

**ANNUAL ADMINISTRATIVE REPORT (FY2008) AND WORK PLAN
(FY2009) 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**



Photo credit: John Van de Graaff

In 2008, very high numbers of staging roseate and common terns were observed on the outer Cape. Approximately 60% of the entire Northwest Atlantic Coast breeding population of roseate terns was observed using Cape Cod National Seashore beaches and intertidal areas during at least part of the post-breeding dispersal/pre-migration period (July to mid-September).

FY2008-FY2009

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FY2008-FY2009

Northeast Region Approval Signature:

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

Cape Cod National Seashore Approval Signatures:

George E. Price, Jr., Superintendent Date

Carrie Phillips, Chief of Natural Resources Management Date

Prepared by:

Megan Tyrrell, Research and Monitoring Coordinator Date

AARWP Checklist

<u>Budget program (MS Access, aarwp_budget.mdb)</u>	
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).]
X	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 2008 and one for FY 2009), 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_FY0809_aarwp.mdb
<u>Annual Report and Work Plan (MS Word)</u>	
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.
X	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 (FY0809) as in the example NCCN_FY0809_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 3.)
X	I have followed my region's procedures for submitting the two files (e.g., NCCN_FY0809_aarwp.doc and NCCN_FY0809_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).
<u>Review of FY 2009 Work Plan by WASO</u>	
	[Enter Yes or No]: Has the FY 2009 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, 2009).

Executive Summary

Cape Cod National Seashore FY 2008 Annual Administrative Report

Cape Cod National Seashore (CACO) is one of eleven prototype parks for long term ecosystem monitoring. CACO's designation as a prototype park occurred in 1996 and since that time park staff have implemented a scientifically rigorous monitoring program for the park. The prototype park status confers the responsibility to develop monitoring protocols that can be used by other parks within the region. In addition, CACO staff conduct special studies aimed at furthering our understanding of results observed during regular monitoring. CACO is one of eight parks in the Northeast Coastal and Barrier Network (NCBN), which extends from Massachusetts to Maryland. Encompassing four major ecosystem types (marine, estuarine, freshwater and terrestrial) with a wide variety of habitats nested within these ecosystems, CACO's 44,600 acres are well suited to encompass the range of habitat and ecosystem diversity contained in other NCBN parks as well as within the Atlantic and Gulf Coast biogeographic region.

Cape Cod is a large glacial peninsula that was formed at the terminal moraine of the Laurentian ice sheet. The ice sheet had completely retreated off Cape Cod and the Gulf of Maine by 15,000 years ago, leaving a mixture of glacial drift, which underlies the towns of Eastham, Wellfleet and Truro, and marine deposits which extend from northern Truro to Provincetown at the terminal hook. Interspersed among these glacial and marine deposits on the lower cape are extensive portions of marsh deposits behind the barrier beaches on both the Atlantic and Cape Cod Bay sides of the peninsula. An exceptional diversity of habitat types are perched on the glacial and marine deposits and encapsulated within the boundaries of the park including: coastal heathlands, pitch pine/oak forests, barrier islands, beaches, spits and dunes, tidal flats, salt marshes, vernal pools, kettle ponds, swamps, dune slack wetlands, and grasslands.

As a coastal park, CACO experiences high pressure from encroaching development and intense tourist and recreational activity. Some climate change effects such as the warming of the kettle ponds have been documented through the long term ecosystem monitoring program at CACO. Sea level rise and increased intensity and frequency of storms are expected to be among the most pressing natural resource management challenges in the near future. The inventory and monitoring program's objectives at CACO were formulated to track changes in habitats and species that are indicative of ecosystem integrity and function as well as the essential elements (e.g. air and water quality, hydrology) that affect virtually every aspect of the natural environment.

CACO's inventory and monitoring program benefits greatly another Natural Resource Challenge program, the Atlantic Research Center (ARC). Through the ARC, CACO provides facilities for visiting researchers including housing, equipment and analytical services. In many cases, the visiting researchers benefit from and leverage the long term monitoring data collected by CACO staff, leading to projects that have direct benefits for natural resource management in the park and the larger region.

CACO received a \$702,400 authorization in FY 2008 for the inventory and monitoring program. The park does not receive separate funds for water quality monitoring, nor have we received funding specifically for inventories. Below are some highlights of the prototype monitoring supported activities from FY2008.

Program Accomplishments

Inventories

- Provided technical assistance and report compilation for amphibian and reptile inventories at NCBN and Northeast Temperate Network parks. Two reports were completed (SAGA and FIIS) and an additional three are underway (WIFL, SAHI and GATE).
- NCBN is finalizing the NPSpecies certification process for CACO fish.
- Hosted a scoping session and field trip in support of the geological resources inventory for the park.
- Prepared final versions of vegetation shapefiles along with aerial photography and associated metadata for contractors to finish the vegetation classification and mapping project.

Vital Signs Monitoring

CACO is currently monitoring 20 vital signs ranging from air quality, to amphibian populations to salt marsh vegetation to groundwater level monitoring. Below are some of the major highlights from the monitoring program.

- Continued to monitor salt marsh accretion, erosion and relative elevation in three estuarine systems. The sites range from a relatively unimpacted marsh to a marsh system that has undergone tidal restoration to a system that is slated for tidal restoration. CACO now has eleven years of data for two sites and eight years of data for one site. How many years of data? The reference marsh has a 3.89 mm/year accretion rate which exceeds the regional sea level rise rate of 2.6 mm/yr, while the two marshes that have been affected by tidal restrictions have highly variable sediment accretion rates.
- Conducted vegetation and nekton monitoring up and downstream of former tidal restrictions in two salt marshes. Pre-restoration vegetation monitoring was also conducted at a site that will be the largest tidal restoration in the Gulf of Maine when it is completed. The number of years of salt marsh vegetation monitoring data varies by marsh system, with 1997 being the earliest year of monitoring data for Hatches Harbor, which continues to recover after the removal of a tidal restriction in 1999. In 2008 monitoring at five additional salt marshes was implemented, with a total of 22 new transects and 150 new plots.
- Continued monitoring and research on salt marsh dieback at three sites that have experienced significant loss of salt marsh grasses. The loss of vegetation is ongoing and progressive rather than sudden and both crab herbivory and changes in hydrology are suspected to drive the loss of salt marsh hay, *Spartina patens*.
- Monitored nekton in a large salt marsh system that has never been subject to tidal restrictions. One species that has never been encountered in this type of sampling was recorded.
- Used GPS to collect high tide shoreline position information in the fall and spring in accordance with the NCBN ocean shoreline position vital sign protocol. In addition, the position of bluff toe/dune toe/vegetation edge was collected as part of the CACO geomorphology protocol development project.
- Completed a sixth year of amphibian monitoring including vernal pond egg mass counts, anuran calling surveys and water quality and hydrology assessment at vernal ponds. Amphibians typically exhibit a high degree of interannual variability, and 2008 had the highest site occupancy rate for bullfrogs but the lowest green frogs. For all eight species

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assessed in the calling surveys, the 2008 indicates that population fluctuations are likely within the normal range and no species has undergone a sustained decline since the calling survey was initiated in 2003.

- Presented the results of a parkwide survey of four-toed salamanders at the Cape Cod Natural History Conference.
- The coastal forest monitoring protocol was forwarded to the regional I&M coordinator for additional peer review and a draft pond vegetation monitoring protocol was also completed and is ready for peer review. CACO staff continue to work with non-park staff scientists that were contracted to write a land bird monitoring protocol and a meso-mammal protocol to receive full first drafts.
- Air quality was monitored through the National Atmospheric Deposition Program (precipitation and atmospheric deposition), the Mercury Deposition Network, the Interagency Monitoring of Protected Visual Environments program (aerosols), and an ozone monitoring partnership with the Commonwealth of Massachusetts.
- Groundwater levels and pond stage were monitored in accordance with the hydrology protocol.
- Communicated the results of monitoring and directed research through interpreter training, leading interpretive programs and furnishing material the park newspaper and website. Resource Briefs (short summaries of monitoring results with accompanying figures) were also drafted for sediment elevation monitoring, salt marsh vegetation monitoring, amphibian monitoring, tidal restoration planning and air quality monitoring. Numerous technical reports and scientific publications were prepared and presentations were given at a wide variety of forums including: community groups, workshops, schools and universities, and scientific meetings.
- Continued to build technical expertise and workforce capacity that promotes consistency in project implementation by filling the vacant Research and Monitoring Coordinator position, creating a permanent hydrology technician position and replacing the vacated aquatic ecology technician position.

Water Quality Monitoring

- Continued the second year of implementation of the estuarine nutrient enrichment protocol. In partnership with the NCBN and the Atlantic Research Center, analyzed chlorophyll samples from similar sampling at three other network parks.
- NCBN tested a new spatial design for baywide seagrass monitoring in CACO.
- Expanded application of instrumentation (YSIs and HOBOS) used for the estuarine nutrient enrichment protocol to other estuarine systems that are experiencing dramatic changes such as salt marsh dieback or tidal restoration. Factors monitored included: water quality, water level recording and tidal inundation data.
- Collected bi-monthly water quality data for 20 kettle ponds; an optical probe was added to the instrumentation which provides measurements of chlorophyll in a depth profile.

Public Interest Highlights

Techniques used in long-term ground and surface monitoring were adapted in support of computer modeling of Beach Point groundwater

East Harbor, a 350-acre back barrier coastal lagoon, has been monitored following a summer-time dissolved oxygen depletion and fish kill in 2001. There is concern that increased development of the adjacent Beach Point barrier beach could affect water quality in the East Harbor lagoon. As the development increases, water use and septic effluent increases. Computer modeling of Beach Point groundwater was conducted in FY2008 by Larry Martin of the Water Resources Division. The modeling was performed to evaluate the potential for groundwater to flow toward, and discharge to, the East Harbor lagoon. The results were surprising, not only does the groundwater table in the barrier beach fluctuate in response to the Cape Cod Bay tides, the simulations of groundwater flow show that the net flow is towards Cape Cod Bay and not the lagoon. Further computer modeling showed that septic effluent, along with any other contaminants that might be introduced to the groundwater system from the developed strip of barrier beach will always flow toward Cape Cod Bay and not the lagoon.

Importance of temperature regimes in tidal restoration assessment- thermal limitation of a major herbivore destabilizes tidal lagoon community

East Harbor (Truro, Massachusetts) is a tidally-restricted salt marsh lagoon that has undergone partial restoration since 2002. After re-introducing seawater to the system after nearly 140 years of impoundment, remarkable transformations in plant and animal communities have occurred that have been captured in the long term vegetation and nekton monitoring programs. In the past several years, however, macroalgae (particularly *Ulva intestinalis*) has proliferated and caused a number of problems - including losses of seagrass and bottom-water anoxia leading to shellfish mortality. While a host of marine fish, crustaceans, and other benthic invertebrates have become established throughout the system, an important herbivore, *Littorina littorea* (common periwinkle), has been notably absent. Although *L. littorea* successfully colonized the main tidal creek that connects the open lagoon with Cape Cod Bay, it is absent throughout the open lagoon. Thermal tolerance bioassays using individuals from the tidal creek suggest a lethal high-temperature limit of ~27-30°C and data from *in situ* temperature loggers show that this threshold is exceeded in many parts of the system during July and August. Moreover, intensive deployment of temperature loggers in combination with water quality monitoring instruments indicate there is a well-defined spatial gradient in temperature that corresponds with the presence/absence of *L. littorea*. Further enhancement of tidal exchange could lower water temperatures throughout East Harbor and allow this species to greatly expand its range, with the potential to significantly reduce the extent of macroalgae biomass as indicated by grazing experiments conducted during the summer of 2008. This study highlights the importance of temperature in system responses to tidal restoration.

Synergism between physical disturbance due to herbivory and altered hydrology responsible for high marsh dieback

Dieback of high marsh species in salt marshes of outer Cape Cod was discovered as a result of salt marsh vegetation monitoring and reported in 2003. The loss of *Spartina patens* (salt marsh hay) in particular has been extremely rapid, leaving large, bare areas in its place. Analysis of aerial photography has revealed that these losses have been occurring for at least 2 decades and consistently occur along the seaward edge of the high marsh zone - indicating a link with hydrology. However, high marsh dieback only occurs in marshes with high levels of disturbance in the form of crab herbivory, ice scour, and/or large accumulations of wrack. In the summer of 2008, manipulative field experiments and hydrologic monitoring were conducted to test the

hypothesis that flooding stress is acting synergistically with physical disturbance to cause plant mortality. The data revealed that areas with high marsh vegetation loss are flooded more regularly and for longer periods of time than unaffected marshes. In addition, *S. patens* in these areas had a reduced ability to recover from simulated disturbance compared with plants in unaffected marshes. These preliminary results support the premise that multiple stresses are responsible for the disappearing high marsh at CACO.

Coastal Barrier Beach Breach Continues to Improve Estuarine Habitat

In April 2007, a powerful northeast storm created a breach of the coastal barrier dune approximately 65 feet wide located east of Pleasant Bay in Chatham at the southern extent of CACO. As a result of this breach, increased flushing of Pleasant Bay by cold, nutrient poor Atlantic Ocean water continues to occur resulting in increased tide heights and dramatic improvements to water clarity and submerged aquatic vegetation habitat, as documented with the estuarine nutrient enrichment monitoring. Water clarity measurements in August 2007, as compared to August 2006, from continuous PAR sensors placed in Pleasant Bay northwest of the breach at our submerged aquatic vegetation monitoring site established by USGS, indicate an approximate 30% increase in light penetration. Measurements for clarity in 2008 continue to show increased light penetration and this year's surveys of the seagrass *Zostera marina* from the estuarine nutrient enrichment protocol indicate increased fecundity and vigor throughout Pleasant Bay and Little Pleasant Bay.

Chatham Breach Used as Case Study for Coastal Management and Planning

CACO presented a breach management and response case study to Regional NPS and Army Corps of Engineers (ACOE) staff. On May 1, 2008, NER Regional Scientist Mary Foley convened a forum with ACOE engineers from throughout the eastern US. CACO GIS specialist Mark Adams and cooperative researcher Graham Giese (Provincetown Center for Coastal Studies) presented a case study of monitoring and management response to the Chatham Nauset Beach inlet formation (April 17, 2007- April 30, 2008). Giese and Adams' monitoring efforts incorporated inventory and monitoring GPS shoreline change survey data, historical photo/LIDAR interpretation and additional profile survey data to present a picture of geologic change within a barrier/embayment that has management implications for NPS and many other federal, state and local agencies. These issues are keenly followed by the general public. Important survey parameters such as high tide stations, barrier beach width, rates of spit formation, sediment transport volumes and tidal phase differences have been captured by the prototype monitoring program and associated studies. Monitoring data from the Chatham event shed new light on previous cyclic models of barrier/embayment morphological change. Hypotheses about the effects of sea level change and sediment supply were discussed as well as recommendations for future monitoring parameters that will assist decision makers. The Chatham case study will inform management in other NPS units where coastal change creates management challenges because of high private property values and complicated federal/state/local jurisdictions (e.g. FIIS). The forum will also influence further policy agreements between the NPS and ACOE about when and if intervention in natural coastal processes is warranted.

Vegetation mapping as essential component for tidal restoration project modeling.

The CACO prototype monitoring 2000 vegetation map provided input to hydrologic modeling for the development of alternatives for tidal restoration in Wellfleet's Herring River. The Herring River restoration project is potentially one of the largest wetland restorations in the northeastern US. Vegetation GIS polygons from the 2000 vegetation map were refined, attributes added and critical sites selected as baseline observations for habitat changes that hydrologists will use for testing their model. Sites chosen reflect both the National Vegetation Classification System types (developed by NatureServe) as well as attributes for altered habitats such as upland woodland types that now occupy former floodplains. Adaptive management and permitting processes will weigh land cover types resulting from changed conditions, e.g. uplands may become marsh, freshwater marsh may become tidal marsh, tidal cycles may be reintroduced to freshwater bogs. The 2000 vegetation map and field observation data provided the best available land cover information for existing conditions for the restoration NEPA process. Future vegetation mapping will coincide with an implemented restoration alternative and will further inform adaptive management.

Vernal Pond Amphibian Monitoring Provides Insight into Significance of Cape Cod National Seashore for Spotted Salamanders

Since they began in 2002, counts of spotted salamander egg masses in CACO vernal ponds have indicated a widespread and abundant population of this ecologically important amphibian. In 2008, egg masses were found in 30 of the 39 ponds. The overall average amount of egg masses was 184 egg masses/pond for all 39 ponds, which increases to 239/pond when the nine ponds that did not contain egg masses are excluded. Compared to similar studies elsewhere in the Northeast, CACO spotted salamanders consistently have higher occupancy rates and egg mass counts, indicating the park harbors a relatively robust population. Landscape analysis throughout the Northeast U.S. has shown that the ideal landscape for spotted salamanders is non-urbanized, non-fragmented, roadless, and forested with well drained soils, moderately hilly topography and many long hydroperiod vernal ponds. This describes much of the CACO landscape, particularly the Eastham vernal pond area. This complex of ponds in close proximity, with varied hydroperiods and many supporting large numbers of spotted salamanders, appears to be exceptional habitat for spotted salamanders.

Volatility in Annual Wood Frog Egg Mass Counts Highlights Need For Long Term Monitoring

After a Cape Cod National Seashore record of 270 wood frog egg masses in 2007, a record low, 30, was recorded in 2008. However, an analysis based on data going back to the start of this monitoring program in 2002 indicates a positive long term trend, with a slope of 0.312, and no evidence to suggest a decline is occurring. Wood frogs breed in vernal ponds where both amount of egg laying and the success of these breeding efforts can vary greatly in response to variation in rainfall and groundwater levels. This natural variability in the size of wood frog populations underscores the challenge of monitoring the status of amphibian populations and underscores the importance of long term data to document inter-annual variability.

I. Overview and Objectives

Cape Cod National Seashore was established as a prototype park for the NPS long term ecosystem monitoring program in 1996. Encompassing four major ecosystem types (marine, estuarine, freshwater and terrestrial) with a wide variety of habitats nested within these ecosystems, CACO's 44,600 acres are well suited to encompass the range of habitat and ecosystem diversity contained in other parks within the Atlantic and Gulf Coast biogeographic region. As a prototype park, CACO's scientific staff are responsible for implementing a scientifically rigorous monitoring program and for developing protocols that can be used by other parks within the Northeast Coastal and Barrier Network and within the larger region as well. In addition, CACO staff conduct special studies aimed at furthering our understanding of results observed during regular monitoring.

The approach to monitoring at CACO is based on Roman and Barrett's 1999 report *Conceptual Framework for the Development of Long-term Monitoring Protocols at Cape Cod National Seashore* as well as an update published in 2002 by Boland *et al.* These documents outline the ecosystem based and issue oriented approach to monitoring. A prioritization and implementation scheme, *2003 Cape Cod National Seashore LTEM Project Prioritization*, by Phillips (2003) was written to allow for phased in approach as program capacity grows.

CACO's integrated monitoring objectives are:

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.

CACO's funding structure for the prototype monitoring program does not include separate funding for water quality monitoring. Objectives 1 and 3 include water quality monitoring (e.g. kettle pond and estuarine nutrient enrichment) as applicable under Servicewide Strategic Goal 1a4e: Water Quality Protection, Restoration, and Monitoring.

CACO's inventory and monitoring program benefits greatly another Natural Resource Challenge program, the Atlantic Research Center (ARC). Through the ARC, CACO provides facilities for visiting researchers including housing, equipment and analytical services. In many cases, the visiting researchers benefit from and leverage the long term monitoring data collected by CACO staff, leading to projects that have direct benefits for natural resource management in the park and the larger region. Examples of these Natural Resource Programs enhancing one another include:

- Five graduate and one undergraduate student's research was supported by monitoring data, technical expertise of monitoring program staff, and the housing, lab and field facilities of the ARC. The students' research topics ranged from tracking changes in plant and invertebrate communities following tidal restoration, to understanding the role

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of crab herbivory in salt marsh dieback to furthering our knowledge of the ecology of the threatened spadefoot toad (*Scaphiopus h. holbrooki*), all of which are of interest and relevance to natural resource management at CACO.

- Long term housing from the ARC program in combination with technical assistance from prototype monitoring staff facilitated research by a community college faculty member studying factors influencing habitat use and reproductive success in Fowler's toad.
- Field assistance from prototype monitoring biotechs, in addition short term housing from the ARC program aided USGS cooperators Hilary Neckles and Blaine Kopp to implement the seagrass portion of the estuarine nutrient enrichment protocol.

II. Accomplishments (FY2008) and Scheduled Activities (FY2009)

Inventories

FY2008 Accomplishments:

- Continued to provide technical assistance and report compilation for amphibian and reptile inventories at NCBN and NETN parks.
- Provided NatureServe with the remaining images, metadata and related files for completing the CACO vegetation map.

Scheduled FY2009 Activities:

- Review, as needed, documents and maps provided by NatureServe for completing CACO's vegetation map.

Vital Signs Monitoring and Water Quality Monitoring

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. Specifically, the water quality monitoring that is being used for restoration planning for the Herring River contributes to NPS Strategic Plan Goal Ia4 because the restricted portion of the system does not meet water quality standards for metals and acidity.

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

FY2008 Accomplishments:

- In accordance with the salt marsh sediment monitoring protocol (Cahoon et al., 2006), 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. Data were collected in both fall and spring. 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 2008 were incorporated in a system-specific report for Hatches Harbor and Herring River salt marsh dieback sites.
- Elevations at 3 of the Herring River SET sites were measured with a Real Time Kinematic Trimble unit. A new periodic monitoring element, SET mount elevations, was discussed due to potential for changes in the mount elevations to occur via ice or other physical damage.
- Completed quality assurance and quality check of all SET data from 1998 to present.
- Continued to document the data management procedures and database entities in a Standard Operating Procedure as an appendix to the protocol document.

Scheduled FY2009 Activities:

- In FY2009, 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). Data for all sites except the Herring River Gut

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will only be collected during the spring 2009 sampling period due to a temporary staffing shortage.

- We will continue to communicate with Drs. Don Cahoon and Charley Roman to assess whether continued monitoring of the salt marsh pool sites in Nauset Marsh is feasible and worthwhile. This determination will be facilitated after the preliminary SET report is written, scheduled for the spring of FY09.
- SET mount elevations will continue to be measured as equipment (Real Time Kinematic Trimble) and staff resources allow. Knowledge of the absolute elevations of the SET mounts will provide a valuable baseline to monitor changes due to ice or other physical damage.
- We will assess the utility of adding periodic checks of the elevations of the SET mounts to the SET protocol.
- Sediment elevation data collected in 2009 will be incorporated in a system-specific report for Hatches Harbor and other reports for other restoration or research areas (e.g. Herring River EIS).
- All SET data for Hatches Harbor from 1998 to present will be incorporated into an internal NPS Technical Report to begin development in FY09.
- 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 monitoring erosion at wetland dieback monitoring sites at Lieutenant Island, Middle Meadow and the Herring River Gut site.

Task 1.2-Monitor estuarine nutrient enrichment

FY2008 Accomplishments:

- In partnership with volunteers from the town of Orleans Water Quality Task Force (WQTF), the NCBN Estuarine Nutrient Enrichment Protocol (Kopp and Neckles, 2007) was implemented (excluding sediment sampling) at CACO. Ancillary data and data interpretation for the FY08 field season will be provided by the Pleasant Bay Alliance, USGS, NCBN, the Town of Orleans WQTF, and the Town of Eastham Department of Natural Resources.
- 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 at Pleasant Bay and Duck Harbor, and sampling and analysis for chlorophyll-a in Pleasant Bay, Nauset Marsh, and surrounding kettle pond strata.
- Chlorophyll samples were analyzed from CACO, ASIS, COLO, and GATE.
- 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.
- Ancillary data and data interpretation will also be provided for the FY08 field season by the Pleasant Bay Alliance, USGS, NCBN, the Town of Orleans WQTF, and the Town of Eastham Department of Natural Resources.
- Supplied USGS with all data for network wide interim report.

Scheduled FY2009 Activities:

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- Implement the 4th year of Estuarine Nutrient Enrichment (ENE) monitoring. This will involve the collection of the full compliment of data (including sediment sampling) as described in the NCBN protocol (Kopp and Neckles, 2007) in three strata: Pleasant Bay, Nauset Marsh, and surrounding kettle ponds.
- Continue to share staff with the NCBN for 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.
- Dennis Skidds and Eric Endrualt, NCBN, have developed a comprehensive database and user's manual for seagrass and water quality monitoring. We will begin populating the database in FY2009.

Task 1.3 - Monitor salt marsh vegetation

FY2008 Accomplishments:

- Conducted vegetation monitoring at Hatches Harbor and East Harbor as a follow up to tidal restoration efforts.
- Conducted vegetation monitoring at a proposed tidal restoration project in the Herring River (upstream of the restoration site) and in the Herring River Gut (seaward of the restoration site).
- Continued vegetation monitoring at the West End marsh, Pleasant Bay, Nauset Marsh, Middle Meadow and Jeremy Marsh.
- This monitoring included 22 new transects and 150 new plots.
- Continued field monitoring and research on salt marsh dieback at Lieutenant Island, the Herring River Gut site and Middle Meadow.
- Conducted field research on macroalgae growth in East Harbor

Scheduled FY2009 Activities

- Conduct vegetation surveys in Hatches Harbor and East Harbor; continue salt marsh dieback field research and monitoring.

Task 1.4 - Monitor estuarine benthos and nekton

FY2008 Accomplishments:

- Continued monitoring nekton in the East Harbor, Moon Pond and Hatches Harbor estuarine systems.
- Continued nekton monitoring in Nauset marsh. This was the fifth consecutive year of nekton monitoring in the five-year monitoring effort to improve estimates of annual variability in order to refine sampling frequency as recommended in the CACO protocol.
- Provided technical support to Jody Wennemer, a graduate student from Antioch College, studying relationship between molluscs and submerged aquatic vegetation in East Harbor and Moon Pond.

Scheduled FY2009 Activities

- Continue to monitor nekton response to restored East Harbor, Moon Pond and Hatches Harbor.

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- With new aquatic ecologist, analyze existing nekton data to optimize sampling frequency for reference and restored salt marshes.
- Support refinements in data management methods and statistical analysis of nekton data with NCBN.
- Continue testing methods for reliable monitoring of areas of East Harbor and Hatches Harbor not supported by the existing protocol.
- Examine feasibility of adding additional sites salt marsh sites (e.g. Middle Meadow, Jeremy Marsh, West End Marsh) for nekton monitoring, including pre-restoration monitoring for the Herring River.
- Provide guidance and technical assistance to URI Ph.D. student studying relationship between nekton and *Phragmites australis*.
- Serve as committee member for Jody Wennemer's masters thesis, providing guidance and technical assistance as necessary.

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.

CACO proposes implementing the NCBN Ocean Shoreline Position protocol. In addition to shore line position, CACO is collecting field data for dune/bluff morphology and edge of vegetation (portions of the second and third priority vital signs).

FY2008 Accomplishments:

- Collected high tide (vital sign 1) shorelines by GPS in fall 2007 and spring 2008. Collected partial bluff toe/dune toe/vegetation edge GPS lines in spring 2008.
- Collected bluff toe GPS lines in 2005, 2007 and 2008 (between Eastham Coast Guard Beach and Head of the Meadow Beach, Truro) and for dune toe/vegetation edge in 2008 (between Head of the Meadow and Long Point, Provincetown). Additional vital signs such as overwash fans, breaches and floodplains, artificial structures, and near-shore bathymetry and tide levels will also be incorporated into CACO's draft protocol at intervals of 5-10 years. CACO has collected preliminary data for each of these vital signs.

Scheduled FY2009 Activities:

- Complete data collection for shorelines and bluff/dune toes for fall 2008 and spring 2009. Edit and refine metadata and prepare field data forms. Extract comparable features from 2005 LIDAR and other LIDAR data sources from USGS/NASA.
- Write draft field methods to mirror NCBN coastal change SOPs with details local to CACO.
- Extract elevation profiles from 2005 LIDAR data for the 229 Marindin stations (at 300 meter intervals). These profiles will include 3D feature points for berm, bluff/dune toe, and bluff/dune crest and, where applicable, back barrier marsh edge. These profiles are also the subject of 3D surveys within a separate study (PMIS 105313) that will lead to additional coastal change monitoring proposals.

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- Formalize data acquisition methods for overwash fans, breaches and floodplains, artificial structures, near-shore bathymetry and tide levels based on field experience and preliminary data.

Task 2.2 - Monitor beach and barrier island nesting birds

FY2008 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 FY2009 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. One of the ponds included in the kettle pond water quality monitoring program is Ryder Pond, whose nutrient levels in the past did not meet surface water quality standards, thus CACO's monitoring in this pond specifically contribute to NPS's Strategic Plan Goal Ia4E.

Task 3.1 - Monitor kettle pond water quality and limnology

FY2008 Accomplishments

- Continued to collect bi-monthly water quality data from 20 kettle ponds, following the 2003 KPWQ Monitoring protocol (Portnoy *et al.* 2003).
- Added an optical chlorophyll probe to instrumentation used to obtain temperature and light profile data. Chlorophyll data is now obtained at the surface via two methods and in a depth profile via the optical probe.
- Following recommendations for original kettle pond monitoring protocol (Portnoy *et al.* 1993), collected phytoplankton at 0.1 m depth and mounted permanently onto slides for later identification.
- Dissolved inorganic nitrogen and phosphate were analyzed in-house for spring samples and both were below detection limits.
- Documented changes to the sampling protocol resulting from addition of chlorophyll probe and phytoplankton sampling.

Scheduled FY2009 Activities:

- Continue to collect water quality data from kettle ponds following the 2003 protocol incorporating changes and additions to the protocol.
- With new aquatic ecologist, revisit the kettle pond water quality data and apply recent data to answer questions posed in the protocol. Compose a draft technical report and outreach material (e.g. poster, resource brief) summarizing key questions answered with the data set. If warranted, prepare a scientific publication.

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- With the new aquatic ecologist, analyze temperature profiles for all ponds to compare and examine contributing role of climatic forcing. Prepare a summary for outreach and interpretative purposes. If warranted, prepare a scientific publication.
- Evaluate the appropriateness of the 303d listing (based on excessive nutrients, organic enrichment and low dissolved oxygen) for Ryder Pond and provide an update to the Commonwealth of Massachusetts' Department of Environmental Protection.

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

Scheduled FY2009 Activities:

- Re-survey dune slack wetlands that were initially characterized in 2004; expand and improve existing draft monitoring protocol for this ecosystem type.

Task 3.3 - Monitor pond vegetation

FY2008 Accomplishments

- Completed report on Province Lands ponds vegetation monitoring.
- Completed the draft pond vegetation monitoring protocol for peer review.
- Continued monitoring and assessment of bio-control of purple loosestrife (*Lythrum salicaria*) in 2008.

Scheduled FY2009 Activities:

- Continue to evaluate the impacts of *Galerucella* beetles on purple loosestrife in Great Pond (Beech Forest).
- With assistance from the data manager, finish writing the data handling and reporting section of the protocol to comply with recommendations from Oakley *et al.* (2003).
- Make revisions to protocol based on comments from NPS staff and, if returned within the fiscal year, outside reviewers.

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

FY2008 Accomplishments:

- Reviewed Elizabeth Colburn's (Harvard Forest) draft report and protocol provided comments.

Scheduled FY2009 Activities:

- Follow up with Dr. Colburn to get revised version in Oakley *et al.* (2003) format and when completed, forward to the Regional I&M Coordinator for peer review.

Task 3.5 - Inventory and monitor amphibians

FY2008 Accomplishments:

- Conducted the sixth year of long term amphibian monitoring according to the protocol (Paton *et al.* 2003). This program consists of vernal pond egg mass counts, anuran calling surveys, and habitat monitoring activities as follows:
- Counted egg masses of spotted salamanders and wood frogs three times at each of 40 vernal ponds over a six week period in early spring. Data on within-pond habitat structure were also collected.
- Sampled thirty ponds park-wide for calling anurans one night/week for 16 weeks, from mid-spring until mid-summer.

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- Collected water samples from all 64 amphibian monitoring sites and analyzed at the NACL (North Atlantic Coastal Laboratory) for pH, alkalinity, conductivity, color, chloride, and sulfate.
- Collected and entered hydrology data (pond stage) monthly at all 40 vernal ponds being monitored.
- Entered and proofed all 2008 data, did preliminary tabulation and trend analysis of all long term data on egg mass counts and estimated site occupancy rates for anurans through 2008.
- Completed data analysis from a parkwide survey (2006-2007 field seasons) of four-toed salamanders (*Hemidactylium scutatum*). Observations were related to the salamander's distribution, abundance, and breeding habitat use. Survey data are being used to assist planning and environmental assessment of proposed tidal restoration projects. Results of this analysis were presented at the 2008 Cape Cod Natural History conference, and are currently available in Powerpoint format. A written final Natural Resource Technical report is planned.
- Provided a second year of technical and logistic support to Megan McLean and advisor, Dr. Rachel Thiet of Antioch College, New England for a study of Eastern spadefoot toad (*Scaphiopus h. holbrooki*) activity on Provincelands 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 technical and logistical support and field assistance to Brad Timm, Ph.D. student and Dr. Kevin McGarigal, University of Massachusetts for a study of Eastern spadefoot toad habitat use and movements at CACO. FY2008 was the fourth year of this project, which has been hampered by lack of rain in 2007 and 2008. 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 were critical to development of the successful proposal.
- Collaborated with Dr. Peter Paton (University of Rhode Island) and Dr. Todd Tupper (Northern Virginia Community College) to analyze six year's anuran calling survey data (2001, 2003-2007) collected jointly by CACO staff and Dr. Tupper. The first paper focuses on methodological aspects of this work, including adequacy of sampling. A preliminary draft entitled "Temporal variation in anuran detection probabilities at Cape Cod National Seashore: implications for long-term monitoring" is currently being revised for submission to Copeia. A second paper, focused on habitat factors affecting site occupancy rates will follow.

Scheduled FY2009 Activities:

- Implement the seventh year of amphibian monitoring and related activities as described above.
- Continue to provide technical assistance for both McLean and Timm spadefoot toad studies. FY2009 activity will consist primarily of providing assistance with analysis and review of draft reports, thesis, and dissertation.
- Complete manuscript on "Temporal variation in anuran detection probabilities at CACO" and submit to Copeia.

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Task 3.6 - Inventory and monitor aquatic turtles

FY2008 Accomplishments:

- Continued monitoring spotted turtles through incidental encounters. Two individuals, last captured and marked in 2000 and 2001 were recaptured. The first had moved to another pond, about 600 meters away. The second was found in the same wetland as previously, about 110 meters from its location in 2001.

Scheduled FY2009 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 objective 4 contribute to GPRA Goals Ia1A and Ia1H.

FY2008 Accomplishments

Task 4.1 - Monitor coastal forest vegetation

- Submitted the coastal forest vegetation monitoring protocol to the Regional I&M coordinator for additional outside peer review.

Scheduled FY2009 Activities:

- Make revisions to protocol based on comments from outside reviewers

Task 4.4 – Inventory terrestrial reptiles

FY2008 Accomplishments:

- Continued inventory of eastern box turtles and eastern hog-nosed snake through incidental encounters. In FY 2008 there were 61 box turtle records and 4 hog-nosed snake records. Inventory includes marking for future recognition, collecting data on size, weight, age, sex, and location, and photo-documentation.

Scheduled FY2009 Activities

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

Task 4.5 - Monitor land birds

FY2008 Accomplishments:

- Received partial report from Mark Faherty, University of Massachusetts, Amherst on landbird point count surveys. Continued to work with Faherty to guide and facilitate completion of report and protocol.

Scheduled FY2009 Activities:

- Continue to work with Mark Faherty to complete first draft of report and make it comply with Oakley *et al.* (2003) format. This project was initiated through a cooperative agreement with UMass in FY2000.

Task 4.7 - Develop a protocol for long-term meso-mammal monitoring

FY2008 Accomplishments:

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- 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 are being drafted.

Scheduled FY2009 Activities:

- A draft monitoring protocol in Oakley *et al.* (2003) format is expected in early FY2009. CACO staff will 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 described for objective 5 contribute to GPRA Goals Ia1H, Ia1D, Ia3, and Ia4C.

Task 5.1 - Monitor meteorologic, atmospheric deposition, and air quality parameters

FY2008 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 updating all data source links for the meteorological and atmospheric monitoring protocol (USGS, URI, CACO 2001).
- Precipitation data used in conjunction with monitoring for the national programs listed above was entered into an hourly database for use for other projects.

Scheduled FY2009 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

FY2008 Accomplishments:

- Continued implementation of the ground water and pond stage portion of the hydrology monitoring protocol (McCobb and Weiskel, 2003), including the six observation wells that were added in FY07.
- Finalized a map for Cape Cod National Seashore observation well network.
- Began to quality assure and quality check all water level data from 2000 to the present (20% completed).

Scheduled FY2009 Activities:

- Continued implementation of the ground-water and pond-stage portion of the hydrology monitoring protocol.
- Continue archiving and developing data transfer protocols for observation well and the pond-stage portion of the protocol.

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- Continue to document the data management methods into a formal procedure to accompany the refinements of the field methods.
- Continue to 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 cover type map and develop long term approach for cover type change monitoring.

FY2008 Accomplishments:

- CACO prepared final versions of vegetation shapefiles for the 2000 vegetation mapping project along with compressed orthophotos and associated metadata. Additional spatial and attribute editing was required to conform with NCBN recommendations. Final files and text documenting the process have been submitted to Natureserve contractors for review by North Carolina State University cooperators.
- CACO has been testing methods for remotely sensed vegetation cover type mapping via an agreement with cooperating researcher Brad Timm of U Mass Amherst. The method uses multiple forms of remote sensing imagery such as the freely available MassGIS digital ortho photo geotiffs (four spectral bands: R,G,B & IR) as well as similar satellite data from Digital Globe (QuickBird). Brad Timm tested the Random Forests method in heathlands/dunelands communities of the Province Lands, collecting hundreds of field observations and classifying them using the Virtual Forests R statistical routines. Preliminary accuracy estimates exceed the 80% standard used in traditional photogrametric vegetation interpretation

Scheduled FY2009 Activities:

- Work with cooperator Brad Timm to implement vegetation/habitat classification for estuaries and other wetland types using existing QuickBird imagery and MassGIS Geotiffs. Acquire current Quickbird imagery for 2008 as available. Continue to refine Random Forests method.

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

Task 6.1 - Enhance commonalities and coordination among protocols

FY2008 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
 - Used water level recorders in 6 observation wells on Beach Point in collaboration with Tom Camberari (Cape Cod Commission) and Larry Martin (NPS) to obtain a continuous time series of water level data.

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

Scheduled FY2009 Activities:

- Continue to build on the comprehensive field and lab procedure for water quality instruments to increase efficiency, promote consistency, and ensure data quality.
- Continue developing a data management procedure to include in the comprehensive field and lab procedure document.
- Continue to maximize use of existing instrumentation to support multiple monitoring and studies.

Task 6.2 - Integrate analysis of monitoring results

FY2008 Accomplishments:

- Wrote synthesis of monitoring results for 2007 for Hatches Harbor and East Harbor.

Scheduled FY2009 Activities:

- Write synthesis of monitoring results for 2008 for Hatches Harbor and East Harbor.

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

Task 7.1 – Share information with non-technical audiences

FY2008 Accomplishments:

- Wrote text and provided figures for a resource brief for long-term monitoring of sediment elevation, salt marsh vegetation, tidal restoration, amphibian monitoring and air quality monitoring.
- Oral presentation and field trip with general public and park historian, Bill Burke, on Fort Hill cultural and natural resources restoration
- Led two nighttime walks for “In the Field with a Park Scientist” on anuran calling surveys.
- Wrote “Snakes of Cape Cod National Seashore” for CACO newspaper.
- Updated “Amphibians and reptiles of Cape Cod National Seashore” on CACO website and created several webpages documenting changes in biota since East Harbor restoration.
- Gave presentation on small mammal inventory and monitoring at CACO to biology class at Nauset Regional high school.
- Spoke with three reporters for local newspapers resulting in two articles on spadefoot toads in Provincetown and one article about spring peepers on Cape Cod.
- Wrote and issued press release on spadefoot toad management issues at CACO and research being conducted to address them.
- Worked with Alison Argo, a documentary filmmaker, to facilitate filming of amphibian monitoring and management activities at CACO for an upcoming PBS Nature Series on amphibian declines.
- Responded to public phone and e-mail contacts requesting information on various aspects of park natural resources such as snakes, turtles, mammals, and birds.
- Provided CACO interpreters with updated list of CACO mammals and assisted with their adaptation of it for public distribution.

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- Provided CACO interpreters with information on predator-prey relations and meso-mammals for use in interpretive program development.
- Provided USFWS staff at Monomoy National Wildlife Refuge (NWR) with information on Cape Cod amphibians and reptiles and provided guidance on interpretive display for species likely to occur at Monomoy NWR.
- Presented “Chatham 2007 Barrier Breach and Long Shore Sediment Transport” to Chatham Historical Society. January 2008 and Chatham Pleasant Bay Alliance Symposium II, June 2008. (Mark Adams, Graham, Giese).
- Guided a field trip for the Association of American Geographers on coastal orientation, wave exposure and expected future coastal change. (Mark Adams, Graham, Giese, John Portnoy, Bob Cook), April 2008.
- Held a workshop “Coastal survey and monitoring techniques”, Cape Cod Sea Camp teacher training. (Mark Adams and CACO education interpreters), April 2008.
- Conducted a technical workshop “NPS response to barrier beach breaches – a Chatham case study”. Participants included NER Regional Scientist Mary Foley and Army Corps of Engineers. (Mark Adams and Graham Giese), May 2008.
- Held a training session for CACO seasonal interpreters (all natural resource management and prototype monitoring staff), June 2008.
- Conducted a forum and discussion for “Portrait of a Coast” film screening, Highland Center Festival, Shoreline change, coastal management and community response. (Graham Giese and Mark Adams), August 2008.

Scheduled FY2009 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.
- Finish layout and production of resource briefs.

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

FY2008 Accomplishments:

- Presented a poster describing water quality monitoring with an autonomous underwater vehicle at the Estuarine Research Federation Conference in Rhode Island and the National Monitoring Conference in New Jersey. The poster was also presented at the Restore America’s Estuaries Conference in Rhode Island.
- Shared water quality data collected in Wellfleet Harbor with Barnstable County technicians (Diane Murphy) and senior scientists (Bill Walton) for long term monitoring of aquaculture resources.
- Shared total rainfall data with Department of Environmental Protection aquaculturists for fecal coliform monitoring and shellfish closure assessments.
- Gave a presentation, followed by extensive discussion, on developing long-term ecological monitoring programs for protected lands to a graduate class on ecological monitoring from UMass Amherst. Protocol design, development, and testing were a primary focus of the presentation and discussion.
- Posted journal articles and NPS Reports on CACO website.

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- Shared technical information on wetland restoration with other NPS personnel at Aquatic Resources Professionals meeting in Fort Collins, CO.
- Gave presentation “Distribution and abundance of four-toed salamanders at Cape Cod National Seashore at Cape Cod Natural History Conference.
- Provided information and project review re: wetlands, spadefoot toad, eastern box turtles and other threatened and endangered species to Denver Service Center for bike trail renovations and road construction on route 6 in Provincetown.
- Led field trip/discussion of CACO amphibian monitoring program with graduate students from University of Massachusetts, Amherst.
- Provided overview of CACO wildlife prototype monitoring activities and available data to Town of Truro Open Space Committee.
- Led field trip/discussion of spadefoot toad issues and research at CACO to from University of Massachusetts, Amherst’s Ecosystem Based Management class (Brad Timm).

Scheduled FY2009 Activities:

- Continue to share technical information through seasonal interpreter training, providing input to management on park projects, and as opportunities arise.
- Develop layout and formatting to complete resource briefs.
- Develop updated monitoring program web pages to be hosted within CACO web site and conforming to the new guidelines.
- Present preliminary analyses of nekton as indicators and ecosystem instability and during partial tidal restoration of East Harbor at 2009 George Wright Society meeting.
- Review, as needed, documents and maps provided by the Geological Resources Division for CACO’s geological inventory.

Task 7.3 - Document program methods, activities, and findings

Please also refer to Reports, Publications and Presentations section below where full citations are provided.

FY2008 Accomplishments:

- Completed the following reports, manuscripts, and peer-reviewed journal papers:
 - SAGA amphibian and reptile inventory (Cook *et al.*, in press)
 - FIIS amphibian and reptile inventory (Cook *et al.*, in review)
 - Variables influencing Fowler's toad breeding effort at CACO (Tupper and Cook, 2008)
 - Herptofaunal restoration in an urban landscape (GATE) (Cook, in press)
 - Annual report on tidal restoration at East Harbor (Portnoy *et al.*, 2008)
 - Annual report on tidal restoration at Hatches Harbor (Smith *et al.*, 2008)
 - Assessment of vegetation in Provincelands permanent freshwater ponds (Smith *et al.*, 2007)
 - Dune migration and wetland formation in the Provincelands (Forman *et al.*, 2008)
 - Effect of salt-killed vegetation on halophyte establishment following tidal restoration (Smith, 2007)
 - Plant community response to incremental hydrologic restoration (Smith *et al.*, in press)
 - Vegetation development in dune-slack wetlands (Smith *et al.*, 2008)

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- Multi-decadal changes in CACO salt marshes- vegetation loss, species shifts and geomorphic change (Smith, 2008)

Scheduled FY2009 Activities

The following protocols and protocol development reports, and inventory reports should be available for review in FY2009:

- draft landbird protocol or report (being prepared by UMass)
- draft meso-mammal protocol or report (being prepared by USGS)
- WIFL amphibian and reptile inventory
- SAHI amphibian and reptile inventory
- GATE amphibian and reptile inventory
- Temporal variation in anuran detection probabilities (Paton, Cook and Tupper)

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

FY2008 Accomplishments:

- Continued the analytical partnership with the NCBN to support implementation of the estuarine nutrient enrichment protocol.
- Began to develop a network of water quality instrument users in order to better serve coordination between protocols within the NCBN.
- Continued as lead investigator for the NPS-Wildlife Conservation Society inventory of Northeast Region amphibians and reptiles.
- Completed redrafting of preliminary amphibian and reptile inventory report on Fire Island National Seashore (FIIS), currently in review.
- Continued working on first draft of amphibian and reptile inventory reports for Gateway NRA (GATE), which is ca. 95% completed.
- Began redrafting of preliminary amphibian and reptile inventory report on William Floyd Estate (WIFL).
- Worked with Northern Temperate Network data manager to resolve problems and errors in SAGA and MORR amphibian and reptile inventory database.
- Presented results of GATE amphibian and reptile survey at World Congress of Herpetology, Manaus, Brazil.
- Finalized chapter on status of translocated populations of amphibians and reptiles at GATE, to be published in monograph “Urban Herpetology”
- Provided guidance to and reviewed proposals by staff of Gateway’s “Jamaica Bay Institute” for monitoring amphibians and reptiles, small mammals, and grassland birds on Floyd Bennett Field.
- Conducted a NPS methods workshop “RTK and GPS survey methods” for ASIS. Participants included staff from: FIIS, DEWA, ASIS and Rutgers University.
- Provided technical assistance for visiting researcher Rachel Hehre for “Historical Mapping of Changing Geomorphology of NER Coastal Parks”, Cheryl Hapke, PI – USGS. Provided equipment, technical support and logistics to URI cooperator Rachel Hehre for GPS surveys. Elevation monuments surveyed will be used for groundtruthing historical map data which track changes in coastal features.

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- Provided the laboratory facility, consumable supplies, and technical oversight (supported by the NCBN for chlorophyll- α analysis for the NCBN's implementation of the estuarine nutrient enrichment monitoring protocol at ASIS, COLO, and GATE.
- Supplied a list of CACO fish to Linda Fabre-Arnold, (NCBN) to support certification of the species list for NPSpecies.
- Hosted geologists from GRD, USGS and the Commonwealth of Massachusetts for a scoping session for the CACO geological resources inventory and provided feedback on project development as requested.

Scheduled FY2009 Activities:

- Continue the analytical partnership with the NCBN to support implementation of the estuarine nutrient enrichment protocol.
- Continue to provide technical and analytical assistance and support as opportunities arise.
- Continue as lead investigator for the NPS-Wildlife Conservation Society inventory of Northeast Region amphibians and reptiles. Activities in F2009 will continue to focus on finalizing reports:
 - Revise and finalize Fire Island National Seashore (FIIS)
 - Complete redrafting of William Floyd Estate (WIFL), Sagamore Hill NHS (SAHI), Gateway NRA (GATE).
 - Begin redrafting of Saratoga NHS (SARA), Minuteman NHS (MIMA), and Saugus Ironworks (SAIR).
 - Continue to provide technical, data management, and analytical assistance and support as needed
- Replace the new aquatic ecologist with Linda Fabre-Arnold as the contact person for CACO fish.

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

FY2008 Accomplishments:

- Provided technical assistance to University of Rhode Island and FIIS graduate students and scientists for water quality monitoring efforts and data collection.
- Provided advice to network in the form of written documentation on the advantages of visual estimate methodology in monitoring plant communities.
- Provided field support for seagrass monitoring by the MA Department of Environmental Protection and NOAA as well as for an atmospheric mercury deposition study by USGS.
- Provided technical assistance and laboratory analyses for water quality monitoring by non-profit groups, towns within CACO boundaries and USGS
- Provided technical assistance on porewater sulfides and nutrient analyses for visiting researcher studying East Harbor's benthic mollusks
- Provided Cape Cod Commission, Pond and Lake Sampling (PALS) organization with water samples and water profile data from six ponds.
- Provided the Massachusetts Natural Heritage and Endangered Species program with reports of all observations during FY2008 of state-listed threatened and endangered species at CACO.

Scheduled FY2009 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 comprehensive data management program.

FY2008 Accomplishments:

- Until the position of data manager is filled, CACO continues to manage data under the structure and server hardware configuration set up by our former data manager. Previous data sets are being archived on an accessible server with folders for programmatic information, protocol documents, databases and reports and publications.
- CACO staff have also started to scan reports for digital storage and web posting.
- Project managers manage project-specific data and current datasets (maintaining database input and verification and local backups via external hard disks, CDs and flash drives).
- As server file sharing has become more reliable for large files (raster data), GIS data has been partially standardized under an accessible GIS server so that all users can access and query the same base cartographic data.

Scheduled FY2009 Activities:

- Continue server maintenance, archiving and data backups.
- Hire data manager and revise data management plan including provisions for:
 - maintaining server, archiving and backups for all monitoring data,
 - refine and troubleshoot Access databases
 - develop new Access databases as needed.

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

FY2008 Accomplishments:

- The vacant Research & Monitoring Coordinator position was filled. This is a combined position coordinating both the Prototype Monitoring Program and the Atlantic Research Center.
- A permanent Hydrology Technician position was created and filled.
- The permanent Aquatic Ecology Technician position that was vacated in August was filled with a seasonal hire.
- Re-evaluated and revised the Aquatic Ecology Ecologist position that was vacated early in FY2008. This had been a GS-9 position based on the premise that CACO's GS-13 Ecologist would provide higher level expertise to the program while mentoring the GS-9 Aquatic Ecologist. In anticipation of the GS-13 Ecologist's retirement at the close of FY2008, we reassessed the needs of park management and the monitoring program with respect to aquatic ecology. As a result, we have redefined this position to be a Subject-To-Furlough GS-11 that will provide aquatic ecology expertise and assistance to park management in addition to performing monitoring program duties. Salary and support will be shared with the monitoring program providing 80-85% of the position's cost and CACO base funds providing 20-25%. The position has been approved by the Position Management Review Board.

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Scheduled FY2009 Activities:

- Fill the Aquatic Ecologist position as described above.
- Reassess current staffing structure relative to priority projects and existing expertise, and revise and fill the vacant Data Manager and Aquatic Ecology Technician positions accordingly.
- Recruit and fill 5 biotech positions and 4 Student Conservation Association interns for implementation of long term monitoring protocols.
- Assess whether the Aquatic Ecology technician position should be filled on a permanent basis, subject to furlough, to insure consistency in implementation of water quality and nekton monitoring programs.

Task 9.3 Secure an adequate work force to complete scheduled field and laboratory tasks.

FY2008 Accomplishments:

- Hired five seasonal BioTechs for the following projects:
 - amphibian monitoring
 - salt marsh vegetation monitoring
 - kettle pond water quality and salt marsh nekton monitoring
 - GIS support for a variety of monitoring and research projects.
- Recruited and supported four Student Conservation Association (SCA) volunteers for the amphibian, salt marsh vegetation, nekton, and kettle pond water quality monitoring projects.

Scheduled FY2009 Activities:

- Hire four seasonal BioTechs for monitoring: vegetation, amphibians, kettle pond water quality and nekton. In addition, hire a GIS tech to support on-going projects as well as a seasonal biotech for field and lab assistance with the estuarine nutrient enrichment monitoring.
- Recruit and support four Student Conservation Association interns, VIPs or other students to assist with amphibian monitoring, vegetation monitoring, water quality and nekton monitoring.
- Collaborate with the ARC to bring a URI Coastal Fellow or other student to begin evaluating effects of climate change and sea level rise on coastal and estuarine resources using a combination of GIS, LIDAR and field vegetation and elevation data.

III. Staffing

Inventory and Monitoring Staff (CACO)

The staff listed below all receive full or partial salary support from the prototype monitoring program funds.

Megan Tyrrell, Research and Monitoring Coordinator (started June 2008)

Robert Cook, Wildlife Ecologist

Stephen Smith, Plant Ecologist

Kelly C. Medeiros, Hydrology technician

Lisa Nicholson, Budget Tech

Krista Lee, Physical Scientist

Judith Oset, Physical Science technician

Michelle Galvin, Aquatic Ecology tech (left August 2008)

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Evan Gwilliam, Aquatic Ecologist (left October 2008)
Holly Bayley, Vegetation biotech (summer seasonal) and Aquatic Ecology tech (fall seasonal)
Sasha Greenspan, Amphibian monitoring biotech (seasonal)
Scott Buchanan, Amphibian monitoring biotech (seasonal)
Lena Rosa Curtis, Vegetation- Student Conservation Association (seasonal)
Fiana Shapiro, Amphibian monitoring- Student Conservation Association (seasonal)
Laura Evans, Water Quality monitoring- Student Conservation Association (seasonal)
Michael Molloy, Water Quality monitoring- Student Conservation Association (seasonal)
Claire Palmer, GIS tech (seasonal)

Natural Resource Management staff (CACO)

The staff listed below are part of the Division of Natural Resource Management, and each makes significant contributions to the prototype monitoring program but their salaries are supported by other funds.

Carrie Phillips, Division Chief
John Portnoy, Restoration Ecologist
Mark Adams, GIS specialist
Mary Hake, Plover and Colonial Waterbird BioTech
Katy Kughen, Plover and Colonial Waterbird BioTech

Contractors/Cooperators:

Dr. Larry Martin, Hydrologist, NPS Water Resources Division (Beach Point groundwater project)
Dr. Steve Forman, University of Illinois, Chicago (analysis of dunes landscape)
Dr. Mark Bertness, Brown University (role of marsh crabs in salt marsh vegetation loss)
Mark Faherty, University of Massachusetts, Amherst (landbird point-count protocol)
Dr. Curtice Griffin, University of Massachusetts, Amherst (landbird point-count protocol)
Dr. Kevin McGarigal, University of Massachusetts, Amherst (spadefoot toad ecology study)
Allan O'Connell, USGS, Patuxent Wildlife Research Center (meso-mammal protocol)
Brad Timm, University of Massachusetts, Amherst (spadefoot toad ecology study)
Dr. Todd Tupper, George Mason University (Fowler's toad study, analysis of anuran calling surveys)
Dr. Peter Paton, University of Rhode Island (analysis of anuran calling surveys)
Megan McLean, Antioch College of New England (spadefoot toad activity study)
Dr. Rachel Thiet, Antioch College of New England (spadefoot toad activity study)
Dr. Julie Ellis, Tufts University Cummings School of Veterinary Medicine (common eider die-off research)
Dr. Graham Giese, Provincetown Center for Coastal Studies (shoreline change)
Dr. Hilary Neckles, USGS Patuxent Wildlife Research Center (seagrass monitoring)
Dr. Blaine Kopp, USGS Patuxent Wildlife Research Center (seagrass monitoring)
Jesse Wheeler, Antioch College of New England (seed dispersal in salt marsh restoration)
Victoria Rubino, Antioch College of New England (effects of filter feeders on sediment chemistry and macroalgae)
Dr. Frank Caruso, University of Massachusetts, Amherst (role of pathogens in salt marsh dieback)

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Robert Maietta, MA Department of Environmental Protection (atmospheric mercury deposition and fish tissue study)

Jody Wennemer, Antioch College of New England (bivalve and submerged aquatic vegetation relationships in restoring lagoon)

Dr. Betty Niekirk, Virginia Institute of Marine Science (ENE protocol collaborator)

Dr. John Riehl, Wellfleet Natural Resources Advisory Board (Wellfleet Harbor Monitoring)

Bruce Campbell, CEO, NECi (nitrate enzymatic analytical method development)

Mark Olson, Biologist, USGS Water Research Center (aqueous mercury deposition study)

Dr. David Krabbenhoft, Research Scientist, USGS Mercury Research Lab (aqueous mercury deposition study)

Dr. Charles Roman, Research Coordinator, NAC CESU (salt marsh protocols and program planning)

Dr. Mary-Jane James-Pirri, Graduate School of Oceanography, University of Rhode Island (salt marsh protocols)

Sara Stevens, NCBN coordinator (ENE coordination, nekton coordination)

Beth Johnson, I&M regional coordinator (protocol peer review and coordination, report review)

Dennis Skidds, NCBN data manager (ENE database)

Linda Fabre-Arnold, NCBN research associate, (CACO fish)

Erika Patenaude, NCBN biotech (nekton sampling)

D. Reports, Publications and Presentations

Reports:

Cook, R. P. 2008. Snakes of Cape Cod National Seashore. Park News 2008-2009 Seashore News. Cape Cod National Seashore, Wellfleet, MA.

Cook, R. P. *in prep.* Amphibians and reptiles of Gateway NRA: Impacts of urbanization and restoration. Technical Report NPS/NER/NRTR-XXXX/xxx. National Park Service, Boston, MA. 95% complete

Cook, R. P., D. K. Brotherton, and J. L. Behler. 2008. *in press.* Saint-Gaudens National Historical Site, Amphibian and Reptile Inventory, March-September 2001. Technical Report NPS/NER/NRTR-2008-120. National Park Service, Boston, MA.

Cook, R. P., D. K. Brotherton, and J. L. Behler. *in review.* Fire Island National Seashore, Amphibian and Reptile Inventory, 2002 & 2003. Technical Report NPS/NER/NRTR-XXXX-XX. National Park Service, Boston, MA.

Portnoy, J., S. Smith, K. Lee, K. Chapman, M. Galvin, E. Gwilliam, P. Lyons and C. Thornber. 2008. Annual Report on Estuarine Restoration at East Harbor (Truro, MA), Cape Cod National Seashore. National Park Service, Cape Cod National Seashore, Wellfleet MA 49 pp.

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Smith, S., K. Chapman, M. Galvin, E. Gwilliam and J. Portnoy. 2008. Hatches Harbor Salt Marsh Restoration: 2007 Annual Report. National Park Service, Cape Cod National Seashore, Wellfleet MA 32 pp.

Smith, S.M., K. Fiedler and H. Bayley. 2007. Assessment of vegetation in permanent freshwater ponds of the Province Lands, Cape Cod National Seashore. National Park Service, Cape Cod National Seashore, Wellfleet MA 30 pp.

Publications:

Cook, R. P. 2008. *in press*. Potential and limitations of herpetofaunal restoration in an urban landscape. In Mitchell J. C. and R. E. Jung (eds.), *Urban Herpetology*. pp 102-115. *Herpetological Conservation* Vol. 3. Society for the Study of Amphibians and Reptiles. Salt Lake City, UT.

Forman, S.L., Z. Sagintayev, M. Sultan, **S. M. Smith**, R. Becker, M. Kendall, and L. Marin. 2008. The 20th century migration of parabolic dunes and wetland formation at Cape Cod National Sea Shore, MA: Landscape response to a legacy of environmental disturbance. *The Holocene*, Vol. 18, No. 5, 765-774.

Lyons, P., C.. Thornber, **J. Portnoy**³, and E. Gwilliam. In press. *Dynamics of Macroalgal Blooms along the Cape Cod National Seashore*. *Northeastern Naturalist*. 2008.

Paton, P. W. C., **R. P. Cook**, and T. Tupper. *in prep*. Temporal variation in anuran detection probabilities at Cape Cod National Seashore: implications for long-term monitoring.

Smith, S.M. 2007. Removal of salt-killed vegetation during tidal restoration of a New England salt marsh: effects on wrack movement and the establishment of native halophytes. *Ecological Restoration* 24:268-273.

Smith, S.M., C.T. Roman, M-J. James-Pirri, K. Chapman, J. Portnoy, and E.Gwilliam 2008. Responses of plant communities to incremental hydrologic restoration of a tide-restricted salt marsh in southern New England (Massachusetts, U.S.A.). *Restoration Ecology* (in press).

Smith, S.M., M. Hanley, and K.T. Killingbeck. 2008. Development of vegetation in dune slack wetlands of Cape Cod National Seashore (Massachusetts, USA). *Plant Ecology* 194: 243-256.

Smith, S.M. 2008. Multi-decadal changes in salt marshes of Cape Cod, Massachusetts: a photographic analysis of vegetation loss, species shifts, and geomorphic change. *Northeastern Naturalist* (in press).

Tupper, T. A. and **R. P.Cook**. 2008. Habitat variables influencing breeding effort in northern clade *Bufo fowleri*: Implications for conservation. *Applied Herpetology* 5:101-119.

Tupper, T. A. *submitted*. Fowler's toad (*Bufo fowleri*): diet. Note submitted to *Herpetological Review*.

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Tupper, T. A. and M. McLean. *in prep.* Oviposition site selection in Fowler's toad (*Bufo fowleri*): implications for conservation.

Presentations:

Chapman, K. and K. Lee 2008. Poster: A trial of a new Autonomous Underwater Vehicle in a tidally restricted salt marsh. Estuarine Research Federation Conference Providence, RI.

Chapman, K. and K. Lee 2008. Poster: A trial of a new Autonomous Underwater Vehicle in a tidally restricted salt marsh. National Monitoring Conference Atlantic City, NJ.

Cook, R. P. 2008. "Distribution and abundance of four-toed salamanders at Cape Cod National Seashore" Cape Cod Natural History Conference, March 8, 2008. Barnstable MA. 200 people

Cook, R. P. 2008. "Potential and limitations of translocations in restoring the herpetofaunal community at Gateway National Recreation Area" Sixth World Congress of Herpetology, August, 21, 2008. Manaus, Brazil. 30 people

Cook, R. P. 2008. "Small mammal inventory and monitoring" Cape Cod National Seashore. Nauset Regional High School, March 13, 2008. Eastham, MA.

Galvin, M.G. 2008. "Pond and Lake Ecology" Ponds in Peril Workshop. Association to Preserve Cape Cod Cape Cod & Islands Association of Realtors, West Yarmouth, MA. January 24, 2008.

Phillips, C. 2008. "Development of Long-Term Monitoring Programs for Protected Lands: Protocol Development and Design". University of Massachusetts Amherst Ecological Monitoring class. April 5, 2008. Cape Cod National Seashore

Smith, S. 2007. "Understanding salt marsh dieback on Cape Cod" Estuarine Research Federation, Nov 6, 2007, Providence, RI

Smith, S. 2008. "Salt marsh restoration and landscape change" Cape Cod Natural History Conference. Cape Cod Museum of Natural History, March 8, 2008. Barnstable MA and Center for Coastal Studies, March 19 2008. Provincetown, MA.

Smith, S. 2008. Seminar on salt marsh landscape change at University of Southern Maine, March 2008, Portland, ME.

Smith, S. 2008. Presentation at Salt Pond Visitor Center on Exotic Plants for general public (Sept 2, 2008)

Smith, S. 2008. "Responses of plant communities to incremental hydrologic restoration of a tide-restricted salt marsh in southern New England (Massachusetts, U.S.A.)". Aquatic Resource professionals, Feb 12, 2008, Ft. Collins, CO. (Oral presentation)

Smith, S. 2008. "Ecosystem instability and development during partial tidal restoration of East Harbor". Abstract submitted to George Wright Society Conference, March 2009, Portland, OR;

Timm, B. 2008. Resource Partitioning Between Sub-Adult Fowler's Toads (*Bufo fowleri*) and Eastern Spadefoots (*Scaphiopus h. holbrookii*) in the Provincelands Dunes of Cape Cod National Seashore. Cape Cod Natural History Conference, March 8, 2008. Barnstable MA.

Timm, B. 2008. Ecology and conservation of Eastern spadefoot toad at Cape Cod National Seashore. New England Aquarium, Boston, MA.

Tyrrell, M.C. and M.G. Galvin. 2008.- Kettle Pond Ecology and Water Quality Monitoring. Wellfleet NonResidents Taxpayers Association. Wellfleet, MA (August 11 2008).

V. Budget Narrative

In FY2008 the Cape Cod Prototype Monitoring Program received an authorization of \$702,400 from the NPS I&M program for regular program expenses and operations. Approximately 69% of these funds were used to support permanent, term, and temporary staff in addition to stipends and housing for student conservation association interns. The data manager position was vacant for FY2008 and the Aquatic Ecologist position was vacated as of late October 2007. The salary lapse for these two positions was absorbed by the park in accordance with CACO policy. We plan to fill the aquatic ecologist and data manager positions in early January 2009 and early February 2009 respectively. Our expenditures for operations and equipment was substantially lower in 2008 (~2%) as compared to 2007 because substantial investments were made in 2007 for the analytical laboratory facilities and equipment

Our anticipated authorization for FY2009 is \$702,400. Our projected budget estimates will result in 89% of this authorization being spent on personnel. The majority of this increase compared to FY2008 will be due to filling the two vacant permanent staff positions as well as standard increases in salary and associated expenses for staff. We plan to present the results of several long term monitoring projects at scientific meetings in FY2009, thus our budget expenditure in travel will also be higher in this category as compared to FY2008. We budgeted \$57,000 for permanent change of station costs in FY2009, in anticipation that our two new permanent hires may incur these expenses. If this amount is not enough for PCS expenses, we will cover the remaining costs with CACO natural resource management funds.

A summary of our FY2008 expenditures and FY2009 budget plan is appended to the end of this report.

References:

- Boland, K., R. Cook, E. Gwilliam, C. Phillips, J. Portnoy, and S. Smith. 2002. 2002 Update of the Conceptual Framework for the Development of Long-Term Monitoring Protocols at Cape Cod National Seashore. Cape Cod National Seashore, Wellfleet, MA. 74pp.
- Cahoon, D. R., Lynch, J.C., and Hensel, P.F. 2001. Monitoring salt marsh elevation: a protocol for the Long-term Coastal Ecosystem Monitoring Program at Cape Cod National Seashore. Final Protocol to the Long-term Coastal Ecosystem Monitoring Program, Cape Cod National Seashore, Wellfleet, MA 02667, 104 pp.
- Kopp, B.S. and H. A. Neckles. 2007. A Protocol for Monitoring Estuarine Nutrient Enrichment in Coastal Parks of the National Park Service Northeast Region. Technical Report, USGS Patuxent Wildlife Research Center, Augusta, ME. 196 pp.
- National Park Service. 1998. Forging a Collaborative Future: General Management Plan for Cape Cod National Seashore. U.S. Department of Interior, National Park Service. 208pp.
- Oakley, K.L., L.P. Thomas and S.G. Fancy. 2003. Guidelines for long-term monitoring protocols. Wildlife Society Bulletin 31(4): 1000-1003.
- Paton P.W.C., B. Timm, and T. Tupper. 2003. Monitoring Pond-Breeding Amphibians: A Protocol for the Long-term Coastal Ecosystem Monitoring Program at Cape Cod National Seashore. Technical Report, USGS Patuxent Wildlife Research Center, Coastal Field Station, Narragansett, RI. 113 pp.
- Paton, P.W.C., R.P. Cook, and T. Tupper. *in prep.* Temporal variation in anuran detection probabilities at Cape Cod National Seashore: implications for long-term monitoring.
- Phillips, C. 2003. 2003 Cape Cod National Seashore LTEM Project Prioritization Report. Cape Cod National Seashore, Wellfleet, MA. 99pp.
- Portnoy, J., L. Martin, and C. Roman. 1993 Water Quality Monitoring and Research Plans for Kettle Ponds: Cape Cod National Seashore Technical Report NPS/NRWRD/NRTR-93-15. 56 pp.
- Portnoy, J, K. Lee, J. Oset, E. Gwilliam, and J. Budreski. 2003. Water Quality Monitoring Protocol for Kettle Ponds of Cape Cod National Seashore. Cape Cod National Seashore, Wellfleet, MA. 52 pp.
- Roman, C.T. and N.E. Barrett. 1999. Conceptual Framework for the Development of Long-term Monitoring Protocols at Cape Cod National Seashore. USGS Patuxent Wildlife Research Center, University of Rhode Island, Narragansett, RI. 59pp.

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Tupper, T. A. *submitted*. Fowler's toad (*Bufo fowleri*): diet. Note submitted to Herpetological Review.

Tupper, T. A. and M. McLean. *in prep*. Oviposition site selection in Fowler's toad (*Bufo fowleri*): implications for conservation. will be submitted to Applied Herpetology.

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Draft Vital Signs Summary Table for Cape Cod National Seashore					
Vital Sign	Measure	Current Condition 2008	Data Sources	Reference Condition	Data Source for Reference Condition

Salt Marsh Vegetation

Hatches Harbor	Change in <i>Phragmites</i> infested area	-1 ha	7	decline from pre-restoration	7
Hatches Harbor	Change in <i>Phragmites</i> frequency (# plots w. Phrag/total # plots)	+0.02	7	decline from pre-restoration	7
Hatches Harbor	Change in area with native salt marsh vegetation	+12	7	increase from pre-restoration	7
Hatches Harbor	Change in <i>Spartina alterniflora</i> frequency	+0.31	8	increase from pre-restoration	8
Hatches Harbor	Change in <i>Spartina patens</i> frequency	+0.06	8	increase from pre-restoration	8
Hatches Harbor	Max distance (m) of <i>S. alterniflora</i> expansion upslope	260	8	increase from pre-restoration	8
Hatches Harbor	Max distance (m) of <i>S. patens</i> expansion upslope	260	8	increase from pre-restoration	8
Hatches Harbor	Max distance (m) of <i>Salicornia/Suaeda</i> spp. expansion upslope	480	8	increase from pre-restoration	8
Hatches Harbor	Max distance (m) of <i>Phragmites</i> retreat upslope	260	8	increase from pre-restoration	8
East Harbor	Change in <i>Phragmites</i> infested area	-1.2 ha	9	decline from pre-restoration	9
East Harbor	Change in <i>Typha</i> infested area	-1.9 ha	9	decline from pre-restoration	9

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East Harbor	Change in area with native salt marsh vegetation	+0.9 ha		decline from pre-restoration	9
East Harbor	Change in frequency of <i>Phragmites</i> in Moon Pond area	-0.16	9	increase from pre-restoration	8
East Harbor	Change in frequency of <i>Typha</i> in Moon Pond area	-0.20	8	decline from pre-restoration	8
Salt Marsh Nekton					
Hatches Harbor, unrestricted	Species richness for site, pools and creeks, traps only	1.23	10		
Hatches Harbor, unrestricted	Average density (all nekton in streams) /m2	20.9	10		
Hatches Harbor, unrestricted	Average density (all nekton in pools) /m2	0	10		
Hatches Harbor, restricted	Species richness for site, pools and creeks, traps only	0.5	10		
Hatches Harbor, restricted	Average density (all nekton in streams) /m2	4.64	10		
Hatches Harbor, restricted	Average density (all nekton in pools) /m2	no water in pools	10		
East Harbor	Species richness for lagoon, traps and seine	1.19	10		
East Harbor	Average density (all nekton) in lagoon /m2	3.21	10		
Moon Pond	Species richness for creeks, traps only	2.33	10		
Moon Pond	Average density (all nekton in streams) /m2	34.06	10		
Moon Pond	Average density (all nekton in pools) /m2	N/A	10		
Nauset Marsh	Species richness for site, pools and creeks, traps only	1.69	10		
Nauset Marsh	Average density (all nekton in streams) /m2	4	10		
Nauset Marsh	Average density (all nekton in pools) /m2	40	10		
Salt Marsh Elevation					
Hatches Harbor	Sediment accretion+elevation	TBD			
Herring River	Sediment accretion+elevation	TBD			
Nauset Marsh	Sediment accretion+elevation	TBD			
Amphibian Monitoring					
Fowler's Toad	Calling Survey Estimated Site Occupancy Rate	0.4309	1	max-min for time series (2003-2008)	1
Grey Treefrog	Calling Survey Estimated Site Occupancy Rate	0.0760	1	0.42-0.52	1
Spring Peeper	Calling Survey Estimated Site Occupancy Rate	0.9333	1	0.03-0.33	1
American Bullfrog	Calling Survey Estimated Site Occupancy Rate	0.5524	1	0.90-1.00	1
Green Frog	Calling Survey Estimated Site Occupancy Rate	0.6682	1	0.27-0.55	1
Pickeral Frog	Calling Survey Estimated Site Occupancy Rate	0.2001	1	0.67-0.90	1
Anuran Community	# species detected by calling surveys	6	1	0.13-0.24	1
				6 to 8 species	1

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Wood frogs	total # egg masses	30	1	30-273	1
Spotted Salamander	total # egg masses	7168			
			1	5322-7168	1
Threatened species (Box Turtles)	Number of Captures (incidental encounters)	60	2	annual range from 19-89	
Ocean shoreline position	# acres eroded/accreted compared to baseline	TBD			
Estuarine Nutrient Enrichment					
Pleasant Bay	Dissolved oxygen (mg/L)	7.4		>2.0 mg/L to avoid suppressed diversity and abundance of benthic fauna	
			3		
Pleasant Bay	Salinity (ppt)	29.5	3		
Pleasant Bay	Maximum Temperature (C)	28.2		<30 C, lethal limit for grazing herbivores	13
			3		
Pleasant Bay	Turbidity NTU	89.5	3		
Pleasant Bay	Chlorophyll a concentration ug/L	207.2	3		
Nauset Marsh	Dissolved oxygen (mg/L)	8.1	3		
Nauset Marsh	Salinity (ppt)	30.5	3		
Nauset Marsh	Maximum Temperature (C)	28.2		<30 C, lethal limit for grazing herbivores	13
			3		
Nauset Marsh	Turbidity NTU	273.5	3		
Nauset Marsh	Chlorophyll a concentration ug/L	33.9	3		
ENE seagrass distribution	Seagrass bed size	TBD			
ENE seagrass condition	within bed % cover	TBD			
Kettle Pond Water Quality					
	Total Phosphorus (uM)	0.14			
			6		
Kettle Ponds	Total Nitrogen (uM)	14.3	6		
Kettle Ponds	Dissolved inorganic nutrients (NH4, PO4, NO3)	3.1	6		
Kettle Ponds	Dissolved oxygen (%), 1 m depth	0.97	5		

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Kettle Ponds	Dissolved oxygen (mg/L)	7.9	5	
Kettle Ponds	pH	5.78	5	
Kettle Ponds	Light transmission (% of surface at 1 m depth)	0.62	5	
Kettle Ponds		7		>1.3 m annual average (Carlson trophic state index for eutrophic conditions)
	Secchi depth, average 20 ponds (m)		4	14
Air Quality				
Acidic deposition and stress	Wet deposition of Ammonium mg/L	0.07	11	
Acidic deposition and stress	Wet deposition of Nitrate mg/L	1.36	11	
Acidic deposition and stress	Wet deposition of Sulfate mg/L	1.29	11	
	Mercury			
	Ozone (ppb)	42.6	12	<51 ppb is considered safe for all individuals

References:

- 1: CACO LTEM Program, Amphibian Monitoring Data
- 2: CACO LTEM Program data, incidental captures of reptiles
- 3: Average fixed YSI, June 26 -Sept 5 2008, 15 min intervals
- 4: 20 kettle ponds sampled from April to September of 2008 for maximum visible secchi depth.
- 5: 20 kettle ponds sampled in July and August of 2008 measuring percent light transmission, pH and dissolved oxygen.
- 6: 20 kettle ponds sampled in Spring of 2008 for total nitrogen, total phosphorous and dissolved inorganic nutrients.
- 7: GIS analysis of aerial photography (1991, 1997, 2007) with delineations informed by ground-level vegetation monitoring plots.
- 8: Ground-level monitoring plots (1998-2008)
- 9: GIS analysis of aerial photography (2000, 2007) with delineations informed by ground-level vegetation monitoring plots
- 10: 1m sq. throw trap, pool and creeks combined, Sept 2008 data
- 11: National Atmospheric Desposition program, September 2008 values
- 12: MA Dept. of Environmental Protection Ozone monitoring, daily peak 8 hour average for Sept 2007
- 13: Hamby, R.J. 1975. Heat effects on a marine snail. Biological Bulletin 149: 331-347.
- 14: Heiskary, S.A. and Walker, W.W. 1988. Deveoping phosphorous criteria for Minnesota lakes. Lake Reservoir Manage. 4: 1-9.
- 15: www.mass.gov/?pageID=mg2terminal&L=4&L0=Home&L1=Resident&L2=Environment&L3=Air+Quality&sid=massgov2&b=terminalcontent&f=airquality_healthguide&csid=massgov2

Budget Summary

FY08 Admin Report

Network: Cape Cod NS Prototype

Category: 1_Income

Description	\$ Amount	\$\$ Source	Where \$ Went	Comments
Authorized Amount	\$702,400.00	Prototype \$\$ - Annual		
Subtotal	\$702,400.00			

Category: 2_Personnel

Description	\$ Amount	\$\$ Source	Where \$ Went	Comments
Data Manager	\$0.00	Prototype \$\$ - Park Base	NPS	
Aquatic Ecology Tech	\$47,001.00	Prototype \$\$ - Park Base	NPS	Galvin til pp 17. Bayley start 18b
Hydrology Tech	\$62,868.00	Prototype \$\$ - Park Base	NPS	
Amphibian Biotech 842	\$17,496.00	Prototype \$\$ - Park Base	NPS	
Research and Monitoring Coordinator	\$14,866.00	Prototype \$\$ - Park Base	NPS	Split with Atlantic Research Center
Wildlife Ecologist	\$101,385.00	Prototype \$\$ - Park Base	NPS	
Aquatic Ecologist	\$4,150.00	Prototype \$\$ - Park Base	NPS	
Physical Scientist	\$24,569.00	Prototype \$\$ - Park Base	NPS	
Physical Sci Lab Tech	\$23,610.00	Prototype \$\$ - Park Base	NPS	
GIS Tech	\$7,968.00	Prototype \$\$ - Park Base	NPS	
Vegetation Biotech 843	\$7,304.00	Prototype \$\$ - Park Base	NPS	
Amphibian Biotech 844	\$17,272.00	Prototype \$\$ - Park Base	NPS	
SCAs rent + salary	\$29,349.00	Prototype \$\$ - Park Base	NPS	
Budget Tech	\$28,928.00	Prototype \$\$ - Park Base	NPS	
Plant Ecologist	\$96,004.00	Prototype \$\$ - Park Base	NPS	
Subtotal	\$482,770.00			

Category: 4_Contracts

Description	\$ Amount	\$\$ Source	Where \$ Went	Comments
University of Illinois- NADP/MDN	\$11,072.00	Prototype \$\$ - Park Base	Univ_Non-CESU	
Subtotal	\$11,072.00			

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Category: 5_Operations/Equipme

<i>Description</i>	<i>\$ Amount</i>	<i>\$\$ Source</i>	<i>Where \$ Went</i>	<i>Comments</i>
Laboratory equipment and supplies	\$6,800.00	Prototype \$\$ - Park Base	Other non-Federal	
Computer hardware, software and supplies	\$1,200.00	Prototype \$\$ - Park Base	Other non-Federal	
Office and misc supplies, equipment	\$120.00	Prototype \$\$ - Park Base	Other non-Federal	
Field equipment and supplies	\$3,500.00	Prototype \$\$ - Park Base	Other non-Federal	
Subtotal	\$11,620.00			

Category: 6_Travel

<i>Description</i>	<i>\$ Amount</i>	<i>\$\$ Source</i>	<i>Where \$ Went</i>	<i>Comments</i>
Meetings, Conferences, Training	\$720.00	Prototype \$\$ - Park Base	Other non-Federal	
Subtotal	\$720.00			

Category: 7_Other

<i>Description</i>	<i>\$ Amount</i>	<i>\$\$ Source</i>	<i>Where \$ Went</i>	<i>Comments</i>
Salary lapse	\$196,818.00	Prototype \$\$ - Park Base	NPS	
Subtotal	\$196,818.00			

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	\$703,000	\$679,588				\$11,072	\$12,340
Totals	\$703,000	\$679,588				\$11,072	\$12,340

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	\$703,000	\$482,770		\$11,072	\$11,620	\$720	\$196,818
Totals	\$703,000	\$482,770		\$11,072	\$11,620	\$720	\$196,818

Expense Totals By Category

<i>Category</i>	<i>SubTotal</i>	<i>Percent</i>
2_Personnel	\$482,770	68.67%
4_Contracts	\$11,072	1.57%
5_Operations/Equipment	\$11,620	1.65%
6_Travel	\$720	0.10%
7_Other	\$196,818	28.00%
	\$703,000	

Budget Summary

FY09 Work Plan

Network: Cape Cod NS Prototype

Category: 1_Income

Description	\$	\$\$ Source	Where \$ Went	Comments
Anticipated Authorization for FY2009	\$702,400.00	Prototype \$\$ - Park Base		
Subtotal	\$702,400.00			

Category: 2_Personnel

Description	\$	\$\$ Source	Where \$ Went	Comments
GIS Tech	\$8,278.00	Prototype \$\$ - Park Base	NPS	
Research and Monitoring Coordinator	\$49,525.00	Prototype \$\$ - Park Base	NPS	
Budget Tech	\$9,795.00	Prototype \$\$ - Park Base	NPS	
Data Manager	\$59,809.00	Prototype \$\$ - Park Base	NPS	starting pp 4 Feb 2009
Physical Scientist	\$26,625.00	Prototype \$\$ - Park Base	NPS	
Plant Ecologist	\$99,498.00	Prototype \$\$ - Park Base	NPS	
Wildlife Ecologist	\$105,728.00	Prototype \$\$ - Park Base	NPS	
Aquatic Ecologist	\$59,548.00	Prototype \$\$ - Park Base	NPS	starting pp 2 Jan 2009
Aquatic Ecology Tech 852	\$33,145.00	Prototype \$\$ - Park Base	NPS	
Hydrology Tech	\$65,798.00	Prototype \$\$ - Park Base	NPS	
Vegetation Biotech 843	\$8,278.00	Prototype \$\$ - Park Base	NPS	
Physical Science Tech	\$25,520.00	Prototype \$\$ - Park Base	NPS	
Amphibian Biotech 842	\$18,832.00	Prototype \$\$ - Park Base	NPS	
ENE Biotech 848	\$1,380.00	Prototype \$\$ - Park Base	NPS	20% NZI, plan 80% NCBN
Student Interns	\$30,306.00	Prototype \$\$ - Park Base	Other non-Federal	salary+rent
Background checks for seasonals	\$200.00	Prototype \$\$ - Park Base	NPS	
Amphibian Biotech 844	\$19,324.00	Prototype \$\$ - Park Base	NPS	
Subtotal	\$621,589.00			

Category: 4_Contracts

Description	\$	\$\$ Source	Where \$ Went	Comments
University of Illinois- NADP	\$12,600.00	Prototype \$\$ - Park Base	Univ_Non-CESU	
Subtotal	\$12,600.00			

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Category: 5_Operations/Equipm

<i>Description</i>	<i>\$</i>	<i>\$\$ Source</i>	<i>Where \$ Went</i>	<i>Comments</i>
Field Equipment and supplies	\$2,500.00	Prototype \$\$ - Park Base	Other non-Federal	
Lab analyses, equipment and supplies	\$5,000.00	Prototype \$\$ - Park Base	Other non-Federal	
Computer hardware, software and supplies	\$500.00	Prototype \$\$ - Park Base	Other non-Federal	
Office and misc. supplies, equipment	\$200.00	Prototype \$\$ - Park Base	Other non-Federal	
Subtota	\$8,200.00			

Category: 6_Travel

<i>Description</i>	<i>\$</i>	<i>\$\$ Source</i>	<i>Where \$ Went</i>	<i>Comments</i>
Meetings, Confereneces, Trainings	\$3,000.00	Prototype \$\$ - Park Base	Other non-Federal	
Subtota	\$3,000.00			

Category: 7_Other

<i>Description</i>	<i>\$</i>	<i>\$\$ Source</i>	<i>Where \$ Went</i>	<i>Comments</i>
Permanent Change of Station costs	\$57,000.00	Prototype \$\$ - Park Base	Other non-Federal	
Subtota	\$57,000.00			

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.-</i>	<i>Univ_Non-</i>	<i>Other non-</i>
Prototype \$\$ - Park Base	\$702,389	\$591,283				\$12,600	\$98,506
Totals	\$702,389	\$591,283				\$12,600	\$98,506

Analysis of Expenses by Category

<i>Funding Source</i>	<i>Total \$\$</i>	<i>Personne</i>	<i>Coop</i>	<i>Contracts</i>	<i>Operations/Equi</i>	<i>Travel</i>	<i>Othe</i>
Prototype \$\$ - Park Base	\$702,389	\$621,589		\$12,600	\$8,200	\$3,000	\$57,000
Total	\$702,389	\$621,589		\$12,600	\$8,200	\$3,000	\$57,000

Expense Totals By Category

<i>Category</i>	<i>SubTotal</i>	<i>Percent</i>
2_Personnel	\$621,589	88.50%
4_Contracts	\$12,600	1.79%
5_Operations/Equipment	\$8,200	1.17%
6_Travel	\$3,000	0.43%
7_Other	\$57,000	8.12%
	\$702,389	