ANNUAL ADMINISTRATIVE REPORT (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

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FY2009

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John Karish, Regional Inventory and Monitoring ~~Coordinator,~~ PROGRAM MANAGER — Date
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Cape Cod National Seashore FY 2009 Annual Administrative Report

Cape Cod National Seashore (CACO) is a prototype park in the Inventory and Monitoring program 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. 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, interdunal wetlands, and grasslands.

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 by Boland *et al*. (2002). 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 a 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 and coordinate monitoring activities with 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.

As a coastal park, CACO experiences high pressure from encroaching development, intense recreational activity, and climate change impacts. The 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. Sea level rise, increased intensity and frequency of storms, and acidification are expected to be among the most pressing natural resource management challenges in the near future. Understanding these and other climate change related factors are increasingly becoming a prominent theme in staff discussions and we plan to emphasize climate change as a context for data analysis and dissemination of monitoring results. We will present these results in a variety of forums such as resource briefs and workshops for staff and other environmental monitoring entities in the region.

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. In FY09, research of one faculty member and five graduate and one undergraduate students was supported by monitoring data, technical expertise of monitoring program staff, as well as the housing, lab and field facilities of the ARC.

CACO received a $702,400 authorization in FY 2009 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 Cape Cod Ecosystem Monitoring (CCEM) supported activities from FY2009.

I. Program Accomplishments

CACO is currently monitoring 20 vital signs ranging from air quality to shoreline position to groundwater level monitoring. Below are some of the major highlights from the monitoring program.

Inventories

- Provided technical assistance and report compilation for amphibian and reptile inventories in NCBN and NETN parks. The SAGA report is in press. Three other reports and their associated databases (WIFL, SAHI and FIIS) were completed and are under review. The GATE report is underway and will be finalized in FY2010. The redrafting process for three additional reports (MIMA, SAIR and SARA) will begin in FY210.
- Provided guidance to the Geological Resources Division in support of the geological resources inventory for the park.
- Reviewed final versions of vegetation shapefiles along with aerial photography and associated metadata for contractors tasked with finishing CACO's vegetation map. The map will be finalized in FY2010.
- Continued inventory of eastern box turtles and eastern hog-nosed snake through incidental encounters. Inventory includes marking for future recognition, collecting data on size, weight, age, sex, and location, and photo-documentation. In FY 2009 there were 60 box turtle records and 23 hog-nosed snakes.

Vital Signs Monitoring

- Continued to monitor salt marsh accretion, erosion and relative elevation in three estuarine systems. CACO now has twelve years of data for two sites and nine years of data for one site. Elevations at all 22 of the surface elevation table (SET) sites were measured with a Real Time Kinematic Trimble unit; SET elevations will be reassessed

periodically to account for changes due to ice or other physical damage. Results from the SETs will be presented at the Coastal and Estuarine Research Federation meeting in Portland, OR in November 2009.

- To track vegetation community changes, continued annual salt marsh and seagrass monitoring in East Harbor, a partially restored tidal lagoon.
- Conducted mid and late summer nekton monitoring in four long term monitoring sites: East Harbor, Moon Pond, Hatches Harbor and Nauset Marsh. Investigated the feasibility of adding a nekton monitoring site in West End Marsh, Provincetown in lieu of non-quantitative seining and found conditions at the site were amenable to the technique described in the protocol.
- Implemented the third year of the NCBN 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 (ASIS, COLO, and GATE).
- Continued application of instrumentation (multi-parameter water quality sondes and extended deployment pressure loggers) 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.
- Conducted a Water Quality Monitoring Workshop in May 2009 emphasizing the use of multi parameter data loggers and presented results on how to improve accuracy of tidal data by compensating for barometric pressure, salinity and temperature. Attendees included local state and federal agencies as well as private companies and contractors. Information from workshop was disseminated to both the NCBN and NETN.
- Hosted a Ph.D. student from the University of Rhode Island to use multivariate statistics to assess trends and recommend a sampling frequency for nekton monitoring at various salt marshes.
- Continued salt marsh dieback field research and monitoring at two sites that have experienced significant loss of salt marsh grasses.
- Used GPS to collect CACO's high tide shoreline position information in the fall and spring in accordance with the NCBN draft ocean shoreline position protocol. CACO will use results of the NCBN shoreline position protocol and the on-going NRPP Shoreline change study to add refinements to a CACO-specific geomorphic change monitoring protocol.
- 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.
- Monthly groundwater levels at 32 wells and pond stage at 3 ponds was monitored in accordance with the hydrology protocol. Monthly monitoring was also conducted at an additional 7 wetland wells in a future tidal restoration site. A preliminary quality assurance and quality check for all water level data from 1999 to present and a second internal review of the groundwater level data were conducted.
- Re-surveyed dune slack wetlands that were initially characterized in 2004; expanded and improved monitoring protocol for this ecosystem type. Over 150 new wetlands were mapped and characterized. New information on dune slack hydrology was also obtained, showing unanticipated temporal and spatial variation in water levels.

- Continued to collect water quality data from 20 kettle ponds, following the kettle pond water quality monitoring protocol. Parameters monitored on a bi-monthly basis in 10 ponds include: dissolved oxygen, light attenuation, pH, chlorophyll concentration, temperature, transparency, specific conductance, alkalinity and pond stage. Nutrient, cation and anion sampling was conducted in spring and fall in 20 kettle ponds.
- In accordance with the amphibian monitoring protocol, collected and entered monthly water level data at 40 vernal ponds. Pond hydroperiod is a significant determinant of amphibian community structure and reproductive success.
- Collaborated with Dr. Peter Paton (University of Rhode Island) and Dr. Todd Tupper (Northern Virginia Community College) to analyze six year's of anuran calling survey data (2001, 2003-2007) collected jointly by CACO staff through the amphibian monitoring protocol and Dr. Tupper at 103 wetlands. The effect of diel, seasonal, and annual variation, as well as water and air temperature, on detection probability was analyzed, and peak calling season and detection probabilities of CACO anurans were estimated.
- The CACO coastal forest monitoring protocol and a draft pond vegetation monitoring protocol are under internal 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 drafts. All protocols will comply with the Oakley *et al*. (2003) format.

Information transfer to park staff and the general public

- Analyzed multi-decadal trends of secchi transparency and pH of l0 intensively monitored kettle ponds. Secchi data generally indicates that water clarity has degraded and surface water pH is increasing over time. Both trends likely indicate an increase in primary productivity in the water column. Shared kettle pond water quality trends regarding water clarity and trophic status with CACO managers and municipal natural resource managers. Provided water samples and water quality profile data to local volunteer monitoring group, county natural resource managers, and scientists from the MA Department of Environmental Protection.
- Drafted resource brief on effects of climate change in kettle pond ecology as assessed by the multi-decadal kettle pond water quality monitoring program.
- Communicated the results of monitoring and directed research to other NPS staff, contractors and visitors through training and leading interpretive programs. Further outreach included: writing press releases and providing information for the PBS Nature series "Frogs: the thin green line" which included CACO spadefoot toads and actions taken by park to protect them.
- Redesigned and updated the Cape Cod Ecosystem Monitoring program website. New postings include: two additional resource briefs on groundwater level monitoring and seagrass monitoring and updates to the CACO mammals and amphibians and reptiles pages.
- Prepared numerous technical reports and scientific publications including for the NPS Northeast Region Newsletter "Science and Management" and the CACO newspaper.

- Presentations using information garnered from monitoring were given at a wide variety of forums including: community groups, classrooms, environmental organizations, schools and universities, and scientific meetings.
- Provided data on CACO avifauna to consultant and staff working for CACO on Wind Turbine environmental assessment, and reviewed draft document for technical accuracy regarding CACO flora and fauna.
- Advised and provided technical support to a first year graduate student using radio telemetry to study eastern hog-nosed snake movement and ecology.

Program management

- Filled a two year vacancy in the aquatic ecologist position by recruiting and hiring a GS-11 aquatic ecologist (80% supported by CCEM funds, 20% CACO funded). EOD is early January 2010.
- Continued to address remaining vacancy in the program by initiating the process to hire a data manager.

Data Management

- Addressed need for insuring program continuity by documenting changes in protocols, archiving data and developing data management procedures. These procedures will be formalized when the CACO data management plan is completed.
- CACO staff have supervised volunteers scanning reports from the CCEM and other projects for digital storage and web posting.
- Continued to conduct server backups of Cape Cod Ecosystem Monitoring data and oversight of archived data. Data recovery and data structure refinement tasks have taken place as needed. Hardware and software maintenance has been ongoing.
- Collaborated with NCBN data manager to make improvements to salt marsh vegetation and nekton database. Arranged to have a short term detail for NCBN data manager at CACO in November 2009.

II. Public Interest Highlights

Vital Signs Monitoring

Cape Cod reference salt marsh keeping up with sea level rise

Currently Cape Cod National Seashore is monitoring sediment elevation changes at 22 sites in three different marsh systems: Hatches Harbor, Herring River and Nauset marsh. Nauset marsh has never been subject to tidal restrictions. The surface elevation change is measured using a surface elevation table (SET) and vertical accretion is measured using artificial soil marker horizons. At Nauset marsh, the surface processes are resulting in a 3.89 mm/yr accretion rate which exceeds the regional sea level rise rate of 2.6 mm/yr. These data indicate that Nauset marsh is capable of maintaining its sedimentary budget under prevailing conditions in the last decade.

Incidental observation helps fill distribution gap of grey treefrog at CACO

Although common on the "Upper Cape", the grey treefrog (*Hyla versicolor*) had never been recorded at CACO until 2001, when one was heard calling in Eastham. At the time this record

seemed consistent with the post-glacial re-colonization model, published by Dr. James Lazell in his 1976 book "This Broken Archipelago", and suggested that grey treefrogs were expanding their range outward on the Cape Cod peninsula. However, subsequent observations of grey treefrog in Provincetown in 2003, at the tip of Cape Cod, and discovery of historic records from Wellfleet, suggested that grey treefrogs were not re-colonizing the outer cape for the first time since the retreat of the glaciers. An incidental encounter with a vocalizing grey treefrog in Wellfleet this spring helps fill in the gap in this species' distribution at CACO, and lends further support to an alternative theory that the present day distribution of amphibians and reptiles at CACO reflects where species already present have been able to survive the dramatic changes in habitat and land use that followed European contact.

Vegetation loss in the upper zones of Wellfleet Bay salt marshes

Dieback of high marsh vegetation 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. In the summer of 2009, manipulative field experiments and hydrologic monitoring were conducted to test the hypothesis that flooding stress may be acting synergistically with physical disturbance to cause plant mortality. The data indicate that *Sesarma* crabs have achieved greater densities than expected in the high marsh (>30/m^2) and can cause high levels of plant mortality there. Any recovery from intense herbivory appears to be influenced by other factors, such as flooding regime.

Comparisons of two LiDAR datasets and historical beach profiles reveal elevation changes over a 118 year interval

CACO, with cooperator Provincetown Center for Coastal Studies, is utilizing LiDAR data collected for coastal geomorphology monitoring in conjunction with a three-year study to analyze 118 years of coastal sediment movement on outer Cape Cod. The NCBN has established a data stream that has delivered EAARL LiDAR to CACO since 1999. These data do not contain significant bathymetry due to turbulence and turbidity of north Atlantic coastal waters but the second return "bare earth" values are suitable for elevation and volume measurements on beaches, bluffs, and dunes. CACO has used EAARL LiDAR data to populate the sub-aerial portions of 229 cross-shore elevation profiles for comparison and analysis with profiles collected by Henry Marindin in 1887 in the same locations. The nature of the elevation changes is variable over the entire dataset; some areas appear relatively stable and others are more dynamic. EAARL LiDAR will continue to be valuable for monitoring of sub-aerial shoreline features, coastal dune fields, and estuarine basin modeling. Future applications of EAARL data to vegetation analysis could result in additions of canopy class and biomass to traditional land cover mapping. SHOALS is another type of LiDAR distributed by the Army Corps of Engineers. Its significant bathymetric coverage at CACO appears valid when compared with Marindin's 1887 data. SHOALS bathymetry fills a significant gap for managers and will add the potential for calculating littoral sediment volumes which are a substantial part of the coastal sediment budget. Both sources of LiDAR will be compared with on-the-ground survey information collected with differential GPS, survey-grade GPS and single-beam sounder GPS. This study and other

monitoring have provided guidance for management decisions regarding CACO's public access and facilities such as beach parking lots, visitor use buildings and roads.

Dramatic shifts in vegetation in a partially-restored lagoon due to colonization failure of key micro- and macroalgal grazers

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 2004, soft-shelled clams (*Mya arenaria*) proliferated and greatly improved water clarity by removing (through filtration-feeding) phytoplankton from the water column. Several years of macroalgae (particularly *Ulva intestinalis*) blooms followed that ultimately caused losses of seagrass and, ironically, widespread mortality of *Mya*. Furthermore, while a host of marine fish, crustaceans, and other benthic invertebrates have become established throughout the system, an important herbivore, *Littorina littorea*, and the detritivore/herbivore, *Ilyanassa obsoleta* have been conspicuously absent. Grazing experiments conducted over the last 2 years have revealed the potential for both these organisms to significantly reduce the extent of macroalgae and attached microalgae (periphyton) if they were to become well-established in the lagoon. An important factor in *Littorina's* absence appears to be lethal high temperatures during the summer months. *Ilyannas's* absence is under investigation but may be related to dispersal dynamics and/or larval development constraints.

Interdunal vernal wetland hydrology

Interdunal vernal wetlands contain a high diversity of plant species amid a relatively inhospitable sand dune landscape. Hydrologic monitoring in interdunal vernal wetlands (dune slack wetlands) was conducted over a period of several months using HOBO water depth loggers. The data indicate that water level fluctuations in these wetlands do not strictly adhere to the simple model of a rising and falling groundwater table. Instead, water levels were highly variable among different wetlands across the dune landscape and often showed different temporal trends throughout the monitoring period. The results suggest that dune vernal wetland hydrology is complex, and influenced by variables other than the elevation of the groundwater table relative to the wetland. Further studies are planned to better understand the mechanisms of water transference and loss within these systems. The complexities in hydrology likely contribute substantially to the variation in vegetation community composition observed in these insular habitats.

III. Staffing

Inventory and Monitoring Staff (CACO)

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

Megan Tyrrell, Research and Monitoring Coordinator
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
Holly Bayley, Aquatic Ecology tech
Jesse Wheeler, Vegetation tech
Adam Thime, Vegetation & water quality monitoring- Student Conservation Association (seasonal)
April Londo, Water quality monitoring- Student Conservation Association (seasonal)
Jessica Foley, Water quality monitoring- Student Conservation Association (seasonal)
Katie Reid, 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 entirely supported by other funds.
Carrie Phillips, Division Chief
Mark Adams, GIS specialist
Mary Hake, Plover and Colonial Waterbird BioTech
Tim Smith, Restoration Ecologist

Contractors/Cooperators:

Dr. Larry Martin, Hydrologist, NPS Water Resources Division (hydrology monitoring)
Mark Faherty, University of Massachusetts, Amherst (landbird point-count protocol)
Dr. Allan O'Connell, USGS, Patuxent Wildlife Research Center (meso-mammal protocol)
Brad Timm, University of Massachusetts, Amherst (spadefoot toads, vegetation change monitoring)
Dr. Todd Tupper, George Mason University (Fowler's toad study, analysis of anuran calling surveys, chytrid fungus study)
Dr. Peter Paton, University of Rhode Island (analysis of anuran calling surveys)
Dr. Graham Giese, Provincetown Center for Coastal Studies (shoreline change)
Dr. Blaine Kopp, USGS Patuxent Wildlife Research Center (Estuarine nutrient enrichment and 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)

Sara Stevens, NCBN coordinator (ENE coordination, nekton coordination, vegetation change monitoring)
Dennis Skidds, NCBN data manager (ENE database, salt marsh database)
Scott Buchanan, Montclair State University (hog-nosed snake ecology)
Lori Erb, Massachusetts Natural Heritage Program (box turtle surveys and disease screening)
Dr. Mark Borrelli, Provincetown Center for Coastal Studies (coastal geomorphology)

IV. Reports, Publications and Presentations

Reports:

Boland, K. and R. P. Cook. 2009. Eastern spadefoot toads at Cape Cod National Seashore. Seashore Science Series, Cape Cod National Seashore.

Cook, R.P., D.K. Brotherton, and J.L. Behler. *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., M. Tyrrell, and S. Smith. *in press.* I&M data protect wildlife and rare plants. Science and Management, Northeast Region National Park Service.

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

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

Smith, S.M., K.Chapman, K. Lee, M. Tyrrell, J. Wennemer, and R. Thiet. 2009. Annual Report on Estuarine Restoration at East Harbor (Truro, MA), Cape Cod National Seashore, 2008. National Park Service, Cape Cod National Seashore, Wellfleet, MA.

Smith, S.M., H. Bayley, and L.R. Curtis. 2008. Salt marsh vegetation monitoring report 2008. National Park Service, Cape Cod National Seashore, Wellfleet, MA.

Smith, S. M. 2009. Gull Pond littoral zone vegetation analysis. National Park Service, Cape Cod National Seashore, Wellfleet, MA.

Publications:

Cook, R.P. 2008. 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.

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

Smith, S.M., C.T. Roman, M-J. James-Pirri, K. Chapman, J. Portnoy, and E. Gwilliam. 2009. 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. 2009. Multi-decadal changes in salt marshes of Cape Cod, Massachusetts: a photographic analysis of vegetation loss, species shifts, and geomorphic change. Northeastern Naturalist 16(2):183-208.

Timm, B. *in review*.The diets of subadult Fowler's toads (*Bufo fowleri*) and Eastern spadefoots (*Scaphiopus h. holbrookii*) at Cape Cod National Seashore, USA." Herpetological Review.

Timm, B. *in review. Scaphiopus h. holbrookii* (Eastern spadefoot): predation. Herpetological Review (Natural History Note).

Tupper T.A., Adams L.B., Timm B.C. 2009. *Bufo fowleri* diet. Herpetological Review 40: 200-201.

Tupper T. A., McLean, M.D., Buchanan S. *in press*. Oviposition in northern clade *B. fowleri*: implications for conservation. Applied Herpetology.

Valiela, I., E. Kinney, J. Culbertson, E. Peacock, and S. Smith. 2009. Global losses of mangroves and salt marshes. In: C. Duart (ed.) Global Loss of Coastal Habitats: Rates, Causes and Consequences. Fundacion BBVA. ISBN: 978-84-96515-84-0.

Presentations:

Cook, R. 2009. Anuran calling surveys at Cape Cod National Seashore. and Small mammal inventory and monitoring at Cape Cod National Seashore. Class in Quantitative Ecology, Cape Cod Community College, February 24, 2009.

Cook, R. 2009. Amphibians and reptiles of Cape Cod National Seashore. Public Program, Province Lands Visitor Center, July 5, 2009.

Lellis-Dibble, K. and M.C. Tyrrell. 2009. Multivariate analysis of nekton monitoring data at CACO and recommendations for monitoring. University of Rhode Island Coastal Institute IGERT Program. August, Matunuck RI.

McLean, M. 2009. Environmental factors as predictors of amphibian movements on Province Lands Road. Cape Cod Natural History Conference, March 2009.

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Smith, S. 2009. Changes in Cape Cod salt marshes during the last 60 years: an analysis of vegetation losses, species shifts, and geomorphic change; Northeastern Chapter of the Geological Society of America conference – March, Portland ME

Smith, S. 2009. The importance of temperature regime in tidal restoration: a case study of periwinkles (*Littorina littorea*) and macroalgae in a partially-restored salt marsh lagoon; Northeastern Estuarine Research Society meeting – April, Salem MA

Smith, S. 2009. Hatches Harbor salt marsh restoration. Rotary Club of Orleans.-September, Orleans MA and Province Lands Visitor Center seminar August Provincetown, MA

Stevens, S. and M. Adams. 2009. NCBN LiDAR applications. NE Airborne LIDAR Workshop for the Coastal Zone, Woods Hole, MA, May 2009.

Timm, B. 2008. Eastern Spadefoot: Denizen of the Cape Cod Dunes. Public Program, Wellfleet Public Library, October 2008.

Timm, B. 2009. Movement ecology of Eastern spadefoots (*Scaphiopus h. holbrookii*) at Cape Cod National Seashore. Oral presentation, Northeast Fish and Wildlife Conference. Lancaster, PA. April, 2009.

Tyrrell, M.C. 2009. Marine invasive species in the Gulf of Maine. Salt Pond Visitor Center evening lecture series, August, Eastham, MA.

Tyrrell, M.C. and H.K. Bayley. 2009. Nekton as Indicators of Estuarine Restoration Success in a Tidal Creek and Lagoon. George Wright Conference- February, Portland, OR (poster)

V. Connect the Dots – Resource Condition Summary Table

Vital Sign	Measure	Current Condition 2009	Data Sources	Reference Condition	Data Source for Reference Condition	Comments
Salt Marsh Vegetation						assess success of tidal restoration efforts for facilitating reduction in invasives and increasing native marsh vegetation
East Harbor	Change in biomass of *Phragmites* in Moon Pond area	~1000g/m^2	8	increase from pre-restoration	8	
East Harbor	Change in % cover of *Typha* in Moon Pond area	decline from 2008	8	decline from pre-restoration	8	
Salt Marsh Nekton						
Hatches Harbor, unrestricted	Species richness for site, pools and creeks, traps only	4	10			
Hatches Harbor, unrestricted	Average density (all nekton in streams) /m2	4.63	10			
Hatches Harbor, unrestricted	Average density (all nekton in pools) /m2	3.66	10			
Hatches Harbor, restricted	Species richness for site, pools and creeks, traps only	3	10			
Hatches Harbor, restricted	Average density (all nekton in streams) /m2	0.83	10			
Hatches Harbor, restricted	Average density (all nekton in pools) /m2	2.3	10			
East Harbor	Species richness for lagoon, traps and seine	11	10			
East Harbor	Average density (all nekton) in lagoon /m2	13.73	10			
Moon Pond	Species richness for creeks, traps only	13	10			

Moon Pond	Average density (all nekton in streams) /m2	24.2	10			
Moon Pond	Average density (all nekton in pools) /m2	N/A	10			
Nauset Marsh	Species richness for site, pools and creeks, traps only	11	10			
Nauset Marsh	Average density (all nekton in streams) /m2	30.43	10			
Nauset Marsh	Average density (all nekton in pools) /m2	41.36	10			
Surface Elevation						2.6 mm/year is avg SLR for region
Hatches Harbor	Sediment accretion+elevation	TBD				
Herring River	Sediment accretion+elevation	TBD				
Nauset Marsh	Sediment accretion+elevation	TBD				
Threatened species (Box Turtles)	Number of Captures (incidental encounters)	60	2	annual range from 19-89		data range from 1999-2009, sampling not standardized
Ocean shoreline position	# acres eroded/accreted compared to baseline	TBD				
Estuarine Nutrient Enrichment						
Pleasant Bay	Dissolved oxygen (mg/L)	TBD	3	Good(> 5 ppm), Fair (2-5 ppm), Poor (< 2 ppm)	22	
Pleasant Bay	Salinity (ppt)	TBD	3			
Pleasant Bay	Maximum Temperature (C)	TBD	3	<30 C, lethal limit for grazing herbivores	13	
Pleasant Bay	Turbidity NTU	TBD	3			strongly influences seagrass, correlated with nutrient enrichment
Pleasant Bay	Chlorophyll a concentration ug/L	TBD	3	Good(< 5 µg /l), Fair (5-20 µg /l), Poor (> 20 µg /l)	22	correlated with dissolved inorganic nutrients
Pleasant Bay	Attenuation of Photosynthetically Available Radiation (Kd m-1)					
Nauset Marsh	Dissolved oxygen (mg/L)	TBD	3			
Nauset Marsh	Salinity (ppt)	TBD	3			

Nauset Marsh	Maximum Temperature (C)	TBD	3	<30 C, lethal limit for grazing herbivores	13
Nauset Marsh	Turbidity NTU	TBD	3		
Nauset Marsh	Chlorophyll a concentration ug/L	TBD	3		
Nauset Marsh	Attenuation of Photosynthetically Available Radiation (Kd m-1)				
Kettle Pond Strata	Dissolved oxygen (mg/L)	TBD		>2.0 mg/L to avoid suppressed diversity and abundance of benthic fauna	
Kettle Pond Strata	Salinity (ppt)	TBD		Long term avg for site or comparable to similar sites	
Kettle Pond Strata	Maximum Temperature (C)	TBD		<30 C, lethal limit for grazing herbivores	
Kettle Pond Strata	Turbidity NTU	TBD		Comparable to similar sites	
Kettle Pond Strata	Chlorophyll a concentration ug/L	TBD		Long term avg for site or comparable to similar sites	
Kettle Pond Strata	Attenuation of Photosynthetically Available Radiation (Kd m-1)			Long term avg for site or comparable to similar sites	
Kettle Pond Strata	Surface nutrients at fixed monitoring station	TBD		Long term avg for site or comparable to similar sites	
Kettle Pond Strata	Sediment C:N ratio at fixed monitoring station	TBD		Long term avg for site	
Kettle Pond Strata	Secchi disk depth	TBD		Comparable to similar sites	
ENE seagrass condition	total biomass all transects	TBD		Long term avg for site	
ENE seagrass condition	shoot density all transects	TBD		Long term avg for site or comparable to similar sites	

ENE seagrass distribution	Seagrass bed size	TBD				important biogenic habitat type, sensitive to eutrophication
ENE seagrass condition	within bed % cover	TBD				declines indicate early warning for reduced abundance and distribution of this habitat type
Kettle Pond Water Quality	Total Phosphorus (uM)	0.2	6	.26 (uM)	18	
Kettle Ponds	Total Nitrogen (uM)	15.2	6	30 (uM)	18	
Kettle Ponds	Dissolved inorganic nutrients (NH4, PO4, NO3)	TBD	6			
Kettle Ponds	Dissolved oxygen (%), 1 m depth	0.99	5			
Kettle Ponds	Dissolved oxygen (mg/L)	10.29	5	5 mg/L	17	
Kettle Ponds	pH	5.81	5	4.5-8	23	
Kettle Ponds	Light transmission (% of surface at 1 m depth)	10.29	5			
Kettle Ponds	chlorophyll a	5.81		2.90 ug/L	18	
Kettle Ponds	Secchi depth, average 20 ponds (m)	7	4	4.5	18	
Air Quality						
Acidic deposition and stress	Wet deposition of Ammonium mg/L	7.35	11			
Acidic deposition and stress	Wet deposition of Nitrate mg/L	37.891	11			
Acidic deposition and stress	Wet deposition of Sulfate mg/L	56.673	11			
Acidic deposition and stress	Wet deposition of Mercury ppb	4.95				
Haze Index - Moderate Days	Interagency Monitoring of Protected Visual Environments (IMPROVE) Deciviews/yr	TBD		TBD		
High Ozone Measure	# of annual exceedances for 8 hour ozone concentration	2	12	<0.075 ppm 8 hour average ozone standard	12,15	
Groundwater level	Average water level (ft-MSL)	8.28	19			
	Nauset Lens Average water level (ft-MSL)	12.77	19,20			
	Chequessett Lens Average water level (ft-MSL)	6.74	19-21			
	Pamet Lens Average water level (ft-MSL)	4.84	19-21			

Pilgrim Lens	Average water level (ft-MSL)	5.21	19-21

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 (1998-2009)
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, all 2009 data
11: National Atmospheric Deposition program, annual total (Jan-Sept) values, http://nadp.sws.uiuc.edu/nadpdata/mdn
12: MA Dept. of Environmental Protection Ozone monitoring, www.epa.gov/NE/airquality/03exceed
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. Developing 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_health
16: US EPA National Coastal Assessment and the NOAA National Eutrophication Assessment (USEPA 2001, 2002, 2004, and Bricker *et al*. 1999).
17: http://www.epa.gov/waterscience/criteria/wqctable/
18: http://www.epa.gov/waterscience/criteria/nutrient/ecoregions/
19: Annual water level data collected 10 of 12 months in 2008, from McCobb and Weiskel (2002) protocol
20: 9 of 28 wells do not have elevation data so not used in annual average of water level
21: 6 of 8 wells used for Nauset data, 8 of 11 used for Chequessett data, 4 of 7 used for Pamet data and 1 of 2 used for Pilgrim data
22: US EPA National Coastal Assessment and the NOAA National Eutrophication Assessment (USEPA 2001, 2002, 2004, and Bricker *et al.* 1999).
23: Portnoy *et al*. 2001 Kettle Pond Atlas, H. Bayley best professional judgment

VI. Budget Narrative

In FY2009 the Cape Cod Ecosystem Monitoring Program received an authorization of $702,400 from the NPS I&M program for regular program expenses and operations. Approximately 63% 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 FY2009 and the Aquatic Ecologist position was vacated as of late October 2007. The salary lapse for these two positions ($157,559) was absorbed by the park in accordance with CACO policy. We plan to fill the data manager position in FY2010. A summary of our FY2009 expenditures is appended to the end of this report.

Budget Summary

FY09 Admin Report Network: Cape Cod NS Prototype

Category: 1_Income

Description	$ Amount	$$ Source	Where $ Went	Comments
	$702,400.00	Prototype $$ - Park Base		
Subtotal	*$702,400.00*			

Category: 2_Personnel

Description	$ Amount	$$ Source	Where $ Went	Comments
Hydrology Technician	$61,983.00	Prototype $$ - Park Base	NPS	
SCA rent, background checks	$4,743.00	Prototype $$ - Park Base	NPS	
Research and Monitoring Coordinator	$51,481.00	Prototype $$ - Park Base	NPS	
Plant Ecologist	$99,038.00	Prototype $$ - Park Base	NPS	
Physical Scientist	$26,685.00	Prototype $$ - Park Base	NPS	
Physical Scientist Lab Tech	$24,759.00	Prototype $$ - Park Base	NPS	
Budget Tech	$10,100.00	Prototype $$ - Park Base	NPS	
Aquatic Ecology Tech	$37,669.00	Prototype $$ - Park Base	NPS	
Vegetation Tech	$8,022.00	Prototype $$ - Park Base	NPS	
GIS Tech	$1,761.00	Prototype $$ - Park Base	NPS	
Law Enforcement support	$2,870.00	Prototype $$ - Park Base	NPS	
Seasonal Biotech 1	$2,144.00	Prototype $$ - Park Base	NPS	VUA 1 Bersin
Seasonal Biotech 2	$2,005.00	Prototype $$ - Park Base	NPS	VUA 2 Torres
Shorebird Tech	$2,178.00	Prototype $$ - Park Base	NPS	N District shorebird Harrison
Wildlife Ecologist	$105,154.00	Prototype $$ - Park Base	NPS	
Subtotal	*$440,592.00*			

Category: 3_Coop. Agreements

Description	$ Amount	$$ Source	Where $ Went	Comments
Student Conservation Association	$3,840.00	Prototype $$ - Park Base	Other non-Federal	Fall KPWQ intern
University of Massachusetts, Amherst	$16,000.00	Prototype $$ - Park Base	University-CESU	Cover type monitoring
USGS Eastern Region	$7,400.00	Prototype $$ - Park Base	USGS	Seagrass
Subtotal	*$27,240.00*			

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*			

Category: 5_Operations/Equipme

Description	$ Amount	$$ Source	Where $ Went	Comments
Field equipment and supplies	$26,181.00	Prototype $$ - Park Base	Other non-Federal	
Student Conservation Assoc	$7,680.00	Prototype $$ - Park Base	Other non-Federal	KPWQ, Veg
Office Supplies	$2,317.00	Prototype $$ - Park Base	Other non-Federal	
Laboratory analysis	$2,342.00	Prototype $$ - Park Base	University-CESU	cation analysis
Lab equipment, supplies	$11,922.00	Prototype $$ - Park Base	Other non-Federal	
Computers/Computing needs	$7,782.00	Prototype $$ - Park Base	Other non-Federal	
Subtotal	*$58,224.00*			

Category: 6_Travel

Description	$ Amount	$$ Source	Where $ Went	Comments
Outreach/Communications/Meetings	$5,479.00	Prototype $$ - Park Base	Other non-Federal	
Subtotal	*$5,479.00*			

Category: 7_Other

Description	$ Amount	$$ Source	Where $ Went	Comments
Unexpended funds	$2,234.00	Prototype $$ - Park Base	NPS	
Salary Lapse	$157,559.00	Prototype $$ - Park Base	NPS	taken by park per CACO policy
Subtotal	*$159,793.00*			

Budget Analysis

Analysis of Expenses by Where $ Went

Funding Source	Total $$	NPS	USGS	Other Federal	Univ.-CESU	Univ_Non-CESU	Other non-Federal
Prototype $$ - Park	$702,400	$600,385	$7,400		$18,342	$11,072	$65,201
Totals	$702,400	$600,385	$7,400		$18,342	$11,072	$65,201

Analysis of Expenses by Category

Funding Source	Total $$	Personnel	Coop Agree.	Contracts	Operations/Equip.	Travel	Other
Prototype $$ - Park	$702,400	$440,592	$27,240	$11,072	$58,224	$5,479	$159,793
Totals	$702,400	$440,592	$27,240	$11,072	$58,224	$5,479	$159,793

Expense Totals By Category

Category	SubTotal	Percent
2_Personnel	$440,592	62.73%
3_Coop. Agreements	$27,240	3.88%
4_Contracts	$11,072	1.58%
5_Operations/Equipment	$58,224	8.29%
6_Travel	$5,479	0.78%
7_Other	$159,793	22.75%
	$702,400	

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