Monitoring in the Context of Climate Change

"Satellite measurements show sea-level is rising at 3.4 millimeters per year since these records began in 1993. This is 80% faster than the best estimate of the IPCC Third Assessment Report for the same time period."

-The Copenhagen Diagnosis, 2009

Status and Trends

The Northeast Coastal and Barrier Network (NCBN) monitoring program collects valuable data for tracking the conditions of park ecosystems in the context of climate change. Understanding both the rate and extent of change to park ecosystems and biota will help park managers determine and develop adaptation strategies and initiatives to reduce the vulnerability of park systems against actual or expected climate change effects.

In 2010, the NCBN will be collaborating with the Southeast Coast Network, Northeast Temperate Network, and the National Capital Region Network to enhance existing monitoring for coastal parks by adding additional climate-related metrics and/or vital signs. The goal is also to assure climate related monitoring is significant and comparable on a regional basis. Planning will include partnerships with NOAA, USFWS, and other federal and nonfederal agencies.

Monitoring Key Resources

Salt Marsh Monitoring

"Salt marshes and seagrass beds like rain forests are hot spots for biodiversity. They provide important and valuable ecosystem functions, including a large carbon sink capacity. The world is losing these coastal habitats four times faster than its rain forests and the rate of loss is accelerating."

-Duarte, 2009; Waycott et al., 2009

Salt marsh monitoring is a key component of the NCBN monitoring program. The Network is monitoring the effects of sea level-rise and climate change on NCBN salt marshes by measuring changes in marsh vegetation communities, nekton (fish and decapods) diversity and richness, soil salinity, and sediment elevation. Detecting shifts in species composition and spatial distribution of vegetation on the marsh, including the presence of invasive species may suggest changes in salinity levels, tidal flow, and groundwater levels. Nekton serve as indicators of ecosystem change because they are sensitive to environmental changes such as temperature and nutrient levels.

Researchers at Fire Island NS sampling nekton. Photo by Sara Stevens

Understanding changes in salt marsh elevation is necessary for interpreting long-term trends in salt marsh viability. The mean elevation of salt marsh surfaces must increase to keep pace with the annual rise in sea level and subsidence of salt marsh organic substrates. About 25% of the area originally covered by salt marshes has been globally lost, with current loss rates at about 1 to 2% per year (Bridgham et al., 2006). Parks included in this monitoring program are Assateague NS, Cape Cod NS, Colonial NHP, Fire Island NS, Gateway NRA, George Washington Birthplace NM, and Sagamore Hill NHS.

Example of nekton caught in a throw trap. Photo by Sara Stevens

Estuarine Nutrient Enrichment

Eutrophication is a process in which excessive nutrient input to water bodies stimulates algal growth and can lead to serious problems such as low dissolved oxygen, loss of submerged aquatic vegetation (SAV), and the associated loss of fish and invertebrate species. Human health risks include consumption of shellfish contaiminated with algal toxins or direct exposure to waterborne toxins.

Climate change may have a significant influence on the development of future eutrophic symptoms. Because warmer water holds less oxygen, global warming may lower dissolved oxygen or flushing times, and exchange rates may increase with rising sea levels and increased rainfall. The NCBN has incorporated seagrass monitoring and water quality monitoring into its nutrient enrichment monitoring protocol which are also compatible with the NPS National Marine Water Quality Monitoring Effort and EPA National Coastal Assessment.

Seagrass Monitoring

Seagrass ecosystems, considered high biomass producers, are significant carbon sinks. A recent assessment indicates that about one-third of the global seagrass area has been already lost, and that these losses are accelerating, from less than 0.9% per year in the 1970's to more than 7% per year since 2000 (Waycott et al., 2009).

Seagrass monitoring at Cape Cod NS, Fire Island NS, and Assategue NS provides these parks with information on changing distribution of seagrass resources and site-specific trends in habitat characteristics. This information is valuable for assessing system-wide responses to estuarine nutrient enrichment and on the overall condition of seagrass resources throughout park estuaries.

Water Quality Monitoring

NCBN developed an estuarine water quality monitoring program capable of diagnosing local causes of nutrient enrichment, detecting changes in nutrient loads, and determining if nutrient inputs are near to exceeding thresholds that would result in shifts in ecosystem structure and function. Estuarine nutrient monitoring variables such as sediment organic carbon content and benthic faunal species composition are sampled every five years. Other variables (chlorophyll a, dissolved oxygen concentration, attenuation of photosynthetically active radiation, and the required ancillary data of temperature and salinity) are measured biennially.

This protocol includes probability-based spatial sampling strategies, methods for incorporating non-Park Service data, and instructions on reporting and interpreting results. Parks included in this monitoring program are Assateague NS, Cape Cod NS, Colonial NHP, Fire Island NS, Gateway NRA, George Washington Birthplace NM, and Sagamore Hill NHS.

Coastal erosion is considered a high prioriy management issue for NPS Resource Managers within the NCBN. Photo by Charles Roman

Coastal Shoreline Monitoring

As a result of systematic coastal shoreline and topography mapping and monitoring conducted by the NCBN, parks are able to identify areas of "critical erosion" where both park infrastructure and natural resources are threatened by rapid increase in erosion due to factors such as increased storm intensity and frequency, and sea level-rise. Since early 2001, the Network has partnered with USGS and NASA to collect LiDAR data for the coastal parks on a two-year basis. These data sets have been used widely by scientific and academic communities as well as park staff, and the Regional Field Technical Support Center to better understand habitat/vegetation change, elevation change, and changes in coastal geomorphic features including dunes, cliffs, shorelines, and edge of vegetation along the barrier islands. Parks included in this monitoring program are Assateague NS, Cape Cod NS, Fire Island NS, Gateway NRA, and George Washington Birthplace NM.

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Northeast Coastal and Barrier Network
Coastal Institute in Kingston, #105
1 Greenhouse Road
Kingston, Rhode Island 02881
http://science.nature.nps.gov/im/units/ncbn/index.aspx

Program Manager
Sara Stevens
401-874-4548
Sara_Stevens@nps.gov

Data Manager
Dennis Skidds
401-874-4305
Dennis_Skidds@nps.gov

Biological Technician
Erika Patenaude
401-874-4305
Erika_Patenaude@nps.gov

Quantitative Ecologist
Penelope Pooler
401-874-7060
Penelope_Pooler@nps.gov

Science Communicator/Research Associate
Linda Fabre
401-874-4305
linda@edc.uri.edu

Monitoring Climate Change at Cape Cod National Seashore

Long-term Monitoring

The Cape Cod Ecosystem Monitoring program seeks to identify and understand long-term changes in hydrologic, chemical, and biological features of ponds, salt marshes, and estuaries that occur in Cape Cod National Seashore. The long-term monitoring program provides critical data for understanding changes in these ecosystems related to climate change. Many ecosystems within the Cape Cod National Seashore are vulnerable to the increases in air temperature, precipitation, and sea level that are projected in future decades (Frumhoff et al. 2007). Monitoring of vegetation in coastal marshes, amphibians in wetlands, and water quality in permanently flooded kettle ponds are the longest standing programs at Cape Cod National Seashore going back as far as the 1950s. Estuarine water quality and nekton monitoring have been added to the Cape Cod Ecosystem Monitoring program in recent years.

Gull Pond shoreline, Wellfleet, Massachusetts. *Photo: Steve Smith*

Gull Pond, top left, and other kettle ponds within the Cape Cod National Seashore. Gull Pond is connected in a chain to three other ponds by small artificially maintained sluiceways, and ultimately to the Cape Cod Bay via the Herring River outlet.

Status and Trends

Water Quality Monitoring

Cape Cod's climate is changing, and records show that winters are shorter and summers are hotter and longer (Frumhoff et al. 2007). As with many ecosystems within Cape Cod National Seashore, kettle ponds are susceptible to climate-related changes in air temperature, precipitation, and sea level, which drive physical, chemical and biological processes. Gull Pond, the largest and deepest kettle pond in the park, has been monitored by National Park Service natural resource staff for decades to study what its history reveals about changes in the climate and the environment, as well as assess the impact of current human use. It covers 44 hectares, with an average depth of 10 meters and a maximum depth of 20 meters. Gull Pond has also been the subject of paleolimnologic research that documented the influences of climate, physical setting and human activities on its modern water quality and biology. Data obtained by Cape Cod Ecosystem Monitoring staff shows that average surface water temperature at the warmest time of year has been increasing since 1980 (Figure 1). This increase in pond water temperature over time is likely related to higher air temperatures associated with atmospheric warming. Thermal stratification is common, and over the spring and summer the top layers of the pond become warm and oxygen-rich, while the bottom layers become stagnant and often oxygen-poor (hypoxic). Warming and changes in seasonal trends associated with climate change could result in longer periods of stratification, consequently prolonging the duration and volume of bottom water hypoxia. Prolonged hypoxic conditions can lead to significant biological changes including algal blooms and fish kills.

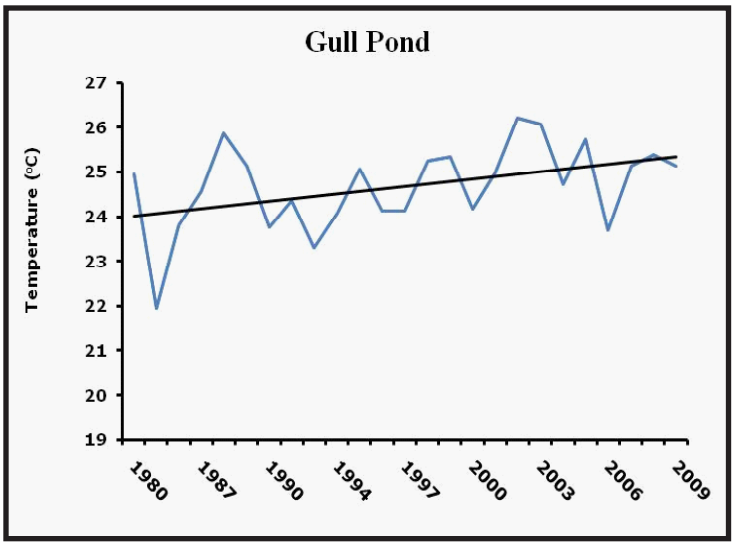

Figure 1: Average surface water temperatures in °C for the month of August across several decades.

Managment Implications

Natural resource management issues relating to kettle ponds and other Cape Cod National Seashore ecosystems are complex, involving federal, state, town and private ownership, as well as significant public use. Systematic long-term monitoring programs provide critical information to continue to assess the current and future impacts of climate change and to develop management strategies to mitigate the effects of climate change on wetland and coastal resources.

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More Information

Sophia Fox
Aquatic Ecologist
Cape Cod National Seashore

Phone/Email
508-487-3262 ext. 109
Sophia_Fox@nps.gov

Links & Resources

Cape Cod National Seashore Ecosystem Monitoring Program: http://www.nps.gov/caco/naturescience/cape-cod-ecosystem-monitoring.htm

Cape Cod National Seashore
99 Marconi Site Road
Wellfleet, MA 02667
http://www.nps.gov/caco/naturescience/index.htm

Monitoring Coordinator
Megan Tyrrell
508-487-3262 ext. 105
Megan_Tyrrell@nps.gov

Aquatic Ecologist
Sophia Fox
508-487-3262 ext. 109
Sophia_Fox@nps.gov

Plant Ecologist
Stephen M. Smith
508-487-3262 ext. 104
Stephen_M_Smith@nps.gov

Wildlife Ecologist
Robert Cook
508-487-3262 ext. 106
Robert_Cook@nps.gov

Hydrologic Technician
Kelly Medeiros
508-487-3262 ext. 117
Kelly_Medeiros@nps.gov

Aquatic Ecology Technician
Holly Bayley
508-487-3262 ext. 118
Holly_Bayley@nps.gov