



## 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

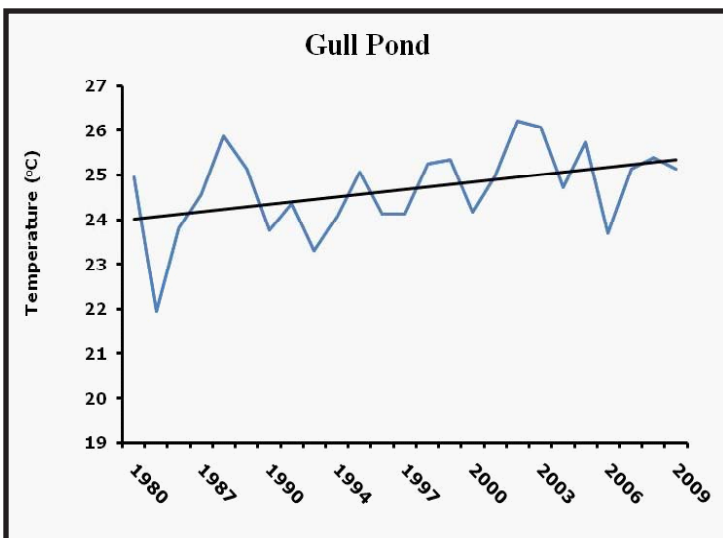


Figure 1: Average surface water temperatures in °C for the month of August across several decades.

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.

### MANAGEMENT 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.

### References

- Frumhoff, P.C., J.J. McCarthy, J.M. Melillo, S.C. Moser, and D.J. Wuebbles. 2007. *Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions*. Synthesis report of the Northeast Climate Impacts Assessment (NECIA). Cambridge, MA: Union of Concerned Scientists (UCS).

## More Information

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### Links & Resources

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



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99 Marconi Site Road  
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