HARMFUL ALGAL BLOOMS AND HYPOXIA: FORMULATING AN ACTION PLAN

HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY AND ENVIRONMENT

COMMITTEE ON SCIENCE AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

ONE HUNDRED ELEVENTH CONGRESS

FIRST SESSION

SEPTEMBER 17, 2009

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HARMFUL ALGAL BLOOMS AND HYPOXIA: FORMULATING AN ACTION PLAN

THURSDAY, SEPTEMBER 17, 2009

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON ENERGY AND ENVIRONMENT,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
Washington, DC.

The Subcommittee met, pursuant to call, at 2:21 p.m., in Room 2318 of the Rayburn House Office Building, Hon. Brian Baird [Chairman of the Subcommittee] presiding.

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Committee on Science and Technology
Subcommittee on Energy and Environment

Hearing on

Harmful Algal Blooms and Hypoxia: Formulating an Action Plan

Thursday, September 17, 2009
1:00 p.m. – 3:00 p.m.
2318 Rayburn House Office Building

Witness List

Dr. Robert Magnien
Director
Center for Sponsored Coastal Ocean Research
National Oceanic and Atmospheric Administration

Ms. Suzanne E. Schwartz
Acting Director
Office of Wetlands, Oceans, and Watersheds
U.S. Environmental Protection Agency

Mr. Dan L. Ayres
Lead Biologist
Coastal Shellfish
Washington State Department of Fish and Wildlife

Dr. Donald M. Anderson
Senior Scientist, Biology Department
Director, National Office for Harmful Algal Blooms
Woods Hole Oceanographic Institution

Dr. Greg L. Boyer
Professor of Biochemistry
Director, Great Lakes Research Consortium
College of Environmental Science and Forestry
State University of New York

Dr. Donald Scavia
Graham Family Professor of Environmental Sustainability
University of Michigan

HEARING CHARTER

SUBCOMMITTEE ON ENERGY AND ENVIRONMENT
COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

Harmful Algal Blooms and Hypoxia: Formulating an Action Plan

THURSDAY, SEPTEMBER 17, 2009
1:00 P.M.–3:00 P.M.
2318 RAYBURN HOUSE OFFICE BUILDING

Purpose

On Thursday, September 17, 2009 the Subcommittee on Energy and Environment of the Committee on Science and Technology will hold a legislative hearing to examine Harmful Algal Blooms (HABs) and Hypoxia research and response needs to develop and implement action plans to monitor, prevent, mitigate and control both marine and fresh water bloom and hypoxia events. The Subcommittee will also receive testimony on draft legislation entitled *"The Harmful Algal Blooms and Hypoxia Research and Control Act of 2009."* Witnesses will provide their comments on, and suggestions to, the bill.

Witnesses

Dr. Robert Magnien is the Director of the Center for Sponsored Coastal Ocean Research in the National Oceanic and Atmospheric Administration (NOAA). Dr. Magnien will discuss NOAA's current HABs and hypoxia activities, as well as the need for the implementation action plans to address both marine and fresh water blooms and hypoxia events.

Ms. Suzanne E. Schwartz is Acting Director of the Office of Wetlands, Oceans, and Watersheds, U.S. Environmental Protection Agency (EPA). Ms. Schwartz will discuss EPA's current HABs and hypoxia activities as well as the agency's role in addressing the impacts and research needs of freshwater harmful algal blooms.

Mr. Dan Ayres is a Coastal Shellfish Manager and Lead Biologist at the Washington State Department of Fish and Wildlife Region Six Office. Mr. Ayres will discuss the impacts HABs and hypoxia events impose on the west coastline. He will also discuss research and need for response and implementation plans regarding HABs and hypoxia for prevention, control, and mitigation.

Dr. Donald Anderson is a Senior Scientist and Director of the Coastal Ocean Institute at Woods Hole Oceanographic Institution. Dr. Anderson will discuss the impacts HABs and hypoxia events impose on the Nation's coastlines. He will also discuss the current research and need for response and implementation plans regarding HABs and hypoxia for prevention, control, and mitigation.

Dr. Greg L. Boyer is a Professor of Biochemistry at the State University of New York College of Environmental Science and Forestry and Director of the Great Lakes Research Consortium. Dr. Boyer will discuss impacts of freshwater harmful algal blooms and hypoxia and the research and implementation needs to respond to freshwater HABs events.

Dr. Donald Scavia is a Graham Family Professor of Environmental Sustainability and Professor of Natural Resources and Environment at the University of Michigan. Dr. Scavia will discuss the impacts of HABs and hypoxia on the Great Lakes and Chesapeake Bay areas, as well as the needs for an implementation strategy for hypoxia in the Northern Gulf of Mexico and Mississippi River.

Background

Harmful Algal Blooms and Related Impacts

A harmful algal bloom (HAB) is a bloom, or rapid overproduction of algal cells, that produces toxins which are detrimental to plants and animals. These outbreaks are commonly referred to as "red" or "brown" tides. Blooms can kill fish and other aquatic life by decreasing sunlight available to the water and by using up the available oxygen in the water, which then results in a hypoxia (severe oxygen depletion) event. These produced toxins accumulate in shellfish, fish, or through the accumulation of biomass that in turn affect other organisms and alter food webs. In recent years, many of the Nation's coastlines, near-shore marine waters, and freshwaters have experienced an increase in the number, frequency, duration and type of HABs. Blooms can be caused by several factors; for example, an increase in nutrients can cause algae growth and reproduction to increase dramatically. In other instances, an environmental change in the water quality, temperature, sunlight, or other factors allows certain algae to out-compete other microorganisms for nutrients, which can result in a bloom of the algae with the advantage.

Harmful algal blooms are one of the most scientifically complex and economically significant coastal management issues facing the Nation. In the past, only a few regions of the U.S. were affected by HABs, but now all U.S. coastal regions have reported major blooms. These phenomena have devastating environmental, economic, and human health impacts. Impacts include human illness and mortality following direct consumption or indirect exposure to toxic shellfish or toxins in the environment; economic hardship for coastal economies, many of which are highly dependent on tourism or harvest of local seafood; as well as dramatic fish, bird, and mammal mortalities. There are also devastating impacts to ecosystems, leading to environmental damage that may reduce the ability of those systems to sustain species due to habitat degradation, increased susceptibility to disease, and long-term alterations to community structure.

The Harmful Algal Bloom and Hypoxia Research and Control Act and Current Federal Research

Scientific understanding of harmful algal blooms and hypoxic events has progressed significantly since the early 1990s; however, there is a need for additional efforts in monitoring, prevention, control and mitigation of these complex phenomena. Practical and innovative approaches to address hypoxia and HABs in U.S. waters are essential for management of aquatic ecosystems and to fulfill a stronger investment in the health of the coasts and oceans called for by the U.S. Ocean Action Plan[1] and recent reports on ocean policy. Recognizing this need, in 2004 Congress reauthorized and expanded the *Harmful Algal Bloom and Hypoxia Research and Control Act of 1998* (Public Law 105–383) by passing the *Harmful Algal Bloom and Hypoxia Amendments Act of 2004* (Public Law 108–456).

The 1998 *Harmful Algal Bloom and Hypoxia Research and Control Act* (HABHRCA) established an Interagency Task Force to develop a national HABs assessment and authorized funding for existing and new research programs on HABs. This includes two multi-year research programs at NOAA that focus on HABs, the Ecology and Oceanography of Harmful Algal Blooms (ECOHAB) program and the Monitoring and Event Response for Harmful Algal Blooms (MERHAB) program. These programs involve federal, State, and academic partners and support interdisciplinary extramural research studies to address the issues of HABs in an ecosystem context. HABHRCA was reauthorized in 2004, requiring assessments of HABs in different coastal regions and in the Great Lakes and plans to expand research to address the impacts of HABs. The law also authorized research, education, and monitoring activities related to the prevention, reduction, and control of harmful algal blooms and hypoxia and reconstituted the Interagency Task Force on HABs and Hypoxia.

The 2004 reauthorization also directed NOAA to produce several reports and assessments. The *Prediction and Response Report*, released in September 2007, addresses both the state of research and methods for HAB prediction and response, especially at the federal level. The *National Scientific Research, Development, Demonstration, and Technology Transfer Plan for Reducing Impacts from Harmful Algal Blooms* (RDDTT Plan) establishes research priorities to develop and demonstrate prevention, control and mitigation methods to advance current prediction and response capabilities.

The law also required development of local and regional Scientific Assessment of Hypoxia and a Scientific Assessment of Harmful Algal Blooms. These assessments were to be initiated at the request of State, tribal, or local governments or for affected areas identified by NOAA. Funding was also authorized for ongoing and new programs and activities such as: competitive, peer-reviewed research through the

[1] U.S. Commission on Ocean Policy. Bush Administration, 2004. *http://ocean.ceq.gov/actionplan.pdf*

ECOHAB program; freshwater harmful algal blooms added to the research priorities of ECOHAB; a competitive, peer-reviewed research program on management measures to prevent, reduce, control, and mitigate harmful algal blooms supported by the MERHAB program; and activities related to research and monitoring of hypoxia supported by the competitive, peer-reviewed Northern Gulf of Mexico program and Coastal Hypoxia Research Program administered by NOAAs National Ocean Service.

The HABHRCA authorized funds were directed to conduct research and seek to control HABs and hypoxia in U.S. marine waters, estuaries and the Great Lakes. The 2004 reauthorization also required a reporting requirement on *The Scientific Assessment of Freshwater Harmful Algal Blooms* that describe the state of the knowledge of HABs in U.S. inland and freshwaters and presents a plan to advance research and reduce the impacts on humans and the environment. However, since the completion of the report, the Environmental Protection Agency (EPA) has unilaterally determined its obligations regarding implementation of the report recommendations and the agency has ceased participation in freshwater HAB research and mitigation activities.

The investigation into marine blooms is critically important, as are HABs found in the Great Lakes; therefore, there is a need to research and respond to HABs in inland waterways, such as rivers, lakes and reservoirs. The Environmental Protection Agency oversees a wide array of programs specifically designed to protect and preserve the coastal and marine waters of the United States, including watershed protection programs working through partnerships and an array of regulatory programs. EPA currently has no research and development effort that addresses freshwater harmful algal blooms. In conjunction with its statutory responsibilities to ensure water quality under the *Clean Water Act* and the *Safe Drinking Water Act*, EPA has a program of research and development on water treatment technologies, health effects of water pollutants, security from deliberate contamination, and watershed protection. Current annual funding for these activities is approximately $50 million.

Currently, EPA and Louisiana researchers are studying whether the dead zone pollution violates water quality standards. With EPA's assistance, the State of Louisiana could set standards using the legal authority of the *Federal Clean Water Act*, including non-point source runoff of nitrogen and phosphorus fertilizer. EPA and the National Oceanic and Atmospheric Administration (NOAA) are co-leads of a Federal Workgroup of thirteen federal agencies committed to supporting the Gulf of Mexico Alliance, a partnership formed by the five Gulf State Governors. In addition, EPA is also a participating member of the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force. However, at present, there is a lack of significant federal research and development aimed at addressing freshwater HABs. Because of the agency's complementary work on inland water ecosystems, the EPA is a logical federal entity to partner with NOAA to develop and implement a research, development, and demonstration program to address freshwater harmful algal blooms and hypoxia through research, monitoring, prevention, mitigation, and control. As the lead agency with oversight over freshwater quality, the EPA should ensure the protection of aquatic ecosystems to protect human health, support economic and recreational activities, and provide healthy habitat for fish, plants, and wildlife by conducting research to develop HAB prevention, control and mitigation technologies.

Reauthorization of the Harmful Algal Bloom and Hypoxia Research and Control Act

For the past 12 years, the science community has been guided by the National Plan for Marine Biotoxins and Harmful Algae (Anderson, et al., 1993)[2]. This plan has served as the foundation for the development of national, regional, State and local programs and the advancement of scientific knowledge on HABs and their impacts. HABs have increased in their type, frequency, location, duration and severity, yet the decision-making and management systems have not changed. Thus, the national plan was updated to reflect the current state of the HAB problem, needs, priorities and approaches. The new plan, *Harmful Algal Research and Response: A National Environmental Science Strategy 2005–2015*[3] (HARRNESS) is composed of

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[2] Anderson, D.,Galloway,S.B., Joseph, J.D. A National Plan for Marine Biotoxins and Harmful Algae. 1993. *http://hdl.handle.net/1912/614*; *https://darchive.mblwhoilibrary.org/bitstream/1912/614/1/WHOI-93-02.pdf*

[3] *HARRNESS, Harmful Algal Research and Response: A National Environmental Science Strategy 2005–2015*. National Plan for Algal Toxins and Harmful Algal Blooms. *http://www.esa.org/HARRNESS/*

views from the research and management community and outlines a framework for actions over a ten-year period.

The HABs issue has been approached at a multi-agency level to address its many dimensions. There is presently a range of programs and agencies that address specific aspects of HABs. There have been several reports and assessments on the range of aspects. The reauthorization of the HABHRCA should build upon and utilize the findings and results of these workings to formulate a national action strategy as well as develop regional research action plans. There is also a need to expand the work and research of Harmful Algal Blooms to include both marine and freshwaters.

Draft Legislation:

The Harmful Algal Blooms and Hypoxia Research and Control Amendments Act of 2009

SECTION-BY-SECTION ANALYSIS

The *Harmful Algal Blooms and Hypoxia Research and Control Amendments Act of 2009*

Purpose: To establish a National Harmful Algal Bloom and Hypoxia Program, to develop and coordinate a comprehensive strategy to address harmful algal blooms and hypoxia, and to provide for the development and implementation of comprehensive regional action plans to reduce harmful algal blooms and hypoxia.

Section 1: Short Title

The *Harmful Algal Blooms and Hypoxia Research and Control Amendments Act of 2009*

Section 2: Amendment of Harmful Algal Bloom and Hypoxia Research and Control Act of 1998

Section 2 explains that the text the bill modifies is the *Harmful Algal Bloom and Hypoxia Research and Control Act of 1998,* unless otherwise expressly stated.

Section 3: Definitions

Section 3 provides definitions for the Act, including: Administrator of the Environmental Protection Agency; the National Harmful Algal Bloom and Hypoxia Program; and the Under Secretary of Commerce for Oceans and Atmosphere.

Section 4: National Harmful Algal Bloom and Hypoxia Program

Section 4 directs the Under Secretary of Commerce for Oceans and Atmosphere, through the Interagency Task Force, to establish and maintain a National Harmful Algal Bloom and Hypoxia Program. The bill outlines tasks for the Under Secretary to ensure through the Program: 1) to develop a national strategy to address both marine and freshwater HABs and hypoxia; 2) to ensure the coordination of all federal programs related to HABs and hypoxia; 3) to work with regional, State, tribal, and local government agencies; 4) to identify additional research needs and priorities; 5) to support international research efforts on HABs and hypoxia; 6) to ensure the development and implementation of methods and technologies to protect ecosystems damaged by HABs; 7) to coordinate an outreach, education, and training program; 8) to facilitate regional, State, tribal, and local efforts to implement response plans, strategies, and tools; 9) to provide resources for training of regional, State, tribal and local coastal and water resource managers; 10) to enhance observations, monitoring, modeling, data management, information dissemination, and operational forecasts; 11) to oversee the updating of the Regional Research and Action Plans; and 12) to administer peer-reviewed, merit-based competitive grant funding.

In addition, Section 4 directs the Under Secretary to work cooperatively with other offices, centers, and programs within NOAA, as well as, with States, tribes, non-governmental organizations, and other agencies represented on the Task Force. Section 4 also directs the Under Secretary and the Administrator of the Environmental Protection Agency to jointly carry out the duties for the freshwater aspects of the Program.

This bill also requires the Under Secretary to transmit to Congress an action strategy that outlines the specific activities to be carried out by the Program, a timeline for such activities, and the programmatic roles of each federal agency in the Task Force. The action strategy shall be published in the *Federal Register* and be periodically revised by the Under Secretary. Section 4 also requires the Under Secretary to prepare a report to Congress describing the budget, activities, and progress of the Program.

Section 5: Regional Research and Action Plans

Section 5 directs the Under Secretary, through the Task Force, to oversee the development and implementation of Regional Research and Action Plans by identifying the appropriate regions and sub-regions to be addressed by each Plan. The bill outlines some contents the Plans should identify: 1) regional priorities for ecological, economic, and social research related to the impacts of HABs and hypoxia; 2) research, development, and demonstration activities to advance technologies to address the impacts of HABs and hypoxia; 3) actions to minimize the occurrence of HABs and hypoxia; 4) ways to reduce the duration and intensity of HABs events; 5) research and methods to address the impacts of HABs on human health; 6) mechanisms to protect vulnerable ecosystems that could be or have been affected by HABs; 7) mechanisms by which data is transferred between the Program and State, tribal, and local governments and relevant research entities; 8) communication, outreach, and dissemination methods used to educate and inform the public; and 9) the roles that Federal agencies can play to assist implementation of the Plan.

Section 5 directs the utilization of existing research, assessments, and reports in the development of the Plans. Section 5 also provides a list of individuals and entities that the Under Secretary may work with to develop the Plans. The bill also requires that the Plans be completed within 12 months of the date of enactment and updated once every five years. Furthermore, Section 5 requires that the Under Secretary submit a report to Congress not later than 12 months after the date of enactment and once every two years after the completion of the Regional Research and Actions Plans.

Section 6: Northern Gulf of Mexico Hypoxia

Section 6 directs the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force to transmit a report to Congress and the President on the progress made toward attainment of the coastal goals of the 2008 Gulf Hypoxia Action Plan. The initial report is required no later than two years after the date of enactment and every five years thereafter. The reports are required to assess progress made toward nutrient load reductions, the response of the hypoxia zone and water quality throughout the Mississippi/Atchafalaya River Basin and the economic and social effects. The reports shall include an evaluation of current policies and programs and lessons learned. In addition, Section 6 requires the reports to recommend appropriate actions to continue to implement or, if necessary, revise the strategy set forth in the 2008 Gulf Hypoxia Action Plan.

Section 7: Authorization of Appropriations

Section 7 provides a five year authorization to the Under Secretary to carry out the Program and a separate authorization for the development of the Regional Research and Action Plans. Section 7 also provides a five year authorization to the Administrator for the freshwater HABs Program.

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[COMMITTEE PRINT]

SEPTEMBER 14, 2009

111TH CONGRESS
1ST SESSION

H. R. ______

To establish a National Harmful Algal Bloom and Hypoxia Program, to develop and coordinate a comprehensive and integrated strategy to address harmful algal blooms and hypoxia, and to provide for the development and implementation of comprehensive regional action plans to reduce harmful algal blooms and hypoxia.

IN THE HOUSE OF REPRESENTATIVES

Mr. BAIRD introduced the following bill; which was referred to the Committee on

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A BILL

To establish a National Harmful Algal Bloom and Hypoxia Program, to develop and coordinate a comprehensive and integrated strategy to address harmful algal blooms and hypoxia, and to provide for the development and implementation of comprehensive regional action plans to reduce harmful algal blooms and hypoxia.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

f:\VHLC\091409\091409.205.xml (448381I5)
September 14, 2009 (2:55 p.m.)

SECTION 1. SHORT TITLE.

This Act may be cited as the ''Harmful Algal Blooms and Hypoxia Research and Control Amendments Act of 2009''.

SEC. 2. AMENDMENT OF HARMFUL ALGAL BLOOM AND HYPOXIA RESEARCH AND CONTROL ACT OF 1998.

Except as otherwise expressly provided, whenever in this Act an amendment or repeal is expressed in terms of an amendment to, or repeal of, a section or other provision, the reference shall be considered to be made to a section or other provision of the Harmful Algal Bloom and Hypoxia Research and Control Act of 1998 (16 U.S.C. 1451 note).

SEC. 3. DEFINITIONS.

The Act is amended by inserting after section 602 the following:

''SEC. 602A. DEFINITIONS.

''In this title:

''(1) ADMINISTRATOR.—The term 'Administrator' means the Administrator of the Environmental Protection Agency.

''(2) PROGRAM.—The term 'Program' means the National Harmful Algal Bloom and Hypoxia Program established under section 603A.

"(3) UNDER SECRETARY.—The term 'Under Secretary' means the Under Secretary of Commerce for Oceans and Atmosphere.".

SEC. 4. NATIONAL HARMFUL ALGAL BLOOM AND HYPOXIA PROGRAM.

The Act is amended by inserting after section 603 the following:

"SEC. 603A. NATIONAL HARMFUL ALGAL BLOOM AND HYPOXIA PROGRAM.

"(a) IN GENERAL.—Except as provided in subsection (d), the Under Secretary, through the Task Force established under section 603(a), shall establish and maintain a National Harmful Algal Bloom and Hypoxia Program pursuant to this section.

"(b) DUTIES.—The Under Secretary, through the Program, shall—

"(1) develop and promote a national strategy to understand, detect, predict, control, mitigate, and respond to marine and freshwater harmful algal bloom and hypoxia events;

"(2) ensure the coordination of all Federal programs that address marine and freshwater harmful algal blooms and hypoxia, and other ocean and Great Lakes science and management programs and centers that address the chemical, biological, and physical components of marine and freshwater harmful algal blooms and hypoxia;

"(3) coordinate and work cooperatively with regional, State, tribal, and local government agencies and programs that address marine and freshwater harmful algal blooms and hypoxia;

"(4) identify additional research, development, and demonstration needs and priorities relating to monitoring, prevention, control, mitigation, and response to marine and freshwater harmful algal blooms and hypoxia;

"(5) support international research efforts on marine and freshwater harmful algal blooms and hypoxia, and support international information sharing, mitigation, control, and response activities;

"(6) ensure the development and implementation of methods and technologies to protect the ecosystems affected by marine and freshwater harmful algal blooms;

"(7) coordinate an outreach, education, and training program that integrates and augments existing programs to improve public education about and awareness of the causes, impacts, and mitigation efforts for marine and freshwater harmful algal blooms and hypoxia;

"(8) facilitate regional, State, tribal, and local efforts to develop and implement appropriate marine and freshwater harmful algal bloom and hypoxia response plans, strategies, and tools, including outreach programs and information dissemination mechanisms;

"(9) facilitate and provide resources for training of regional, State, tribal, and local coastal and water resource managers in the methods and technologies for monitoring, preventing, controlling, mitigating, and responding to marine and freshwater harmful algal blooms and hypoxia events;

"(10) develop and enhance critical observations, monitoring, modeling, data management, information dissemination, and operational forecasts;

"(11) oversee the development, implementation, review, and periodic updating of the Regional Research and Action Plans under section 603B; and

"(12) administer peer-reviewed, merit-based competitive grant funding to support—

"(A) the projects maintained and established by the Program; and

"(B) the research and management needs and priorities identified in the Regional Research and Action Plans.

"(c) COOPERATIVE EFFORTS.—The Under Secretary shall work cooperatively with other offices, centers, and programs within the National Oceanic and Atmospheric Administration and other agencies represented on the Task Force established under section 603(a), States, tribes, and nongovernmental organizations concerned with marine and freshwater aquatic issues related to harmful algal blooms and hypoxia.

"(d) FRESHWATER PROGRAM.—With respect to the freshwater aspects of the Program, the Under Secretary and the Administrator shall jointly carry out the duties otherwise assigned to the Under Secretary under this section and section 603B.

"(e) ACTION STRATEGY.—

"(1) IN GENERAL.—Not later than 12 months after the date of enactment of the Harmful Algal Blooms and Hypoxia Research and Control Amendments Act of 2009, the Under Secretary, through the Task Force established under section 603(a), shall transmit to the Congress an action strategy that identifies—

"(A) the specific activities to be carried out by the Program and the timeline for carrying out such activities; and

"(B) the roles and responsibilities of each Federal agency in the Task Force established under section 603(a) in carrying out Program activities.

"(2) FEDERAL REGISTER.—The Under Secretary shall publish the action strategy in the Federal Register.

"(3) PERIODIC REVISION.—The Under Secretary shall periodically review and revise the action strategy prepared under this subsection as necessary.

"(f) REPORT.—Every 2 years after the submission of the action strategy, the Under Secretary shall prepare and transmit to the Congress a report that describes—

"(1) the activities carried out under the Program and the budget related to these activities; and

"(2) the progress made on implementing the action strategy.".

SEC. 5. REGIONAL RESEARCH AND ACTION PLANS.

The Act is amended by inserting after section 603A the following:

"SEC. 603B. REGIONAL RESEARCH AND ACTION PLANS.

"(a) IN GENERAL.—The Under Secretary, through the Task Force established under section 603(a), shall—

"(1) identify the appropriate regions and subregions to be addressed by each Regional Research and Action Plan; and

"(2) oversee the development and implementation of the Regional Research and Action Plans.

"(b) CONTENTS.—The Plans developed under this section shall identify—

"(1) regional priorities for ecological, economic, and social research on issues related to the impacts of harmful algal blooms and hypoxia;

"(2) research, development, and demonstration activities needed to develop and advance technologies for improving capabilities to predict, monitor, prevent, control, and mitigate harmful algal blooms and hypoxia;

"(3) actions to minimize the occurrence of harmful algal blooms and hypoxia;

"(4) ways to reduce the duration and intensity of harmful algal blooms and hypoxia, including in times of emergency;

"(5) research and methods to address human health dimensions of harmful algal blooms and hypoxia;

"(6) mechanisms to protect vulnerable ecosystems that could be or have been affected by harmful algal blooms and hypoxia events;

"(7) mechanisms by which data, information, and products are transferred between the Program and State, tribal, and local governments and relevant research entities;

"(8) communication, outreach, and information dissemination methods that State, tribal, and local governments and nongovernmental organizations can undertake to educate and inform the public concerning harmful algal blooms and hypoxia; and

"(9) the roles that Federal agencies can play to help facilitate implementation of the Plan.

"(c) BUILDING ON AVAILABLE STUDIES AND INFORMATION.—In developing the Plans under this section, the Under Secretary shall utilize and build on existing research, assessments, and reports, including those carried out pursuant to existing law and other relevant sources.

"(d) DEVELOPMENT OF PLANS.—The Under Secretary may develop Plans under this section with assistance from the individuals and entities described in subsection (g).

"(e) PLAN TIMELINE AND UPDATES.—The Under Secretary, through the Task Force established under section 603(a), shall ensure that the Plans developed under this section are completed not later than 12 months after the date of enactment of the Harmful Algal Blooms and Hypoxia Research and Control Amendments Act of 2009, and updated once every 5 years thereafter.

"(f) REPORTS.—Not later than 12 months after the date of enactment of this Act, and once every two years after the completion of the Regional Research and Actions Plans, the Under Secretary shall transmit to the Congress a report that describes—

"(1) the contents of each Plan;

"(2) the activities taken to implement the Plans, including a description of research funded and actions and outcomes of Plan response strategies carried out; and

"(3) Federal funding provided to implement the Plans.

"(g) CONSULTATION.—In developing the Plans under this section, as appropriate, the Under Secretary shall consult with—

"(1) State coastal management and planning officials;

"(2) tribal resource management officials;

"(3) water management and watershed officials from both coastal States and noncoastal States with water sources that drain into water bodies affected by harmful algal blooms and hypoxia;

"(4) public health officials;

"(5) emergency management officials;

"(6) nongovernmental organizations concerned with marine and aquatic issues;

"(7) science and technology development institutions;

"(8) economists;

"(9) industries and businesses affected by marine and freshwater harmful algal blooms and hypoxia;

"(10) scientists, with expertise concerning harmful algal blooms or hypoxia, from academic or research institutions; and

"(11) other stakeholders.".

SEC. 6. NORTHERN GULF OF MEXICO HYPOXIA.

Section 604 is amended to read as follows:

"SEC. 604. NORTHERN GULF OF MEXICO HYPOXIA.

"(a) TASK FORCE INITIAL PROGRESS REPORTS.—Not later than 2 years after the date of enactment of the Harmful Algal Blooms and Hypoxia Research and Control Amendments Act of 2009, the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force shall complete and transmit to the Congress and the President a report on the progress made by Task Force-directed activities toward attainment of the coastal goal of the 2008 Gulf Hypoxia Action Plan.

"(b) TASK FORCE 5-YEAR PROGRESS REPORTS.—After the initial report required under subsection (a), the Task Force shall complete and transmit to Congress and the President a report every 5 years thereafter on the progress made by Task Force-directed activities toward attainment of the coastal goal of the 2008 Gulf Hypoxia Action Plan.

"(c) CONTENTS.—The reports required by this section shall assess progress made toward nutrient load reductions, the response of the hypoxic zone and water quality throughout the Mississippi/Atchafalaya River Basin, and the economic and social effects. The reports shall—

"(1) include an evaluation of how current policies and programs affect management decisions, including those made by municipalities and industrial and agricultural producers;

"(2) evaluate lessons learned; and

"(3) recommend appropriate actions to continue to implement or, if necessary, revise the strategy set forth in the 2008 Gulf Hypoxia Action Plan.".

SEC. 7. AUTHORIZATION OF APPROPRIATIONS.

Section 605 is amended to read as follows:

"SEC. 605. AUTHORIZATION OF APPROPRIATIONS.

"There are authorized to be appropriated—

"(1) to the Under Secretary to carry out sections 603A and 603B, [$______] for each of fiscal years 2010 through 2014, of which up to [$________] shall be allocated each fiscal year to the development of the Regional Research and Action Plans required by section 603B; and

"(2) to the Administrator to carry out sections 603A and 603B, [$________] for each of fiscal years 2010 through 2014.".

Chairman BAIRD. I want to thank our witnesses for joining us. We apologize for the delay. It happens here sometimes. We have clusters of votes, and normally, of course, you have to sit and listen to us talk at you for far too long, so we are going to dispense with that so we can hear people who know what they are talking about, which is actually theoretically the purpose of a hearing on Capitol Hill.

So I will recognize Mr. Inglis, who I think is going to say the same thing, and then we will hear from our witnesses.

[The prepared statement of Chairman Baird follows:]

PREPARED STATEMENT OF CHAIRMAN BRIAN BAIRD

Good afternoon. I want to welcome everyone to today's legislative hearing on Harmful Algal Blooms (HABs) and draft legislation for the reauthorization of the *Harmful Algal Bloom and Hypoxia Research and Control Act*.

Last year the Subcommittee convened and discussed the impact harmful algal blooms and hypoxia has on our coastlines and in bodies of freshwater. I know in the State of Washington, HABs have made it increasingly difficult to manage important fisheries. It has also been our responsibility to protect citizens from the threats that these blooms cause on our beaches and subsequently result in wide area closures.

Harmful algal blooms pose serious threats because of their production of toxins and reduction of oxygen in the water. These impacts include alteration of the ocean's food web, human illnesses, and economic losses to communities and commercial fisheries.

The Gulf of Mexico Hypoxia and the even more recent occurrences of coastal dead zones, such as those in Oregon, have also caused many fish, crabs, and other aquatic organisms to either flee or die in suffocating waters.

I believe we have taken some important steps and made great advances in our research findings due to the 1998 *Harmful Algal Bloom and Hypoxia Research and Control Act* and in the 2004 reauthorization. However it is now time to build upon the numerous reports and assessments that came out of these two laws.

This reauthorization calls for action plans to begin responding to the needs of our communities. This bill establishes a National Harmful Algal Bloom and Hypoxia Program, with the National Oceanic and Atmospheric Administration (NOAA) tasked as the lead in overseeing the development of these plans. In addition, there needs to be more work done on the freshwater HABs. HABs affect not only our coastlines, but our inland waters as well. I think my colleagues will agree that we expect to see a collaborative effort between NOAA and the Environmental Protection Agency (EPA) in addressing the threat of HABs to freshwater.

Since the last reauthorization of the *Harmful Algal Bloom and Hypoxia Research and Control Act* in 2004, there has been an increase in the number, frequency, and type of blooms and hypoxic events in recent years. We need to continue the valuable ongoing research while now implementing strategic national and regional plans.

We must use our research and advances in our understanding of these blooms and the hypoxic events they cause to better monitor, mitigate, and control these occurrences and even prevent them, if possible.

We have a distinguished panel of witnesses here today, and I hope they will offer us expert testimony on how we can move forward together in responding to this problem.

I want to thank all of our witnesses for being here today. At this time, I would like to recognize our distinguished Ranking Member, Mr. Inglis of South Carolina for his opening statement.

Mr. INGLIS. Yes, Mr. Chairman. I am looking forward to hearing from the witnesses.

[The prepared statement of Mr. Inglis follows:]

PREPARED STATEMENT OF REPRESENTATIVE BOB INGLIS

Good afternoon and thank you for holding this hearing, Mr. Chairman.

In the 110th Congress, this subcommittee held a hearing on Harmful Algal Blooms and Hypoxia issues. We discussed previous legislation and the progress made on a new national plan, HARRNESS: Harmful Algal Research and Response:

A National Environmental Science Strategy 2005–2015, and how it will help coordinate the Federal Government's efforts on HAB and hypoxia research.

Today we are here to discuss next steps. We will discuss legislation that will push federal efforts beyond previous statutes and make use of what we've learned to date. Hopefully we can place greater emphasis on the critical areas of monitoring, control, and mitigation.

South Carolina's Phytoplankton Monitoring Network is a collaborative effort of scientists and academics from all over the United States. Since it was started in 2001, the Network has reported over 70 algal blooms. Cooperative efforts like these and advancements in monitoring coordination are important first steps in dealing with harmful algal blooms, but we have a lot of work left to do to develop an event response program.

Once blooms are identified, several questions arise: Could the bloom have been predicted? How do we control the bloom without causing further harm? What can we do to mitigate the economic impacts of these blooms?

I'm also interested in how to properly use regional partnerships to leverage greater resources and appropriately differentiate the HAB and hypoxia issues and impacts on our diverse coast line. Moreover, I hope the witnesses can talk to the appropriate level of resources that the Federal Government should invest in an event response program.

I hope as we discuss this piece of legislation we can keep in mind that the end goal is to minimize the negative impacts of HABs and hypoxia on our coasts and economy.

I look forward to hearing from our distinguished panelists about all these issues. Thank you again, Mr. Chairman, and I yield back the balance of my time.

Chairman BAIRD. I thank the gentleman for his eloquent speech.

[The prepared statement of Mr. Costello follows:]

PREPARED STATEMENT OF REPRESENTATIVE JERRY F. COSTELLO

Good afternoon. Thank you, Mr. Chairman, for holding today's hearing to review prevention and response needs of harmful algal blooms (HAB) and hypoxia events and to receive testimony on draft legislation to reauthorize and expand the *Harmful Algal Blooms and Hypoxia Research and Control Act of 1998.*

The Subcommittee has examined the ecological and health risks posed by HABs and hypoxia several times through hearings and legislation. Yet these harmful events continue to occur in our coastal regions and happen regularly in the Great Lakes and other major waterways. The spread of HABs and hypoxia to new regions of the country will require efforts to monitor, prevent, and respond to these outbreaks.

In particular, we must take action to address the development of HABs and hypoxia in our inland waterways, including the Mississippi River and the Great Lakes. The Mississippi River serves as a vital transportation corridor for the movement of goods and as a center for recreation in Illinois. A HAB or hypoxia outbreak in the Mississippi River could have a severe effect on the economy and cause major health risks. Previous outbreaks have occurred in the Mississippi River Delta, yet the Environmental Protection Agency has no research program in place to address inland, freshwater HABs or hypoxia. I look forward to hearing from our witnesses how their research efforts may address these concerns to manage HBAs and hypoxia in our inland waterways.

I am pleased Subcommittee Chairman Baird has proposed legislation to build upon the 2004 expansion of the *Harmful Algal Bloom and Hypoxia Research and Control Act* to combat the harmful effects of these occurrences. The guidelines set forth in the proposed legislation aim to manage HABs and hypoxia more efficiently by creating a national strategy to address marine and freshwater outbreaks. This strategy focuses on regional efforts to address HABs and hypoxia and prevent their spread. I would like to hear from our witnesses if this regional approach will be effective in preventing the development of HABs and hypoxia in areas of the country, such as the Midwest.

I welcome our panel of witnesses, and I look forward to their testimony. Thank you again, Mr. Chairman.

Chairman BAIRD. It my privilege to introduce our outstanding panel of witnesses, who bring great expertise. Dr. Robert Magnien—and if I mispronounce, please forgive me—is the Director of the Center for Sponsored Coastal Ocean Research of the National Oceanic and Atmospheric Administration. Ms. Suzanne Schwartz is Acting Director of the Office of Wetlands, Oceans and Watersheds at the U.S. EPA. Mr. Dan Ayres hails from my home state—good to see you again, Dan—the Coastal Shellfish Manager and Lead Biologist at the Washington State Department of Fish and Wildlife Region 6 office. Dr. Donald Anderson is Senior Scientist and Director of the Coastal Ocean Institute at Woods Hole Oceanographic Institute. Dr. Greg L. Boyer is Professor of Biochemistry at the State University of New York, College of Environmental Science and Forestry and Director of Great Lakes Research Consortium, and Dr. Donald Scavia is a Graham Family Professor of Environment Sustainability and Professor of Natural Resources and Environment at the University of Michigan, a state from whence hails our delightful Dr. Ehlers, who has been a passionate advocate of this. I should also mention that Representatives Connie Mack and Kathy Castor of Florida both have been very strong advocates of that. As witnesses should know, you will have five minutes for spoken testimony. Those of you are dying to hear what Mr. Inglis and I were going to say can find those on our web sites. Don't rush out and bookmark that right now.

With that, let us hear from Dr. Magnien and the rest of our distinguished panel.

STATEMENT OF DR. ROBERT E. MAGNIEN, DIRECTOR, CENTER FOR SPONSORED COASTAL OCEAN RESEARCH, NATIONAL CENTERS FOR COASTAL OCEAN SCIENCE, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, U.S. DEPARTMENT OF COMMERCE

Dr. MAGNIEN. Good afternoon, Mr. Chairman and Members of the Subcommittee. My name is Robert Magnien and I am Director of NOAA's Center for Sponsored Coastal Ocean Research. In this role, I administer on behalf of the Department of Commerce and NOAA the five national programs on harmful algal blooms and hypoxia that are authorized by the *Harmful Algal Bloom and Hypoxia Research Control Act* (HABHRCA) *of 1998*. I also coordinate these programs nationally and internationally.

NOAA views hypoxia and harmful algal blooms, or HABs, as significant threats to the health of the American public and the U.S. economy. HABs, which now occur in all states, are a growing problem worldwide. They threaten human and ecosystem health and the vitality of fish and shellfish, protected species and coastal economies. Similarly, hypoxia, or areas of low dissolved oxygen called dead zones, have increased 30 fold since 1960. They now occur in over 300 U.S. coastal systems including the Great Lakes, signaling severe degradation of water quality and habitats nationwide. I appreciate the opportunity to comment on the draft reauthorization so that we can build upon the many successes of this legislation.

In 1998, HABHRCA authorized NOAA to take action to address the growing problems of HABs and hypoxia and coordinate interagency efforts. A major component of this responsibility is NOAA's leadership of the Nation's only competitive research programs focused solely on these issues, three for HABs and two for hypoxia. HABHRCA also authorizes NOAA to carry out intramural research and assessment activities. Active areas of research include HAB and hypoxia forecasting, development of new methods for HAB cell and toxin detection, and understanding the impacts of HABs and hypoxia on aquatic life and coastal economies. The 2004 reauthorization required five reports. Four have been submitted to Congress and the fifth is undergoing interagency approval.

Many significant research advances supported by HABHRCA programs have greatly improved HAB and hypoxia management. These accomplishments are described in the HABHRCA reports that were submitted to Congress in my written testimony. Let me just highlight two.

HAB forecasting has been extended to new areas, an outcome of many years of sustained research, and shows great promise in providing early warning to public health and resource managers. Forecasts in the western Gulf of Mexico, the Great Lakes, the Gulf of Maine, Chesapeake Bay and the Pacific Northwest are in various stages of development. NOAA has preliminary plans for a national HAB forecasting system which will make routine forecasts, like weather forecasts, in areas where HABs are a major threat. In 2008, the interagency Mississippi Gulf of Mexico Task Force updated the Gulf Hypoxia Action Plan, which reaffirmed the goal of reducing the hypoxic zone and prescribed 45 percent reductions in both nitrogen and phosphorus. The recommendations were based in large part on the many years of NOAA-funded research authorized by HABHRCA.

Regarding the draft bill, it addresses two issues that are consistent with NOAA goals. First, it will establish an overarching HAB and hypoxia program within NOAA. This will enhance the visibility of these issues as a national priority and improve coordination within NOAA and with other federal agencies. Secondly, regional research and action plans will be developed with input from local experts and managers. These plans will guide future research priorities toward development of products that are of greatest benefit to those on the front lines of managing these threats as well as the public. We note, however, that all mention of specific ongoing HAB and hypoxia programs that were identified in prior versions of HABHRCA have been removed. NOAA has found the specification of programs helps to clarify the intent of Congress when implementing this legislation. Much of the Nation's progress in improving HAB and hypoxia management and response has come from information and products developed under these highly successful programs. Further, one of the HABHRCA reports presented to Congress last year, called "HAB Management and Response," recommended that progress would be enhanced if event response and infrastructure programs were added.

Finally, the role of research within NOAA is not specified in the draft legislation as it was in the previously enacted legislation. Such authorization assures that the valuable research conducted within NOAA will be continued. We understand that this bill is only a draft so we would welcome additional opportunities to work with the Committee to develop the language of this bill.

Thank you, Mr. Chairman and Members of the Committee, for this opportunity to comment on the pending legislation and update you on NOAA's programs. NOAA strongly supports reauthorization

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of HABHRCA and the new opportunities it will provide. I will be happy to answer any questions that you may have.

[The prepared statement of Dr. Magnien follows:]

PREPARED STATEMENT OF ROBERT E. MAGNIEN

Introduction

Good morning Mr. Chairman and Members of the Subcommittee. My name is Robert E. Magnien and I am the Director of the National Oceanic and Atmospheric Administration's (NOAA) Center for Sponsored Coastal Ocean Research (CSCOR). CSCOR provides competitive funding for regional-scale, multi-disciplinary research on understanding and predicting the impacts of major stressors on coastal ecosystems, communities, and economies in order to support informed, ecosystem-based management. In this capacity, I administer the five national programs solely focused on harmful algal blooms (HAB) and hypoxia that were authorized by the *Harmful Algal Bloom and Hypoxia Research and Control Act of 1998* (HABHRCA) and reauthorized in 2004. I serve on the Interagency Working Group on Harmful Algal Blooms, Hypoxia, and Human Health of the Joint Subcommittee on Ocean Science and Technology to coordinate NOAA's programs with other federal agencies. Additionally, I serve as the U.S. representative for the Intergovernmental Oceanographic Commission panel on HABs to maximize international opportunities for exchange of relevant research.

At NOAA, we work to protect the lives and livelihoods of Americans, and provide products and services that benefit the economy, environment, and public safety of the Nation. By improving our understanding of, and ability to predict changes in, the Earth's environment, and by conserving and managing ocean and coastal resources, NOAA generates tremendous value for the Nation. NOAA's role is all the more important given the profound economic, environmental, and societal challenges currently facing the country. Two of these challenges are HABs and hypoxia, which together represent a significant threat to the health of the American public and the U.S. economy.

HABs, which now occur in all U.S. states,[1,2] are a growing problem worldwide. HABs threaten human and ecosystem health, and the vitality of fish and shellfish, protected species, and coastal economies. Similarly, hypoxia occurs in over 300 U.S. coastal systems,[3] including the Great Lakes. There has been a 30-fold increase in hypoxia events since 1960,[3] signaling severe degradation of water quality and aquatic habitats nation-wide. HABs and hypoxia are two of the most complex phenomena currently challenging management of aquatic ecosystems. Given the profound, pervasive, complex and growing impacts of HABs and hypoxia, these are important issues NOAA will continue to address in the coming years.

I appreciate the opportunity to comment on the draft HABHRCA reauthorization before this committee so we can maximize the opportunities to reduce or prevent HAB and hypoxia events and their impacts in an efficient and coordinated manner. In order to provide context for the importance of HABHRCA reauthorization, I will first describe the nature of the problem in more detail, discuss NOAA's role in addressing HABs and hypoxia in our coastal and Great Lakes waters, and highlight some of the significant advances NOAA has made as a result of HABHRCA.

Harmful Algal Blooms in the United States

Generally, algae are simple plants that in general are beneficial because they provide the main source of energy that sustains aquatic life. However, some algae cause harm to humans, animals, and the environment by producing toxins or by growing in excessively large numbers. When this occurs they are referred to as "harmful algal blooms" or HABs. Sometimes, certain algal species accumulate in such high

[1] Lopez, C.B., Dortch, Q., Jewett, E.B., Garrison, D. 2008. *Scientific Assessment of Marine Harmful Algal Blooms.* Interagency Working Group on Harmful Algal Blooms, Hypoxia, and Human Health of the Joint Subcommittee on Ocean Science and Technology. Washington, D.C., 62 pp.

[2] Lopez, C.B., Jewett, E.B., Dortch, Q., Walton, B.T. Hudnell, H.K. 2008. *Scientific Assessment of Freshwater Harmful Algal Blooms.* Interagency Working Group on Harmful Algal Blooms, Hypoxia, and Human Health of the Joint Subcommittee on Ocean Science and Technology. Washington, D.C., 65 pp.

[3] Jewett, E.B., Lopez, C.B., Kidwell, D.M. Bricker, S.B., Burke, M.K., Walbridge, M.R., Eldridge, P.M., Greene, R.M., Hagy, J.D., Buxton, H.T., Diaz, R.J. In Prep. *Scientific Assessment of Hypoxia in U.S. Coastal Waters.* Interagency Working Group on Harmful Algal Blooms, Hypoxia, and Human Health of the Joint Subcommittee on Ocean Science and Technology. Washington, D.C., 149 pp.

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numbers that they discolor the water, and are commonly referred to as "red tides" or "brown tides." Table 1 lists some of the major HAB-causing organisms in the United States.

Some algae produce potent toxins that cause illness or death in humans and other organisms. Fish, seabirds, manatees, sea lions, turtles, and dolphins are some of the animals commonly affected by harmful algae. Humans and other animals can be exposed to algal toxins through the food they eat, the water they drink or swim in, or the air they breathe. Other algae species, although nontoxic to humans and wildlife, form such large blooms that they degrade habitat quality through massive overgrowth, shading, and oxygen depletion (hypoxia), which occurs after the bloom ends and the algae decay. These high biomass blooms can also be a nuisance to humans when masses of algae accumulate along beaches and subsequently decay.

HABs can have major negative impacts on local economies when, for example, shellfish harvesting is restricted to protect human health or when tourism declines due to degradation of recreational resources. HABs can also result in significant public health costs when humans become ill. A recent conservative estimate[4] suggests that HABs occurring in marine waters alone have an average annual impact of $82 million in the United States. In 2005, a single HAB event in New England resulted in a loss of $18 million in shellfish sales in Massachusetts alone.[5] Economic impacts can be difficult to calculate as they vary from region to region and event to event, but they are a primary concern of coastal communities that experience HAB events.

In addition to impacting public health, ecosystems, and local economies, HABs can also have secondary social and cultural consequences. For example, along the Washington and Oregon coasts, tens of thousands of people visit annually to participate in the recreational harvest of razor clams. However, a series of beach closures in recent years due to high levels of the HAB toxin domoic acid prevented access to this recreational fishery. These harvesting closures have not only caused economic losses, they have also resulted in an erosion of community identity, community recreation, and a traditional way of living for native coastal cultures.

As mentioned above, the geographic distribution of HAB events in the United States is broad. All coastal states have experienced HAB events in marine waters in the last decade, and freshwater HABs occur in the Great Lakes and in many inland waters. Evidence indicates the frequency and distribution of HAB events and their associated impacts have increased considerably in recent years in the United States and globally.[6]

Although all coastal states experience HABs, the specific organisms responsible for the HABs differ among regions of the country (see Figure 1). As a result, the harmful impacts experienced vary in their scope and severity, which leads to the need for specific management approaches for each region and species. Some species need to be present in very high abundances before harmful effects occur, which makes it easier to detect and track the HAB. However, other species cause problems at very low concentrations and can in essence be hidden among other benign algae, making them difficult to detect and track. The factors that cause and control HABs, from their initiation to their decline, vary not only by species, but also by region due to differences in local factors such as the shape of the coastline, runoff patterns, oceanography, nutrient regime, other organisms present in the water, etc. Consequently, the development of HAB management strategies requires a regional approach.

[4] Hoagland, P., and Scatasta, S. 2006. The Economic Effects of Harmful Algal Blooms. In E. Graneli and J. Turner, eds., *Ecology of Harmful Algae.* Ecology Studies Series. Dordrecht, The Netherlands: Springer-Verlag, Chap. 29.

[5] Jin, D., Thunberg, E., and Hoagland, P. 2008. Economic Impact of the 2005 Red Tide Event on Commercial Shellfish Fisheries in New England. *Ocean and Coastal Management* 51(5):420–429.

[6] GEOHAB, 2006. *Global Ecology and Oceanography of Harmful Algal Blooms, Harmful Algal Blooms in Eutrophic Systems.* P. Glibert (ed.). IOC and SCOR, Paris and Baltimore, 74, pp.

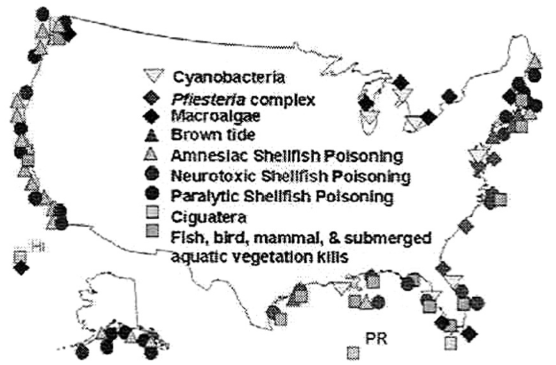

Figure 1. This map shows the geographic distribution of HAB events in the United States

As noted above, the causes of HABs are complex and are controlled by a variety of factors. While we know the causes of HAB development vary between species and locations, we do not have a full understanding of all the factors involved, including the interplay of different contributing factors. In general, algal species grow best when environmental conditions (such as temperature, salinity, and availability of nutrients and light) are optimal for cell growth. Other biological and physical processes (such as predation, disease, toxins and water currents) determine whether enhanced cell growth will result in biomass accumulation (or what we call a "bloom"). The challenge for understanding the causes of HABs stems from the complexity and interrelationship of these processes for individual species and among different HAB species. The complexity of interactions between HABs, the environment, and other plankton further complicate the predictions of when and where HAB events will occur. Knowledge of how these factors control the initiation, sustainment, and decline of a bloom is a critical precursor for advancing HAB management.

Human activities are thought to contribute to the increased frequency of some HABs.[3] For example, increased nutrient pollution has been acknowledged as a factor contributing to increased occurrence of several high biomass HABs.[7] Other human-induced environmental changes that may foster development of certain HABs include changes in the types of nutrients entering coastal waters, alteration of food webs by overfishing, introductions of non-indigenous species that change food web structure, introduction of HAB cells to new areas via ballast water or other mechanisms, and modifications to water flow.[1] It should also be noted that climate change will almost certainly influence HAB dynamics in some way since many critical processes governing HAB dynamics—such as temperature, water column stratification, up-welling and ocean circulation patterns, and freshwater and land-derived nutrient inputs—are influenced by climate. The interactive role of climate change with the other factors driving the frequency and severity of HABs is in the early stages of research, but climate change is expected to exacerbate the HAB problem in some regions (*http://www.cop.noaa.gov/stressors/extremeevents/hab/current/CC_habs.html*).

Hypoxia in the U.S.

Hypoxia means "low oxygen." In aquatic systems, low oxygen generally refers to a dissolved oxygen concentration less than two to three milligrams of oxygen per liter of water (mg/L), but sensitive organisms can be affected at higher thresholds (e.g., 4.5 mg/L). A complete lack of oxygen is called anoxia. Hypoxic waters generally

[7] Heisler, J., Glibert, P.M., Burkholder, J.M., Anderson, D.M., Cochlan, W., Dennison, W.C., Dortch, Q., Gobler, C.J., Heil, C.A., Humphries, E., Lewitus, A., Magnien, R., Marshall, H.G., Sellner, K., Stockwell, D.A., Stoecker, D.K., and Suddleson, M. 2008. Eutrophication and Harmful Algal Blooms: A Scientific Consensus. *Harmful Algae* 8(1):3–13.

do not have enough oxygen to support fish and other aquatic animals, and are sometimes called dead zones because the only organisms that can live there are microbes.

The incidence of hypoxia has increased 10-fold globally in the past 50 years and almost 30-fold in the U.S. since 1960, with over 300 coastal systems[3] now experiencing hypoxia (see Fig. 2). The increasing occurrence of hypoxia in coastal waters worldwide represents a significant threat to the health and economy of our nation's coasts and Great Lakes. This trend is exemplified most dramatically off the coast of Louisiana and Texas, where the second largest eutrophication-related hypoxic zone in the world is associated with the nutrient pollutant load discharged by the Mississippi and Atchafalaya Rivers.

Although coastal hypoxia can be caused by natural processes, the dramatic increase in the incidence of hypoxia in U.S. waters is linked to eutrophication due to nutrient (nitrogen and phosphorus) and organic matter enrichment, which has been accelerated by human activities. Sources of enrichment include point source discharges of wastewater, non-point source atmospheric deposition, and non-point source runoff from croplands, lands used for animal agriculture, and urban and suburban areas.

The difficulty of reducing nutrient inputs to coastal waters results from the close association between nutrient loading and a broad array of human activities in watersheds and explains the growth in the number and size of hypoxic zones. While nutrients leaving water treatment facilities can often be controlled through improvements in technology and facility upgrades, diffuse runoff from non-point sources, such as agriculture, is more difficult to control. Although there have been some welcome efforts to optimize fertilizer applications, agriculture remains a leading source of nutrient pollution in many watersheds due in part to the high demand for nitrogen intensive crops. Another exacerbating factor is the short-circuiting of water flow due to drainage practices, including tile drainage and ditching, that have been used to convert wetlands to croplands. Wetlands serve as filters and the loss of wetlands increases the transport of nitrogen into local waterways and ultimately coastal waters. Atmospheric nitrogen deposition from fossil fuel combustion remains an important source of diffuse nutrient pollution for rivers and coastal waters.

Unfortunately, hypoxia is not the only stressor impacting coastal ecosystems. Overfishing, HABs, toxic contaminants, and physical alteration of coastal habitats associated with coastal development are several problems that co-occur with hypoxia and interact to decrease the ecological health of coastal waters and reduce the ecological services they can provide.

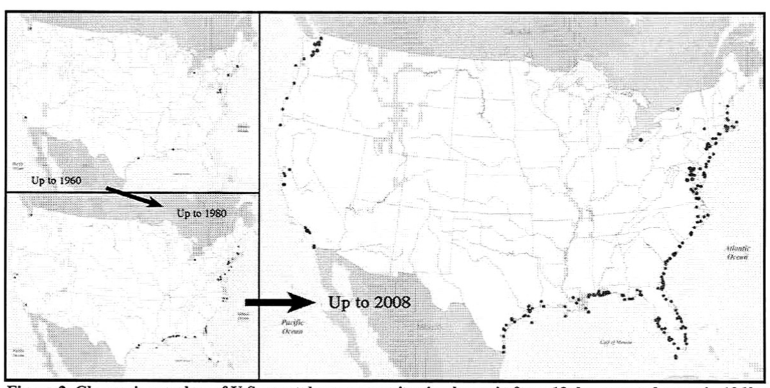

Figure 2. Change in number of U.S. coastal areas experiencing hypoxia from 12 documented areas in 1960 to over 300 now. Not shown here are one hypoxic system in Alaska and one in Hawaii. Source: adapted from Jewett et al. (In prep.).

HABHRCA Today

HABHRCA authorizes NOAA to take action to address the growing problem of HABs and hypoxia in the United States. The existing statute:

1. Establishes a mechanism for interagency coordination through an interagency Task Force;

2. Requires reports assessing the causes and impacts of HABs and hypoxia and plans to improve management and response; and
3. Authorizes funding for HAB and hypoxia research through national competitive research programs, and for research and assessment within NOAA.

Since 2005, the Interagency Working Group on HABs, Hypoxia and Human Health of the Joint Subcommittee on Ocean Science and Technology has been meeting monthly to coordinate interagency efforts with regard to HABs and hypoxia. A major focus for the group has been writing the five reports mandated by the 2004 reauthorization of HABHRCA. Four of the five reports have been submitted to Congress and the fifth is undergoing interagency approval (*http://www.cop.noaa.gov/stressors/extremeevents/hab/habhrca/Report_Plans.html*). These reports provide guidance for NOAA HAB and Hypoxia programs. Specifically, the *HAB Management and Response: Assessment and Plan*[8] recommended the formation of the Prevention, Control, and Mitigation of HABs Program, which NOAA established this year. The Plan also highlights the need for an enhanced HAB event response program and a new infrastructure program, which have been incorporated into drafts of the 2009 reauthorization of HABHRCA.

NOAA HAB and Hypoxia Programs

The goal of NOAA's programs is to prevent or reduce the occurrence of HABs and hypoxia and/or to minimize their impacts. Developing useful products for HAB and hypoxia management is a multi-step process that requires a variety of approaches, and must be based on a strong scientific understanding of the causes and impacts of HABs and hypoxia.

NOAA leads the Nation's three competitive research programs solely focused on HABs and authorized by HABHRCA:

1. The Ecology and Oceanography of Harmful Algal Blooms (ECOHAB) Program is focused on research to determine the causes and impacts of HABs. The ECOHAB Program provides information and tools necessary for developing technologies for, and approaches to, predicting, preventing, monitoring and controlling HABs.
2. The Monitoring and Event Response for Harmful Algal Blooms (MERHAB) Program focuses on incorporating tools, approaches, and technologies from HAB research programs into existing HAB monitoring programs. MERHAB also establishes partnerships to enhance existing, and initiate new, HAB monitoring capabilities to provide managers with timely information needed to mitigate HAB impacts on coastal communities.
3. The newer Prevention, Control, and Mitigation of HABs (PCM HAB) Program, transitions promising prevention, control, and mitigation technologies and strategies to end users. The PCM HAB Program also assesses the social and economic costs of HAB events, and strategies to prevent, control and mitigate those events, which will aid managers in devising the most cost-effective management approaches.

HABHRCA also authorizes research on hypoxia to assess the causes and impacts of this serious problem in order to guide scientifically sound management programs to reduce hypoxic zones and thereby protect valuable marine resources, their habitats and coastal economies. NOAA leads the Nation's two competitive research programs solely focused on hypoxia and authorized by HABHRCA.

1. The Northern Gulf of Mexico Hypoxia Program (NGOMEX) supports multi-year, interdisciplinary research projects to inform management in ecosystems affected by Mississippi/Atchafalaya River inputs. NGOMEX supports research with a focus on understanding the causes and effects of the hypoxic zone over the Louisiana-Texas-Mississippi continental shelf and the prediction of hypoxia's future extent and impacts.
2. The Coastal Hypoxia Research Program (CHRP) supports multi-year, interdisciplinary research projects to inform management of hypoxic zones in all of the Nation's coastal waters except those covered by NGOMEX. The objective of CHRP is to provide research results and modeling tools, which will be used by coastal resource managers to assess alternative management strategies for preventing or mitigating the impacts of hypoxia on coastal eco-

[8] Jewett, E.B., Lopez, C.B., Dortch, Q., Etheridge, S.M., Backer, L.C. 2008. *Harmful Algal Bloom Management and Response: Assessment and Plan.* Interagency Working Group on Harmful Algal Blooms, Hypoxia, and Human Health of the Joint Subcommittee on ocean Science and Technology. Washington, DC., 76 pp.

systems, and to make informed decisions regarding this important environmental stressor.

HABHRCA authorizes NOAA to carry out research and assessment activities, which has led to a world-class intramural research program on HABs. Much of this research is conducted in collaboration with external partners, including academic researchers, State and federal resource and public health managers, and private enterprises. Active areas of research include HAB and hypoxia forecasting, development of new methods of HAB cell and toxin detection, and understanding the impacts of HAB toxins on higher trophic levels, including humans.

NOAA's extramural and intramural research is leading to the development of a number of operational activities that provide valuable products and assistance. For example, NOAA currently provides twice weekly HAB forecasts for Florida coastal waters (*http://tidesandcurrents.noaa.gov/hab/development.html*) and has developed preliminary plans for a National HAB Forecasting System, which will make routine forecasts in any areas where HABs are a major threat. Forecasts in the western Gulf of Mexico, the Great Lakes, the Gulf of Maine, and the Pacific Northwest are in various stages of development through a combination of extra- and intramural research efforts (*http://tidesandcurrents.noaa.gov/hab/development.html*). NOAA scientists have been instrumental in developing citizen HAB monitoring networks around the country. Additionally, the NOAA Analytical Response Team provides state-of-the-art toxin analyses during HAB events, especially events that involve unusual animal mortality (*http://www.chbr.noaa.gov/habar/eroart.aspx*).

Other NOAA programs, including the Oceans and Human Health Initiative, Sea Grant, the Office of Protected Resources, fisheries management programs, and the Integrated Ocean Observing System Program, collaborate with the HABHRCA-authorized HAB and Hypoxia programs to address specific issues that relate to their research or operational portfolios. Many of NOAA's HAB and hypoxia accomplishments have resulted from these coordinated efforts and through external partnerships.

Major Accomplishments

In the decade following the passage of the original HABHRCA legislation, several significant advances have greatly improved management. Many of these accomplishments are described in the four HABHRCA reports that were submitted to Congress in the last two years. Rather than list every accomplishment, I will focus on recent outstanding achievements.

In the last year, HAB prediction and forecasting has been extended to new areas and shown great promise in providing early warning to public health and resource managers. In most cases, the ability to provide HAB forecasts is the outcome of years of research efforts focused on the causes of HABs. Examples of regional HAB forecasting include:

- In the Gulf of Maine, NOAA-funded researchers issued a seasonal advisory in the spring of 2009 predicting that there would be moderately severe blooms of *Alexandrium fundyense*, the New England HAB organism that produces a potent neurotoxin, which accumulates in shellfish and can cause human illness and death. That timely prediction provided State managers several months to prepare for the intensive monitoring required to protect public health. A severe bloom did, in fact, occur and the researchers provided weekly forecasts of the bloom intensity and location. Nearly all of the shellfish beds in Maine and New Hampshire and some of the shellfish beds in Massachusetts were closed to harvesting. There was concern the bloom would spread to affect more State waters to the south and reach federal waters offshore. NOAA provided event response funding to support monitoring of the actual bloom location and intensity so the Food and Drug Administration and State managers would have the information necessary to make decisions if the bloom were to spread to new areas.
- In parts of western Lake Erie, blooms of the cyanobacterial HAB *Microcystis* are common. Excessive nutrient levels and shallow water depth promotes *Microcystis* blooms, which are a potential concern to human health due to toxin exposure through drinking water or recreational use. In 2008, NOAA produced the first ever *Lake Erie Harmful Algal Bloom Bulletin*, which predicted *Microcystis* blooms based on satellite imagery in combination with hydrological, meterological and limnological data. The bulletin aids in notifying users of possible human health risks associated with drinking water quality and Great Lakes beach conditions.

- Along the Washington coast, a toxic diatom, *Pseudo-nitzschia*, sometimes blooms and is transported to beaches where razor clams are harvested recreationally and by tribes. When exposed to such blooms, the clams accumulate the toxin, which can result in illness and death if the clams are eaten. NOAA-funded scientists have improved early warning of *Pseudo-nitzschia* blooms by determining how winds move HABs from their source region to coastal beaches. Since 2008, they have issued an interactive HAB Bulletin that managers from the Washington State Departments of Health and Fish and Wildlife use to determine well in advance of openings whether shellfish toxin levels will require closures. Managers can communicate this knowledge to harvesters and owners of coastal businesses catering to harvesters to minimize impacts.

Detection is a critical first step in protecting human health, as it is not possible to predict and respond to a problem that cannot be easily quantified or tracked. Many new methods of detecting HAB cells and toxins have been developed, tested, and in some cases put into routine use for a variety of purposes.

- Local and State shellfish managers needed quick field tests to determine if shellfish are toxic to humans. Working with commercial partners, NOAA scientists developed, and have now made commercially available, a quick test for the potent neurotoxin domoic acid, which is produced by *Pseudo-nitzschia*, a HAB-causing organism that occurs along all U.S. coasts.
- Long-term, cost-effective HAB monitoring systems require sensors that can be deployed in the water remotely and left for long periods of time. Recently NOAA scientists, working with partners at Monterey Bay Aquarium Research Institute, successfully used a robotic underwater sensor, the Environmental Sample Processor, to detect the HAB organism *Pseudo-nitzschia* and its toxin domoic acid. This is the first time that HAB organisms and their toxins have been measured remotely, which is a critical first step in using Integrated Ocean Observing Systems to provide early warnings of HABs.
- Similarly, NOAA funding has contributed to the development of automated sensors for *Karenia brevis*, the Florida red tide organism, which can be deployed underwater either on gliders or stationary sampling platforms. A number of these sensors have been built and are in routine use for HAB monitoring in Florida, where they provide an efficient means of ground-truthing satellite observations, a critical element for accurate HAB forecasting.

NOAA is currently funding research on novel HAB mitigation and control measures. For example, research on both the east and west coasts has investigated why some shellfish accumulate toxins but others of the same species do not when they are exposed to the HAB species, *Alexandrium*. *Alexandrium* produces Paralytic Shellfish Poisoning (PSP) toxins that can cause severe illness or death in humans. Small genetic differences in shellfish appear to determine whether an individual shellfish become toxic. Researchers have mapped what they call the “toxin resistance” of soft shell clams in New England, providing local resource managers with new insights on why particular harvesting areas become toxic much more quickly than others. Research into “toxin resistance” may also lead to the development of shellfish seed stocks that are appropriate for areas that are exposed to *Alexandrium* blooms.

NOAA has already begun to develop the Regional Research and Action Plans that are called for in drafts of the 2009 reauthorization of HABHRCA. As a part of this work, NOAA organized the 2009 West Coast HAB Summit, which brought together 80 leading scientists, managers, and industry representatives for the first time in Portland, Oregon, to discuss region-specific HAB issues and begin to develop the West Coast Regional Research and Action Plan. At the Summit, the representatives also endorsed the vision of the West Coast Governors Agreement on Ocean Health to establish a regional HAB monitoring, alert and response network and forecasting system. Seizing on the opportunities of new and emerging technologies, this system will provide advanced early warning of HABs, minimize fishery closures, protect the economy of coastal communities, mitigate the impacts to marine life and protect public health.

Through its HABHRCA-authorized hypoxia programs, NOAA has provided the research foundation upon which management of the “dead zone” in the Gulf of Mexico is based as described in the Mississippi River/Gulf of Mexico Watershed Nutrient

Task Force Action Plan.[9] Ongoing targeted regional research is furthering our understanding of impacts on fisheries and local economies and filling gaps in our understanding of the factors driving the size and location of the hypoxic zone, including climate change. This information is vital to support the Task Force's adaptive management approach to addressing this major coastal problem.

NOAA has collaborated closely with the U.S. Environmental Protection Agency in developing and promoting implementation of management strategies to reduce nutrient pollution contributing to the Gulf of Mexico hypoxic zone. The Undersecretary of Commerce for Oceans and Atmosphere and NOAA Administrator (Dr. Jane Lubchenco) sits on the EPA-chaired interagency Mississippi River/Gulf of Mexico Watershed Nutrient Task Force, and NOAA also plays a leading role on the Task Force's Coordinating Committee, and co-chairs its Monitoring, Modeling and Research Workgroup. The Task Force released the 2008 Gulf Hypoxia Action Plan, which reaffirmed the goal of reducing the hypoxic zone and suggested 45 percent reductions of both nitrogen and phosphorus.

NOAA-funded research has demonstrated that widespread reproductive impairment occurs in a common marine fish, Atlantic croaker, in the hypoxic zone west of the Mississippi River. More recently, the actual molecular mechanism behind the reproductive impairments in fish was identified. Atlantic croaker exposed to hypoxia had significantly less of the hormone progestin, which is critical to the croaker reproductive cycle. The reduction in progestin resulted in reduced ovarian and testicular growth in adults, and a decrease in hatching success and larval survival. Identification of this molecular mechanism adds to a growing body of evidence that nonlethal hypoxia impacts pose long-term threats to living resource populations in the hypoxic zone.

NOAA-funded researchers are providing predictive modeling tools to resource and water quality managers in Narragansett Bay in Rhode Island to help mitigate hypoxia events, which have led to major fish kills and resulted in nutrient reduction criteria for waste water treatment facilities (WWTF). These predictive modeling tools will provide alternative management options for WWTFs (such as relocation of outfall pipes to locations where outward currents would speed nutrients out of the ecosystem) and will generate ecological impact scenarios for various nutrient loading estimates, thereby helping to determine allowable nutrient loadings for WWTFs into local rivers that drain into Narragansett Bay.

NOAA Comments on the House Bill

We only just recently received a copy of the draft bill to review, and therefore have not had a sufficient amount of time to fully review and comment on its content. However, based on an initial review, the House HAB and hypoxia bill addresses two issues that are consistent with our goals for improving out HABs and hypoxia efforts:

1. It will establish an overarching HAB and Hypoxia Program within NOAA. This will enhance the visibility of these issues as a national priority and improve coordination within NOAA between programs that primarily address HABs and hypoxia and those that conduct research and response as part of a larger mission, such as Sea Grant, OHHI, OPR, IOOS and the NOAA labs. Coordination with NOAA partners in other federal agencies will also be improved.
2. Regional Research and Action Plans will be developed with input from local experts on HABs and hypoxia. These plans will help further coordinate federal, regional, State, and local entities and recommend specific actions they can undertake to prevent, reduce or minimize HABs, hypoxia, and their impacts. The plans will also provide guidance for NOAA research and operational programs to better target regional needs.

We note that all mention of specific ongoing HAB and hypoxia programs that were specified in prior versions of HABHRCA have been removed. NOAA has found that the specification of programs helps to clarify the intent of Congress when implementing this legislation. Much of the progress in improving HAB and hypoxia management and response has come from information and products developed through these highly successful programs. Further, the HAHBRCA report presented to Congress last year, HAB Management and Response: Assessment and Plan, rec-

[9] Mississippi River/Gulf of Mexico Watershed Nutrient Task Force. 2008. *Gulf Hypoxia Action Plan 2008 for Reducing, Mitigating, and Controlling Hypoxia in the Northern Gulf of Mexico and Improving Water Quality in the Mississippi River Basin.* Washington, DC.

ommended that progress would be enhanced if an Event Response and Infrastructure Program were added.

Additionally, the role of research within NOAA is not specified in the legislation. In the previous legislation, specific authorization was given for research and assessment in NOAA. Such authorization assures that the valuable research conducted within NOAA will be continued.

We understand that this bill is only a draft. As such, we would welcome additional opportunities to work with your Subcommittee as you continue to work on the language of this bill.

CONCLUSION

Thank you for this opportunity to comment on the pending legislation and to update you on NOAA's HAB and hypoxia programs. NOAA strongly supports reauthorization of HABHRCA and the new opportunities it will provide. With this legislation in place, NOAA and its many partners and affected communities will be able to build on its numerous accomplishments. Over the last ten years we have made enormous progress in understanding the causes and consequences of HABs and hypoxia, leading to the development of many tools and information products which, in turn, have directly improved HAB and hypoxia management, particularly in the area of prediction and mitigation. We anticipate that in the next ten years we will continue to make progress and our ability to prevent and control, as well as mitigate, HAB events will be greatly enhanced.

Table 1. Major HAB organisms causing problems in U.S. marine systems, their major toxins (if characterized), their direct acute impacts to humans and ecosystem health, and regions of the U.S. that have been impacted by these HAB organisms. 'Not characterized' indicates that toxins have been implicated but not characterized.

Organisms	Toxins	Acute Human Illness*	Direct Ecosystem Impacts	Impacted Regions
Alexandrium spp.	Saxitoxins	Paralytic Shellfish Poisoning	Marine mammal mortalities	Northeast, Pacific Coast, Alaska
Aureococcus anophagefferens (Long Island Brown Tide)	Not characterized	--	Shellfish mortality, seagrass die-off	Northeast, Mid-AtlanticCoast
Aureoumbra lagunensis (Texas Brown Tide)	Not characterized	--	Seagrass die-off	Gulf of Mexico (Texas)
Dinophysis	Okadaic Acid	Diarrhetic Shellfish Poisoning	--	Gulf of Mexico, possibly New England and Pacific Coast
Gambierdiscus spp., *Prorocentrum* spp., *Ostreopsis* spp.	Ciguatoxin, Gambiertoxin, and Maitotoxin	Ciguatera Fish Poisoning	--	Gulf of Mexico (Florida, Texas), Hawaii, Pacific Islands, Puerto Rico and U.S. Virgin Islands
High biomass bloom formers	†	--	Low dissolved oxygen, Food web disruption	All regions
Karenia spp.	Brevetoxins	Neurotoxic Shellfish Poisoning, Acute respiratory illness	Fish kills, mortalities of other marine animals	Gulf of Mexico, South-Atlantic Coast
Karlodinium spp.	Karlotoxins	--	Fish kills	Mid- and South- Atlantic Coast, Gulf of Mexico (Alabama, Florida)
Macroalgae	‡	--	Low dissolved oxygen, seagrass and coral overgrowth and die-off, beach fouling	All regions
Marine Cyanobacteria (CyanoHABs) (*Lyngbya* spp)	Lyngbyatoxins	Dermatitis	Seagrass and coral overgrowth and die-off, beach fouling	Gulf of Mexico and South-Atlantic Coast (FL), Hawaii and Pacific Territories
Pfiesteria spp.	Free radical toxin, others not characterized	--	Fish kills	Mid- and South-Atlantic Coast
Pseudo-nitzschia spp.	Domoic Acid	Amnesic Shellfish Poisoning	Mortality of seabirds and marine mammals	Pacific Coast, Alaska, Gulf of Mexico, Northeast, Mid-AtlanticCoast
Pyrodinium bahamense	Saxitoxins	Puffer Fish Poisoning	--	South-Atlantic Coast (Florida)
Some raphidophytes (e.g., *Heterosigma akashiwo, Chattonella spp.*)	Brevetoxins (*Chattonella*), other icthyotoxins not characterized	--	Fish kills	Pacific Coast (Washington), Mid-Atlantic Coast

*This table only captures the major acute human illnesses associated with these HAB species. Other, less severe acute health effects, such as skin irritation, may occur with some of these HAB groups. Chronic effects, such as tumor promotion, can also occur. A table of short- and long-term health effects is given in[8,10].

†Some high biomass bloom formers may produce toxins.

‡Some macroalgae have been shown to produce bioactive compounds, such as dopamine and dimethylsulfoniopropionate (DMSP), which may have direct ecosystem effects (Van Alstyne et al. 2001)

[10] Ramsell, J.S., Anderson, D.M., and P.M. Glibert (eds.). 2005. Harmful Algal Research and Response: A National Environmental Science Strategy 2005-2015. Ecological Society of America, Washington, D.C., 96 pp.

BIOGRAPHY FOR ROBERT E. MAGNIEN

Robert Magnien has been Director of NOAA's Center for Sponsored Coastal Ocean Research (CSCOR) since 2003. CSCOR is responsible for administering the competitive research programs called for in the Harmful Algal Bloom and Hypoxia Research and Control Act (HABHRCA), which include the only three national programs devoted solely to Harmful Algal Bloom (HAB) research. CSCOR also administers the two national competitive Hypoxia research programs called for in HABHRCA and other regional-scale applied research programs to provide the predictive capabilities necessary for management of coastal systems in an ecosystem context. Dr. Magnien has served as the NOAA lead on HAB and hypoxia coordination internally, across the Federal Government, and internationally.

From 1983 to 2003 Dr. Magnien held several positions in the State of Maryland's Chesapeake Bay Program from its inception and served in numerous leadership roles (technical and policy) for the EPA-led regional Chesapeake Bay Program. He last served from 1995 to 2003 for Maryland's Department of Natural Resources as Director of the Tidewater Ecosystem Assessment (TEA) Division and, additionally, from 2002 to 2003 as Director of the Resource Assessment Service, which oversees the Maryland Geological Survey and three other Divisions which include most of the State's science capabilities related to the management of the Chesapeake Bay and freshwaters. In these capacities Dr. Magnien led Maryland's efforts to respond to threats posed by HABs and reported to the Governor and his cabinet as needed. He also provided both scientific and policy leadership on regional efforts to understand and manage the Chesapeake Bay's hypoxia problem as well as numerous other issues such as water quality, habitat restoration, dredging operations, toxic contaminants, ecological forecasting, and information management.

Dr. Magnien has authored numerous peer-reviewed publications, technical reports, agency documents and workshop reports and has also made numerous invited and submitted presentations at international, national, and regional scientific conferences. These publications and presentations include his work on harmful algal blooms, hypoxia, large-scale monitoring programs, environmental assessments and the interactions between science and policy.

Dr. Magnien received a Ph.D. in Aquatic Ecology from Dartmouth College and a B.S. in Biology from the State University of New York at Albany.

Chairman BAIRD. Thank you, Dr. Magnien.

Ms. Schwartz.

STATEMENT OF MS. SUZANNE E. SCHWARTZ, ACTING DIRECTOR, OFFICE OF WETLANDS, OCEANS, AND WATERSHEDS, U.S. ENVIRONMENTAL PROTECTION AGENCY; ACCOMPANIED BY DR. RICHARD M. GREENE, ECOSYSTEM DYNAMICS AND EFFECTS BRANCH OFFICE OF RESEARCH AND DEVELOPMENT, U.S. ENVIRONMENTAL PROTECTION AGENCY

Ms. SCHWARTZ. Good afternoon, Mr. Chairman and Members of the Subcommittee. I am Suzanne Schwartz, the Acting Director of the Office of Wetlands, Oceans, and Watersheds within the Office of Water at the U.S. Environmental Protection Agency (EPA). I would also like to introduce now to you Dr. Rick Green of our Office of Research and Development, who is sitting behind me, who is the Agency's technical expert on the subject of hypoxia and harmful algal blooms. Thank you for the opportunity to discuss some of the things that EPA is doing to address the threats to human health and our marine and freshwater resources from harmful algal blooms and hypoxia.

Obviously, everyone here knows the problems associated with harmful algal blooms. I would, however, just note that the second largest hypoxic zone in the world is located in the northern Gulf of Mexico. It is not something we are proud of. There is very strong evidence connecting hypoxia and algal blooms with nutrient pollution, excessive nitrogen and phosphorus in the water, with the most significant sources of nutrients coming from agricultural runoff as well as residential and commercial fertilizers, animal waste, sewage treatment plants and air deposition from utilities and vehicles. EPA's focus, while we have done research, has largely been to look at ways to control those sources of this pollution.

EPA has statutory authority under the *Clean Water Act* and the *Marine Protection Research and Sanctuaries Act* to protect oceans and coastal waters as well as freshwater lakes, rivers and streams. We have a number of programs under the *Clean Water Act* that look specifically to regulating discharges into waters of the United

States and establishing limits for pollutants that can go into waters of the United States. We regulate discharges of sewage from vessels as well as discharges of other materials. Under the *Safe Drinking Water Act,* we promulgate drinking water standards for the protection of human health from exposure to contaminants.

It is clear that the discharges of nitrogen and phosphorus and their effects on the development of hypoxia and harmful algal blooms is a problem now more than ever. In response, since the introduction of HABHRCA, we have worked to adopt a watershed approach to reducing nutrient discharges that involves identifying high-priority watersheds and applying both voluntary and regulatory tools to achieve water quality goals. In the Mississippi River basin states, EPA has approved a total of about 3,500 nutrient-related TMDLs, total maximum daily loads, which identify a maximum amount of pollutant that a water body can receive and still achieve water quality standards. We are also working closely with the states on developing nutrient management and nutrient reduction strategies. Just today EPA is seeking public input on a draft nutrient TMDL for the Chesapeake Bay, which again we will be looking at innovative ways to address the non-point sources in particular as well as the point sources that are causing the problems. We also have non-point source grant program and other grant programs where we provide some financial assistance for nutrient management.

We are working with the states on assessing the Nation's waters. The National Lakes Assessment Report, which is due for release in December, will include for the first time the occurrence of microcystin, the most commonly measured algal toxin in lakes across the country. The surveys will provide information on nutrient levels in our waters as well. EPA is also working with the states to support the development of numeric nutrient water quality standards. We are engaged in rule-making for that purpose in Florida. We are carefully considering our response to a petition to do the same in the Mississippi/Atchafalaya River basin and we have just recently provided to EPA's Science Advisory Board methodologies for states to use in developing their own criteria.

EPA has a long history of doing research whether it is in the Great Lakes, through the ECOHAB program or through other programs. We are also in the process of reviewing the addition of algal toxins on the EPA Candidate Contaminant list for drinking water. We have worked with EPA's Science Advisory Board as well as the National Academy of Sciences, and I would just highlight that they found that while the *Clean Water Act* had much reduced direct discharges from point sources into the Mississippi River, problems stemming from urban runoff, agriculture and other non-point sources have proven difficult to address. This is an issue that confronts the EPA because our statutory authority is focused primarily on point source pollution and we have limited regulatory authorities over non-point source pollution.

The Office of Research and Development is working to guide the science on Gulf hypoxia and nutrient management decisions, to help forecast the effects of nutrient management actions that are taken and provide options to guide restoration and decision-making. As part of the Task Forces, we have been actively participating as well and we chair the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force.

In conclusion, EPA is an active participant in research and control of freshwater and marine hypoxia and harmful algal blooms, and particularly their primary cause, excess nutrients. We appreciate the Subcommittee's efforts in this area. We look forward to working with you further on the bill. We do have some comments that I won't provide at this time and I thank you very much. I will be happy to answer questions.

[The prepared statement of Ms. Schwartz follows:]

PREPARED STATEMENT OF SUZANNE E. SCHWARTZ

Good afternoon Mr. Chairman and Members of the Subcommittee. I am Suzanne Schwartz, Acting Director of the Office of Wetlands, Oceans and Watersheds, within the Office of Water, U.S. Environmental Protection Agency (EPA). I would also like to introduce to you Dr. Rick Greene of our Office of Research and Development, who is here with me as the Agency's technical expert on the subject of hypoxia and harmful algal blooms. Thank you for the opportunity to discuss some of the things EPA is doing to address the threats to human health and our marine and freshwater resources from harmful algal blooms (HABs) and hypoxia.

HARMFUL ALGAL BLOOMS AND HYPOXIA—THREATS TO HUMAN HEALTH AND ECOSYSTEMS

Harmful algae and hypoxia, or low dissolved oxygen, represent a serious and growing threat to freshwater and marine mammals and fisheries, as well as to human health. While the understanding of the causes and impacts of harmful algal blooms and hypoxic events is not complete, it is known that the death and decay of algal blooms can lead to oxygen depletion in the water, resulting in widespread mortality of fish, shellfish and other invertebrates. These algae can grow, displacing native species, and altering habitat. Public health officials and ocean resource managers have had to increasingly respond to the adverse impacts of harmful algae by sensitive public.

There are over 405 hypoxic zones around the world (*Science,* 2008), and the second largest zone in the world is located in the Gulf of Mexico. There is strong evidence connecting hypoxia and algal blooms with nutrient pollution—excessive nitrogen and phosphorus—in the water, with the most significant sources of nutrients coming from agricultural runoff, largely from the upper Mississippi River Basin, as well as residential/commercial fertilizers, animal waste, sewage treatment plants, and air deposition from utilities and vehicles. NOAA has provided a conservative estimate that the cost of hypoxia and algal blooms to the U.S. seafood and tourism industries is approximately $82 million annually.

EPA RESPONSE

Programmatic

EPA has statutory authority under the *Clean Water Act* (CWA) and the *Marine Protection, Research and Sanctuaries Act* (MPRSA) to implement programs designed to provide protections for oceans and coastal waters and freshwater lakes, rivers and streams. For example, EPA and delegated States may issue permits for the discharge of pollutants to waters of the U.S., including the territorial seas, under section 402 of the CWA. In addition, EPA may issue section 402 permits for discharges to ocean waters beyond the territorial seas. For discharges to coastal and marine waters, section 403 of the CWA includes additional requirements related to permitting such discharges. CWA section 303 directs states to adopt water quality standards for their waters establishing the designated uses and water quality criteria to protect those uses. By regulation, publishes scientific information related to water pollution. CWA section 312 addresses discharge of sewage and other materials from vessels. EPA also works with the Army Corps of Engineers to manage ocean dumping of dredged material under the MPRSA. Also under the MPRSA, EPA regulates the dumping of materials (other than dredged materials) into the ocean. Additionally, EPA has authority under the Safe Drinking Water Act to promulgate drinking water standards for the protection human health from exposure to contaminants, possibly including toxins created by harmful algal blooms, which might be present in public drinking water systems.

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It is clear that the discharges of nitrogen and phosphorus, and their affect on the development of hypoxia and harmful algal blooms is a problem, now more than ever. In 2008, the Gulf of Mexico hypoxic zone was among the largest ever recorded since measurements began over twenty years ago. Last year, while it was smaller in size, it was more severe in terms of oxygen depletion. In response, since the introduction of HABHRCA, EPA has worked to adopt a watershed approach to reducing nutrient discharges that involves identifying high-priority watersheds and applying both voluntary and regulatory tools to achieve water quality goals. In the Mississippi River Basin States, EPA has approved a total of about 3500 nutrient-related TMDLs (Total Maximum Daily Loads), which identify the maximum amount of pollutant that a waterbody can receive and still achieve water quality standards. The nonpoint source grant program under CWA section 319, and the Targeted Watershed Grants provide financial assistance to states that are implementing their own nutrient management programs.

EPA is also working with the states to assess the condition of the Nation's waters through a series of statistical surveys on rivers and streams, lakes and reservoirs, coastal waters and wetlands. The National Aquatic Resource Surveys are beginning to contribute significant information we can use to evaluate the extent and impact of toxic algae, nutrients and other key indicators. The National Lakes Assessment report, due for release in December, will include the first national picture of the occurrence of microcystin (the most commonly measured algal toxin), in lakes across the country. These data will provide valuable information in assessing the scope of toxic algal problem nationally. The Surveys also provide information on nutrient levels in our waters which can be related to land use, harmful algal bloom risk levels and other issues such as hypoxia.

EPA is also working with the States to support implementation of *Clean Water Act* regulatory tools through the development of numeric nutrient water quality standards. EPA is engaged in proposed rule-making for numeric nutrient criteria for the State of Florida, following the Agency's January 2009 determination that numeric nutrient criteria are needed in Florida. EPA is also at this time carefully considering its response to a petition to establish nutrient criteria within the Mississippi/Atchafalaya River Basin. The great distances between the sources of nutrients contributing to hypoxia in the Gulf, and the impact that factors other than nutrients—temperature, precipitation and storm events—have on the size of the hypoxic zone, complicate the regulatory issues.

Harmful algal blooms are of concern in the Great Lakes and other waters because of their toxicity and impact on human and ecosystem health. A particularly toxic species is present in have significant cyanobacterial blooms. These blooms cause fouling of the beaches and shoreline, economic and aesthetic losses, taste and odor impairments of drinking water, and direct risks to human, fish and animal health. EPA's Great Lakes National Program Office funds research on harmful algal blooms research and coordinates with NOAA's Center of Excellence for Great Lakes and Human Health (CEGLHH).

EPA has had a long-standing collaboration with NOAA through the Interagency Ecology and Oceanography of Harmful Algal Blooms Program, authorized by HABHRCA in 1998 and 2004. A Memorandum of Understanding that is still in effect allowed the participating agencies, EPA, NOAA, NSF, NASA, and ONR, to fund competitive research on the causes and impacts of HABs and to develop methods of detection, prevention and control EPA funded nearly 30 projects between 1997 and 2006, several of them joint efforts with NOAA.

EPA continues to evaluate the human health implications from harmful algal blooms and the toxins they produce in drinking water. The Agency included cyanotoxins as a group and discussed the three algal toxins, anatoxin, microcystin, and cylindrospermopsin, on the draft Candidate Contaminant List published in February 2008. The CCL identifies contaminants that may occur in public water systems and may require a drinking water regulation. The Agency sought public comment and review by the Science Advisory Board of the draft CCL 3. EPA is reviewing comments on the draft CCL 3 and anticipates publishing a final list soon.

Scientific

In 2006, EPA's Office of Water requested that the EPA **Science Advisory Board (SAB)** convene an independent panel to evaluate the state of the science regarding hypoxia in the Northern Gulf of Mexico and potential nutrient mitigation and control options in the Mississippi-Atchafalaya River basin (MARB).

The SAB Panel found that the Gulf of Mexico ecosystem appears to have gone through a regime shift with hypoxia such that today the system is more sensitive to inputs of nutrients than in the past, with nutrient inputs inducing a larger response in hypoxia than has been evidenced in other coastal marine ecosystems such as the Chesapeake Bay. Further, the SAB suggested that changes in benthic and fish communities exposed to hypoxia are cause for concern. The recovery of hypoxic ecosystems may occur only after long time periods or with further reductions in nutrient inputs. If actions to control hypoxia are not taken, the SAB warned that further ecosystem impacts could occur within the Gulf.

In 2008 the **National Academy of Science** (NAS), published **"Mississippi Water Quality and the Clean Water Act,"** which found that while the *Clean Water Act* had much reduced direct discharges from point sources into the Mississippi River, problems stemming from urban runoff, agriculture and other non-point sources had proven difficult to address. A second NAS study, supported by the EPA entitled, **"Nutrient Control Actions for Improving Water Quality in the Mississippi River Basin and Northern Gulf of Mexico,"** recommended more collaborative action between EPA and USDA. A third study, **"Clean Water Act Implementation Across the Mississippi River Basin"** is currently underway.

To respond to the challenge posed by hypoxia, the EPA's Office of Research and Development has ongoing hypoxia research and modeling activities that will help guide the science needed to address Gulf hypoxia and support nutrient management decisions. The goal of that effort is to develop a suite of model applications, data products and other tools to assess and predict the relationships between nutrient loads and Gulf hypoxia, quantify sources of error and uncertainty associated with nutrient load reduction targets, forecast the effects of nutrient management actions in the Basin on Gulf hypoxia, and provide defensible options to guide restoration and decision-making.

In addition, the Office of Research and Development has published multiple regression models that describe the relationship between the Gulf hypoxic area and nitrate and phosphorus concentrations and spring discharge in the Mississippi-Atchafalaya Rivers. These models explain much of the variability in the size of the hypoxic zone over the past 25 years and provide improved capabilities for evaluating dual nutrients management strategies to address Gulf hypoxia. However, model predictions indicate that with gradual nutrient reductions (e.g., 45 percent over 10 years), much more than a decade would be required before a significant downward trend in hypoxic area could be observed.

Harmful Algal Bloom and Hypoxia/Gulf Hypoxia Task Forces

In response to the human health and environmental risks posed by the threat of excess nutrient pollution to the Nation's fresh and marine waters, EPA, NOAA, and other federal and State agencies have been working collaboratively to better understand, and ultimately, manage or respond effectively and efficiently to nutrient pollution and hypoxia in particular. EPA is an Interagency Working Group on HABs, Hypoxia, and Human Health (IWG–4H) led by NOAA, which, among other responsibilities, implements the reporting requirements of HABHRCA 2004.

Recently a **Scientific Assessment of Freshwater Harmful Algal Blooms** was developed through the Interagency Working Group on HABs, Hypoxia and Human Health (IWG–4H), which examined the causes, ecological consequences, and economic costs of freshwater HABs. It was based, in large part, on a workshop report from the International Symposium on Cyanobacterial Harmful Algal Blooms (ISOC–HAB) sponsored by EPA, and other agencies, held September 2005, which focused on: 1) occurrence of freshwater blooms and toxins, 2) causes, prevention, and mitigation, 3) toxins, toxin kinetics and dynamics, 4) human health and ecological effects, 5) analytical methods for identifying and quantifying freshwater HAB organisms and toxins, and 6) risk and/or impact assessments for freshwater HABs.

In addition, the EPA chairs and manages the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force, comprised of fifteen States and Federal Agencies, which work together to reduce, mitigate, and control hypoxia in the northern Gulf of Mexico and improve water quality in the Mississippi/Atchafalaya River Basins. In 2008, the Task Force published their second Action Plan, identifying three goals and eleven actions designed to accelerate the reduction of nitrogen and phosphorus in the Mississippi watershed, and ultimately reduce the Gulf hypoxic zone to 5,000 km. On September 23rd and 24th, the Gulf Hypoxia Task Force will meet in Des Moines, IA, to discuss a variety of strategic proposals that have the potential for significant reductions in nutrient discharges to the Gulf. The Task Force will also be presenting its first Annual Report, and FY 2010 operating plan in a public forum.

In conclusion, EPA believes that harmful algal blooms and hypoxia represent serious threats to human health and the environment and we have robust research ongoing that is targeting the causes and their impacts. In addition, EPA is using its regulatory authority under the *Clean Water Act* (including the *Beach Act*) to address the causes of harmful algal blooms where necessary, and ultimately to protect human health and the environment. The Gulf Hypoxia Task Force, which engages federal agencies and the states in a voluntary collaborative effort, is proposing innovative approaches to reducing nutrient discharges that could have significant results. At the same time, EPA appreciates the Subcommittee's efforts to improve the effectiveness of this overall effort, and to increase the focus on the freshwater impacts of HABs and hypoxia. We look forward to working with you in the future.

Thank you for the opportunity to address the Subcommittee. We will be happy to answer your questions.

BIOGRAPHY FOR SUZANNE E. SCHWARTZ

Suzanne Schwartz is the Acting Director of the Office of Wetlands, Oceans and Watersheds (OWOW) at the United States Environmental Protection Agency (EPA) within the Office of Water. OWOW promotes a watershed approach to manage, protect, and restore the water resources and aquatic ecosystems of the Nation's marine and fresh waters. OWOW's programs include wetlands regulation and restoration, regulation of ocean dumping and vessel discharges, monitoring and assessment, including the National Aquatic Resource Surveys, non-point source pollution management, TMDL oversight, and building capacity of State and local governments and watershed organizations.

Suzanne has served as the Deputy Director of OWOW since April 2007. Previously she was the Director for EPA's Oceans and Coastal Protection Division. In this capacity she was responsible for the Clean Water Act Nation Estuary Program; the regulation of disposal of wastes in the ocean, and other ocean, marine and coastal programs.

Since Suzanne joined EPA in 1980 she has worked on a number of water issues in a variety of staff and management positions. Prior to coming to EPA, Suzanne was the founding editor of the Environmental Law Institute's *National Wetlands Newsletter*. She holds a law degree from Columbia University School of Law.

BIOGRAPHY FOR RICHARD M. GREENE

Dr. Greene is the Chief of the Ecosystem Dynamics and Effects Branch, Gulf Ecology Division, National Health and Environmental Effects Research Laboratory in EPA's Office of Research and Development. He is the EPA lead for Gulf of Mexico Hypoxia research and water quality research supporting nutrient criteria development in estuarine and coastal waters. Dr. Greene serves as the EPA representative on numerous federal/State science teams, advisory committees and task forces, including the interagency Mississippi River/Gulf of Mexico Watershed Nutrients Task Force Coordinating Committee. He recently co-chaired the symposium "Hypoxia in the Northern Gulf of Mexico: Assessing the State of the Science" which was conducted as part of the Task Force's reassessment of the 2001 Action Plan for Reducing, Mitigating and Controlling Hypoxia in the Northern Gulf of Mexico.

Dr. Greene holds a Doctor of Philosophy in Oceanography from the State University of New York, Stony Brook, a Master of Science in Biological Sciences from California State University, Fullerton, and a Bachelor of Science in Biology from Oregon State University. In addition, he was a postdoctoral researcher in the Oceanographic and Atmospheric Sciences Division at Brookhaven National Laboratory, and a research faculty in the Oceanography Department, Texas A&M University. His research interests and expertise include estuarine and coastal water quality; nutrient dynamics and eutrophication; improving the science supporting numeric nutrient criteria development; phytoplankton production and bloom dynamics; and coastal oceanographic processes.

Chairman BAIRD. Thank you, Ms. Schwartz.

Mr. Ayres.

STATEMENT OF MR. DAN L. AYRES, FISH AND WILDLIFE BIOLOGIST, COASTAL SHELLFISH LEAD, WASHINGTON STATE DEPARTMENT OF FISH AND WILDLIFE

Mr. AYRES. Mr. Chairman and Members of the Subcommittee, thank you for the opportunity to speak today.

As the Washington Coastal Shellfish Manager, I am here today to represent the many State and tribal fishery managers, aquaculture industry managers and human health experts who, like me, work hard to manage important shellfish resources, allowing for the maximum socioeconomic value these resources can provide to the small communities along the Washington coast. We each have responsibility in our respective areas to manage the harvest of the bountiful natural resources we have been blessed with in the Pacific Northwest.

The West Coast aquaculture industry, which produces a large portion of the Nation's oysters, mussels and hardshell clams, is valued at more than $110 million annually. In an average year, landings in the West Coast Dungeness Crab Fishery have a value just to the fishermen of between $25 million to $45 million, making this fishery an important coastal economic driver for the hundreds of licensed fishers, both State and tribal, and many more people involved in shoreside processing operations, and the fishery that I know so well, Washington State's Recreational Razor Clam Fishery, that draws very large numbers of participants from great distances to the small communities along our coast during the October to May period when few visitors would otherwise be present. The 2008–2009 season recorded just under 250,000 digger trips and generated an estimated $12.5 million to the many small tourist-related coastal businesses.

However, all of us find our jobs are made much more difficult by the ever-present threat of harmful algal species that are naturally occurring in the waters of the West Coast and the potential harm they pose to human health. When the growth of these species bloom and produce dangerous toxins, then the fisheries we manage are disrupted and the activities and income of those who depend on them are greatly impacted.

This last winter, NOAA hosted the first ever West Coast Harmful Algal Blooms Summit. This three-day workshop in Portland, Oregon brought together West Coast scientists, State and tribal fishery managers, human health experts and aquaculture industry members to design a West Coast regional HAB monitoring, alert and response network as well as a West Coast regional HAB forecasting network. In addition, workshop participants also began developing a West Coast HAB research and action plan. Joining regional expert scientists and managers to address regional HAB problems is very valuable. The solutions to these problems can best be found within each region with the help, support and guidance of federal agencies. We applaud NOAA's efforts along with representatives of the West Coast Governors' Agreement on Ocean Health to organize and execute the West Coast HAB summit. Direction to federal agencies to continue to organize and fund regional workshops that result in regional HAB research action plans around the Nation should be an integral part of future legislation.

In 2007, I participated in a NOAA-sponsored workshop that brought together a group of HAB researchers and coastal managers from all around the Nation to provide input into the National Scientific Research, Development, Demonstration and Technology Transfer Plan on Reducing Impacts from Harmful Algal Blooms, the RDDTT plan. The major result was a call for three new federal programs. First, a program that focuses on methods for prevention, control and mitigation of HABs, second, a comprehensive national HAB event response program, and third, a core infrastructure program. While we see all three programs as important to move the

Nation ahead in addressing HAB-related issues, as a State fishery manager, I worked hard on the HAB Event Response Program. Today we want to strongly encourage you to consider this as a potential new program that federal agencies are directed to implement. Such a program will improve access to existing resources for better response through information sharing, communication, and coordination and will provide essential new resources. However, improving our national response to regional HAB events is only half the battle. We want to encourage you to include in any future HAB legislation support for continued research into ways to mitigate for and some day actually prevent HAB events. The other two programs proposed in the RDDTT plan will certainly move the Nation in that direction. The Prevention, Control and Mitigation Program will focus on moving promising technologies and strategies that arise through basic research programs from development to demonstration to technology transfer for field application by managers. The Core Infrastructure Program will increase availability of adequate analytical facilities, research and reference materials, technical training and access to data.

Finally, in reviewing the Committee's draft legislation for the reauthorization of the Harmful Algal Bloom and Hypoxia Research and Control Act, we are very concerned that two key existing HAB programs administered by NOAA are not specifically identified. On the Washington coast, we are now enjoying the results from the work of two important projects that were funded through these programs, the Monitoring and Event Response for Harmful Algal Bloom, the MERHAB program, and Ecology and Oceanography of Harmful Algal Blooms, the ECOHAB program. My written testimony includes specific examples of why these programs should be continued.

So in the end, the ability to predict the onset of these harmful algal blooms, to better respond on a region-wide basis and to find innovative ways to mitigate and even prevent them will be a huge step forward in allowing us to better accomplish our mission: to provide our citizens access to some of the best seafood in the world. Thank you.

[The prepared statement of Mr. Ayres follows:]

PREPARED STATEMENT OF DAN L. AYRES

I am pleased to submit this prepared testimony to Members of the Subcommittee on Energy and Environment of the United States House of Representatives.

As a Washington State coastal shellfishery manager, I represent the many State and tribal fishery managers, aquaculture industry members, and human health experts, who like me, work hard to manage important sustainable shellfish resources, allowing for the maximum socioeconomic value these resources can provide to the small communities along the Washington Coast. We each have responsibility in our respective areas—to manage the harvest of the bountiful natural resources we've been blessed with in the Pacific Northwest.

Each of us can tell you the story of how important these resources—and the ability to harvest them—are to the citizens of our State and tribal communities.

The West Coast aquaculture industry, which produces a large portion of the Nation's oysters, mussels and hard-shell clams, is valued at more than $110 million annually.[1]

[1] *http://www.pcsga.org/pub/farming/farm_benefits.shtm*

In an average year, landings in the West Coast Dungeness crab fishery[2] have a value—just to the fishermen—of between $25 to $45 million, making this fishery a very important coastal economic driver for the hundreds of licensed fishers (both State and tribal) and many more people involved in shore-side processing operations.

And the fishery that I know so well, Washington State's recreational razor clam fishery[3] is a very popular activity that draws very large numbers of participants from great distances to the small communities along the Washington coast during the October to May season when few visitors would otherwise be present. The most recent 2008–09 season recorded just under 250,000 digger trips and generated an estimated $12.5 million to the many small tourist-related coastal businesses.

Razor clams also provide an important source of sustenance and much-needed income to members of the Quinault Indian Nation[4] who have a very long history of depending on safe sources of shellfish.

However, all of us find our job is made much more difficult by the ever present threat of harmful algal species that are naturally occurring in the waters of the Washington coast and the threat they pose to human health.

When the growth of these species takes off—or bloom—and produce dangerous toxins,[5] then the fisheries we manage are disrupted and the activities and income of those who depend on them are greatly impacted.

For example, the Washington and Oregon razor clam fisheries have seen numerous closures—often erasing an entire season for State and tribal recreational and commercial fishers and creating a big economic loss for the tourist communities who depend on these visitors.

In Puget Sound, not a year goes by when some areas are closed and the harvest and shipment of shellfish is banned because of harmful algae. Some of these closures can last for many months—perhaps affecting a shellfish grower's entire annual income.

This last winter, the NOAA Center for Sponsored Coastal Ocean Research hosted the first-ever West Coast HAB (Harmful Algal Bloom) Summit.[6] This three day workshop, in Portland, Oregon, brought together a large group of West Coast scientists, State and tribal fisheries managers, human health experts and aquaculture industry members to design a West Coast Regional HAB Monitoring, Alert and Response Network as well as a West Coast Regional HAB Forecasting Network. In addition, workshop participants also focused on beginning the process of developing a West Coast HAB Research and Action Plan.

The concept of joining regional expert scientists and managers to address regional HAB problems has proven to be very valuable. The solutions to these problems can best be found within each region—with the help, support and guidance of federal agencies. We applaud NOAA's efforts, along with representatives of the West Coast Governor's Agreement on Ocean Health to organize and execute the West Coast HAB Summit.

Much work remains on these important regional plans and NOAA remains the collaborative yet driving force that will ensure these plans reach their goals of completion and implementation.

Direction to federal agencies to continue to organize and fund regional workshops that result in regional HAB research action plans around the Nation should be an integral part of future legislation.

I was honored to be invited in 2007 to participate in a NOAA-sponsored workshop that brought together a group of HAB researchers and coastal managers from

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[2] *http://wdfw.wa.gov/fish/shelfish/crabreg/comcrab/coast/index.htm*; *http://www.oregondungeness.org/general-info/ODCC_the_fishery.htm*; *http://www.dfg.ca.gov/marine/dungeness.asp*

[3] Washington State has actively managed razor clam populations along 58 miles of its Pacific Ocean coastline for more than 70 years. *http://wdfw.wa.gov/fish/shelfish/razorclm/razorclm.htm*

[4] *http://209.206.175.157/index1.htm*

[5] Eating of fish and shellfish containing domoic acid causes the human illness known as amnesic shellfish poisoning (ASP). Symptoms include vomiting, nausea, diarrhea and abdominal cramps within 24 hours of ingestion. In more severe cases, neurological symptoms develop within 48 hours and include headache, dizziness, confusion, disorientation, loss of short-term memory, motor weakness, seizures, profuse respiratory secretions, cardiac arrhythmia, coma. People poisoned with very high doses of the toxin can die. There is no antidote for domoic acid. Research has shown that razor clams accumulate domoic acid in edible tissue (foot, siphon and mantle) and are slow to depurate (purify) the toxin. Eating of fish and shellfish containing saxitoxin causes human illness known a paralytic shellfish poisoning (PSP). Symptoms include tingling of the lips followed by paralyzing of the diaphragm and possible death.

[6] *http://www.cop.noaa.gov/stressors/extremeevents/hab/current/HAB_Summit09/west_coast_summit.html*

around the Nation to provide input into the National Scientific Research, Development, Demonstration, and Technology Transfer Plan on Reducing Impacts from Harmful Algal Blooms,[7] (RDDTT Plan). The major result of this plan was the call for three new federal programs. First, a program that focuses on development, demonstration, and technology transfer of methods for prevention, control, and mitigation of HABs; also, a comprehensive national HAB Event Response program: and finally, a Core Infrastructure program.

While we see all three new programs as important to move the Nation ahead in addressing HAB-related issues, as a State fishery manager I worked hard on the HAB Event Response Program. Today we want to strongly encourage you to consider this as a potential new program the federal agencies are directed to implement. Such a program will improve access to existing resources for response through better information sharing, communication, and coordination and provide essential new resources. Our proposal lays out a regionally based, federal HAB Event Response Program linked to a network of Regional HAB Coordinators.

However, it is true that improving our national response to regional HAB events is only half of the battle. We would like today to also encourage you to include in any future HAB legislation support for continued research into ways to mitigate for and someday actually prevent HAB events.

The other two programs proposed in the RDDTT Plan will certainly move the Nation in that direction. The Prevention, Control and Mitigation Program will focus on moving promising technologies and strategies that arise through basic research programs from development to demonstration to technology transfer for field application by managers or other end-users. The Core Infrastructure Program will increase availability of adequate analytical facilities, reference and research materials, technical training, and access to data; improve integration of HAB activities with existing monitoring and emerging observational programs; and enhance communication and regional and national coordination.

We are concerned that two key existing HAB programs administered by NOAA are not called out specifically in the Committee's draft legislation for the reauthorization of the *Harmful Algal Blooms and Hypoxia Research and Control Act.* On the Washington Coast we now are enjoying the results from the work of two important projects that were funded through these programs, the Monitoring and Event Response for Harmful Algal Bloom (MERHAB) program and Ecology and Oceanography of Harmful Algal Blooms (ECOHAB) program.

MERHAB provided five years of funding that allowed Seattle-based NOAA HAB researchers, University of Washington oceanographers and algae experts, State and tribal fishery managers and human health experts to form a successful partnership we call the Olympic Region Harmful Algal Bloom project. MERHAB funding allowed us to ramp up our ability to monitor for harmful algal species in our marine waters—providing much needed advance notice of potential HAB events. This endeavor started with MERHAB funds in 2000 and transitioned to State dollars (generated by a surcharge on shellfish licenses) in 2005. In addition, on-going MERHAB funded programs in our region continue to add to our ability to monitor for and respond to potential HAB events. In just the last few days, data collected by the Oregon's MOCHA (Monitoring Oregon Coastal HABs)[8] project—funded by MERHAB—alerted our staff to watch closely for increases in the harmful algae species that could produce PSP (paralytic shellfish poison) in shellfish.

ECOHAB funding of an ambitious five-year project, ECOHAB–PNW,[9] has provided us with valuable understanding of how HAB events initiate in Washington's northern off-shore marine waters and how and why they then move to our near-shore waters, potentially affecting Washington's coastal shellfish resources. ECOHAB is also funding a new project (PNW–TOX) that will allow University scientists in both Washington and Oregon to look specifically at HAB events that initiate in Oregon's off-shore waters and then move to both Oregon and southern Washington's near-shore waters affecting shellfish resources on the coasts of both states.

Programs such as MERHAB and ECOHAB are vitally needed by Washington State and the other states of our region.

As you continue to work on the draft of the reauthorization of the *Harmful Algal Blooms and Hypoxia Research and Control Act* we urge you to specifically direct NOAA to continue the very valuable MERHAB, ECOHAB and the newly started PCM HAB programs.

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[7] *www.whoi.edu/fileserver.do?id=43464&pt=10&p=19132*
[8] *http://bioloc.oce.orst.edu/strutton/hab_intro.html*
[9] *http://www.ecohabpnw.org/*

In the end, the ability to reliably predict the onset of these harmful algal blooms—both when and where they can be expected—to better respond on a region-wide basis and to share expertise, and to find new innovative ways to mitigate and even prevent these dangerous blooms will be a huge step forward in allowing us to better accomplish our mission—to provide our citizens safe access to some of the best seafood found anywhere in the world.

BIOGRAPHY FOR DAN L. AYRES

Dan Ayres is a Fish and Wildlife Biologist who leads the Washington Department of Fish and Wildlife's coastal shellfish unit based in Montesano and Willapa Bay. He manages Washington's very popular razor clam fishery and oversees the unit's work managing the coastal Dungeness crab, pink shrimp and spot prawn fisheries, the Willapa Bay oyster reserves and research projects in Willapa Bay.

He has also worked closely with other State and federal agencies on harmful algal bloom issues since the marine toxin domoic acid was first found along the Washington Coast in 1991. Dan is currently serving his second term on the National Harmful Algal Bloom Committee. He has represented WDFW in testimony on this topic at both the State and federal level. He has collaborated on several national HAB plans including: *Harmful Algal Research and Response: A National Environmental Science Strategy* (2005); *Harmful Algal Research and Response: a Human Dimensions Strategy* (2006); *Harmful Algal Bloom Research and Development, Demonstration and Technology Transfer—National Workshop Report* (2008). He also worked to organize the recently held *West Coast HAB Summit* (2009) and is currently working with the team developing the reports that will be products of the summit.

Chairman BAIRD. Thank you, Mr. Ayres.

Dr. Anderson.

STATEMENT OF DR. DONALD M. ANDERSON, SENIOR SCIENTIST, BIOLOGY DEPARTMENT, WOODS HOLE OCEANOGRAPHIC INSTITUTION; DIRECTOR, U.S. NATIONAL OFFICE FOR HARMFUL ALGAL BLOOMS

Dr. ANDERSON. Chairman Baird and Ranking Member Inglis, my name is Don Anderson and I am a Senior Scientist at the Woods Hole Oceanographic Institution where I direct the U.S. National Office for Harmful Algal Blooms. I am also Co-Chair of the National HAB Committee and have been actively involved in research on HABs and in formulating our national HAB program.

I was asked to talk about technologies used to mitigate and control HABs. Mitigation is a term that includes well-proven strategies such as monitoring programs for toxins in shellfish, public education and outreach, scientifically based siting of aquaculture facilities, and other activities that reduce HAB impacts. In a major advance for the United States, we are now forecasting HABs over time scales ranging from weeks to months. For example, an ECOHAB program in the Pacific Northwest has identified an eddy, or a circulating water mass, off Puget Sound that serves as an incubator for the toxic cells that cause amnesic shellfish poisoning. This is a debilitating illness that can cause death or permanent memory loss in some victims. As the water spins off of that eddy, it carries cells to shore, causing sudden and significant outbreaks that are now easier to manage, given this understanding.

On the East Coast, again with ECOHAB and MERHAB support, we have taken forecasting a step further and now have computer models that allow us to evaluate conditions that caused past outbreaks, but we can also look forward with forecasts. For the last two years, we successfully forecast major regional red tides months in advance and have provided weekly forecasts as well. The value of this information is evident in the commitment by Maine, Massachusetts and New Hampshire to pay nearly one-half million dollars for the collection of data needed to initiate these forecasts for the next two years.

Another important mitigation tool relies on DNA probes for identifying and enumerating HAB species. In a very exciting development this technology is now being incorporated into robotic instruments that can be deployed remotely, collecting water and conducting the manipulations needed to detect and count HAB cells and measure their toxins. This brings us one step closer to a dream that I share with many in my field—arrays of instruments deployed along a coast that can detect HABs, monitor their development and provide real-time data to the computer models that then predict landfall and impacts. This is the approach used by the Weather Service to provide accurate weather forecasts. There are significant challenges to do this with biological systems in the ocean but I think we are up to that challenge.

In the area of control of marine HABs, I am afraid progress has been regrettably slow. This is not for a lack of strategies, as there are methods to kill HAB cells using bacteria, parasites, viruses, chemicals or even minerals such as clay that can be sprayed over a bloom to capture the toxic cells and carry them to bottom sediments. The stumbling block has been transitioning these laboratory studies to the field. And why is this? One reason is that given a choice, scientists will propose fundamental research on bloom dynamics, for example, rather than undertake the risky, controversial and highly visible task of trying to control a bloom. Another reason is that we do not have a separate program with its own funding line and yet another is that we have no agency that currently has a clear mandate to control marine nuisance organisms just like the Agricultural Research Service has for control of terrestrial pests. To jump-start progress, this HABHRCA legislation needs to explicitly call for a program on prevention, control and mitigation of HABs and authorize funds for that specific program. If the funding is significant and targeted, scientists and engineers will participate and move this field forward. This is also an area where the HAB community should work with those who seek to manage invasive species or again with agencies such as the Agricultural Research Service.

A related comment is that we need to authorize two other programs as detailed in my written testimony and as you have also heard so far today. One is the National HAB Event Response Program and the other an infrastructure program. The need for the former was clearly evident this year when a red tide closed shellfish beds in Maine, New Hampshire and much of Massachusetts, leading to requests to NOAA from Senator Snowe and from the FDA for information on the offshore extent and status of the bloom. This led to a scramble for funds to support cruises and personnel on a very short notice. Had there been a national program other than response, this would have been much more effective and timely.

I will close by saying that I am strongly supportive of the involvement of EPA in our national HAB program. The inclusion of freshwater HABs is important as well. This committee, I believe, has shown great foresight and initiative in recognizing this need and acting upon it.

Mr. Chairman, that concludes my testimony.

[The prepared statement of Dr. Anderson follows:]

PREPARED STATEMENT OF DONALD M. ANDERSON

Mr. Chairman and Members of the Subcommittee. I am Donald M. Anderson, a Senior Scientist in the Biology Department of the Woods Hole Oceanographic Institution, where I have been active in the study of red tides and harmful algal blooms (HABs) for 30 years. I am here to provide the perspective of an experienced scientist who has investigated many of the harmful algal bloom (HAB) phenomena that affect coastal waters of the United States and the world. I am also Director of the U.S. National Office for Harmful Algal Blooms, co-Chair of the National HAB Committee, and have been actively involved in formulating the scientific framework and agency partnerships that support and guide our national program on HABs. Today my testimony will briefly summarize HABs and their impacts and provide some examples of the nature of our national HAB program and the technologies that have been developed to help mitigate and control these outbreaks. I will also provide my perspective on the research, programmatic, and legislative needs to move towards a National HAB action plan, and will offer some comments about the Committee's draft legislation for the reauthorization of HABHRCA (*Harmful Algal Bloom and Hypoxia Research and Control Act*). Other than a few general comments, I will restrict my comments to marine HABs, as testimony on freshwater HABs is being provided by my colleague Dr. Greg Boyer.

Background

HABs are caused by algae—many of them microscopic. These species sometimes make their presence known through massive "blooms" of cells that discolor the water (hence the common use of the term "red tide"), sometimes through illness and death of humans who have consumed contaminated shellfish or fish, sometimes through mass mortalities of fish, seabirds, and marine mammals, and sometimes through irritating aerosolized toxins that drive tourists and coastal residents from beaches. Macroalgal or seaweed blooms also fall under the HAB umbrella. Excessive seaweed growth, often linked to pollution inputs, can displace natural underwater vegetation, cover coral reefs, and wash up on beaches, where the odor of masses of decaying material is a serious deterrent to tourism. As you will hear from Dr. Boyer, there are also HABs in freshwater systems that pose threats to human, animals, and ecosystems as a result of toxins present in drinking and recreational waters.

With regard to human health, one major category of HAB impact occurs when toxic phytoplankton are filtered from the water as food by shellfish which then accumulate the algal toxins to levels that can be lethal to humans or other consumers. These poisoning syndromes have been given the names paralytic, diarrhetic, neurotoxic, azaspiracid, and amnesic shellfish poisoning (PSP, DSP, NSP, AZP, and ASP). All have serious effects, and some can be fatal. A sixth human illness, ciguatera fish poisoning (CFP) is caused by biotoxins produced by dinoflagellates that grow on seaweeds and other surfaces in coral reef communities. Ciguatera toxins are transferred through the food chain from herbivorous reef fishes to larger carnivorous, commercially valuable finfish. Yet another human health impact from HABs occurs when a class of algal toxins called the brevetoxins becomes airborne in sea spray, causing respiratory irritation and asthma-like symptoms in beach-goers and coastal residents, typically along the Florida and Texas shores of the Gulf of Mexico.

Distribution of HAB Phenomena in the United States. With the exception of AZP, all of the poisoning syndromes described above are known problems within the U.S. and its territories, affecting large expanses of coastline (Fig. 1). PSP occurs in all coastal New England states as well as New York, extending to offshore areas in the northeast, and along much of the west coast from Alaska to northern California. Overall, PSP affects more U.S. coastline than any other algal bloom problem. NSP occurs annually along Gulf of Mexico coasts, with the most frequent outbreaks along western Florida and Texas. Louisiana, Mississippi, North Carolina and Alabama have also been affected intermittently, causing extensive losses to the oyster industry and killing birds and marine mammals. ASP has been a problem for all of the U.S. Pacific coast states. The ASP toxin has been detected in shellfish on the east coast as well, and in plankton from Gulf of Mexico waters. Until recently, DSP was virtually unknown in the U.S., but a major outbreak was recently reported along the Texas coast, resulting in an extensive closure of shellfish beds in that area. CFP is the most frequently reported non-bacterial illness associated with eating fish in the U.S. and its territories, but the number of cases is probably far higher, because reporting to the U.S. Center for Disease Control is voluntary and there is no confirmatory laboratory test. In the Virgin Islands, it is estimated that nearly 50 percent of the adults have been poisoned at least once, and some estimate that 20,000–40,000 individuals are poisoned by ciguatera annually in Puerto Rico and the U.S. Virgin Islands alone. CFP occurs in virtually all sub-tropical to tropical U.S. waters (i.e., Florida, Texas, Hawaii, Guam, Virgin Islands, Puerto Rico, and many Pacific Territories). As tropical fish are increasingly exported to distant markets, ciguatera has become a problem for consumers far from the tropics. For example, recent poisonings of restaurant patrons in the Washington, DC area and elsewhere were linked to fish caught in the Flower Garden Banks National Marine Sanctuary in the Gulf of Mexico south of Texas. The FDA subsequently issued a letter of guidance to seafood processors that recommends that certain fish species caught around that sanctuary should be avoided.

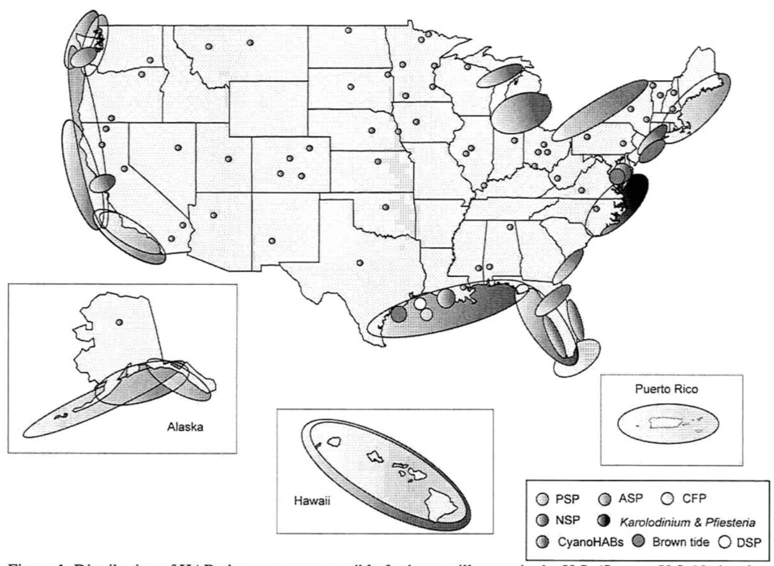

Figure 1. Distribution of HAB phenomena responsible for human illnesses in the U.S. (Source: U.S. National Office for Harmful Algal Blooms.)

Recent Trends. The nature of the HAB problem has changed considerably over the last three decades in the U.S. Virtually every coastal state is now threatened by harmful or toxic marine algal species, whereas 30–40 years ago, the problem was much more scattered and sporadic. In inland states, HABs in rivers, lakes, reservoirs, and other water bodies have increased as well. Overall, the number of toxic blooms, the economic losses from them, the types of resources affected, and the number of toxins and toxic species have all increased dramatically in recent years in the U.S. and around the world (Ramsdell et al., 2005).

There are many reasons for this expansion, some of which involve human activities. Some new bloom events likely reflect indigenous populations that have been discovered because of better detection methods and more observers rather than new species introductions or dispersal events. Other "spreading events" are most easily attributed to dispersal via natural currents, while it is also clear that man may have contributed to the global HAB expansion by transporting toxic species in ship ballast water. The U.S. Coast Guard, EPA, and the International Maritime Organization are all working toward ballast water control and treatment regulations that will attempt to reduce the threat of species introductions worldwide.

Of considerable concern, particularly for coastal resource managers, is the potential relationship between the apparent increase in HABs and the accelerated eutrophication of coastal waters due to human activities (Anderson et al., 2002). Some

HAB outbreaks occur in pristine U.S. waters with no influence from pollution or other anthropogenic effects, but in other areas, linkages between HABs and eutrophication have been noted (Anderson et al., 2008). Coastal waters are receiving massive and increasing quantities of industrial, agricultural and sewage effluents through a variety of pathways. Just as the application of fertilizer to lawns can enhance grass growth, marine algae can grow in response to various types of nutrient inputs. Shallow and restricted coastal waters that are poorly flushed appear to be most susceptible to nutrient-related algal problems. Nutrient enrichment of such systems often leads to eutrophication and increased frequencies and magnitudes of phytoplankton blooms, including HABs.

Economic and Societal Impacts. HABs have a wide array of economic impacts, including the costs of conducting routine monitoring programs for shellfish and other affected resources, short-term and permanent closure of harvestable shellfish and fish stocks, reductions in seafood sales (including the avoidance of "safe" seafoods as a result of over-reaction to health advisories), mortalities of wild and farmed fish, shellfish, submerged aquatic vegetation and coral reefs, impacts on tourism and tourism-related businesses, and medical treatment of exposed populations. A conservative estimate of the average annual economic impact resulting from HABs in the U.S. is approximately $82 million (Hoagland and Scatasta, 2006). Cumulatively, the costs of HABs exceed a billion dollars over the last several decades. These estimates do not include the application of "multipliers" that are often used to account for the manner in which money transfers through a local economy. Furthermore, individual bloom events can approach the annual average, as occurred for example in 2005 when a massive bloom of *Alexandrium* species along the New England coast closed shellfish beds from Maine to southern Massachusetts. The impact to the Massachusetts shellfish industry alone was estimated by the State Division of Marine Fisheries to be $50M, with similar large impacts occurring in Maine. Additional unquantified losses were experienced by the tourist industry and by restaurants and seafood retailers, as consumers often avoided all seafood from the region, despite assurances that no toxins had been detected in many of these seafood products.

HAB Program Development

In addition to providing background information on HABs, I was asked to comment on the technologies that are used for the mitigation and control of HABs. I was also asked to comment on the draft HABHRCA legislation and the need for action plans and research strategies, including those at the regional level. Below I will highlight some of the technologies that have been developed under past funding initiatives. This will demonstrate some of the extraordinary progress that has been made in our ability to monitor and manage HABs, but it will also help to demonstrate where there are gaps in our national program that need to be filled through specific, thematic funding programs that I believe should be specified in the draft legislation.

Our national HAB program is viewed by many colleagues in other disciplines as a model program that has succeeded because of its organization and planning. As recently as 20 years ago, this was not the case, however, as there was very little research on HABs, and that being conducted in the academic community was scattered and unfocused. To help rectify this problem, we formulated a *National Plan* (Anderson et al., 1993) that guided activities in this field for the next 10–15 years, identifying major impediments to progress and identifying the steps that were needed to overcome those impediments. The *National Plan* was broadly based, however, encompassing ecology, physiology, toxicology, human health, economics, ecosystem health, and many other topics. This breadth exceeded the mandate and resources of any single agency or program, and thus for implementation purposes, it was necessary to break the plan into a series of programs on complementary topics that together would meet all needs. The first thematic area was the "*Ecology and Oceanography of HABs*," which was addressed by the ECOHAB program. This was followed by MERHAB (*Monitoring and Event Response of HABs*), and then by *Ocean and Human Health* (OHH) programs. The latter began with a partnership between the National Institute of Environmental Health Sciences (NIEHS) and the National Science Foundation (NSF), who have supported four *Centers for Oceans and Human Health* that include significant HAB research and outreach activities. This program is in transition at the moment, due to the decision of NIEHS not to participate in the renewal process for the Centers due to budgetary issues. NSF has provided interim support, and efforts are underway to encourage NIEHS to re-join the program. NOAA has also created an *Oceans and Human Health Initiative* (OHHI) that supports extramural research and focused activities at three federal OHHI centers. As discussed below, several other programs are needed to complete the national program.

Research progress and technological advances

ECOHAB projects have been highly successful in unraveling the fundamental mechanisms behind the blooms or outbreaks of toxic and harmful algae throughout the U.S. In some cases, the advances represent the accumulation of knowledge that leads to a conceptual understanding of the dynamics of blooms that can stretch for 1,000 km or more. Imagine the complexity of the biological, chemical, and physical phenomena that underlie blooms that occur on that scale. Yet as a result of the ECOHAB program's sustained investment in regional survey cruises and multi-disciplinary research teams, we now have what I believe is the best fundamental understanding of several regional HABs anywhere in the world. In the Northeastern U.S., for example, this has led to our ability to forecast toxic PSP outbreaks on an annual basis, which we have done quite successfully for the last two years, and which we will continue to do in the future. (See *www.whoi.edu/page.do?pid=24039&tid=282&cid=41211*). We also provide weekly numerical model predictions of bloom status that are posted on the Internet and widely used by resource managers within the region. The value of these long and short-term forecasts is seen in the actions of three states (Maine, Massachusetts, and New Hampshire) who contributed nearly $500,000 of emergency ("failed fishery") funds for the collection of data needed to initialize the models that will be used to forecast the regional blooms for 2010 and 2011.

In a similar manner, a regional ECOHAB program on the west coast of the U.S. has identified an eddy or circulating water mass off Puget Sound that serves as a reservoir or incubator for the toxic cells that cause ASP poisonings on that coast. (ASP is a debilitating illness that includes permanent loss of short-term memory in some victims). As water spins off of that eddy, it carries the cells to shore, causing sudden and significant outbreaks that are now easier to manage given this understanding of the source. I expect that Dan Ayres will provide more information on the value of this type of information in his accompanying testimony.

In the Gulf of Mexico, a second phase of the ECOHAB–Florida program is investigating nutrient uptake by the toxic red tide organism *Karenia brevis*, and is conducting surveys of nutrient concentrations in the region that are addressing the sensitive and highly controversial issue of the potential link between red tide blooms and nutrient inputs from land, including those associated with agriculture and other human activities. This ongoing research has obvious implications to policy decisions concerning pollution and water quality in the region.

These are but a few of the advances in understanding that have accrued from ECOHAB regional funding. Equally important are the discoveries from smaller, targeted research projects, as well as those that provide management tools to reduce the impacts of HABs on coastal resources. The most effective HAB management strategies are monitoring programs that involve sampling and testing of wild or cultured seafood products directly from the natural environment, as this allows unequivocal tracking of toxins to their site of origin and targeted regulatory action. Numerous monitoring programs of this type have been established in U.S. coastal waters, typically by State agencies. This monitoring has become quite expensive, however, due to the proliferation of toxins and potentially affected resources. States are faced with flat or declining budgets and yet need to monitor for a growing list of HAB toxins and potentially affected fisheries resources. Technologies are thus urgently needed to facilitate the detection and characterization of HAB cells and blooms. This need is being addressed through the MERHAB program. MERHAB projects have contributed valuable technologies to these ongoing monitoring programs, such as the application of species-or strain-specific DNA "probes" that can be used to label only the HAB cells of interest so they can then be detected visually, electronically, or chemically. With technological advances that often started with ECOHAB projects and moved to MERHAB applications, progress has been rapid and probes of several different types are now available for many of the harmful algae, along with techniques for their application in the rapid and accurate identification, enumeration, and isolation of individual species. One example of the direct application of this technology in operational HAB monitoring is for the New York and New Jersey brown tide organism, *Aureococcus anophagefferens*. The causative organism is so small and non-descript that it is virtually impossible to identify and count cells using traditional microscopic techniques. Antibody probes were developed that bind only to *A. anophagefferens* cells, and these are now used routinely in monitoring programs run by State and local authorities, greatly improving counting time and accuracy.

These probes are now being incorporated into a variety of different assay systems, including some that can be mounted on buoys and left unattended while they robotically sample the water and test for HAB cells. Clustered with other instruments that measure the physical, chemical, and optical characteristics of the water column, information can be collected and used to make "algal forecasts" of impending toxicity. These instruments are taking advantage of advances in ocean optics, as well as the new molecular and analytical methodologies that allow the toxic cells or chemicals (such as HAB toxins) to be detected with great sensitivity and specificity. **A clear need has been identified for improved instrumentation for HAB cell and toxin detection, and additional resources are needed in this regard.** This can be accomplished during development of the Integrated Ocean Observing System (IOOS) for U.S. coastal waters, and through a targeted research program on HAB prevention, control, and mitigation (see below). These are needed if we are to achieve our vision of future HAB monitoring and management programs—an integrated system that includes arrays of moored instruments as sentinels along the U.S. coastline, detecting HABs as they develop and radioing the information to resource managers. Just as in weather forecasting, data from instrumented networks can also be assimilated into numerical models to improve forecast accuracy.

This capability is consistent with ECOHAB and MERHAB goals to develop and incorporate forecasts or predictions of bloom development and movement into management and mitigation programs. Prediction of HAB outbreaks requires numerical models which account for both the growth and behavior of the toxic algal species, as well as the movement and dynamics of the surrounding water. Numerical models of coastal circulation are advancing rapidly in the U.S., and a number of these incorporate HAB dynamics as well. A model developed to simulate the dynamics of the organism responsible for paralytic shellfish poisoning (PSP) outbreaks in the Gulf of Maine is relatively far advanced in this regard (McGillicuddy et al., 2005), and is now being transitioned from academic use towards an operational mode. Here again, congressional support is needed to provide the appropriations needed to turn these academic tools into operational programs, as discussed below. Note also that scientists from the New England region are working with colleagues in Washington State to help them adapt the Gulf of Maine numerical model for use in Puget Sound waters, since closely related organisms cause PSP outbreaks in both regions.

In the Gulf of Mexico, satellite images of ocean color are now used to detect and track toxic red tides of *Karenia brevis.* Bloom forecast bulletins are now being provided to affected states in the Gulf of Mexico by the NOAA NOS Center for Coastal Monitoring and Assessment. The combination of warning and rapid detection is a significant aid to the Gulf states in responding to these blooms. As is the case with the Gulf of Maine HAB forecasting system and one for the Great Lakes, Congressional attention is needed to provide the mandate and funding to make these HAB forecasting systems operational within NOAA. In FY 2010, funds were requested for this purpose in the President's budget, but were not included in either the House or Senate appropriations. **I would like to see this operational HAB forecasting capacity within NOAA authorized in the HABHRCA legislation, and a specific funding line recommended.**

Other practical strategies to mitigate the impacts of HAB events include: regulating the siting of aquaculture facilities to avoid areas where HAB species are present, modifying water circulation for those locations where restricted water exchange is a factor in bloom development, and restricting species introductions (e.g., through regulations on ballast water discharges or shellfish and finfish transfers for aquaculture). Each of these strategies requires fundamental research such as that being conducted through ECOHAB, but further advances would occur if they are moved to practical application through a new program on the prevention, control, and mitigation of HABs.

Several approaches to directly control or suppress HABs are under study as well—similar to methods used to control pests on land—e.g., biological, physical, or chemical treatments that directly target the bloom cells. Here however, progress towards direct field applications has been slow, and efforts are needed to change the nature and the pace of this line of investigation. To date, other than one study in which copper sulfate was dropped from crop dusting planes to control a Florida red tide over 50 years ago, there has not been a single effort to control a natural HAB in U.S. waters. Another sign of the lack of progress in this topic area is seen in the submissions of scientific papers to the forthcoming 5th U.S. HAB Symposium—a national meeting of U.S. HAB researchers and managers. Of the nearly 200 abstracts submitted to this conference, only two involve bloom control studies.

The reasons for this lack of progress in bloom control will be discussed below, and recommendations will be offered for ways to change this worrisome trajectory, but it is not for lack of possible strategies. One example is work conducted in my own laboratory, again through ECOHAB support, using ordinary clay to control HABs. When certain clays are dispersed on the water surface, the tiny clay particles aggregate with each other and with other particles, including HAB cells. The aggregates then settle to the ocean bottom, carrying the unwanted HAB cells from the surface waters where they would otherwise grow and cause harm. As with many other new technologies for HABs, initial results are quite promising and small-scale field trials have been conducted, but continued support is needed to fully evaluate benefits, costs, and environmental impacts.

Another intriguing bloom control strategy is being evaluated for the brown tide problem. It has been suggested that one reason the brown tides appeared about 15–20 years ago in the Long Island region was that hard clams and other shellfish stocks have been depleted by overfishing. Removal of these resources altered the manner in which those waters were "grazed"—i.e., shellfish filter large quantities of water during feeding, and that removes many microscopic organisms from the water, including natural predators of the brown tide cells. If this hypothesis is valid, a logical bloom control strategy would be to re-seed shellfish in the affected areas, and to restrict harvesting.

In general, bloom control is an area where very little research effort has been directed in the U.S. (Anderson, 1997), yet considerable effort is needed before these means are used to control HABs in natural waters given the high sensitivity for possible damage to coastal ecosystems and water quality by the treatments. The U.S. lags behind countries like Japan, China, South Korea and Australia in pursuing and implementing bloom control strategies. At the current pace of research and development, options for HAB control may not be in place for many years unless a concerted effort is made to encourage and promote these kinds of studies. As discussed below, this could be accomplished as part of a national program on HAB prevention, control, and mitigation, and through cooperation with other fields of science where control of aquatic or terrestrial pests is more common.

Comments on the draft legislation

It is my belief that the 1993 *National Plan* provided the guidance and perspective that led to the creation of several multi-agency partnerships for HAB studies, and to many individual agency initiatives on this topic. Together, ECOHAB and MERHAB have funded over $100 million in marine and freshwater (Great Lakes) HAB research since the programs began in 1996 and 2000, respectively. Significant funding has also been provided by the COHH and OHHI programs. After more than 10 years of strong program growth and diverse research activities, the 1993 *National Plan* became outdated, however, and thus was replaced by *HARRNESS (Harmful Algal Research and Response: A National Environmental Science Strategy 2005–2015;* Ramsdell et al., 2005). Several hundred scientists and managers, from a wide array of fields, contributed to the knowledge base on which this new national science and management strategy is based. *HARRNESS* is the plan that will guide U.S. HAB research and monitoring well into the future, and is one that I enthusiastically support.

At the conceptual level, *HARRNESS* is a framework of initiatives and programs that identify and address current and evolving needs associated with HABs and their impacts. At the programmatic level, several of the existing national programs will continue to function, and new programs will need to be added. In the former category, ECOHAB should continue to address the fundamental processes underlying the impacts and population dynamics of HABs. Research results have been brought into practical applications through MERHAB, a program formulated to transfer technologies and foster innovative monitoring programs and rapid response by public agencies and health departments. MERHAB should also continue under the new *HARRNESS* framework.

Two relatively new programs (the Centers for Oceans and Human Health (COHH) initiative of NIEHS and NSF and NOAA's OHHI) should also continue under HARRNESS. They fill an important niche by creating linkages between members of the ocean sciences and biomedical communities to help both groups address the public health aspects of HABs. The COHH focus on HABs, infectious diseases, and marine natural products, whereas the NOAA OHHI Centers and extramural funding include these subjects in addition to chemical pollutants, coastal water quality and beach safety, seafood quality, sentinel species as indicators of both potential human health risks and human impact on marine systems. The partnership between NIEHS, NSF, and NOAA clearly needs to be sustained and expanded in order to provide support to a network of sufficient size to address the significant problems under the OHH umbrella. This is best accomplished through additional funds to these agencies, as well as through the involvement of other agencies with interests in oceans and human health, including, for example, EPA, NASA, FDA, and CDC.

A number of the recommendations of *HARRNESS* are not adequately addressed by existing programs, however. As a result, the HAB community needs to work with Congressional staff and agency program managers to create new programs, as well as to modify existing ones, where appropriate. Specific recommendations are given below in this regard.

Freshwater HABs. With the exception of the Great Lakes, which fall under NOAA's jurisdiction, freshwater systems that are impacted by HABs have not been comprehensively addressed in ECOHAB, MERHAB, or the OHH HAB programs. This is because NOAA's mandate includes the Great Lakes and estuaries up to the freshwater interface, but does not include the many rivers, ponds, lakes, and reservoirs that are subject to freshwater HAB problems. Freshwater HABs are an important focus within HARRNESS, and therefore **I strongly support the inclusion of EPA in the draft HABHRCA legislation before us. More direction should be provided, however, so that EPA and NOAA move this program forward in a productive and efficient manner.** As the draft legislation reads now, the direction of the freshwater HAB program will be determined by the Regional Research Action Plans. There is certainly a need for prioritization and planning at the regional level, but national planning workshops and a national research agenda for freshwater HABs are also needed, as was done with the 1993 *National Plan* and *HARRNESS* for marine HABs. This is particularly true given that two federal agencies will be involved. Coordination and the division of responsibilities will be important issues to resolve.

It is critical however that appropriations be increased to include this new area of investigation. If appropriations remain level, and a new freshwater program is established, resources will be drawn away from marine issues that are already thinly funded, and research progress will decrease dramatically and the productive scientific community working on HABs will grow smaller and less effective.

The support provided to HAB research through ECOHAB, MERHAB, Sea Grant, and other national programs has had a tremendous impact on our understanding of HAB phenomena, and on the development of management tools and strategies. Since HAB problems facing the U.S. are diverse with respect to the causative species, the affected resources, the toxins involved, and the oceanographic systems and habitats in which the blooms occur, we need multiple teams of skilled researchers and managers distributed throughout the country. This argues against funding that ebbs and floods with the sporadic pattern of HAB outbreaks or that focuses resources in one region while others go begging. **I cannot emphasize too strongly the need for an equitable distribution of resources that is consistent with the scale and extent of the national problem, and that is sustained through time.** This is the only way to keep research teams intact, forming the core of expertise and knowledge that leads to scientific progress. To achieve this balance, we need a scientifically based allocation of resources, not one based on political jurisdictions. This is possible if we work within the guidelines of HARRNESS and with the inter-agency effort that has been guiding its implementation.

New Programs to be Established and Sustained. The 1998 *Harmful Algal Bloom and Hypoxia Research Control Act* (HABHRCA) and the *Harmful Algal Bloom and Hypoxia Amendments Act of 2004* (2004 HABHRCA Reauthorization) authorized the establishment of three national programs on HABs: 1) "Ecology and Oceanography of Harmful Algal Blooms" (ECOHAB) (HABHRCA Sec. 605 (2)); 2) "Monitoring and analysis activities for HABs" (renamed Monitoring and Event Response for Harmful Algal Blooms or MERHAB) (HABHRCA Sec. 605 (4)); and 3) "A peer-reviewed research project on management measures that can be taken to prevent, reduce, control, and mitigate HABs." (HABHRCA Sec. 605 (3)). Under HABHRCA the ECOHAB program was authorized as an interagency (NOAA, NSF, EPA, NASA, ONR), competitive research program, led by NOAA, and the MERHAB program was established as a NOAA competitive research program. A *Federal Register* Notice (FRN), published 5/04/2009 (*http://edocket.access.gpo.gov/2009/E9-10187.htm*), announced that NOAA was establishing the Prevention, Control, and Mitigation of Harmful Algal Blooms (PCMHAB) Program.

Guidelines for the PCMHAB are given in the National Scientific Research, Development, Demonstration, and Technology Transfer Plan on Reducing Impacts from Harmful Algal Blooms (RDDTT Plan; Dortch et al., 2008). The proposed RDDTT program has two other essential components. These are: 1) a comprehensive national HAB Event Response program: and 2) a Core Infrastructure program. **Together with the PCM component, these are interdependent and critical for improving future HAB research and management, and I therefore urge the Committee to include these as specific, named programs in the draft legislation.** Justification for this emphasis is as follows.

Prevention, Control, and Mitigation of HABs. Congress mandated a program for HAB Prevention, Control and Management in the legislation reauthorizing the *Harmful Algal Bloom and Hypoxia Research and Control Act of 1998* and again in the 2004 reauthorization. Further rationale for this program is that much of the focus of past HAB research has been on fundamental aspects of organism physiology, ecology, and toxicology, so less effort has been directed towards practical issues such as resource management strategies, or even direct bloom suppression or control (Anderson, 1997). As discussed above, progress in the area of bloom suppression or control has been very slow. I have attached a commentary that I wrote for the journal *Nature* more than 10 years ago (Annex 1) that discussed why progress in bloom control was advancing so slowly. Unfortunately, many of the points in that discussion are still valid today. Among the impediments to progress is that scientists have chosen to focus more on less controversial, and therefore more easily funded lines of work. Societal concern about bloom control strategies that might involve the use of chemicals or engineered or non-indigenous organisms is significant, and therefore it has been difficult to move research from the laboratory to the field. In the case of my own laboratory's work on the use of clay dispersal to control blooms, we have seen that a few vocal opponents can raise environmental concerns that delay or stop field applications, even though this method is environmentally benign in comparison to the damage from the HAB itself, and that this same bloom control strategy is used routinely elsewhere in the world to protect fish farms (e.g., Korea).

Yet another impediment is that there is no specific funding specified for PCM research. As a result, PCM proposals compete with ECOHAB and MERHAB submissions for funds. Given the controversial nature of many PCM strategies, it is not surprising that peer reviews of the proposals are variable and sometimes negative, and that more conservative projects on bloom dynamics, toxin chemistry, or other topics are selected. **I therefore strongly recommend that specific wording be inserted in the draft HABHRCA legislation to establish and sustain a national program on Prevention, Control and Mitigation of HABs, and that specific funds be authorized for that program.**

In this context, Congressional oversight may be needed to establish an agency mandate for control of marine and freshwater nuisance species. Unlike the Agricultural Research Service of the USDA, which has a mandate for control of terrestrial plant pests, there is no federal agency with this responsibility for marine waters. This is an area where the growing concern about invasive species could be of great help to the HAB field, as technologies, regulations, policies, and environmental concerns are common to both fields. I can see a great deal of value in the convening of a workshop to in which HAB investigators would meet with those working on control strategies for invasive species, insects, aquatic vegetation, other pest infestations, as well as with those working on bioremediation strategies used for oil spill and pollution events.

Event Response. A major HAB outbreak in the Gulf of Maine in 2009 highlighted the need for an Event Response program as part of the national HAB program. During this event, virtually the entire coastline of the State of Maine was closed to shellfish harvesting due to dangerous levels of toxicity. The same was true for New Hampshire, and for portions of Massachusetts. Government officials, resource managers, and the general public were anxious for information on the offshore extent of the bloom, and it's potential duration, yet there were no research programs ongoing to provide such information. Senator Snowe made a direct request to NOAA to provide this type of information, resulting in a scramble to find funding for ships and research personnel on short notice. Had there been a national HAB Event Response Program, as described in the RDDTT report (Dortch et al., 2008), the response would have been significantly more comprehensive, rapid, and efficient.

This is but one example of the need for rapid response to HABs that occur throughout the US. In some cases, local resources are sufficient, but in unexpected events, or those that are more significant and dangerous than normal, additional resources are needed that can be rapidly mobilized and used to protect the public health and fisheries resources. **It is therefore my recommendation that specific wording for a national HAB Event Response program be included in the HABHRCA legislation, and that specific funds be authorized for that program.**

Infrastructure. Researching and implementing new PCM strategies and improving event response will not be possible without certain types of infrastructure, including chemical analytical facilities, reference and research materials, toxin standards, HAB culture collections, tissue banks, technical training centers, and databases. At the present time, many of these facilities or resources are maintained by individual investigators or laboratories, with no centralized coordination or support. Personally, I maintain a culture collection of HAB species that exceeds 400 strains, yet I do not receive direct funding for its expenses. For other infrastructure needs, the necessary resources to not exist, and therefore funds are needed to provide these to the HAB community. For example, analytical standards for some HAB toxins are not available, severely restricting research and management progress. Likewise, molecular probes that allow the accurate and rapid identification of HAB species are also not universally available.

The RDDTT report (Dortch et al., 2008) identifies and prioritizes infrastructure needs for the national HAB program. What is needed is the Congressional recognition of the need for such a program, and therefore **I recommend that specific wording for a national HAB infrastructure program be included in the HABHRCA legislation, and that funds be authorized for this specific program.**

Although PCMHAB will be the program that the public will most readily perceive as 'progress' in the management of HABs, the program is part of an integrated approach to HAB risk management that must include Event Response and Infrastructure programs. **Furthermore, since many agencies are involved in HAB research and response, it will be necessary to specify that these new programs should be interagency partnerships, and funding should be provided to agencies with major roles.** In addition to NOAA, NSF, and EPA, other agencies, such as FDA, CDC, NSF, and NIEHS also contribute substantially and should be named as partners in the national HAB program.

Regional Research Action Plans. As emphasized above, HAB phenomena are diverse throughout the US, and therefore impacts and research needs will vary across regions. I therefore support the congressional directive to create regional research action plans through a series of meetings involving managers, scientists, government officials, industry, and other stakeholders. My only concern here is the timescale for these meetings. Having participated in a very successful meeting of this type in Florida, I know that a significant cost is involved, and that considerable time is needed to plan, convene, and then report on the results of such a meeting. Given the inclusion of "freshwater" regions involving inland states, of which there may be many, I can envision NOAA HAB program officials struggling to organize and run a large number of meetings in a short period of time, and having to commit significant funds that would otherwise be directed to research. **I would thus recommend a more gradual approach to the regionalization.**

SUMMARY AND RECOMMENDATIONS

The diverse nature of HAB phenomena and the hydrodynamic and geographic variability associated with different outbreaks throughout the U.S. pose a significant constraint to the development of a coordinated national HAB program. Nevertheless, the combination of planning, coordination, and a highly compelling topic with great societal importance has initiated close cooperation between officials, government scientists and academics in a sustained attack on the HAB problem. The rate and extent of progress will depend upon how well federal agencies work together, and on how effectively the skills and expertise of government and academic scientists can be targeted on priority topics that have not been well represented in the national HAB program. The opportunity for cooperation is clear, since as stated in the ECOHAB science plan (Anderson, 1995), "*Nowhere else do the missions and goals of so many government agencies intersect and interact as in the coastal zone where HAB phenomena are prominent.*" The HAB community in the U.S. has matured scientifically and politically, and is fully capable of undertaking the new challenges inherent in an expanded national program, exemplified in HARRNESS. This will be successful only if a coordinated interagency effort can be implemented to focus research personnel, facilities, and financial resources to the common goals of a comprehensive national strategy.

In summary:

- Marine HABs are a serious and growing problem in the U.S., affecting every coastal state; freshwater HABS are an equally significant problem in inland states. HABs impact public health, fisheries, aquaculture, tourism, and coastal aesthetics. HAB problems will not go away and will likely increase in severity.
- HABs are just one of many problems in the coastal zone that are affected by nutrient inputs and over-enrichment from land. They represent a highly visible indicator of the health of our coastal ocean. More subtle impacts to fish-

eries and ecosystems are likely occurring that are far more difficult to discern.

- A coordinated national HAB Program was created over 15 years ago and partially implemented. That *National Plan* has been updated with a new plan called HARRNESS that can guide the next decade or more of activities in HAB research and management.

Recommendations:

- Sustain and enhance support for the national HAB program HARRNESS.
- Sustain and enhance support for the ECOHAB, MERHAB and OHH programs, and authorize new programs. In the latter context, a separate program on the practical aspects of HAB prevention, control and mitigation (PCMHAB) needs to be authorized, as it was in past HABHRCA legislation, and two new programs (HAB Event Response and HAB Infrastructure) should be authorized as well, each with a specific amount of funds to insure that resources are indeed directed to these programs by NOAA and EPA.
- Recognize that NOAA will require funds for *operations* in support of HAB management, such as HAB forecasting; authorize these activities with specific language, and specific funding allocations.
- Encourage interagency partnerships, as the HAB problem transcends the resources or mandate of any single agency.
- Freshwater HABs are an important focus within HARRNESS, and therefore EPA should be included in the draft HABHRCA legislation. More direction should be provided, however, so that EPA and NOAA move this program forward in a productive and efficient manner. For example, national planning workshops and a national research agenda for freshwater HABs are needed, given that two federal agencies will be working on the topic. The direction of the freshwater program should not be determined solely by Regional Research Action Plans.
- Encourage methods and instrument development for land-and mooring-based HAB cell and toxin detection, and for bloom forecasting through instrument development support for the Integrated Ocean Observing System.
- Recommend appropriations that are commensurate with the scale of the HAB problem in both marine and fresh waters. The national HAB program is well established and productive, but it needs additional resources if new topics, responsibilities and tasks are added through new legislation. Research should be peer-reviewed and competitive, and should take full advantage of the extensive capabilities of the extramural research community.

Mr. Chairman, that concludes my testimony. Thank you for the opportunity to offer information that is based on my own research and policy activities, as well as on the collective wisdom and creativity of numerous colleagues in the HAB field. I would be pleased to answer any questions that you or other Members may have.

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Annex 1. Turning back the harmful red tide. (*Nature* 388:513–514. 1997)

Turning back the harmful red tide

Harmful algal blooms are a serious and increasing problem in marine waters, yet scientists and funding agencies have been slow to investigate possible control strategies.

Donald M. Anderson

Each holiday season I await the visit of one relative with trepidation. Years ago he asked whether I had "stopped that red tide problem yet?" — a simple question from one convinced that science solves problems directed to a so-called expert on the destructive and often visible 'blooms' of phytoplankton that kill fish, make shellfish poisonous and cause numerous other problems in coastal waters. I explained that we did not understand the causative organisms, their ecology or oceanography well enough to propose control strategies, but that one day we would.

Although temporarily satisfied with my argument, each year thereafter my brother-in-law repeated the question, and each year my answer was the same. Whatever progress had been made, there were new questions to be addressed. Eventually, he concluded that I did not want to solve the problem, as that would end my research programme. He is wrong, of course, but the explanation is far more complex than he would think, and is in part the subject of this article.

Throughout history, blooms of microscopic algae have had a major impact on fish, birds, mammals and other organisms in the marine food web. These 'red tides' (now termed harmful algal blooms) take many forms and have many effects. Some toxic algae kill wild and farmed fish. Others produce potent neurotoxins that accumulate in filter-feeding shellfish and poison human consumers. Algal toxins can alter the structure and function of marine ecosystems, affecting fecundity and survival at all levels.

Even non-toxic algae can be harmful when they accumulate in sufficient numbers — sometimes millions of cells per litre — to discolour the water, shade submerged vegetation, disrupt food-web dynamics and cause oxygen depletion. At the other extreme, toxic algae can be a tiny fraction of the total phytoplankton population and still be dangerous. Diarrhetic shellfish poisoning, for example, has been reported with *Dinophysis* concentrations of a few hundred cells per litre.

The scale and timing of harmful algal blooms is highly variable. Some are localized, occurring in bays or estuaries; others are massive, covering thousands of square kilometres. Some occur at the same time and place each year; others strike in random fashion. Some last a few weeks, others years.

Harmful algal blooms are not new phenomena. Red tides are recorded in the Bible and in the fossil record. What is new is the recent proliferation of harmful blooms[1]. There is debate about the nature and causes of this expansion. Some call it a global epidemic linked to pollution and human changes to coastal ecosystems[2]. Others argue that the expansion is in part an artefact reflecting increases in the number of scientists, advances in toxin detection, and the proliferation of aquaculture and other activities requiring product monitoring[1,3].

One thing is certain — there is a growing global problem at a time when human reliance on coastal zones for food, recreation and commerce is rapidly expanding. Nevertheless, there is practically no exploration of direct control of marine blooms — attempting to kill or remove the cells or reduce their toxicity. At an international conference on harmful algae held in Vigo, Spain, in June, only one contribution of more than 400 abstracts from 58 countries addressed direct control of marine blooms. Imagine the difference if the conference had been on agricultural pests or on algal blooms in fresh water, where control efforts are common.

Research efforts on mitigation strategies such as shellfish-monitoring and aquaculture site management are critically important, but they treat the symptoms without attacking the problem. Government officials and the public want to know what is being done, or what can be done, in terms of direct intervention. So far, we have little to offer other than tentative predictions of bloom reductions decades from now if nutrient loadings are reduced.

I believe that some harmful algal blooms can be controlled or managed, not 20 years from now, but in the near future, economically and without disastrous environmental consequences. This belief may brand me as a heretic among my colleagues, some of whom fear that the ocean will be further despoiled by inept human attempts to manipulate ecosystems we do not understand.

At the heart of this negativism is a conviction that mankind does not possess the skills, knowledge or right to manipulate the marine environment on any significant scale. We are, however, already doing exactly that. By polluting coastal waters, we change the abundance and relative amounts of critical plant nutrients, which in turn alters the species composition of planktonic ecosystems. Indeed, this may be why there is an increasing number of harmful algal blooms. We are harvesting fish and shellfish at an alarming rate, removing components of the food-web with little knowledge of how such enormous manipulations affect other levels.

P. J. S. FRANKS, SIO

Some red tides, such as this non-toxic bloom of *Noctiluca* off California, cover huge areas, making it difficult to foresee environmentally benign bloom-control strategies (see also http://www.redtide.whoi.edu/hab/).

To replace dwindling natural fishery resources, we are turning coastal waters and wetlands into marine farms at an extraordinary rate. Whether by fish or shrimp farms (which have been likened to small cities with respect to their production of organic matter as pollutants), or by shellfish or seaweed culture (which strip plankton and nutrients from the water), we are altering near-shore waters significantly. Coastal ecosystems are no longer pristine and will not revert to their 'natural' state without intervention.

From land to ocean

Distrust of our ability to control pests and diseases seems to be based more on pessimism than on fact. When biological control is discussed, for example, some are quick to point out failures such as the introduction of the mongoose to oceanic islands or the giant toad to Australia[4]. Obscured by these failures is a multitude of successes in terrestrial biocontrol of weeds and pests[4]. Overall, 165 insect pests and 35 weed species have been controlled. Less than 2 per cent of the introductions became pests themselves, and many of those were 'generalist' predators — an approach that is no longer practised.

Other examples of terrestrial management strategies include integrated pest

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management, which combines biological control with chemical agents such as narrow-spectrum pesticides, and ecologically based pest management, which attempts to work with ecosystem processes in the management effort[5]. The conceptual framework for pest management on land is far advanced, and should be a valuable resource in planning the management of marine systems. Instead it is largely ignored and misunderstood.

Extrapolation from land to the ocean will admittedly be difficult, as marine and terrestrial systems differ in scale, complexity and dynamics[6]. Application of a control agent to a single crop on a parcel of land is certainly simpler than the marine equivalent, where water motions will change the distribution and abundance of target organisms and applied control agents. Control of an outbreak at one site may have no effect on blooms in later years at the same location[6]. Another difference is that the community of organisms in marine ecosystems is more diverse and complex than that in single-crop agricultural systems.

Yet another factor that has stalled progress is the tendency to generalize that all blooms are massive. One colleague argues that blooms, like tornadoes or hurricanes, can be tracked and their movements predicted, but never controlled. He may be right about the larger blooms, but many are small or localized, either permanently or during key stages of development. For example, destructive brown tides in Texas or New York are thought to begin in certain bays and then to spread to adjacent waters. A widespread coastal bloom might be localized and accessible at an earlier stage.

Another constraint is that most countries have no official policy for funding marine pest management. In the United States, the Department of Agriculture puts extensive resources into terrestrial pest management. By contrast, the equivalent agency responsible for the oceans, the National Oceanic and Atmospheric Administration, has no marine pest-control programmes. Lacking strong leadership or targeted funding programmes at the national level, scientists opt for research on fundamental ecological or oceanographic issues less likely to be rejected during peer-review.

Control options

But there are signs of change in at least some parts of the world. South Korea has established a harmful algal bloom engineering division at its National Fisheries Research and Development Institute. And Australia's Commonwealth Scientific and Industrial Research Organization has established a Centre for Research on Introduced Marine Pests, which plans a proactive approach to marine pest management consistent with the country's aggressive reliance on terrestrial biological control. It is not clear whether this new programme will support research on control of harmful algal blooms.

During a red tide in Florida 40 years ago, copper sulphate was applied to 10,000 acres of shoreline using crop-dusting planes[7]. The treatment was initially effective, but blooms reappeared within weeks. Copper was deemed too expensive and non-specific to be used other than for short-term, small-scale bloom control. In another study, 4,700 chemicals were screened for use against Florida's red-tide alga, but none was sufficiently potent in natural sea water without also having adverse effects on other organisms.

Since then, chemical control options have received little attention, and no significant bloom-control research has been undertaken in the United States. Japan, China and Korea are exploring control strategies because they 'farm' their coastal waters heavily through aquaculture. Faced with significant economic losses from red tides, Japan initiated a broad evaluation of bloom-control strategies in the mid-1970s. Much of our knowledge of possible approaches comes from this outdated but useful series of studies[9], which continues to this day, but at a much-reduced level of effort.

One promising strategy treats blooms with flocculents such as clay that scavenge particles, including algal cells, from sea water and carry them to bottom sediments. Removal efficiencies of 95–99 per cent have been achieved in laboratory cultures using clay, and small-scale field trials near fish farms have also been successful, though expensive[8]. New clays that are an order of magnitude more efficient in cell removal have been tested in China; this capacity can be further increased using coagulants such as polyhydroxy aluminium chloride[9].

Applications in China have been limited to tests in shrimp aquaculture ponds but, in 1996, 60,000 tons of clay were used in Korea to control a *Cochlodinium* red tide threatening near-shore fish farms. About 100 km^2 were treated over several weeks, and nearly 100,000 tonnes of clay are now stockpiled in anticipation of the next bloom.

Clay is a non-toxic, naturally occurring material. Fish and bottom-dwelling organisms are unaffected by extremely high clay loadings near pottery industries[10]. The prospects look good, but considerable research is needed before large-scale field applications can be attempted. Obvious concerns are the fate and effects of sedimented cells and toxins on bottom-dwelling animals, and the collateral mortality of co-occurring planktonic organisms.

Biological control of harmful algal blooms also has potential. Zooplankton that graze on bloom species have been proposed as control agents[8] but remain untested because of the impracticality of growing and maintaining predators in sufficient quantity. Viruses are abundant in marine systems, replicate rapidly and tend to be host-specific, suggesting that a single algal species could be targeted[11]. Parasites[12] also have potential to control algal bloom species, but specificity is largely unknown. There are numerous examples of bacterial strains[13] exhibiting strong and specific algicidal activity, although no field applications have yet been attempted.

Prognosis for the future

I have mentioned only a few of many potential control strategies. We must cautiously explore all possible approaches, but this requires funding at the scale needed to provide data to support informed decisions and override our preconceptions. We also need to establish guidelines for acceptable marine treatments.

In one sense, the problems we face with harmful algal blooms are similar to those encountered in agriculture or medicine, fields in which control of pests and diseases is a practical reality. The marine environment is admittedly different, but our hesitancy reflects a *de facto* acceptance that the problems are insurmountable. I believe they are not, and that we can make progress if new resources are made available and if we learn from the mistakes and successes of more than 100 years of experience controlling terrestrial pests.

There is a thin line to walk here — to argue that we have been too cautious and that success is possible, without promising more than we can deliver, unrealistically raising the expectations of the public and politicians. I also worry that funds needed for ecological studies might be diverted to control. I see the risks, but I also see the chance that this article may initiate a debate that will ultimately direct scientific thought and resources towards practical solutions. My brother-in-law would no doubt approve. □

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BIOGRAPHY FOR DONALD M. ANDERSON

Don Anderson is a Senior Scientist in the Biology Department of the Woods Hole Oceanographic Institution (WHOI), where he also serves as Director of the Cooperative Institute for the North Atlantic Region. He served as Director of WHOI's Coastal Ocean Institute, from 2004 to 2008. He earned a doctorate from MIT in 1977 and joined the WHOI scientific staff in 1978. In 1993, he was awarded the Stanley W. Watson Chair for Excellence in Oceanography, in 1999 was named a NOAA Environmental Hero, and in 2006 received the Yasumoto Lifetime Achievement Award from the International Society for the Study of Harmful Algae.

Anderson's research focus is on toxic or harmful algal blooms (HABs). His research ranges from molecular and cellular studies of toxin genetics and regulation to the large-scale oceanography and ecology of the "blooms" of these micro-organisms.

Along with an active field and laboratory research program, Anderson is heavily involved in national and international program development for research, monitoring, and training on marine biotoxins and harmful algal blooms.

Anderson is author or co-author of over 240 scientific papers and 13 books.

Chairman BAIRD. Dr. Boyer.

STATEMENT OF DR. GREGORY L. BOYER, PROFESSOR OF BIOCHEMISTRY, STATE UNIVERSITY OF NEW YORK, COLLEGE OF ENVIRONMENTAL SCIENCE AND FORESTRY; DIRECTOR, NEW YORK'S GREAT LAKES RESEARCH CONSORTIUM

Dr. BOYER. Chairman Baird, Ranking Member Inglis, thank you for inviting me to testify at this hearing. My name is Greg Boyer I am a Professor of Biochemistry at the State University of New York College of Environmental Science and Forestry and Director of New York's Great Lakes Research Consortium. I have worked on harmful algal blooms for more than 35 years including marine and freshwater toxins, but today I would like to specifically address freshwater harmful algal blooms in this draft legislation.

The written testimonies provided will expand on many of the facts and details, so let me briefly review just a few key points. Marine and freshwater blooms are caused by the very rapid growth of microscopic plant-like organisms, but unlike marine systems, most freshwater blooms are caused by blue-green algae, which is actually a photosynthetic bacteria. This makes them similar but not identical to their marine counterparts, so therefore some of the treatment options will be the same, but many of the approaches for prevention, control and mitigation of these freshwater blooms will be different than those for marine systems.

Some marine blooms produce very toxic compounds. Saxitoxin, a neurotoxin found in both marine and freshwater systems, is one of the most toxic nonprotein toxins known and is a regulated biowarfare agent. Microcystins, a common liver toxin found in blooms in every state of the union, goes by the trivial name of "fast death factor." An outbreak in the Potomac River caused 5,000 to 8,000 cases of human gastrointestinal illness. Anatoxin-A, another neurotoxin produced by blue-green algae, goes by the trivial name is very fast death factor. A recent bloom in Lake Champlain resulted in the deaths of several family pets. These dogs barely made it off the beach before collapsing and dying in front of the family's children. Simply put, these are not nice compounds.

Toxic blooms are becoming much more common and being reported in new locations each year. A recent study from my own laboratory found 50 percent of the samples collected from western Lake Erie over the last five years had measurable levels of toxin.

That number is probably typical for any impacted water body in the United States.

Our existing HAB research programs have been very successful for coastal waters. This is especially true for marine systems where their interagency program, ECOHAB, has made tremendous strides in understanding the ecology of harmful algal blooms in the western Gulf of Maine and in the Gulf of Mexico. Similarly, NOAA's MERHAB program has developed exciting new technologies for monitoring blooms both in the Gulf of Mexico and the Great Lakes region. I am also strongly supportive of NOAA's new program in prevention, control and mitigation. These programs need to be continued and all three programs adequately funded so they can continue to provide for essential research in their respective areas.

However, freshwater algal blooms offer an additional challenge. Most of the pictures you have been watching did not occur in the Great Lakes and are thus not under NOAA's jurisdiction. The *Clean Water Act* and the *Safe Drinking Water Act* clearly give the U.S. EPA oversight of our nation's freshwater resources; thus, U.S. EPA needs to be more actively involved in both development and implementation of a freshwater harmful algal bloom research and control program. The bill under discussion needs to provide clear direction to U.S. EPA as to their role. It needs to provide sufficient authority and it needs to allocate funds necessary to carry out that work. It should clearly delineate U.S. EPA's responsibility for freshwater HABs and direct NOAA and the U.S. EPA to cooperatively administer the program where they have overlapping jurisdictions so that duplication can be avoided. I also want to emphasize that providing funds for extramural research is absolutely essential to the success of the HAB programs and the best way to harness the vast talents of the scientific community at large.

Freshwater HABs adversely impact all segments of U.S. society: north, south, east, west and in the middle, and the impacts on health, ecology and economics on affected communities is large. These programs require a federally directed program with interagency cooperation and the recognition that different research will be needed for different areas. We cannot borrow from one program to pay for another. Therefore, I would like to thank the Committee for having the foresight to understand the gaps in our efforts and work towards trying to improve the Nation's water quality, both in marine and freshwater systems. With that, I will end my comments. Thank you.

[The prepared statement of Dr. Boyer follows:]

PREPARED STATEMENT OF GREGORY L. BOYER

Introduction

Good morning Mr. Chairman and Members of the Subcommittee. My name is Gregory Boyer, and I am a Professor of Biochemistry at the State University of New York's College of Environmental Science and Forestry (SUNY–ESF). I am also the Director of New York's Great Lakes Research Consortium (NY–GLRC), a Consortium of over 300 scientists located at 18 New York academic institutions and seven Canadian affiliate institutions with interests in all aspects of Great Lakes Science and Policy. However more importantly, I am a career scientist who has worked on the chemistry and ecology of harmful algal blooms (HABs) for more than 35 years, starting from my Ph.D. work on the chemistry of paralytic shellfish poisons, the neurotoxins produced by selected marine red tides, and continuing in my current work on the toxins produced by freshwater HABs. In 2002, I became the lead scientist for MERHAB–Lower Great Lakes, a NOAA-sponsored regional program to develop monitoring and event response protocols for harmful algal blooms in the lower Great Lakes. Working with MERHAB–LGL, NOAA's Oceans and Human Health Initiative (OHHI), and with the US–EPA Great Lakes National Program Office (GLNPO), I have spent many thousands of hours on our Great Lakes and inland waterways examining and responding to freshwater harmful algal blooms. I also operate a rapid response laboratory at SUNY–ESF for toxic HAB samples submitted from hospitals, health departments, State environmental conservation agencies, lake monitoring organizations and concerned citizens from across North America. These efforts give me a unique ground-up perspective from the needs of our national program to address both marine and freshwater HABs.

Today, my colleagues, Donald Anderson and Dan Ayres, will speak to you about marine harmful algal blooms so I would like to confine my comments to the issue with Freshwater HABs. This topic was first brought to your attention in a hearing last summer by Dr. Ken Hudnell. Here, I would like to summarize the types and impacts of freshwater harmful algal blooms in the United States, as well a comment specifically on the proposed legislation that is being developed by Chairman Bart Gordon that directs the EPA to participate in freshwater HAB research and authorizes funds for freshwater research applications.

BACKGROUND

Blooms of freshwater algae occur across the United States and around the world. Under the proper conditions of light, temperature, and nutrients, these small aquatic plant-like organisms can grow to extremely dense concentrations, blocking out light from reaching the water below the surface, clogging the water intakes of our nation's power and industrial plants, and leading to taste and odor issues with our drinking water. Unsightly and smelly surface accumulations interfere with the use of local beaches and recreational parks, leading to a decrease in the recreational and tourism dollars flowing to small businesses and local municipalities. Upon their death, the decay of these blooms can consume the available oxygen in the water column, leading to fish kills and local hypoxia [low oxygen concentrations].

Freshwater HABs are not simply a nuisance issue. In addition to those generalized effects described above, there are a number of freshwater algal species that produce extremely potent toxins. When these occur in natural systems, bad things can happen, including illness and mortalities to domestic animals, widespread loss of fish and wildlife, and potential harm to humans using the waters for drinking or recreational purposes.

Toxins and Their Health Effects

There are currently more than 300 different toxins reported to be produced by freshwater algae. These toxins vary widely in their chemistry, their effect on ecosystems, and in their potential effect on animals and humans who are exposed to them. Most toxins are produced by a group of 20 or more species of blue-green algae (a.k.a. cyanobacteria); however there are also species that are not blue-green algae that produce of toxins that have dramatic impacts on aquaculture and fish communities. Some of the major toxins and species include:

Peptide Liver Toxins. The peptide liver or hepatotoxins called microcystins are probably the most common toxins produced by blue-green algae. Microcystins are named for the genus of cyanobacteria (*Microcystis*) from which they were first identified. Subsequent work has shown that they can be produced by a number of different genera and species. The peptide toxins also include a second, closely-related group of compounds (nodularins) that are usually associated with more saline environments such as marine systems, the Great Salt Lake in Utah, or the Salton Sea in California. *Microcystis* is an extremely common genus of cyanobacteria and it is likely this toxin will be found in every state of the United States. It has been associated with recent animal fatalities in the Midwest, Northeast, and Oregon, and is of major concern to drinking water suppliers that must use impacted waters (example: western basin of Lake Erie) as their source water. One of the first describe toxic events in the United States (1931) refers to an outbreak of *Microcystis* in the Ohio and Potomac Rivers that caused intestinal illness in an estimated 5,000–8,000 people. Nebraska (2004) recently experienced a similar event on a smaller scale with a number of dog, livestock, and wildlife fatalities, and more than 50 accounts of human skin rashes, lesions and flu-like gastrointestinal illness.

Microcystins have been linked with animal deaths and human illnesses all over the world. The acute human toxicity of these toxins was graphically observed in Brazil in 1996, when naturally occurring concentrations of toxin in the water supply for a hemodialysis center led to the death of over 50 patients. There are also concerns over long-term sub-acute exposure. Microcystin–LR, the most studied member of the class, was recently reclassified by the International Agency for Research on Cancer into risk group 2B (*possibly carcinogenic to humans*) based on a review of existing scientific evidence. This raises further questions about the risk from chronic exposure to this group of toxins through drinking water supplies. To date, the United States does not have regulatory standards or guidelines for the concentrations of cyanobacteria toxins allowed in drinking water. However standards exist at both the international level (World Health Organization), national level (e.g., Australia Brazil, Canada, France, Japan, New Zealand, Norway, Poland, Spain), and exist or are under development at the State Level (CA, FL, IA, NE and OR). The US–EPA, as a first step for issuing such as standard, placed microcystins on its Critical Contaminant List or CCL as described under the *Safe Drinking Water Act* (SDWA) as amended in 1996. The drinking water CCL is a list of priority contaminants, known or anticipated to occur in public water systems, where further research may be necessary before US–EPA can decide if a regulatory ruling is needed under the SDWA. Microcystins have been on the US–EPA's CCL–1 (1998), CCL–2 (2005), and now CCL–3 (2008). They remain on the CCL, in part, because of missing information in terms of their health effects, routes of exposure and analytical methodology. The US–EPA, as part of their toxicological assessment associated with the CCL, has determined that microcystins, anatoxin-a and cylindrospermopsin (discussed below) are the cyanobacterial toxins of most concern (highest priority), followed by paralytic shellfish poisoning (PSP) toxins and anatoxin-a(S).

Freshwater Cytotoxins. The second group of cyanobacterial toxins is the cylindrospermopsin derivatives. This group is also produced by a number of different genera of cyanobacteria, including members of the genus *Cylindrospermopsis* for which they are named. The major toxin, cylindrospermopsin, results in generalized cell death (cytotoxin) but have also been linked to DNA damage as well as possible tumor initiation. However, in accordance with US–EPA *''Guidelines for Carcinogen Risk Assessment''* (2005), this toxin should be listed as *''inadequate information to assess carcinogenic potential''* until further studies have been completed.

Cylindrospermopsin-producing species are generally associated with tropical or arid environments, and toxic *Cylindrospermopsis* blooms are common in the warmer drinking water reservoirs of Florida. Recently, the major potentially-toxic species (*C. raciborskii*) has been identified in temperate Europe and in several of the Great Lake States (MI, OH, WI), suggesting that its observed range has expanded from southern states (FL, NC) to more northern temperate climates. The factors responsible for this potential spread and the production of toxins in these more northern climates are an area of active investigation.

Freshwater Neurotoxins. A third class of toxins are the neurotoxic cyanobacterial toxins; anatoxin, anatoxin-a(S), and the PSP toxins discussed below. The most important member of the class, anatoxin-a, was originally reported from an *Anabaena* species (hence the name), but like the microcystins, this toxin can be produced by a number of different species and genera. Blooms containing anatoxin-a in many states across the United States. They have recently been associated with domestic animal (dog) and livestock (cattle) fatalities in NY, VT, OR, and in the mid-western states. A toxic bloom containing anatoxin-a occurred as recently as this last month in Elk Creek (Douglas County, OR). This bloom resulted in the deaths of several household pets and widespread media coverage of the event.

A second neurotoxin, anatoxin-a(S), is very distinct in both its chemistry and mode of action from anatoxin-a. Originally differentiated from anatoxin-a because the affected dogs showed extremely salivation (hence the S), this toxin is commonly reported in the prairie states. However anatoxin-a(S) symptoms are identical to organophosphate pesticide intoxication and hence its occurrence is likely under-reported in this and in other regions of the country.

Paralytic Shellfish Poisoning (PSP) Toxins. These freshwater toxins are produced by selected strains of blue-green algae and are very similar or identical to the PSP neurotoxins produced by marine red-tide dinoflagellate species. Blue-green algae produce a larger variety of PSP toxins than their marine counterparts, with almost twice as many different variations in chemical structures. Several toxins, including saxitoxin, are produced by both freshwater and marine algae. Saxitoxin is considered one of the most potent ''non-protein'' toxins known with a toxicity about 1,000 times greater than cyanide. Saxitoxin is a regulated biological warfare agent listed in the *Public Health Security and Bioterrorism Preparedness and Response Act of 2002* through the ''Select Agents'' program. Production of PSP toxins have been associated with domestic and wild-life fatalities in the United States, but a major bloom {to my knowledge} has never occurred in a drinking water supply reservoir. Such blooms have occurred in Australia, leading to the deaths of tens of thousands of livestock and forcing entire communities to shift to bottled or tanker water supplies.

Golden Algae Fish Toxins. Most toxic freshwater blooms are caused by cyanobacteria; however there are a number of non-cyanobacterial toxic species that are important in saline or aquaculture facilities. Perhaps the most problematic are the blooms of the fish-killing species *Prymnesium parvum*, which is also referred to as a "golden algae". These blooms were first suspected of causing massive fish kills in Texas in the mid 1980's. Since that time, the blooms of golden algae have expanded and been reported in nine southern states (TX, NM, CO, NC, SC, GA, AR, AL and OK) and are suspect in two others (NE, FL). These blooms have been estimated to kill more than 17 million fish worth over $6.5 million dollars in Texas alone and now threaten the survival of several endangered or threatened fish species. They continue to result in the loss of millions of dollars to local economies due to a decrease in fish-related tourism each year.

In addition to these major categories described above, there have been a large number of different toxic events where either the bloom was not directly associated with the die-off of an easily observable species, or where a definitive cause and effect relationship has not be established. Harmful algal blooms can cause dramatic changes in ecosystems through the effect on the lower food web. They may also be responsible for many of the common ailments (e.g., swimmers itch) experienced by recreational users that come in contact with these blooms.

Occurrence and Causes of Freshwater HABs in the United States

As evidenced from the discussion above, freshwater toxic algal blooms are not confined to any geopolitical boundaries. Blooms of toxic blue-green algae are widespread and have occurred in all 50 states of the United States (Figure 1). While not all blooms of cyanobacteria are toxic, many of the toxic species are cosmopolitan or widely distributed between ecosystems. Blooms are not confined to large lakes such as the Great Lakes, but occur in all sorts of water bodies ranging from smaller prairie potholes, rivers, reservoirs, impoundments to large lake ecosystems.

Figure 1. The approximate location of documented freshwater cyanobacterial harmful algal blooms in the United States through 2005. This map is not a complete representation of all toxic cyanobacterial outbreaks, but illustrates their widespread occurrence. (modified from "*Scientific Assessment of Freshwater Harmful Algal Blooms*", *Interagency working, IWG-4H*)

A recent study by a NOAA-sponsored regional program to look at the occurrence of toxic algal blooms in the lower Great Lakes (MERHAB–LGL) has found that 50 percent of the samples collected from western Lake Erie over the last decade contained detectable levels of blue-green algal toxins. A significant fraction of these samples also exceeded the World Health Organization's guidelines for safe drinking water. As the Great Lakes in total contain more than 84 percent of North America's fresh surface waters, 22 percent of the world's fresh surface waters, and currently provide drinking water for more than 40 million people, broad scale efforts to protect these essential resources from HABs are essential.

These studies in the Great Lakes are not an exception. Similar to the Great Lakes, there has been a rapid proliferation of toxic cyanobacteria blooms in other freshwater ecosystems, including those in the Northeast (VT, NY), Midwest (NE, IA), southern (FL), and western states (NM, CO, OR). Broad scale studies in Europe and the mid-western United States have shown a similar high percentage (~50 percent) of their blooms contain toxic species and/or toxins. Each year, new toxic blooms are reported in areas where they have not been previously reported. The increased number of scientific papers on freshwater harmful algal blooms over the last several decade, the increased numbers of reports in the popular press, and the increase in health advisories due to cyanobacterial toxins all suggest that, if anything, the occurrence of toxic freshwater blooms has increased over the past 30–40 years.

Causes and Costs of Freshwater Harmful Algal Blooms.

Blooms of freshwater algae, especially cyanobacteria, are triggered by a number of factors. These include, but is not limited to:

- Increases in nutrient loading from point and non-point sources. Like all plant species, freshwater algae must obtain the basic building blocks of nitrogen and phosphorus needed for growth. These are often obtained through runoff due to agricultural or land-use practices in the surrounding watershed. For example, the US–EPA has recently started extensive efforts to look at nutrient inputs from the watersheds surrounding the Maumee River region [near Toledo, OH] in western Lake Erie as a causative factor for the large blooms of toxic blue-green algae that occur in the western basin.
- Extended periods of high solar radiation that promote photosynthesis. This means bright, sunny days such as those that often come at the end of the summer season.
- Warm temperatures that can accelerate the growth of the organisms and lead to thermal stratification or separation of the water column into distinct layers.
- Calm wind conditions that also lead to a stable water column with little mixing. This can allow buoyant species to rise to the surface and shade competing species. Changes in hydrology, such as the formation of an impoundment in a normally flowing river may also increase the intensity and occurrence of bloom events.
- Changes in the ecosystem through the introduction of invasive species such as dreissenid mussels that selectively feed on non-cyanobacterial species. This can provide a selective pressure for the formation of selected species.

These general conditions lead to increased blooms of all algae, not specifically harmful or toxic algal species. We have a very poor understanding of those environmental factors that specifically lead to the formation of a toxic bloom over a non-toxic bloom. This lack of basic scientific research has hampered our efforts to design specific remediation techniques for freshwater HABs, to forecast the occurrence of toxic blooms, and to predict the effects of large- scale ecosystem changes such as global climate change on freshwater harmful algal blooms.

For the same reason, it is difficult to provide an economic assessment for the costs associated with a toxic freshwater algal bloom in comparison to the costs associated with a non-toxic bloom. Dodds and co-workers from Kansas have calculated that the annual value of losses in recreational water usage, waterfront real estate, alteration of ecosystem structure, loss of endangered species, fish kills, and impacts on drinking water exceed $2.2 billion dollars annually as a result of eutrophication in U.S. freshwaters due to increased nutrients and the resulting algal growth. Not all of these expenses are due to harmful algae, but anecdotal information provided by large water providers in states such as Florida suggest that their treatment costs needed to ensure water safety may increase more than a $100,000 per week in response to a toxic cyanobacteria bloom. Added to this would be the millions of dollars in lost recreational activities, monitoring and response expenses, health care costs, and damage to the aquaculture/fishing industry. In addition, there are also costs where it is difficult to assign a monetary value, e.g., what is the value for the loss of an endangered or threatened species or permanent changes to an ecosystem? Our nation's freshwaters have faced increasing stress due to rising population pressure, land use changes, and the increased demand for freshwater resources. Once a harmful algal bloom becomes established in a given ecosystem, it is very difficult and costly to reverse the situation. Research funds spent understanding the basic science surrounding a toxic bloom, followed by translation of that knowledge into specific prevention, control, and mitigation technologies are funds well spent in the long run.

NEED FOR A NATIONAL PROGRAM FOR FRESHWATER HABs.

Congress passed the *Harmful Algal Bloom and Hypoxia Research and Control Act in 1998* to authorize funds for research on marine HABs and hypoxia. This Act was expanded in the 2004 Reauthorization Act to include all freshwater bodies. This latter act also calls for a series of reports to clearly assess the status and outline our

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research needs. Members of the scientific community and the Interagency Working Group on Harmful Algal Blooms, Hypoxia and Human Health (IWG–4H) have prepared a number of reports, including the *"Scientific Assessment of Freshwater Harmful Algal Blooms," "Cyanobacterial Harmful Algal Blooms, State of the Science and Research Needs,"* and the *"Harmful Algal Blooms Research Development Demonstration and Technology Transfer"* (HAB RDDTT) report. These reports clearly document an increased awareness on a national scale of impacts such as toxin-contaminated drinking water or seafood, mortality of fish and wildlife, damages to aquaculture enterprises, economic losses in coastal and lake-side communities from HABs and the impacts on Public Health. They also clearly identify the research needs and limitations to progress, as well as provide a path forward to protect against long-term ecosystem change.

The marine HAB community has benefited tremendously from the initial 1993 national plan for harmful algal blooms and the subsequent formation of the competitive, peer-reviewed, merit-based interagency research program in Ecology and Oceanography of Harmful Algal Blooms (ECOHAB) and NOAA's Monitoring and Event Response of Harmful Algal Blooms (MERHAB), as called for in the *Harmful Algal Bloom and Hypoxia Amendment Act of 2004.* These programs have led to dramatic increase in our understanding of marine bloom events, increases in detection technology, improvements in event response, a better understanding of the societal aspects of harmful algal blooms, and an overall improvement in coordination between agencies.

Freshwater HABs and their root causes do not respect geopolitical and agency boundaries. Thus a regional and multi-agency approach is again required. We need a similar emphasis on freshwater ecosystems, including, but not limited to, the Great Lakes ecosystems. As called for in the *Scientific Assessment of Freshwater Harmful Algal Blooms,* prepared by the IWG–4H, a successful freshwater HAB program must foster collaboration between agencies, minimize unnecessary duplication, and provide the essential resources for those agencies to carry out their mission. Furthermore, Congress must all authorize sufficient funding levels for each of these programs (Freshwater HABs, ECOHAB, MERHAB and Prevention Control and Mitigation) if they are collectively to have a chance for success, not simply shift funds from one to another.

Of key importance is the question of which agency should direct this important endeavor for freshwater systems. The Department of Commerce through NOAA has a mandated requirement to protect our marine environments, the Great Lakes and estuaries. However, the *Clean Water Act of 1968* and the *Safe Drinking Water Act of 1974* (and amendments) provide for US–EPA oversight of our nation's freshwater resources that we use for drinking, swimming and recreational purposes. Previously, EPA, NOAA and other agencies joined together in soliciting research proposals for funding from the ECOHAB competitive research-grant program. Each agency reviewed and selected research proposals for funding by their agency that were appropriate for the agency's mission. Unfortunately, due to a lack of clear authority from Congress and limited funding resources to research, monitor, control and prevent freshwater HABs, the EPA has withdrawn or limited its support for HAB research grant programs over the past several years. EPA participation in HAB-related programs and funding HAB research is essential and EPA needs to reestablish their participation in those grant programs. Critical research is needed to assess the frequency and concentrations with which cyanobacteria and cyanotoxins occur in recreational and finished drinking waters. Health research is needed to obtain the dose-response data needed to set limits for safe exposure to cyanobacterial toxins, and for determining cancer assessments. Alternative routes of exposure such as fish consumption need to be carefully evaluated in these risk assessments. Risk management research is needed to assess the efficacy and sustainability of ecological and chemical approaches to freshwater HAB control, to develop improved and less expensive control technologies, and to devise enhanced mitigation strategies. New techniques in molecular biology, biochemistry and chemistry need to be applied to this problem as we constantly challenge the classical definitions of what is a "toxic" or "non-toxic" bloom. Thus, all of these recommendations and technologies need to be based on the best available science in this rapidly changing field.

The organisms and causes of freshwater HABs are very different from those that cause marine HABs, and therefore potential control and remediation technologies are also likely to be very different between marine and freshwaters systems. A freshwater HAB program that specifically addresses those differences is needed. These freshwater locations needs to extend beyond the Great Lakes into other impacted large water bodies such as Lake Champlain (VT) and Lake Mead (NV, AZ) and even to smaller freshwater ecosystems such as the Klamath River (CA, OR) or Elk Creek (OR) which suffer from freshwater HABs. Congress needs to provide the

US–EPA with a clear statutory mandate to participate in freshwater HAB research, and authorize funding for that research. The EPA, working with other affected agencies, needs to develop a comprehensive National Freshwater-HAB Research and Control Program, just as NOAA has done for HABs in oceans, estuaries, and the Great Lakes, and the US–EPA needs to work with NOAA in administering this program for the betterment of all. Congressman Baird's and this committee's legislation accomplishes all of these goals related to freshwater HAB programs and I commend you for recognizing this deficiency.

Smaller freshwater lakes and rivers are very different from larger freshwater systems such as the Great Lakes, which are in turn very different from our estuaries and coastal systems. In spite of these differences between freshwater, estuarine, and marine HABs, it is essential to realize that these water-body types are intimately interconnected; nutrients that enter waterways through their upland watersheds continually stimulate HABs as they flow from the smaller streams, to the larger freshwater lakes, to estuaries and finally to our coasts. Holistic legislation that addresses both marine and freshwater HABs is needed if we are to understand, control and remediate the problem of harmful algal blooms that occur within all our nation's waters.

Thank you for the opportunity to express my viewpoint.

BIOGRAPHY FOR GREGORY L. BOYER

Gregory L. Boyer is a Professor of Biochemistry at the State University of New York's College of Environmental Science and Forestry (SUNY–ESF) in Syracuse, NY.

Dr. Boyer received his B.A. Degree in Biochemistry from the University of California at Berkeley and his Ph.D. degree in Biochemistry from the University of Wisconsin. After postdoctoral fellowships at the Plant Research Labs at Michigan State University and in the Department of Oceanography at the University of British Columbia, he joined the Faculty of Chemistry at SUNY–ESF in 1985. Dr. Boyer's expertise line in the area of biologically active natural products produced by algae and he has more than 35 years experience working with toxins, hormones and siderophores produced by marine and freshwater algae. He was Director of NOAA's MERHAB–Lower Great Lakes project to develop a Tier-based Monitoring for Toxic Cyanobacteria in the Lower Great Lakes'' and is the current Director of New York's Great Lakes Research Consortium. The NY–GLRC consists of 18 New York Universities and nine Canadian Universities, almost 400 scientists in total, working on all aspects of Great Lakes Science, education and outreach. He is the Great Lakes Co-Chair of the Science Advisory Council for New York Oceans and Great Lakes Ecosystem Conservation Council, a member of New York's Great Lakes Basin Advisory Council and an active advocate for Great Lakes protection, outreach and public education.

Chairman BAIRD. Dr. Scavia.

STATEMENT OF DR. DONALD SCAVIA, GRAHAM FAMILY PROFESSOR OF ENVIRONMENTAL SUSTAINABILITY; PROFESSOR OF NATURAL RESOURCES & ENVIRONMENT; PROFESSOR OF CIVIL AND ENVIRONMENTAL ENGINEERING, UNIVERSITY OF MICHIGAN

Dr. SCAVIA. Thank you, Mr. Chairman and Members of the Subcommittee. I thank you for the opportunity to comment on the formulation of an action plan for harmful algal blooms and hypoxia. My name is Don Scavia. I am the Graham Family Professor of Environmental Sustainability as well as Professor of Natural Resources and Environment and Professor of Civil Engineering at the University of Michigan. Prior to joining Michigan's faculty five years ago, I also held several positions in NOAA, most recently as the Chief Scientist of the National Ocean Service. While there, I was responsible for implementing NOAA's portions of this statute and leading the assessments on behalf of the White House. I also directed the office that established several of the NOAA and interagency programs under the statute, including the ECOHAB program, the MERHAB program and the northern Gulf of Mexico research program.

While much has been accomplished in the past 10 years since enactment of the first law, much remains unfinished, and I am pleased that the Subcommittee is considering reauthorizing this Act. Because the other witnesses have focused on harmful algal blooms, I am going to focus my comments on the causes, consequences and controls of hypoxia.

In 2008, a report documented hypoxia in more than 400 ecosystems across the globe, affecting a total of more than 245,000 square kilometers, and most of those problems are driven by nutrient pollution, nitrogen and phosphorus. The U.S. national assessment called for in this original statute, reported in 2003, that two-thirds of the Nation's estuaries showed symptoms of nutrient pollution and a 2007 update of that study indicated that those conditions have not improved and that worsening conditions are expected in two-thirds of our estuaries with only about 20 percent potentially improving in the future. And again, the primary driver of this problem is the overloading of the system with nitrogen and phosphorus.

If we consider three iconic systems, Lake Erie, the Chesapeake Bay and the Gulf of Mexico, we see that while there is lots of year-to-year variability, the dead zones in the Chesapeake Bay and the Gulf have not gotten smaller, even after decades of research, management discussions and plans, and the dead zone in Lake Erie, once thought to be under control and shrinking, has grown again to sizes that we haven't seen in decades. Clearly, the nutrient pollution problem is not under control, and if more is not done to reduce this pollution, we can expect further degradation of our coastal and Great Lakes waters and loss of important recreational and commercial resources. We know that much of the end-of-the-pipe sources of pollution have been regulated and reduced so most of the nutrient pollution now comes from diffuse sources, a large portion of that from agricultural sources. Currently, policy instruments to control these sources are mostly voluntary and incentive based and clearly are not fixing the problem. These instruments are the jurisdictions of other statutes like the Farm Bill and the EPA programs, and while the algal bill cannot do what these statutes are supposed to do, the provisions in the current draft can actually help in some very important ways. They can independently identify the geographies and the needed actions in these areas and then measure and report progress from an ecosystem perspective. As we all know, what gets measured and reported gets done; however, we are not reporting at the right scale or in the right context to influence the impacts of hypoxia and harmful algal blooms.

I have outlined some recommendations for the reauthorization in my written testimony and I will only emphasize one here. The current draft calls for a report on the progress of the Gulf Action Plan two years after enactment of the reauthorization and every five years thereafter. This system has been studied for decades. The action plan has been in place since 2001, so I recommend the task force report progress one year after enactment and every two years thereafter. But reporting should be focused at scales that matter. For example, the report should include details on the specific management metrics and expenditures and updates on environmental conditions at sub-basin or State levels. These reports should be matched up with USGS estimates of nutrient contributions from these sub-basins and these states to ensure that the actions and the management measures that are taking place are actually targeted in the areas that matter most. The biannual reports from the regional plans should also follow this approach.

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 the original 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. That ends my testimony. Thank you.

[The prepared statement of Dr. Scavia follows:]

PREPARED STATEMENT OF DONALD SCAVIA

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 U.S. 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 percent of the estuaries, with only 20 percent 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 impacts1,[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 percent 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 run-off 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 nonpoint phosphorus load reductions achieved the target load of 11,000 metric tons 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 re-emerged 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 inter-annual 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 5,000 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 five 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 percent to 45 percent, recommended that phosphorus loads also be reduced by 45 percent, 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 percent 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 eight 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 five percent of the Mississippi drainage basin supplying 40 percent 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 three 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 two years after enactment of the reauthorization and every five 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.

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BIOGRAPHY FOR DONALD 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 multi-disciplinary 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 Bachelor's, Master's, 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.

DISCUSSION

Chairman BAIRD. Outstanding testimony. I thank you. By the way, the haste with which I began the hearing was an example how seriously I take this, not any shortsightedness on it. I wanted to hear from you folks and your testimony was certainly worthwhile. Indeed, I wish every colleague and many people in the country could hear it. I remember when I first moved to a community, I am a whitewater kayaker and I go into lakes and practice rolling my boat, flipping my boat over, and I am real hesitant because there is nobody else on this lake. I paddled to shore. It was a little inland lake, you know, a city lake, and I said, why is nobody out here? They said oh, because that water is really unhealthy for you. The idea that water in a lake could kill you and kill your pets is really an alien idea to us. It just doesn't seem right, and yet it is clearly the case, and if it doesn't kill you, it can permanently remove your hippocampi, which is a bad deal; as a neuropsychologist, I know. So questions then.

First of all, the suggestions are well taken. It sounds like the elements that were prescribed in the prior legislation you find important. To be perfectly honest, we kind of took those for granted and said they'll continue. You feel the need to specify that because you feel they are valuable. Sometimes we get the reverse feedback on this committee and other committees here: "Don't over-direct us." They were included in prior bills precisely because testimony suggested they were important and we assume they will continue but we will make that explicit because there seems to be unanimity. I think the point is well taken also on the issue of we have studied a lot of this and it is time to take action, I think, and certainly to report on that action in a more timely manner and measure that, and I applaud the recommendations for improved monitoring, both in the freshwater upstream as well as the downstream area.

STATEMENTS FROM REPRESENTATIVES CONNIE MACK AND WILLIAM DELAHUNT

I want to at this point invite my colleague, Connie Mack, who has been a champion of this, given his residence in Florida, and ask unanimous consent that Representative Mack join us on the dais. Also, Representative Mack and Mr. Delahunt from Massachusetts both have statements they would like to introduce into the record. I would ask unanimous consent. Hearing no objection, so ordered.

[The prepared statement of Mr. Mack follows:]

PREPARED STATEMENT OF REPRESENTATIVE CONNIE MACK

I would like to begin by thanking Chairman Baird, Ranking Member Inglis and the Members of the Subcommittee for holding this important hearing. I appreciate the chance to speak on harmful algal blooms (HABs) and how they are affecting our nation's coastlines, oceans, and inland waters.

A little over a year ago, I appeared before this committee with Congressman Boyd and testified about the importance of this issue and the legislation I introduced to combat red tide. Since then, the Committee has crafted new language to improve the legislation we've worked on by including freshwater HABs and instituting regional action plans. These are important efforts, and it is time we recognize that although harmful algal blooms affect our entire nation, they are different throughout the county.

I represent the coastal areas of Southwest Florida. If you haven't been there, it's a beautiful part of the country, with miles and miles of white sandy beaches. For Southwest Florida, like many communities, a healthy environment and a healthy economy go hand-in-hand. When I was growing up in Cape Coral, Florida, red tide blooms were short-lived nuisances that lasted just a few days.

Today, however, these blooms continue for months at a time, and they have long-lasting implications that threaten the environment, people's health, and our overall quality of life. It is imperative that we do more to understand and combat this problem. These blooms cause dangerous respiratory distress, burning eyes, as well as the potential for severe food poisoning from contaminated shellfish. HABs not only affect our personal health, they also affect the health of our economy. Red tide and other toxic blooms cost tens of millions of dollars annually to communities across America. From New England to the Great Lakes, from California to Florida, these toxic blooms affect us all.

Legislation regarding these toxic blooms was first introduced in 1998 under the *Harmful Algal Bloom and Hypoxia Research and Control Act.* This law authorized appropriations for NOAA to research, monitor, and manage activities for the prevention and control of HABs. It also established an interagency task force to develop a comprehensive coordinated federal response to toxic blooms and hypoxia. By holding the hearing today, your committee is giving this issue the attention it deserves.

Last year, I introduced the *Save Our Shores Act* to increase our commitment to researching HABS. Since then, I have been working with the Committee to introduce a new bill to tackle red tide and other harmful algal blooms. This legislation will ensure that scientists and experts in the field, not politicians, determine where research money is spent. Additionally, by improving reporting requirements, Congress and NOAA will be able to measure the effectiveness of these research efforts.

Finally, we need to reduce the gap between authorized and appropriated funds. Annual funding has fallen far short and we need to close this disparity.

Once again, I commend the Committee for bringing up such an important issue. The sooner we can understand what factors contribute to these toxic blooms, the sooner we can develop solutions to save our nation's coastlines, oceans, and inland waters from the scourge of HABs.

[The prepared statement of Mr. Delahunt follows:]

PREPARED STATEMENT OF REPRESENTATIVE WILLIAM DELAHUNT

Chairman Baird, Ranking Member Inglis, Members of the Committee:

I commend you for holding this hearing and thank you for granting me the opportunity to testify today on the importance of formulating action oriented plans to prevent, mitigate and respond to harmful algal blooms and hypoxia events.

As many of you know, I represent the 10th District of Massachusetts. It is an area with a rich maritime history that encompasses communities on the south shore of Massachusetts, from Quincy to Cape Cod and the Islands of Martha's Vineyard and Nantucket. The economic health and vitality of these coastal communities is tied directly to the health of the ocean. New England's shellfish industry is an important part of the region's economy and provides hundreds of jobs that pump millions of dollars into the economy of these communities. Over the last ten years, we have seen increasingly serious outbreaks of harmful algal blooms, commonly referred to as "red tide."

These blooms have caused vast areas of our coastline to close, and shut down the harvest of clams, mussels, oysters and other shellfish. This negative economic impact ripples throughout our coastal communities, from fishermen to buyers, processors, and restaurants. In 2005, New England coastal communities suffered from the worst red tide outbreak in over thirty years, leading to a Presidential disaster declaration in many coastal counties. The red tide resulted from an unusually severe combination of environmental conditions that caused toxic algae to cover significant portions of the region's coast.

In Massachusetts alone, the red tide impacted over 2,000 commercial shellfishermen and over 250 shellfish aquaculture grants, resulting in economic damages exceeding $35 million dollars. Again in 2008, Massachusetts waters suffered another massive and unanticipated red tide bloom, forcing an infusion of federal commercial fishery disaster aid to prevent the collapse of the local industry. This summer, Maine waters were affected and the economic losses to this region were estimated in the millions of dollars.

To better prepare for future algal blooms, scientists and researchers from Woods Hole, located in my district, convened a national workshop in 2006 and issued a report entitled, *"A Plan for Reducing HABs and HAB Impacts."* I am pleased to see that both Senator Snowe and Congressman Baird have read and implemented many of the report's recommendations to create a comprehensive national program to prevent, control and mitigate the economic and environmental impacts of these events.

It is my belief that we need to take additional measures this year to help address this serious threat to New England. That is why I strongly support the creation of a Harmful Algal Bloom Event Response Program, as part of the national program. It is critical that we provide a rapid and thorough response to these outbreaks. Senator Snowe has endorsed such an approach and has included similar provisions in her legislation, S. 952. I strongly support Senator Snowe and I strongly support Congressman Baird's efforts in the House to coordinate national and regional action plans to reduce these harmful blooms.

The health of New England's waters is vital to the economic prosperity of our coastal communities, and as such I support the investment in planning and research that may alleviate some of these economic and environmental hardships in the future.

I welcome the opportunity to work with you in making sure the House of Representatives takes the additional steps necessary to establish a robust Harmful Algal Bloom program. Thank you.

Chairman BAIRD. I will recognize myself for a few more minutes and then Mr. Inglis will proceed in questioning as time allows.

THE INEFFICACY OF TRADITIONAL WATER TREATMENT

I want to make one thing clear and make sure my understanding is correct in the case of normal filtration of water. You know, as a backpacker and a climber, I am used to carrying a water filter with me, and you filter out the protozoan and whatnot but you don't filter out the toxin. Is that correct? So if there were a mountain lake, which there are in Oregon where when you get to the lake there is a sign that says caution, there is blue-green algae here, if water is coming out of that lake and I filter that water, am I still getting the toxin potentially even if I am not getting the algae per se?

Dr. BOYER. One of the issues there is if the toxin is in the algae, then your filter will be very effective, but if the toxin is released from the cells, it will go straight through. That is true for boiling too. We quite often boil ourselves to release the toxins because it is a very easy way to get it into the water so that we can work with it, so a boil-water advisory, for example, is meaningless when you start talking about things like microcystin.

Chairman BAIRD. That is what I thought. I think it is so important to help the public understand this, that your normal defenses against this don't work, filtering, boiling. Iodine, to my knowledge, doesn't work, or Clorox, I mean, because it is a chemical toxin that is released from the organism. Is that accurate?

Dr. BOYER. That is pretty much true. A lot of the basic technologies that we would normally use in water treatment are not very effective for freshwater toxins.

Chairman BAIRD. And that is also the case with the fish or the shellfish, right? Mr. Ayres, if you close a beach, somebody can't say well I am going to cook the razor clams.

Mr. AYRES. Exactly. You can't cook it out of the clams. You can't freeze it out of them. You just simply have to wait for them to naturally purge themselves of that toxin. Yes, exactly, you cannot treat it in any way.

GROWING DEAD ZONES AND THEIR CAUSES

Chairman BAIRD. This issue of dead zones is profoundly troubling, and I am glad you raised it, Dr. Scavia. Expanding from everything I hear—by the way, Puget Sound and Hood Canal, we have got a major problem, an increasing zone off of Oregon. It seems in most areas, they are expanding, not diminishing. Is that accurate?

Dr. SCAVIA. That is true. In areas where we have had the dead zones or hypoxic areas, those areas are getting larger in many cases and we are seeing more estuarine systems having that. The study that was done between 2003 and 2007 showed there was no improvement and with the forecast, we are expecting it to increase in about two-thirds of the estuaries.

Chairman BAIRD. In both the freshwater and the marine environments, the culprit, at least a prime suspect, if not known culprit, seems to be nutrient sources, nitrogen and phosphorus. To what extent does acidification play a role or temperature change play a role as well? I mean, weigh those out for us a little bit, and both environments, if you would.

Dr. BOYER. Well, I will take a stab at the freshwater. You are exactly right. The prime culprits are nutrients coming in through the watershed. Acidification probably has very little, if no, effect on dead zones. I already forgot what your——

Chairman BAIRD. Temperature.

Dr. BOYER. Oh, temperature. Temperature is going to be a much trickier issue because associated with rising temperatures are often changes in weather patterns, which then lead to increased nutrients. Many of these organisms grow better under higher temperatures so you would expect that to also be a problem, and temperatures also need to be in a more stable water column in many cases, which also leads to algal growth. So it is going to be sort of a tricky issue there but it is——

Chairman BAIRD. Great. Excellent testimony. I will close then and I will ask if I get time. You know, one of the great paradoxes of this is, you hear your testimony, you know the importance of it, and yet to try to get the public fired up about this—well, actually we did a radio interview this week and we said maybe we should talk about algal blooms, and the fear was, they are going to say what is he talking about, algae. Well, it can kill you, badly it can kill you. I love the name. I decided if I was an ultimate fighter, one of those guys, I would like the name—what was it—severe death factor? That would be——

Dr. BOYER. Fast death factor or very fast death factor.

Chairman BAIRD. With that, I recognize my friend and colleague, Mr. Inglis.

CURRENT CONTROL AND MITIGATION STRATEGIES

Mr. INGLIS. Thank you, Mr. Chairman.

Dr. Magnien, I was wondering about the control and mitigation technologies that are currently employed when HABs or hypoxia events are detected, and who decides what technology is used and what is the decision protocol for making those decisions about the control and mitigation approaches?

Dr. MAGNIEN. Well, we define control as actually methods that you would use to suppress a bloom once it is present, and mitigation is more in the realm of warning people that a bloom is there and making sure they don't eat shellfish or come into contact with the water and get sick. Dr. Anderson mentioned a little bit about these techniques, especially the control techniques, are not very well advanced and that is one of the reasons why we have initiated this prevention, control and mitigation program to get more research dollars applied to that. They can include techniques like spreading of clay, which is a very common technique in the Far East around aquaculture facilities. They coagulate the bloom and it settles out. They can include things like viruses or bacteria, disease agents that are put out, just like we do for various infestations in forests, introduce bacteria to control caterpillar growth. So those, you know, are some of the aspects of those programs that really require additional research. One of the big mitigation areas of research is this forecasting where we give people warning or resource managers warning so that a Dan Ayres can have much more lead time in the decisions he has to make in terms of opening and closing a beach for razor clams, or the forecast that we issued through Don Anderson's research in New England this year that gave managers there a heads up that they would need to gear up and have more staff on board in order to deal with a red tide, a big red tide, which in fact did come, and they were very appreciative of that advanced warning, and that allowed them to mitigate the impacts.

Mr. INGLIS. Who is it that makes the decision? Who makes the call on those kind of, what course to pursue?

Dr. MAGNIEN. Most of the decisions on the front lines are State resource managers, again, those folks like Dan Ayres, a shellfish manager, a public health official. Some of that is made at the county level. County health officials are empowered with closing water bodies. We have seen that happen in certain areas, especially with beach closures: water contacts recreation. So it is usually at the State and local level where those decisions are made but those are the same people that lack the tools and the resources to support those decisions, and that is what we are trying to provide to them.

Mr. INGLIS. Great. Thanks.

And Dr. Anderson, why is there so little research into control and mitigation?

Dr. ANDERSON. Well, I tried to address that in my written testimony. I even have an annex there which is telling because it is a commentary I wrote in the journal *Nature* more than 10 years ago about that exact question: Why is it that progress is so slow? And as I said, we are not that much further along now. The answers are several, and one of them truly is that without a targeted program that has money explicitly and specifically for, let us say, bloom control, then scientists will tend to propose more safe research, things that are fundamental science, that build on what they have done before. In my own lab, I put an entire Ph.D. student into the use of clay to control these red tide organisms. That student has struggled to find funding as he moved along, and he has actually left the field. It is very sad to say that. But as much as that seems like where the money should be coming from, it has been difficult to get funding for actual transitioning of these lab technologies to the field, and part of it is also that we have permitting issues. And scientists, I guess we are just not used to having to say "In order to do this particular line of research, I need to go get permits from the state, from the Corps of Engineers, from the EPA." They need to do all these things and they are all going to be asked for more data, and that tends to slow down progress dramatically. So there are a number of steps that I think can be alleviated by this program that we propose, this PCM HAB program, because it has development stages, developing the technologies, and it has demonstration and transitioning stages so that you take something all the way and with substantial resources for all of those steps.

Chairman BAIRD. Thank you, Mr. Inglis.

Mr. Mack.

COMMENTS FROM REPRESENTATIVE MACK

Mr. MACK. Thank you, Mr. Chairman, and I also want to thank the Ranking Member for having me and letting me join today, and I also want to thank all of you for being here and your testimony.

First of all, a little bit about me, I guess, and why I have an interest in this, but I grew up in southwest Florida, Fort Myers, where I spent most of my childhood when I wasn't in school and sports at the beach on the water enjoying fishing and water skiing and just enjoying the outdoors in southwest Florida, and one of the main economic drivers of southwest Florida is people coming down to come to the beach and have a little vacation and rest and relaxation. I also have a cousin who works at Woods Hole as a scientist, and we were talking one day that I decided I was going to run for Congress and we were talking about red tide. Frankly, we were talking about it because we were out at the beach——

Chairman BAIRD. He didn't mean that in a political sense, of course.

Mr. MACK. Yeah. We were at the beach and we were talking about how again growing up we would have red tide blooms, I guess you would call it, that would come around once a year sometime in August, last for four to seven, maybe 10 days, and that was it, and now we see red tide blooms that are off the coast of Florida that will last 13, 14 months straight. And so we started talking about things that we thought we could focus on and how to make the process a little bit better, and a couple of things that we talked about and that I think are very important. And I want to again commend the Committee for taking this up and trying to move forward with the legislation that I think will have a huge impact, but I wanted to see if there was a way to stop duplication of research because funding is so limited that if there is a peer review organization, a group that can look at the research that is being done, who is looking to get research dollars, we would have some mechanism to ensure that we are not duplicating research, and for me, having been in politics a little bit before I even ran for this office, you know, all of us want to try to bring home those dollars to our district, so for me, the Florida Gulf Coast University or Moat Marine, you know, we all end up finding ourselves trying to get the dollars so we can go back home and say we are trying to do something to help, but in the long run, is that really helping us further research into red tide if we are splitting up the available funds and really not having a consistent funding mechanism? So the peer review process was important, not duplicating research, consistency of funding, and I am sure that is something all of you deal with. Mr. Chairman, as you know, you will have research projects that will be moving along nicely and then funds run out and they have to stop, and so that stopping and starting and stopping and starting hinders the progress made in research. And the last thing that we talked about was a reporting process that right now there is so much reporting requirements that I am not saying that we should do away with reporting at all. What I am suggesting is, we need to do a better job of streamlining those reports so you can really spend more time doing the research, spend less resources in doing the reports that are required but at the same time, given the committee of oversight, given those who need to have the information to determination whether or not we are being successful, and what changes might need to be made.

So these have been the thought process and the ideas that I have had for some time and I am very pleased that the Committee is moving forward with this, Mr. Chairman, and I just wondered if I could make one other statement. We talk a lot about mitigation. We talk a lot about, you know, what can we do and what nutrients have really kind of pumped up and kind of, you know, energized these events. We still need to get back to trying to figure out what causes it in the first place, and we recognize that the red tide events that happen in the Gulf of Mexico will be different from what happens in the inland waterways, but if we solely focus our energies, Mr. Chairman, on just how to mitigate and warn people, I think we are missing the point. Really what we need to do is try to find out how it starts and that is going to give us the best place to start with, how to control it, and then I will end with this, Mr. Chairman. Thank you for your patience. Someone said who makes the call. I think maybe it was the Ranking Member. Who makes the call on closing the beach? And I wrote a note down to myself, the one who drew the short straw because that person is never the popular one, although it is very important for the safety of our community.

So again, Mr. Chairman, I want to congratulate you on your efforts in this legislation, and again, I want to thank the panelists for being here.

Chairman BAIRD. I want to thank the gentleman for his comments and his initiative on this. He has been a champion of this for an issue that, as I mentioned earlier, is not sort of a politically—you know, if you do a poll, this is not going to come up on most people's radar screen very high, but for areas like Mr. Mack's, that of his childhood and his current district, and parts of mine, this is a profoundly important issue and it deserves the kind of attention that has gotten, and again, I acknowledge Mr. Ehlers and Ms. Castor as well.

THE ECONOMIC COSTS OF HYPOXIA AND HABS

I want to follow up a little bit on a couple of the points Mr. Mack made. Let me talk for just a second about the economics of it. He talked about the impact on his district and on his state. Repeat real quickly the economic costs, the best estimate of economic cost we have got in terms of both hypoxia and harmful algal blooms. Do we have any? I mean, in our state, Mr. Ayres, you threw out some numbers.

Mr. AYRES. Well, yeah. I mean, I threw out some numbers, and it depends on the fishery that is being affected. We do have—NOAA recently funded a study on the razor clam fishery specifically and what would be lost, and that number was much higher than we would have expected, in the neighborhood of $16 million to the coastal economy, and that is to the small communities that you know so well. Sixteen million dollars to the state's economy is not a big deal but to these—well, I don't know, Governor Gregoire may disagree, but to our small coastal communities, that is a big hit to them, so it really depends on the scale you want to look at and how that plays out, but it is a big—-

Chairman BAIRD. The local hotel owners tell me it is their season.

Mr. AYRES. Yeah, exactly.

Chairman BAIRD. In our coastal area, you know, you could rent your garage when the clam season——

Mr. AYRES. And you are right. I mean, it is not a big deal on people's radar screen until it doesn't happen, and then when it doesn't happen and they realize what they don't have——

Chairman BAIRD. That raises the other side of the issue—and I think I know the answer to this and I am going to guess the answer is "more." But if the question were, what do you think are necessary—other than just something more, what kind of funding levels do you think, and let us assume that some of the kind of intervention approaches, control and mitigation strategies, some of the immediate response kind of things, what kind of numbers should we be talking about relative to what we have been spending on research and control, et cetera if we were to make a national effort commensurate with the importance of the issue for human health, aquatic health and weather? Any thoughts?

Dr. SCAVIA. I will take a partial shot at that, partially because I used to run the program that Rob Magnien runs and he can't answer this question so I will for him. I think the overall program focused on harmful algal blooms and hypoxia, the NOAA part of it to fund the research, prevention, remediation needs to be at least $40 million a year, and that is actually not a lot more than what they are doing now, but I think that is the level we need to bring it up to. I don't know if Dr. Anderson has additional from the pure mitigation side.

Dr. ANDERSON. Not just from the pure mitigation side but if you look at the back of the, we call it the RDDTT report, R–D–D–T–T, we actually try to break this down into costs for ECOHAB, for MERHAB, for PCM and so forth. We even broke it down into freshwater versus marine, and that is when you get up to these numbers that are $40 million a year, so that was at least our first shot at it.

Chairman BAIRD. A conscientious effort to say what is a realistic number.

Dr. ANDERSON. Yes, and we do acknowledge that if we are going to try, for example, some of these control methods, some of them could be extraordinarily expensive, much more than we give out in a lot of these targeted research grants. If you are going to try to control a red tide over a few, let us say, square miles or so, it could cost a $1 million just by itself. So on the control and mitigation side, the costs might go up the closer we get to demonstration projects.

POTENTIAL CHANGES AT EPA

Chairman BAIRD. To punctuate that, though, a little bit, you know, if you have got a—a couple years ago we had these hearings. We talked about municipal water supplies for major cities that had blue-green algae, and you can literally overnight have an all-hands-on-deck crisis situation where your community is instantly out of most of its water, and the costs of dealing with that and the lack of the remediation strategy, the lack of a testimony strategy could be—suddenly the most important thing on your mind is, what you are going to do with that? Not to put you on the spot, Ms. Schwartz, but is EPA—what can do EPA do better—let me phrase it that way—in the freshwater realm here, and not only the freshwater realm as freshwater per se but as a contributor to the ultimate marine environment?

Ms. SCHWARTZ. Well, I think there are certainly things we could be doing better. We are looking actively at different ways that we can be more effective in controlling non-point sources in particular of nutrients. We are looking actually—you know, most everybody else here has been talking about control and mitigation of the blooms themselves. Our focus has really been more on addressing the nutrients, getting to the sources so that hopefully we would prevent the blooms from being at least as frequent or as serious as they are, and I would offer, although I don't have a figure to give you, that the figures that have been thrown around don't include the costs of prevention in that sense. We are working closely with USDA on a number of things, and I would urge you in fact as you are looking at your legislation to think about the different agencies that really do need to participate because, again, if you are going to get to the underlying causes, certainly USDA is a huge player in the Gulf of Mexico hypoxia. They are just about to announce some exciting new efforts to try to address the particular sources or the hottest sources, at least, in the upper Midwest as well as along the Mississippi to address the hypoxic zone in the Gulf of Mexico. So we think that there is a need to bring everybody in. And if you look at what we are going to be proposing shortly in the Chesapeake Bay, we have really looked very seriously. There is a huge nutrients and sediments issue there as well. We are looking very closely at what steps we can take, whether it is to increase the activities we regulate under the *Clean Water Act*, more CAFOs, concentrated animal feeding operations, whether those numbers should come down in terms of how many animals are considered a regulated point source, looking at stormwater discharges and how those are regulated. Obviously when we have permitting authority or the state has permitting authority, you could control what is released much more readily than when you don't have that authority, as is the case for most non-point sources.

Chairman BAIRD. And it seems from what you are saying earlier, it seems to me this non-point source issue is huge, especially with agriculture and urban runoff. Is that a fair appraisal? And that if you were just to do the pie chart kind of model of what percentage of the cause—I mean, algal blooms have been here for a long time and, you know, it has not just started now but they seem to be worsening and they seem to be growing, so too with areas of hypoxia. There seems to be a consensus that these nutrient issues, much of it from non-point sources, a substantial portion from ag, is a contributor to the downstream consequences. Is that a fair portrayal? I am not going to ask you to put a number on it but a fair portrayal. So we have to address that, how we deal with the non-point sources.

Mr. Mack, I am going to have to leave shortly but I want to give you a chance to follow up with any questions you might have.

Mr. MACK. Thank you, Mr. Chairman.

RESEARCH FUNDING ON THE CAUSES OF HABS AND HYPOXIA

I guess to try to narrow this down, on one side I think the Committee and the Congress needs to find a way to ensure that the appropriate amount of funding is available and that we are not duplicating research, as I said, and that it is consistent. I guess I would love to hear from whoever would like to answer it but how much of the research dollars that are available now are going to, or what percentage of it is going to actually trying to identify not what makes the bloom larger but how the bloom began in the first place, and I know that it is a little difficult. Of course, I am interested in the Gulf of Mexico but I know it is a little difficult because all the algae blooms are different in different parts so they may have different causes but do we have a good understanding of that?

Dr. MAGNIEN. Yeah, I am glad you asked that question because I didn't want to leave the impression that these programs that you have heard so much about, the ECOHAB, prevention, control and mitigation don't deal with that. In fact, they do. The ECOHAB program is looking at the fundamental processes that generate these blooms and we need to understand that in order to prescribe some kind of a preventative solution. You know, we would like to prevent as many of these blooms as possible. So the ECOHAB program looks at that. The prevention, control and mitigation—I talked about the control and mitigation because Representative Inglis asked me about that—but prevention is also, the P is prevention. That gets at, you know, what is the cause and understanding that. In your area in Florida, we have a huge project ongoing now to look at that. It has been a very controversial issue. A lot of people say we can't control it, we can only mitigate, but we are putting in some large dollars, a multi-million-dollar grant now to continue to investigate that question as to whether there are ways either to lessen the severity. Some people say that maybe we can't control the initiation, but some of the local sources of nutrient pollution enhance it and prolong it, so we are very much looking at that as well as the economic impacts. You heard a little bit about that. We have sort of piecemeal information. We know there are big impacts in certain areas and certain blooms, up to $50 million or more, but we don't have comprehensive numbers and that economic impact will help guide where we put some of our effort in terms of research on these issues as well.

Mr. MACK. Anybody else want to—yes, Dr. Anderson.

Dr. ANDERSON. The HAB forecasts that we have been able to do in the northeast region, and in fact with your cousin being actively involved in that, are based on exactly what you are looking for. We have identified the source of our blooms. We know that there are beds of these dormant cells in certain locations in the Gulf of Maine and we have over the years learned that if we can map those out and count them, then that gives us a very good indication of what the next year's red tide will be like. So there we have identified the source and understand the linkage to the subsequent blooms. The challenges, well, other than using that for forecasting, could we somehow use that source information in an actual bloom control strategy? That is where it truly becomes challenging because yes, there are mechanisms. In my lab we actually mate toxic and nontoxic cells of this HAB organism and produce a nonviable cell from that. It is like a sterile fruit fly. But the question to all of you would be, can you imagine me trying to propose to put an introduced organism into the Gulf of Maine in huge numbers to do this? The societal challenge of doing that is dramatic, even though the technology might suggest a way to step from that knowledge of the source to a control mechanism. That is where we need to move forward, to take that knowledge and that little bit of laboratory science and figure out a way to get it out into the field.

Mr. MACK. Thank you.

Yes, ma'am.

Ms. SCHWARTZ. One thing I would like to point out is, if you look at what has been done for the Gulf of Mexico hypoxic zone, the Department of Interior, the USGS actually did some mapping and some modeling. It is called the Sparrow Model and it actually shows the level of concentration provided to the Mississippi River so you can actually identify where the largest contributions are coming from, both separately for nitrogen and for phosphorus from within the basin, and that is something that we feel is really going to be helpful to us in order to target—again, we are never going to have enough resources to take care of everything all at once, but to target the greatest sources. So we think work like that can be done. EPA is putting in probably about $4 million to $5 million a year specifically on hypoxia in both HABs research and implementation activities. We have a lot of other efforts underway on nutrients more broadly but without the ability to really target where the source is and without, you know, some sort of regulatory or voluntary program to make sure that it is addressed, it is really hard to do much.

Mr. MACK. And Mr. Chairman, I know you have got to go but I just wanted—you know, these events, these red tide events can cripple communities like, you know, Sanibel Island, Florida. You get an algae bloom off of Sanibel and it just has a devastating impact on the quality of life of the residents and tourism, and so again, Mr. Chairman, I just want to commend you for your efforts.

Chairman BAIRD. Thank you, Mr. Mack. That is why we intend to try to move this legislation forward with alacrity. I appreciate the input of the panelists. We hope to incorporate many of your suggestions in the revision that we will bring up for markup, hopefully soon. I thank you for your expertise and your work.

CLOSING

The record of this hearing will remain open for two weeks for additional statements from Members and for answers to any follow-up questions the Subcommittee may ask. The witnesses are again thanked for their expertise and their participation, and with that, the hearing stands adjourned.

[Whereupon, at 3:30 p.m., the Subcommittee was adjourned.]

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