# U.S. Senate Committee on Environment and Public Works Hearing on an Examination of the Impacts of Global Warming on the Chesapeake Bay

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Testimony of
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Chairman Boxer and members of the Committee, I am Donald F. Boesch and am pleased to appear before you today to address what is known about the impacts of global warming on the Chesapeake Bay, what future effects are likely, and what can be done to address the consequences to this magnificent ecosystem, its living resources and the people who live in the Bay region. This is a special honor for me because Maryland's two senators and our Governor are all here today.

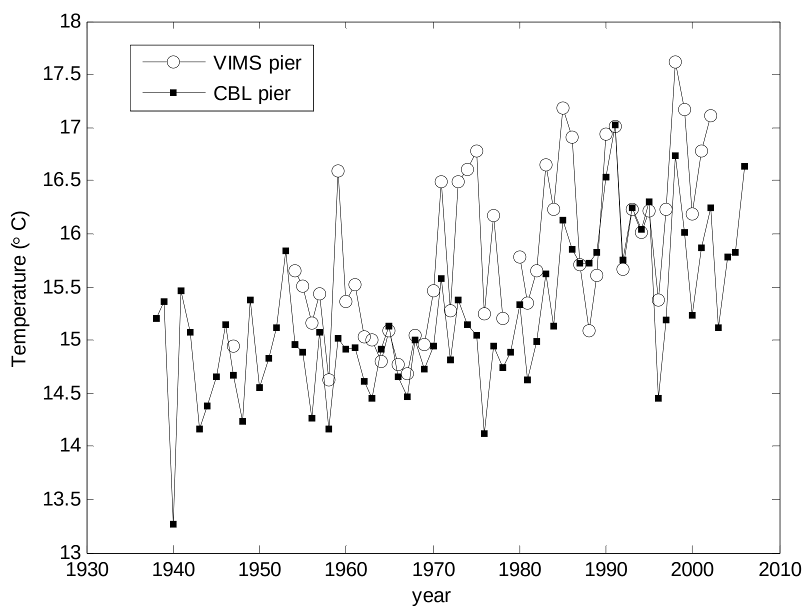
By way of background, I am a marine ecologist who has conducted research along our Atlantic and Gulf coasts and in Australia and the East China Sea. Over 25 years of my career have been spent studying the Chesapeake Bay or directing scientists who do. Although not a climate scientist, I have been engaged in several assessments of the possible consequences of climate change on coastal environments and try to keep closely abreast of the emerging climate change literature. Most notably, I served as co-chair of the Coastal Areas and Marine Resources Sector Team for the U.S. National Assessment of Climate Variability and Change[1] and as co-editor of the report *Chesapeake Futures: Choices for the 21st Century*.[2] And, currently I am serving as chair of the Scientific and Technical Working Group of the Maryland Commission on Climate Change.

## A Warming Bay

Global climate change is not just something in the Chesapeake Bay's future. Evidence is building that it has already resulted in changes in the Bay environment over the last several decades. Based on long-term records from the piers at the Chesapeake's two historic marine laboratories—extending back to 1938 at my Center's Chesapeake Biological Laboratory on Solomons Island, Maryland, and to 1948 at the Virginia Institute of Marine Science at Gloucester Point—it is clear that the Bay has been warming. While annual Bay water temperatures have varied in relation to large-scale climate cycles, such as the North Atlantic Oscillation, there has been a superimposed warming trend of about 1°C or nearly 2°F since the 1960s. This is, by the way, consistent with the observed increases in air temperature over much of the Bay region during that same time period.

Because of the close connection of air temperature—the monthly averages rather than the daily extremes—and the temperature of Bay waters, the General Circulation Models used to project future climate conditions as a function of increasing greenhouse gases provide some insight into further changes in temperature in the Bay. Depending on the emission scenarios, these models suggest a 3 to 5°C (5 to 9°F) increase in annual mean temperature by the end of this is century.[3] These increases in air temperature may be modulated somewhat as water temperatures respond, but even if we act today to dramatically reduce greenhouse gas emissions around the world, the Chesapeake Bay is still very likely to experience significant additional warming.

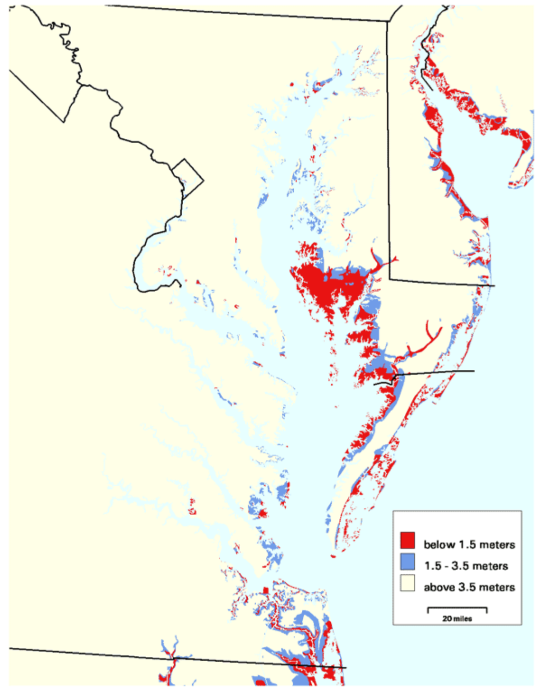
The much warmer waters during the summer and much milder temperatures during the winter would have substantial consequences for the organisms that live in the Bay and how this ecosystem works. Species that are already stressed by high summer temperatures, such as the eelgrass that provides important habitats in the lower Bay, may be greatly reduced or eliminated. Milder winter temperatures are likely to open the back door to invaders from warm temperate areas around the world who hitchhike into the Bay in ships' ballast waters. With earlier spring warming the critical timing of spawning of species such as striped bass and blue crabs will adjust, potentially out of phase with other processes, such as food production, that are critical to the success of their young.[4]




Mean annual water temperature at the Chesapeake Biological Laboratory (mid-bay) and the Virginia Institute of Marine Science (lower-bay).[5]

## Inundation

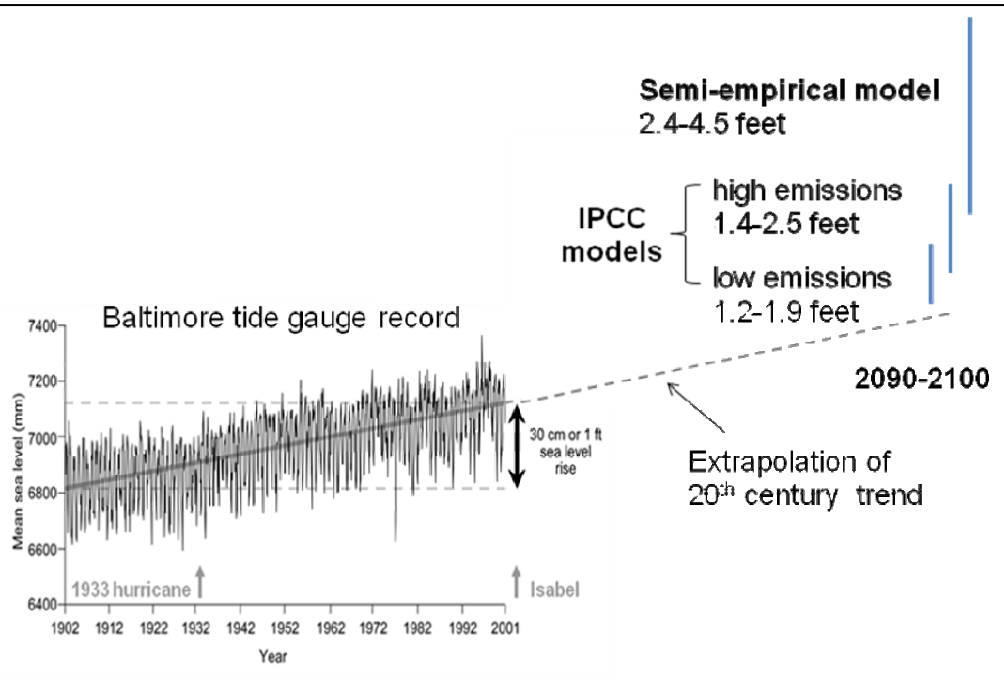
The Chesapeake Bay region is one of the areas of the country most sensitive to the effects of sea-level rise because of its 8,000 miles of shoreline and extensive, low lying areas, particularly on the Eastern Shore.[6] Sea level has been rising in the Bay for a long time, initially as a result of the melting of glaciers at the end of the last ice age. In fact the Bay itself is a series of drowned river valleys, inundated by the rise in the ocean levels of over 300 feet 7,000 to 12,000 years ago. Sea level has been rather stable in recent centuries, however, rising only slowly as a result of the sinking of the land—a slow subsidence of the Earth's crust that had bulged upward under the weight of glaciers to the north. Still this has been enough to cause the abandonment and, in some cases, disappearance of several islands that had human habitation in the 19th and early 20th centuries.




Land areas estimated to be less than 3.5 meters above mean sea level in 2000.[6]

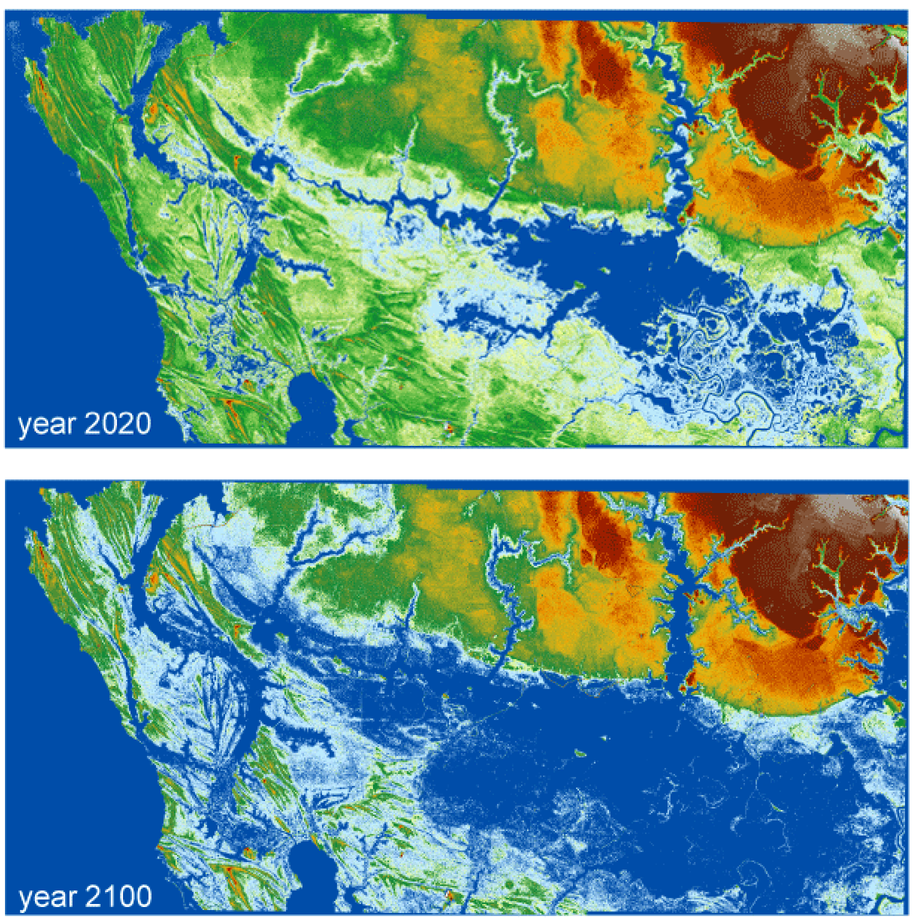
During the 20th century the Bay level rose a little over one foot relative to the land over most areas of the Bay. Accurate tide gauge records at six locations in the Bay showed this relative sea-level rise to range from 2.7 mm per year in Washington, DC to 4.5 mm per year in Hampton Roads, Virginia,[7] with the difference apparently related to differences in subsidence rates. With the rise in the surface of the ocean during the 20th century averaging 1.7 mm per year,[8] subsidence rates vary from 1.0 to 2.9 mm per year and, because this is a slow geological process, are expected to remain constant for the foreseeable future. Satellite altimeter measurements suggest that globally the level of the ocean was rising faster, as much as 3.1 mm per year, during the period 1993 to 2003 than earlier in the century[8]; although this effect is not yet clearly evident in the Chesapeake Bay tide gauge representation of relative sea level because of variation due to winds and other factors.

The Intergovernmental Panel on Climate Change projected average global rise in sea level through the 21st century for different greenhouse gas emission scenarios.[8] If one adds to their rates the average regional subsidence rates for the Chesapeake Bay of 1.8 mm per year, the projections equate to relative sea level rises by the 2090-2100 time period of 0.37 to 0.57 meter (1.2 to 1.8 feet) with aggressive reduction of greenhouse gas emissions and 0.44 to 0.73 meter (1.4 to 2.5 feet) if emissions continue to grow. However, there are several reasons to believe that these estimates might be too low. First, as mentioned earlier, satellite evidence indicates that the rise of the global ocean level during 1993-2003 was already much faster than the low emissions estimate. Secondly, the IPCC projections excluded acceleration of the melting of polar ice sheets and evidence is mounting that the melting of the Greenland ice sheet has accelerated. Recently published empirical projections suggest an increase in ocean levels of between 0.5 and1.3 m,[9] which with regional subsidence would equate to 0.69 to 1.38 meters (2.1 to 4.8 feet) by century's end.




Baltimore tide gauge record for the 20th century with relative sea level rise projections.

While there remains uncertainty, not only as related to behavior of the climate, but also of the level of accumulated greenhouse gases, it appears likely that relative sea level in the Chesapeake Bay will rise twice as much during this century than it did in the previous century and could rise three or more times as much. This rise would probably be measured in several feet, rather than the catastrophic sea level rise of 20 feet or more associated with the complete melting of Greenland as depicted in some popular animations. Still, it is important to keep in mind that sea level would not simply reach a plateau in 2100 but will continue to rise under almost any emission assumption. Furthermore, a rise in Bay water level of just a foot or two will place into jeopardy extensive intertidal wetlands, many of which are already showing deterioration due to inundation,[10] and additional low lying islands. Sea level rise will have profound, but poorly understood effects on the Bay itself. For example, the deepening of the Bay will allow saline ocean water to extend farther up the estuary. Already, this effect seems to be evident in the slight increase in salinity when one factors out the effects of freshwater inflow variations and hydrodynamic models project shifts in salinity significant enough to allow oyster diseases to penetrate deeper into the estuary.[11]




Changes in tidal marshes at Blackwater National Wildlife Refuge, Maryland, projected under mid-range sea-level rise scenario.[10]

But the effects will be felt in the built environment as well, as roads, utilities, sewerage and drainage systems are threatened with inundation and erosion of developed shorelines and saltwater intrusion into aquifers progress, not only on the Eastern Shore and the imperiled communities on Smith and Tangier Islands, but also in part of the cities of Hampton Roads, Baltimore, Annapolis, Alexandria and the Nation's Capital itself.

These effects will be experienced not just through the slow encroachment of mean sea level but during the extremes, when storm surges build on top of the inexorably slowly rising Bay. For example, in 2003 Hurricane Isabel resulted in storm surges up to 9 feet, typically exceeding the maximum recorded levels of a 1933 hurricane, which had a very similar trajectory and intensity, by about one foot.[12] This is the approximate increase in relative sea level over that 70 year interlude. Add to this the potential for increased frequency and intensity of tropical cyclones as result of warmer ocean waters and there emerges the considerable likelihood of significantly increased vulnerability of the Chesapeake Bay's coastal communities and environments as a result of global climate change.

## What Happens on Land Matters

As a large, but shallow estuary with limited exchange with the ocean, the Chesapeake Bay is particularly affected by what drains into it from its 64,000 square mile watershed. Greatly increased inputs of sediments and nitrogen and phosphorus nutrients as a result of land uses, agricultural inputs and atmospheric fallout are the root cause of the deterioration of the Bay during the latter half of the 20th century. And, reducing those nutrient and sediment inputs are the main focus of the Chesapeake Bay restoration program.

Climate change could affect the runoff of nutrients and sediments in a number of ways that interact, making prediction of future conditions somewhat difficult. The wild card is how climate change will affect precipitation and ultimately river runoff. Model projections for precipitation in the Mid-Atlantic region do not have the same level of consistency as those for temperature. However, there is considerable agreement for increased precipitation during the winter and spring.[13] This would likely mean the flushing out of more nutrients through river flow to the Bay during the critical January-May time period, exacerbating water quality problems in the Bay, particularly summertime oxygen depletion of the deep waters of the Bay or the so-called "dead zone."[14] On the other hand, models have less agreement in summer precipitation, with most predicting little or no overall increase but with most rain delivered during intense events that punctuate dry spells. Keeping in mind that warmer temperatures mean more evaporation and plant transpiration this would suggest significantly less river discharge during the summer, which could further allow the salt-water intrusion into the Bay discussed in the context of sea-level rise. Compounding these physical phenomena are the human responses, particularly in agriculture, to changing energy costs, temperature, soil moisture and water availability. These, as well as the still needed pollution abatement practices, will affect the inputs of nutrients in the first place.

## Restoring the Chesapeake

Substantial public investments have been made and individual actions taken to restore the Chesapeake Bay. Almost $3.7 billion has been spent on that effort between 1995 and 2004[15] and it has been estimated that an additional $15 billion will be required to achieve the water quality objectives of the Chesapeake 2000 Agreement.[16] While some of the changes in the regional climate that are anticipated over the remaining century might actually result in improvements in environmental quality, the tally sheet of reasonable expectations is heavily tilted toward the detrimental in terms of ecosystem recovery. For example, higher winter-spring runoff will require even more efforts to control non-point source pollution in order to receive the same water quality goal for the Bay. The loss of tidal wetlands will reduce their natural cleansing capabilities, and so on.

There are two corollary implications for Bay restoration. First, the impacts of climate change must be factored into restoration goals and actions. No longer should this be put off as too hypothetical, too political or too daunting. Second, mitigating the causes of climate change to avoid dangerous extreme changes should become part of the Bay restoration agenda.

## Seeking Common Solutions

Integrating climate change mitigation and adaptation with Chesapeake Bay restoration requires the search for common solutions. If considered with an open mind, there are opportunities and savings rather than additional costs to be realized. Governor Martin O’Malley has created the Maryland Commission on Climate Change to recommend a Plan of Action for mitigating and adapting to climate change.[17] The Commission has discovered that as practical strategies to reduce the emissions of greenhouse gases are developed in other states there are significant net economic benefits, although initial investments are usually required to achieve them. Energy conservation and emphasizing transportation options that get many of the single-occupancy vehicles off the roads favor smart growth and reduce impacts to the Bay. At the same time, we need to mitigate if not avoid apparent solutions to the fossil fuel dependence that result in additional degradation of the Bay. In that vein, the rapid increase in growing corn, which has high fertilizer requirements and concomitant nutrient losses, to produce ethanol is particularly troublesome,[18] particularly when, on careful inspection, this seems to produce few if any net reductions in greenhouse gas emissions.

## Sound Scientific Guidance

To accomplish this integrated approach to Bay restoration and climate change mitigation and adaptation will require innovative and rigorous science to understand both the synergistic as well as the antagonistic interconnections. While the Chesapeake Bay has a robust scientific community actively engaged in supporting Bay restoration, there is a critical need to build capacity in research, monitoring and assessment related to the consequences of regional climate change. This is largely because the federal science agencies have not invested much in this area. In a recently released review of the U.S. Climate Change Science Program, the National Research Council [19] concluded that:

- Discovery science and understanding of the climate system are proceeding well, but use of that knowledge to support decision making and to manage risks and opportunities of climate change is proceeding slowly.
- Progress in understanding and predicting climate change has improved more at global, continental, and ocean basin scales than at regional and local scales.
- Our understanding of the impact of climate changes on human well-being and vulnerabilities is much less developed than our understanding of the natural climate system.

The Chesapeake Bay Program's Scientific and Technical Advisory Committee[3] has prepared a review and agenda to support the practical understanding of regional climate change that could serve as a blueprint for the needed federal investments. However, we are not in this predicament alone—other regions of the country face similarly daunting challenges in assessing and responding to their climate future.

As I mentioned at the beginning, over seven years ago I contributed to the U.S. National Assessment of Climate Variability and Change, performed under Congressional mandate. Unfortunately, we have lost much the intervening time—a critical period of time when one considers the pace of climate change and the immediacy of decisions that will be required—when informed regional assessments and response strategies could have been developed. I urge Congress to make up for this lost time by authorizing and supporting the regional studies of regional climate dynamics and ecosystem and social responses that are needed to manage our future wisely.

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