Testimony of Dr. Donald Scavia

Graham Family Professor of Environmental Sustainability
Professor of Natural Resources & Environment
Professor of Civil and Environmental Engineering
University of Michigan

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Mr. Chairman, Members of the Subcommittee, I thank you for this opportunity to testify today on formulating an action plan for dealing with Harmful Algal blooms and Hypoxia. My name is Donald Scavia and I am the Graham Family Professor of Environmental Sustainability, as well as Professor of Natural Resources & Environment and Civil & Environmental Engineering at the University of Michigan. Prior to joining Michigan's faculty, I held several positions in the National Oceanic and Atmospheric Administration, the most recent as the Chief Scientist for the National Ocean Service.

While in NOAA, I was responsible for implementation of NOAA's components of the Harmful Algal Bloom and Hypoxia Research and Control Act of 1998, as well as leading several of the mandated assessment reports on behalf of the White House Office of Science and Technology Policy. I also directed the office that established several NOAA and interagency research programs under this statute, such as the Ecology and Oceanography of Harmful Algal Blooms (ECOHAB) research program, the Monitoring and Event Response for Harmful Algal Blooms *(*MERHAB) research program, and the Northern Gulf of Mexico Hypoxia (NGOMEX) research program. While much has been accomplished, much remains unfinished. So, I am pleased that the subcommittee is considering a bill to reauthorize this Act.

Because other witnesses will be focusing on harmful algal blooms, I will focus my remarks on hypoxia – its causes, consequence, and controls – and how this reauthorization can help address the problems.

Hypoxia - coastal and Great Lakes "dead zones"

Hypoxia, regions of lakes and oceans with seriously depleted oxygen, has become an issue of global importance. A 2008 review[1] reports hypoxia from more than 400 ecosystems, affecting a total area of more than 245,000 square kilometers, and that most of these problems are driven by nutrient pollution. The US National Assessment[2] called for in the original statute reported that in 2003, two-thirds of the Nation's estuaries showed symptoms of nutrient pollution, and a 2007 update[3] of that study indicated those conditions have not improved and that worsening conditions are expected in 65% of the estuaries, with only 20% likely to show improvements. Recent studies in the Great Lakes have shown that the dead zone in Lake Erie, once thought to be under control and shrinking, has grown again to sizes not seen in decades. Clearly, the nutrient pollution problem is not under control, and if more is not done to reduce this pollution to coastal and Great Lakes waters, we can expect further degradation and loss of important recreational and commercial resources.

I will focus my comments on three iconic sites of hypoxia – Chesapeake Bay, Lake Erie, and the northern Gulf of Mexico, and then draw some common conclusions in the context of the pending legislation.

The Chesapeake Bay

The causes and consequences of oxygen depletion in Chesapeake Bay have been the focus of research, assessment, and policy action over the past several decades[4]. During that period, this 11,000 km^2 estuary has been the subject of a series of intergovernmental agreements[5-8] focused on reducing the impacts[1,9] of nutrient over-enrichment[10] from its 167,000 km^2 watershed. The Chesapeake 2000 agreement[8] recommitted the parties to nutrient reduction goals established under the 1987 agreement that called for a 40% reduction of nitrogen and phosphorus loads. In addition, Chesapeake 2000 adopts the broader goal of taking sufficient action by 2010 to correct nutrient- and sediment-based water quality problems, such that Chesapeake Bay is no longer designated as "impaired" under the U.S. Clean Water Act.

This goal will obviously not be reached. For example, while significant commitments and efforts have taken place over these decades, summer hypoxia in the Chesapeake Bay has changed little from its long term average since 1985. My colleague Donald Boesch, President of the University of Maryland Center for Environmental Science, summarized some of the reasons why in reflecting on recent Government Accountability Office and EPA Office of the Inspector General reports in testimony before the Subcommittee on Water Resources and Environment: limited control over air emissions that impact water quality, uncontrolled land development, and limited implementation of agricultural conservation practices. Earlier this year, the regional governors and the EPA Administrator recommitted to increasing the pace of progress in reducing nutrient pollution based on achieving two-yield milestones[11]. Furthermore, President Obama issued an executive order calling on the federal government to lead a renewed effort to restore and protect the nation's largest estuary and its watershed[12].

Among the three systems, the Chesapeake is most vulnerable to nutrient loads from air emissions because of the amount of high density population centers compared to those of the Gulf of Mexico and Lake Erie. While uncontrolled land development and increased impervious surfaces contribute nutrients and sediments from urban areas, agricultural sources of nutrient loads are the largest contribution to the Bay, and traditional best management practices, often designed for other reasons, are apparently not doing the job. Research has shown that the Chesapeake Bay has gone through a regime shift such that the system is now more sensitive to nutrient inputs than in the past, with nutrient inputs inducing a larger response in hypoxia, The inability to effectively and efficiently reduce nutrient run-off from agricultural lands is thus more important than in the past, and a common thread among all three iconic systems, as well as many other coastal, estuarine, and lake systems.

Climate change could also affect the runoff of nutrients and sediments in a number of ways. Climate models for precipitation in the Mid-Atlantic region project increased precipitation during the winter and spring. This would likely result in flushing more nutrients through river flow to the Bay during the critical January-May time period, exacerbating water quality problems, including summertime oxygen depletion[13]. So, changes in practices and policies today to reduce nutrient loads may not be sufficient in a different climate regime. We may already be seeing this in Lake Erie.

Lake Erie

Lake Erie has seen significant impacts cause by high nutrient loads – phosphorus as opposed to nitrogen because phosphorus is the most critical nutrient in freshwater systems. These excessive loads resulted in harmful and nuisance algal blooms, poor water clarity, and summer hypoxia in the hypolimnion of the central basin[14,15]. Excess phosphorus entered the lake primarily from agricultural runoff and point source discharges[16]. The extent of hypoxia in the 1960s was one of the motivations for significant environmental legislation, including the Clean Water Act. In addition, U.S. and Canada signed a Great Lakes Water Quality Agreement[17] to reduce phosphorus loads at a scale unprecedented in any region of the world[18]. Unlike the Chesapeake and the Gulf of Mexico, a combination of point and non-point phosphorus load reductions achieved the target load of 11,000 metric tonnes per year and the Lake responded rapidly and close to that predicted by models. We thought the problem had been solved.

However, despite this apparent success at reversing summer hypoxia, the extent of oxygen depletion in the central basin of Lake Erie recently enlarged and reemerged as a potential hazard to ecosystem health[19]. Several natural and anthropogenic factors have been proposed for causing this resurgence, including changes in climate and hydrology[20], invasion of zebra and quagga mussels[21], and changes in agricultural loading. While investigations are still underway to evaluate the potential effects of invasive mussels, recent analyses have shown that, to date, the direct climate effect of warming has not been the cause of increased hypoxia[22]. However, new evidence is pointing to the intersection of agricultural practices and changes in precipitation patterns as a primary cause.

Colleagues Peter Richards and David Baker at Heidelberg College have been monitoring loads to Lake Erie for decades and have shown that, after the significant decrease in response to the Water Quality Agreement, the amount total phosphorus entering the Lake has remained relatively constant while the proportion of that load that is in the form algae are most responsive to has increased dramatically since the mid 1990s[23,24]. They suggest that while increases in fall and winter broadcasting of phosphorus fertilizers is a important cause, it is compounded by increasing intensity of winter and spring rainfall events. Thus, phosphorus can be lost from fields prior to interacting with soil particles. They also report that current practices are leading to increased phosphorus concentrations in the upper layer of the soil and, combined with the increased storm intensity, also contribute to this reversing trend in loads of available phosphorus. It is important to note that, while most climate models project increases in the intensity of winter and spring storms, such trends are already found in the climate records of the Midwest.

The Great Lakes Restoration Initiative, proposed in the President's budget for $475 million in the upcoming fiscal year, if focused appropriately should provide significant funds for action in the working lands of Lake Erie's watersheds. While agriculture is now the dominant source of nutrients from Lake Erie watersheds, nowhere has this become more significant than in the lands draining to the northern Gulf of Mexico.

Northern Gulf of Mexico

The development, extent, and persistence of hypoxia in bottom waters of the northern Gulf of Mexico were first mapped in 1985. Since then, a large volume of data has been collected and a wide range of papers and reports have been published that increased our understanding of the seasonal and interannual distribution of hypoxia and its variability, history, and causes. An Integrated Assessment[25] of the causes, consequences, and actions needed to reduce hypoxia, mandated in HABHRCA-1998, was completed in 2000 and an Action Plan for Reducing, Mitigating, and Controlling Hypoxia in the Northern Gulf of Mexico[26], also mandated in that law, was endorsed by federal agencies, states, and tribal governments and delivered to the President and the Congress in 2001. That Action Plan set a goal of reducing the size the hypoxic region to less than 5000 square kilometers by 2015 and called for a long term adaptive management strategy coupling management actions with enhanced monitoring, modeling, and research. The Action Plan also called for an assessment every 5 years of *"the nutrient load reductions achieved and the response of the hypoxic zone, water quality throughout the Basin, and economic and social effects. Based on this assessment, the Task Force will determine appropriate actions to continue to implement this strategy or, if necessary, revise the strategy."*

The most recent reassessment conducted under the EPA Science Advisory Board[27] focused instead primarily on the scientific basis for the original plan and it reconfirmed the relationship between the nitrogen load from the Mississippi River, the extent of hypoxia, and changes in the coastal ecosystem (e.g., worsening hypoxia). They recommended that nitrogen load reduction targets be increased from 30% to 45%, recommended that phosphorus loads also be reduced by 45%, and emphasized that significant time had been lost because of a lack of implantation of the original Action Plan. The panel also cites several studies[28,29] that suggest climate change will likely create conditions where larger nutrient reductions, e.g., 50 – 60% for nitrogen, would be required to reduce the size of the hypoxic zone.

The SAB Panel affirmed the major findings of the original Integrated Assessment; although, they point out that while the 5,000 km^2 target remains a reasonable endpoint, it may no longer be possible to achieve this goal by 2015. Further, they said that it is even more important to proceed in a directionally correct fashion to manage factors affecting hypoxia than to wait for greater precision in setting the goal for the size of the zone. The panel also found that the Gulf of Mexico ecosystem appears to have gone through a regime shift such that the system is now more sensitive to nutrient inputs than in the past, with nutrient inputs inducing a larger response in hypoxia, and if actions to control hypoxia are not taken, further ecosystem impacts could occur within the Gulf, as has been observed in other ecosystems.

The panel concluded:

"*In sum, environmental decisions and improvements require a balance between research, monitoring and action. In the Gulf of Mexico, the action component lags behind the growing body of science. Moreover, certain aspects of current agricultural and energy policies conflict with measures needed for hypoxia reduction. Although uncertainty remains, there is an* *abundance of information on how to reduce hypoxia in the Gulf of Mexico and to improve water quality in the MARB, much of it highlighted in the Integrated Assessment. To utilize that information, it may be necessary to confront the conflicts between certain aspects of current agricultural and energy policies on the one hand and the goals of hypoxia reduction and improving water quality on the other. This dilemma is particularly relevant with respect to those policies that create economic incentives*."

Even though the Action Plan has been in place for 8 years, nutrient loads to the Gulf have not been substantially reduced and the size of the hypoxic zone has not decreased. In fact, in recent years, it has set new records. So I fully support these findings of the EPA panel that immediate action be taken to reduce nutrient loads, and that an effective process be put in place to track progress and adjust over time. I also support the recommendations of the recent report of EPA's Office of the Inspector General that asks EPA to identify significant waters of national value – like the Gulf of Mexico, Chesapeake Bay, and Lake Erie -- and establish appropriate nutrient criteria for them as drivers for more effective upstream criteria. I will return to these thoughts when commenting on the Bill under consideration.

Common issues/Common impacts/Common needs

There is a growing body of literature[30-37] pointing to hypoxia impacts on fisheries in all three systems. While to date no major species collapses have been documented in these systems as a direct result of hypoxia, much of this literature points to pending impacts and the need to avoid a tipping point, where critical species populations collapse and may not be recoverable. Regime shifts reported in all three systems may portend such tipping points.

Nitrogen and phosphorus pollution from agricultural sources is the primary driver of hypoxia in these three iconic systems, as well as many of the other coastal and estuarine regions suffering from hypoxia and other symptoms, such as harmful algal bloom and loss of fish habitat. This is well documented in the numerous publications, reports, and assessments for these specific systems, and more generally for the Nation in the assessment[2] carried out under the statute being considered here. It is clear for most of these stressed systems, that more effective policies and practices are needed for reducing the loss of nutrients from working agricultural lands.

There are of course, USDA conservation programs that can be brought to bear on these issues, but funding for them is not adequate to meet the need and it is important to increase the targeting of those resources to areas that can do the most good. For example, an analysis of the Environmental Working Group[38] points out that within the 5% of the Mississippi drainage basin supplying 40% of the nitrogen to the Gulf of Mexico, the ratio of crop subsidies to conservation spending is 500:1. Even a modest change in that ratio, would make a significant difference. Such targeting is also consistent with the recent report of EPA's Office of the Inspector General, calling for EPA to set nutrient criteria first for significant waters of national value in a way to guide upstream targets.

I underscore that it is farm policy, not farmers that make it difficult to reach these environmental goals. For example, to understand how farmers might respond to different practices that could affect water quality, my Michigan colleague Joan Nassauer, and her collaborators conducted in-depth interviews with Iowa farmers in 1998 and in 2007 completed a web survey of more than 500 Iowa farmers on farming preferences. Their analyses demonstrate that Corn Belt farmers understand the difference between current cropping practices and future innovations that could result in dramatically improved water quality. Given adequate technology to adopt conservation innovations and assuming their income is unaffected, farmers prefer a more diverse landscape that shows better conservation and improved water quality.

Specific Comments on the Draft Bill

I understand that much of the discussion above falls under different jurisdictions and different statutes, but the Harmful Algal Bloom and Hypoxia Research and Control Act reauthorization can help frame more action, coordinate and track progress, and ensure adequate research and monitoring is in place to support adaptive management approaches.

I believe most elements of the current draft bill represent positive steps forward and I applaud the subcommittee's effort to reauthorize this important law. With regard to specific sections:

Section 603A(b) - Specifically including the Environmental Protection Agency in the reauthorization is important, both because that agency chairs the Gulf of Mexico Task Force and because of its broader freshwater responsibilities. I would suggest, however, that explicit mention be made in this section of the need for a NOAA-EPA partnership in the Great Lakes because NOAA already has significant investments in both harmful algal bloom and hypoxia research there.

Section 603A(c)6 - This refers only to freshwater harmful algal blooms. It should probably apply to both freshwater and marine blooms.

Section 603A(e) - This calls for regional plans to be completed in 12 months. This may be difficult to do depending on the number and scale of the regions. It may be better to require a staged implementation such that all are completed in 3 years.

Section 603A(f) – Biennial reports from the Regional Research and Action Plans should follow the recommendations provided below for the Gulf Task Force to ensure appropriate tracking of implementation and progress.

Section 604(a) and 604(b) - These sections call for a report on Gulf Action Plan progress 2 years after enactment of the reauthorization and every 5 years thereafter. The EPA Science Advisory Hypoxia Panel, EPA Office of the Inspector General, and many individuals and organizations working on the Gulf hypoxia problem since enactment of the original law have identified lack of progress in implementing the Action Plan. For better accountability, I recommend Task Force reports to Congress every year, and that the reports include both details on specific management actions called for in the plan as well as updates on environmental conditions (e.g. river nutrient concentrations, nutrient loads from each sub-basin and to the Gulf, etc). These reports should include estimates of expenditures by sub-basin, as well as metrics of action such as new acres enrolled in each conservation program. To help guide targeting of actions to the most important regions, implementation expenditures and actions should be reported juxtaposed with USGS estimates of nutrient contributions to the Gulf from specific sub-basins and states.

Section 605 – The current draft does not yet specify spending authorizations; however, I recommend the following considerations:

- Authorize at least $40 million to NOAA and at least $5 million to EPA.
- To avoid duplication, it would be good to identify several efforts already administered by NOAA in support of this legislation (e.g., ECOHAB, MERHAB, PCM, NGOMEX and CHRP).
- Require research funds appropriated to NOAA be allocated through a competitive, peer review process, and that the funds are restricted to extramural grants. NOAA has strength in its own labs and offices, but those entities are funded adequately through other appropriations.

Mr. Chairman, thank you for your leadership in reauthorizing the Harmful Algal Bloom and Hypoxia Research and Control Act. Conditions in our Nation's coastal and Great Lakes waters have unfortunately not improved in the past 10 years since its enactment, and in some cases, like Lake Erie, have gotten worse. It is time to increase implementation accountability and to ensure we have the research and monitoring programs in place to track progress. This bill is an important step in that direction, and I appreciate the opportunity to comment on it.

This concludes my testimony and I would be happy to answer any questions you or other members of the subcommittee may have.

Footnotes

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Donald Scavia

Graham Family Professor of Environmental Sustainability
Professor of Natural Resources and Environment
Professor of Civil and Environmental Engineering
Director, Graham Environmental Sustainability Institute
University of Michigan, Ann Arbor
www.sitemaker.umich.edu/scavia

Dr. Scavia and his students combine numerical models, laboratory, field work, and assessments to improve the understanding of interactions between human activities on land and their impacts on coastal marine and freshwater ecosystems. His research and teaching support integrated assessments that integrate natural science, social science, and environmental policy making. As Director of the Graham Institute, Dr. Scavia leads efforts to engage the full multidisciplinary assets of the University of Michigan to support sustainable communities, ecosystems, and economies.

He serves on Advisory Boards for the Environmental Law and Policy Center, the National Wildlife Federation Great Lakes Program, North American Nitrogen Center, Annis Water Research Institute, Central Michigan University Biological Station, and as Science Advisor to the Healing our Waters Great Lakes Coalition. At UM, he also serves on the Executive Committee for the Erb Institute for Global Sustainable Enterprise and the Michigan Memorial Phoenix Energy Institute.

He has been Associate Dean for Research, Director of the Michigan Sea Grant Program, Director of the Cooperative Institute for Limnology and Ecosystems Research, Associate Editor for *Estuaries and Coasts*; Associate Editor for *Frontiers in Ecology and Environment*, and has served on the Boards of Directors for the American Society of Limnology and Oceanography and the International Association for Great Lakes Research.

Prior to joining the Michigan faculty in 2004, Dr. Scavia was the Chief Scientist of NOAA's National Ocean Service, Director of the National Centers for Coastal Ocean Science, the Director of NOAA's Coastal Ocean Program. Prior to that, he was a senior scientist at NOAA's Great Lakes Environmental Research Laboratory. He holds Bachelors, Masters, and Doctorate degrees in Environmental Engineering from Rensselaer Polytechnic Institute and the University of Michigan, and has published over 70 articles in the primary literature and books, co-edited two books, and led development of dozens of interagency scientific assessments and program development plans.