HARMFUL ALGAL BLOOMS: ACTION PLANS FOR SCIENTIFIC SOLUTIONS

HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY AND ENVIRONMENT

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

ONE HUNDRED TWELFTH CONGRESS

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WEDNESDAY, JUNE 1, 2011

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HARMFUL ALGAL BLOOMS: ACTION PLANS FOR SCIENTIFIC SOLUTIONS

WEDNESDAY, JUNE 1, 2011

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

The Subcommittee met, pursuant to call, at 2:05 p.m., in Room 2318 of the Rayburn House Office Building, Hon. Andy Harris [Chairman of the Subcommittee] presiding.

RALPH M. HALL, TEXAS
CHAIRMAN

EDDIE BERNICE JOHNSON, TEXAS
RANKING MEMBER

U.S. HOUSE OF REPRESENTATIVES

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

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Subcommittee on Energy & Environment

Harmful Algal Blooms: Action Plans for Scientific Solutions

Wednesday, June 1, 2011
2:00 p.m. to 4:00 p.m.
2318 Rayburn House Office Building

Witnesses

Dr. Robert Magnien, Director of the Center for Sponsored Coastal Ocean Research, National Oceanic and Atmospheric Administration (NOAA).

Dr. Richard Greene, Chief, Ecosystems Dynamics and Effects Branch, Gulf Ecology Division, Office of Research and Development, U.S. Environmental Protection Agency (EPA).

Dr. Donald Anderson, Senior Scientist and Director of the Coastal Ocean Institute, Woods Hole Oceanographic Institution.

Dr. Kevin Sellner, Executive Director, Chesapeake Research Consortium

Dr. Stephanie Smith, Chief Scientist, Algaeventure Systems

Dr. Beth McGee, Senior Water Quality Scientist, Chesapeake Bay Foundation

HEARING CHARTER

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

Harmful Algal Blooms: Action Plans for Scientific Solutions

WEDNESDAY, JUNE 1, 2011

2:00 P.M. TO 4:00 P.M.

2318 RAYBURN HOUSE OFFICE BUILDING

Purpose

On Wednesday, June 1, 2011, the Subcommittee on Energy and Environment of the Committee on Science, Space, 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 2011." Witnesses have been asked to provide comments on, and suggestions to, the bill.

Witnesses

- *Dr. Robert Magnien*, Director of the Center for Sponsored Coastal Ocean Research, National Oceanic and Atmospheric Administration (NOAA).
- *Dr. Richard Greene*, Chief, Ecosystems Dynamics and Effects Branch, Gulf Ecology Division, Office of Research and Development, U.S. Environmental Protection Agency (EPA).
- *Dr. Donald Anderson*, Senior Scientist and Director of the Coastal Ocean Institute, Woods Hole Oceanographic Institution.
- *Dr. Kevin Sellner*, Executive Director, Chesapeake Research Consortium
- *Dr. Stephanie Smith*, Chief Scientist, Algaeventure Systems
- *Dr. Beth McGee*, Senior Water Quality Scientist, Chesapeake Bay Foundation

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 depleting the available oxygen in the water, causing hypoxia. The 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, HABs may result from naturally occurring environmental changes in water quality, temperature, sunlight, or other factors allowing certain algae to out-compete other microorganisms for nutrients.

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 almost all U.S. States have reported blooms. In severe cases, these phenomena can have serious environmental, economic, and human health impacts. Such 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 fish, bird, and mammal mortalities. Broader ecosystem impacts are also a concern, wherein environmental damage may reduce the ability of those systems to sustain species due to habitat degradation and increase susceptibility to disease..

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

In 1998, Congress passed the Harmful Algal Bloom and Hypoxia Research and Control Act (HABHRCA, Public Law 105–83), which established an Interagency Task Force to develop a national HABs assessment and authorized funding for existing and new research programs on HABs. The Interagency Task Force includes:

- Department of Commerce
- Environmental Protection Agency
- Department of Agriculture
- Department of the Interior
- Department of the Navy
- Department of Health and Human Services
- National Science Foundation
- National Aeronautics and Space Administration
- Food and Drug Administration
- Office of Science and Technology Policy
- Council on Environmental Quality
- Other federal agencies as the President considers appropriate

The funding went to support two multi-year research programs at the National Oceanic and Atmospheric Administration (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.

In 2004, HABHRCA was reauthorized by Public Law 108–456, which required assessments of HABs in different coastal regions and in the Great Lakes and included 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 reauthorization expired in 2008, however, the Consolidated Appropriations Act of 2008 (P.L. 110–161) provided authorizations through 2010.

The 2004 reauthorization also directed NOAA to produce several reports and assessments, which have since been completed:

- The *Prediction and Response Report* (September 2007) addresses both the state of research and methods for HAB prediction and response, especially at the federal level.
- The 2008 *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 *Scientific Assessment of Marine Harmful Algal Blooms* (December 2008) described the state of the science with respect to understanding HABs causes and controls and developing predictive models; developing detection methods for cells and toxins; characterizing toxins and impacts; HAB impacts on food webs and fisheries; and, assessing public health, economic and sociocultural impacts.
- The 2008 *Scientific Assessment of Freshwater Harmful Algal Blooms* released in 2008 that describes 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.
- The *Scientific Assessment of Hypoxia in U.S. Coastal Waters* (September 2010) assesses the prevalence of low-oxygen “dead-zones”, or hypoxic zones, in U.S. coastal waters and outlines a series of research steps needed to address these occurrences.

Additionally, the 2004 reauthorization directed NOAA, in coordination with the Task Force, to conduct local and regional scientific assessments if requested by 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 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 to conduct research and reduce HABs and hypoxia in U.S. marine waters, estuaries and the Great Lakes. In its role as a task force participant, the Environmental Protection Agency (EPA) has signed memorandums of understanding to fund competitive research in these areas. However, since the completion of the freshwater report in 2008, EPA has ceased participation in freshwater HAB research and mitigation activities, asserting that its obligations regarding implementation of the report recommendations have been addressed. As a result, although EPA 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, the agency currently has no research and development effort that directly addresses freshwater harmful algal blooms.

Other Interagency Efforts

EPA and 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 the lead agency of the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force.

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

The first national plan to outline a roadmap for the scientific community was the *National Plan for Marine Biotoxins and Harmful Algae*.[1] This plan 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. In the years that followed, HABs have increased in type, frequency, location, duration and severity, while decision-making and management systems did not change. Thus, the national plan was updated to reflect the current state of the HAB problem, needs, priorities and approaches. The revised plan, *Harmful Algal Research and Response: A National Environmental Science Strategy 2005–2015*[2] (HARRNESS) is composed of views from the research and management community and outlines a framework for actions over a ten-year period.

[1] 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.mblwholibrary.org/bitstream/1912/614/1/WHOI-93-02.pdf.

[2] *HARNESS, 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/HARNESS/.

Funding Levels of HABs Programs.

NOAA HABHRCA Funding FY 2007 – FY 2010*

	FY 2007 Enacted	FY 2008 Enacted	FY 2009 Enacted	FY 2010 Enacted
[1]NOAA TOTAL	$13.1M	$11.4M	$14.6M	$12.6M
Regional Research and Action Plans	$0.0M	$0.0M	$0.0M	$0.0M
[2]Intramural Research and Assessment Activities	$6.0M	$3.4M	$3.4M	$2.6M
[3]ECOHAB	$2.8M	$3.0M	$5.1M	$4.7M
[4]MERHAB	$1.9M	$1.6M	$1.5M	$0.6M
[5]NGOMEX	$1.7M	$2.4M	$2.7M	$2.4M
[6]CHRP	$0.7M	$0.9M	$1.9M	$1.3M
[7]PCM HAB	$0.0M	$0.0M	$0.0M	$1.0M
Event Response	$0.01M	$0.06M	$0.04M	$0.02M
Infrastructure	$0.0M	$0.0M	$0.0M	$0.0M

[1]Estimates do not include administration costs or ship charter costs
[2]Funding includes research related to HAB and Hypoxia research funded out of NCCOS Base funds
[3]Ecology and Oceanography of Harmful Algal Blooms program
[4]Monitoring and Event Response for Harmful Algal Blooms program
[5]Northern Gulf of Mexico Ecosystems and Hypoxia Program
[6]Coastal Hypoxia Research Program
[7]Prevention, Control, and Mitigation of Harmful Algal Blooms program
*NOTE: HABHRCA programs do not receive individual line items in the administration budget, so FY12 request levels are unknown.

Discussion Draft: the Harmful Algal Blooms and Hypoxia Research and Control Amendments Act of 2011

Section-by-Section Analysis

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 2011

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; State; 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 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 ensure the development and implementation of methods and technologies to protect ecosystems damaged by HABs; 6) to coordinate education programs; 7) to facilitate regional, State, tribal, and local efforts to implement response plans, strategies, and tools; 8) to provide resources for training of regional, State, tribal and local coastal and water resource managers; 9) to oversee the updating of the Regional Research and Action Plans; and 10) 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, nongovernmental organizations, and other agencies represented on the Task Force to avoid duplication.

This bill also requires the Under Secretary to maintain an existing competitive grant program at NOAA; conduct marine and freshwater HAB and hypoxia event response activities; and facilitate and coordinate among Federal agencies and increase the availability of analytical facilities and technologies, operational forecasts, and reference and research materials.

Section 4 requires that all monitoring and observation data collected shall conform to standards and protocols developed pursuant to the National Integrated Coastal and Ocean Observation System Act of 2009.

The bill 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, progress of the Program, and the need to revise or terminate activities under the Program.

Section 5: Regional Research and Action Plans

Section 5 directs the Under Secretary, through the Task Force, to oversee the development of Regional Research and Action Plans by identifying the appropriate regions and sub-regions to be addressed by each Plan. It directs the Under Secretary, through the Task Force, to oversee the implementation of the Regional Research and Action Plans only at the request of the State. 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) ways to reduce the duration and intensity of HABs events; 4) research and methods to address the impacts of HABs on human health; 5) mechanisms to protect vulnerable ecosystems that could be or have been affected by HABs; 6) mechanisms by which data is transferred between the Program and State, tribal, and local governments and relevant research entities; 7) communication and dissemination methods used to educate and inform the public; and 8) 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 24 months of the date of enactment and updated once every five years.

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 two 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

The discussion draft does not propose specific funding levels for the program. However, the bill specifies that the Under Secretary shall ensure a substantial portion of appropriated funds go toward extramural research activities.

Section 8: Unfunded Mandates

The draft states that the neither the Act nor the amendments made by the Act shall constitute a financial burden to State, tribal, or local governments.

Chairman HARRIS. The Subcommittee on Energy and Environment will come to order. Good afternoon, everyone. Before we start, we are going to be taking votes, probably in the next half-hour, 20 minutes or half-an-hour, so we will have to have a break and come back and continue. But we are going to go ahead and get started.

Welcome to today's hearing entitled "Harmful Algal Blooms: Action Plans for Scientific Solutions". In front of you are packets containing the written testimony, biographies and truth-in-testimony disclosures for today's witness panel.

I now recognize myself for five minutes for an opening statement.

Good afternoon. Harmful algal blooms, or HABs, and hypoxia, are issues that this Committee is very familiar with, as this is the third hearing on this topic in three years. HABs are an abundance of freshwater or marine algae that can produce toxins or are produced in large enough numbers to harm the surrounding environment.

Virtually every state has been affected by HABs, making this a national problem. However, the different types of algae, the causes of their explosive growth, and the effect they have on the ecosystem varies so greatly that there is no single, national solution to deal with HABs.

While this is an important environmental issue, HABs and hypoxia can also have a direct detrimental effect on human society. The bodies of water that are affected by HABs are the same as the ones we use for drinking water, for recreational purposes and as the source of livelihoods such as commercial fishing.

Like all Marylanders, my family and I cherish a clean and healthy Chesapeake Bay. We are privileged to live so close to this remarkable resource and share a commitment to caring for it and its wildlife. Harmful algal blooms cause oxygen depleted dead zones that can kill fish and other marine life in the Bay, and the collaborative efforts reauthorized in legislation I will introduce help harness the ingenuity and resources available from the private sector, academia, local governments and non-profits, as well as the Federal Government.

In today's hearing, we will be discussing not only the current state of research in HABs and hypoxia, we will be discussing draft legislation to reauthorize the Harmful Algal Bloom and Hypoxia Research and Control Act. This statute was first authorized in 1998 and again in 2004. As of the current fiscal year, the programs authorized under this law have now expired. The reports required under the law have provided us with a great deal of information on the research needed to not only try to prevent HABs and hypoxia, but to control, mitigate, protect and respond to these events. Although there is a great need for it, the technology to address HABs and hypoxia does not seem to be advancing as quickly as the rest of the research areas.

Now, in a utopian world, we would prevent these incidents from occurring entirely. However, in the world we live in, some of these events are naturally occurring and therefore could not be prevented, and other events are exacerbated by human activities. We need to make sure that the research in prevention does not hinder or eclipse the parallel research path of control and mitigation through technology solutions.

Given the importance of these issues to human health, economic prosperity and the environment, I think it is important for us to ensure that these research programs continue and work on providing multiple ways of addressing HABs and hypoxia in the future. The legislation I have asked all our witnesses to comment on is in draft form in order to provide structure for our discussion today. I look forward to hearing from our witnesses on their thoughts on how we might improve the language and I look forward to working with the minority as we move along this process.

[The prepared statement of Mr. Harris follows:]

PREPARED STATEMENT OF CHAIRMAN ANDY HARRIS

Good afternoon. The title of today's hearing is *Harmful Algal Blooms: Action Plans for Scientific Solutions.* Harmful algal blooms, or HABs, and hypoxia, are issues that this Committee is very familiar with, as this is the third hearing on this topic in three years. HABs are an abundance of freshwater or marine algae that can produce toxins or are produced in large enough numbers to harm the surrounding environment. Virtually every State has been affected by HABs, making this a national problem. However, the different types of algae, the causes of their explosive growth, and the effect they have on the ecosystem varies so greatly that there is no single, national solution to deal with HABs.

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Chairman HARRIS. The Chair now recognizes Mr. Miller for an opening statement.

Mr. MILLER. Thank you, Chairman Harris. I also want to welcome the witnesses to today's hearing. Harmful algal blooms and their hypoxic effects may not be something that most of us think about every day, the exception obviously being the witnesses for today's hearing, but it is an important issue that affects most of our districts, in fact, all of our districts.

For the past two years, this Subcommittee and the Full Committee have discussed the effects of harmful algal blooms and the resulting hypoxia on our coastlines and in fresh water. HABs pose a serious threat because of toxins they can produce and because they reduce oxygen and sunlight in the water. Those threats alter the ocean's food web, affect human health, and create economic losses for communities and commercial fisheries.

In addition to hearing about the effects of HABs, we will also discuss the draft legislation for the reauthorization of the Harmful Algal Bloom and Hypoxia Research and Control Act. Because of the 1998 Harmful Algal Bloom and Hypoxia Research and Control Act—we really need to shorten that—and the 2004 reauthorization, we have made significant advances in our research findings and have taken important steps to solve some of the problems associated with HABs. However, numerous reports and assessments required by the law have revealed an increase in the number, frequency, and type of blooms in recent years. We need to continue this valuable research and implement strategic national and regional plans. The 2010 Harmful Algal Bloom and Hypoxia Research and Control Act authorization expired—you know, if we turn the military loose on that, they can come up with an acronym for that act. We passed a reauthorization in the House in 2010, and I want to commend Brian Baird, a former Member of this Committee, for his good work on that legislation, but the Senate did not act on it as was true with many other issues. It appears that there remains some interest in ensuring that HAB research continues with the draft legislation we are discussing today, which does appear very similar in many respects to the legislation that Brian Baird worked on in the last Congress. But I am a little disappointed that we are holding a legislative hearing on this new draft HABs reauthorization without the witnesses having had sufficient time to review and to comment on the draft. I understand the witnesses did not receive the discussion draft until last Tuesday night, and especially for those witnesses speaking on behalf of government agencies, it is very hard to turn around written testimony in that period of time. But I hope that the two agency witnesses whose written testimony did not include official comments may be able to comment in their testimony today, at least in response to our questions.

Witness testimony was invaluable in developing the 2010 version of the bill, and I understand that the draft is almost the same as the previous legislation but contains a number of word changes and in its current form does not include the freshwater HABs and authorization level section. While I understand you intend to add, Mr. Chairman, those sections later in the process, it would be very helpful if our witnesses could review that and provide comments so we can create the best bill possible. The excluded sections could affect the results and success of the program, and while there may be an opportunity for technical comments later from these witnesses and from those with whom they consult, a primary purpose of legislative hearings like this one is to discuss technical questions. It is to get into the weeds.

I hope as we move forward that we can work together and with more consideration for everyone's time. Reducing HABs can and should be a bipartisan effort. It was in the last Congress, it should be again, and I hope that will be the case this time. We must continue to invest in a way that will move this research forward and advance our understanding of these blooms and their hypoxic effects. We need to monitor, mitigate, and control these occurrences better and to prevent them, if possible.

We have a very distinguished panel of witnesses here today who do think about harmful algal blooms every day of their lives, and I hope they will offer us their best testimony possible that we can move forward in responding to the problem.

Again, I want to thank all the witnesses for being here today, and thank you, Mr. Chairman. I yield back 15 seconds of time.

[The prepared statement of Mr. Miller follows:]

PREPARED STATEMENT OF RANKING MEMBER BRAD MILLER

Thank you Chairman Harris. I want to also welcome the witnesses to today's hearing. Harmful algal blooms (HAB) and their hypoxic effects may not be something that most of us think about every day, but it is an important issue that affects many of our districts.

For the past two years this Subcommittee and Committee has discussed the effect of harmful algal blooms and the resulting hypoxia on our coastlines and in freshwater. HABs pose a serious threat because of toxins they can produce and because they reduce oxygen and sunlight in the water. These threats alter the ocean's food web, affect human health, and create economic losses for communities and commercial fisheries.

In addition to hearing about the effects of Harmful Algal Blooms, we will also discuss the draft legislation for the reauthorization of the Harmful Algal Bloom and Hypoxia Research and Control Act.

Because of the 1998 Harmful Algal Bloom and Hypoxia Research and Control Act and the 2004 reauthorization, we have made significant advances in our research findings and have taken important steps to solve some of the problems created by harmful algae blooms. However, numerous reports and assessments, required by this law, have revealed an increase in the number, frequency, and type of hypoxic events and blooms in recent years. We need to continue this valuable research and implement strategic national and regional plans.

In 2010 Harmful Algal Bloom and Hypoxia Research and Control Act authorization expired. We passed a reauthorization in the House last year but the Senate did not act on it. It appears that there remains some interest in ensuring that HAB research continues with the draft legislation we are discussing today.

I am a little disappointed, however, that we are holding a legislative hearing on this new draft HABs reauthorization without the witnesses having sufficient time to review and comment on the draft. I understand that the witnesses did not receive the discussion draft until last Tuesday night. Therefore, the two agency witnesses' written testimonies do not include official comments on the bill.

Witness testimony was invaluable in developing the 2010 version of this bill. I understand that your draft is almost the same as the previous version, but contains a number of word changes, and in its current form does not include the freshwater HABs and authorization levels sections. While I understand you intend to add these sections later in the process, it would be very helpful if our expert witnesses could review them and provide comments so that we can create the best bill possible. These excluded sections could affect the results and success this program has seen in the past. While there will be opportunity for technical comments later from these folks, a primary purpose of legislative hearings like this one is to discuss technical questions. I hope as we move forward with this bill that we can work together better and with more consideration for everyone's time. Reducing HABs can and should be a bipartisan effort, as it has been in the past; and I hope that will be the case this time around.

We must continue to invest in a way that will move this research forward and advance our understanding ofthese blooms and the hypoxic events they cause. We need to monitor, mitigate, and control these occurrences better and to prevent them, if possible.

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

Again, I want to thank all of our witnesses for being here today. And, thank you, Mr. Chairman. I yield back the balance of my time.

Chairman HARRIS. Thank you very much, Mr. Miller, and obviously I am new around here, but I think we gave the same eight days to the witnesses to see the legislation, that they got last year, before last year's legislation. So hopefully we are welcome to the comments.

If there are other Members who wish to submit additional opening statements, your statements will be added to the record at this point.

At this time I would like to introduce our witness panel. Our first witness will be Dr. Robert Magnien, the Director of the Center for Sponsored Coastal Ocean Research at NOAA. He serves on the Interagency Working Group on Harmful Agal Blooms, Hypoxia, and Human Health and is the U.S. representative in care of the Intergovernmental Oceanographic Commission Panel on HABs. Before joining NOAA, he spent 20 years in the Chesapeake Bay Program for the State of Maryland.

Dr. Richard Greene, our second witness, is the Chief of Ecosystem Dynamics and Effects Branch at the Environmental Protection Agency's Gulf Breeze Laboratory. He also serves as the EPA's representative on the Interagency Mississippi River/Gulf of Mexico Watershed Nutrients Task Force Coordinating Committee.

Dr. Don Anderson is a Senior Scientist in the Biology Department of the Woods Hole Oceanographic Institute. He also serves as the Director of the U.S. National Office for Harmful Algal Blooms. In addition to active field and lab research, Dr. Anderson is very involved in national and international program development for research, monitoring, and training on marine biotoxins and harmful algal blooms.

Dr. Kevin Sellner is the Executive Director of the Chesapeake Research Consortium, encouraging active research programs across six consortium member institutions and their extended partners. In addition to being a plankton ecologist for the last 30 years, Dr. Sellner also serves as the Executive Secretary of the Chesapeake Bay Program's Scientific and Technical Advisory Committee, is a member of the USGS Chesapeake Bay Science Advisory Team, member of the Maryland Harmful Algae Task Force and organizer for the Chesapeake Community Modeling Program.

Dr. Stephanie Smith is the Chief Scientist for the private technology firm Algaeventure Systems. Prior to her current work, Dr. Smith served as the Senior Scientist in the applied biology and aerosol technology product line at Battelle and also built an extramural research program at Wright State University in Dayton, Ohio.

Finally, Dr. Beth McGee is the Senior Water Quality Scientist at the Chesapeake Bay Foundation, the largest non-profit organization dedicated to protecting and restoring the Chesapeake Bay. Prior to her work at the Foundation, Dr. McGee has worked on water quality issues, conducted research, and served on several technical Subcommittees and advisory groups. Dr. McGee has also worked for a variety of state and federal agencies including the U.S. Fish and Wildlife Service, the U.S. EPA, and the Maryland Department of the Environment.

I welcome all our witnesses. As the witnesses should know, spoken testimony is limited to five minutes each, after which the Members of the Committee will have five minutes each to ask questions.

I now recognize our first witness, Dr. Robert Magnien, Director, Center for Sponsored Coastal Ocean Research at NOAA.

STATEMENT OF DR. ROBERT MAGNIEN, DIRECTOR OF THE CENTER FOR SPONSORED COASTAL OCEAN RESEARCH, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA)

Dr. MAGNIEN. Good afternoon, Mr. Chairman, and Members of the Subcommittee. As noted, my name is Robert Magnien, and I am Director for NOAA's Center for Sponsored Coastal Ocean Research. In this capacity, I have managed the only national research program focused solely on harmful algal blooms and hypoxia. These five programs are authorized under the Harmful Algal Bloom and Hypoxia Research and Control Act. We fondly refer to it as HABHRCA. That is our short name for it.

Mr. MILLER. Thank you, Dr. Magnien.

Dr. MAGNIEN. HABs and hypoxia represent significant threats to the health of the American public and the U.S. economy. Algae are simple microscopic plants that are normally beneficial because they provide the primary source of energy to sustain aquatic life. However, during harmful blooms which occur in all U.S. States, algae threaten human health through toxins that can enter seafood or drinking water supplies. Harmful blooms also threaten economically and recreationally important coastal resources such as fish, shellfish, sea birds, and marine mammals.

Hypoxia, or more commonly known as dead zones, refer to critically low levels of light-sustaining oxygen in water bodies. These zones occur in over 300 coastal systems, including the Great Lakes. There has been a 30-fold increase in coastal systems affected by hypoxia since 1960.

HAB and hypoxia management are particularly challenging because of the complex underlying causes as well as the great difficulties in detecting and predicting these threats. Giving the growing threat of HABs and hypoxia, along with different challenges in different regions, there is a compelling need to strategically target and coordinate research.

HABHRCA has required NOAA to lead federal agencies in preparing five reports that assess the causes and impacts of HABs and hypoxia and plans to improve management and response. These reports were submitted to Congress between 2007 and 2010 and provide guidance for NOAA's HABs and hypoxia programs as well as other federal- or state-supported research.

A major part of NOAA's responsibility is its leadership of the Nation's only competitive research programs that focus solely on HABs and hypoxia. In addition to the competitive programs, NOAA supports a diverse portfolio of internal research.

I will spend the remainder of my time reviewing just a few of the important advances we have made in the management and mitigation of HABs and hypoxia impacts. From years of focused HABHRCA research, we are seeing the expansion of HAB forecasting capabilities that are nearing or actually in an operational status in the Gulf of Mexico, Lake Erie, New England, Chesapeake Bay, and the Pacific Northwest. Similar to severe weather forecasts, these early warnings allow coastal managers and other resource users to take precautionary and proactive measures that minimize risks to human health and coastal economies.

Detection of HABs is a critical first step in protecting human health. HABHRCA research has developed new molecular technologies for rapid and inexpensive detection of HABs and their toxins. These are now being adopted for routine use in a number of states.

In order to manage hypoxia, alternative management options must be generated using models that synthesize complex ecosystem phenomena that cause this program. HABHRCA authorized research has provided this predictive capability for the Nation's largest hypoxic zone, the northern Gulf of Mexico, providing the scientific foundation for the action plan of the Interagency Mississippi River/Gulf of Mexico Watershed Nutrient Task Force. Similar prediction tools are nearing completion to support management decisions in Narragansett Bay and Lake Erie.

Our hypoxia research is also yielding important findings of widespread chronic reproductive impairments in Gulf of Mexico fish. In Chesapeake Bay, innovative modeling tools are being developed to more quantitatively document the impacts of hypoxia on living resources in order to better tailor our management plans.

So those are just the very few of the accomplishments that are bringing practical, science-based solutions to bear on these serious problems. This has led to direct and significant improvements in HAB and hypoxia management and new capabilities in states who are often on the front lines of protecting public health and vital economic interests.

NOAA strongly supports the reauthorization of HABHRCA and its specific programs so that we, along with our scientific and management partners, can continue to build on this strong record of accomplishment.

Thank you for this opportunity to update you on NOAA's HAB and hypoxia programs.

[The prepared statement of Dr. Magnien follows:]

PREPARED STATEMENT OF DR. ROBERT MAGNIEN, DIRECTOR OF THE CENTER FOR SPONSORED COASTAL OCEAN RESEARCH, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA)

Introduction

Good morning Mr. Chairman and members of the Subcommittee. My name is Robert Magnien and I am the Director of the National Oceanic and Atmospheric Administration's (NOAA) Center for Sponsored Coastal Ocean Research (CSCOR). CSCOR, as one Center of the National Centers for Coastal Ocean Science, 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 Subcommittee on Ocean Science and Technology to coordinate NOAA's programs with other federal agencies. I also serve as NOAA's representative to the Coordinating Committee for the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force, which is addressing the Nation's largest hypoxic zone in the northern Gulf of Mexico. Additionally, I serve as the U.S. representative and Chair of the Intergovernmental Oceanographic Commission panel on HABs to maximize international opportunities for exchange of relevant research and management information. Though I am the Director of CSCOR, this testimony speaks about programs across NOAA, where multiple offices work together to achieve mission goals.

NOAA's mandate includes protecting the lives and livelihoods of Americans, and providing 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 cause significant adverse human health and economic impacts.

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 ecosystems,[3] including the Great Lakes. There has been a 30-fold increase in hypoxia events since 1960, 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.

At this very time, with unprecedented amounts of freshwater and associated nutrients and other chemicals entering the Gulf of Mexico from the Mississippi River Basin, we are witnessing some of these complex factors that drive HABs and hypoxia. NOAA's longstanding HABHRCA research has demonstrated the relationship between nutrient inputs and hypoxia and provided the ability to forecast the size of the hypoxic zone both in the short-term and for long-term management purposes. In addition, NOAA's spring flood outlook, issued in mid-February, indicated a "high risk" for flooding along the Mississippi. Based on the high flows and expected high nutrient loads which will be measured by the U.S. Geological Survey, this year's zone will likely be one of the largest ever. NOAA will issue its annual forecast for the size of the hypoxic zone in June. There is also the potential for toxic algal blooms to develop in Lake Pontchartrain as has been the case in the past when floodwaters have been diverted into the lake. NOAA is moving on a number of fronts to assist in the response to the flooding, including adding capabilities onto its existing HABHRCA research, monitoring, and response projects in the Gulf region in order to provide local, state, and federal officials with the latest and most scientifically accurate information on these coastal impacts.

I appreciate the opportunity to update the Subcommittee on major accomplishments in NOAA's HAB and hypoxia programs. I will first describe the nature of the problem in more detail, then discuss NOAA's role in addressing HABs and hypoxia in our coastal and Great Lakes waters, and conclude with some of the significant advances that NOAA has made as a result of HABHRCA.

Harmful Algal Blooms in the United States

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 ex-

[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, an dHuman 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. Hypoxia, and Human Health of the 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] Committee on Environment and Natural Resources. 2010. 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., 164 pp.

cessively large numbers. When this occurs they are referred to as "harmful algal blooms" or HABs. Sometimes, certain algal species accumulate in such high numbers that they discolor the water, and are commonly referred to as "red tides" or "brown tides." Figure 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 estimate 1A[4] suggests that HABs occurring in marine waters alone have an average annual impact of $82 million in the United States. This is a conservative estimate since comprehensive data that includes the various economic impacts of all major blooms is not available. 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 significant 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 type, scope and severity, which led to the need for specific management approaches for each region and species and region-specific scientific understanding to support an effective and efficient management response. 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, essentially being 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.

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[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. Globabl Ecology and Oceanography of Harmful Algal Blooms, Harmful Algagl Blooms in Eutrophic Systems. P. Gilbert (ed.). IOC and SCOR, Paris and Baltimore, 74 pp.

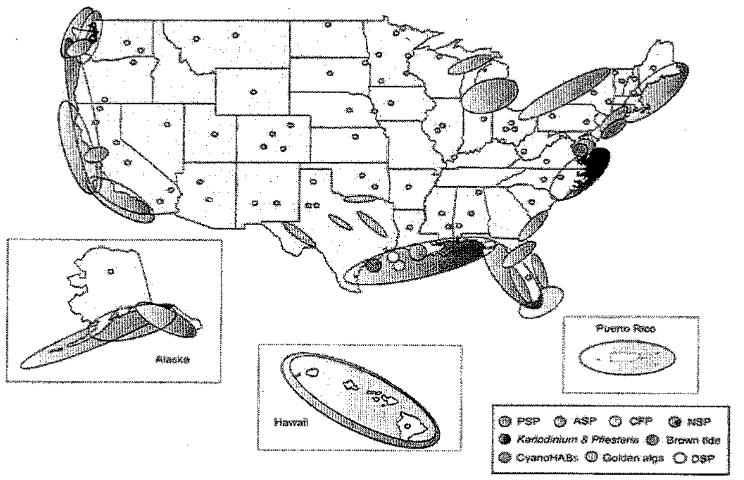

Figure 1. Distribution of major HAB syndromes and events in the U.S. Source: NOAA U. S. National Office for Harmful Algal Blooms (http://www.whoi.edu/redtide/page.do?pid=14898), Woods Hole, MA.

As noted above, the causes of HABs are complex and are controlled by a variety of factors. While we know that the underlying causes leading to 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 complicates 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. 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. 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, upwelling 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 and shift species distributions geographically. (http://www.cop.noaa.gov/stressors/extremeevents/hab/current/CC—habs.aspx).

Hypoxia in the U.S.

Hypoxia means "low oxygen." In aquatic systems, low oxygen generally refers to a dissolved oxygen concentration less than 2 to 3 milligrams of oxygen per liter of

[7] Heisler, J., Glibert, P.M., Burkhold3er, 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.

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 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 tolerant 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 ecosystems3 now experiencing hypoxia (see Fig. 2). The increasing occurrence of hypoxia in coastal waters 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, nonpoint source atmospheric deposition, and nonpoint 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 nonpoint sources, such as agriculture, is more difficult to control. Conservation programs, such as those administered by USDA's Natural Resources Conservation Service, play an important part in helping to reduce edge of field runoff from agricultural operations. Although progress has been made in recent years to better optimize nutrient application through the development of nutrient management plans and best practices, 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. The USDA Agricultural Research Service has led recent efforts to design drainage control structures to increase retention time and denitrification in drainage systems. Wetlands serve as filters and can reduce the transport of nitrogen and phosphorus 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.

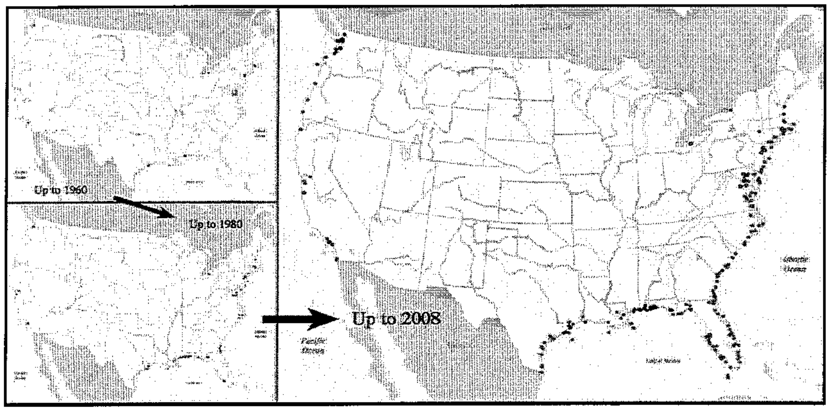

Figure 2. Change in number of U.S. coastal areas experiencing hypoxia from 12 documented areas in 1960 to over 300 now. Not shown here are one hypoxic system in Alaska and one in Hawaii. Source: adapted from Committee on Environment and Natural Resources. 2010[3]

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 within the National Ocean Council has been meeting regularly to coordinate interagency efforts with regard to HABs and hypoxia. A major focus for the group has been developing the five reports mandated by the 2004 reauthorization of HABHRCA. The reports were submitted to Congress between 2007 and 2010 (http://www.cop.noaa.gov/stressors/extremeevents/hab/habhrca/Report—Plans.aspx). These reports provide guidance for NOAA HAB and hypoxia programs as well as other federal or state-supported research that may address aspects of these topics. 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 in 2009. The Plan also highlights the need for an enhanced HAB event response program and a new infrastructure program, which were incorporated into legislation to reauthorize HABHRCA in the 111th Congress.

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

[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, an Human Health of the Joint Subcommittee on Ocean Science and Technology. Washington, DC., 76 pp.

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 Ecosystem and Hypoxia Assessment Program (NGOMEX) supports multiyear, 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 multiyear, 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 ecosystems, 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 by scientists from the National Centers for Coastal Ocean Science 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 levels in the food web, including fish, mammals, and 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 HAB forecasts for Florida and Texas coastal waters (http://tidesandcurrents.noaa.gov/hab/) and has developed plans for a National HAB Forecasting System, which will make routine forecasts in any areas where HABs are a major threat. Forecasts in the Great Lakes, the Gulf of Maine, and the Pacific Northwest are in various stages of development and transition to operations through a combination of extra- and intramural research efforts.

NOAA scientists have been instrumental in developing citizen HAB monitoring networks around the country. Additionally, the NOAA Analytical Response Team (http://www.chbr.noaa.gov/habar/eroart.aspx) and the Wildlife and Algal Toxin Research and Response Network (WARRN–West, http://www.nwfsc.noaa.gov/warrnwest/) provide state-of-the-art toxin analyses during HAB events, especially events that involve unusual animal mortality.

NOAA coordinates and collaborates across the agency on HABHRCA-authorized HAB and hypoxia programs and related efforts to address high priority needs for research, observations, and forecasting. Many of NOAA's HAB and hypoxia accomplishments have resulted from these coordinated efforts and through external partnerships.

Major Accomplishments

Since the original HABHRCA legislation in 1998, several significant advances have greatly improved management. Many of these accomplishments are described in the five HABHRCA reports that were submitted to Congress. Rather than list every accomplishment, I will focus on recent outstanding achievements.

Harmful Algal Blooms

In the last few years, 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 Florida, the operational forecast system has issued over 500 forecasts since September 2004. These include the critical 2005 year, when *Karenia brevis* blooms (Florida red tide) struck three regions of Florida, on both the east and west coast, and produced anoxia on the Florida shelf for the first time in over 30 years. This forecast was made operational by strong NOAA-wide coordination, particularly between the National Ocean Service and National Environmental Satellite, Data, and Information Service, which processes and analyzes NASA MODIS satellite data through its Coast Watch Program.
- In Texas, an operational forecast began in September 2010 (following a several year demonstration). This system added new modeling capabilities which increase the adaptability of the forecasts. Previously, managers could respond only in a bay with a reported problem, and had no information as to which other bays were at greatest risk. The new forecasts provide this information to better target sampling and response. This is particularly important given the appearance in 2008 and 2010 of toxic blooms of *Dinophysis*, which were previously unknown in this area.
- In the Gulf of Maine, NOAA-funded researchers have issued seasonal advisories every year since 2008. Each spring they predict the severity and extent of 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 prediction provides state resource and public health managers time to prepare for the intensive monitoring required to protect public health and assists shellfish harvesters and processors in making business decisions. Weekly forecasts of *Alexandrium* distributions, based on models and weather forecasts, are also provided to state and local shellfish and public health managers around the Gulf of Maine via a listserv.
- In western Lake Erie, NOAA scientists have developed a Forecast System for cyanobacterial blooms starting in 2008. These blooms of the cyanobacterial HAB *Microcystis* have been recurring each summer for over 10 years, with particularly severe blooms in 2003, 2009, and 2010. The blooms are a significant expense for public water suppliers, and a potential human health risk through recreational use. In 2010, over 150 resource managers and local decision makers received the weekly demonstration forecasts of bloom location and intensity based on a sophisticated combination of satellite imagery from the European Space Agency (ENVISAT–1), circulation models, water analysis and meteorological data. In early October, NOAA determined that the bloom had ended, allowing Ohio to safely end sampling and analysis of water. (http://www.glerl.noaa.gov/res/Centers/HABS/lake__erie__hab/lake__erie__hab.html)
- In Chesapeake Bay, a novel forecasting technique using a hybrid approach of water quality modeling and statistical techniques to predict HABs is nearing operational status. This forecasting tool also holds promise for other important applications such as pathogens and fish habitat which have been difficult to predict using other methodologies.
- 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 by humans. 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, these scientists 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.

- State, local, and tribal shellfish and public health managers need quick tests that can be used for cheap and rapid screening for toxicity in many shellfish samples. NOAA- sponsored state, federal, and academic partnerships have demonstrated that new quick tests are reliable for screening large numbers of samples to rapidly assess the presence of HAB toxins in both shellfish and seawater and helped incorporate the new protocols into existing shellfish monitoring programs. States that routinely employ advanced HAB toxin screening tools include Washington, Oregon California, Florida, and Maine, and it is part of the screening method for the Shipboard/Dockside Screening Protocol for shellfish harvesting in Federal waters of Georges Bank.
- In Chesapeake Bay, new molecular techniques for detection of harmful algal species developed through the competitive HABHRCA programs are now in routine use by state agencies responsible for protecting resources and public health. These programs also allowed the state of Maryland to develop a unique and highly successful "Eyes on the Bay" website to display and communicate the latest information on HABs, hypoxia, and other observations in Chesapeake Bay. (http://mddnr.chesapeakebay.net/eyesonthebay/habs.cfm)
- For the last three years, a new instrument, developed and maintained with NOAA funding and located at Port Aransas Pass in Texas, has provided early warning of HAB outbreaks, resulting in closures of oyster harvesting before there were any human health impacts. One of the species detected has never before caused problems in the U.S., although it is common in Europe and there was no routine monitoring in place for that organism.

NOAA is addressing gaps in our understanding of the causes of HABs and responding to emerging HAB issues.

- Ciguatera fish poisoning (CFP) is the most common HAB-caused seafood illness in tropical and subtropical areas of the world. The incidence is increasing, perhaps linked to anthropogenic causes, such as overfishing, eutrophication and global warming. Economic impacts in the U.S. due to human illness, which are believed to be hugely under-reported, are estimated to be $21M/yr. [9] The causative toxins were thought to come from one HAB species but NOAA scientists have determined that the difficulty in predicting CFP outbreaks is because there are multiple species of varying toxicity. Studies are underway to understand what controls the distribution and toxicity of these species in order to allow public health managers to minimize the incidence of this illness.
- Fish-killing algae in the Pacific Northwest have been shown to have severe economic impacts on mariculture. In addition, these algae might be a major factor in controlling the size of some wild salmon runs. NOAA scientists and NOAA-funded scientists are trying to identify the very ephemeral toxin and determine the causes of the blooms in order to develop protocols to minimize impacts on mariculture.

NOAA has always funded research on novel HAB mitigation and control measures through its existing HAB research programs. However, as our understanding of the causes of HABs has improved, more opportunities for preventing and controlling HABs have become available. In 2009, NOAA announced the establishment of a new Prevention, Control, and Mitigation of HABs Program, which is described above. The first projects were funded in 2010, and involve a diverse array of approaches on which we will be reporting at a later date.

Hypoxia

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. [10] 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. NOAA also forecasts and tracks the extent of hypoxia each year utilizing a number of internal and external programs and in concert with other fed-

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[9] Anderson, D.M., Hoagland, P., Kaoru, Y., and White, A.W. 2000. Estimated Annual Economic Impacts from Harmful Algal Blooms (HABs) in the United States. Technical Report WHOI 2000-11. Woods Hole Oceanographic Institution, 99pp.

[10] 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.

eral agencies. 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, the U. S. Department of Agriculture, and other federal and state agencies in developing science-based management strategies to reduce nutrient pollution contributing to the Gulf of Mexico hypoxic zone. The Assistant Secretary of Commerce for Conservation and Management, Dr. Larry Robinson, sits on the interagency Mississippi River/Gulf of Mexico Watershed Nutrient Task Force, and NOAA also plays a leading role on the Task Force's Coordinating Committee. 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 total nitrogen and phosphorus.

NOAA-funded research through the NGOMEX program has demonstrated that widespread reproductive impairment (reduced ovarian and testicular growth in adults, and decrease in hatching success and larval survival) 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, adding to a growing body of evidence that non-lethal hypoxia impacts pose long-term threats to living resource populations in hypoxic zones. Other studies are determining the impacts of hypoxic zones on the economics of shrimp fisheries, and on populations of other ecologically and commercially valuable fisheries.

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 State nutrient reduction criteria[11] for waste water treatment plants (WWTPs). These predictive modeling tools will provide alternative management options for WWTPs (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 WWTPs into local rivers that drain into Narragansett Bay.

CONCLUSION

Thank you for this opportunity to update you on NOAA's HAB and hypoxia programs. Over the last twelve years, we have made enormous progress in understanding the causes and consequences of HABs and hypoxia. This has led to direct and significant improvements in HAB and hypoxia management which have, in turn, protected public health and vital economic interests. The Administration supported reauthorization of HABHRCA in the last Congress and continues to support reauthorization in the 112th Congress. We just recently received the draft legislation. We will review it, along with other interested Departments and agencies. We would appreciate an opportunity to comment before the Subcommittee considers the legislation.

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.

[11] RIDEM. 2005. Plan for managing nutrient loadings to Rhode Island waters (http://www.dem.ri.gov/pubs/nutrient.pdf). 17 pp. and RIDEM. 2006. Water quality regulations. Office of Water Resources, Department of Environmental Management, State of Rhode Island and Providence Plantations. [http://www.dem.ri.gov/programs/benviron/water/quality/surfwq/index.htm]

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 [12].

†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)

Chairman HARRIS. Thank you very much. I now recognize our second witness, Dr. Richard Greene, Chief of Ecosystems Dynamic and Effects Branch, Gulf Breeze Laboratory at the EPA. Dr. Greene?

STATEMENT OF DR. RICHARD GREENE, CHIEF, ECOSYSTEMS DYNAMICS AND EFFECTS BRANCH, GULF ECOLOGY DIVISION, OFFICE OF RESEARCH AND DEVELOPMENT, U.S. ENVIRIONMENTAL PROTECTION AGENCY (EPA)

Dr. GREENE. Thank you, Mr. Chairman. Chairman Harris, Ranking Member Miller, and other Members of the Subcommittee. It is a pleasure to be here with you today to discuss EPA's research relating to HABs and hypoxia.

As you know, I am Richard Greene, with EPA's Office of Research and Development. For the last 13 years, I have been the

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

Chief at the Gulf Ecology Division. I have a Ph.D. in Oceanography, and for the last ten years have been the ORD lead for Gulf hypoxia and estuarine nutrient research. Although I serve in an ecology research division along the Gulf, this testimony addresses programs across EPA offices and laboratories relevant to the focus of this hearing.

Toxic or otherwise harmful algal blooms, or HABs, and hypoxia, which is low dissolved oxygen, represent significant and continuing threats to freshwater, estuarine and coastal ecosystems, aquatic life, and to human health. Scientific understanding of the causes and impacts of HABs and hypoxia on aquatic resources and human health has progressed over the last five to ten years. However, there is still much to be learned to improve our ability to predict when and where those events will occur, the specific impacts they will have on human health and aquatic ecosystems and how best to prevent, control or mitigate those problems.

We know that by and large many HAB and hypoxia events are inextricably linked to nitrogen and phosphorus pollution. We need to improve the science supporting the development of sustainable solutions for controlling and reducing nutrient pollution, HABs and hypoxia, to protect water resources and human health. EPA, working with NOAA and other federal, state and private-sector partners is committed to that goal.

In the area of freshwater HABs, EPA's National Aquatic Resource Surveys are contributing important information necessary to evaluate the extent and impact of harmful algae, nutrients and other key indicators on ecological condition and potential human health risks.

The 2009 report on the national lakes assessment included three indicators with respect to the condition and safety of recreational water use. The study reported the microcystin, a cyanotoxin, and one of the indicators measured was present in about 30 percent of lakes and at levels of concern in about one percent of lakes based on World Health Organization thresholds of risks.

While the survey results are a good start in our understanding, much more needs to be learned about algal toxins in lakes. For example, it is currently unknown how microcystin occurrence correlates with the occurrence of other classes of cyanotoxins that were not measured or the associated human health risks. There are relatively few documented cases of severe human health effects in this country associated with exposure to cyanobacteria or their toxins. However, EPA is conducting research to assess human exposure and effects in drinking water systems in certain parts of the United States.

EPA coordinates and collaborates with NOAA and other federal agencies, as well as state and academic institutions on research in the northern Gulf hypoxic zone. EPA has ongoing research in the northern Gulf to assess and predict the relationships between nutrient loads and hypoxia; the physical, chemical and biological processes regulating dissolved oxygen; and the effects of nutrient load reduction scenarios on hypoxia.

The research and modeling efforts under way fill important research gaps identified in 2007 by EPA's Science Advisory Board, State of the Science Evaluation, regarding Gulf hypoxia and are critical to information needs and goals of the Gulf Hypoxia Task Force.

HABHRCA identifies two interagency task groups, the HABs and Hypoxia Task Force which is chaired by NOAA, and the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force, also known as the Gulf Hypoxia Task Force which is co-chaired by EPA.

EPA is an active participant in the HABs and Hypoxia Task Force which, among other responsibilities, implements HABHRCA's reporting requirements. The Gulf Hypoxia Task Force is comprised of 17 State and federal agencies. It provides a forum for State water quality and agriculture agencies to partner on the best means to prevent, control or—sorry, state, local and regional efforts to address nutrient loading, encouraging a holistic approach that takes into account upstream sources and downstream impacts. Its federal and State members, including EPA, have assisted in organizing and providing technical and funding support for two nutrient reduction strategy workshops, the second of which will occur in Columbus, Ohio, in mid-June.

The Task Force Working Group is developing a proposed set of indicators of progress to measure progress towards addressing nitrogen and phosphorus pollution in the Mississippi River Basin and reducing the size of the hypoxic zone.

In conclusion, EPA has made progress in understanding and addressing harmful algal blooms, hypoxia and the broader issues of nutrient pollution in the United States. However, there is much more to be done.

Thank you for the opportunity to be here today, and I will be happy to answer questions.

[The prepared statement of Dr. Greene follows:]

PREPARED STATEMENT OF DR. RICHARD GREENE, CHIEF, ECOSYSTEMS DYNAMICS AND EFFECTS BRANCH, GULF ECOLOGY DIVISION, OFFICE OF RESEARCH AND DEVELOPMENT, U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA).

Good afternoon Chairman Harris, Ranking Member Miller, and other members of the Subcommittee. My name is Richard Greene, with EPA's Office of Research and Development (ORD). For the last 13 years, I've served as Chief of the Ecosystem Dynamics and Effects Branch at the Gulf Ecology Division, within the National Health and Environmental Effects Research Laboratory. I have a Ph.D. in Oceanography and over the last 10 years have been the ORD lead for Gulf of Mexico hypoxia research and estuarine nutrient research in the Gulf. Although I serve in an ecology research Division along the Gulf of Mexico, this testimony addresses programs across EPA offices and laboratories relevant to the focus of this hearing. It is a pleasure to be here with you today to discuss the EPA's research relating to harmful algal blooms and hypoxia.

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

Toxic or otherwise harmful algal blooms and hypoxia, or low dissolved oxygen, represent significant and continuing threats to freshwater, estuarine and coastal ecosystems, aquatic life and human health. Scientific understanding of the causes and impacts of harmful algal blooms and hypoxia on aquatic ecosystems and human health has progressed over the last 5–10 years. However, there is still much to be learned to improve our ability to predict when and where those events will occur, the specific impacts they will have on human health and aquatic ecosystems, and how best to prevent, control or mitigate those problems. We know that by-and-large many HAB and hypoxia events are inextricably linked to nitrogen and phosphorus pollution. However, we need to improve the science supporting the development of sustainable solutions for controlling and reducing nutrient pollution, HABs and hypoxia, and protecting water resources and human health. EPA, working with NOAA, and other federal, state, and private sector partners, is committed to that goal.

Nationally, nitrogen and phosphorus pollution is one of the top causes of water quality impairments. EPA's National Aquatic Resource Surveys (NARS) show that of the stressors assessed, nitrogen and phosphorus are the most pervasive in the nation's wadeable streams, with more than 200,000 stream miles showing high concentrations (those greater than 95 percent of the regionally-relevant least-disturbed reference condition).[1] The NARS also report that an estimated four million lake acres showed high concentrations of phosphorus, and 1.9 million acres showed high concentrations of nitrogen.[2] Streams and lakes with high levels of nitrogen and phosphorus were about two times more likely to have poor biological health.[3] For streams, biological health was determined by evaluating the health of macroinvertebrate communities compared with least-disturbed, regionally-relevant, reference conditions. In lakes, biological condition was determined by analyzing the condition of zooplankton and phytoplankton communities using an observed/expected model. The ecological impacts of excess nutrients on our waters includes harmful algal blooms. The recent NARS lakes assessment found microcystin (an algal toxin that can harm humans, pets, and wildlife) present in about one-third of lakes and at levels of concern in one percent of lakes based on World Health Organization recreational exposure guidelines.[4] Although there are relatively few documented cases of severe human health effects, exposure to cyanobacteria or their toxins may produce allergic reactions such as skin rashes, eye irritations, respiratory symptoms, and in some cases gastroenteritis, liver and kidney failure, or death. The most likely exposure route for humans is through accidental ingestion or inhalation during recreational activities, though cyanotoxins are also potentially a cause for concern in drinking water.[5]

Under Section 303(d) of the Clean Water Act, states develop lists of impaired waters every two years and are then required to develop clean-up plans, also known as Total Maximum Daily Loads (TMDLs), for those waters. A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still safely meet water quality standards. Currently, more than 15,800 waters have nitrogen- or phosphorus-related impairments. States or EPA has developed more than 8,000 nitrogen- or phosphorus-related TMDLs for more than 5,000 of these waters.

Grand Lake St. Marys stands out as one recent example of the potentially significant and far-reaching costs associated with the human health, economic, recreational and ecosystem impacts of nitrogen- and phosphorus-contaminated waters. Grand Lake St. Marys, Ohio's largest inland water body, has suffered from increasing nitrogen and phosphorus loading from farm runoff, failing septic systems, and fertilizer applied to lawns. As a result, the lake has experienced massive blooms of toxic cyanobacteria, which have led to the death of fish, birds, and dogs, and illnesses of at least seven people. The State of Ohio has issued fish consumption, recreational use, and health warnings, including "no contact" and "algal bloom" advisories.[6]

In addition to Grand Lake St. Marys, freshwater HABs or the cyanoHABs have now been documented in at least 35 states and at least 18 states now have some type of CyanoHAB research or response program.

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[1] Wadeable Streams Assessment: A Collaborative Survey of the Nation's Streams EPA 841–B-06–002 December 2006. Chapter 2—see page 35—http://water.epa.gov/type/rsl/monitoring/streamsurvey/upload/2007__5__9__streamsurvey__05__chap2a__5-2-07.pdf

[2] Note—The NLA reported information as the number and/or percent of lakes. See—U.S. Environmental Protection Agency (USEPA). 2009. *National Lakes Assessment: A Collaborative Survey of the Nation's Lakes*. EPA 841-R-09-001. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, D.C. See Chapter 3—http://water.epa.gov/type/lakes/upload/nla-newchapter3.pdf. To make the lake statement more consistent with the streams statement (e.g., using miles and acres rather than miles and percent of lakes), ORD–Corvallis calculated the area associated with the % of lakes presented in the NLA document on page 26. The area figures were emailed by Steve Paulsen, EPA-ORD to Sarah Lehmann, EPA-OW on 2-16-2011.

[3] Wadeable Streams Assessment: A Collaborative Survey of the Nation's Streams EPA 841 - 06-002 December 2006. See Chapter 2—page 49. http://water.epa.gov/type/rsl/monitoring/streamsurvey/upload/2007__5__14__streamsurvey__06__chap2b__5-2-07.pdf

[4] U.S. Environmental Protection Agency (USEPA). 2009. *National Lakes Assessment: A Collaborative Survey of the Nation's Lakes.* EPA 841-R-09-001. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, D.C. See Chapter 4—http://water.epa.gov/type/lakes/upload/nla__newchapter4.pdf

[5] IBID

[6] Spencer Hunt, *New Tests find Grand Lake St. Marys Safe,* The Columbus Dispatch, 30 Oct. 2010. *One Algal Toxin Advisory Removed; Others Continue*, Ohio EPA. 29 Oct. 2010. Ohio EPA http://www.epa.state.oh.us/pic/glsm__algae.aspx

EPA continues to evaluate the human health implications of cyanoHABs and the toxins they produce in drinking water. Cyanotoxins have been included in all three Candidate Contaminant Lists (CCL) published so far pursuant to the Safe Drinking Water Act. EPA must periodically publish this list of contaminants and decide whether to regulate at least five or more contaminants on the list. A drinking water CCL is the primary source of priority contaminants from which EPA makes decisions about whether regulations are needed. The contaminants on the list are known or suspected to occur in public water systems but are currently unregulated by existing drinking water standards. The Agency included cyanotoxins as a group in the most recent CCL (CCL 3, October 8, 2009) and focuses research and data collection on three algal toxins: Anatoxin-a; Microcystin-LR; and Cylindrospermopsin.

EPA RESEARCH

Freshwater HABs

EPA's National Aquatic Resource Surveys are beginning to contribute significant information necessary to evaluate the extent and impact of harmful algae, nutrients, and other key indicators on ecological condition and potential human health risks. The 2009 report on the National Lakes Assessment included three indicators with respect to the condition and safety of recreational water use: 1) microcystin—a common algal toxin, 2) cyanobacteria—the group of unicellular or filamentous algae, some of which produce algal toxins, and 3) chlorophyll-a—a measure of all algae present. The study reported that microcystin was present in about 30% of lakes and at levels of concern in about 1% of lakes, based on World Health Organization thresholds of risk. While the survey results are a good start in our understanding, much more is to be learned about algal toxins in lakes. For example, it is currently unknown how well microcystin occurrence correlates with the occurrence of other classes of cyanotoxins that were not measured, or the associated human health risks. In addition, there are relatively few documented cases of severe human health effects associated with exposure to cyanobacteria or their toxins. In addition, ORD is conducting a pilot study to assess human exposure and effects, and potential developmental toxicity associated with the cyanotoxins microcystin, cylindrospermopsin and anatoxin-a in drinking water systems in the southeastern United States. The pilot study is to determine whether a new blood serum assay for microcystin exposure can reliably detect low levels of human exposure to the toxin. A second study of developmental toxicity uses human placenta cells in culture to determine whether microcystins disrupt normal placental formation for pregnancy maintenance.

Gulf of Mexico Hypoxia

ORD coordinates and collaborates research in the northern Gulf hypoxia zone with NOAA and other federal, state and academic organizations. ORD has ongoing research and modeling efforts in the northern Gulf of Mexico to assess and predict: the relationships between nutrient loads and hypoxia; the physical, chemical, and biological processes regulating dissolved oxygen dynamics in the Gulf; and the effects of nutrient load reduction scenarios on hypoxia. ORD has partnered with Naval Research Laboratory modelers to develop integrated water quality simulation modeling tools that will improve our ability to evaluate the effectiveness of nutrient load reductions on Gulf hypoxia. The research and modeling efforts underway fill important research gaps identified in 2007 by EPA's Science Advisory Board state-of-the science evaluation regarding Gulf hypoxia and are critical to the information needs and goals of the Mississippi River/Gulf of Mexico Watershed Nutrients Task Force (Gulf Hypoxia Task Force).

In 2009, ORD published research on multiple regression models that described the size of the Gulf hypoxic zone based on river discharge and nitrogen and phosphorus concentrations. Those results supported the need for a dual nutrient management strategy—reductions in both nitrogen and phosphorus loads—to achieve the goal of reducing Gulf hypoxia. Equally significant were results of model predictions demonstrating that substantial and sustained nitrogen and phosphorus reductions will be needed before it will possible to discern statistically significant reductions in hypoxic area against the background of natural variability.

ORD scientists, as well as NOAA and NOAA-funded academic groups are working on parallel efforts to develop multiple 3D numerical simulation models for the northern Gulf system that link nutrient inputs, physical circulation processes, and ecological and water quality responses. EPA, NOAA and the scientific community consider the development of multiple models and modeling approaches as offering many advantages compared to a single model or modeling approach for addressing complex problems like the Gulf of Mexico hypoxia. All the research groups met recently in Mississippi at a NOAA-sponsored workshop to report on progress of the modeling efforts. The groups are about a year or two away from being able to run 3D model simulations and examine the effects of nutrient load reduction scenarios on dissolved oxygen dynamics and ultimately, the size, frequency, and duration of hypoxia in the northern Gulf.

EPA PARTICIPATION IN INTERAGENCY TASK FORCES AND WORKGROUPS

Harmful Algal Bloom and Hypoxia Task Force

ORD is an active participant in the Interagency Working Group on HABs, Hypoxia, and Human Health (IWG–4H) within the National Ocean Council, which is led by NOAA and which, among other responsibilities, implements the reporting requirements of the Harmful Algal Bloom and Hypoxia Research and Control Act (HABHRCA) of 2004. In these efforts, ORD staff were co-authors on the *Scientific Assessment of Hypoxia in U.S. Coastal Waters*, released in 2010, and the *Scientific Assessment of Freshwater Harmful Algal Blooms*, released in 2008, through IWG–4H.

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 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.

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 Western Lake Erie and Saginaw Bay (Lake Huron)—two areas of the Great Lakes that typically have significant cyanobacterial blooms. These blooms cause fouling of the beaches and shoreline, economic and aesthetic losses, taste and odor problems in 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). Grants associated with nutrient related controls, management, and restoration have been a significant area of emphasis in the Great Lakes Restoration Initiative. Restoration related activities are under way as part of grant-funded projects at several sites across the Great Lakes.

Mississippi River/Gulf of Mexico Watershed Nutrients Task Force

In addition to EPA's participation in the Federal interagency Task Force on HABs and Hypoxia, EPA OW co-chairs the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force (Gulf Hypoxia Task Force) which is comprised of 17 state and federal agencies. The Gulf Hypoxia Task Force provides a forum for state water quality and agriculture agencies to partner on local, state, and regional efforts to mitigate nutrient loading, encouraging a holistic approach that takes into account upstream sources and downstream impacts. The Task Force's goal of reducing the size of the Gulf hypoxic zone to a five-year running average of 5,000 km^2 is a very challenging commitment.

In its most recent *Gulf Hypoxia Action Plan* (2008), the Gulf Hypoxia Task Force emphasized its commitment to work with states to develop nutrient reduction strategies and increase accountability, and both remain top priorities of the current Gulf Hypoxia Task Force leadership. To facilitate nutrient strategy development, the Gulf Hypoxia Task Force produced a State Nutrient Reduction Strategy Report in September 2010 that identifies essential strategy components and potential federal funding sources. As recommended in that report, Gulf Hypoxia Task Force federal and state members, including EPA, have assisted in organizing and providing technical and funding support for two nutrient reduction strategy workshops, the second of which is occurring in mid-June in Columbus, Ohio. A Gulf Hypoxia Task Force working group is developing a proposed set of "indicators of progress" to measure progress towards addressing nitrogen and phosphorus pollution in the Mississippi and Atchafalaya River Basin (MARB) and reducing the size of the Gulf hypoxic zone.

More broadly, EPA has asked interested and willing states to join the Agency, other federal partners, and stakeholders and work collaboratively to achieve substantial near-term reductions of nitrogen and phosphorus pollution, using a transparent and accountable action framework, while some states continue to develop numeric criteria for nitrogen and phosphorus pollution to provide a clearly measureable and objective basis for longer-term reduction strategies.while some states continue to develop numeric criteria for nitrogen and phosphorus pollution to provide a clearly measureable and objective basis for longer-term reduction strategies.while some states continue to develop numeric criteria for nitrogen and phosphorus pollution to provide a clearly measureable and objective basis for longer-term reduction strategies.[7]

ORD provides technical support to OW for Gulf Hypoxia Task Force activities and also participates in the Task Force Coordinating Committee. ORD collaborates and coordinates with NOAA and other organizations thru the Gulf of Mexico Hypoxia Research Coordination Workshop series (sponsored by NOAA) which seeks to coordinate monitoring and modeling activities in the Gulf hypoxic zone.

CONCLUSION

In conclusion, EPA has made progress in understanding and addressing harmful algal blooms, hypoxia, and the broader issues of nutrient pollution in the U.S., and there is much more to do. EPA programs are targeting the causes and their impacts, working with states and federal partners to identify and protect healthy watersheds and their receiving waters and restore impaired waters. These efforts will improve management of nutrients, HABs and hypoxia, and help create safe and sustainable water resources for the future generations. We look forward to working with the Committee in the future.

Thank you for the opportunity to be here today, and I will be happy to answer your questions.

Chairman HARRIS. Thank you, Dr. Greene. I now recognize our third witness, Dr. Don Anderson, Senior Scientist and Director at Woods Hole Oceanographic Institute. Dr. Anderson?

STATEMENT OF DR. DONALD ANDERSON, SENIOR SCIENTIST AND DIRECTOR OF THE COASTAL OCEAN INSTITUTE, WOODS HOLE OCEANOGRAPHIC INSTITUTION

Dr. ANDERSON. Mr. Chairman and Members of the Subcommittee, my name is Don Anderson, and I am a Senior Scientist at the Woods Hole Oceanographic Institution where I have studied harmful algal blooms, or HABs, for over 30 years. I have also been very actively involved in the formulation of the programs and legislation that we are talking about today.

For the purposes of this discussion, it is important to emphasize that HABs occur in both marine and fresh waters as you are hearing. Marine HABs, as you can see here, sometimes discolor the water. They also then can cause illness and death of human consumers, of contaminated fish or shellfish, through mass mortalities of fish, sea birds, marine mammals and sometimes through irritating aerosols that drive tourists and residents from beaches. Seaweeds can also cause harm as seen in these extraordinary images from China just before the 2008 Olympics.

Now, freshwater HABs are primarily caused by cyanobacteria or blue-green algae. These create serious problems, first due to the reduction of light and oxygen in water, and second, through the production of some of the most potent natural toxins known to man. These affect humans through recreational exposure and drinking water and also affect fish, wildlife, and domestic animals.

Marine HABs affect virtually every coastal State in the United States, and many of them must contend with multiple toxins or

[7] N. Stoner, March 16, 2011. Working in Partnership with States to Address Phosphorus and Nitrogen Pollution through Use of a Framework for State Nutreint Reductions. U.S. Environmental Protection Agency, Washington D.C. See http://water.epa.gov/scitech/swguidance/standards/criteria/nutrients/upload/memo__nitrogen__framework.pdf

HAB impacts. For freshwater HABs, at least 36 States report human or animal poisonings, and a number of them have action plans or monitoring programs for HABs as well. Now, it is also worth mentioning that golden algae blooms as you see here are a different type of a freshwater HAB that have killed millions of fish in Texas year after year, also affecting Arizona, New Mexico, Colorado, Wyoming, North Carolina, South Carolina, Oklahoma, and Nebraska.

Now, conservative estimates of the economic impact of marine HABs are nearly $100 million per year or over a billion dollars over the last decade. There is, however, no national estimate for freshwater HAB costs, but impacts of individual outbreaks can be in the same range or even higher than those for marine HABs.

Now, turning to programmatic issues, our National Marine HAB Program, is viewed by many as a model program that has succeeded because of its organization, structure, and planning. We have two national plans that have guided program development and research activities for nearly 20 years. However, the breadth of the problem exceeded the mandated resources of any single agency, and thus we took the plan and divided it into a series of complementary programs. This led to ECOHAB, the Ecology and Oceanography of Harmful Algal Blooms, followed by MERHAB or Monitoring and Event Response of HABs, and then to two ocean and human health programs, or OHH programs, one within NOAA and one funded by NSF and NIEHS. With encouragement from Congress, the PCMHAB program was recently formulated to support research to prevent, control and mitigate HABs. Programs in event response and infrastructure were also encouraged and had been formulated and proposed.

So this is a very strong and diverse program, but its coverage of HABs in fresh waters is limited. The reauthorization of HABHRCA in 2004 expanded the Act to include blooms in all U.S. fresh waters, but the Act did not include a mandate or funding authorization for the EPA which is the appropriate agency to establish and maintain such a program. NOAA's support for fresh water HABs only includes the Great Lakes, not inland lakes, ponds, rivers, and reservoirs.

Now, given the foregoing comments and the details of the HABHRCA discussion draft, I offer the following recommendations. First, sustain support for ECOHAB, MERHAB and OHH programs, and authorize programs on the practical aspects of HAB prevention, control and mitigation, or PCMHAB and of that response and infrastructure.

Second, EPA and freshwater HABs should be included in the HABHRCA legislation and clear direction provided to move that program element forward such as by requiring EPA to participate in established or anticipated NOAA programs like ECOHAB, MERHAB, PCMHAB and so forth.

Third, there are significant benefits to have a formally recognized and congressionally mandated HABs and hypoxia program within NOAA. Currently this does not formally exist, and wording to create such a program should be included in the legislation.

Fourth and finally, the schedule for reports for program implementation, status updates and regional research action plans is tight and demanding on NOAA's limited staff. This will also drain considerable resources from the research budget. The schedule I think should be relaxed, possibly reverting to the five-year cycle of status reports required in the original HABHRCA.

Let me close by saying that it is vitally important to reauthorize HABHRCA so that we can maintain the momentum that we have built up for addressing HABs. We have a strong and highly respected program, and from the perspective of one that has worked in this field for over three decades, I can see a clear acceleration of benefits from that sustained research support. It is leading to many practical tools to assist State and federal managers and others on the front lines trying to protect public health, fisheries, tourism and other economic and social interests.

That concludes my testimony, Mr. Chairman.

[The prepared statement of Dr. Anderson follows:]

PREPARED STATEMENT OF DR. DONALD ANDERSON, SENIOR SCIENTIST AND DIRECTOR OF THE COASTAL OCEAN INSTITUTE, WOODS HOLE OCEANOGRAPHIC INSTITUTION

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 over 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, their impacts and trends. I will also provide my perspective on the research, programmatic, and legislative needs for the reauthorization of the Harmful Algal Bloom and Hypoxia Research and Control Act (HABHRCA), and will offer some specific comments on the Discussion Draft of the bill.

BACKGROUND

An excellent background on marine HABs has been provided by Rob Magnien in his written testimony for this hearing, so I will be brief and cover aspects that I feel need to be emphasized or included.

Marine HABs. HABs are caused by algae—many of them microscopic. In the ocean, 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.

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 or cause serious illness in humans and marine animals. 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 beachgoers and coastal residents, typically along the Florida and Texas shores of the Gulf of Mexico.

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. PSP occurs in all coastal New England states as well as New York, extending to offshore areas in the northeast such as Georges Bank, 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 U.S. Virgin Islands, it is estimated that nearly 50% 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, 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.

Freshwater HABs. Freshwater HABs are primarily caused by cyanobacteria (blue-green algae), although other organisms such as golden algae also cause destructive and dangerous freshwater blooms in many midwestern states. Cyanobacteria are found in virtually all ecosystems, but are primarily a problem (termed cyanoHABs) in fresh to brackish waters. Their blooms generally consist of dense mats or aggregations of cells floating on the water surface or suspended in the water column. These huge masses of organic material create serious problems for humans and aquatic ecosystems in two ways. The first is that the biomass of the blooms reduces water transparency, resulting in light limitation that can inhibit the growth of suspended and bottom-dwelling plants. As blooms collapse, decomposition processes deplete oxygen in the water column, killing fish and other organisms that are unable to escape to oxygenated waters. Repeated bloom cycles may irrevocably alter aquatic ecosystems, extinguishing biota that contribute to healthy ecosystems, while creating conditions for continued cyanoHAB bloom dominance.

The second and more serious problem is that many cyanobacteria produce cyanotoxins, some of the most potent natural toxins known to man. Freshwater HABs thus pose serious risks for human and animal health, aquatic-ecosystem sustainability and economic vitality (Dodds et al., 2009; Falconer, 2008; Hudnell, 2008; Lopez et al., 2007; Stewart et al., 2008). From the public health perspective, an unquantified but significant amount of human morbidity and mortality result from exposure to high levels of cyanoHAB toxins during recreational activities and lower doses in drinking water. Health effects can be acute, as might occur after swallowing a mouth full of contaminated water, leading to serious illness or death due to respiratory arrest or organ failure. Lower level exposures cause a multi-system, flu-like illness. Every year there are multiple reports of animal deaths in the U.S. due to cyanotoxin exposure, and occasionally there are reports of human deaths. Most non-lethal cases of acute cyanotoxin poisoning recover within day or weeks. However, an unknown percentage of susceptible individuals continue to suffer neurological and other symptoms for many months or years. The scientific literature also contains reports of chronic illness following acute exposure or repeated, low-level exposure to cyanotoxins. Little is known about the effects of repeated, low-level exposures, but cancer and neurodegeneration are outcomes implicated in the scientific literature. For example, laboratory studies indicate that microcystins are a cause and promoter of liver, colon and other cancers. Microcystin levels in drinking water are potentially linked to liver cancer incidence in Chinese epidemiological studies. Other studies indicate that cylindrospermopsin and other cyanotoxins also may be carcinogenic.

The toxins also affect freshwater ecosystems, where fish, zooplankton, macro-invertebrates, wading birds and aquatic vertebrates suffer further lethal and sub-lethal effects. For example, data from Florida show strong correlations between *Cylindrospermopsis* and cylindrospermopsin concentrations and alligator death rates.

Another important freshwater HAB problem is caused by the "golden algae" *Prymnesium parvum* which blooms in reservoirs, rivers, and lakes, and causes extensive fish kills. These blooms have killed millions of fish in Texas year after year, and have also impacted Arizona, New Mexico, Colorado, Wyoming, North Carolina, South Carolina, Oklahoma, and Nebraska.

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 freshwater 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 HAB 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. coastal waters with no influence from pollution or other anthropogenic effects, but in other areas, linkages between marine 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, 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 in marine systems. Nutrient enrichment of coastal waters often leads to eutrophication and increased frequencies and magnitudes of phytoplankton blooms, including HABs.

The prevalence and duration of harmful algal blooms in freshwater is also rapidly expanding in the U.S. and the world. In part, this reflects rising temperatures, as some HAB species, notably the cyanobacteria, thrive under warmer temperatures. But the main stimulus has come from growing nutrient inputs into our water bodies. Recent assessments by the U.S. Environmental Protection Agency indicate that 44% of river and stream miles and 64% of lake and reservoir acres are impaired pursuant to section 303(d) of the U.S. Clean Water Act (EPA, 2009). Eutrophication, the processes through which the flux of growth-limiting nutrients from watersheds to receiving waters stimulates freshwater HABs, continues to increase (Hudnell 2010). Analyses of data from EPA's first eutrophication survey in 1972 indicated that 10–20% of all U.S. lakes and reservoirs were eutrophic (Gakstatter and Maloney 1975). The Agency recently reported that over 50% of all U.S. lakes and reservoirs are now eutrophic or hypereutrophic (EPA, 2009a). This alarming rate of increase supports my view that a national program on freshwater algal blooms is urgently needed and should be included in the HABHRCA legislation, as detailed below.

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 marine 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. A recent study estimated the direct and indirect costs of the 2005 outbreak at nearly $50 million for Massachusetts and $23 million for Maine. Furthermore, a one-week state-wide closure in Maine (soft-shell clams, mahogany quahogs, and mussels) is estimated to cost the state $1.2 M in lost harvester sales and a total economic loss of $2.9 M. Typical duration of harvesting closures in Maine range from 4 to 16 weeks.

There is no national estimate of the economic and social impact of freshwater HABs, but the impacts are certainly significant. For example, a single golden algae outbreak in Texas in 2001 caused an estimated $18 million loss to local economies; these blooms and their associated fish kills are near annual occurrences. Another example is the closure of Grand Lake St. Marys in Ohio last summer due to toxic cyanoHAB blooms. That cost the local community an estimated $200M in lost tourism income. In addition, countless fish, waterfowl, and pets were sickened and killed by the lake's toxic conditions, and the state of Ohio confirmed seven lake toxin-caused illnesses with 21 others possibly linked to lake exposure, including a case in which an individual was temporarily blinded.

HAB PROGRAM DEVELOPMENT

In addition to providing background information on HABs, I was asked to provide my perspective on the research, programmatic, and legislative needs for the reauthorization of HABHRCA. To accomplish this, I will first provide some background on the development of the suite of activities, facilities, and funding programs that constitute our national strategy for dealing with this significant problem in both marine and fresh waters.

Our national marine HAB "program" or strategy is viewed by many colleagues in other disciplines as a model program that has succeeded because of its organization, structure, and planning. As recently as 25 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 rectify this problem, we formulated a *National Plan for Marine Biotoxins and Harmful Algae* (Anderson et al., 1993) that guided activities in this field for the next 10–15 years. The *National Plan* was broadly based, 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, however, and thus for implementation purposes, it was necessary to break the plan into a series of programs on complementary topics. 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 conduct significant HAB research and outreach activities. NOAA then created an *Oceans and Human Health Initiative* (OHHI) that supports extramural research and focused activities at three federal OHH centers.

The 1993 *National Plan* provided the guidance and perspective that led to the creation of several multi-agency partnerships and 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 funding programs that identify and address current and evolving needs associated with HABs and their impacts. In this context, the existing programs should continue to function, and new ones added to address important gaps. In the former category, ECOHAB is a critical, core program that is needed to address the fundamental processes underlying the impacts and dynamics of HABs. ECOHAB's 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 future national plan.

Two relatively new programs (the Centers for Oceans and Human Health (COHH) initiative of NIEHS and NSF and NOAA's OHHI) should also continue as we move forward. They fill an important niche by creating linkages between members of the ocean sciences and biomedical communities to help both groups address public health aspects of HABs. The COHH focus is 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.

The reauthorization of HABHRCA in 2004 expanded the Act to include blooms in all U.S. freshwaters. The Act mandated an assessment of freshwater HABs (Lopez et al., 2008), leading to an interagency monograph that described science and research needs (Hudnell, 2008). This effort to address freshwater HABs at the national level was hampered because the Act did not contain a mandate or funding authorization for the EPA, which is the appropriate Agency to establish and maintain such a plan. All U.S. freshwaters are within the purview of the EPA, as defined in the Clean Water Act (2002) and the Safe Drinking Water Act (2002). The Agency acknowledges its mandate for safe and clean water in Goal 2 of the 2006–2011 EPA Strategic Plan (EPA, 2008), "Ensure drinking water is safe. Restore and maintain oceans, watersheds, and their aquatic ecosystems to protect human health, support economic and recreational activities, and provide healthy habitat for fish, plants, and wildlife". Although the EPA recognizes the need for a National Research and Control Plan for Freshwater HABs (Lopez et al., 2008), the Agency has not begun development of a plan primarily due to the lack of clear Congressional direction and funding.

I believe it is imperative that the reauthorization of HABHRCA contain an EPA mandate and funding authorization for freshwater HABs. I make specific recommendations on this below.

Prevention, Control, and Mitigation of HABs. The 2004 HABHRCA Reauthorization authorized the establishment of three national programs on HABs. Of these, two existed (ECOHAB, MERHAB), but the third did not. This was to be "a peer-reviewed research project on management measures that can be taken to prevent, reduce, control, and mitigate HABs." (HABHRCA Sec. 605 (3)). In response, NOAA has since established the Prevention, Control, and Mitigation of Harmful Algal Blooms (PCMHAB) Program.

Guidelines for the PCMHAB are given in the Congressionally requested *National Scientific Research, Development, Demonstration, and Technology Transfer Plan on Reducing Impacts from Harmful Algal Blooms* (RDDTT Plan; Dortch et al., 2008). This plan includes PCMHAB, but has two other essential components as well. These are: 1) a comprehensive national HAB Event Response program: and 2) a Core Infrastructure program. Together with the PCMHAB 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 legislation. Justification for this programmatic emphasis is as follows.

Prevention, control, and mitigation (PCM) of HABs has always been a priority within Congress. PCM issues were included in the original HABHRCA in 1998, and were included 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). Progress in the area of bloom suppression or control has been slow, but is now increasing due to the new PCMHAB program. Among the impediments to progress is that scientists often choose 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 for many years, there was no specific funding specified for PCM research. As a result, PCM proposals competed 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 were variable and sometimes negative, and that more conservative projects on bloom dynamics, toxin chemistry, or other topics were selected. **I therefore strongly recommend that specific wording be inserted in the draft HABHRCA legislation to 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 meeting 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 U.S. 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 targeted funding for its expenses. This has become a significant financial burden that has made me begin culling cultures from the collection. 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.**

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. It is also critical that appropriations be increased to include these new areas of effort. The current programs are effective, and the new ones (PCMHAB, Event Response, and Infrastructure) are needed to complete the coverage of this diverse and widespread problem.

COMMENTS ON THE DRAFT LEGISLATION

I offer the following comments on specific aspects of the HABHRCA Discussion Draft.

Freshwater HAB program. HABHRCA, as enacted and re-authorized, did not contain a mandate or funding authorization for freshwater HABs, other than those covered by NOAA's mandate, which includes the Great Lakes. The freshwater HAB problem is huge, and includes every inland state, as well as those on the coast, which are also faced with marine HAB problems. The EPA is the appropriate Agency to establish such a plan. The 2010 bill to reauthorize HABHRCA contained the EPA mandate, a modest funding authorization, and direction for the Agency to use those funds to support research and control projects for freshwater HABs by becoming a partner with NOAA in the three existing NOAA grant programs (ECOHAB, MERHAB, and PCMHAB). That bill passed in the House with bipartisan support, but did not come up for a vote in the Senate. **I urge this Committee to include the EPA mandate, funding authorization, and direction to participate in existing national HAB funding programs in the current effort to reauthorize HABHRCA.** A National Research and Control Plan for Freshwater HABs will protect our citizens and industries, and ensure that they have a sustainable supply of usable freshwater into the future.

National HAB Program within NOAA. In Section 4, the Discussion draft states that ". . . the Undersecretary, through the Task Force established under section 603(a), shall maintain a National Harmful algal Bloom and Hypoxia Program pursuant to this section". The implication of this sentence is that a formal HABs and Hypoxia Program exists within NOAA, but this is not the case. The program exists as a competitive research activity under the National Center for Coastal Ocean Science (NCCOS). **The wording should be changed to ". . . shall establish and maintain . . . ."** There are significant benefits to having a formally recognized and congressionally mandated HABS and Hypoxia program within NOAA. This simple wording change will make a huge difference to the way our program is viewed, supported, and managed within NOAA.

Named Programs and Authorizations. In Section 7 of the Discussion draft, the authorization details are not provided. As I stated earlier, Congress has requested that the national HAB research and monitoring effort be expanded to include several new program areas such as prevention, control, and mitigation of blooms, event response, and infrastructure. These enhanced responsibilities and needs will require modest increases to authorization levels.

I have been told very clearly by managers within NOAA that the congressional mandate for HABs and hypoxia provided through HABHRCA is a critical factor in deciding priorities for funding, staffing, and other resource allocations within NOAA. The same holds for individual programs—if they are congressionally recognized and mandated, their longevity and support are assured.**Accordingly, I recommend that the individual programs (e.g., ECOHAB, MERHAB, PCMHAB, Event Response, Infrastructure) be named specifically in the bill.**

Regional Research Action Plans. As emphasized above, HAB phenomena are diverse throughout the U.S., 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 concerns here are the timescale and costs for these meetings. Having participated in a very successful meeting of this type in Florida, I know that a significant cost is involved (at least $250 -300K), 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. Progress thus far has been excellent, as the U.S. HAB program is seen as a model for other scientific disciplines in the U.S. and the world. The rate and extent of progress from here 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 strategy. 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. 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.

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.

Donald M. Anderson, PhD Senior Scientist Woods Hole Oceanographic Institution

Summary points and recommendations

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 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. Cumulatively, the costs of marine HABs exceed a billion dollars over the last several decades. There is no national estimate of the economic and social impact of freshwater HABs, but the impacts are truly significant. For example, the closure of Grand Lake St. Marys in Ohio last summer due to toxic cyanoHAB blooms cost the local community an estimated $200M in lost tourism income.

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. Research and management programs such as ECOHAB, MERHAB, and the Oceans and Human Health initiatives have been highly successful and productive, but new programs are needed to cover gaps such as prevention, control and mitigation of blooms, event response, and core infrastructure.

Recommendations:

Sustain and enhance support for the national HAB plan called 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 specific funding lines 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. This could fall under the Event Response or Infrastructure programs.

Encourage interagency partnerships, as the HAB problem transcends the resources or mandate of any single agency.

Freshwater HABs are an important focus but are generally not comprehensively addressed in ECOHAB, MERHAB, or the OHH HAB programs. EPA should therefore be included in the HABHRCA legislation. Clear direction should be provided so that EPA and NOAA move this program forward in a productive and efficient manner. One way to accomplish this is to require EPA to participate in the established or anticipated NOAA programs like ECOHAB, MERHAB, PCMHAB, Event Response, and Infrastructure.

The ECOHAB, MERHAB, PCMHAB, HAB Event Response, and HAB Infrastructure programs should be named in the HABHRCA legislation.

The wording in Section 4 of the Discussion draft should be changed to read that ". . . the Undersecretary, 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". There are significant benefits to having a formally recognized and congressionally mandated HABS and Hypoxia program within NOAA. Currently, this does not exist.

The schedule for reports for program implementation, status updates, and multiple regional research action plans is very tight and demanding on NOAA's limited staff. This will also drain considerable resources from the research budget unless separate appropriations are made explicitly for these reports. The schedule could be relaxed, possibly reverting to the 5-year cycle of status reports that was required by the original HABHRCA

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 as 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.

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Chairman HARRIS. Thank you very much, Dr. Anderson. I now recognize our fourth witness, Dr. Kevin Sellner, the Executive Director of the Chesapeake Research Consortium. Dr. Sellner?

STATEMENT OF DR. KEVIN SELLNER, EXECUTIVE DIRECTOR, CHESAPEAKE RESEARCH CONSORTIUM

Dr. SELLNER. Thank you. I extend my appreciation to the Subcommittee Chair and Subcommittee Members and staff for this invitation to discuss the importance of HABHRCA—I will get used to that acronym in a while—re-authorization to mitigating the frequent and reoccurring blooms of harmful algae that now typify many of our Nation's waters.

As my colleagues have just summarized, harmful algal blooms are a serious and recurring threat to human and domestic animal health, living resource viability, ambient dissolved oxygen levels in our eutrophic lakes, reservoirs, and coastal systems and a substantial economic drain on our already stretched fiscal resources for local governments, states, and agencies responsible for safeguarding our Nation's waters and its citizens.

I will focus my comments on techniques and approaches to mitigate these algal accumulations, removing them from surface waters and thereby reducing exposures to our citizens and their domesticated animals.

Just as on the extremely productive U.S. farmlands, the supply of nutrients to U.S. waters governs all algal production, and thus reducing these inputs will have the greatest impact at limiting these events. However, that focus area is not integral to HABHRCA but addressed in other legislation and existing federal programs and agencies.

For bloom removal, direct intervention in dense algal accumulations is fairly routine in small enclosed systems using chemical additives, such as copper sulfate or potassium permanganate, chemicals we have in our labs. However, these are problematic for open systems with subsequent copper toxicity, an issue for the other ecosystem processes, while permanganate dosing is critical to prevent mortalities of all organisms, not just the bloom algae.

Other techniques that move or mix the water can be effective using paddle wheel devices or aerators and bubblers. These generally are most effective in systems without large, shallow areas where the blooms in the shallows can persist outside of these mixed areas.

Biological controls using viruses, parasites and grazers of the blooms have also been proposed, but the expense in producing the numbers of these bloom-controlling organisms prohibits this technique for large, open systems.

Finally, harvest of bloom biomass for biofuels has been proposed, but the technology is hardware rich and labor intensive, so impractical for large blooms at this time. And there are more details in my written testimony.

Of great promise is the application of sediments to bind with and remove the bloom to bottom waters. This approach is common to Asian countries and used in agriculture areas as blooms approach. We have recently adapted this technique for Maryland waters, identifying mixtures of local sediments and a byproduct of our crab shells to effectively remove laboratory strains and field blooms of a globally common toxin-producing algae Microcystis aeruginosa from the water—it was the billion green example that Don just showed in his slides.

These results are now the foundation for a field demonstration effort in a lake outside Denton, Maryland, and possibly in Frederick, Maryland, at Fountain Rock Park, where natural blooms will be treated with local sediments and the crab shell byproduct to assess efficacy for routine mitigation in the lake and then ideally as a routine tool for state intervention throughout the waters of Maryland's borders.

Three other points need to be made for continued technique development and routine implementation in U.S. waters. First, continued research into social sciences should be imbedded in any future bloom research or mitigation as citizen awareness breeds understanding and acceptance of intervention. Without an ability to assess public and other stakeholder reservations and developing strategies to overcome those perceptions, future mitigation will likely fail. Social scientists are critical to future success, and a reauthorized HABHRCA should include this commitment.

Second, integration and coordination at the national level is absolutely necessary such that workshops to identify management needs, research priorities to meet those needs and coordination across the suite of agencies, scientists and citizens occurs frequently to address the mandated requirements from Congress and from the executive branch. This has been fulfilled through NOAA staffing in the past, but appropriations for NOAA staffing have steadily declined over the last several years, severely limiting the agency's ability to meet those requirements.

Finally, in past HABHRCA legislation, EPA had been identified as a leader in freshwater bloom ecology, monitoring and control in this role for the agency needs to be reinstituted as freshwater issues are beyond NOAA's mandate. EPA leadership in freshwater bloom activities is critical.

Thank you for this opportunity, and my colleagues and I look forward to HABHRCA's reauthorization so we might continue to expand our ability to limit bloom events in U.S. waters.

[The prepared statement of Dr. Sellner follows:]

PREPARED STATEMENT OF DR. KEVIN SELLNER, EXECUTIVE DIRECTOR, CHESAPEAKE RESEARCH CONSORTIUM

Introduction

I extend my appreciation to the Subcommittee Chair, Subcommittee members and staff, and agency administrators for this invitation to discuss the importance of HBHRCA re-authorization to mitigating the frequent and reoccurring blooms of harmful algae that now typify many of our nation's waters.

As my colleagues have just summarized, harmful algal blooms are a serious and recurring threat to human and domestic animal health, living resource viability, ambient dissolved oxygen levels in our eutrophic lakes, reservoirs, and coastal systems, and a substantial economic drain on our already stretched fiscal resources for local governments, states, and agencies responsible for safeguarding or nation's waters and its citizens.

I have prepared comments to outline the spectrum of mitigation options now or soon available for mitigating these recurrent algal proliferations and accumulations. There are some techniques that show high potential for reducing blooms in many systems and in some areas and other nations, are applied more frequently than we do in the U.S. Just as on the extremely productive US farmlands, the supply of nutrients to US waters governs all algal production, and thus reducing these inputs will have the greatest impact at limiting these 'events'. However, that focus area is not integral to HABHRCA but addressed in other legislation and existing Federal programs and agencies. HABHRCA IS critical to exploring the reasons for these recurring blooms, and most importantly 3 critical factors for reducing these recurring aquatic stresses locally to nationally.

Mitigation and Prevention of Harmful Algal Blooms

First, HABHRCA authorizes support for expanding prevention, control, and mitigation research for harmful algae, a recent US commitment long after a report from the community requested such a program more than a decade ago. Through HABHRCA, NOAA's Center for Sponsored Coastal Ocean Research now administers a Prevention, Control, and Mitigation competitive research program which funds research projects designed to develop and apply technologies to reduce harmful blooms in US waters. Based on research in freshwaters from China and saline waters from Korea, Japan, the Philippines, and Florida's western shelf in the Gulf of Mexico, an inexpensive but very efficient bloom mitigation technique employing sediment to bind with and remove bloom algae from the water column looks very promising as an operational technology for bloom removal. I am part of a recent award, focusing on removing blooms of toxic, dense surface scum algae *Microcystis aeruginosa,* common throughout the world. This bloom-former can produce the toxins known as microcystins, lethal to domesticated animals drinking from lakes, ponds, and tributaries containing *M. aeruginosa* blooms and induce liver tumors in humans and other animals through continuous lower level exposures over time. Our laboratory work over the past 3 years with an honors undergraduate research team at the University of Maryland indicates that laboratory grown and field collected blooms are rapidly removed from the water column on additions of mixtures of local sediments and a crab shell by-product (chitosan). We are now expanding that work to field blooms in a lake outside Denton, MD where blooms of the algae will be trapped in large containers and treated with sediment-chitosan mixtures to determine removal efficiencies for these field conditions and importantly fate of the settled bloom and its toxin. We believe that the technique will work very well, freeing the water from the cells and the toxin and thereby reducing toxin impacts on domestic animals drinking from the lake as well as citizens (such as Girl Scouts in the Girl Scouts of America camp surrounding the lake) using the lake for swimming, boating, and fishing. From these results, we anticipate moving to open water applications for eventual technique application as a standard protocol for state staffs deployed to remove blooms from Maryland's fresh and bay waters. HABHRCA enabled program initiation, selection of the project for support, and most likely use of this inexpensive procedure as a standard tool in protecting state waters in the next 5–10 years.

Authorization enables exploration of other mitigation procedures used in other systems and nations. For example, in freshwater systems with rapidly increasing depths from shores, aeration through bubbling or mixing of the water column has proven effective in reducing blooms of these dense surface 'scums' so common globally. Some chemical additives have also been used to remove developed blooms, such as copper sulfate or permanganate additions. The former is a concern, however, due to ancillary copper toxicity issues while permanganate additions must be used cautiously due to the bursting of bloom cells and release of internal toxins into the surrounding water or living resource mortalities if too much of the permanganate is added. In systems with higher salinity such as estuaries or coastal ocean areas, sediments can be added for removing cells as discussed above, using compounds other than chitosan to bind the sediments and algae. These approaches appear very promising but not without substantial effective outreach and education of local residents to the benefits of the additions versus the impacts of non-intervention (see social science needs below).

Other techniques propose to harvest the bloom biomass from bloom areas and concentrate the algal cells for harvest and biofuel/compost production. Large filtration devices or multiple screens can be deployed in the water, concentrating bloom biomass for removal and processing. This technique, however, is expensive and can be used in small bloom areas only, or if implemented in very large blooms, is hardware and labor intensive and therefore requires very large fiscal commitments. Preventative technologies can also be used to create chemical conditions in receiving waters that favor beneficial algae rather than the harmful species. One alternative is to divert waters known to support algal blooms across fine meshes on gently sloped land and allow the natural flora to colonize the mesh and remove nutrients supporting expected recurring blooms, yielding attached algae for harvest, processing, and biofuel production. These 'algal turf scrubbers' (ATS) have been used effectively in multi-acre systems in Florida and Texas and been used in demonstration projects in the Chesapeake Bay watershed. Similarly, filling large translucent floating 'bags' with bloom-supporting water followed by enrichment with rapidly growing high lipid-containing algae can result in high nutrient uptake by the 'preferred alga', reducing the likelihood for growth of the harmful species. Harvest of the lipid-rich algae can, in turn, yield biofuels. A third option is the introduction of materials that bind available nutrients, with one commercial product Phoslockr very effective at binding available phosphorus in the water as well as in loads entering waters treated with the compound. It will continue to bind phosphorus, the nutrient that favors the proliferation of freshwater cyanobacteria generally, as long as the binding sites of the Phoslock remain available. All three of these preventative measures, however, are costly. ATS systems require land and initial construction across several acres but continuous algae harvest and returns from the production of butanol, omega-3 fatty acids, compost, and carbon and nutrient credits make long-term profit probable; additionally nutrients in river discharges are also continuous, insuring a likely permanent source of nitrogen and phosphorus to produce the algae in the ATS and reduce the likelihood for harmful algae production in natural waters.

The Importance of Social Sciences from HABHRCA

Outreach and education are critical to future application of research results to societal problems in US waters and hence social science outlined in HABHRCA insures effective and continuous dialog with citizens and stakeholders directly or indirectly tied to harmful algal bloom impacts or intervention. It is currently a required component of the Prevention, Control, and Mitigation Program administered by NOAA, a direct result of HABHRCA. The public is deeply concerned about the proliferation of blooms in local waters, and informing the community on the detrimental aspects of blooms versus the benefits to local health, healthy ecosystems, and local livelihoods on bloom removal is now integral to NOAA's research commitment. In the program, researchers on the blooms, their fate, and aspects of toxin removal now actively collaborate with social scientists to work with citizens and other stakeholders to outline the bloom problem, potential impacts on the local community and the waters they use, and modes of intervening in reducing these threats to local-to-regional citizens and user groups. An example of this interaction of science and citizens is embedded in our current Denton, MD project where natural and social scientists will meet with citizens next month to encourage discussion, communication, and cooperation in reducing the bloom effects in the local lake. Without this comraderie and understanding, no matter how efficient the technique is in removing a local bloom, citizen anxiety of 'interfering with mother nature' could prevent any routine mitigation in state waters, effectively preventing protection of citizens and their animals and health, perpetuating the status quo of dying animals and threats to citizen health from toxin exposure. Social science research and subsequent citizen-scientist cooperation arising from HABHRCA are critical to future success in routinely mitigating blooms in our very productive national waters.

National Integration, Coordination, and Reporting of Harmful Algal Bloom Management, Research, and Prevention, Control, and Mitigation

An effective collaboration of scientists and non-scientists must be informed and facilitated by strong Federal leadership, so I encourage continued support of intramural NOAA staffing to meet this national need. National workshops must be held to collect needed expert opinion of on-going and emerging harmful algal issues, draft reports required by Congress and agency leaders, and provide career opportunities for students entering the field to protect future citizens from these expanding blooms and toxins. NOAA's Center for Sponsored Coastal Ocean Research staff have provided this excellence in the past 15 years, but excellence requires support so HABHRCA re-authorization and subsequent agency appropriations for intramural coordination, integration, and reporting in NOAA and would insure continued national leadership for the excellent research needed (supported in NOAA-administered competitive peer-reviewed extramural research for the Ecology and Oceanography of Harmful Algal Blooms (ECOHAB), Monitoring and Event Response of Harmful Algal Blooms (MERHAB), and Prevention, Control, and Mitigation of Harmful Algal Blooms (PCM HAB)), communication with scientists and users of that science, and implementation of mitigation procedures most effective at reducing threats to our citizens and ecosystems.

Re-Institution of EPA Leadership for Freshwater Harmful Algal Bloom Research, Response, and Prevention, Control, and Mitigation

One more point needs to be made: previous HABHRCA language identified EPA as a leader in Freshwater Harmful Algal Bloom research and the language is missing in this year's re-authorization. Freshwaters are beyond NOAA's mandate and hence it is important to re-institute the EPA lead role in Freshwater Bloom Research as EPA has a strong and historic commitment to freshwater health, so EPA is a natural lead for specific harmful algae research and mitigation. This is beyond its identified role in water pollution and nutrients, and re-authorization should reinstall the requirement for EPA leadership in specific algal bloom research efforts.

Concluding Remarks

I appreciate the opportunity to the subcommittee of the importance of re-authorizing HABHRCA for safe-guarding our nation's waters from toxins and bloom-induced losses to our economies and health of our citizens, their animals, and our important and productive aquatic ecosystems.

Chairman HARRIS. Thank you very much, Dr. Sellner. They called us to vote, but I think if Dr. Smith and Dr. McGee, if you stick to those five minutes, we want to get through your testimony and then break and come back for questions.

I now recognize our fifth witness, Dr. Stephanie Smith, Chief Scientist for Algaeventure Systems. Dr. Smith?

STATEMENT OF DR. STEPHANIE SMITH, CHIEF SCIENTIST, ALGAEVENTURE SYSTEMS

Dr. SMITH. Thank you, sir, for the opportunity to come before your Committee and speak today. I am Stephanie Smith, Chief Scientist at Algaeventure Systems in Marysville, Ohio, and it is my privilege to bring you our unique perspective on harmful algal blooms and also our support for this legislation.

There are five key points that I want to make sure you get from what I have to tell you today. First, addressing freshwater HABs is going to require a suite of multiple technologies that have to be developed both at the fundamental and at the applied levels. Second, far less appears to be known about freshwater HABs than marine, and strategies for addressing HABs in marine systems, as we have come to find, do not translate to success for freshwater systems.

It is our opinion through our past experiences over this last year that there is insufficient assessment of HAB prevalence in inland lakes to truly understand the magnitude of the problem or the damage to the economies of those communities.

It appears that more is known about monitoring and prevention of HABs than about control and mitigation. We believe more needs to be done to address an ongoing HAB, especially in a freshwater environment, and those writing in the scientific literature have also pointed to the need for more to be done in the area of remediation.

The current level of funding which we understand to be on the order of $36 million is of course insufficient to meet all of the needs that we are pointing out today, especially when one considers that most of that will be spent in marine environments and the cost of developing mitigation or remediation strategies is very high. The funding level also doesn't match the magnitude of the damages assessed, even as the single example I am going to tell you about is going to demonstrate.

Probably as demonstrated by the length of my introduction and apparently the size of the font on my testimony page, we are newcomers to freshwater HABs. We arrived at this as an area of interest, not through years of scholarship but through the recognition that freshwater HABs are a devastating problem for inland lake communities and economies, and it is in need of very creative solutions and technologies.

AVS was founded on the belief that algal products are going to be one of the strongest grown industries over the next 1,000 years, and we have invented some transformational technologies for dewatering algal biomass to overcome a major energy and cost barrier in our industry.

The first is the solid/liquid separation system, or the SLS, and the second is the rapid accumulation and concentration system, or RAC. The RAC pre-concentrates algal biomass over 30-fold so it can be more efficiently dewatered and then dried with the SLS. These technologies exemplify our inventive spirit but frankly blue-green algae was not part of our original plan. That changed in the summer of 2010 when freshwater harmful algal blooms all over Ohio and the most devastating one at the Grand Lakes–St. Mary's Reservoir in the city of Celina. This algal bloom contained a dangerous cocktail of toxins that included microcystins, anatoxins, cylindrospermopsin and saxitoxins, and it is estimated that this bloom cost this community between $60 and $80 million in lost revenue. Of course, there were also health consequences. There were eight confirmed human illnesses and four dog illnesses. The Grand Lakes–St. Mary's residents and as we were to come to find, most residents that experience a bloom, were desperately asking who is in charge of a situation like this? Are there actually any remediation strategies or solutions? Of course, a surprising number of solutions were proposed and some were tested, including our own which aim to stimulate the growth of non-harmful algae, or diatoms, in the lake. None of these approaches were successful in reversing this bloom.

So going forward, we plan to develop our SLS and RAC technologies in a way that would allow them to be deployed in lakes for the recovery of biomass, but as with our diatom approach, these technologies must undergo additional research and development.

We also have a novel concept in development for diverting nutrient-laden waters of these eutrophic lakes into a controlled algal growth system wherein the biomass could be dewatered for biofuels or other algal products. We do not yet know whether any of our technologies will have a significant impact heading off a freshwater HAB, especially the one the magnitude experienced by GLSM last year. But we are confident that freshwater HABs can be approached with our technologies in combination with those of others toward a positive outcome.

The summer of 2010 at Grand Lakes–St. Mary's and our monitoring and experimentation since then support the five key points that I want to leave you with, and I will be happy to entertain any questions.

[The prepared statement of Dr. Smith follows:]

PREPARED STATEMENT OF DR. STEPHANIE SMITH, CHIEF SCIENTIST, ALGAEVENTURE SYSTEMS

Chairman Harris, Ranking Member Miller, thank you for the opportunity to come before the Science, Space and Technology Subcommittee on Energy and the Environment. My name is Dr. Stephanie A. Smith, Chief Scientist at Algaeventure Systems (AVS) located in Marysville, Ohio, and I am here to offer proponent testimony on the Harmful Algal Bloom and Hypoxia Research and Control Act (HR 3650), which aims 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.

It is my great privilege to bring to you the unique perspective our company has acquired regarding freshwater harmful algal blooms (FHABs), and to describe the technologies that have been developed by our company and which we would like to adapt for FHAB remediation. We further envision novel remediation approaches, and the legislation at hand could greatly influence the development of such technologies by us or other creative people. So perhaps this is the time to make one of the most important points I hope to communicate to you: addressing FHABs will require a suite of technologies that come together to attack the problem, and which must be developed at both the fundamental and applied levels. Our company is certainly on the applied end of the spectrum, but we fully expect to engage other scientists, inventors, entrepreneurs, and engineers to improve our own technologies so that they work in concert with those developed by others, resulting in tailored solutions for FHAB sites.

I wish to point out that compared with those we hope to engage, and to the distinguished panel you have assembled today and in years past, we are newcomers to FHABs. I am a microbiologist with broad experience in photosynthetic microbiology and microbial processes, and professional experience at both Wright State University in Dayton, OH, and the Battelle Memorial Institute in Columbus, OH. As a microbiologist I have over the years learned about HABs, the organisms, toxins, and conditions involved, while my own research focus has always been in the enzymology of bacterial carbon fixation, and bioremediation strategies and technologies that leverage natural microbial processes. I very recently joined Algaeventure Systems, which was formed in 2008 under the leadership CEO Ross Youngs. Univenture, a plastics technology and manufacturing company founded by Mr. Youngs, sought alternatives to making their products from petroleum. After intensive research exploring the opportunities presented by terrestrial-based crops including corn, soy and palm, it was revealed that only algae held the potential to sustainably yield bioplastics with the same, or better, performance characteristics than petroleum-based plastics.

Algaeventure Systems, Inc. was thus founded on the belief that algal products will be one of the strongest growth industries over the next 100 years, and that taking carbon dioxide from the air, nutrients and water from waste streams, and turning these things into useful products is absolutely necessary for a growing world population with shrinking resources. But shortly after starting this business, Mr. Youngs and his team recognized that dewatering algal biomass as part of the product cycle threatened to be an industry-crushing expense that would make algal products unaffordable in today's marketplace. Algaeventure Systems thus invented a key technology that has been selected & called "transformational" by the US Department of Energy's Advanced Research Project Agency (ARPA–E).

Termed the solid-liquid-separation system, or the SLS, this low-energy, unbelievably simple yet inarguably effective machine is one of our key technologies that we feel can be applied for recovering biomass from freshwater systems, including those which are laden with cyanobacterial biomass.

Mr. Youngs and his team more recently invented a second key technology that will operate in concert with the SLS, called the Rapid Accumulation and Concentration system, or RAC. Again, low-energy consuming and remarkably inexpensive, this machine was conceptualized because of the search for materials to which algae might attach for growth. Looking to nature, the team sought to mimic the passive capturing of planktonic microbes by the "feather duster" worm's appendages. Those research efforts led to a material that is almost like an algae-magnet; in our own test systems and others it grabs algae out of the water and with a simple mechanical squeezing action releases the algae such that the biomass is concentrated over 30-fold. When this pre-concentrated algal biomass is introduced onto the belt of our SLS system, a flaky mass that resembles fish food is produced. The biomass is then manageable, cheap to transport because it is lighter, and can be used for processing into various products.

These technologies exemplify the inventive and entrepreneurial spirit of this company, but with that said, "blue-green algae," as cyanobacteria are often called, were not part of the original plan for this algae company. Then, Summer 2010 brought several toxic FHABs to our state, and the most devastating may have been the one that hit the Grand Lakes–St. Mary's (GLSM) reservoir in the City of Celina. GLSM enjoys approximately $150–200 million in revenue as a consequence of recreational lake activities and tourists that are drawn to this 13,000-acre reservoir, which also happens to be the primary source of potable water for the city of Celina. The shutdown of Ohio's largest inland lake due to dangerous levels of a cocktail of cyanobacterial toxins (microcystin, anatoxin, cylindrospermopsin, saxitoxins) has been estimated to have cost the community $60–80 million in lost revenue. And of course there were health consequences. Numbers vary according to reports, but the Ohio EPA reported 8 confirmed human illnesses and 4 dog illnesses, including 3 deaths of dogs believed to have directly ingested the lake water. A "no contact" recommendation was placed on the lake in July, which ended the tourist season early, and created numerous and unbearable hazards for the property owners and residents.

The GLSM residents, and as we were to find, most communities that experience FHABs, seemed to be desperately asking, "Can anyone help us with this? Who's in charge of solving problems like this? Is there not a solution for this problem?" For those first questions, bear in mind that when it comes to inland lakes, excepting the Great Lakes, NOAA is not the agency that responds. Agencies of note that were assisting in the situation included the Ohio EPA, the Ohio Department of Natural Resources, Ohio Department of Agriculture, the USDA and the USGS. But perhaps the most impressive efforts came from the community itself, which formed a Lake

Improvement Association (LIA), and had the leadership of key city personnel, most notably the tireless Planning and Community Development Director, Kent Bryan. It was through these community leaders that AVS was able to fully engage and become rapidly educated about HABs, and began to formulate options that might have an impact. The ODA provided financial resources to test some ideas, and due to the urgency of the situation by August of that year, the permitting process was accelerated by the EPA, the City of Celina, and the ODNR to facilitate testing of approaches. Under normal circumstances, such as where we find ourselves today in trying to implement and test new approaches, permitting can take 60 days to 6 months.

To the question of whether there was a solution to this problem, a surprising number of solutions were proposed, and many tested, but none successful. These ideas were tested at the peak of the FHAB, a nonideal time, and a demonstration that actual *remediation* of FHABs is something for which technologies do not presently exist. Among the ideas that were explored, AVS derived one from the scientific literature on marine HABs, in which addition of silica to ocean or estuarine environments was shown to stimulate growth of marine diatoms, a type of silica-requiring algae that could out-compete the toxic algae and thereby possibly stave off a HAB. [1] As early as 1971 the hypothesis had been put forth that in eutrophic freshwater systems seasonal succession of diatoms was closely linked to available silica, and that as they consumed nutrients in the water, including silica, the latter would become limiting and lead to diatom decline through the warmer months. [2] [3] [4] If the diatoms became limited for silica while other nutrients were still available, it could create an advantageous situation for toxic cyanobacteria. If this phenomenon were occurring at GLSM, Mr. Youngs deduced that adding silica to the lake could possibly stimulate the growth of diatoms, and give them a competitive edge over the cyanobacteria. With the time short for trying to remediate this bloom, in collaboration with Bowling Green State University (Bowling Green, OH), the City of Celina, the US and Ohio EPA, the ODNR and the Ohio Department of Agriculture, AVS led the testing of a silica amendment in a small marina in the lake. While the treatment was clearly non-harmful to the environment (one reason it was readily permitted under the rushed circumstances), it had no effect on the bloom that was in progress. When I officially joined AVS in April 2011, and our team reexamined the many factors that were stacked against this approach working (e.g., the late stage of the bloom, the high temperatures, and the fact that water samples taken much later indicated that silica might not be limiting), we agreed that AVS needed better data than was currently available to design a well-thought out approach going forward.

AVS has thus initiated our own monitoring of water quality and algal diversity, to supplement what was already ongoing by the Ohio EPA at GLSM. We have added two other lakes to our monitoring program, one which has frequently experienced FHABs over the years, and a HAB-free small pond on our own property. Our assessments have already taught us that the concentrations of soluble silica in these lakes is quite high, but it remains to be seen whether the concentrations remain that high throughout the year, or what the correlation might be with relative diatom biomass in the water column samples. In fact we have also learned that the toxic cyanobacterial species dominate the biomass in the water columns of the two lakes that have previously experienced HABs, even in the months of March, April, and May when we know silica concentrations should not limit diatoms from flourishing. This means that some mitigation strategies could possibly be implemented *early* relative to the late summer HAB to limit the growth of these cyanobacteria before they get out of hand. Likewise, perhaps a comprehensive strategy would combine early-season approaches with bloom remediation in July-August, so that technologies applied in the latter have a greater probability of success when applied on a less severe bloom. We do not yet know whether a condition could be created wherein diatoms, or some other algal species, could be stimulated to outcompete cyanobacteria. We plan to continue our monitoring for a full year to cover a complete seasonal cycle, and if we can find the funding we will add other lakes and analyses to our program. Our resources are currently too limited to have a full sampling regimen that yields a thorough scientific analysis of these lakes, but our observations are nonetheless enlightening and we look forward to sharing them with others as we process the data.

[1] Egge and Aksnes. (1992) Mar. Ecol. Prog. Ser. 83:281–289.
[2] Kilham, P. (1971) Limnol. Ocean. 16(1):10–19.
[3] Gibson et al. (2000) Freshwater Biol. 45:285–293.
[4] Kristov et al. (2000) Hydrolog. Processes. 14:283–295.

As for new technologies to combat FHABs, our company now plans to develop our SLS and RAC in a way that would allow them to be deployed in lakes for the recovery of biomass, and we want to explore the possibility that the biomass could in fact be put to good use, turning a potentially disastrous scenario into a positive, and possibly even revenue-generating scenario. Both technologies were developed with eukaryotic algae that are approximately 5–10 times larger than typical cyanobacterial cells. In addition to having smaller cells, cyanobacteria can be filamentous, forming fibrous mats on the surface of the water or adhered to rocks and sediments. These properties require that our technologies undergo some additional research and development to efficiently capture this type of biomass. The City of Celina is allowing us to do some testing at their lake to see how the RAC in particular will operate with cyanobacterial biomass, which we all anticipate will reappear in force this summer. This work is in part is being funded by the Air Force/ Air Force Research Laboratories.

We also have a novel concept in development for diverting the nutrient-laden waters of these eutrophic lakes into a controlled algal growth system, wherein the biomass generated could be used for biofuels or other algal products. Nutrient removal and recovery is an intense area of interest in the scientific community and is viewed as an important long-term strategy to reducing HABs,[5] and we believe that deliberate culturing of useful algal species can be one of many successful approaches to that. We do not yet know whether our own approaches of utilizing the SLS, RAC, and our algal culturing system can have a significant impact upon heading off or remediating a FHAB, especially one of the magnitude experienced by GLSM last year. But we are confident that FHABs can be approached with our technologies in combination with those developed by others towards a positive outcome.

Finally, I would be remiss if I did not point out that we are a small business, and in order for us to pursue solutions to FHABs with the same inventiveness and intensity we bring to all of our pursuits, we must be able to finance it. We are reaching the end of the funds we had available to develop some of our technologies directed at FHABs, and that is in no small part why we believe this legislation is so important. Applying creative solutions in a way that positively impacts our world and communities, while still supporting a successful business model that will create jobs and products, is a core mission of our organization, and we would like FHAB remediation to be part of our business model.

In closing, our organization arrived at FHABs as an area of interest not through years of scholarship directed at this specific topic, but rather through the recognition that FHABs are a devastating problem for inland lake communities and economies, in need of creative solutions and technologies. The Summer of 2010 at GLSM, and the monitoring and experiments we have conducted since then, not only support the point made at the beginning of this treatise regarding collaborative technology development, but also bring out several others that are directly relevant to the legislation at hand, and which I want to leave you with:

1. As stated earlier, addressing FHABs will require a suite of technologies that come together to attack the problem, and which must be applied at both the fundamental and applied levels.

2. Far less appears to be known about FHABs than about marine HABs and how they might be addressed, and strategies for addressing HABs in marine systems will not necessarily translate to freshwater systems.

3. It is our opinion, through this past year's experiences, that there is currently insufficient assessment of HAB prevalence in inland lakes to truly understand the magnitude of the problem or the damaged economies.[6]

4. It appears that more is known about monitoring and prevention of HABs (both marine and freshwater), than about control and mitigation. We believe that more needs to be done to address ongoing HABs, especially in freshwater environments, and those writing in the scientific literature have also pointed to the need for more to be done in the area of remediation.

5. The current level of funding, which we understand to be on the order of $36M may be insufficient for addressing the needs we point out in this testimony, when one considers that most of those funds may be spent on marine environments, and the cost of developing mitigation or remediation strategies. The funding level also

[5] Paerl, H. (2008) Chapter 10 in Cyanobacterial Harmful Algal Blooms: State of the Science and Research Needs. Editor K. Hudnell. Springer Science + Business Media, LLC. New York, NY.

[6] Dodds et al. (2009) Env. Sci. Technol. 43:12–19.

does not appear to match the magnitude of the damages assessed, even as the single example (GLSM) provided in this testimony demonstrates.

Chairman Harris, Ranking Member Miller, thank you once again for the opportunity to testify before you today, and at this time, I welcome any questions from members of the subcommittee.

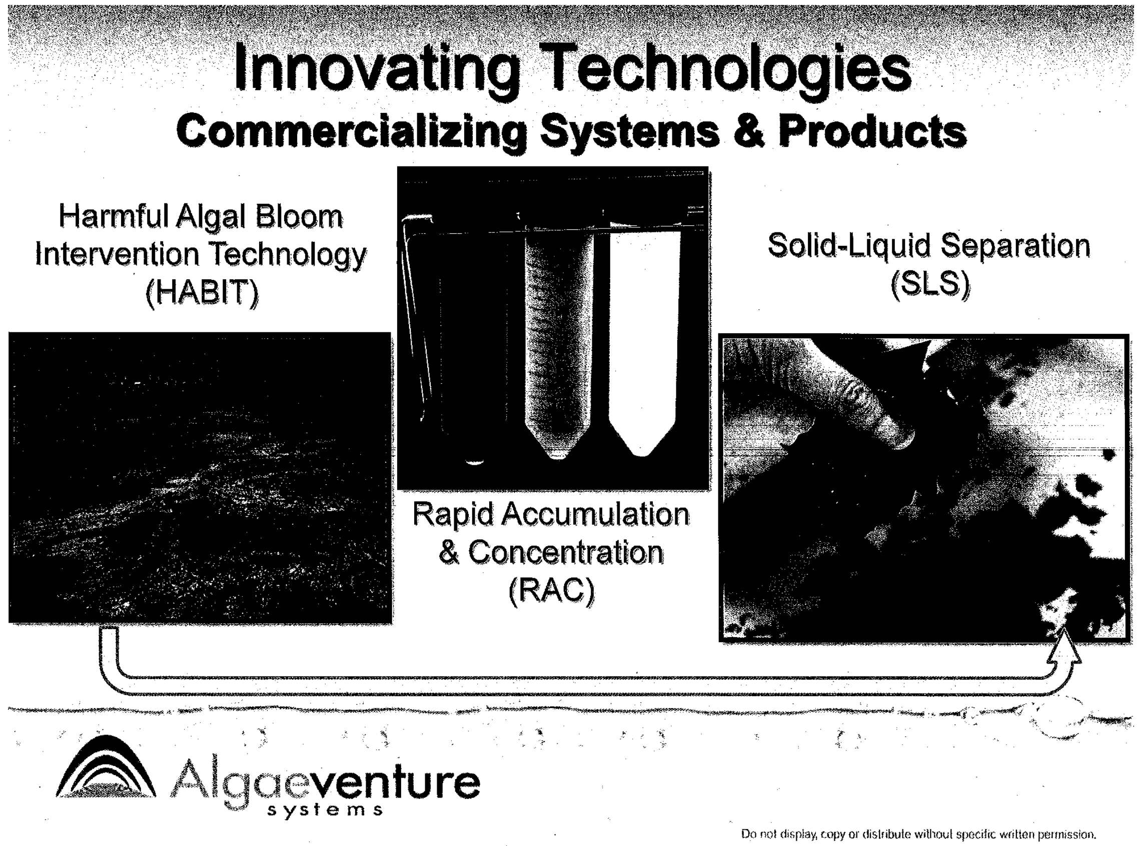
Congressional Testimony, HABHRCA
Dr. Stephanie A. Smith, Chief Scientist
June 1, 2011

Algaeventure Systems: Who We Are

- Boot-strapped start-up
- Parent company Univenture, Inc. profitable for the last 19 years
- Inc. 500 Fastest Growing 5 times
- SBA National Business Person
- Ernst & Young Entrepreneur of the Year
- 2002 International Plastics Design
- Over 50 Issued Patents Worldwide
- *R&D* 100 Award – November 2009
- 8x Commercialization Participant or Lead
- **US DOE ARPA-E R&D Award 2009**
- **Commercial Deployment Arm, AlterE**
- **US DOE "Entrepreneurial Mentor Corps" Program Members**

Algaeventure systems

AlterE Technologies


Innovating Technologies
Commercializing Systems & Products
Harmful Algal Bloom Intervention Technology (HABIT)
Rapid Accumulation & Concentration (RAC)
Solid-Liquid Separation (SLS)
Algaeventure systems
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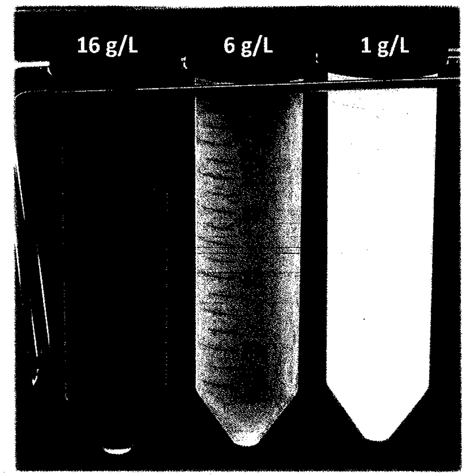
Rapid Accumulation & Concentration (RAC)

- Passive agglomeration technology
- Concentrates without chemicals, flocculants or screens



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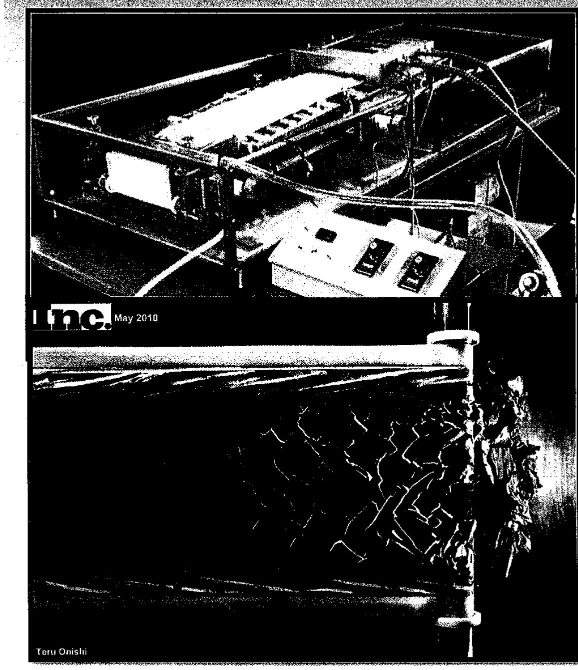
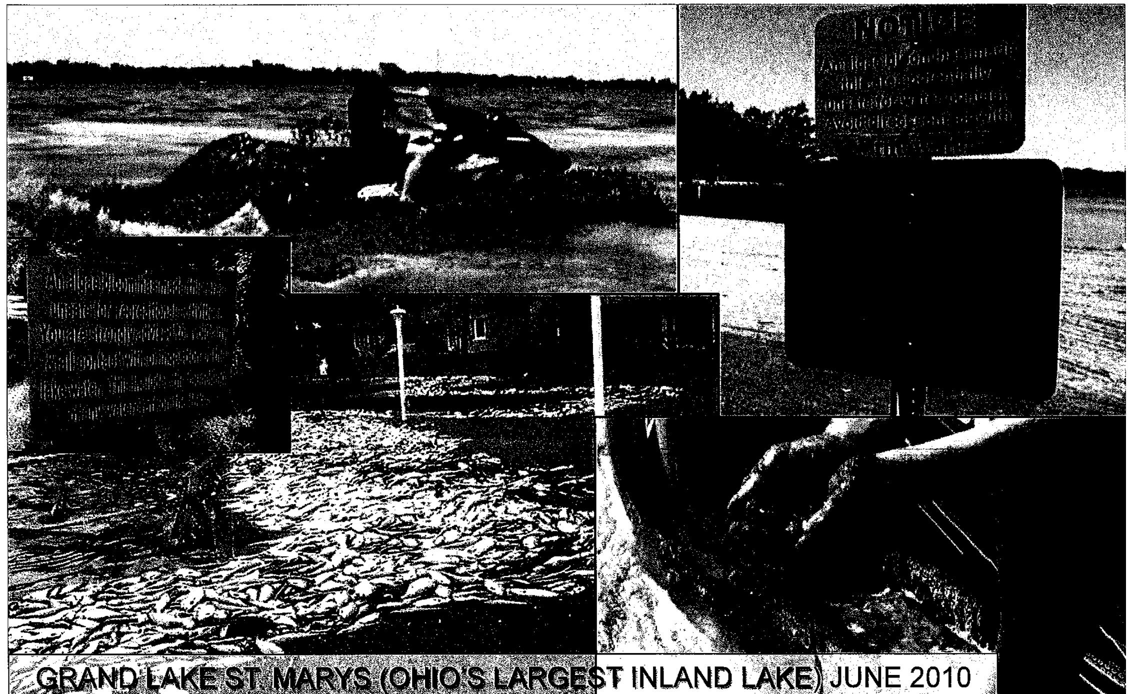
Solid-Liquid Separation (SLS)



- Dewaters and dries algae
- Called "disruptive" and "transformational" technology
- Development funded by the DOE ARPA-E program
- Low energy, low cost materials
- Currently in scale-up and commercialization phases
- Planned testing with algae harvested from natural bodies of water

Algaeventure systems

http://www.youtube.com/user/AlgaeVS



GRAND LAKE ST MARYS (OHIO'S LARGEST INLAND LAKE) JUNE 2010

Algaeventure systems

Silica Concept

GLSM: Aug.- Sept. 2010

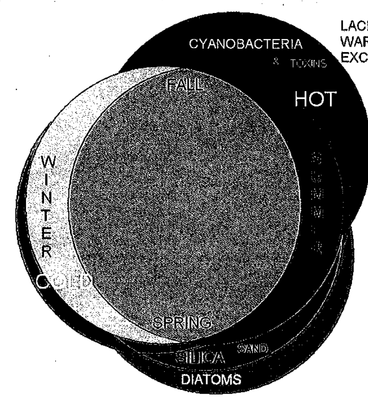
–Small scale and lake testing

–Large scale in lake cove

–EPA, ODNR permits & ODA contract issued

–We have learned that:

- There were no adverse affects, but no impact
- Complexity of FHABs will require multiple approaches
- Cyanobacteria appear to dominate in these lakes even in early spring



BGSU Bowling Green State University

Ohio EPA

USDA

Algaeventure systems

Rapid Accumulation & Concentration (RAC) for Remediation

RAC floating dock, Grand Lake St. Marys

Algaeventure systems

Key Points

- Addressing FHABs will require a suite of technologies
- Less appears to be known about FHABs than about marine HABs
- Insufficient assessment of HAB prevalence in inland lakes
- More is known about monitoring and prevention, than about control and mitigation
- Planned funding may be insufficient, considering the magnitude of the impacts

Algaeventure systems

Chairman HARRIS. Thank you very much, Dr. Smith, and I now recognize our final witness, Dr. Beth McGee, Senior Water Quality Scientist at the Chesapeake Bay Foundation. Dr. McGee?

STATEMENT OF DR. BETH McGEE, SENIOR WATER QUALITY SCIENTIST, CHESAPEAKE BAY FOUNDATION

Dr. MCGEE. Thank you, Chairman Harris, Mr. Miller and other Members of the Subcommittee, I really appreciate the opportunity to speak with you today. Again, my name is Beth McGee. I am a Senior Water Quality Scientist with the Chesapeake Bay Foundation.

You have my written testimony which highlights some of our recommendations for research needs in the Chesapeake Bay, so I would just like to take my time here to highlight just a few points.

Probably the most notorious HAB species in the Bay was pfiesteria. You may recall back in the summer of 1997 this microbe, which was actually first identified in North Carolina waters, drew a fury of media attention and public concern because it was blamed for numerous fish kills and even human health concerns in the Chesapeake Bay, specifically in the Pocomoke River on the Eastern Shore.

Since that time, fortunately we have not seen any reoccurrences of pfiesteria at least in the Chesapeake Bay, but the events were certainly a wakeup call nationally to the problems associated with harmful algal blooms. And I think actually it was one of the reasons that triggered the original 1998 legislation that we are talking about today.

Certainly the Chesapeake Bay has other problems with harmful algal blooms, things like mahogany tides will cause fish kills, we have the cyanobacteria, blue-green algae that have also been talked about that have caused human health concerns, but probably the most systemic problem in the Chesapeake Bay is problems with anatoxin and hypoxia. On average, about 75 percent of the Chesapeake Bay has insufficient levels of dissolved oxygen. What that translates into is a huge amount of the Bay, every year that is basically off limits for the aquatic life that live in the Bay.

Ultimately the solution to both of these problems, that is anoxia, hypoxia and harmful algal blooms, is reducing excess nutrients. In the Chesapeake Bay we in fact have a very detailed nutrient reduction strategy that has just been developed by the States in collaboration by the Federal Government. It is mandated under the Clean Water Act, and while the Chesapeake Bay Foundation is certainly supportive of the research and monitoring needs that have been identified by some of the other panelists, we believe that the strategy, this nutrient reduction strategy that we have in the Chesapeake Bay, needs to be the principal means by which local, State and Federal Governments solve the problems associated with anoxia and HABs in the Chesapeake.

With that, I thank you again for the opportunity to be here today, and I will be happy to answer any questions after your break.

[The prepared statement of Dr. McGee follows:]

PREPARED STATEMENT OF DR. BETH MCGEE, SENIOR WATER QUALITY SCIENTIST, CHESAPEAKE BAY FOUNDATION

Chairman Harris, Mr. Miller and members of the subcommittee, we appreciate today's invitation and your interest in this important topic.

For more than 40 years, the Chesapeake Bay Foundation has been working to protect and restore the Chesapeake Bay. The Chesapeake Bay is the nation's largest estuary, and its 64,000 square mile watershed—from Cooperstown, New York to Cape Henry, Virginia and westward to the Allegheny Mountains—is a large part of the Mid-Atlantic region. More than 17 million people live in the Chesapeake Bay watershed, a number that is increasing by roughly 150,000 each year.

Starting in 1998, the Chesapeake Bay Foundation has issued a State of the Bay report that grades the health of the bay on a scale from 1 to 100. Last year, the numeric score was "31"—a D+. The score was an improvement from the previous report card, but still indicates a Bay that is dangerously out of balance. The most systemic problem continues to be an overload of nitrogen and phosphorus pollution that fuel algae blooms that ultimately, lead to a lack of dissolved oxygen—that is, hypoxia and anoxia—in many parts of the Bay and its rivers. On average, over the last 10 years, more than 75% of the Chesapeake Bay and its tidal rivers have had insufficient levels of dissolved oxygen.

These poor water quality conditions can result in mortality or stress to aquatic animals like crabs, oysters, and rockfish. In turn, these impacts have economic consequences.

For example, low oxygen levels can drive blue crabs from their preferred habitat and kill many of the small bottom organisms on which the blue crabs feed. A study by the University of Maryland demonstrated that decreases in dissolved oxygen can reduce crab harvests and revenue to watermen.

Another critical Bay species, commercially, recreationally, and as an important part of the Bay ecosystem, is the oyster. Unfortunately, a combination of overharvesting, disease, and poor water quality has decimated the oyster populations in the Chesapeake Bay. Extended periods of zero oxygen conditions can be fatal to oysters and recent studies have indicated that low oxygen levels can stress the immune systems of oysters, making them more susceptible to disease. The decline of the Bay oyster over the last 30 years has meant a loss of more than $4 billion for Maryland and Virginia.

The rockfish (striped bass) has been, and remains, the most popular commercial and recreational fish in the Bay, generating roughly $500 million of economic activity related to fishing expenditures, travel, lodging, gear and so on. Faced with a catastrophic collapse in the fishery, commercial and recreational fishing were banned in the Maryland portion of the Bay from 1985–89 and in Virginia during 1989. The dramatic decline of the population was due to several factors including overfishing and low dissolved oxygen in deeper parts of the Bay. Today, the rockfish population is at its highest in decades. However, scientists are concerned about the high prevalence of disease which has been attributed to poor water quality and limited availability of its preferred prey.

Although arguably the Chesapeake Bay's most pervasive problem is anoxia and hypoxia, like many other coastal and estuarine systems, it also suffers from the effects of harmful algal blooms (HABs.) Scientists estimate there are more than 1,400 species of algae in the Chesapeake Bay and its tidal rivers; 34 are potentially harmful. HABs represent a significant threat to aquatic life, human health, and regional economies.

Probably the most notorious HAB species in the Bay is *Pfiesteria*. During the summer of 1997, this microbe, first found in North Carolina waters, drew a fury of media attention and public concern when it was blamed for fish kills and human health problems in the Chesapeake Bay, specifically the Pocomoke River in Maryland. This led to closures of public waterways to commercial and recreational use, resulting in substantial economic losses to the local seafood and tourism industries. Since that time, there have been no reported *Pfiesteria* outbreaks in the Chesapeake and the role that *Pfiesteria* played in the observed effects is still being debated in the scientific community. Nonetheless, the events triggered intense research into all types of toxic algae and, since then, state health officials in Maryland have set up surveillance systems and tried to be more vigilant about warning the public about HABs through websites (http://www.dnr.state.md.us/bay/hab/) and swimming beach notices—a model that other tidal Bay states would be well-served to emulate.

Other harmful algae in the bay include species that produce reddish-brown "Mahogany Tides," including *Prorocentrum minimum, Karlodinium veneficum,* and *Cochlodinium polykrikoides.* Blooms of these algae can cause dissolved oxygen problems, in addition to being directly toxic to fish and shellfish. In particular, *Karlodinium* is thought to be responsible for numerous recent fish kills in Maryland. In addition, recent studies have demonstrated that some species produce a toxin that is highly toxic to oyster larvae. As a result, several researchers have speculated that the increase in the distribution and magnitude of blooms of some toxic species in the Bay may be negatively impacting native oyster restoration efforts in Virginia and Maryland—an activity in which the Chesapeake Bay Foundation is heavily invested.

Blooms of blue-green algae, also known as cyanobacteria probably represent the most significant HAB-related risk to human health in the Chesapeake Bay. In particular, cyanobacteria produce toxins that have been associated with liver and kidney disease, vomiting, fevers, and skin rashes in people. A recent Chesapeake Bay study reported that between 2000 and 2006, 31 percent of the waters tested for cyanobacteria blooms had enough toxins to make them unsafe for children to swim in. The toxins can also cause fish kills, bird, pet, and livestock deaths. Typically associated with freshwater systems, cyanobacteria blooms have been causing problems in the Potomac River and other waterways at least since the 1930s. The first confirmed presence of toxins in the Chesapeake Bay's tidal waters came in 2000 in the Sassafras River on Maryland's Eastern Shore. Since then, state officials have issued no-swimming advisories or beach closures due to blooms on the Sassafrass, Potomac, and Transquaking rivers.

Research, Monitoring and Communication Needs

In our view, additional research is needed to understand factors involved in, among other things, bloom initiation and the effects of climate variability and change. Additional monitoring and communication is also important.

Understanding factors involved in bloom initiation. We know that nutrients certainly play a role in bloom formation, but the timing of nutrient input and the flow pathways are also critically important to bloom initiation and subsequent transport to adjacent waterways. From the management perspective, for example, understanding this relationship may help identify geographic areas and stormwater management approaches that should be targeted. Better understanding of bloom formation will also improve scientists' ability to predict the formation of blooms, thereby increasing the ability to protect humans from exposure.

Understanding the effects of climate variability and change. Warmer water temperatures appear to be expanding the range of HABs into the Chesapeake Bay and causing others to bloom earlier. For example, a toxic alga normally associated with Florida and the Gulf Coast, *Alexandrium monilatum,* in 2007 was believed to have been responsible for killing whelks (a species of sea snail) in the York River in Virginia. It was the first known bloom in this area. Increasing temperatures will also select for different species in the normal successional pattern in the Bay, with unknown consequences on the living resources. Better understanding of these likely effects will help the Bay region better adapt to the ecosystem changes caused by climate change.

Improved monitoring and communication. Probably because of their experience with "Pfiesteria hysteria", Maryland does a fairly good job of regular monitoring for common HABs, posting that information in "real time" on a web page where it is visible to the public, and providing a HAB hotline—accessible via the web and by phone—where the public can report unusual events such as HAB or fish kills. Virginia's program, while providing some periodic monitoring, a public hotline, and state agency response to reported HAB events, does not report real-time information to the public. Due to the apparent increase in the frequency and extent of HABs in Virginia's tidal rivers, particularly the James, we believe timely release of this information is critically important to inform and protect the public.

Draft Bill

The letter of invitation that I received from Chairman Harris asked me to comment on the subcommittee's draft legislation for the reauthorization of the Harmful Algal Bloom and Hypoxia Research and Control Act.

First, there is much that is good in the draft that was shared with us. It is virtually impossible to dispute the need for additional federally supported research, development and implementation of action plans for certain unaddressed aspects of the hypoxia/HAB challenge, and coordination of federal, State, and local government activities. As a general matter, the Chesapeake Bay Foundation supports reauthorization of the Harmful Algal Bloom and Hypoxia Research and Control Act.

Second, no one should be surprised that we believe that the Act deserves a special Chesapeake Bay section, parallel but not identical to the Northern Gulf of Mexico section. We have been on the front lines of the Chesapeake Bay hypoxia and HAB questions for more than a generation. Scientists worldwide have recognized for decades that nutrient over-enrichment and hypoxia are the principal systemic water quality problems of the Chesapeake Bay. A better understanding of the underlying processes by which HABs are initiated will lead to better management strategies. That said, it is also time to address the underlying cause of these problems: excessive levels of nutrients.

We have one overwhelming concern with this draft legislation: its failure to acknowledge, or in any way support, the widely accepted strategy to get nutrients under control under the authority of the Federal Water Pollution Control Act (the Clean Water Act.) There is a detailed action strategy in place that has been developed and agreed to by the federal government and the Chesapeake Bay jurisdictions—New York, Pennsylvania, West Virginia, Virginia, Maryland, Delaware, and DC. It has been reinforced by the federal courts and by the Congress. It needs to be acknowledged and supported by this subcommittee. In a time of such concern about the federal deficit, we simply cannot afford to have some federal agencies, six states and the District of Columbia working on one part of the problem, and other federal agencies on another.

Expanding on that point, Section 8 of the draft bill is particularly problematic. "Nothing in this Act, or the amendments made by this Act, shall be construed to require a State, tribal, or local government to take any action that may result in an increased financial burden to such government." We want to be very clear: successfully addressing the nutrient over-enrichment of the Chesapeake Bay in order to address the widespread hypoxia problem is going to require changes at the individual, local, and State levels that will impose costs. Unless the federal government is prepared to fund every penny of every necessary change-a prospect far beyond rational consideration-there will be costs to individuals and governments. We believe that such costs are manageable and will create jobs and spur local economies, and that it is an appropriate role for the federal government to assist in supporting some of the costs of necessary pollution reduction activities. However, pollution from all sources must be reduced. Individuals, businesses, and units of government cannot expect to perpetually "externalize" their costs by polluting the public's commonwealth.

In sum, it is the view of the Chesapeake Bay Foundation that harmful algal blooms are a serious threat to ecological and human health in estuaries and coastal areas in North America and much of the rest of the world. Current policies that allow for externalization of the costs of pollution are at least in part to blame. While there is a need for more research, monitoring and communication, there is also a pressing need to reverse the policies that are substantially contributing to the harmful algal blooms in this country and abroad. In the Chesapeake Bay watershed, we have a strategy in place; it needs to be the principal means through which the federal, state and locals governments bring the Chesapeake Bay back into balance.

Thank you for the opportunity to address the subcommittee today. I look forward to the discussion.

Chairman HARRIS. Thank you very much, Dr. McGee. The Subcommittee will recess until 10 minutes after the last vote begins. We will resume the hearing for Member questioning at that time, and I want to thank the panel and look forward to seeing you, again, 10 minutes after our last vote begins. The Committee stands in recess.

[Recess.]

Chairman HARRIS. The Committee is now back in session, and again, I want to thank the panel for their testimony, and I will first recognize myself for five minutes.

Dr. McGee, thank you very much for being here. You state in your written testimony that the Chesapeake Bay should have a separate provision in the bill. Given the issues to be addressed in the regional research and action plans, what areas of research do you recommend that could be specific to the Bay that would need to be identified in a separate section?

Dr. MCGEE. Thank you again for the opportunity to be here. In particular, one of the notions, and this is actually more related to sort of public notification rather than research, is we believe Maryland does a really good job of doing some routine monitoring for harmful algal blooms, for posting information related to blooms on their web page sort of in real time. Unfortunately, in Virginia, the information is a little less readily available. There is no real-time access for the public to be notified of when blooms are occurring and therefore can protect themselves. So that would be, I think, one example around the sort of monitoring public notification that I believe this legislation could address that could be specific to the Bay to sort of up the bar for both Maryland and Virginia and other coastal states within the Bay region.

Chairman HARRIS. And that would be regarding notification. But with regards to research, because again, you know, the focus of this Committee really is the research aspects. Are there aspects of that research that would be particular to the Bay?

Dr. MCGEE. I guess,specific to the Bay but issues that I have heard from scientific colleagues include the effects of climate change, for example. We are seeing blooms of algal species that are from more southern regions that we are now starting to see show up in the Bay on a regular basis. So having a better understanding, being able to better predict what species may be affecting the Chesapeake Bay waters, and therefore, the residents of the Chesapeake Bay are important.

As I mentioned, we do have problems with mahogany tides, in particular, which are responsible for fish kills, et cetera. There is an unclear understanding of what triggers those, the initiation of those blooms, so better understanding those. You know, those are not necessarily problems that are unique to the Chesapeake Bay. I think the species are perhaps unique to the Bay and other areas, but they would probably be applicable nationwide.

Chairman HARRIS. Thank you. Let me just ask, I will ask you and other Committee Members my comment because in your testimony you mentioned that, you know, we should concentrate on kind of what I will call the upstream effect of nutrients, adding nutrients that promote the growth of the algae that could result in hypoxia or harmful algal blooms. But downstream you could also remove some of the algae by for instance increasing the population of Menhaden, for instance. Is that something we should be looking at, looking at the effect, the cost benefit effect of increasing the population of Menhaden to in fact remove some of the algae so for instance our dead zones are smaller?

Dr. MCGEE. The Chesapeake Bay Foundation has thought a lot about that. I mean, oysters are another example of a really good in-stream filter that is removing algae, and we actually do a lot of oyster restoration because of that important ecological role. But ultimately, our sense is that you really need to stop pollution at the source because there are no doubt going to be effects from the nutrients as they travel downstream to where you might have the Menhaden or the oyster bar. And so there are going to be effects that we are going to miss, and so ultimately the solution we think needs to be both of those. It needs to be protecting and restoring our in-stream filters but also reducing the sources of nitrogen and phosphorous pollution coming into the Bay.

Chairman HARRIS. Any other panel would comment on the use of the natural eaters of the algae? Yeah, Dr. Anderson?

Dr. ANDERSON. I would make the comment that there is old law of unexpected consequences, and we see it an awful lot with some of these systems. The amazing pictures that I showed you from China are a perfect example of where they have started a huge aquaculture industry down near Shanghai and porifera, the algae you get in sushi, and the green algae that you saw in huge masses is a contaminant that grows on those racks for porifera, and they just get thrown in the water and it grows. And that is a situation where an effort to help clean up the nutrients with this huge aquaculture site that is removing nutrients, did a good job there, but produce a problem elsewhere.

So yes, it can be a great idea, but I think without very careful and thorough research of all possible outcomes of these things, we have to be careful with that kind of manipulation. I am totally for trying those things. I have been arguing forever we need to try to mitigate these HABs, but we have to do it in a very careful and scientific way.

Chairman HARRIS. Thank you very much. Mr. Miller?

Mr. MILLER. Thank you. Dr. Anderson, or I think several of you, spoke in your testimony of the need for mitigation. I understand the concern that some of what Mr. Harris just asked you about kind of creates other complications, and we might need to find a way to deal with Menhaden and on and on.

What are some of the other ways that we may mitigate the effects of HABs? Yes, sir. Dr. Sellner?

Dr. SELLNER. Well, as I said in my testimony and I maybe spoke a little bit too rapidly, there are a number of other ways that are routinely used, particularly in Asia. In Asia there is a routine application of a mixture of local sediments and some type of flocculating agent. In our case, it is blue crab shells, or a byproduct of those shells. And those are used around the aquaculture pens like Don was referring to, and they are usually addressing planktonic organisms that are floating in or are growing in response to the nutrients that are being excreted by the animals in the pens. So you can apply those types of sediments to remove the phytoplankton, thereby not allowing the organisms in the pens to be exposed either to the low dissolved oxygen from the bloom, and it will also remove any toxin associated with the algae to the bottom.

The nice thing about those waters generally is that they have a strong bottom current, so you don't transfer the problem from the surface to remain at the bottom and exacerbate a low dissolved oxygen situation or transfer the toxin down to shellfish or fish that are living on the bottom.

So, that is a very viable technique that is used throughout mostly in China, Korea and Japan at regular intervals. Other ways in very small systems, we have ways to mix water in freshwater enclosed systems, destratifying the water. That means if you notice when you go swimming you can often be floating on the surface and you extend your feet down and they are freezing because the water is stratified, warm at the top and denser, colder water at the bottom. Well, that is stratification actually favors the growth of many of our HAB species. So if we can destratify the water, we can produce the diatoms like my colleague was referring to, and the diatoms are generally indicative of healthy waters and support those organisms that we would harvest. It reduces the harmful algal blooms so that there are no toxins, et cetera.

The issue again, you get too many diatoms is that, like in the Chesapeake, if you get too many diatoms and it goes below that stratification, then you have perpetuation of the low-dissolved oxygen problem. So that is the Chesapeake's problem, but if you mix the water—we are not going to mix the Chesapeake. We have already tried to do that about 20 years ago under a former DNR director, and that wasn't a wise move. But in small lakes, that mixing process can work and does work effectively.

Mr. MILLER. Actually, that has used up almost all my time. It certainly sounds like all the efforts to mitigate create more potential problems and are more complicated which means more things can go wrong than simply producing fewer of the nutrients that create the algal blooms.

Dr. Greene and Dr. Magnien, quickly, I know that every president, whether it is kind of censor what government officials are saying in a sinister way or just to know what they are saying, wants to see a testimony. This Administration has been no exception, and it is a somewhat cumbersome process which did not make it possible for you to review the draft legislation in a way to comment, in your written testimony. But do you have any comment now. Dr. Magnien, you appeared to want to answer the last question. Do you want to try to do both quickly?

Dr. MAGNIEN. Yeah, if I have a little bit of time, on the mitigation, we typically look at that as not necessarily controlling the bloom as much as dealing with it like we do with hurricanes or tornados. And one of the best ways to deal with that for harmful algal blooms is to be able to forecast and detect it early and stay out of harm's way essentially, either move aquaculture resources or alert public health officials that something is offshore and about to come in. So I wanted to put that on the table in terms of an important mitigation tool, and I mentioned that and I have more examples in my written testimony.

As regards to the draft legislation, yes, we did receive it recently, but I am prepared to give some comments on that legislation today. We are very supportive of the reauthorization, have been for a number of years. It is really important that we maintain the momentum that we have built. Many years are often required to get to the point of actually providing a forecast or a tool to a manager. We have had some good success. We are seeing an acceleration of these benefits as a result of our research, and reauthorization would certainly help us continue on that path and bring these things to fruition that we have been able to support so far.

We are very pleased that the HABHRCA draft includes the establishment of an overarching HABs and hypoxia program within NOAA. This will enhance the visibility of these issues as a national priority and improve the coordination within NOAA with other federal agencies and the affected user community.

In addition, we are pleased that the legislation includes both event response activities and improvements in infrastructure under the NOAA list of responsibilities. One of the HABHRCA reports that we presented to Congress that I had mentioned earlier had management and response and assessment plan recommends in fact that progress would be enhanced if event response and infrastructure programs were added in this legislation.

And finally, we note however that all mention of specific programs and their associated funding levels are no longer in the draft bill as they were in the prior version. NOAA has found that the specification of these programs and the funding amounts to go with them helps to clarify the intent of Congress when implementing this legislation, and much of the progress we have made is because of that specificity and working closely with this Committee and your staff and ensuring we are on track.

So those are a summary of NOAA's comments on the legislation. We would be happy to continue to work with staff to go over any other additional questions as this legislation moves forward.

Mr. MILLER. Mr. Chairman, it is up to you whether to allow—I mean, obviously, I am over time, but Dr. Greene? Okay.

Chairman HARRIS. Thank you very much. My colleague from Maryland, Mr. Bartlett?

Mr. BARTLETT. I have a farm pond surrounded by a pasture that drains into it. Obviously it has a huge nutrient load, and for probably 30 years I struggled with filamentis algae. If I didn't use copper sulfate, it covered the pond so that it looked like I could walk on it and by fall—I hate to use copper sulfate because amphibians are exquisitely sensitive to that. It just kills them all. So I usually just suffered with filamentis algae.

And four years ago I put a pair of mute swans, pinioned, so they will not become feral and they won't leave, put a pair of mute swans on the pond. It is the most environmentally correct way to control filamentis algae. They ate it all. It is incredible. For four years now I have had a pond that is crystal clear. So this is, at least for a small farm pond, a great environmental way to control filamentis algae. I don't know how many grazers there are that could control other places, but at least for my farm pond, it worked very well.

I gather that one of the nutrient loads in the bay is from septic systems. I don't know what percents of the nutrients are septic systems, but I know the governor is concerned about it and would like to ban further development on well and septic. You know, when you look at our septic systems, by regulation you have to eject the effluent from septic tank into the soil below the root zone of most of our plants, and then we are surprised when it ends up in our aquifers and ends up in the bay. We clearly have a disposal system rather than a recycling system. If you would inject the effluent from the septic tank at the root zone, most of those nutrients—what is poison to the bay is golden for your crops. It is exactly the nutrients that the farmer pays a lot of money for to put on his crops, and it poisons the bay. It is golden on the crops.

I have worked for a number of years now trying to get some change in the regulations for septic systems. They will not permit composting toilets, which of course you have no effluent running into the bay. They will not permit composting toilets. They force you to put the effluent under the root zone and then express great surprise when it ends up in the bay. Is there any way we can bring sanity to this process?

Dr. MCGEE. I appreciate your comments, Congressman. With respect to the loads from septic systems, watershed wide, it is somewhere around six to seven percent, but that is expected to grow as our region continues to grow. So it is concerning because it is obviously a source and a growing one.

I am not an environmental engineer, but I am wondering one reason why there is a depth requirement is because septic systems are primarily really designed to take bacteria out, and if you would inject the effluent from the septic system at too shallow a level, you could be I think potentially exposing humans to bacteria. So I think that could be one regulatory reason why the switch isn't occurring.

Mr. BARTLETT. As far as I know, all pathogens are exquisitely sensitive to ultraviolet light. I think there is just a modest exposure to light, and they are all dead. Am I wrong?

Dr. MCGEE. I think——

Mr. BARTLETT. I just think this is a disposal system, out of sight out of mind. You don't need to worry about it because you can't see it anymore.

Dr. SMITH. Yeah, I am actually a microbiologist, and yeah, coliform bacteria, I mean the USGS has done a lot of really good source studies. You know, you can trace, for example, a lot of coliforms that come from cattle and so forth to the site even of those cattle because those coliforms can persist in streams and waterways all the way down to the tap. So as Dr. McGee pointed out, those bacteria are the primary reason, and just transient exposure to UV light, I mean, it has to be pretty intense UV light, far more intense than what they would typically get when they are floating around in murky waters. So that is not sufficient to kill those bacteria in those systems.

Mr. BARTLETT. Well, you know, if you injected the root zone of the plant, it doesn't get to the surface. The plants absorb it. I know a scientist who does this, and he does it very successfully. He has a gray water system, and all of the nutrients go into a bed that is a growing thing.

I went to Pennsylvania, and I saw a system, a constructed wetland, that handled the waste from I think a dozen homes, and it was really pretty small. And there was no effluent from that. There are a lot of things we can do if they would simply change the regulations so that they were legal to do.

My time is up. I thank you very much.

Chairman HARRIS. Thank you, and we are going to have a second round of questions.

Dr. Sellner, let me ask you a question. In your statement you included a description of the techniques you are using I think at that lake outside of Denton, Maryland, is that right?

Dr. SELLNER. Um-hum.

Chairman HARRIS. Will that technology be transferrable to—I take it it is a totally freshwater environment—to the marine environment of the bay or the estuarial environment of the bay, and if it is, when do you anticipate you can move some of that research to that environment?

Dr. SELLNER. Yes, it is transferrable. Actually Don and his student have done some very nice work on the Florida red tide using a similar approach with sediments and flocculation.

It can be done very readily because the process is similar. We actually had a high-school student take our method that we are using at Wollaston Lake outside of Denton and try it with prorocentrum, one of the mahogany tides that Dr. McGee was talking about, and they took it out just as effectively as the cyanobacteria that we are studying in the lake, Wollaston.

So it looks very effective. One of the lessons we have learned from our colleagues, both Don and our Asian colleagues is that you must change the flocculating agent, just because of the salt effect. But the sediment, combined with the flocculent, works very well.

The limitation though about going to the open water, and I should say the method we are using at Lake Wollaston will be used, can be used in tidal freshwaters, so Upper Potomac, Mattawoman Creek, you know, Sassafras, Bud's Creek, Transquaking, Higginsmill Pond which drains into the Transquaking, it can be used in those flowing waters. So it is not just limited to a basin of a lake.

So yes, the technique is quite applicable in terms of timeframe. As I was talking with your staff member just at break, one of the limitations is permitting and liability that we have to address in terms of federal and state concerns of unexpected consequences. Right now we are doing work to suggest that following the toxin to make sure that we don't move it to the bottom, and if it does go to the bottom, does it impact oysters or swimming Menhaden for example? We believe that the bacterial process that Dr. Smith knows about will actually degrade the toxin through time so that it would be a temporary pulse to the bottom, but it would through bacterial activity, natural bacterial activity, would actually disappear through time.

But it is important to consider open systems that as long as the water is moving, you don't take substrate and allow it just to accumulate in one area, substrate meaning the algal biomass.

Chairman HARRIS. And if that were a successful technological solution, do you think that there would be private sector interests? I mean, do you see it eventually that technology migrates into the private sector to actually do some of the mitigation and control?

Dr. SELLNER. It certainly can be done that way. Right now the State of Maryland, as you likely know, DNR has some very good event response capacities. They routinely send out SWAT teams. Our approach right now has been that it would become a tool in the State's toolbox, and this technique is inexpensive relative to many other techniques that are out there, commercial products that are available. Crab shells are local.

So it could be done by a private firm. I think a cost benefit analysis would need to be done because no offense to Dr. Smith and her company, but overhead rates in businesses are higher than, you know, the state rates for their teams that are normally out in the field.

So as long as that cost benefit analysis was done, I think any way to get the technique routinely used should be explored.

Chairman HARRIS. And Dr. Smith, are there some other solutions that you can think of or discuss with us about something that could be available for when an HAB is predicted to occur, something that might make it less likely to occur, to mitigate it, other solutions out on the horizon?

Dr. SMITH. Yeah, we had looked at the possibility. I didn't get to talk much about it, of whether you could add silica to a system and potentially promote the growth of diatoms, but the way to do that would probably have to be very early in the spring because when it is really warm—and it also points to the fact that climate change is going to be a huge issue here—when it is really warm, speaking as a microbiologist, nothing is going to grow faster than a cyano. I mean, they are going to outgrow anything, no matter how much silica you can put into a system or anything else.

So there is potential for an amendment like that to work. I think that would probably work even more in some marine systems than in freshwater systems. What we are learning now is that a lot of our freshwater systems don't appear to be that limited for silica actually, so that might not be the factor that is holding back the growth of beneficial algae. So that would be another area for very fundamental research. If you wanted to promote the growth of something that you like better than a cyano, how are you going to do that? And there could be some very good basic research done in that area because I think there have been some examples in the past where, you know, just getting a bunch of diatoms might not necessarily be a good thing, either.

So there really has to be some fundamental work there. I think more on the applied end, especially with these filamentis cyanos, as Mr. Bartlett pointed out, it does look like you can walk across a pad of these. I don't know if I would do that on a 13,000 acre lake like Great Lakes-St. Mary's, but I think there are also almost what I would call more brute-force technologies that I think could be looked into for just harvesting that biomass. I mean, it almost looks like you could just rake it off of the surface.

With that said, those technologies have to be very low-energy technologies, and they have to be done in a way that won't lice that biomass and release more toxins. So that is something we are considering very strongly. You have to have sort of a passive harvesting technology to try to get your hands on that biomass so that you don't create a bigger problem.

Chairman HARRIS. Thank you very much. Mr. Miller?

Mr. MILLER. Thank you, Mr. Chairman. Dr. Greene, comments on the legislation?

Dr. GREENE. Yes, thank you, Mr. Miller. We are encouraged by the legislation in that it recognizes the continuing needs for further research and management tools to address harmful algae and hypoxia. We are a little unclear at the moment what the omission of the freshwater piece may have and how that may impact EPA's role in the future. We are certainly looking forward to providing written comments once we see the next draft legislation.

Mr. MILLER. Thank you, Dr. Greene. Dr. McGee, in your testimony you discuss the importance of understanding what led to bloom initiation, bloom formation, the importance of scientists understanding that. Who is now doing research into bloom formation?

Dr. McGee. Actually, the scientist who made the recommendation to me because I queried some of my colleagues prior to testifying here today, was a researcher down at Old Dominion University. Her name is Margie Mulholland. I am sure there are others. Dr. Sellner probably knows some as well. But that was one suggestion that came to me.

Mr. Miller. Is that research going on now or is that . . .

Dr. McGee. There was some preliminary—yes, there is research going on right now, but clearly more—I think it seems the little I know about harmful algae blooms that the more you dig into it, the harder they are to understand. So I am sure that one question was answered and many more came up.

Mr. Miller. Dr. Sellner, Dr. McGee said this is an area you are more familiar with as well.

Dr. Sellner. Yes, I am going to actually defer to Don because he is very familiar with all of the initiation that is going on. I could say some things, but I think Don has them at the tip of his fingers.

Mr. Miller. Dr. Anderson, are you going defer to Dr. Green?

Dr. Anderson. No, I am very happy to handle, Mr. Miller. We actually, in the Gulf of Maine, New England area, are heavily invested in studies of the initiation of blooms of an organism that cause paralytic shellfish poisoning, and that organism has actually a resting stage or a cyst. It is in bottom sediments. It is all through the Gulf of Maine, billions and billions of them are down there. And we have studied them. We now know what time of year they come up, that they have got a little internal clock that regulates that emergence, just like we have a daily rhythm that wakes us up. They have got a yearly rhythm. We have got that all parameterized, we have got it modeled, and that is now the basis of the forecast that Rob Magnien has been mentioning that we are now issuing every year for how big our blooms are going to be and when they are gong to occur and so forth. All based on the size of the sea bed of these cells that have been dropped by the preceding blooms that we go out and map every year, and we have been working with these NOAA programs with the methods to both map these out and to just try to make that a much more efficient and less expensive procedure because we are finding through year after year of mapping these features, that there are common aspects of the distributions that we can then start to have a much more efficient sampling program to sample just a few locations and extrapolate and know how many are out there.

So bloom initiation is extraordinarily important, and this is a good example of where sustained research has led to a predictive tool and a forecasting tool that is soon to become operational within NOAA.

Mr. Miller. Okay. I know that Dr. McGee talked about the role of nutrients as being obviously central, and our own Dr. Bartlett did as well. How big a role do nutrients play in bloom formation, Dr. McGee or Dr. Anderson or Dr. Sellner?

Dr. Anderson. I think I will just take a quick shot at them. I am sure Kevin would like to say something. I wrote a paper very recently about the U.S. HABs and nitrification, and we walked around the country with experts from each area and for each one said with these big outbreaks, in New England and the Chesapeake and the Gulf of Mexico, how critical are nutrients from land in these outbreaks. And the answer is in some, it is extraordinarily important, in some areas. But in other areas, in the Gulf of Maine for example, along the West Coast in California, in Alaska and some parts of Washington, it is natural nutrient sources that are driving these. So it is a very important point for the Committee to realize that simple nutrient reductions are not going to eliminate the HAB problem. It will only affect some of them.

Mr. MILLER. My time is expired.

Chairman HARRIS. Dr. Sellner, did you want to say something about that?

Dr. SELLNER. Yeah, just a little bit. Don hit on the Gulf of Maine example, but resting stage that he was talking about is actually characteristic of many of the HABs. So for example, Denton Lake or actually in your case, Mr. Bartlett, the filamentis forms, they actually have overwintering stages. They are not necessarily cued to an internal clock like Alexandria is in the Gulf of Maine. But when the waters begin to warm, you know, as Dr. Smith alluded to, for most microbes, warming in a lake, normal seasonal increase in spring, it is, oh, yes, it is time to get out of my winter doldrums. A little bit of light hits the bottom, if they are sitting in nutrients, bang. They have a competitive advantage.

So there are many overwintering or resistant stages for many of the HABs out there. So that is one of the processes that we have to imbed into all of our basic research but also our mitigation. So there are aspects of this initiation that a number of groups are studying. Margie Mulholland who Dr. McGee referred to down at Old Dominion is investigating accocladinium, a very large dinaflagalant that occurs down there and it initiates not far from the Norfolk Naval Base, not attributing it to the naval base, but it is to Elizabeth River and there is a source there in the sediments that essentially acts as a seed bed for the rest.

In the York River, there is a bloom former there, Alexandrium monilatum, that now has come in from the coastal ocean during a drought, forms a cyst and actually resides in the sediments. And so now it is there, waiting for that warming period or those optimal conditions, and then when those optimal conditions occur, nutrients are around because nutrients are very plentiful, and the blooms take off.

So nutrients are essential to all plant growth, and the HABs generally have a life stage that permits use of that under optimal conditions as well as relatively rapid growth rates or competitive advantages where they bash their competitors, I will put it simply.

Chairman HARRIS. Thank you very much, Dr. Sellner. Mr. Bartlett?

Mr. BARTLETT. Thank you. I have been interested in two things, one is trying to save our farmland because right now the only development you can do with well and septic is on farmland because it can't slope more than 25 percent or they won't perk it, and it has got to perk and of course that is by definition farmland. So I have been trying to encourage development that doesn't chew up farmland and reduces the nutrient load.

So I have been trying to promote the composting toilets which really work very well. They have worked very well for a couple of hundred years in Scandinavia. There is no question that they work. And I wanted to use rainwater, and we have prohibitions against using cistern water, so I said, gee, let me see if I understand this. The rain falls on the hog lot, and then it flows out of the hog lot into the stream. Then it goes into the stream, into the reservoir, and you pull it out of the reservoir and treat it and tell me it is drinking water. I say can I please have it before it goes through the hog lot? That seems to be a rational request to make. Enough water falls on the roof of the average home to meet all of your water needs for the year if you separate your composting toilet from your gray water.

We are about the only major country in the world that flushes their toilets and washes its streets and puts out its fires with drinking water. So gee, you know, you might be washing the car and drink from the hose, so you couldn't use gray water. I said, you don't drink from your toilet, do you? You know, you learn what you can drink from and where you can't drink from. I didn't see that as a reasonable objection to using cistern water.

You know, you could go out on an abandoned freeway and with a Clivus Multrum, any composting toilet, Clivus Multrum is the granddaddy of them, and it absolutely works, and with a gray water system and just, you know, build a bed out there and put your gray water in that bed and catch water from the roof of your house, and that would meet all of your water needs for the year. It is going to be a race from any community, whether they are brought to their knees due to lack of energy from oil or lack of water. So we certainly need to conserve water. This also would markedly reduce nutrients in the Bay. There would be no nutrients escape that house built out on the center of the abandoned freeway, would there?

What can we do to get the regulation changed so you can do that? You know, the only time they will let you use these alternative systems is when you don't need to use them? Yes?

Dr. MCGEE. If I could respond, what you have described is exactly what we have at the Chesapeake Bay Foundation headquarters.

Mr. BARTLETT. I have been there. You do a great job.

Dr. MCGEE. So we have composting toilets, we have cisterns on our roof. We use the water so we don't have flush toilets. We use the water from the roof as fire suppression and for hand washing, the only potable water. And as a result, we use about ten percent of the water of an office building of our size. And we did run into trouble as you noted with the county in terms of reusing our cistern water and also where our gray water goes. And we actually sent a little bit of our water to the sewage treatment plant because they wouldn't let us manage it on site.

So we share your concerns. I am not sure it is a federal issue or a state issue or a county issue. I suspect it is perhaps a combination of all three. But one of the reasons why we did what we did at the Chesapeake Bay Foundation building is to show people what is possible, to demonstrate that it is possible that the toilets don't have to smell, et cetera. So I appreciate your comments.

Mr. BARTLETT. I am very familiar with composting toilets. Clivus Multrum was one of the first ones. It really works very well. That is an anaerobic system. There are aerobic systems that work very well and compost very quickly. You end up at the end of a year with like a water bucket of humus from the waste from a whole household. It really is a very effective system.

There are a lot of people that get a lot of satisfaction on resting lightly on the environment. They would really like to do that. You can't do it today. How can you all help us to bring some sanity to these regulations so that you can do that if you want to?

Dr. SELLNER. As I pointed out in the testimony, HABHRCA in the past has had a very strong commitment to social science aspects of research, and that social science research leads to very effective, developing effective communication strategies with our public and with other stakeholders out there.

So I do believe, and as we found in the Florida red tide situation, that if we can effectively and routinely communicate across our citizens, and unfortunately many of us my age and perhaps a little bit older aren't reachable anymore but the students are, so what we have found is when we have a very effective communication and education programs with school districts, the kids are the major influence at their homes. So they go home and embarrass you into using, you know, don't leave the water running while you are brushing your teeth, you know, why do you take, and this is a tough one, showers. They love showers. They are going to be in there forever, but they are the ones who actually come home and embarrass us older folks into doing the right thing.

So I think our focus, and HABHRCA actually emphasizes that social science, is to continue to embed funding down the road in that outreach and effective communication, whether it be HABs, whether it be nutrients, whether it be any other issue is we find we can only do our job at application if we can talk routinely and constantly with our citizens and stakeholders. So investment in that social science is a critical area.

Chairman HARRIS. Thank you very much, Dr. Sellner, and you are right, you know, sometimes we have to think outside the box, and of course, the purview of this Committee is research, and some of the best research comes from outside-the-box thinking, especially on complex topics like this.

Anyway, I want to thank all the witnesses for your valuable testimony and the Members for their questions. The Members of the Subcommittee may have additional questions for the witnesses, and we will ask you to respond to those in writing. The record will remain open for two weeks for additional comments from Members. The witnesses are excused, and the hearing is adjourned. Thank you.

[Whereupon, at 4:20 p.m. the Subcommittee was adjourned.]

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