**WRITTEN TESTIMONY OF**
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**JOINT HEARING ON**
**CLIMATE CHANGE IMPACTS IN CHESEAPEAKE BAY**

**BEFORE THE**
**SUBCOMMITTEE ON INSULAR AFFAIRS, OCEANS, AND WILDLIFE AND**
**SUBCOMMITTEE ON NATIONAL PARKS, FORESTS AND PUBLIC LANDS**
**COMMITTEE ON NATURAL RESOURCES**
**U. S. HOUSE OF REPRESENTATIVES**

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## INTRODUCTION

Good morning, Chairwoman Bordallo and members of the Committee. I am Robert Wood, Director of the Cooperative Oxford Laboratory, a cooperative scientific research laboratory, administered by the National Oceanic and Atmospheric Administration (NOAA). The Cooperative Oxford Laboratory brings together the combined missions and resources of the Maryland Department of Natural Resources, NOAA, and the U.S. Coast Guard in assessing the trends and factors affecting the ecosystem health of Chesapeake Bay. I also recently served as a co-author on the Chesapeake Bay Program's Scientific and Technical Advisory Committee report entitled, *Climate Change and the Chesapeake Bay: State-of-the-Science Review and Recommendations*. Many of the points I will make in this testimony are covered in greater detail in that report, and I have submitted a copy of that report with my testimony for the record.

Thank you for inviting me to testify on the consequences of climate change for the Chesapeake Bay. I will provide background on the topic, address some potential consequences of climate change within the Bay, and discuss current and upcoming federal government action.

## LOCAL-SCALE CLIMATE CHANGE IN CHESAPEAKE BAY

By the end of this century, based on a range of carbon dioxide ($CO_2$) emissions scenarios, global carbon $CO_2$ concentrations will be 50 to 160 percent higher than they are today. $CO_2$ is one of a number of "radiatively active" (a.k.a. "greenhouse") atmospheric gases (methane, for example is another) that traps heat within the earth's atmosphere. Accordingly, there is scientific consensus that the trend in increasing atmospheric $CO_2$ will warm the planet, influence global atmospheric and oceanic circulation, and alter the hydrological cycle (evaporation, precipitation, river flow, and related processes). These changes in the global climate will have ramifications for the Bay's regional climate and will, in turn, affect the Bay's organisms, their habitats, and therefore, the valuable and important ecosystem services that the Bay provides to coastal communities and the nation as a whole. However, we cannot provide a detailed forecast for when and exactly how the Bay may change. There are uncertainties in exactly how the Bay's regional climate will respond to global changes. In addition, the net effect of future climate change scenarios will depend upon how humans prepare for and respond to these changes, as well as how organisms respond.

## CHANGES THAT MAY OCCUR

In order to prepare for changes in organisms, habitats and services, it is first important to understand how the Bay is likely to change in order to determine how those resources are likely to respond. Scientists typically approach this problem by linking studies of how the Bay's ecosystem (including humans) has responded to historic and contemporary climate variability and change, including sea level rise. Often this means that scientists use coupled atmosphere-ocean models to provide a projection of future climate conditions. Using a variety of methods, scientists translate these projections into potential changes that may occur within the waters and watershed of the Bay. Then, using specialized studies that focus on critical physical, chemical, and biological processes, scientists can evaluate how these changes may relate to the Bay's ability to sustainably deliver ecosystem goods and services, including safe recreational opportunities, productive fisheries, and safe commercial navigation.

***What are some important changes that might occur to alter Chesapeake Bay and affect its coastal communities?***

### *Projected Climate Changes*

Although the climate models typically used to project future global climate change scenarios are in relatively close agreement, differences emerge when comparing their forecasts at smaller, regional scales. Our inability to precisely predict how the Bay's climate will change is impacted by differences in the projections of these models for the Chesapeake Bay region, especially with respect to storminess, precipitation, and streamflow. However, it seems likely that winter and spring streamflow will increase, and that summertime heat waves and precipitation intensity are likely to increase. The models also agree that atmospheric $CO_2$, water temperature and sea level will all increase over time. In fact, long term relative sea level rise and warming of Bay waters has already been well documented.

### *Likely Ecosystem Responses*

Being a coastal estuary, the Bay's ecosystem is fundamentally shaped by the dynamic mixing of freshwater river flow and runoff from its watershed with oceanic waters. This means that plants, animals, sediments, and contaminants carried within these two differing sources of water also mix. Because the Chesapeake is a shallow estuary, its volume is relatively small compared to the volume of freshwater that enters the Bay as runoff from its large watershed. Accordingly, the Chesapeake is highly responsive to changes in precipitation and temperature.

Model projections predict climate changes will likely alter the biogeochemistry of the Bay through changes in nutrient, sediment, and salinity levels. Because the Chesapeake Bay currently straddles the boundaries of temperate mid-latitude and sub-tropical climate boundaries, it is currently subject to pronounced climate variability. As such, the plants and animals that occupy the Bay have already developed some strategies to cope with an environment that is subject to large changes in salinity and temperature. Therefore, determining exactly when changes will exceed what we have come to accept as 'natural variability' of the Bay is difficult. However, over time, warming, higher sea level, and changes in salinity and circulation are expected to have far-reaching impacts on a wide variety of important processes, organisms, and habitats throughout the Bay ecosystem, including erosion rates, phytoplankton, submerged aquatic vegetation, wetlands, bacteria, zooplankton, fish, and shellfish.

While the exact response of the Bay ecosystem to future climate changes remains unresolved, some changes are more likely than others. Likely changes include:

(1) ***Sea Level Rise* —** sea level within the Bay will rise (and its variability will increase), thereby increasing the likelihood of coastal flooding, submergence of estuarine wetlands, and shoreline erosion;
(2) ***Harmful algal blooms* —** warming and higher levels of atmospheric $CO_2$ are conditions that are favored by algae species that are harmful for humans, fish, and shellfish;
(3) ***Dead zones* —** warming and increased winter-spring stream flow will reduce the amount of dissolved oxygen in the Bay, limiting the available habitat for many important Bay species like oysters and striped bass;
(4) ***Seagrasses* —** warming will reduce the prevalence of eelgrass, the dominant submerged aquatic vegetation in the Bay;
(5) ***Shifts in Species Ranges* —** warming would likely shift the range of species in the Bay, favoring expanding ranges and abundances of plants and animals that are able to tolerate warmer temperatures. For species whose southernmost distribution limits occur within the Chesapeake, like the soft clam *Mya arenaria*, warming waters could dramatically reduce their occurrence or eliminate their presence from the Bay;
(6) ***Changes in the seasonal timing of migration and reproduction* —** warming will influence the growth rate, age of sexual maturity, and timing of spawning for many Bay organisms. Production of some species, especially spring spawning fish and shellfish could be inhibited by resulting mismatches that could occur between the age-sensitive dietary needs of developing fish and shellfish and the abundance of their prey;
(7) ***Food Web Shifts* —** warming will likely alter the relative abundance of fish and shellfish species in the Bay, which, in turn, could lead to large shifts in the Bay's overall food web as predator and prey dynamics shift;
(8) ***Invasive Species* —** changes in Bay salinity and temperature are likely to enhance the probability that invasive species may gain a foothold within the Bay (because some species will be able to expand their range, see (5)) and further disturb the ecosystem; and
(9) ***Diseases* —** warming and increased nutrient loading events are likely to increase the abundance of pathogenic bacteria capable of causing disease in fish, shellfish, and humans.

***So What does this all mean? The Striped Bass Example***

Although charting the course of the Chesapeake's response to future climate changes is difficult, we can better resolve the question at hand by simply asking, how are the most probable effects of climate change likely to affect key Bay species? The striped bass is one of the most ecologically and economically important species of the Bay and coastal area. To illustrate, let us analyze the potential effects on this particular species.

Striped bass spawn each spring in the upper tidal reaches of the Bay and its tributaries. Young striped bass depend upon the shallow shoreline areas for shelter and access to abundant prey. As sea levels rise, shoreline residents are likely to take protective measures to save their land from erosion. Armoring shorelines with sea walls and similar structures would replace valuable marshland habitats with an unvegetated stony shoreline that is unlikely to offer the necessary resources for the fish.

As sea levels rise, it is also likely that late winter and early spring conditions will be wetter and warmer. It has been established that cool, high flow conditions are associated with years of high striped bass production. While river flow is likely to be enhanced, warm conditions could cause shifts in the zooplankton community, thereby depriving the young fish of their preferred zooplankton prey species. In addition, the occurrence of large blooms of algae that may be inedible or even harmful to striped bass could further compromise production of these fish.

Warmer conditions could also cause disruptive shifts to occur in the Bay food web. In the past, striped bass spawning has occurred around the same time as the spring phytoplankton bloom. If the spring bloom does not occur at the same time spawning occurs, due to these climate changes, the traditional food of very young striped bass may not be available in the appropriate amount. Reduced food availability at early life stages would be expected to dramatically affect survival of these young fish and therefore could reduce striped bass production and abundance in the Bay.

In the main stem and lower tributaries of the Bay, important habitat for larger juvenile and adult striped bass is also likely to be reduced. As warmer, nutrient rich, turbid waters reduce seagrasses due the combined effects of shading and physiological stress, juvenile and adult striped bass will lose valuable foraging habitat. Seagrass beds are very productive habitats for juvenile blue crabs and small forage fish.

With warm and wet springtime conditions, phytoplankton may reach such high levels that many of the organisms could sink into deep waters before they could be eaten by other organisms. In the deeper waters in the main stem of the Bay, this mass of phytoplankton would be consumed by bacteria, and as a result, oxygen in these deep waters would be consumed faster than it could be replenished. The resulting low-oxygen zones (or dead zones**)** created would prevent juvenile and adult striped bass from occupying these areas. With these same projected climate changes, the Bay's surface waters could become too warm to allow for effective foraging by striped bass on important surface-feeding prey like Atlantic menhaden. This combination of warm surface waters and low oxygen deep waters would create a 'habitat squeeze' that could force striped bass into a relatively narrow depth zone where prey may not be readily available. Another threat could emerge as these fish, stressed by prolonged periods of warm, low oxygen waters, may also be exposed to an increased abundance of pathogenic bacteria, which would likely cause disease to increase in the Bay's striped bass population.

Unfortunately, the processes and pressures described above are already observable in today's Bay. Relative sea level rise (including land subsidence) and population growth over past decades has accelerated the development of sea walls and other hardened shorelines and has eliminated some of the Bay's productive shoreline habitats. In addition, land use practices and development have led to enhanced runoff and nutrient enriched waters, especially in years when the weather is warm and wet. Climate changes, especially if coupled with human responses that may exacerbate, rather than mitigate, stress on the ecosystem may lead to an undesirable 'drift' in the average conditions in the Bay so that, for example, years of high stress on the striped bass, which now occur intermittently, could become the average condition in future years.

## NOAA'S ROLE IN ASSESSING AND ADAPTING TO CLIMATE CHANGE

NOAA, through development and delivery of climate information and services, implementation of a global observing system, and focused research and modeling to understand key climate processes, works to help society understand, plan for, and respond to climate variability and change. The NOAA climate mission is an end-to-end endeavor focused on providing a predictive understanding of the global climate system to allow the public to incorporate the information and products into their decision-making. Across the agency, scientists and technical experts are assisting local communities in studying, predicting, and responding to these potential changes. Just this month, the U.S. Global Change Research Program, which NOAA is a part of, released a new report titled *Global Climate Change Impacts in the United States*, which addresses the broad impacts of climate change in the U.S. and in regions such as the Chesapeake Bay.

NOAA and partners work to restore the natural buffers (e.g., near-shore oyster reefs and seagrass beds) that reduce wave damage and protect coastal property from erosion. Protection and restoration of these coastal resources can help protect coastal communities against the onslaught of coastal hazards, sea level rise, and other effects of climate change, and will enhance the ecosystem's resilience. NOAA also works with communities to restore eroding shorelines with natural vegetation rather than sea walls and other hardened shorelines which present barriers to the migration of habitat inland as sea level rises.

NOAA has a wide range of programs and tools to assist localities in planning for climate change. NOAA Sea Grant engages a network of the Chesapeake Bay area's top universities in conducting scientific research, education, training and extension projects designed to foster science-based decisions about the use and conservation of aquatic resources. Sea Grant's extension and education activities help inform policy, law and regulation, and management practices for industry and government agencies. The Chesapeake Inundation Prediction System can predict street-level inundation from coastal storms and sea level rise to assist local planners. NOAA's Chesapeake Network for Educating Municipal Officials helps communities to foster well-planned growth, preserve water quality, and protect natural areas in the Chesapeake watershed. Chesapeake Bay National Estuarine Research Reserve System's Coastal Training Program links local planners with new tools and available expertise. Through a series of workshops, planners and other officials are invited to participate in forums such as how to plan for climate change impacts, and adaptation and shoreline management.

## EXECUTIVE ORDER 13508, *CHESAPEAKE BAY PROTECTION AND RESTORATION*

On May 12, 2009, President Obama issued Executive Order (EO) 13508, *Chesapeake Bay Protection and Restoration*, calling for a greater federal role and accountability for Bay protection and restoration. The EO requires seven reports to be completed within 120 days (*i.e.*, by September 15, 2009) and a coordinated federal strategy to be disseminated for public review at 180 days (*i.e.*, by November 13, 2009). NOAA is helping to co-lead the production of 3 of these 7 reports with our interagency partners.

As part of the reports on climate change, the EO requires agencies to "develop a strategy for adapting … to the impacts of a changing climate on water quality and living resources of the Chesapeake Bay watershed." Efforts to address these changes will be integrated into all of the reports called for in the EO, as well as the overarching federal strategy for the protection and restoration of the Chesapeake Bay. The reports will build on existing capabilities and planning efforts, such as those related to the impacts of sea level rise and storm surge on coastal communities, predictive modeling of inundation and sea level rise, community resilience assessments and adaptive strategies, research on the impacts of climate change on living resources, and development of innovative practical applications (such as living shorelines) to protect coastal communities and resources.

## CONCLUSION

This testimony has focused on those changes that scientists have the most confidence in projecting. However, it is important to note that our insights are limited by our current understanding of the processes that shape the contemporary Bay, under contemporary or historic climatic conditions. Even if we were blessed with a perfect understanding of today's Bay, it is entirely possible that changes in climate may lead to changes in ecosystem dynamics that we can not predict.

Given the looming specter of climate change-induced alterations of the Bay ecosystem, there is great need for enhanced ecosystem research and observation designed to identify and better predict the nature and magnitude of these changes. Further, because the human response to these changes will help determine their overall impact on the ecosystem and its coastal communities, it is also imperative to identify changes in human behavior, both within the watershed and on the water, that will help restore a resilient Chesapeake Bay and protect the surrounding communities.