enrichment monitoring project is being implemented by the NCBN, USGS, and CACO.

**Utility of an autonomous underwater vehicle for monitoring water quality tested in a back barrier coastal lagoon** - East Harbor, a 350-acre back barrier coastal lagoon, has been monitored following a summer-time dissolved oxygen depletion and fish kill in 2001. In FY2005 and FY2006, water quality and tidal data were continuously monitored by an YSI 6600EDS multi-parameter data logger at one station in the lagoon. A new unique tool for obtaining wider spatial resolution, the YSI-AUV (Autonomous Underwater Vehicle), was tested in FY2007. The AUV records GPS position, fixed water quality and bathymetric data while underway. This new tool provided us with a more comprehensive data set, allowing for a better understanding of the dynamics of the East Harbor system.

**Salt marsh dieback** - “Sudden wetland dieback” (SWD) in New England has received a great deal of attention from scientists and resource managers over the past several years. Through analysis of salt marsh vegetation monitoring data and related studies, program scientists have determined that that much of the dieback on Cape Cod does not appear to fit the definition of SWD. Analysis of aerial photography suggests that salt marsh vegetation losses on Cape Cod have been occurring for at least two decades and appear more progressive than sudden. Careful inspection of relict peat has revealed that many dieback areas have arisen from losses of *Spartina patens* and *Distichlis spicata* (high marsh species), rather than *S. alterniflora* (low marsh). Water level recorders placed in the root zone show that high marsh dieback edges are considerably downslope of mean high tide, which is considered the seaward limit of flood tolerance for high marsh species. In contrast, *S. alterniflora* losses have occurred at many different elevations. The most severe low marsh losses have occurred along the banks of large tidal creeks, around marsh islands, and in places that receive high wave energy. The work of a cooperator, Dr. Mark Bertness (Brown University) has shown that low marsh dieback is likely the result of heavy grazing pressure from a species of nocturnal crab (*Sesarma reticulatum*). Bertness speculates that there have been substantial reductions in the populations of one or more predators on this crab.

**Hatches Harbor Tidal Restoration shows excellent results 6 years later** - Hydrologic restoration of Hatches Harbor, a tide-restricted marsh in CACO has resulted in significant plant community changes seven years following the re-introduction of seawater. Since 1999, incremental increases in flow through a tide-restricting dike have facilitated the rapid decline of salt-intolerant vegetation while encouraging the expansion of native salt marsh species. These changes show strong spatial gradients and are correlated with marsh surface elevation, distance from the point of seawater entry, and porewater salinity. *Phragmites australis* (common reed) has substantially declined within the floodplain, allowing native salt marsh grasses to proliferate. Now that maximum flow capacity through the existing dike structure has been reached, continued recovery may be limited less by changing physico-chemical conditions and more by rates of growth, seed dispersal, and seed germination of salt marsh taxa.

**CACO freshwater wetlands support an abundance of turtles** - From 1999 through 2003, CACO implemented an intensive field study of the abundance, distribution, population structure, and feasibility of monitoring fresh-water turtles. After initial drafting and peer review, the revised report was finalized and published as an NER technical report. This report provides in-depth information on CACO's freshwater turtle species and communities, as well as a thorough assessment of a variety of survey and analysis techniques that are likely to be of utility to others considering an aquatic turtle monitoring program. CACO supports four species of freshwater turtles, and two of them, the painted turtle and snapping turtle, have densities and biomass estimates that rank among some of the highest known.

**Four-toed salamander inventory details distribution and abundance of special concern species at CACO** - The four-toed salamander (*Hemidactylium scutatum*) is a Massachusetts Species of Special Concern whose distribution and abundance at CACO was poorly known. The limited information available suggested it occurred in some of the park's tidally restricted wetlands proposed for tidal restoration. To assist in planning for these restorations, and to facilitate a more informed evaluation of alternatives, a breeding season inventory of four-toed salamanders was conducted in FY2006 and FY 2007. The first year's effort found that four-toed salamanders occur in both tidally restricted wetlands and isolated wetlands (e.g. vernal ponds). However, both frequency of occurrence and abundance was greater in tidally-restricted wetlands, although the difference in frequency was not statistically significant. Sampling of additional sites in 2007 showed them to be less widespread and abundant in other tidally restricted wetlands at CACO, but still generally more abundant than in vernal ponds. Four-toed salamanders are limited to the primary glacial deposits of CACO and do not occur in the post-glacial portion of the park.

**Amphibian monitoring shows continued increase in CACO wood frog population** - Amphibian monitoring in FY2007 showed that numbers of breeding wood frogs (*Rana sylvatica*) continue to increase. The total number of egg masses found (260) far exceeds the previous maximum of 160 recorded in 2005 and trend analysis of data from 2002 through 2007 show a nearly significant, positive trend (slope=0.79,  $p=0.06$ ). Wood frogs are relatively rare at CACO and restricted to the southern end of the park. Amphibian diversity at CACO is greatest in the park's south, a phenomenon that is consistent with the post-glacial recolonization hypothesis of Lazell (1976). Results from 2007 suggest they are increasing in abundance, and that their range expansion northward, into Wellfleet also continues.

**Refining protection for spadefoot toads** - In 2001, data collected during development of the amphibian monitoring protocol indicated that CACO's Province Lands support perhaps the largest concentration of Eastern spadefoot toads (*Scaphiopus h. holbrooki*) in the northeastern United States. Spadefoots are listed as threatened by the state of Massachusetts. Unfortunately many are killed on park roads on rainy nights, particularly on Province Lands Road, which bisects an area of temporary wetlands used by spadefoots. Further monitoring led to a program of road closures on rainy nights to protect spadefoots and additional research is being conducted to refine this operation.

One researcher, from Antioch University of New England is studying the numbers of spadefoot toads on a park road at night relative to environmental conditions such as weather and groundwater conditions. A second researcher, from the University of Massachusetts, Amherst, is studying post-breeding movements of spadefoot toads using radio-telemetry, a first for this species. To date, several individuals have moved to locations greater than 400 meters from their breeding pond. Together, this research will better enable the park to anticipate when spadefoot toads will be active, and develop a more effective program to protect them from road kill.

**Fowler's toad research identifies preferred habitats** - Recently completed research conducted by George Mason University Ph.D. student Todd Tupper found Fowler's toads to be most abundant at shallow, open-shored, shrub-free ponds, set into an early successional landscape with bare, unvegetated patches. CACO supports some of the most robust remaining populations of this amphibian species, which is declining in some areas of the northeastern United States. These results are useful for understanding likely effects of woodland succession at CACO, and for helping conservation efforts throughout the species range.

## **I. Overview and Objectives**

### Ecological Context

Cape Cod is a large glacial peninsula that extends 60 miles into the Atlantic Ocean from the coast of Massachusetts. Cape Cod National Seashore (CACO) encompasses 44,600 acres of marine, estuarine, fresh water, and terrestrial ecosystems. Marine and estuarine ecosystems include barrier islands, beaches, spits, tidal flats, salt marshes, salt ponds, and soft-bottom benthos. Freshwater ecosystems include kettle ponds, vernal pools, sphagnum bogs, forested swamps, and dune slack wetlands. Terrestrial systems include pitch pine and scrub oak barrens, pitch pine forests, oak forests, heathlands, dunes, and grasslands. Many of these habitats are globally uncommon and the species that occupy them are correspondingly rare.

During the past three centuries Cape Cod ecosystems have been altered profoundly by human occupation. For example, construction of dikes and ditches in estuaries has changed natural tidal regimes resulting in water quality degradation and loss of native plant and animal species. Beach and dune stabilization efforts have interfered with natural processes shaping shorelines. Discharges from non-point sources of pollution such as landfills, septic systems, and golf courses have adversely affected surface and ground-water quality. Fire suppression has altered the distribution and volume of the heathland and pitch pine communities that predominated before European settlement. Some of the highest ozone levels in the northeast have been recorded at CACO. The park includes many municipal and private in-holdings and is surrounded by varying densities of residential and commercial development. Add the over 5 million visitors that come to CACO each year, and the significance of the challenges facing CACO managers becomes apparent.

### Program Overview

In 1996, CACO was identified as a prototype park for long-term ecosystem monitoring within the Atlantic and Gulf Coast biogeographic region. As a prototype park and in partnership with U.S. Geological Survey (USGS), CACO was charged with developing and refining long-term monitoring protocols that would support management of Cape Cod's natural resources and that could be of utility to other Atlantic and Gulf Coast parks. With the advent of the network approach to inventory and monitoring, our mission expanded to include focused technical support to the Northeast and Coastal Barrier Network (NCBN). Specifically, our role as a prototype park is to:

- develop and implement a long-term ecological monitoring program that is scientifically sound and relevant to management of park resources;
- test inventory and monitoring methods;
- develop long-term monitoring protocols relevant to CACO and to systems common among parks in the NCBN and the broader biogeographic region;
- conduct studies to refine monitoring questions and help interpret monitoring results; and
- share our experience and technical expertise with parks and networks nation-wide, and with the NCBN and networks in the broader biogeographic region.

Development of the CACO Prototype Monitoring Program was a collaborative effort primarily between USGS and the National Park Service (NPS). USGS provided the bulk of the funding for development of a conceptual framework for the program and for protocol development. CACO began receiving funding specifically for the long-term monitoring program in 1997. Over the past ten years, this funding has been used to support continued collaboration with USGS and other cooperators on protocol development, to implement completed monitoring protocols, to initiate specific studies needed to develop monitoring approaches, to provide information and technical assistance to the NCBN and other parks in the broader biogeographic region, and to build the personnel and logistical capabilities needed for long-term monitoring. We have developed a prioritized approach for phasing in monitoring projects as program capacity allows, made substantial investments in durable lab and field equipment, and have made significant progress on a comprehensive data management system. Over the next few years, our attention will be focused on implementing our highest priority projects, phasing in our mid-priority projects as program capacity allows, and completing and maintaining the data-management system.

The CACO Prototype Monitoring Program also emphasizes partnership and integration with the Atlantic Research Center (ARC), another element of the Natural Resource Challenge located at Cape Cod National Seashore. We have already seen substantial benefits from an integrated approach to management of these two highly related programs. For example, in FY2007:

- the ARC provided housing to several cooperators working on ecological questions arising from monitoring results;
- information generated through protocol development and monitoring has attracted externally funded research that is facilitated by ARC housing and analytical services;
- ARC resources supported benthic invertebrate monitoring in East Harbor; and
- integration of research and prototype monitoring coordination roles have improved efficiency and integration, and have made a larger portion of each funding source available to support monitoring and research projects.

As ARC facilities and partnerships develop, we anticipate that the synergy between the two programs will grow, particularly with respect to attracting and supporting research that expands on the results of long-term monitoring.

### Objectives

Our program objectives are listed below. The ecosystem approach for organizing our monitoring objectives (objectives 1-6) is based on the *Conceptual Framework for the Development of Long-term Monitoring Protocols at Cape Cod National Seashore* (Roman and Barrett 1999) and its 2002 Update (Boland *et al.* 2002). These documents also describe the conceptual models used to select specific monitoring components, provide justification for each monitoring project, enumerate the specific monitoring questions being addressed, and identify the parameters being measured. Selection of the specific activities planned under these objectives has been guided by the project prioritization and implementation scheme described in *2003 Cape Cod National Seashore LTEM Project Prioritization Report* (Phillips 2003). Objectives seven through eight

address information sharing, reporting, and technical support to other monitoring programs. Objective nine focuses on program management and infrastructure.

Cape Cod Prototype Monitoring Program Objectives:

1. Assess and monitor the integrity of estuarine and salt marsh ecosystems.
2. Assess and monitor the integrity of beach, spit, and barrier island ecosystems.
3. Assess and monitor the integrity of pond and freshwater wetland ecosystems.
4. Assess and monitor the integrity of coastal upland ecosystems.
5. Assess and monitor park-wide and multiple-system indicators of ecosystem integrity.
6. Integrate monitoring efforts and results within and across ecosystems.
7. Share information, report findings, and document program activities.
8. Provide technical assistance to the NCBN, to other networks and parks, and to other entities with common monitoring objectives.
9. Develop and sustain a comprehensive data management program, appropriate staff resources, laboratory infrastructure, and programmatic procedures to ensure program objectives can be met now and into the future.

Objectives 1 and 3 include water quality monitoring and include 303d-listed water bodies (Herring River and Ryder Pond). These activities are supported by the program's \$702,400 budget; we do not receive separate funding for water quality monitoring.

## **II. Accomplishments (FY2007) and Scheduled Activities (FY2008)**

### Objective 1 - Assess and monitor the integrity of estuarine and salt marsh ecosystems:

The accomplishments and planned activities in the following tasks contribute to the estuarine restoration goals in CACO's General Management Plan (GMP) (NPS 1998) and GPRA Goals Ia1A, Ia1H, Ia1B, Ia1J, Ia1D, Ia4E, and Ia4C.

#### *Task 1.1 - Monitor salt marsh sediment elevation response to sea level rise*

##### **FY2007 Accomplishments:**

- Salt marsh accretion, erosion, and relative elevation were measured at established salt marsh surface sediment elevation table (SET) sites in three estuaries (Hatches Harbor, Herring River/Wellfleet Bay and Nauset Marsh). SET measurements were not collected from the salt marsh pool sites in Nauset Marsh due to severe ice damage to the SET mounts.
- Sediment elevation data collected in 2007 were incorporated in a system-specific report for Hatches Harbor and Herring River salt marsh dieback sites.
- A new feldspar horizon was established at each sediment elevation monitoring site.
- Elevations at 3 of the 22 sites were measured with a Real Time Kinematic Trimble unit. A new monitoring element was planned and will continue to develop for measuring any changes in SET mount elevations.
- A final map of all sites within the three systems was generated.
- Continued to document the data management procedures and database entities in a Standard Operating Procedure as an appendix to the protocol document.
- Continued to measure erosion at wetland dieback monitoring sites.

- Collected elevation data at wetland dieback monitoring sites.

Scheduled FY2008 Activities:

- In FY2008, we will continue to collect accretion, erosion, and relative elevation measurements at established marsh-surface SET sites in three estuaries (Hatches Harbor, Nauset Marsh, Herring River/Wellfleet Bay).
- We will continue to work with Dr. Cahoon to determine whether or not continued monitoring of the salt marsh pool sites in Nauset Marsh is feasible and worthwhile, and if so, to determine what additional site design and quality control measures should be incorporated into current methods to account for ice damage.
- Sediment elevation data collected in 2008 will be incorporated in a system-specific report for Hatches Harbor and any other reports for other restoration or research areas (eg Herring River restoration, salt marsh die-back sites).
- Relative elevations will continue to be measured for all 22 sites in all three systems, and will continue developing a monitoring element for measuring any changes in SET mount elevations.
- Continue to document the data management procedures and database entities in a Standard Operating Procedure as an appendix to the protocol document.
- Continue to maintain metadata records and archive them in the GIS Data Store.
- Continue to collect elevation data and monitoring erosion at wetland dieback monitoring sites.

*Task 1.2 - Monitor estuarine nutrient enrichment*

FY2007 Accomplishments:

- In FY2007, the final Estuarine Nutrient Enrichment Protocol was received from USGS and fully implemented (excluding sediment sampling) at CACO. Implementation of the protocol included field work during July and August involving the deployment of continuous multi-parameter sondes and PAR sensors, spatial water quality monitoring, assessing submerged aquatic vegetation, and sampling and analysis for chlorophyll-a in Pleasant Bay, Nauset Marsh, and surrounding kettle pond strata.
- For the second year, the NCBN and CACO partnered to hire, train, and supervise a biological technician who assisted with field work at CACO and analyzed chlorophyll samples from both CACO and FIIS using Atlantic Research Center laboratory facilities.
- Field work in Pleasant Bay was supported by two dedicated volunteers from the Town of Orleans Water Quality Task Force (WQTF).
- CACO staff assisted Drs. Hilary Neckles and Blaine Kopp, USGS, with submerged aquatic vegetation (SAV) monitoring in Pleasant Bay and Duck Harbor.
- Completed data entry forms for CACO's park-specific elements of the protocol.

Scheduled FY2008 Activities:

- Ancillary data and data interpretation will be provided for the FY07 field season by the Pleasant Bay Alliance, USGS, NCBN, the Town of Orleans WQTF, and the Town of Eastham Department of Natural Resources.
- Supply USGS with all data from FY07 for a network wide interim report.

- Implement the third year of Estuarine Nutrient Enrichment monitoring. This will involve the collection of the full compliment of data (including sediment sampling) as described in Kopp et. al 2007 in three strata: Pleasant Bay, Nauset Marsh, and surrounding kettle ponds.
- Continue to support the NCBN with chlorophyll analysis and offer sediment analysis support as needed.
- Assist Drs. Hilary Neckles and Blaine Kopp, USGS, with submerged aquatic vegetation (SAV) monitoring in Pleasant Bay and Duck Harbor.
- Supply USGS and NCBN with all data for network wide reporting.

### *Task 1.3 - Monitor salt marsh vegetation*

#### FY2007 Accomplishments:

- Continued to monitor vegetation response to restoration of marine influence at East Harbor and Hatches Harbor.
- Completed numerous field experiments on salt marsh die-back. Results will be presented at the Estuarine Research Federation conference in Providence, RI on Nov 8 and at the Wellfleet Harbor conference on Nov 10.
- Prepared a monitoring report on the salt marsh vegetation monitoring work completed in FY2006.
- Prepared a report on salt marsh dieback work conducted in 2004-2006 (Smith 2006)
- Incorporated 2006 vegetation monitoring data into a system-specific report for Hatches Harbor and East Harbor.
- Provided technical assistance and troubleshooting to the NCBN to complete a joint protocol database.
- Two manuscripts were written. One is in press at Ecological Restoration (Smith, S. in press) ant the other is in review at Restoration Ecology (Smith, S.M., *et. al.*: in review).
- Completed data entry forms and queries for CACO's park-specific elements of the protocol.

#### Scheduled FY2008 Activities:

- Contribute to integrative system specific reports for Hatches Harbor and East Harbor.
- Continue to monitor vegetation response to restoration at Hatches Harbor and East Harbor, and continue with pre-restoration monitoring at Herring River.
- Continue to monitor submerged aquatic vegetation and macroalgae along existing transects in East Harbor
- Continue research on salt marsh dieback
- Conduct second round of salt marsh vegetation monitoring in CACO unrestricted marshes and expand the monitoring plot network

### *Task 1.4 - Monitor estuarine benthos and nekton*

#### FY2007 Accomplishments:

- Completed final report on nekton monitoring results from 2003 through 2005.
- Continued monitoring nekton response to the restoration of marine influence in East Harbor and Hatches Harbor. Monitoring methods are described in the nekton monitoring protocol (Raposa and Roman 2001).

- Continued nekton monitoring at Nauset Marsh. This was the fourth year of a five year effort to improve estimates of annual variability in order to refine the sampling frequency recommended in the protocol.
- Incorporated nekton data collected in 2007 into system-specific annual reports for Hatches Harbor and East Harbor restoration projects.

Scheduled FY2008 Activities:

- Continue monitoring nekton response to the restoration of marine influence in East Harbor and Hatches Harbor. Monitoring methods are described in the nekton monitoring protocol (Raposa and Roman 2001).
- Continue nekton monitoring at Nauset Marsh for the final year of a five-year effort to improve estimates of annual variability in order to refine the sampling frequency recommended in the protocol. In FY08 or FY09, collaborate with NCBN staff to analyze this five year data set and revise the protocol if appropriate.
- Continue testing methods for reliable monitoring of areas of East Harbor and Hatches Harbor not supported by the existing protocol.
- Support refinements in data management methods and statistical analysis of nekton data.

Objective 2 - Assess and monitor the integrity of beach, spit, and barrier island ecosystems.

The accomplishments and planned activities in Task 2.1 implement the long-term monitoring strategy under the Coastal Processes Goal and Threatened and Endangered Species Goal in CACO's GMP and contribute to GPRA Goals Ia1H, Ia2A, and Ia1D.

*Task 2.1 - Develop geomorphic shoreline change monitoring protocol*

FY2007 Accomplishments:

- In FY2007 we collected high-tide shoreline and bluff toe lines by differential GPS in support of NCBN data collection goals.
- Monitored formation of new Nauset Barrier Beach overwash inlet (Patriot's Day storm event). Collected bi-weekly GPS shorelines around inlet. Provided maps and public information updates to Town of Chatham, cooperating researchers, NPS management and State officials. In addition, monitored changes in Pleasant Bay tidal range and lag time in response to the new inlet.
- Integrated shoreline change monitoring results into a paper prepared in collaboration with the Provincetown Center for Coastal Studies and presented at the Coastal Sediment conference (Geise and Adams 2007).
- In cooperation with the NCBN, reviewed LIDAR products from NASA and USGS cooperators.

Scheduled FY2008 Activities:

- The NCBN has completed the draft final shoreline change monitoring protocol and will be distributing it for peer review in FY08. CACO will participate in this peer review and develop additional elements or modifications to adapt the protocol to shoreline conditions and monitoring questions unique to CACO. Specifically we will add annual bluff toe GPS line data collection.
- Collect high-tide shoreline and bluff toe lines by differential GPS in support of NCBN data collection goals.

- Continue to collect bathymetry profiles and upland elevation profiles for the Eastham-Wellfleet-Truro eroding coast and calculate volumes to test sediment flux hypotheses. Compare field elevations to values derived from 2005 LIDAR.

#### *Task 2.2 - Monitor beach and barrier island nesting birds*

##### FY2007 Accomplishments:

- CACO's Division of Natural Resource Management (NRM) monitored the breeding population and productivity of piping plovers (*Charadrius melodus*) at CACO. This monitoring project was initiated in 1985 and is funded with NRM base funds.
- NRM also monitored breeding populations and nesting effort of beach-nesting colonial waterbirds.

##### Scheduled FY2008 Activities:

- NRM will continue to monitor piping plover and beach-nesting colonial waterbird productivity.

#### Objective 3 - Assess and monitor the integrity of pond and freshwater wetland ecosystems.

All the tasks associated with this objective further the strategies described in CACO's GMP for protecting water quality, water quantity, and wetlands. This work contributes to GPRA Goals Ia1A, Ia1H, Ia1B, Ia1J, Ia1D, Ia1B, and Ia4E. Also, the kettle pond water quality monitoring project includes Ryder Pond - a pond that is 303-d listed for nutrients.

#### *Task 3.1 - Monitor kettle pond water quality and limnology*

##### FY2007 Accomplishments:

- Collected water quality monitoring data from all 20 CACO kettle ponds as guided by the protocol (Portnoy *et al.* 2003).
- Working in conjunction with the USGS Water Resources Division, created a suite of custom data analysis tools for the kettle pond water quality data.
- Recent (since the inception of the CACO Prototype Monitoring Program) and historic (extending back over 20 years) kettle pond monitoring data has undergone QA/QC, and the data set has been prepared for exploratory analysis.
- The Kettle Pond Database was revised to meet NPS Data Standard NRDT v3.1.

##### Scheduled FY2008 Activities:

- Continue annual monitoring at all ponds according to the current protocol (Portnoy *et al.* 2003).
- If staffing allows (see Task 9.2), undertake a comprehensive review of kettle pond water quality monitoring data and methods, seeking assistance from USGS WRD or NPS WRD experts as needed. Undertake more in-depth analysis of temperature profile data to better define the extent of the warming seen in the Gull Pond epilimnion and to refine hypotheses regarding contributing climatic factors. If warranted, prepare a report or publication.
- If staffing allows (see Task 9.2), develop procedures and specifications for loading citizen scientist kettle pond data from the local communities to support our understanding of kettle pond water quality dynamics.

*Task 3.2 - Characterize and develop monitoring strategies for vernal pools and dune slack wetlands*

FY2007 Accomplishments:

- Completed report on vegetation monitoring of forested vernal ponds (Smith et al. 2007).
- Completed a manuscript on dune slack wetlands that was accepted to the Journal Plant Ecology (Smith, S.M., M. Hanley, and K.T. Killingbeck. in press).

*Task 3.3 - Monitor pond vegetation*

FY2007 Accomplishments:

- Completed a manuscript on algae responses to nutrient enrichment in ponds, which has been published in Hydrobiologia (Smith, S. and K. Lee, 2006)
- Designed and implemented a vegetation monitoring plan for the Province Lands ponds.
- Continued monitoring results of bio-control on purple loosestrife (*Lythrum salicaria*).

Scheduled FY2008 Activities:

- Complete report on Province Lands ponds vegetation monitoring
- Complete the draft pond vegetation monitoring protocol for peer review.
- Continue monitoring results of bio-control of purple loosestrife (*Lythrum salicaria*).

*Task 3.4 - Inventory and develop a monitoring protocol for freshwater aquatic invertebrates*

FY2007 Accomplishments:

- Continued to provide technical assistance and logistical support to the principal investigator developing this protocol (Dr. Elizabeth Colburn, Harvard Forest). A draft report and protocol were produced by Dr. Colburn at the end of FY07. This project was initiated in FY2002 through a cooperative agreement with Harvard Forest.

Scheduled FY2008 Activities:

- Provide review and comment on draft final report and protocol, and forward the final draft to the Regional I&M Coordinator for peer review.

*Task 3.5 - Inventory and monitor amphibians*

FY2007 Accomplishments:

- Conducted the fifth year of amphibian monitoring according to the protocol (Paton *et al.* 2003). This included implementing the egg mass count component at 20 sites and the anuran call count component at 30 sites.
- In addition to conducting the egg mass counts according to the long-term monitoring protocol, we continued egg mass counts at an additional 20 ponds as part of the USGS Amphibian Research and Monitoring Initiative (ARMI) program.
- Collected hydrology data (pond stage) monthly at all 40 vernal ponds being monitored.
- Conducted the second year of a two year survey of four-toed salamanders (*Hemidactylium scutatum*), looking at distribution, abundance, and breeding habitat use. Data from this survey will assist planning and assessment of proposed tidal

- Provided technical and logistic support to Megan McLean and advisor, Dr. Rachel Thiet of Antioch College, New England for a study of spadefoot toad activity on Province Lands road, relative to weather and groundwater conditions. The goal of this research is to develop a model to predict when there will be heavy nighttime activity requiring protective road closures. Such a model, and the data used to develop it, will provide a data-based foundation for decisions of when and for how long this road, which bisects important habitat for the Massachusetts Threatened species, is closed.
- Continued providing technical, logistical, and field assistance to Brad Timm, Ph.D. student and Dr. Kevin McGarigal, University of Massachusetts (UMass) on a study of Eastern spadefoot toad (*Scaphiopus h. holbrooki*) habitat use and movements at CACO. FY2007 is the third year of this project. The need for this study became apparent during development of the amphibian monitoring protocol when data indicated that CACO supported a regionally-significant population of spadefoot toads, and extensive road mortality was observed. This study is supported by competitive NRPP funding. Data from the amphibian monitoring project was critical to development of the successful funding proposal.
- In collaboration with Dr. Peter Paton (University of Rhode Island) and Dr. Todd Tupper (Northern Virginia Community College) began an analysis of five year's anuran calling survey data collected jointly by CACO staff and Dr. Tupper.

Scheduled FY2008 Activities:

- Prepare a monitoring report for the amphibian monitoring work completed in FY2006 and FY2007.
- Implement the sixth year of monitoring according to the protocol and collect additional hydrological data.
- Implement the fourth year of the USGS-ARMI project at CACO.
- Continue to provide technical, logistical, and field assistance for both spadefoot toad studies. FY2008 is anticipated to be the final year of fieldwork for both.
- Complete a report on the terrestrial salamander inventory work conducted in FY2000 and 2001. Prepare a final report on the four-toed salamander survey.
- Continue collaborative analysis of anuran calling survey data.

*Task 3.6 - Inventory and monitor aquatic turtles*

FY2007 Accomplishments:

- Revised and finalized report on aquatic turtle study conducted from 1999 through 2003 (Cook et al. 2007).
- Continued monitoring spotted turtles through incidental encounters. One new individual was marked, several others observed.

Scheduled FY2008 Activities:

- Continue monitoring spotted turtles through incidental encounters.

Objective 4 - Assess and monitor the integrity of coastal upland ecosystems.

The accomplishments and planned activities under Task 4.2 are integral to development of the heathland management plan called for in CACO's GMP. These tasks contribute to GPRA Goals Ia1A and Ia1H.

*Task 4.1 - Monitor coastal forest vegetation*

FY2007 Accomplishments:

- Made revisions to the coastal forest vegetation monitoring protocol based on initial peer review.

Scheduled FY2008 Activities:

- Submit the coastal forest vegetation monitoring protocol to the Regional I&M Coordinator for final peer review, and revise/finalize the protocol as needed.

*Task 4.2 - Inventory terrestrial reptiles.*

FY2007 Accomplishments:

- Continued inventory of eastern box turtles and eastern hog-nosed snake through incidental encounters. In FY 2007 there were 101 box turtle records and 11 hog-nosed snake records. Inventory includes marking for future recognition, collecting data on size, weight, age, sex, and location, and photo-documentation.

Scheduled FY2008 Activities

- Continue monitoring of eastern box turtles and eastern hog-nosed snakes through incidental encounters.

*Task 4.3 - Monitor land birds*

FY2007 Accomplishments:

- Received final report on nesting habitats and productivity of northern harriers (*Circus cyaneus*) at CACO, based on field work conducted in 2004-2005. This study was conducted by Rhys Bowen through a cooperative agreement with the Manomet Center for Conservation Sciences.
- Reviewed draft and received final report from University of Rhode Island graduate student Mike Byrne, studying nesting success in northern harriers (*Circus cyaneus*) throughout the Cape and Islands region.
- Received partial report from Mark Faherty, University of Massachusetts, Amherst on landbird point count surveys.

Scheduled FY2008 Activities:

- We expect to receive draft monitoring protocol based on point counts from Mark Faherty, University of Massachusetts. Once received, we will provide the review and assistance necessary to complete the protocol. This project was initiated through a cooperative agreement with UMass in FY2000.

*Task 4.4 - Develop a protocol for long-term meso-mammal monitoring*

FY2007 Accomplishments:

- The last phase of field work for the meso-mammal protocol development study, led by Dr. Allan O'Connell, USGS, was completed in FY2006. Data analysis has been completed and the report and protocol is being drafted. This work was also the basis for a paper in the Journal of Wildlife Management (O'Connell et al. 2006).

Scheduled FY2008 Activities:

- A draft monitoring protocol is expected in early FY2008. Will provide review and comment on the report and draft protocol.

Objective 5 - Assess and monitor park-wide and multiple-system indicators of ecosystem integrity. The accomplishments and planned activities noted in Task 5.1 implement the research, monitoring, and effects detection strategies in CACO's GMP under the Air Resources Goal; those in Task 5.2 contribute to the water quality and quantity protection strategies in CACO's GMP; and those in Task 5.3, together with the array of vegetation monitoring activities described throughout this report and work plan, are part of the native plant and wildlife habitat restoration strategy described under the biotic resource management goal in CACO's GMP. These activities also contribute to GPRA Goals Ia1H, Ia1D, Ia3, and Ia4C.

*Task 5.1 - Monitor meteorologic, atmospheric deposition, and air quality parameters*  
FY2007 Accomplishments:

- Monitored precipitation and atmospheric deposition through the National Atmospheric Deposition Program (NADP) and the Mercury Deposition Network (MDN), aerosols through the Interagency Monitoring of Protected Visual Environments (IMPROVE) program, and ozone in partnership with the State of Massachusetts.
- Continued to revise the meteorological and atmospheric monitoring protocol (USGS, URI, CACO 2001) and update all data source links.
- All data was quality assured and quality checked and development work for a database continued for CACO precipitation data.

Scheduled FY2008 Activities:

- Continue to implement the meteorologic and atmospheric monitoring programs identified above.
- Continue work on a revised meteorologic and atmospheric monitoring protocol by developing SOPs for in-park procedures, continuing to update links to partner data sources, and further development of data management systems and procedures, including archiving all rain gage data charts electronically.

*Task 5.2 - Monitor hydrology and ground water quality*

FY2007 Accomplishments:

- Continued implementation of the ground water and pond stage portion of the hydrology monitoring protocol (McCobb and Weiskel 2003)
- Collected stream gage data at two sites on the Herring River.
- Documented changes to the surface-water hydrology portion of the protocol.
- Located and collected water level data from six existing observation wells and added these into the monthly sampling.
- Received completed draft protocol for monitoring groundwater quality from John Colman, USGS (Colman and Masterson, 2007).

Scheduled FY2008 Activities:

- Continued implementation of the ground-water and pond-stage portion of the hydrology monitoring protocol.
- Develop archiving and data transfer protocols for stream-gage and the pond-stage portion of the protocol.
- Document the data management method in a formal procedure to accompany the refinements of the field methods.

- Continue to collect stream gage data and work with NPS Hydrologist, Larry Martin, to evaluate and test new approaches for modifying the standard stream gage techniques called for in the surface-water hydrology portion of the protocol.

*Task 5.3 - Complete the cover-type map and develop a long-term approach for cover-type change monitoring*

FY2007 Accomplishments:

- Cover type map (veg 2000) shapefile, accuracy assessment, key and classification system are complete and awaiting final report delivery from Natureserve. CACO is providing final GIS shapefile, aerial photo documentation and archiving, photo interpretation process steps, and spatial accuracy assessment.
- CACO consolidated map categories and created a final GIS shapefile and coverage to coincide with Natureserve's deliverables (accuracy assessment and classification report, field data summary). CACO reviewed and QCed labeling and attributes. CACO also completed metadata for the final vegetation map product.

Scheduled FY2008 Activities:

- A long term approach to cover type mapping is being considered, modeled on URI Fire Island remote sensing project. (Y.Q.Wang, et al., 2007). High resolution satellite imagery (e.g. Quickbird from Digital Globe) will be classified (stratified unsupervised classification using ERDAS Image software) to create pixel-based cover type change maps. Veg2000 will be used as a baseline. Satellite imagery will be acquired to complete CACO coverage during FY08.

Objective 6 - Integrate monitoring efforts and results within and across ecosystems

*Task 6.1 - Enhance commonalities and coordination among protocols*

FY2007 Accomplishments:

- Continued to expand application of instrumentation (YSIs and HOBOS) and expertise developed for the estuarine nutrient enrichment protocol to other systems where estuarine monitoring and studies are being conducted. This included:
  - Collected water quality data (temperature, conductivity, salinity, dissolved oxygen, depth, turbidity and chlorophyll, PAR) in Herring River/Wellfleet Bay, East Harbor, Nauset Marsh and Pleasant Bay
  - Collected tidal data in Hatches Harbor
  - Collected temperature, salinity and depth data in Pleasant Bay in collaboration with Graham Giese (Center for Coastal Studies)
  - Collected tidal data in Middle Meadow, Herring River/Wellfleet Bay and Lieutenant Island for the salt marsh dieback erosion projects
  - Collaborated with Endeco YSI to test an autonomous underwater vehicle for collecting water quality, bathymetry and GPS location data throughout East Harbor
  - Collected water level data in 6 observation wells on Beach Point in collaboration with Tom Camberari (Cape Cod Commission) and Larry Martin (NPS) using HOBOS.
  - Collected tidal data for Herring River pre-restoration modeling in cooperation with Tim Smith (Coastal Zone Management).

- Continued to develop a comprehensive field and lab procedure for use of water quality instruments regardless of project to increase efficiency, promote consistency, and ensure data quality.
- Continued to maximize use of existing instrumentation to support multiple monitoring studies

Scheduled FY2008 Activities:

- Continue to develop a comprehensive field and lab procedure for water quality instruments regardless of project to increase efficiency, promote consistency, and ensure data quality.
- Develop a data management procedure that will provide the same as the field and lab protocols.
- Continue to maximize use of existing instrumentation to support multiple monitoring and studies.

*Task 6.2 - Integrate analysis of monitoring results*

FY2007 Accomplishments:

- Integrated salt marsh vegetation, nekton, sediment elevation, and water level monitoring into a system-specific report for Hatches Harbor.
- Integrated salt marsh vegetation, water quality, nekton and water level monitoring into a system-specific report for East Harbor.
- Collaborated with NPS WRD hydrogeologist (L. Martin) on survey of domestic wells near Herring River flood plain and assessment of their sensitivity to salt-water intrusion with tidal restoration.

Scheduled FY2008 Activities:

- Integrate salt marsh vegetation, macroalgae, nekton, sediment elevation, and lagoon surface-water and Beach Point ground-water level monitoring into system-specific reports for Hatches Harbor and East Harbor.
- If staffing allows, create queries and reports from the monitoring databases to integrate analyses of sediment elevation, vegetation, water quality, and nekton and other measures of salt marsh ecosystem health.
- Maintain synchronization of CACO databases with national data standards to facilitate data exchanges and comparison of methods.

Objective 7 - Share information, report findings, and document program activities.

*Task 7.1 - Share information with non-technical audiences*

FY2007 Accomplishments:

- Program staff led interpretive programs in the "In the Field With A Park Scientist" series created in 2006. These programs give visitors an opportunity to learn about park science programs and projects, engage directly with park scientists, and experience data collection in the field.
- Program staff contributed articles to the 2007 CACO Newspaper (distributed to the visiting public) and to the CACO website.
- Staff gave presentations about the program and the results of monitoring activities to a variety of public groups such as the Gull Pond Citizens Association, local schools,

local workshops, Audubon's Wellfleet Bay Wildlife Sanctuary, and visitors to CACO Visitor Centers.

- Staff interacted with a number of print and radio reporters sharing information on a variety of science issues, including East Harbor lagoon restoration, Herring River salt marsh restoration, mercury contamination in kettle ponds. This resulted in a number of stories focused solely on monitoring and related research projects.
- Posters from a variety of inventory and monitoring projects were featured at the Atlantic Research Center Open House during the Highlands Fest - an event to introduce local communities and visitors to the emerging Highlands Center at CACO.

Scheduled FY2008 Activities:

- Continue to provide information through training, presentations, articles or other appropriate venues as opportunities arise.
- Continue to participate in the "In The Field With A Park Scientist" series.

*Task 7.2 - Share technical information with CACO managers, other NPS audiences, scientists, and other entities interested in monitoring and resource management*

FY2007 Accomplishments:

- Completed a final draft of Cultural Landscape Restoration Plan for CACO. This plan uses an adaptive management approach that entails monitoring the park's coastal heathlands and has incorporated sampling design and data collection procedures developed by the prototype monitoring program.
- Provided information developed through long-term monitoring projects regarding wetlands, spadefoot toads, and sensitive plants in the Province Lands to the Denver Service Center team planning bike trail renovations for CACO.
- Presented three posters and two presentations at the November 2006 State of Wellfleet Harbor Conference on CACO monitoring of estuarine water quality and vegetation.
- Provided training to CACO's seasonal interpretive staff.
- Gave presentations to a variety of technical audiences such as the Hatches Harbor Technical Advisory Committee, the Salt Marsh Die-Back Workshop, the Cape Cod Natural History Conference, an NPS Educators Workshop, the Herring River Technical Committee, The Nature Conservancy, NOAA, Massachusetts Coastal Zone Management, and Massachusetts Natural Heritage Program.

Scheduled FY2008 Activities:

- Depending on funding and coordination with the Fire Program, assist with implementation of the Cultural Landscape Restoration Plan and develop data management and reporting procedures consistent with the standards of the monitoring program.
- Continue to share technical information through seasonal interpreter training, providing input to management on park projects, and as opportunities arise.

*Task 7.3 - Document program methods, activities, and findings*

The specific protocol development, reporting accomplishments, and planned activities identified throughout this report and work plan are summarized below; citations are provided in Section IV.

FY2007 Accomplishments:

- Completed the following reports, manuscripts, and peer-reviewed journal papers:
  - status and habitat use of breeding northern harriers at CACO (Bowen 2007, Byrne 2007)
  - SAGA amphibian and reptile inventory (Brotherton et al, in review)
  - ground-water quality monitoring protocol (Colman and Masterson 2007)
  - herptofaunal restoration in an urban landscape (GATE) (Cook, in press)
  - inventory of aquatic turtles at CACO (Cook et al 2007)
  - migration of parabolic dunes and wetland formation at CACO (Forman et al, in review)
  - cultural landscape / open coastal habitat restoration at CACO (Gwilliam 2007)
  - nekton monitoring 2003 - 2006 at CACO (Gwilliam and Galvin 2007)
  - annual report on Hatches Harbor restoration (Portnoy et al 2006)
  - annual report on East Harbor restoration (Portnoy et al 2006)
  - effects of removing salt-killed vegetation during tidal restoration on wrack movement and establishment of native halophytes (Smith, in press)
  - dune slack wetlands at CACO (Smith et al, in press)
  - salt marsh dieback at CACO (Smith et al, in press)
  - responses of plant communities to incremental hydrologic restoration of a tide-restricted salt marsh (Smith et al 2007)
  - assessment of vegetation in forested vernal wetlands at CACO (Smith et al 2007)
  - response of periphyton to artificial nutrient enrichment in freshwater kettle ponds at CACO (Smith and Lee 2006)
  - determining ground surface topography in tidal marshes (Smith and Warren 2006)
  - variables influencing Fowler's toad breeding effort at CACO (Tupper and Cook, in press)
  - improving call surveys for detecting Fowler's toads (Tupper et al 2007)
  - status report on near-shore fish inventory (Bergstrom et al 2007)

Scheduled FY2008 Activities:

- Produce the following reports, manuscripts, and peer-reviewed journal papers:
  - draft and/or final reports for NCBN and NETN reptile and amphibian inventories (GATE (90% complete), and SARA, MIMA, SAIR, SAHI, WIFL, FIIS, ASIS (all ca. 80% complete)
  - report on the dynamics of macroalgal blooms in CACO marine waters
  - integrated system-specific reports for Hatches Harbor and East Harbor, and potentially Herring River
  - draft landbird monitoring protocol or report (being prepared by UMass)
  - draft meso-mammal protocol or report (being prepared by USGS)
  - reports on CACO snake and terrestrial salamander inventories
  - report on the four-toed salamander inventory
  - report on 2007 amphibian monitoring activities
  - manuscript on high-marsh die back
  - kettle pond vegetation monitoring draft protocol

Objective 8 - Provide technical assistance to other networks, parks, and other entities with common inventory, monitoring, and research objectives.

*Task 8.1 - Share technical expertise with other networks and parks*

FY2007 Accomplishments:

- Provided the laboratory facility, consumable supplies, and technical oversight to the partnership with the NCBN to provide for chlorophyll- $\alpha$  analysis for the NCBN's implementation of the estuarine nutrient enrichment monitoring protocol at FIIS.
- Supported the CACO GIS Specialist to participate in the NCBN's LIDAR forum at URI (hosted by NASA and USGS Remote Applications staff from St Petersburg FL).
- Continued work on amphibian and reptile inventory reports for NCBN and NETN parks (GATE (90% complete), and SARA, MIMA, SAIR, SAHI, WIFL, FIIS, ASIS (all ca. 80% complete)).

Scheduled FY2008 Activities:

- Continue the analytical partnership with the NCBN to support implementation of the estuarine nutrient enrichment protocol.
- Begin to develop a network of water quality instrument users in order to better serve coordination between protocols within the NCBN.
- Continue to provide technical and analytical assistance and support as opportunities arise.
- Complete amphibian and reptile inventory reports for NCBN and NETN parks.

*Task 8.2 - Provide technical assistance to other inventory, monitoring, and research efforts*

FY2007 Accomplishments:

- Provided technical assistance and laboratory analyses in a collaborative water quality monitoring project with Massachusetts Audubon's Wellfleet Bay Wildlife Sanctuary and the Wellfleet Natural Resources Advisory Board focused on Wellfleet Harbor.
- Provided technical and laboratory assistance to the Provincetown Center for Coastal Studies Cape Cod Bay Water Quality Monitoring Program.
- Provided the Massachusetts Natural Heritage and Endangered Species program with reports of all observations during FY2007 of state-listed threatened and endangered species at CACO.
- Provided peer review of paper "Historical versus recent amphibian diversity and distribution in New York City" for the Society for the Study of Amphibians and Reptiles.

Scheduled FY2008 Activities:

- Continue to provide technical and analytical assistance and support as opportunities arise.

Objective 9 - Develop and sustain a comprehensive data management program, appropriate staff resources, laboratory infrastructure, and programmatic procedures to ensure program objectives can be met now and into the future.

*Task 9.1 - Build and maintain a comprehensive data management program; these accomplishments and tasks are in addition to those described under the specific projects above.*

FY2007 Accomplishments:

- Image file metadata and management procedures were modified to more closely match NPS image metadata standards. Began cataloguing and organizing the more than 10,000 digital images on the CACO North Atlantic Coastal Lab server - this includes images generated through regular natural resource management activities, external research facilitated by the Atlantic Research Center, and the prototype monitoring program.
- Provided technical assistance and troubleshooting to the NCBN to complete a joint protocol database.

Scheduled FY2008 Activities:

- Reassess the status of data management program development and develop a work plan in partnership with the NCBN to guide future priorities and activities pertaining to data management.

*Task 9.2 - Build technical expertise and work force capacity that promotes consistency in monitoring project implementation*

Scheduled FY2008 Activities:

- Fill the Research & Monitoring Coordinator position vacated during FY2006. This is a combined position coordinating both the Prototype Monitoring Program and the Atlantic Research Center
- Fill the Data Manager position vacated during FY2007.
- Create and fill a permanent Hydrology Technician position.
- Reassess current staffing structure relative to priority projects and existing expertise. Revise and fill the Aquatic Ecologist position vacated during FY2007 accordingly.

### **III. Staffing**

#### CACO Prototype Staff

Velma Decker, Data Manager  
Lisa Nicholson, Budget Assistant  
Robert Cook, Wildlife Ecologist  
Stephen Smith, Plant Ecologist  
Evan Gwilliam, Aquatic Ecologist  
Michelle Galvin, Aquatic Ecology BioTech  
Kelly Chapman, Hydrology Tech

#### CACO Natural Resource Management Staff

Many critical program functions are also carried out by the Division of Natural Resource Management. The individuals listed below provide management oversight, GIS support,

laboratory management, piping plover and colonial waterbird monitoring, and expertise in chemical analysis, biogeochemistry, and ecology.

Carrie Phillips, Division Chief

John Portnoy, Senior Ecologist

Mark Adams, GIS Specialist

Krista Lee, Chemist

Judith Oset, Laboratory Tech

Mary Hake, Plover and Colonial Waterbird BioTech

Katy Kughen, Plover and Colonial Waterbird BioTech

Primary Science Advisors:

Charles Roman, Research Coordinator, NAC CESU

Don Cahoon, USGS-BRD, Patuxent Wildlife Research Center

Cooperators:

Larissa Bailey, USGS, Patuxent Wildlife Research Center (ARMI project)

Rhys Bowen, independent contractor to Manomet Center for Conservation Sciences (harrier inventory)

Michael Byrne, University of Rhode Island (northern harrier nest productivity)

Elizabeth Colburn, Harvard Forest (freshwater aquatic invertebrate protocol)

John Colman, USGS-WRD, MA-RI District (ground-water quality protocol)

Leslie DeSimone, USGS-WRD, MA-RI District (kettle pond protocol review)

Ethan Esty, University of Rhode Island (surf-zone fish inventory)

Mark Faherty, University of Massachusetts, Amherst (landbird point-count protocol)

Steve Forman, University of Illinois, Chicago (dune slack wetland study and dune grassland protocol development)

Graham Geise, Woods Hole Oceanographic Institution/Center for Coastal Studies (geomorphic shoreline change)

Howard Ginsberg, USGS-BRD, Patuxent Wildlife Research Center (beach macroinvertebrate protocol)

Curtice Griffin, University of Massachusetts, Amherst (landbird point-count protocol)

Mary-Jane James-Pirri, Graduate School of Oceanography, University of Rhode Island (salt marsh vegetation and nekton protocols)

Blaine Kopp, USGS, Patuxent Wildlife Research Center (estuarine nutrient enrichment protocol)

John Masterson, USGS-WRD, MA-RI District (hydrology and ground-water quality protocols)

Kevin McGarigal, University of Massachusetts, Amherst (spadefoot toad study)

Hilary Neckles, USGS, Patuxent Wildlife Research Center (estuarine nutrient enrichment protocol)

Allan O'Connell, USGS, Patuxent Wildlife Research Center (meso-mammal protocol)

Candace Oviat, Graduate School of Oceanography, University of Rhode Island (estuarine benthic macrofauna protocol)

Sheldon Pratt, Graduate School of Oceanography, University of Rhode Island (estuarine benthic macrofauna protocol)

Leslie Sneddon, NatureServe (cover-type mapping project)

Brad Timm, University of Massachusetts, Amherst (spadefoot toad study)  
Todd Tupper, George Mason University (Fowler's toad study)  
Megan McLean, Antioch College of New England (spadefoot toad study)  
Rachel Thiet, Antioch College of New England (spadefoot and East Harbor studies)  
Scott Warren, Connecticut College (salt marsh elevation method development)  
Peter Weiskel, USGS-WRD, MA-RI District (hydrology protocol)

In addition to those listed above, the efforts described in this report and work plan depend on the dedicated efforts of a dynamic cadre of seasonal technicians, research assistants, graduate students, undergraduate student interns, and volunteers.

#### **IV. Reports, Publications, and Presentations**

##### Reports and Publications:

Bengstrom, D., J. DeAlteris, and E. Estey. 2007. 2006 Progress Report: Preliminary Assessment of Fish Utilization of the Waters Adjacent to the Cape Cod National Seashore. University of Rhode Island, Narragansett RI.

Bowen, R.V. 2007. Final Report: Status and Habitat Use of Breeding Northern Harriers at Cape Cod National Seashore. Manomet Center for Conservation Science. Duxbury, MA.

Brotherton, D.K., R.P. Cook, and J.L. Behler. (in review). Saint-Gaudens National Historical Park, Amphibian and Reptile Inventory, March-September 2000. Technical Report NPS/NER/NRTR-XXXX-XXX. National Park Service, Woodstock, VT.

Byrne, M. 2007. Status and habitat use of nesting Northern Harriers at Cape Cod National Seashore; results of the 2006 nesting season. University of Rhode Island

Colman, J.A. and J.P. Masterson. 2007. Monitoring ground-water quality in coastal ecosystems: USGS Open-File Report 2007-1149. USGS, Massachusetts-Rhode Island District, Northborough, MA. 94pp.

Cook, R.P. (in press). Potential and limitations of herpetofaunal restoration in an urban landscape at Gateway National Recreation Area, New York and New Jersey, USA. in Jung, R.E. and J.C. Mitchell (eds.), Urban Herpetology. Herpetological Conservation Vol. 3. Society for the Study of Amphibians and Reptiles. Salt Lake City, UT.

Cook, R.P., K.M. Boland, S.J. Kot, J. Borgmeyer, and M. Schult. 2007. Inventory of aquatic turtles at Cape Cod National Seashore with recommendations for long term monitoring. Technical Report NPS/NER/NRTR-2007/091. National Park Service, Boston, MA.

Forman, S.L., Z. Sagintayev, M. Sultan, S. Smith, R. Becker, M. Kendall, and L. Marina. (in review). The migration of parabolic dunes and wetland formation at Cape Cod

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## **V. Budget Narrative**

In FY2007 the Cape Cod Prototype Monitoring Program received the anticipated \$702,400 authorization for regular program expenses and operations. About 80 percent of these funds were used to support permanent, term, and temporary staff as well as modest stipends and housing for interns and volunteers. Two program positions were vacant for all or part of FY2007: The Research & Monitoring Coordinator position, which is also supported by the Atlantic Research Center, was vacant all year, and the Data Manager position was vacant for part of the year. We plan to fill both of these positions in FY2008. In FY2007 we made a substantial investment, along with the Natural Resource Management Program and the ARC, in expansion of our shared field support and analytical laboratory facilities and equipment.

We anticipate an authorization of \$702,400 again in FY2008. We estimate that about 80 percent of this budget will be dedicated to staff salaries and support for seasonal technicians and volunteers. This reflects anticipated lapse in the Research & Monitoring Coordinator, Data Manager, and the recently vacated Aquatic Ecologist positions. We plan to dedicate this lapse toward PCS costs. While we plan to continue to invest in durable equipment and instruments, we expect to spend less on these types of purchases in order to provide for PCS costs. We hope to increase investment in staff development by supporting more training, and also plan to present the results of several projects at scientific meetings in FY2008. Consequently, we plan to spend more on travel than in previous years. Otherwise, we expect our expenditures will be similar to FY2007.

A summary of our FY2007 expenditures and FY2008 budget plan is provided in the Budget Summary at the end of this report.

## **VI. References Cited (see also Section IV Reports, Publications, and Presentations)**

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## Budget Summary

FY07 Admin Report

Network: Cape Cod NS Prototype

**Category: 1\_Income**

<i>Description</i>	<i>\$ Amount</i>	<i>\$\$ Source</i>	<i>Where \$ Went</i>	<i>Comments</i>
FY2007 Authorization	\$702,400.00	Prototype \$\$ - Park Base		
<b>Subtotal</b>	<b>\$702,400.00</b>			

**Category: 2\_Personnel**

<i>Description</i>	<i>\$ Amount</i>	<i>\$\$ Source</i>	<i>Where \$ Went</i>	<i>Comments</i>
a) Budget Tech	\$27,137.00	Prototype \$\$ - Park Base	NPS	
b) Data Manager	\$46,833.00	Prototype \$\$ - Park Base	NPS	
c) Physical Scientist	\$16,453.00	Prototype \$\$ - Park Base	NPS	
d) Plant Ecologist	\$91,137.00	Prototype \$\$ - Park Base	NPS	
e) Wildlife Ecologist	\$97,724.00	Prototype \$\$ - Park Base	NPS	
f) Aquatic Ecologist	\$71,500.00	Prototype \$\$ - Park Base	NPS	
g) Aquatic Ecology Tech	\$44,027.00	Prototype \$\$ - Park Base	NPS	
h) Lab Tech	\$23,323.00	Prototype \$\$ - Park Base	NPS	
i) Hydrology Tech	\$56,879.00	Prototype \$\$ - Park Base	NPS	
j) Seasonal Bio Techs	\$52,229.00	Prototype \$\$ - Park Base	NPS	
k) Seasonal Interns	\$26,499.00	Prototype \$\$ - Park Base	Other non-Federal	Includes housing
<b>Subtotal</b>	<b>\$553,741.00</b>			

**Category: 4\_Contracts**

<i>Description</i>	<i>\$ Amount</i>	<i>\$\$ Source</i>	<i>Where \$ Went</i>	<i>Comments</i>
University of Illinois - NADP/MDN	\$11,233.00	Prototype \$\$ - Park Base	Univ_Non-CESU	
<b>Subtotal</b>	<b>\$11,233.00</b>			

**Category: 5\_Operations/Equipment**

<b>Description</b>	<b>\$ Amount</b>	<b>\$\$ Source</b>	<b>Where \$ Went</b>	<b>Comments</b>
a) Field Equipment and Supplies	\$27,121.00	Prototype \$\$ - Park Base	Other non-Federal	
b) Laboratory Equipment and Supplies	\$31,280.00	Prototype \$\$ - Park Base	Other non-Federal	
c) Computer Hardware, Software, Supplies	\$7,021.00	Prototype \$\$ - Park Base	Other non-Federal	
d) Office and Misc. Supplies and Equip	\$11,126.00	Prototype \$\$ - Park Base	Other non-Federal	
<b>Subtotal</b>	<b>\$76,548.00</b>			

**Category: 6\_Travel**

<b>Description</b>	<b>\$ Amount</b>	<b>\$\$ Source</b>	<b>Where \$ Went</b>	<b>Comments</b>
Meetings, Conferences, Training	\$5,367.00	Prototype \$\$ - Park Base	Other non-Federal	
<b>Subtotal</b>	<b>\$5,367.00</b>			

**Category: 7\_Other**

<b>Description</b>	<b>\$ Amount</b>	<b>\$\$ Source</b>	<b>Where \$ Went</b>	<b>Comments</b>
Salary Lapse	\$55,511.00	Prototype \$\$ - Park Base	NPS	Partial Research & Monitoring Coordinator lapse and Data Manager lapse
<b>Subtotal</b>	<b>\$55,511.00</b>			

## Budget Analysis

### Analysis of Expenses by Where \$ Went

<i>Funding Source</i>	<i>Total \$\$</i>	<i>NPS</i>	<i>USGS</i>	<i>Other Federal</i>	<i>Univ.-CESU</i>	<i>Univ_Non-CESU</i>	<i>Other non-Federal</i>
Prototype \$\$ - Park Base	\$702,400	\$582,753				\$11,233	\$108,414
<b>Totals</b>	<b>\$702,400</b>	<b>\$582,753</b>				<b>\$11,233</b>	<b>\$108,414</b>

### Analysis of Expenses by Category

<i>Funding Source</i>	<i>Total \$\$</i>	<i>Personnel:</i>	<i>Coop Agree.</i>	<i>Contracts</i>	<i>Operations/Equip</i>	<i>Travel</i>	<i>Other</i>
Prototype \$\$ - Park Base	\$702,400	\$553,741		\$11,233	\$76,548	\$5,367	\$55,511
<b>Totals</b>	<b>\$702,400</b>	<b>\$553,741</b>		<b>\$11,233</b>	<b>\$76,548</b>	<b>\$5,367</b>	<b>\$55,511</b>

### Expense Totals By Category

<i>Category</i>	<i>SubTotal</i>	<i>Percent</i>
2_Personnel	\$553,741	78.84%
4_Contracts	\$11,233	1.60%
5_Operations/Equipment	\$76,548	10.90%
6_Travel	\$5,367	0.76%
7_Other	\$55,511	7.90%
	<b>\$702,400</b>	

## Budget Summary

FY08 Work Plan

Network: Cape Cod NS Prototype

### Category: 1\_Income

Description	\$ Amount	\$\$ Source	Where \$ Went	Comments
Anticipated authorization for FY2008	\$702,400.00	Prototype \$\$ - Park Base		
<b>Subtotal</b>	<b>\$702,400.00</b>			

### Category: 2\_Personnel

Description	\$ Amount	\$\$ Source	Where \$ Went	Comments
a) Research & Monitoring Coordinator	\$40,250.00	Prototype \$\$ - Park Base	NPS	3/4 year, 50% share with ARC
b) Budget Tech	\$27,951.00	Prototype \$\$ - Park Base	NPS	
c) Data Manager	\$44,775.00	Prototype \$\$ - Park Base	NPS	1/2 year
d) Physical Scientist	\$16,947.00	Prototype \$\$ - Park Base	NPS	
e) Plant Ecologist	\$93,871.00	Prototype \$\$ - Park Base	NPS	
f) Wildlife Ecologist	\$100,656.00	Prototype \$\$ - Park Base	NPS	
g) Aquatic Eco	\$37,006.00	Prototype \$\$ - Park Base	NPS	1/2 year
h) Aquatic Eco Tech	\$45,348.00	Prototype \$\$ - Park Base	NPS	
i) Lab Tech	\$24,022.00	Prototype \$\$ - Park Base	NPS	
j) Hydro Tech	\$58,586.00	Prototype \$\$ - Park Base	NPS	
k) Seasonal Technicians	\$53,796.00	Prototype \$\$ - Park Base	NPS	
l) Student Interns	\$29,400.00	Prototype \$\$ - Park Base	NPS	includes housing costs
<b>Subtotal</b>	<b>\$572,608.00</b>			

### Category: 4\_Contracts

Description	\$ Amount	\$\$ Source	Where \$ Went	Comments
University of Illinois - NADP/MDN	\$12,000.00	Prototype \$\$ - Park Base	Univ_Non-CESU	
<b>Subtotal</b>	<b>\$12,000.00</b>			

**Category: 5\_Operations/Equipment**

<b>Description</b>	<b>\$ Amount</b>	<b>\$\$ Source</b>	<b>Where \$ Went</b>	<b>Comments</b>
a) Field Equipment and Supplies	\$20,000.00	Prototype \$\$ - Park Base	Other non-Federal	
b) Laboratory Equipment and Supplies	\$20,000.00	Prototype \$\$ - Park Base	Other non-Federal	
c) Computer Hardware, Software and Supplies	\$5,000.00	Prototype \$\$ - Park Base	Other non-Federal	
d) Office and Misc Supplies and Equipment	\$5,000.00	Prototype \$\$ - Park Base	Other non-Federal	
<b>Subtotal</b>	<b>\$50,000.00</b>			

**Category: 6\_Travel**

<b>Description</b>	<b>\$ Amount</b>	<b>\$\$ Source</b>	<b>Where \$ Went</b>	<b>Comments</b>
Meetings, Conferences, Training	\$15,000.00	Prototype \$\$ - Park Base	Other non-Federal	
<b>Subtotal</b>	<b>\$15,000.00</b>			

**Category: 7\_Other**

<b>Description</b>	<b>\$ Amount</b>	<b>\$\$ Source</b>	<b>Where \$ Went</b>	<b>Comments</b>
PCS costs	\$52,792.00	Prototype \$\$ - Park Base	Other non-Federal	
<b>Subtotal</b>	<b>\$52,792.00</b>			

## Budget Analysis

### Analysis of Expenses by Where \$ Went

<i>Funding Source</i>	<i>Total \$\$</i>	<i>NPS</i>	<i>USGS</i>	<i>Other Federal</i>	<i>Univ.-CESU</i>	<i>Univ_Non-CESU</i>	<i>Other non-Federal</i>
Prototype \$\$ - Park Base	\$702,400	\$572,608				\$12,000	\$117,792
<b>Totals</b>	<b>\$702,400</b>	<b>\$572,608</b>				<b>\$12,000</b>	<b>\$117,792</b>

### Analysis of Expenses by Category

<i>Funding Source</i>	<i>Total \$\$</i>	<i>Personnel: Coop Agree.</i>	<i>Contracts</i>	<i>Operations/Equip</i>	<i>Travel</i>	<i>Other</i>
Prototype \$\$ - Park Base	\$702,400	\$572,608	\$12,000	\$50,000	\$15,000	\$52,792
<b>Totals</b>	<b>\$702,400</b>	<b>\$572,608</b>	<b>\$12,000</b>	<b>\$50,000</b>	<b>\$15,000</b>	<b>\$52,792</b>

### Expense Totals By Category

<i>Category</i>	<i>SubTotal</i>	<i>Percent</i>
2_Personnel	\$572,608	81.52%
4_Contracts	\$12,000	1.71%
5_Operations/Equipment	\$50,000	7.12%
6_Travel	\$15,000	2.14%
7_Other	\$52,792	7.52%
	<b>\$702,400</b>	