Testimony of
Dr. Donald Scavia
Senior Scientist
National Ocean Service
National Oceanic and Atmospheric Administration
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Good morning, Mr. Chairman and members of the Subcommittee. I am Donald Scavia, Senior Scientist of NOAA's National Ocean Service. I appreciate the opportunity to discuss NOAA's role in addressing national issues surrounding harmful algal blooms (HABs) and hypoxia in the nation's Great Lakes and coastal waters, and the Harmful Algal Bloom and Hypoxia Research and Control Act of 1998. My testimony today does not address reauthorization of the Act. NOAA is currently reviewing the draft bill, and will provide comments in the future.

Others on this panel will provide more detailed information on the scope and extent of Harmful Algal Blooms (HABs) and hypoxia. So, I will simply report that HABs are increasing in abundance and intensity in Great Lakes and coastal waters. Harmful Algal Blooms occur in the waters of every coastal and Great Lake State and have been responsible for an estimated $1 billion in economic losses over the past few decades. These blooms have decimated the scallop fishery in Long Island's estuaries; have led to seasonal closures of various shellfisheries on Georges Bank, from North Carolina to Louisiana, and throughout the Pacific Northwest; may have contributed to the deaths of hundreds of manatees in Florida, sea lions in California, and other marine mammals, including dolphins in the Northern Gulf of Mexico. HABs have also caused significant respiratory and other illness in coastal residents and vacationers. There are several causes of harmful algal blooms. Some are natural, but others are human-induced, and on-going research continues to identify and distinguish these causes.

The Harmful Algal Bloom and Hypoxia Research and Control Act brings together the critical issues of harmful algal blooms and hypoxia - or low oxygen syndrome -- because excess nutrient loads can be responsible for the general overgrowth of algae in many coastal ecosystems. And while not all algae are toxic, the death and subsequent decay of massive non-toxic blooms can lead to severe oxygen depletion (e.g., oxygen levels low enough to cause significant ecological impairment) in the bottom waters of estuaries and coastal environments.

While significant attention has been paid in recent years to the enormous hypoxic area off the coasts of Louisiana and Texas, NOAA's recent National Eutrophication Assessment has revealed that at some time each year, over half of our Nation's estuaries experience natural-caused and/or human-induced hypoxic conditions. Thirty percent experience anoxia (e.g., areas where all of the oxygen is absent) resulting in fish kills and

other resource impacts. In addition, hypoxia in the Great Lakes is re-emerging as a problem. Harmful algal blooms and hypoxia are now among the most pressing environmental issues facing coastal states.

To address these important issues facing the Nation's coastal communities, the Harmful Algal Bloom and Hypoxia Research and Control Act of 1998 called for development of three scientific assessments and an action plan; and authorized a suite of scientific programs to help support efforts to prevent, control, and mitigate the impacts of HABs and hypoxia. In response, NOAA and our Federal, state, and academic partners have made considerable progress in the scientific understanding, detection, monitoring, assessment, and prediction of HABs and hypoxia in Great Lakes and coastal ecosystems. These advances are helping coastal managers undertake short- and long-term efforts to prevent and mitigate the detrimental effects of these phenomena on human health and on valuable coastal resources. My remarks outlining these accomplishments are organized around the key sections of the original Public Law.

Sec 604(a) - Assessment of Northern Gulf of Mexico Hypoxia

The National Science and Technical Council, through the Inter-Agency Task Force on Harmful Algal Blooms and Hypoxia, delivered the report, "Integrated Assessment of Hypoxia in the Northern Gulf of Mexico", to the Congress in May 2000. The assessment examined the distribution, dynamics, and causes of Gulf hypoxia; its ecological and economic consequences; the sources and loads of nutrients transported by the Mississippi River system to the Gulf of Mexico; the effects of reducing nutrient loads; methods for reducing nutrient loads; and social and economic costs and benefits of such methods. This integrated assessment provided the scientific underpinning for the subsequent Action Plan to reduce the size of the Gulf of Mexico hypoxic zone.

Sec 604(b) - Plan to Reduce, Mitigate, and Control Gulf Hypoxia.

The Action Plan was delivered to the Congress in January 2001 by the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force, which is composed of eight Federal agencies, nine Mississippi Basin States, and two Indian Tribes. The Action Plan was based on the Integrated Assessment required by this statute, as well as other scientific and public input and consultations required by the law, gathered through seven public meetings. In balancing the environmental, social, and economic needs of this enormous watershed, the Plan established three goals:

Coastal Goal: By the year 2015, reduce the 5-year running average extent of the Gulf of Mexico hypoxic zone to less than 5,000 square kilometers.

- Basin Goal: Restore and protect the waters of the 31 States and Tribal lands within the Mississippi/Atchafalaya River Basin.
- Quality of Life Goal: To improve the communities and economic conditions across the Mississippi/Atchafalaya River Basin.

To connect the environmental endpoint goal for the Gulf of Mexico to actions within the basin, the Action Plan also recognized the need to reduce nitrogen loads by at least 30%. This Watershed Task Force is currently creating sub-basin committees that are to be led by States and tasked with developing implementation strategies. This approach was chosen by the Watershed Task Force with input from the States to best meet local needs. The action plan highlights that there are a variety of options available to meet the overall goal and each has associated costs and benefits that vary by locale. The Watershed Task Force has also drafted a Monitoring, Modeling, and Research Strategy to ensure that actions taken over the next decade to reduce hypoxia are guided by the best science.

Sec 603(b) - National Assessment of Coastal Harmful Algal Blooms

The National Science and Technical Council, through its Inter-Agency Task Force on Harmful Algal Blooms and Hypoxia, produced the report, "National Assessment of Harmful Algal Blooms in US Waters." The assessment, delivered to the Congress in February 2001, examines the ecological and economic consequences of harmful algal blooms; alternatives for reducing, mitigating, and controlling harmful algal blooms; and the social and economic costs and benefits of such alternatives. Highlights from the assessment include:

HAB events threaten human health and marine mammals, contaminate local fish and shellfish, and depress coastal tourist and recreational industries.

- HAB events are increasing nationwide. There are more toxic species, more events, and more areas affected than 25 years ago.
- Natural events (e.g., storms and ocean currents), as well as human activities (e.g., excess nutrient loads), appear to contribute to this increase.
- Management options are limited at this time, with the focus on diligent monitoring. Recent advances in both molecular and remote-sensing detection methods are promising.
- It may be possible to prevent some HABs by controlling nutrient inputs, or to control blooms with clays to precipitate or viruses to attack the algal cells. More research is needed to determine the effectiveness and the potential environmental impacts of these methods.

While the analyses in this report have helped shape subsequent investments in our research and monitoring programs, there is still much to do.

Sec 603(c) - National Assessment of Coastal Hypoxia

The Inter-Agency Task Force on Harmful Algal Blooms and Hypoxia delayed development of this assessment to take advantage of the findings and recommendations of the Gulf of Mexico Integrated Assessment, outlined above, the NOAA Eutrophication

Survey, and the National Research Council report, C*lean Coastal Waters*. With those studies now complete, the Task Force has drafted the assessment and has submitted it for final clearance. The assessment outlines status and trends in coastal hypoxia, its causes and consequences, methods available to reduce its occurrence, and the science needed to reduce uncertainties in future assessments. Once final clearance is achieved, we will deliver the report to the Congress.

Section 605 - Authorization of Appropriations

The Harmful Algal Bloom and Hypoxia Research and Control Act of 1998 also provided authority for NOAA to make progress in addressing some of the eight objectives outlined in the 1993 National Plan for Marine Biotoxins and Harmful Algae. It also extends NOAA's efforts related to Gulf hypoxia. Most of the efforts authorized by this Act are implemented by NOAA through competitive, peer review to engage the best scientists to focus on these important issues.

In our laboratories and through the Ecology and Oceanography of Harmful Algal Blooms program (ECOHAB), NOAA and our partners have investigated factors that regulate the dynamics of HABs and the mechanisms by which they cause harm. We have produced coupled bio-physical models that form a critical base for building HAB forecasts; applied technology from remote sensing, and medical science, to the detection and tracking of algal species and their toxins to help states target their monitoring and management efforts; and developed a national database where research findings are shared and made available to scientists and the public. Through the Monitoring and Event Response for Harmful Algal Blooms program (MERHAB), NOAA puts these new tools within reach for the routine monitoring efforts of States and tribes in several U.S. coastal regions. MERHAB partners are testing and refining these technologies for reliable, cost-effective detection and monitoring of harmful algal species and their toxins. Through the Coastal Ocean Program, we have expanded efforts to monitor, model, and predict changes and impacts of hypoxia on Gulf of Mexico resources. The following paragraphs highlight accomplishments in the five areas of statutory authority:

HAB Research and Assessment Activities in NOAA Laboratories - NOAA's laboratories have focused on two key impediments to effective HAB management: 1) the lack of sensitive, toxin-specific assays and toxin standards for research and field application, and 2) an understanding of how the physiology of these organisms affect toxin movement through the food web. Results from investments in these laboratories have led to developments that are now aiding coastal scientists and managers with critical, timely information on the occurrence of HAB and other toxins. Recent accomplishments include:

Identification of the chemical structures of some key HAB toxins;

- Development of toxin- and species-specific detection probes and assays that will significantly enhance HAB research, monitoring, and management;

- Increased understanding of bio-physical processes controlling red tides originating in the Gulf of Mexico that have traveled in the Gulf Stream as far north as North Carolina; and
- Added insight into physiology and environmental toxicity of *Pfiesteria* species.

Ecology and Oceanography of Harmful Algal Blooms (ECOHAB) - Administered by NOAA's Coastal Ocean Program, ECOHAB is run cooperatively with the National Science Foundation, U.S. Environmental Protection Agency, National Aeronautics and Space Administration, and the Office of Naval Research. ECOHAB seeks to understand the causes and dynamics of HABs; develop forecasts of HAB growth, movement, landfall, and toxicity; and produce new detection methodologies for HABs and their toxins. Projects selected for support must successfully compete in a peer-review process that ensures high-level scientific merit. Some highlights of ECOHAB's large-scale regional studies include:

- The Florida project is testing the hypothesis that the iron in Saharan dust clouds may stimulate red tides in the Gulf of Mexico. Iron in this dust may stimulate growth of nitrogen-fixing algae, ultimately providing a new nitrogen source for red tide organisms. Using satellite sensors, which can detect dust clouds, it may be possible to forecast these offshore red tide blooms.

- The Long Island Brown Tide study has correlated this organism's unique physiology and ecological niche with the series of complex environmental conditions that precipitate these blooms, showing that its ability to grow in conditions of high dissolved organic nitrogen allows it to occupy a particular niche in phytoplankton bloom succession.

- The Gulf of Maine project has described the critical life-history stages of the Paralytic Shellfish Poisoning (PSP) species, documented its dependence on environmental oceanographic conditions and is nearing completion of a biophysical model for simulating and ultimately forecasting the distribution of the species responsible for PSP Gulf of Maine.

- A new large-scale regional effort will begin this year to develop a model of bloom formation and movement in the Pacific Northwest based on physical and biological factors controlling blooms of domoic-acid producing organisms that cause amnesic shellfish poisoning.

Monitoring and Event Response for Harmful Algal Blooms (MERHAB) - Also administered by NOAA's Coastal Ocean Program, MERHAB works through existing tribal, state, and regional monitoring efforts to transfer research results to local monitoring jurisdictions for early detection of HAB events. Projects selected for support successfully compete in a peer-review process that ensures high-level scientific merit and resource management relevance. Highlights of program accomplishments to date include:

- Support for regional HAB mitigation efforts include developing early warning systems along the Olympic coast; providing rapid, cost effective, and highly sensitive toxin detection methods to the Quileute Tribe to help reduce public health risks of coastal Native Americans from California to Alaska; and incorporating continuous, real-time monitoring of inaccessible and remote coastal habitats into Chesapeake Bay and Florida state HAB monitoring programs.
- Similar, recently-initiated efforts seek to augment state HAB monitoring and response capabilities in the Great Lakes, Eastern Gulf of Mexico and Gulf of Maine; and are currently testing the feasibility of new detection methods in coastal waters of Texas, Florida, and Virginia.
- New techniques have enhanced *Pfiesteria* bioassay laboratories in Florida and North Carolina and improved access to expertise, laboratory facilities, sampling platforms, and remote sensing imagery by local and Federal agencies responding to unexpected HAB-related events, such as die-offs of sea lions, bottle-nose dolphins, and manatees;
- Support through the Alliance for Coastal Technologies and the Small Business and Innovative Research program has brought together scientists, state managers, and the private sector to overcome impediments of adopting new technologies

Research on HAB Prevention, Control, and Mitigation (PCM) – While research on HAB prevention and control has received only limited attention to date, some advancements have been made in: using clay to scavenge HAB organisms from the water column; identifying natural *Pfiesteria* predators; using viral agents for suppressing brown tide organisms; and using bacterial agents that may ultimately prove useful in controlling red tide organisms. While research on prevention and control has been limited, there have been significant ECOHAB and MERHAB investments to develop tools that help mitigate HAB impacts. For example:

- New remote sensing tools are used to track Florida Gulf coast HAB movements and provide the first-ever HAB forecasts for Florida resource managers. These tools are also being tested in Texas waters and off the West Coast.

- Biophysical models for the Gulf of Maine and the west Florida Shelf will enhance this ability to forecast HAB movement and landfall providing early warnings.
- New analytical capabilities for rapid and inexpensive detection of algae and toxins, including molecular probes for *Pfiesteria*, moored detectors for species responsible for Amnesic Shellfish Poisoning, optical detectors on moorings and autonomous gliders to detect and map red tide species.

Hypoxia Research and Monitoring - In the 1990s, through support from NOAA's Coastal Ocean Program, the scientific community documented the distribution and dynamics of the hypoxic zone over the Louisiana continental shelf. These model simulations and research studies produced considerable evidence that nutrient loading from the Mississippi and Atchafalaya River system is the dominant factor in driving

hypoxia and that the duration and extent of hypoxia in the region is far greater than it was historically. These efforts provided the primary data and information for the six technical reports and the Integrated Assessment of the causes and consequences of Gulf hypoxia and the Action Plan produced under Sections 604(a) and 604 (b) of this statute.

The Coastal Ocean Program initiated a new study in the Gulf in 2000 to improve our understanding of, and ability to forecast the effects of changes in ocean conditions and river nutrient loads on hypoxia and its effects on Gulf productivity. These studies are providing a consistent and sequential series of long-term data that document the temporal and spatial extent of hypoxia, and are collecting the hydrographic, chemical (including nutrient), and biological data related to the development and maintenance of hypoxia over seasonal cycles. Studies focus on relationships among nutrient fluxes, nutrient ratios, phytoplankton species composition, and carbon production and flux are being conducted and augmented with efforts to model changes in oxygen budgets and the effects of the hypoxic zone on fisheries. These studies are a key component of the Task Force's monitoring, modeling, and research strategy supporting the Action Plan.

While the focus to date has been on hypoxia on the Louisiana and Texas continental shelf, we have recently supported development of a consensus science plan for addressing hypoxia issues nationally. We have begun discussions with that academic science community and other Federal agencies on implementation of a potential joint national program.

Efforts in the Great Lakes

We understand this Subcommittee is particularly concerned with issues related to harmful algal blooms and hypoxia in the Great Lakes. I would like to outline recent accomplishments from our related Great Lakes efforts and suggest where we may be going in the near future.

Support in the early 1990s from the Coastal Ocean Program (COP) helped move the Great Lakes Coastal Forecast System from research to operations. This system, developed by the Great Lakes Environmental Research Laboratory (GLERL) and the Ohio State University for forecasting local winds, waves, water levels, and currents, is now being run routinely for forecasts in Lake Erie and nowcasts in all five Great Lakes. Discussions are underway for incorporating it into NOAA's operational run streams. Early COP support also developed the Great Lakes CoastWatch Program, which is now run out of GLERL. CoastWatch produces remotely sensed environmental data and products to support Great Lakes environmental science, resource management, and decision-making.

These early efforts provided key tools that were subsequently used in two five-year, multi-million dollar regional efforts supported through a joint COP-NSF Coastal Ocean Processes program. From 1998 through 2002, COP and NSF, with support from GLERL and EPA's Great Lakes National Program Office, sponsored the Episodic Events-Great Lakes Experiment (EEGLE) program in Lake Michigan and the Keewenaw

Interdisciplinary Transport Experiment in Superior (KITES) in Lake Superior. The EEGLE program produced information and models of storm-related release, redistribution, and impacts of biologically important materials (sediment, nutrients, contaminants) at the whole-lake scale. The companion KITES study focused on the Keewenaw Current and its role in the transport of these biologically important materials along the Keewenaw Peninsula.

In FY 2002, COP's MERHAB program initiated a new five-year, multi-million dollar effort to develop an improved monitoring system for toxic cyanobacteria in the lower Great Lakes and Lake Champlain. This enhanced 'early warning' system will be based on transferring state-of-the-art HAB research products into local management tools. This tiered system uses a series of indicators or alerts to trigger more intense monitoring and response protocols to provide maximum protection to the public.

To guide future investments in Great Lakes research and monitoring, COP recently sponsored a Great Lakes Research Issues Workshop at the University of Michigan to identify major Great Lakes issues that fit within the goals and mandates of COP and HABHRCA. Scientists from U.S. and Canadian agencies, academia, and the private sector outlined current issues and identified those requiring the most immediate research attention. While the report from that workshop has not been finalized, it appears that the consensus of that community is that the recent degradation of water quality and habitat warrants most immediate research attention.

This "re-degradation" of Great Lakes water quality, which is surprising in that it is a problem that most thought was solved decades ago, is especially evident in Lake Erie where harmful algal blooms, and hypoxia, and phosphorous concentrations have increased in recent years despite decreased phosphorus loads. The origins and fate of nutrients in the Great Lakes seem to be operating under a potentially new paradigm. This situation raises fundamental questions about interactions between land and lake production, including land-lake margin processes, benthic-pelagic coupling, episodic events, species introductions, physical-biological coupling, long-term weather and climate changes, and ecosystem resiliency.

We will continue to work with the Great Lakes community to define and develop a new set of tools to address these re-emerging issues, with a focus on developing ecological forecast models that account for the new ecological state of the Lakes.

Concluding Remarks

The impacts of harmful algal blooms and hypoxia on coastal and Great Lakes ecosystems, resources, and economies are as great now as they were in 1998. Reauthorization and revision of the Harmful Algal Bloom and Hypoxia Research and Control Act is timely and warranted.

We have not had sufficient time to review and provide comment on the draft bill provided in the invitation to testify at this hearing. However, we will provide those

comments soon, and we look forward to working with you and your staff on this important issue.

Mr. Chairman, this concludes my testimony. I would be pleased to answer any questions that you or other Members may have.