U.S. Senate Committee on Environment and Public Works

Hearing on *The Impacts of Global Warming on the Chesapeake Bay*

September 26, 2007

Testimony of

Dr. Christopher R. Pyke[1]

Member, Scientific and Technical Advisory Committee of the Chesapeake Bay Program

Fellow, Center for Coastal Resources Management, Virginia Institute of Marine Science

Director of Climate Change Services, CTG, Energetics, Inc.

INTRODUCTION

Chairman Boxer, ranking member Inhofe and members of the Committee: thank you for your invitation to address the Committee on the important issue of *the impacts of global warming on the Chesapeake Bay*. I am Christopher R. Pyke, and I currently serve as a member of the Scientific and Technical Advisory Committee for the US Environmental Protection Agency's (EPA) Chesapeake Bay Program (Bay Program). I am also a fellow with the Virginia Institute of Marine Science's Center for Coastal Resources Management, and the Director of Climate Change Services for CTG Energetics, Inc., a green building and sustainable design consultancy. Previously, I served as a physical scientist with the U.S. EPA's Global Change Research Program, and as a co-chair of the U.S. Climate Change Science Program's Human Contributions and Responses

[1] *Contact:* Christopher R. Pyke, CTG Energetics, Inc., 101 N. Columbus St., Suite 401, Alexandria, VA 22314, cpyke@ctgenergetics.com, (202) 731-0801

Interagency Working Group. I maintain a long-term interest in the implications of climate change for water quality and aquatic ecosystems, and I am actively engaged in a wide-range of issues linking land use decisions with climate mitigation, impacts, and adaptation. A brief biography summarizing my professional experience is an attachment to this testimony.

In response to Chairman Boxer's letter of invitation, my testimony provides my views on the impact of global warming on the Chesapeake Bay with particular emphasis on findings from a report I am coordinating on behalf of the Bay Program's Scientific and Technical Advisory Committee (STAC). Although my remarks draw extensively on findings in this forthcoming report, my comments reflect only my own professional opinion and they are not necessarily those of the STAC or any other organization.

SUMMARY

Climate change is more than a future threat to the Chesapeake Bay. The Bay Program partners are making long-term, capital-intensive decisions that are expected to yield results for decades into the future. Changes in sea level, temperature, precipitation, and other aspects of climate are likely to alter the cost and efficacy of many these activities. In this context, climate change is an immediate concern for efforts to protect and restore water quality and living resources. **The Bay Program partners can and should take immediate action to assess the implications of changing climatic conditions for their**

activities and ensure that restoration strategies will be effective under future conditions.

This outcome can be promoted by immediate action to:

1. Identify and address climatic assumptions associated with important management and policy decisions (e.g., water quality regulation).

2. Evaluate the sensitivity of water quality protection, living resource restoration, and monitoring strategies to climate change and promote the development and implementation of practices that are resilient and adaptive to changing conditions.

3. Develop a comprehensive, Bay-wide Climate Change Action Plan that will serve as a roadmap to prioritize research and management activities and guide the implementation of adaptive responses.

INTRODUCTION TO STAC CLIMATE CHANGE STUDY

The Chesapeake Bay Program's Scientific and Technical Advisory Committee (STAC) provides guidance to the Bay Program on measures to restore and protect the Chesapeake Bay. STAC accomplishes its mission through technical reports and papers, discussion groups, reviews of Bay Program activities, technical conferences and workshops, and service by STAC members on Bay Program subcommittees and workgroups. STAC reports annually to the Bay Program Executive Council and quarterly to the Implementation Committee. STAC is composed of 38 members drawn from federal and state agencies, universities, research institutions, and private industry.

In December 2006, the Chesapeake Bay Program requested that the STAC evaluate current understanding about the implications of climate change for the Chesapeake Bay, specifically the restoration of water quality and living resources. STAC was asked to review recent and on-going research activities, identify critical knowledge gaps, and make recommendations for next steps in addressing climate change.

STAC's response to this request is being led by Ray Najjar from Pennsylvania State University and myself with assistance from a team of co-authors including Mary Beth Adams, Denise Breitburg, Carl Hershner, Robert Howarth, Michael Kemp, Margaret Mulholland, David Secor, Kevin Sellner, and Robert Wood.

The forthcoming report will include three sections:

1. A review of scientific research and literature
2. An assessment of gaps in understanding and research priorities
3. Recommendations for next steps

A draft version of the report is currently under internal review by the STAC, and it is scheduled for public release at the end of October 2007. The following comments focus on the second two sections of the report. My testimony draws primarily on this study; however, any specific conclusions or interpretations reflect only my professional opinions.

GAPS IN UNDERSTANDING AND RESEARCH PRIORITIES

The STAC review identified four research themes in recent climate change-related research associated with the Chesapeake Bay:

1. Physical drivers of change
2. Environmental monitoring
3. Impacts on restoration strategies
4. Adaptive responses to climate change

Physical drivers of change

Climate variability and climate change create challenges for the restoration of water quality and living resources in the Chesapeake Bay. Understanding of spatial and temporal dynamics associated with physical drivers is essential to effective responses to these challenges. Researchers have identified a variety of physical changes through analysis of historic observations, including trends in sea level, temperature, and precipitation patterns. Modeling studies suggest that historic trends are likely to continue and potentially accelerate across a wide range of socio-economic scenarios. Projections for sea level and temperature are relatively well constrained. While the greatest uncertainty is associated with one of the most important variables required to understand Chesapeake Bay ecosystems: precipitation. Spatial and temporal changes in precipitation patterns can have far-reaching implications for the Bay ecosystems through impacts on watershed hydrology and biogeochemical processes, particularly under warmer temperature regimes. **It is essential to develop a better understanding of potential changes in regional precipitation and the implications of potentially unprecedented combinations of temperature and precipitation.**

Environmental monitoring

Environmental monitoring is an essential component of the Chesapeake Bay Program. Computer models and simulations are used to develop environmental policy and regulation. However, the ultimate success (or failure) of these measures is based on real world conditions. Climate change adds to the already critical need for monitoring and creates new challenges. Chesapeake Bay monitoring systems must be designed to detect long-term trends *and* allow managers to differentiate changes driven by climate from those associated with other sources of degradation (e.g., land use) or restoration action. This information is necessary to evaluate the efficacy of management actions and accurately attribute the causes of improvement or degradation in ecosystem health and water quality. **It is essential that the Bay Program evaluate the consequences of climate change for its existing monitoring systems and ensure that sampling designs**

provide adequate statistical power to detect trends and differentiate sources of improvement or degradation.

Impacts on restoration strategies

Understanding of physical drivers of change and consideration for the effectiveness of environmental monitoring help create the foundation of information needed to consider one of the most critical questions: What are the implications of climate change for the Bay Program's strategies to restore water quality and living resources?

Three of the most important strategies include:

- Bay-wide water quality regulation.
- State tributary strategies designed to achieve the goals of the *Chesapeake 2000* agreement.
- Activities to protect and restore living resources, such as submerged aquatic vegetation and oysters.

These strategies are central to the success of the Bay Program, and climate change is likely to jeopardize the validity of key assumptions used in current approaches to developing and implementing these strategies.

For example, calculations used to estimate TMDLs are based on a carefully selected subset of historic meteorological observations. However, observations and modeling results make it increasingly clear that these historic time series are unlikely to be representative of future conditions. **It is essential to develop methods for calculating TMDLs that explicitly incorporate information about changing climatic conditions.**

State partners have developed implementation plans called tributary strategies. These documents describe the combination of approaches needed to restore Bay water quality. The performance of individual management practices is central to the design of tributary strategies, and our understanding about performance is based on observations under historic climatic conditions. For example, the ability of stormwater detention ponds to capture sediment and remove nutrients varies as a function of precipitation volume and intensity. It is increasingly likely that detention pond designs based on historic precipitation requirements may not meet performance goals under future conditions. Many widely-used water quality Best Management Practices are likely to exhibit similar sensitivities. **It is important for the Bay Program partners to assess the consequences of climate change for the effectiveness of management practices.**

Similar considerations also apply to efforts to address living resources. Restoration efforts rely on understanding of historic relationships between climatic conditions and ecological processes. However, changes in climate are likely to jeopardize these relationships. For example, planting of submerged aquatic vegetation (SAV) is a major emphasis of the Bay Program; however, SAV is known to be highly sensitive to peak summer temperatures and flow regimes. Climate change is likely to alter both of these variables and alter the likelihood of restoration success. Fortunately, it is possible to identify these climatic assumptions and take action to develop more sustainable restoration plans. For example, experience with coral reef ecosystems suggests that it is possible to identify resilient sites where local conditions offset regional climatic stresses and increase the likelihood of restoration success. This suggests that restoration activities in the Bay may benefit from efforts to identify resilient restoration locations at local and regional scales. **The Bay Program partners should assess the vulnerability of living resource restoration efforts to climate change and require projects to take specific steps to increase the likelihood of success under changing conditions.**

Adaptive responses

The serious implications of climate change for the Bay Program lead directly to consideration of potential measures to adapt to changing conditions. This is an emerging area of research that has received relatively limited attention from the scientific community.

It is possible to distinguish between resilient and adaptive responses to climate change impacts. Resilient responses help increase capacity of systems to respond to disturbance and accommodate changing conditions. Resilient responses strive to identify opportunities to make decisions more robust to a range of future conditions. Adaptive responses attempt to actively incorporate observations and model projections to anticipate and respond to changing conditions. The goal is to adjust management practices to increase the likelihood of success under future conditions. Unfortunately, adaptive approaches are often constrained by current practices locked by convention or regulation to historic conditions. For example, standard "design storms" are often used to develop stormwater management systems. Observations and modeling results clearly suggest that these design storms are unlikely to be representative of future conditions. Consequently, systems based on these specifications may fail under future conditions. Adaptation requires identifying these climatic assumptions and taking action to anticipate the consequences of changing conditions. This includes creating dynamic linkages between management and monitoring to provide feedback and facilitate changes in practice over time. **The Bay Program partners can and should take action to increase the resilience of their activities to uncertain precipitation regimes and begin to adapt their management practices to rising temperatures and sea levels.**

NEXT STEPS

Climate change is more than a future threat to the Chesapeake Bay. The Bay Program partners are making long-term, capital-intensive decisions expected to yield results for decades into the future. In this context, climate change is an immediate concern to the restoration of water quality and living resources. **The Bay Program partners can and should take immediate action to assess the implications of changing climatic conditions for their activities and ensure that restoration strategies will be effective under future conditions.**

Identifying climatic assumptions and sensitivities

The Bay Program partners can and should take immediate action to address these issues through its existing authorities, responsibilities, and resources. The first, and perhaps most important, step is to explicitly recognize that climate change is a component of a wide-range of critical decisions associated with TMDLs, tributary strategies, living resource restoration, and many others. **The Bay Program partners can and should immediately require all major resource management decisions to include an assessment that (1) identifies climatic assumptions, (2) evaluates the potential for climatic change to undermine or alter these assumptions, and (3) explicitly considers alternative management options that are more resilient and adaptive.**

Climate Change Action Plan

An assessment of climatic assumptions and sensitivities provides immediate opportunities for improvement to internal Bay Program decision making processes. This is necessary but not sufficient to address the scope of the problem. It is equally important for the Bay Program to take a leadership role in addressing climate change across the watershed. One mechanism for achieving this is the development of a broad-based, Bay-wide Climate Change Action Plan. This Plan would build on and complement state-level Climate Action Plans with a specific emphasis on impacts and adaptation opportunities relevant to the protection and restoration of the Chesapeake Bay. The preparation of the plan should begin with the foundation of information provided by the scientific community and quickly broaden to engage the full spectrum of Bay Program partners at Federal, state, and local levels. The plan should include a detailed roadmap for research and management action to help the Bay Program achieve its mission under changing climatic conditions. **The Bay Program partners should take immediate action to promote and support the development of a Climate Change Action Plan.**

Research coordination and leadership

Improvements to internal decision making and regional coordination are essential components for the Bay Program. A third component involves enhancing the flow of scientific and technical information from the research community to decision makers and managers. Current understanding of the implications of climate change for the Chesapeake Bay is sufficient to raise alarm. For example, there are many reasons to suspect that water quality regulations are highly sensitive to assumptions about climatic conditions. However, the research community cannot yet provide definite recommendations for how to address these concerns.

The current body of knowledge reflects a history where research efforts have generally been broad in scope and, with notable exceptions, lacking in depth and duration. This pattern results from several decades of sporadic funding opportunities, the lack of institutional commitments, and the absence of widely-recognized research priorities. For example, there is no single research group or institution dedicated to climate change research and applications in the Chesapeake Bay.

This situation contrasts with a number of regions with strong, long-standing relationships between climate science, public policy, and ecosystem restoration. For example, the Climate Impacts Group (CIG) at the University of Washington is an award-winning interdisciplinary research group that works to understand natural climate variability and global change to increase the resilience of the Pacific Northwest to fluctuations in climate. The CIG has contributed demonstrably to a foundation of knowledge that supports some of the progressive public policy in the nation with regard to climate change (e.g., King County, Washington's 2007 Climate Plan). The Chesapeake Bay would benefit directly from a similar organization. **The Bay Program partners should take the lead in establishing an entity that links climate science, policy, and management throughout the watershed as quickly as possible.**

ATTACHMENT

DR. CHRISTOPHER R. PYKE is the Director of Climate Change Services for CTG Energetics, Inc., a team of engineers, architects, planners, and environmental scientists dedicated to integrating sustainability principles with the development of the built environment. Dr. Pyke coordinates CTG's climate change services, including greenhouse mitigation, impact assessment, and adaptation. He also contributes his technical expertise to CTG's Sustainable Communities practice. Dr. Pyke is a fellow with the Virginia Institute of Marine Science's Center for Coastal Resources Management, and a member of the Chesapeake Bay Program's Scientific and Technical Advisory Committee. Dr. Pyke conducts research on the environmental impacts of climate and land use change, as well potential adaptation strategies associated with land management, land protection, and the built environment. Prior to joining CTG, Dr. Pyke was a physical scientist with the US EPA's Global Change Research Program. While with the US EPA, Dr. Pyke served as co-chair of the US Climate Change Science Program's Human Contributions and Responses interagency working group. Dr. Pyke was a postdoctoral fellow with The Nature Conservancy's David H. Smith research program while in residence at the National Center for Ecological Analysis and Synthesis and Conservation International. Dr. Pyke served on the National Ecological Observatory Network's Science and Human Dimensions Committee. His recent work includes publications in *Environmental Science and Policy, Frontiers in Ecology and the Environment, Conservation Biology, Biological Conservation, Ecosystems, Ecological Modelling, Climatic Change,* and *Wetlands.* Dr. Pyke received a Ph.D. (2002) and M.A. (1998) degrees in Geography from the University of California, Santa Barbara and a B.S. (1996) in Geology from the College of William and Mary.