GREAT LAKES RESTORATION: HOW? HOW SOON?

COMMITTEE PRINT

BY THE

COMMITTEE ON SCIENCE
HOUSE OF REPRESENTATIVES

ONE HUNDRED NINTH CONGRESS

SECOND SESSION

APRIL 21, 2006

Serial No. 109–A

Printed for the use of the Committee on Science

Available via the World Wide Web: http://www.house.gov/science

U.S. GOVERNMENT PRINTING OFFICE
27–093PS WASHINGTON : 2006

For sale by the Superintendent of Documents, U.S. Government Printing Office
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GREAT LAKES RESTORATION: HOW? HOW SOON?

FRIDAY, APRIL 21, 2006

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

COMMITTEE ON SCIENCE
U.S. HOUSE OF REPRESENTATIVES

Great Lakes Restoration: How? How Soon?

Friday, April 21, 2006
1:00 PM – 3:00 PM (EDT)

L.V. Eberhard Center
Grand Valley State University
301 West Fulton Street
Grand Rapids, MI 49504-6495

Witness List

Panel I

The Hon. George Heartwell
Mayor
City of Grand Rapids

Jan O'Connell
Treasurer
Sierra Club

Panel II

Mr. Gary Gulezian
Great Lakes National Program Office
United States Environmental Protection Agency

Dr. Steven Brandt
Director, Great Lakes Environmental Research Laboratory
National Oceanic and Atmospheric Administration

Ms. Catherine Cunnigham Ballard
Chief, Coastal Management Program
Michigan Department of Environmental Quality

Dr. Alan Steinman
Director, Annis Water Resources Institute
Grand Valley State University

Dr. Don Scavia
Healing Our Waters Coalition

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HEARING CHARTER

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

Great Lakes Restoration: How? How Soon?

FRIDAY, APRIL 21, 2006
1:00 P.M.–3:00 P.M.
L.V. EBERHARD CENTER
GRAND VALLEY STATE UNIVERSITY
301 WEST FULTON STREET
GRAND RAPIDS, MICHIGAN 49504–6495

Purpose

On April 21, 2006 at 1:00 p.m. in Grand Rapids, Michigan, the Subcommittee on Environment, Technology, and Standards of the House Science Committee will hold a briefing to explore how agencies and policy-makers prioritize and manage science to meet resource management information needs for Great Lakes restoration.

The Great Lakes Regional Collaboration (GLRC), a consortium of federal, State, regional, local, and non-governmental stakeholders led by the Environmental Protection Agency (EPA), recently completed a comprehensive strategy for restoring the Great Lakes and associated watersheds. The strategy, which is strongly supported by the many organizations involved in its creation, establishes goals and provides guidance to the many agencies, organizations, and resource managers involved in Great Lakes restoration. It also describes the science and scientific tools needed to support the restoration priorities.

The briefing will examine the following overarching questions:

1. Does the GLRC strategy adequately identify and set priorities for science needs?
2. Will the GLRC strategy help overcome longstanding coordination issues, particularly as they relate to science?
3. Has the GLRC strategy led to or is it expected to lead to effective use of science in making decisions on Great Lakes restoration? What is the appropriate role for regional, federal, State, and local scientists and decision-makers in this process?
4. What near-term progress can be made to meet priority restoration goals with existing science and scientific information? To what extent will additional research be required to meet other high priority goals?

Witnesses:

- Mr. Gary Gulezian of EPA's Great Lakes National Program Office. EPA is the lead federal agency on the Great Lakes Regional Collaboration and is responsible for coordinating research and restoration activities of federal agencies in the Great Lakes.
- Dr. Stephen Brandt, Director of the National Oceanic and Atmospheric Administration's (NOAA) Great Lakes Environmental Research Laboratory (GLERL) in Ann Arbor Michigan. GLERL's mission includes the development of new knowledge, information and tools for use in managing Great Lakes resources.
- Ms. Catherine Cunningham Ballard, Chief of the Coastal Management Program in Michigan's Environmental Science and Services Division of the Department of Environmental Quality. The Coastal Management Program funds scientific research that directly informs coastal management decisions.
- Dr. Alan Steinman, Director of the Annis Water Resources Institute (AWRI) at Grand Valley State University, Muskegon, Michigan. Experts at AWRI study land use changes and the impacts on water resources and ecosystem

services, and provide information and tools to local and state governments and other resource managers.

- Dr. Don Scavia of the Healing Our Waters Coalition. Healing Our Waters is a non-governmental organization involved in Great Lakes restoration and in the Great Lakes Regional Collaboration process.

Summary of Issues:

Great Lakes restoration has been a regional priority since the 1972 Great Lakes Water Quality Agreement with Canada established common water quality objectives to be achieved by both countries. However, most stakeholders in the region believe that restoration efforts have not yet met the water quality or other subsequent ecosystem goals. While there is consensus among those involved in restoration efforts that scientific research and information must underpin any Great Lakes restoration process, research programs in the Great Lakes remain uncoordinated. This hearing will examine the following major issues that relate to science and its role in Great Lakes restoration:

1. Leadership and coordination—Many agencies, non-governmental organizations, resource users, and other stakeholders share the belief that strong leadership and coordination is needed to facilitate cohesive efforts to address the complex and large-scale problems that face the Great Lakes. Currently, the lack of coordination of science programs is widely perceived to result in duplication of effort and missed opportunities to address the complex, multidisciplinary scientific questions facing resource managers.
2. Integrating Science and Resource Management—Individual program and issue-specific efforts are underway to support integration of science and scientific information into Great Lakes resource management decisions. However, the effectiveness and reach of these programs has not yet been evaluated and it is unclear to what extent they reflect priorities in the GLRC strategy.
3. Prioritizing Science and Information Needs—The GLRC strategy identifies science and restoration needs, but does not prioritize the list of needs. This leaves it unclear where scientists and agencies that fund Great Lakes science should focus their efforts.
4. Near-term Opportunities—The GLRC strategy acknowledges that new funding and more research will be required to meet long-term restoration goals. Despite that, opportunities exist for near-term progress by federal, State, regional and local managers based on currently available scientific knowledge and funding. Many stakeholders believe the effectiveness of continued restoration efforts rely critically on identifying and implementing these near-term opportunities.

Background:

Great Lakes Restoration Efforts

The Great Lakes are the largest surface freshwater system in the world. Over 35 million people use the Great Lakes system for drinking water, irrigation, commerce, transportation, food, recreation, and cultural needs. Early concerns with the health of the Great Lakes and those that depend on them focused on industrial pollution and sewage. In 1972, the United States and Canada signed the Great Lakes Water Quality Agreement formally recognizing the need for a comprehensive and coordinated approach to address water quality concerns in the Great Lakes basin. Since then, even as progress has been made reducing point source pollution, there has been growing concern with nonpoint source pollution, such as urban and agricultural runoff, contaminated sediment and the growth of nonnative species.

In 1987, after many unsuccessful efforts to coordinate research and restoration activities in the Great Lakes Congress directed EPA to coordinate federal research and restoration activities related to Great Lakes water quality through the Great Lakes National Program Office (GLNPO).

In 2002, GLNPO completed the *Great Lakes Strategy*. Developed by consensus among federal, State, tribal and regional agencies, the document laid out research and restoration goals, as well as planned actions to reach these goals. However, in 2003 the Government Accountability Office (GAO) ("An Overall Strategy and Indicators for Measuring Progress Are Needed to Better Achieve Restoration Goals," GAO Report 03–515, April 2003) criticized the *Great Lakes Strategy 2002* for simply describing previously planned program activities, failing to prioritize research and restoration activities, and failing to secure meaningful commitments for action from the

participants. Also, GAO recommended that GLNPO be charged with development of an overall Great Lakes restoration strategy in consultation with governors, federal agencies, and other stakeholder organizations.

Great Lakes Regional Collaboration

On May 18, 2004, President Bush issued Executive Order 13340, establishing the Great Lakes Interagency Task Force and charging it with the development of a comprehensive restoration strategy through a process known as the Great Lakes Regional Collaboration (GLRC). Setting it apart from previous efforts, the GLRC involved over 1500 people and brought federal, State, tribal and regional agencies together with academic, industry, and other non-governmental representatives in an attempt to develop a strategy for Great Lakes restoration. This strategy includes the perspectives of, and subsequently has the support of, a broad cross-section of public and private sector stakeholders. GLRC established working groups with representatives of federal, State, tribal and regional agencies, academia, industry, and other non-governmental organizations to develop goals and recommendations in eight priority areas identified by the Council of Great Lakes Governors (Aquatic Invasive Species; Habitat/Species; Coastal Health; Areas of Concern/Sediments; Nonpoint Source Pollution; Toxic Pollutants; Indicators and Information; and Sustainable Development).

Great Lakes Regional Collaboration Strategy

The results of the eight working groups were compiled into a comprehensive restoration strategy. On December 12, 2005, EPA released the GLRC Strategy (*http://www.epa.gov/greatlakes/collaboration/strategy.html*). The document summarizes the issues and proposes actions to address the eight restoration priorities. Each chapter of the strategy addresses one of the priority issues listed above and includes recommended goals, actions and milestones. Some of the recommendations include cost estimates. However, the strategy does not prioritize the recommendations from each individual chapter into an overall recommendation.

Science in the GLRC Strategy

The Indicators and Information chapter of the GLRC Strategy directly addressed the science needs to support Great Lakes restoration with five broad recommendations: implementation of comprehensive and coordinated observing systems; support for ongoing development of science-based indicators of ecosystem health; doubling of funding for Great Lakes research; establishment of a regional information management infrastructure; and creation of a workgroup to improve communication of scientific and technical information between scientists, policy-makers and the public.

Major Issues:

Leadership and Coordination

Problem: As the scale and complexity of issues facing the Great Lakes have increased, so has the call for large-scale, coordinated science programs. In 2003, GAO identified EPA as the federal agency with the statutory authority to take the needed leadership and coordination roles in Great Lakes research and restoration efforts, and noted that EPA had not yet exercised its full authority in these capacities. Currently, the lack of coordination of science programs is widely perceived to result in duplication of effort and missed opportunities to address the complex, multi-disciplinary scientific questions facing Great Lakes resource managers.

GLRC Action: Many participants in GLRC believe EPA exhibited new leadership throughout the development of the GLRC strategy. However, the GLRC strategy expresses community consensus and does not set priorities, and it remains to be seen what the next steps will be now that the GLRC strategy is complete.

Remaining Questions: Will EPA continue to take a strong leadership and coordination role for itself as the GLRC Strategy is implemented, and research and restoration priorities are set? What are the appropriate leadership and coordination roles for the other federal and non-federal participants in the GLRC process?

Integrating Science and Resource Management

Problem: Effectively integrating science and science-based information into resource management practices is critical to the long-term success of any ecosystem restoration efforts. EPA and NOAA, as well as many non-governmental organizations, have begun developing science-to-management initiatives to address this issue in the Great Lakes. These programs bring scientists and resource managers together to collaboratively develop tools that both accurately reflect the state of the scientific knowledge, and meet the real-world information and decision-support needs of resource managers. However, the effectiveness and reach of these programs

have not yet been evaluated and it is unclear to what extent they reflect priorities in the GLRC strategy.

GLRC Action: The GLRC process strengthened working relationships between and among scientists and resource managers who work on Great Lakes issues by bringing them together to develop restoration goals. While this partnership is not formalized in the *Strategy* (or any other official document), it reflects an intangible benefit of the GLRC process because it improves communication among those involved at all levels of Great Lakes research and restoration.

Remaining Questions: Are the current science-to-management programs resulting in better use of science in resource management decisions? Are the programs reaching those resource managers who most need them, and are they meeting their needs for science and scientific information?

Prioritizing Science and Information Needs

Problem: The Indicators and Information chapter of the GLRC strategy focused explicitly on science and information needs. Other chapters called for additional new research and information, highlighting the need for a strong science program to support Great Lakes restoration. However, the science and information needs are not prioritized.

GLRC Action: Specific scientific recommendations include installation of an integrated observing system, formation of a communications working group, development of new ecosystem forecasting models, and doubling of Great Lakes research funding. Costs for these recommendations range from $200 thousand per year to $35 million per year.

Remaining Questions: The GLRC Strategy does not prioritize its recommendations for science needs. What is the process by which these priorities will be set? Will science and information priorities be driven by scientists, managers, or both?

Near-term Opportunities

Problem: While the final Great Lakes Regional Collaboration Strategy was enthusiastically welcomed by the Great Lakes research and management communities, concerns remain about what happens next. The GLRC strategy acknowledges that significant new funding will be required to meet long-term research and restoration goals. The cost for full implementation of the GLRC Strategy over five years has been estimated at over $20 billion.

GLRC Action: Even without new money or further research, some stakeholders believe significant opportunities remain for near-term progress by federal, State, regional and local managers. Examples may include expanding science-to-management programs, wider dissemination of existing scientific information and tools, and implementing more effective networks to disseminate science and management information.

Remaining Questions: What are the near-term opportunities for progress on Great Lakes restoration, based on currently available science and funding? What can federal agencies do to ensure that these opportunities are fully exploited? Are there near-term science needs that, if met, will open up new near-term restoration opportunities? To what extent should these opportunities be pursued if doing so comes at the cost of other programs?

Witness Questions:

Mr. Gary Gulezian, Director of EPA's Great Lakes National Program Office

Please provide a brief overview of the Great Lakes Regional Collaboration (GLRC) and the key elements of the recently published GLRC Strategy, particularly a description of the science needs as outlined in the Strategy. In addition, please address the following questions:

1. What is EPA's role in implementing the Strategy? In particular, what is EPA's role in:
   a. coordinating implementation of new and existing science programs and policies;
   b. setting budget priorities for federal Great Lakes research programs; and
   c. strengthening the relationship between scientists and policy-makers?
2. To what extent has EPA shifted funding to implement the GLRC Strategy and to what extent will it shift funding in the future?
3. What are the biggest challenges that you see in implementing the Strategy, particularly in terms of meeting science and information needs?

4. What outcomes do you expect to see one year from now as a result of implementation of the GLRC Strategy?

Dr. Stephen Brandt, Director of NOAA's Great Lakes Environmental Research Lab

Please briefly describe the role of NOAA and the Great Lakes Environmental Research Lab in the Great Lakes Regional Collaboration (GLRC). In addition, please address the following questions:

1. Has the GLRC led to more informed resource management planning decisions? What kinds of scientific information are now being taken into account in those decisions because of the GLRC? To what extent has the GLRC helped foster new or stronger collaboration between scientists and policy-makers? What is NOAA's role in strengthening the relationship between scientists and policy-makers?
2. To what extent has NOAA shifted funding to implement the GLRC Strategy and to what extent will it shift funding in the future?
3. What are the biggest challenges that you see in implementing the Strategy, particularly in terms of meeting science and information needs?
4. What outcomes do you expect to see one year from now as a result of implementing the GLRC Strategy?

Ms. Catherine Cunningham Ballard, Coastal Manager, Michigan Department of Environmental Quality

Please briefly describe the resource management responsibilities of the Michigan Department of Environmental Quality. In addition, please describe your involvement in the Great Lakes Regional Collaboration (GLRC) by addressing the following questions:

1. What are the top three recommendations in the GLRC Strategy that you believe could be implemented with existing funding? What scientific research, scientific information, or science-based products are required to support the implementation of these three recommendations? Would your answers be different if funding could be increased?
2. Has the GLRC led to more informed resource management planning decisions? What kinds of scientific information are now being taken into account in those decisions because of the GLRC? To what extent has the GLRC helped foster new or stronger collaboration between scientists and policy-makers? What is your role in strengthening the relationship between scientists and policy-makers?
3. Does the Strategy effectively reflect your needs and help you to prioritize your work? Are there additional actions EPA and other federal agencies should be taking to help implement the GLRC? What scientific research, scientific information, or science-based products do you need for making resource management policy decisions? If possible, please describe examples of research that you have found particularly useful to your work as a resource manager.
4. What are the biggest challenges you see in implementing the Strategy, particularly in terms of meeting science and information needs?
5. What outcomes do you expect to see one year from now as a result of implementing the GLRC Strategy?

Dr. Alan Steinman, Director of the Annis Water Resources Institute

Please briefly describe your participation, and that of the Annis Water Resources Institute (AWRI), in the Great Lakes Regional Collaboration (GLRC) and the resulting Strategy. In addition, please address the following questions:

1. What are the top three recommendations in the GLRC Strategy that you believe could be implemented with existing funding? What scientific research, scientific information, or science-based products are required to support the implementation of these three recommendations? Would your answers be different if funding could be increased?
2. Has the GLRC led to more informed resource management planning decisions? What kinds of scientific information are now being taken into account in those decisions because of the GLRC? To what extent has the GLRC helped foster new or stronger collaboration between scientists and policy-makers? What is your role in strengthening the relationship between scientists and policy-makers?

3. Does the Strategy effectively reflect your needs and help you to prioritize your work? Are there additional actions EPA and other federal agencies should be taking to help implement the GLRC?
4. What are the biggest challenges you see in implementing the Strategy, particularly in terms of meeting science and information needs?
5. What outcomes do you expect to see one year from now as a result of implementing the GLRC Strategy?

Dr. Donald Scavia, Healing Our Waters Coalition

Please briefly describe your coalition's participation in the Great Lakes Regional Collaboration (GLRC), and the resulting Strategy. In addition, please address the following questions:

1. What are the top three recommendations in the GLRC Strategy that you believe could be implemented with existing funding? What scientific research, scientific information, or science-based products are required to support the implementation of these three recommendations? Would your answers be different if funding could be increased?
2. Has the GLRC led to more informed resource management planning decisions? What kinds of scientific information are now being taken into account in those decisions because of the GLRC? To what extent has the GLRC helped foster new or stronger collaboration between scientists and policy-makers? What is your role in strengthening the relationship between scientists and policy-makers?
3. Are there additional actions EPA and other federal agencies should be taking to help implement the GLRC?
4. What are the biggest challenges you see in implementing the Strategy, particularly in terms of meeting science and information needs?
5. What outcomes do you expect to see one year from now as a result of implementing the GLRC Strategy?

Mr. EHLERS: I would like to call this field briefing to order. Thank you very much for being here. It's such beautiful weather—we just had a great news conference outdoors and I'm sorry that that delayed us, but I think we kept getting questions just because people were happy to be out there in the sun and fresh air. We tried to put this off as long as possible. But I welcome all of you here and look forward to hearing your testimony, and also I'm pleased to have the interest of visitors here.

Let me just introduce a guest to the audience, Bob Glazier in the back, staff member of Congressman Joe Schwartz from the Battle Creek area. Outstanding Congressman, very good environmentalist, and very interested in this. And it's just a pleasure to have him as a colleague.

The process—this is not a full legislative hearing. If we have a hearing, it's much more formal. There would have to be a Democrat here as well. We would have to have both parties represented to have an official hearing. So it's called a field briefing instead of a field hearing. But we still have an official reporter, so everything you say, whether proper or improper, will be recorded and put into the transcript.

The process is, I read my opening statement, which describes what we are trying to do and how we are going to do it. And then we will hear testimony from a fairly large group of individuals. The first two individuals are honored guests, Jan O'Connell and Mayor Heartwell, who will be joining us shortly. And they will not be receiving questions from us. But after that, we will have a whole series of witnesses who will receive questions. So I hope that makes it very clear precisely what the process is.

For those of you from out of town, welcome to Grand Rapids. For those of you who are from in town, aren't you glad you live here? Especially on a day like this. It's good to have you here in my home town. And particularly I wanted to welcome our panel of witnesses. Some have traveled from some distance to be here. And we appreciate not only their willingness to be here, but the work that they have put into their testimony, the ideas they are bringing forward to help improve the legislation that I have proposed. So thank you for your willingness to come and testify this afternoon about the work that all of you are trying to do—or are doing—to protect and preserve the Great Lakes.

The Great Lakes are a unique and extraordinary resource that provides drinking water, food, recreation and transportation to over 30 million people. And transportation may not seem that important, but without it our state would not have been founded. As you know, in the early days, the only transportation, of course, at one time, maybe hard to believe, there were 20,000 boats on the Great Lakes around the State of Michigan. Michigan was such a bog, travel was almost impossible.

The valuable collection of water surrounding us comprises 95 percent of the surface fresh water to the United States. Unfortunately, this great and beautiful resource faces significant environmental threats. We have been struggling for decades for problems with industrial pollution, sewage and non-native species. And as an attempt to address some of the problems, particularly the pollution entering the Great Lakes, I developed a Legacy Act a few years

ago, which fortunately the President has supported completely and funded rather well, and we are making substantial progress in cleaning up the toxic sediments that are in the rivers, but we have much further to go.

In 2004, I met with the new administrator of the Department of Environmental Protection, better known as the EPA. Mr. Levitt was the Governor of Utah, came to Washington to take on this position. Mr. Levitt as the Governor of Utah was only familiar with one lake, the Great Salt Lake. And because my committee and the subcommittee that I'm chairing involves the EPA, I immediately invited him to my office. We had a very nice visit, which I proceeded at great lengths to talk about the Great Lakes and its problems. Mr. Levitt did a fantastic job at the EPA, but even more fantastic job with the Great Lakes. He really took it to heart. He persuaded the President to issue an Executive Order, which recognizes the Great Lakes as a national treasure. And the Executive Order called for a regional collaboration of national significance on the Great Lakes. This Regional Collaboration met and found the mayors around the Great Lakes—we have our Mayor Heartwell here on behalf of the mayors—involved the mayors, involved the Indian tribes, involved the governors of the other Great Lake states, and it involved the environmental groups. And we have Jan O'Connell, board member of the Sierra Club here representing the environmental groups.

Some 1,500 participants worked for a couple of years to develop recommendations on the Great Lakes. And last year, December 15th, we met in Chicago and released the results of all their work. They developed recommendations for eight key areas, aquatic invasive species, habitat protection, coastal health, areas of concern and contaminated sediments, non-point source pollution, toxic pollution, scientific research and monitoring, and sustainable development.

The Committee I chaired was a Subcommittee of Science. I am interested in the science of the Great Lakes because I am determined that whatever we do will be scientifically appropriate so that we maximize the impact of the dollars we spend and we don't waste money doing it. That's not going to work. Our briefing today will focus on the current environmental management programs in place to address these many issues, how current science research supports effective management, and what science information needs exist for future restoration efforts. Note the emphasis on the science. We need to know what works and what doesn't work. Science can help us answer that question.

Our witnesses will also provide their insights on the recommendations made by the Regional Collaboration and what they see as the next step forward to support protection and clean up of the Great Lakes.

I have introduced legislation in Congress to implement some of the near-term recommendations made under the Regional Collaboration Strategy. This bill, easy to remember number, 5100, H.R. 5100 includes increased funding and flexibility for the Legacy Act to help remediate contaminated sediment in areas of concern. It also includes comprehensive invasive species legislation, and it provides states and cities with assistance to upgrade their water infra-

structure—particularly getting rid of sewer overflows—and reauthorizes and strengthens the Fish and Wild Life Restoration Act. It's a comprehensive, long-standing bill. We hope it passes. And I will work very diligently not only to see that it passes, but also that it gets funded.

On the research and monitoring side, Title VII of the bill authorizes increased resources for the federal agencies already conducting important scientific research and monitoring activities in the Great Lakes. For example, NOAA's Great Lakes Environmental Research Lab, and USGS's Great Lakes Science Center. In addition, it also authorizes extramural grants to universities and other private-sector research institutions. The bill also requires the EPA, USGS and NOAA to submit a coordinated joint research plan every year to identify those research activities that will assist in the implementation of the Regional Collaboration's recommendation. You see, there is a lot of good work going on already, but we want to make sure it's all coordinated. Once again, to get the maximum value for the buck.

This bill also directs the President to establish and maintain an integrated system of ocean, coastal, and Great Lakes observations, data communication and management, analysis, modeling, research, education and outreach. NOAA would be the lead federal agency for implementation and operation of the system. NOAA would also certify one or more regional associations to be responsible for the development and operation of regional observing, such as in the Great Lakes region. The bill also directs the EPA to develop, in coordination with other federal agencies and Canada—remember Canada has to be an equal partner here—indicators of water quality and related environmental factors in the Great Lakes. And a network to monitor those indicators regularly throughout the Great Lakes basin. The EPA would collect initial benchmark data in four years and report to Congress on changes in water quality.

As the Regional Collaboration Strategy recognizes, a successful restoration effort has to include a process to measure progress and to identify when success has been achieved. To ensure that resources are not wasted, it is important that the Strategy include benchmarks to measure progress.

As a scientist, for me this piece is critical. We have to have ways to collect information, analyze it, and determine whether what we are doing is successful or not, and how we might need to change our approach. I am eager to hear great things from our witnesses. Such as, how we can improve our research and monitoring programs to assist the clean up and protection programs that are implemented; how we can ensure that all of our efforts are making the best possible use of what science has shown us about the Great Lakes. And, finally, what we can do right now, with what we already know to move the restoration process forward immediately.

[The prepared statement of Chairman Ehlers follows:]

PREPARED STATEMENT OF CHAIRMAN VERNON J. EHLERS

For those of you from out-of-town, welcome to Grand Rapids! It's good to have you here in my home town. In particular I want to welcome our panel of witnesses. Thank you for your willingness to come and testify this afternoon about the work that you are doing to protect and restore the Great Lakes.

The Great Lakes are unique and extraordinary resources that provide drinking water, food, recreation and transportation to over 30 million people. This invaluable collection of water comprises 95 percent of the surface freshwater of the United States. Unfortunately, the Lakes face significant environmental threats. We've been struggling for decades with problems of industrial pollution, sewage, and non-native species.

In May 2004, President Bush recognized the Great Lakes as a "national treasure" and issued an Executive Order calling for a "regional collaboration of national significance" on the Great Lakes. In December 2005, the Great Lakes Regional Collaboration produced a strategic action plan for protecting and restoring the Great Lakes. The Regional Collaboration is a partnership of Federal, State, and local government officials and program managers; scientists; industry representatives; environmental advocates and interested private stakeholders. The fifteen hundred participants in this ground-breaking initiative focused their attention on addressing the most critical threats to the Lakes. They developed recommendations for eight key areas: aquatic invasive species, habitat protection, coastal health, Areas of Concern and contaminated sediment, non-point source pollution, toxic pollutants, scientific research and monitoring, and sustainable development.

Our briefing today will focus on the current environmental management programs in place to address these many issues, how current science research supports effective management, and what science and information needs exist for future restoration efforts. We need to know what works and what doesn't work, and science can help us answer that question. Our witnesses will also provide their insights on the recommendations made by the Regional Collaboration and what they see as the next steps forward to support protection and clean up of the Great Lakes.

I have introduced legislation in Congress to implement some of the near-term recommendations made in the Regional Collaboration strategy. My bill, H.R. 5100, includes increased funding and flexibility for the Legacy Act program to help remediate contaminated sediment in Areas of Concern. It also includes comprehensive invasive species legislation, it provides states and cities with assistance to upgrade their water infrastructure, and it reauthorizes and strengthens the *Great Lakes Fish & Wildlife Restoration Act.*

On the research and monitoring side, Title VII of the bill authorizes increased resources for the federal agencies already conducting important scientific research and monitoring activities in the Great Lakes—NOAA's Great Lakes Environmental Research Lab and USGS's Great Lakes Science Center. In addition, it also authorizes extramural grants to universities and other private-sector research institutions. The bill also requires the EPA, USGS, and NOAA to submit a coordinated joint research plan every year to identify those research activities that will assist in the implementation of the Regional Collaboration's recommendations.

This bill also directs the President to establish and maintain an integrated system of ocean, coastal, and Great Lakes observations, data communication and management, analysis, modeling, research, education, and outreach. NOAA would be the lead federal agency for implementation and operation of the system. NOAA would certify one or more regional associations to be responsible for the development and operation of regional observing, such as in the Great Lakes region.

The bill directs the EPA to develop, in coordination with other federal agencies and Canada, indicators of water quality and related environmental factors in the Great Lakes and a network to monitor those indicators regularly throughout the Great Lakes basin. The EPA would collect initial benchmark data within four years and report to Congress on changes in water quality.

As the Regional Collaboration strategy recognizes, a successful restoration effort has to include a process to measure progress and to identify when success has been achieved. To ensure that resources are not wasted, it is important that the strategy include benchmarks to measure progress.

As a scientist, for me this piece is critical. We have to have ways to collect information, analyze it and determine whether what we are doing is successful or not, and how we might need to change our approach. I am eager to he three things from our witnesses:

- how we can improve our research and monitoring programs to assist the clean up and protection programs that are implemented;
- how we can ensure that all of our efforts are making the best possible use of what science has told us about the Great Lakes; and
- finally, what we can do right now, with what we already know, to move the restoration process forward.

Witnesses

Our first panel is made up of two local champions of the Great Lakes.

- Jan O'Connell is currently a national board member and treasurer for the Sierra Club.
- George Heartwell is the mayor of Grand Rapids and has been actively involved in the Great Lakes Cities Initiative, a coalition of mayors and other local leaders organized by Chicago's Mayor Daley.

On our second panel, we have a distinguished group of Great Lakes scientists and environmental managers.

- Mr. Gary Gulezian is the Director of the EPA's Great Lakes National Program Office and has been a lead participant on the Regional Collaboration's Executive Committee.
- Dr. Steven Brandt is the Director of the Great Lakes Environmental Research Laboratory within the National Oceanic and Atmospheric Administration.
- Ms. Catherine Cunningham Ballard is the Chief of the Coastal Management Program within the Michigan Department of Environmental Quality. She will provide us with the perspective of an on-the-ground program manager who can attest to current capabilities and future science and resource needs.
- Dr. Alan Steinmann is the Director of Grand Valley State University's Annis Water Resources Institute Muskegon, Michigan.
- Dr. Don Scavia is a Professor of Natural Resources at the University of Michigan and heads the Michigan Sea Grant program. He is also a leading science advisor to the Healing Our Waters Coalition, a coalition over 70 environmental organizations that participated in the Regional Collaboration and that advocates for Great Lakes clean up. It is sponsored in part by the Wege Foundation. I am pleased to recognize Peter Wege and Ellen Satterlee for their contributions to this cause.

Panel I:

Mr. EHLERS: We will now begin with our witnesses. As I mentioned earlier, our first panel is made up of two local champions of the Great Lakes. Jan O'Connell is currently a national board member, treasurer for the Sierra Club. And she will be followed by Mayor Heartwell, who is also a champion of the environment.

Please recognize Ms. O'Connell—I should mention that I have known her for, what, 20 years?

Ms. O'CONNELL: At least.

Mr. EHLERS: Maybe longer. Both of us have been active in the environmental movement here in Grand Rapids. Originally, I think West Michigan Environmental Action Council, and then we both got involved in the Sierra Club. She, of course, is at the national level. And we are very pleased and proud to have you here, Jan.

STATEMENT OF MS. JAN O'CONNELL, DIRECTOR OF THE NATIONAL SIERRA CLUB BOARD

Ms. O'CONNELL: Thank you. Well, good afternoon, Representative Ehlers. Thank you for giving me the opportunity to speak with you today. As you mentioned, I'm a resident of Grand Rapids, and Director of the National Sierra Club Board. The Sierra Club is the Nation's oldest and largest grass roots organization with nearly 800,000 members nationwide. For the past 25 years, the Sierra Club has been a strong advocate for the restoration and protection of the Great Lakes ecosystem. I testified just this past August here at Grand Valley State University before the U.S. EPA in support of full funding to restore the Great Lakes. And I'm here today

again to restate the need to fully fund the restoration of the Great Lakes.

The Great Lakes are at a tipping point. And we cannot afford to wait any longer before taking action to protect this vital, and yet vulnerable resource. Every day we wait, our job gets larger and, of course, more costly. It's time we stop addressing the problems that plague the lake on a piecemeal basis, and start talking and taking a comprehensive approach to bringing the Great Lakes back to health.

The scientific public opinion and physical argument for safeguarding these national treasures have been made. More than 1500 individuals who represented Federal, State, local and tribal governments, non-governmental entities, and private citizens spent countless hours participating on strategy teams as part of the Great Lakes Regional Collaboration to develop a blueprint for comprehensive restoration, which was released in just this past December, '05. The Sierra Club participated fully in this effect contributing staff and volunteer time on many strategy teams. And we fully support the restoration blueprint that resulted from this collaborative process.

Now we need to act, to implement this blueprint for Great Lakes restoration. I want to applaud the efforts of a bipartisan group of U.S. legislators who just this month introduced bills that would implement many of these most critical recommendations in the restoration strategy.

Our own representative Verne Ehlers from Grand Rapids, and Representative Emanuel from Chicago in the House. And in the Senate, Representative DeWine from Ohio, and Representative Karl Levin from Michigan. We support these bills as an important step forward and applaud the leadership of the sponsors. Now we need to act.

I believe at this time the single greatest barrier to restoring the Great Lakes is the lack of adequate funding. And I have heard arguments that it may be difficult to win approval for a project this size that benefits only a region. But I want to bring to the forefront that the Great Lakes are one of the natural wonders of the world, and are more than just water. They are the heart of America's culture, economy and health. They contain one-fifth of the world's fresh water, supplying over 42 million people with their water needs every day. Al Beton, a Ph.D. who sits on our State Executive Committee of the Sierra Club, was the acting Chief Scientist of NOAA in the late '90s. And he is the also former Director of the Great Lakes Environmental Research Laboratory. He is supporting a December, '05 report made by scientists suggesting that the immune system of the Great Lakes is breaking down, and the ecosystem is in danger of collapse. Dr. Beton has stated that the Great Lakes are deteriorating at a rate unprecedented in the recent history, and are nearing the tipping point of an ecosystem-wide breakdown. He, too, has stated that if we want to restore this resource the time to act is now. To date, approximately 60 scientists, including the region's Sea Grant Director, have endorsed this paper, prescription for Great Lakes Ecosystem Protection and Restoration, outweighing the tipping point of irreversible changes. Don Scavia will be telling you more about this report later today.

The report states that despite progress in some areas, the Great Lakes are exhibiting a number of disrupting and disturbing systems that lead scientists to determine that the lakes may be at the verge of a breakdown. Some of the systems—symptoms include: Rapid disappearance of Diporeia. It's a key fish food that is essential to the Great Lakes' food chain. Beach closings caused by bacterial contamination, resurgence of Lake Erie's dead zone, and the sudden and widespread decline in native fish, particularly the yellow perch. This paper provides us with a science-based plan to restore our Great Lakes. And the scientists are also all saying now is the time to act.

One of the areas that I believe needs urgent attention is to set up measures to take action immediately to slow the introduction and spread of invasive species into the Great Lakes. It's been reported that every eight months a new invasive is being added to the 160 alien species that are already present in the lakes. Once in the lakes, invaders are virtually impossible to control or remove. And many cause irreparable ecological harm and economic impacts. Currently this is costing the region an estimated five billion dollars annually to try and control these short-term—by short-term—band-aid approach. Investing in prevention would be a much wiser and more effective use of resources.

We urgently need a permanent barrier in Illinois to stop the 100 pound Asian carp from entering the Great Lakes and destroying the food web. Stringent balanced water standards need to be set up and enforced to prevent the introduction of more costly and damaging invases by a balanced water.

Nationwide, more than 780 scientists, resource managers, agricultural officials, and other experts, plus 120 citizens have signed a call to action on invasive species, all stating that now is the time to act. There are other critical issues that need attention, such as toxic contamination, polluted runoff and sewage overflows. These problems and their solutions are outlined in some detail in the Great Lakes Regional Collaboration Strategy.

From a political perspective it may seem daunting to address the multitude of stressors that are impacting the Great Lakes. But from a scientific perspective, a comprehensive approach is the only way to restore the ecological integrity of the Great Lakes' ecosystem. For that reason, we must find a way to overcome the barriers to full implementation of the Great Lakes Restoration Strategy. It is our responsibility to protect this irreplaceable resource that was left us, and to be good stewards of our riches.

In addition, if we invest wisely in Great Lakes restoration, we have the opportunity to build a new future for the region as a whole: One with healthy communities, good jobs and a strong and growing economy that is based on the responsible use of our most abundant natural resource.

I would like to personally thank Representative Ehlers for putting this briefing together today, and the attention that the U.S. House Committee for Environment, Technology and Standards is giving to this issue; to the science concerns of evidence that best supports the effective restoration of the Great Lakes. Thank you.

[The prepared statement of Ms. O'Connell follows:]

PREPARED STATEMENT OF JAN O'CONNELL

Good afternoon Representative Ehlers and Members of the Committee. Thank you for giving me the opportunity to speak with you today. My name is Jan O'Connell, and I'm a resident of Grand Rapids and Director on the National Sierra Club Board. The Sierra Club is the nation's oldest and largest grassroots organization, with nearly 800,000 members nationwide. For the past 25 years the Sierra Club has been a strong advocate for the restoration and protection of the Great Lakes ecosystem.

I testified just this past August here at Grand Valley State University before the U.S. Environmental Protection Agency (EPA) in support of full funding to restore the Great Lakes and I'm here again today to re-state the need to fully fund the restoration of the Great Lakes. The Great Lakes are at a tipping point and we cannot afford to wait any longer before taking action to protect this vital and yet vulnerable resource. Every day we wait, our job gets larger and more costly. It's time we stop addressing the problems that plague the lakes on a piecemeal basis and start taking a comprehensive approach to bringing the Great Lakes back to health.

The scientific, public opinion, and fiscal argument for safeguarding this national treasure have been made. More than 1,500 individuals—who represented Federal, State, local and tribal governments, non-governmental entities and private citizens—spent countless hours participating on strategy teams as part of the Great Lakes Regional Collaboration to develop a blueprint for comprehensive restoration, which was released in December of '05. The Sierra Club participated fully in this effort, contributing staff and volunteer time on many strategy teams and we fully support the restoration blueprint that resulted from this collaborative process.

Now we need to act to implement this blueprint for Great Lakes restoration. I want to applaud the efforts of a bipartisan group of U.S. legislators who just this month (April) introduced bills that would implement many of the most critical recommendations in the restoration strategy: Reps Vern Ehlers (R–Grand Rapids) & Rahm Emanuel (D–Chicago) (H.R. 5100) and Sens. Mike DeWine (R–Ohio) and Carl Levin (D–Michigan), (S. 2545). We support these bills as an important step forward and applaud the leadership of the sponsors. "Now we need to act!"

I believe at this time the single greatest barrier to restoring the Great Lakes is the lack of adequate funding. And I have heard arguments that it may be difficult to win approval for a project this size that benefits only a region but I want to bring to the forefront that the Great Lakes, are one of the natural wonders of the world and are more than just water. They are the heart of America's culture, economy and health. They contain one-fifth of the world's fresh water surface water, supplying over 42 million people with their water needs every day.

Al Beeton, Ph.D., who sits on the state Executive Committee of the Sierra Club, was the Acting Chief Scientist of NOAA (National Oceanic & Atmospheric Administration) back in the late 90's and also former Director of the Great Lakes Environmental Research Laboratory. He is supporting a December '05 report made by scientists suggesting that the immune system of the Great Lakes is breaking down and the ecosystem is in danger of collapse. "Dr. Beeton, has stated that the Great Lakes are deteriorating at a rate unprecedented in their recent history and are nearing the tipping point of an ecosystem-wide breakdown." "He too has stated that if we want to restore this resource, the time to act is now." To date approximately 60 scientists, including the region's Sea Grant directors, have endorsed this paper, "Prescription for Great Lakes Ecosystem Protection and Restoration: Avoiding the Tipping Point of Irreversible Changes," and its recommendations. Don Scavia will be telling you more about this report later today. The report states that despite progress in some areas, the Great Lakes are exhibiting a number of disturbing symptoms that led scientists to determine that the Lakes may be at the verge of a breakdown. Some of the symptoms include; rapid disappearance of *Diporeia*—a key fish food that is essential to the Great Lakes food chain, beach closings caused by bacterial contamination, resurgence of Lake Erie's "dead zone" and the sudden and widespread decline in native fish particularly the yellow perch. This paper provides us with a science-based plan to restoring our Great Lakes. And scientists are also all saying that, "Now is the time to act!"

One of the areas that I believe needs urgent attention, is to set up measures to take action immediately to slow the introduction and spread of invasive species into the Great Lakes. It's been reported that every eight months a new invasive is being added to the 160 alien species already present in the lakes. Once in the lakes, invaders are virtually impossible to control or remove and many cause irreparable ecological harm and economic impacts. Currently, this is costing the region an estimated $5 billion annually to try and control through a short-term band-aid approach. Investing in prevention would be a much wiser and more effective use of resources. We urgently need a permanent barrier in Illinois to stop the 100-pound

Asian Carp from entering the Great Lakes and destroying the food web. Stringent ballast water standards need to be set-up and enforced to prevent the introduction of more costly and damaging invasives via ballast water. Nationwide, more than 780 scientists, resource managers, agricultural officials and other experts—plus 120 citizens groups back in 2003 signed a "Call to Action on Invasive Species." All stating that now is the time to act!

There are other critical issues that need attention, such as toxic contamination, polluted runoff and sewage overflows—these problems, and their solutions, are outlined in some detail in the Great Lakes Regional Collaboration Strategy. From a political perspective, it may seem daunting to address the multitude of stressors that are impacting the Great Lakes. But from a scientific perspective, a comprehensive approach is the only way to restore the ecological integrity of the Great Lakes ecosystem. For that reason, we must find a way to overcome the barriers to full implementation of the Great Lakes restoration strategy. It is our responsibility to protect this irreplaceable resource that was left to us and to be good stewards of its riches. In addition, if we invest wisely in Great Lakes restoration, we have the opportunity to build a new future for the region as a whole—one with healthy communities, good jobs, and a strong and growing economy that is based on the responsible use of our most abundant natural resource.

I would like to personally thank Representative Ehlers for putting this briefing together here today and the attention the U.S. House Committee for Environment, Technology, and Standards is giving to this issue by being here to listen to the science concerns and evidence that best supports the effective restoration of our Great Lakes.

Mr. EHLERS: Thank you, very much, Ms. O'Connell. I appreciate your testimony.

The next guest is here as a representative of all of the Great Lakes mayors who were active in the whole collaboration process. In that collaboration, I was very pleased that our own mayor in Grand Rapids was a very active participant. I would say he, along with Mayor Daley of Chicago, were a dynamic duo in terms of impact of policies. It was a pleasure for me to get to know Mayor Daley personally for the first time. And we spent a fair amount of time together at a couple of meetings—fascinating individual. And I can see why Chicago is called the City that works. But at the same time I, I still prefer your style.

Now, Mayor Daley is a wonderful person, and it's a pleasure to get to know him—very staunch environmentalist. And he made major contributions to the entire Regional Collaboration. But Mayor Heartwell was right with him. And we are honored today to have the Mayor of the City of Grand Rapids, George Heartwell, presenting his views on this topic.

STATEMENT OF THE HONORABLE GEORGE HEARTWELL, MAYOR OF THE CITY OF GRAND RAPIDS

Mr. HEARTWELL: Thank you, Congressman. You called me a champion of the Great Lakes. And I'm—I'm honored by that title. I believe that my efforts pale by comparison to what you are doing and what you are positioned to do in Washington. And I couldn't have been prouder at the—in Chicago, at the last gathering as the Great Lakes Collaborative Agreement was signed that it was my Congressman who was—who was leading the way and introducing the Collaborative that day.

I'm proud to be the Mayor of a city that understands that it's both its quality of life and its economic future are integrally connected to the Great Lakes. We are an inland city. And it's too easy for inland cities to forget how important the Great Lakes basin is to our own well-being and livelihood.

You have correctly stated that I serve on the Board of Directors of the Great Lakes and St. Lawrence Cities Initiative. We are a group of 85 mayors who, from both United States and Canada, working for the protection and restoration of the Great Lakes. Mayor Daley is indeed our fearless leader, Chairman. And Mayor Daley had tried very hard to clear his calendar to be here today and sends his regrets to you, sir, that he was not able to do that. But has asked that I speak on behalf of the Initiative.

The Great Lakes and St. Lawrence Cities Initiative has been extensively involved in development of the Great Lakes Regional Collaborative Strategy. We are signatories to the compact, signed in December of 2004 in Chicago. And with Jan O'Connell and 200 other people, I was pleased to be a part of the—working on the Strategy right here in Grand Rapids last August. The Strategy provides an excellent guide for Federal, State and local, as well as tribal governments, as well as industry and nonprofits to work on priorities and actions for the Great Lakes. Two key things are needed at this point. Action—not more planning—action, and funding. Cities across the basin will be looking to take key actions on such things as reducing sewer overflows, eliminating beach closures, protecting and restoring key habitats and wetlands, helping clean up contaminated areas of concern, encouraging proper disposal of household hazardous waste, and Mercury, using water more efficiently, many, many others.

Mayors and governors set out priority actions on December 12th, 2005 in a letter to President Bush. I am certain that you have seen that, Congressman. I will also leave a copy when I leave today. We are looking expectantly to the administration, and to Congress, to proceed swiftly on many of these points.

I would only highlight three of them this afternoon in this brief time. First, comprehensive invasive species legislation. Second, funding for water infrastructure, and wetland programs, waterfront revitalization. And, thirdly, completing the electronic fish barrier on the Chicago Sanitary and Ship Canal to keep the Asian carp out of the Great Lakes.

I want to congratulate you, Congressman Ehlers, and Congressman Emanuel as well in the introduction of the *Great Lakes Collaboration Implementation Act.* It does, as you have mentioned, contain many of the things that mayors and governors called for in our letter to the President. The Great Lakes and St. Lawrence Cities Initiative supports this legislation entirely. We are particularly pleased with provisions for addressing invasive species, funding waste water infrastructure, funding wetland and habitat protection, funding for areas of concern under the Great Lakes Legacy Act—a bill which you sponsored, Congressman Ehlers. And also improving indicators information and research. The important use of data that you have been so fundamentally behind.

It's essential that we move ahead with restoration now. Investments today can avoid much larger costs and expenditures down the road. We only need to look to Louisiana and hurricane Katrina to see how that lesson can be learned.

Cities are prepared to do our part. We pledge to work with Congress, with the administration, with States, with tribes, the private sector, with non-governmental organizations to make this happen.

I want to thank you for providing the opportunity this afternoon to speak.

Mr. EHLERS: Well, I want to thank you for participating. I also wanted to pass on to you, and you may have heard this already, but Grand Rapids is becoming known for the good work on the combined sewer overflow (inaudible). And I—as you may recall, I brought the EPA administrator here a few years ago to take a look at what we have done. And he told me after he inspected it, he said, I am going to use Grand Rapids as a model for what other cities in this nation could be doing regarding sewer overflow. And I explained to him how it started, and how the city has basically paid most of it themselves with some funding with the rebuilding home fund. But we taxed the citizens. And people in this city are willing to do this to keep this river and lake clean. And that's a real testimony to the support this community has for a clean lake and clean environment.

Mr. HEARTWELL: Indeed. At this point in our Sewer Separation Project, we have invested more than $2,000 per man, woman and child in Grand Rapids—I'm sorry, over $1,000 per man, woman and child—over $200 million already. By the time we are done, that investment will go to over $320,000,000. So it's—it's a tremendous commitment that this community has made. You have been effective in bringing some resources back from Washington for us to do that. Keep up that good work, please.

Mr. EHLERS: Yeah. But, actually, I'm very proud that Grand Rapids is doing it with so much of their own money, and setting an example for other groups. They won't budge until the Federal Government will say we will pay 50 percent—it's just not going to happen.

One other comment about the centrality of Grand Rapids. This is the home of the Wege Foundation. And the Wege Foundation has founded—funded the Healing the Waters Initiative. I don't know if they have founded it, but they are certainly supporting it. Peter Wege was hoping to appear here today, of course. And I don't see anyone from the Wege Foundation, but they may be hidden behind someone. Am I overlooking someone?

UNKNOWN PERSON: I think they are going to be here, but they will be here late.

Mr. EHLERS: They will be here late. Thank you.

Thank you very much for your testimony, both of you. I appreciate it very much. And we will dismiss you without questioning, which is an honor that very few people get.

Mr. HEARTWELL: Thank you, sir.

Ms. O'CONNELL: Thank you.

Mr. EHLERS: Thank you. Thank you for your good work.

Let me also mention while they are exiting, we have heard references to Representative Emanuel, Senator DeWine and Senator Levin. Recognize that this work did not come out of a vacuum. In fact, in the last Congress, Representative Emanuel introduced the bill to clean up the Great Lakes—quite a different approach, but—from the one I had. I introduced a bill as well. We could not work out an agreement together, but now that the Coalition has come out, we have come together to—on sponsoring the same bill together.

And similarly in the Senate, Senator Levin and Senator DeWine are the sponsors and co-sponsors. But also Senator Voinovich played a very active role in this, but he ceded to his fellow statesperson, Senator DeWine to be the principal co-sponsor. But if you ever see Voinovich, he appeared here at the Healing Our Waters event, great speech. Both of them are very active. So, please, when you talk to people from those states, let them know we appreciate their effort because this is not always a political—politically popular stance. And people need to know how much we appreciate it.

All right. Time to call up the second panel. Put the name tags out.

Panel II:

I want to thank our panel for appearing here. We have Mr. Gary Gulezian, Director of the EPA's Great Lakes National Program Office, and has been a lead participant on the Regional Collaboration's Executive Committee. While I'm talking about the EPA, that reminds me, I talked a great deal about Mr. Levin—Governor Levin who has provided great leadership. But he was—and frankly too good—and got promoted to be Secretary of Health Education. And—not Education, but Health and Human Services. So he has reached a higher office. But he has been replaced by Steve Johnson, who has also taken the Great Lakes to his heart and has been in this community, and also was in Muskegon not too long ago for the opening of the one of the Great Lakes Legacy projects there. We are happy to have you here.

Next, Dr. Steven Brandt is a Director of the Great Lakes Environmental Research Laboratory within the National Oceanic and Atmospheric Administration. By some strange quirk of fate, they ended up not being in the Great Lakes, they are in the fair city of Ann Arbor. But whoever made the decision may have been smoking with when Ann Arbor celebrates—but I'm sure Dr. Brandt would be welcome to move to the west coast of Michigan. But he has done an outstanding job there.

Next, Ms. Catherine Cunningham Ballard is the Chief of the Coastal Management Program within the Michigan Department of Environmental Quality. She will provide us with a perspective of an on the ground program manager who can attest to the current capabilities of future science and resource needs. And we are pleased to have you here because the states are going to be the ones implementing almost everything we do.

Dr. Alan Steinman is the Director of Grand Valley State University's Annis Water Resources Institute in Muskegon, Michigan. Pleased to have you here. It's an outstanding facility doing great work—and they have a couple of nice boats. If you ever want to take a boat ride, call Dr. Steinman and see if you can learn something about the science of the Great Lakes from a boat.

Next, Dr. Don Scavia is a Professor of Natural Resources at the University of Michigan, and heads the Michigan Sea Grant program—a very important outreach from NOAA. He is also a leading science advisor to the Healing Our Waters Coalition, which we have mentioned before. It's a coalition of over 70 environmental or-

ganizations that participated in the Regional Collaboration, and that vigorously advocates for Great Lakes clean-up. It is sponsored in part by the Wege Foundation, as I mentioned. Hopefully we will have a chance to thank him personally later on.

With that, it's my pleasure to adjourn to the participants for their testimony. And we will start with you, Mr. Gulezian.

STATEMENT OF MR. GARY V. GULEZIAN, DIRECTOR, GREAT LAKES NATIONAL PROGRAM OFFICE, U.S. ENVIRONMENTAL PROTECTION AGENCY

Mr. GULEZIAN: Thank you.

Mr. EHLERS: Oh, by the way, I forgot to mention the rules of the House of Representatives. You each have five minutes to present your testimony. Your entire testimony will be entered into the permanent record, but we ask that you shorten your oral testimony to five minutes, so then we will have some time to have some give and take with questions and answers.

Mr. GULEZIAN: Good afternoon, Congressman Ehlers. As you noted, I'm Director of U.S. EPA's National Program Office, which is located in Chicago. Thank you for the opportunity to discuss the Great Lakes Interagency Task Force and the Great Lakes Regional Collaboration as they relate to issues of science, research, and environmental restoration of the Great Lakes.

First a little background. On May 18, 2004, President Bush signed the Great Lakes Executive Order. The Executive Order recognized the Great Lakes as a national treasure and created a Great Lakes Interagency Task Force composed of nine federal agencies. The Order also directed U.S. EPA administrator to convene a Regional Collaboration of national significance. The Federal Interagency Task Force was charged with coordinating the more than 140 federal programs that helped fund and implement environmental restoration and management activities throughout the Great Lakes ecosystem. It was established to ensure that these programs would fund effective, coordinated and environmentally sound activities. EPA provides support for the task force in carrying out its functions. The EPA's administrator serves as the chair of the Great Lakes Interagency Task Force.

The Great Lakes Regional Collaboration was designed to take program coordination beyond the federal level, and to comprehensively address nationally significant environmental and natural resource issues involving the Great Lakes. The Collaboration involves participation of the Federal Government, Great Lakes States, tribal and local governments, communities and other interests. As part of the Regional Collaboration, more than 1,500 people participated in a year long effort to draft the Great Lakes Restoration Strategy that prioritizes problems and recommends long- and short-term actions for achieving a healthy Great Lakes ecosystem.

This Strategy, as you noted earlier, was released to the public last December. The EPA administrator participates as a member of the Executive Committee of the Great Lakes Regional Collaboration, along with representatives from States, tribes and municipalities. This past March, the Great Lakes Regional Collaboration Executive Committee finalized its framework for implementation that will ensure the collaboration continues, and that the priorities in-

cluded in the Great Lakes restoration strategy are pursued. The Task Force and Great Lakes Regional Collaboration provide new opportunities for working cooperatively on Great Lakes' issues. The Great Lakes community now speaks with one voice regarding problems and priorities. With a strengthened network of partners, we are in a better position to focus our energy on common goals.

The Great Lakes Regional Collaboration partners are using the Great Lakes Restoration Strategy to guide ongoing and future Great Lakes basin activities. Appropriate research models, scientific methodologies, restoration activities and management approaches are being designed so that environmental and natural resource problems are addressed collaboratively, efficiently and effectively. For example, the Great Lakes Watershed Restoration Grant Program, a new partnership of five federal agencies and a not-for-profit organization, which was formed as a result of the Great Lakes Regional Collaboration now funds on-the-ground habitat restoration actions across the basin combining the funds of those separate federal agencies.

Collaboration among Great Lakes stakeholders in the science community to address key Great Lakes environmental problems is not new. A number of institutions worked to align their resources to address the most pressing research science and restoration issues in the Great Lakes. These institutions include among others, the International Joint Commissions Council of Great Lakes Research Managers, Great Lakes Fisheries Commission, EPA, State of the Lakes, Ecosystem Conferences, and Lakewide Management Plans. Great strides have been made in understanding and solving environmental problems as a result of the collaborative work of these enterprises. The Lakewide Management process, for example, has involved hundreds of agencies, organizations and individuals from the United States and Canada in actions to detect, investigate and manage environmental problems at a lake basin scale.

The existing infrastructure partnerships has been augmented by the Executive Order which directs The Interagency Task Force to ensure the federal research and monitoring programs are well-coordinated and focused on the areas with the greatest need. And by the Great Lakes Regional Collaboration which lays the foundation for cooperatively addressing environmental problems at the basin wide, lake wide and local scales. These expanded networks of agencies and organizations use existing mechanisms in institutions to address key problems and needs as defined in the Great Lakes restoration strategy.

There is now an emerging understanding of how we must integrate science and management decisions to the Great Lakes. In general, Great Lakes research and science needs to include efficient and comprehensive monitoring of the environment, indicators that help to assess the status of the ecosystem and inform management decisions, and forecasting tools for predicting how specific management actions improve problems. The integration of research and monitoring into programs that are restoring the Great Lakes will ensure that we are addressing the right problems through implementation activities, and that we are aware of any emerging issues before they become major problems.

My written testimony includes several examples of science research and ecosystem management projects that are under way, and where we are working together with other partners to address significant questions about the Great Lakes. These examples include the State of the Lakes Ecosystem Conferences, The Beach Health Workshop, Lake Erie Dead Zone Research, the Lake Michigan Mass Balance Study, Diporeia disappearance investigations, and multi-agency cooperative monitoring. And I would be pleased to answer any questions about those projects later.

In closing, I would like to thank you for inviting me to participate in this briefing. We look forward to working with you and with other partners on science and research issues and how they can contribute to the goal of a cleaner, healthier Great Lakes. I would be happy to answer any questions you may have. Thank you.

[The prepared statement of Mr. Gulezian follows:]

PREPARED STATEMENT OF GARY V. GULEZIAN

Good afternoon Mr. Chairman. I am Gary Gulezian, Director of the U.S. Environmental Protection Agency's Great Lakes National Program Office (EPA) located in Chicago. Thank you for the opportunity to discuss the Great Lakes Interagency Task Force (Task Force), the Great Lakes Regional Collaboration (GLRC), the *Great Lakes Strategy,* and the science and research issues in support of restoring and protecting the Great Lakes, one of our country's most important environmental treasures.

BACKGROUND

On May 18, 2004, President Bush signed the Great Lakes Executive Order that established the Great Lakes Interagency Task Force and promoted a Regional Collaboration of National Significance for the Great Lakes.

The Executive Order directed a Great Lakes Interagency Task Force to, among other activities, "ensure coordinated federal scientific and other research associated with the Great Lakes system." The Task Force increases and improves collaboration and integration among the more than 140 federal programs that help fund and implement environmental restoration and management activities throughout the Great Lakes ecosystem. It helps to ensure that these programs are funding effective, coordinated, and environmentally sound activities. EPA provides support for the Task Force in carrying out its functions. EPA's Administrator serves as the Chair of the Task Force. EPA also coordinates a number of programs and research initiatives in concert with other federal agencies.

The Executive Order supported a Great Lakes Regional Collaboration to address nationally significant environmental and natural resource issues involving the Great Lakes through partnerships among the Federal Government, Great Lakes states, tribal and local governments, communities, and other interests. More than 1,500 people participated in a year-long effort to draft a Great Lakes Strategy that prioritizes problems and recommends long- and short-term actions for achieving a healthy Great Lakes ecosystem.

The EPA Administrator participates as a member of the Executive Committee of the GLRC along with representatives from States, tribes, and municipalities. In March, the GLRC Executive Committee finalized a Framework for Implementation that will ensure the Collaboration continues and that priorities included in the *Great Lakes Strategy* are pursued.

OPPORTUNITIES FOR COLLABORATION INCREASED

The Task Force and the GLRC provide new opportunities for collaboration. The Great Lakes community now speaks with one voice regarding problems and priorities. With a strengthened network of partners we are in a better position to focus our energies on common goals.

GLRC partners are using the *Great Lakes Strategy* to guide ongoing and future Great Lakes basin activities. Appropriate research models, scientific methodologies, restoration activities and management approaches are being designed so that environmental and natural resource problems are addressed collaboratively, efficiently and thoroughly. For example, the Great Lakes Watershed Restoration Grant Program, a partnership of five federal agencies and a not-for-profit organization formed

as a result of the GLRC, now jointly funds on-the-ground habitat restoration actions across the basin.

Underpinning the foundation for collaboration in the Great Lakes is the President's Ocean Action Plan of December 17, 2004, which calls on federal agencies to work together with their partners in State, local and tribal authorities, as well as with the private sector, our international partners and other interests, to make our oceans, coasts, and Great Lakes cleaner, healthier, and more productive. It specifically calls on the new ocean governance structure established by Executive Order 13366 and the Ocean Action Plan to support the Great Lakes Interagency Task Force and Great Lakes collaboration.

SCIENCE, RESEARCH, AND ECOSYSTEM MANAGEMENT

Collaboration among Great Lakes stakeholders and the science community to address key Great Lakes environmental problems is not new. A number of Institutions work to align their resources to address the most pressing research, science, and restoration issues in the Great Lakes. These institutions include: the International Joint Commission's Council of Great Lakes Research Managers, the Great Lakes Fishery Commission, the State of the Lakes Ecosystem Conferences (SOLEC), and Lakewide Management Plans (LaMPs), in partnership with numerous universities. Great strides have been made in understanding and solving environmental problems as a result of these partnerships. The Lakewide Management Plan process, for example, has involved hundreds of agencies, organizations and individuals from the U.S. and Canada in actions to detect, research, and manage environmental problems at a Lake basin scale.

The existing infrastructure of partnerships has been augmented by the Executive Order, which directs the Task Force to ensure that federal research and monitoring programs are well coordinated and focused on the areas with the greatest need; and by the GLRC, which lays the foundation for addressing environmental problems at the basinwide, lakewide and local scales collaboratively. These new expanded networks of agencies and organizations use existing mechanisms and institutions to address key problems and needs as defined by the *Great Lakes Strategy.*

In general, Great Lakes research and science needs include efficient and comprehensive monitoring of the environment; indicators that help to assess the status of the ecosystem and inform management decisions; and, forecasting tools for predicting how specific management actions improve problems. The integration of research and monitoring into programs that are restoring the Great Lakes will ensure that we are addressing the right problems through implementation activities, and that we are aware of any emerging issues before they become major environmental problems.

The following examples illustrate science, research, and ecosystem management projects that are underway and where we are working with other partners or collaborators to address significant questions about the Great Lakes. In addition, our work on the Interagency Task Force and GLRC presents us with new opportunities to strengthen existing mechanisms and institutions to address the pressing Great Lakes environmental problems identified by the *Great Lakes Strategy:*

State of the Lakes Ecosystem Conference (SOLEC)

In 1987, the Great Lakes Water Quality Agreement was amended to require the U.S. and Canada to track and report on progress toward the Agreement's goals. What emerged was the State of the Great Lakes Ecosystem Conference (SOLEC) process, which includes a biennial conference and a series of reports on Great Lakes ecosystem and human health based on indicators. The seventh of these conferences will be held November 1–3, 2006, in Milwaukee, Wisconsin.

The *State of the Great Lakes 2005* report presents the findings from 56 out of approximately 80 Great Lakes indicators plus the status of each Great Lake. Dozens of authors and contributors were involved in the preparation of the indicator reports, representing at least 11 U.S. and Canadian federal agencies, 19 state and provincial agencies, and over 40 municipalities, tribes, academic affiliations, environmental commissions, non-government organizations, industry and private organizations.

One result of SOLEC is the Great Lakes Coastal Wetlands Consortium. Federal, State, provincial, non-governmental organizations, and academic institutions—more than 150 people—are developing a long-term monitoring program to assess the ecological integrity of Great Lakes coastal wetlands. With a better information base, management actions focused on protection and restoration of coastal wetlands will be more effective.

Improving the Health of Great Lakes Beaches

The *Great Lakes Strategy* identifies the issue of beach closings as a significant Great Lakes issue. A November 4, 2005, Beach Health Workshop held in Green Bay, Wisconsin brought together beach managers throughout the basin, the Great Lakes Beach Association (GLBA), U.S. Geological Survey (USGS), National Oceanic and Atmospheric Administration (NOAA), and EPA. Years of collaboration and coordination of beach research and monitoring activities were presented.

In addition, the needs and concerns of beach managers, public health officials, and other stakeholders were expressed and research priorities and strategies for addressing beach closure and recreational water quality issues defined. A primary goal was to forge a new cooperation among federal agencies and State, tribal, and local groups concerned with beach health in order to focus our research efforts in a unified direction that would best serve the beach health community. A series of follow up actions is being pursued by workshop participants, including the development of a standardized sanitary survey for identification of contamination sources impacting beaches.

Lake Erie Dead Zone

Because U.S. and Canadian efforts successfully reduced the amount of phosphorus entering the Great Lakes, throughout the 1980s scientists were cautiously optimistic that the area of low oxygen in Lake Erie during the summer was also being reduced, both in area and duration. In the early 1990s, however, agency scientists and academic researchers identified signs that Lake Erie's low oxygen problems were getting worse instead of better. Beginning in 2002 and continuing in 2003, EPA sponsored the Lake Erie Trophic Study to investigate the causes of the Lake Erie "dead zone" and of increasing phosphorus levels in the Lake. Partners included Lake Erie experts from more than 20 U.S. and Canadian universities and other institutions. Environment Canada extended the study with EPA support in 2004, and the NOAA laboratory in Ann Arbor, Michigan organized the International Field Year on Lake Erie in 2005. Results are informing the management actions of agencies in both Canada and the U.S. in the areas of nonpoint source pollution remediation, wetland restoration, and aquatic invasive species control.

Lake Michigan Mass Balance Study

Combining expertise from federal and State agencies and universities, the importance of atmospheric and river inputs to Lake Michigan of PCBs, mercury, atrazine and trans-nonachlor were measured and modeled by more than 25 researchers. The most recent results of the Lake Michigan Mass Balance Study were presented to the Great Lakes States in October 2005. The study is helping federal and State agencies direct their resources to the sources of pollution that are contributing most significantly to water quality impairments and fish consumption advisories.

Health of the Great Lakes Aquatic Food Chain

One of the most dramatic and enigmatic changes in the biotic community of the Great Lakes has been the decline of the deep-water amphipod *Diporeia. Diporeia* is a very small, shrimp-like organism that is a keystone species in the food web of offshore waters. It is also an important, high-calorie food resource for fish. EPA's Great Lakes National Program Office and NOAA's Great Lakes Environmental Research Laboratory co-sponsored a workshop in October 2005 to better understand the causes of the decline of this organism, to develop a list of research recommendations, and to explore possible management interventions. Cooperative research will improve fishery managers' ability to protect a variety of fish species from possible decline due to food chain disruption.

Cooperative Lakewide Monitoring Approach

A cooperative lakewide monitoring approach to assess each of the Great Lakes over a five-year cycle is being carried out by federal and State agencies. Cooperative monitoring began in Lake Ontario in 2003 and has continued in Lakes Erie, Michigan, and Superior. Each year federal and State agencies, in consultation with academic professionals, identify the priority information needs for each Lake, "pool" their resources, and jointly implement the monitoring and research effort. Following each year of monitoring, data and information are shared among the agencies. The approach has involved consultation with the Lakewide Management Plan leaders, representatives from the Great Lakes Fishery Commission Lake Committees, and key representatives from the scientific community. To date, the cooperative sharing of resources resulting from this approach, including shared research vessel time, has saved an estimated one half million dollars.

CONCLUSION

In closing, I would like to thank you for inviting me to participate in this briefing. We look forward to working with you and with other partners on science and research issues and how they can contribute to the goal of a cleaner, healthier Great Lakes. I would be happy to answer any questions that you may have.

BIOGRAPHY FOR GARY V. GULEZIAN

Gary Gulezian is the Director of the Great Lakes National Program Office (GLNPO) in the United States Environmental Protection Agency's (USEPA) office in Chicago. He has served in this position since September of 1997.

GLNPO is charged with the responsibility to lead and coordinate U.S. efforts in implementing the goals and objectives of the Canada–U.S. Great Lakes Water Quality Agreement. GLNPO brings together federal, State, tribal and local partners in an integrated, ecosystem approach to protect, maintain, and restore the chemical, biological, and physical integrity of the Great Lakes. The program monitors Lake ecosystem indicators; manages and provides public access to Great Lakes data; helps communities address contaminated sediments in their harbors; supports local protection and restoration of important habitats; promotes pollution prevention through activities and projects such as the Canada–U.S. Binational Toxics Strategy (BNS).

Prior to becoming GLNPO's Director, Mr. Gulezian was the Chief of the Air Toxics and Radiation Branch in the United States Environmental Protection Agency's Region 5 office in Chicago. In this capacity, Mr. Gulezian was responsible for coordinating the implementation of the Regional Office's programs which dealt with hazardous air pollutants and radiation. Additionally, Mr. Gulezian had the overall responsibility for directing federal air pollution control efforts in the States of Michigan, Minnesota, and Wisconsin including regulation development, enforcement and grants management.

Mr. Gulezian joined USEPA in 1977. During his tenure with the Agency he has worked with programs involving the control of mobile sources, federal rule-making on State Implementation Plans, cleanup of radioactively-contaminated sites, radiological emergency response, and the control of indoor radon.

Mr. Gulezian holds a Baccalaureate degree from Dartmouth College where he specialized in aquatic biology and a Master's degree from the Harvard University School of Public Health in the field of Environmental Health Sciences.

Mr. Gulezian lives in Oak Park, Illinois, with his wife, Greta, and their three children.

Mr. EHLERS: Thank you, very much. And thanks also to the EPA for their effective management of the Legacy Act. We are making real progress.

Mr. GULEZIAN: We are very excited to have the resources associated with the Legacy Act. And it has been good to clean up some of those contaminated areas.

Mr. EHLERS: Right.

Dr. Brandt.

STATEMENT OF DR. STEPHEN B. BRANDT, ACTING DEPUTY ASSISTANT ADMINISTRATOR, OFFICE OF OCEANIC AND ATMOSPHERIC RESEARCH; DIRECTOR, GREAT LAKES ENVIRONMENTAL RESEARCH LABORATORY, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, U.S. DEPARTMENT OF COMMERCE

Dr. BRANDT: Thank you, Chairman Ehlers. I appreciate the opportunity to speak to you about how NOAA research is prioritized to meet user needs and about NOAA's role in the Great Lakes Regional Collaboration. Research underpins NOAA's science-based mission of understanding and predicting changes of the Earth's environment to improve the quality of people's lives and to meet our nation's economic, social and environmental needs.

NOAA's five year research plan emphasizes an ecosystem-based approach to management and restoration, the integration of research and observations, a focus on prediction and forecasting, and translating research findings into decision support tools.

This plan is totally consistent with the Great Lakes Research Collaboration Strategy that states that research "must transition to the ecosystem approach with greater emphasis on predicted forecasting, and that restoration efforts will require coupled research and observation programs." All NOAA research is targeted toward such applications. Research information services, ace decision-making, management, public safety, and environmental and economics sustainability. Research also serves the public by improving NOAA forecasts by developing new tools and services. To ensure that NOAA research meets the needs of policy-makers, we regularly seek feedback from the policy-makers and other stakeholders. I will provide two examples of how we work with our stakeholders to ensure that research needs—research meets user needs and is accessible to users. Most of NOAA's research in the Great Lakes is conducted by the Great Lakes Environmental Research Laboratory and the National Sea Grant Program.

The National Sea Grant Program engages top universities to conduct research to support NOAA's mission. Sea Grant works in every coastal state and every Great Lakes coastal state to conduct applied research, extension and education to foster science-based decisions about the use and conservation of our nation's aquatic resources. Sea Grant is unique in that it has about nearly 60 extension agents living in coastal areas throughout the region, as well as two regional extension agents located with GLERL. The role of these extension agents is to ensure that NOAA research immediately gets into the hands of those that require this information for decision-making. The other equally important role of these agents is to take the pulse of the user communities on a daily basis and assess their needs. This regular feedback helps steer NOAA research priorities and research information services.

Focused workshops are another example of how NOAA integrates its science into management. For example, in 2003, a workshop was held at GLERL to assess the region's need in ecological forecasting. A published report identified stakeholder's needs for 24 different ecological forecasts. Subsequently, GLERL has set nearly all of its research and ecological priorities to meet these needs. Operational systems are now in place in providing detailed forecasts for waves, water levels, circulation and water temperature.

Last November, GLERL teamed up with the Great Lakes Beach Association, the USGS and EPA to host a beach health workshop to identify concerns and information needs of beach managers and public health officials to define research priorities for forecasting beach closures for public health. This workshop helped forge new cooperation between federal agencies, and State, tribal and local groups concerned with beach health, and helped to set research priorities for NOAA's Center of Excellence for Great Lakes' health. This center will also set up a web site, for example, as a hub for information on beach closures throughout the Great Lakes basin, and to learn about the current forecasting technologies being devel-

oped. My written testimony has a number of other similar examples.

NOAA has a long history, and is a strong supporter of partnerships. NOAA strongly supports the Great Lakes Regional Collaboration, which is a unique partnership of Federal, State, local governments, tribes and other stakeholders. NOAA is also one of the 11 agencies on the regional working group, and has had an expert on each of the eight strategy teams developed as part of the Collaboration. The Collaboration effort has increased national visibility of the Great Lakes as a natural resource, and has been a valuable resource for combining agency expertise and fostering a spirit of cooperation on Great Lakes issues. NOAA considers the Strategy a valuable user-generated, comprehensive document for determining regional priorities and needs. And NOAA will use it as an important reference for prioritizing regional activities.

As part of the Administration's response to the Strategy, the Task Force released a list of near-term action items that could be initiated over the next two years at present funding levels. NOAA is taking the lead on several items, including implementation of the U.S. contribution to observing systems, which in a large part would be defined by and be responsive to local needs.

Finally, NOAA's '07 budget requests funds to develop a Great Lakes Habitat Restoration Program and office in the Great Lakes region, which will serve as a focal point for NOAA's restoration efforts in the region. The program will support science-based restoration projects that achieve significant improvement and habitat function and human use benefits, while insuring appropriate monitoring and feedback. Working with our partners, results will be used to apply lessons learned to other science-based restoration efforts throughout the Great Lakes basin.

Mr. Chairman, that concludes my testimony. I'm happy to answer any questions you may have.

[The prepared statement of Dr. Brandt follows:]

PREPARED STATEMENT OF STEPHEN B. BRANDT

Good morning, Chairman Ehlers. I am Stephen Brandt, Acting Assistant Administrator for the National Oceanic and Atmospheric Administration (NOAA) Office of Oceanic and Atmospheric Administration and Director of the NOAA Great Lakes Environmental Research Laboratory (GLERL). I appreciate the opportunity to speak to you about how NOAA research is applied to meet user needs through information services and through transition of research to operations, and about NOAA's role in Great Lakes regional collaboration.

THE ROLE OF RESEARCH IN SERVING THE PUBLIC

Research underpins NOAA's science-based mission of understanding and predicting changes in the Earth's environment and conserving and managing coastal and marine resources to meet our nation's economic, social, and environmental needs. Robust environmental observation, assessment, and prediction capabilities provide the foundation for performing NOAA's mission. Research is the cornerstone on which to build and improve environmental forecasts that can enable ecosystem-based management and provide critical weather and climate information for decision-makers and the public.

We ensure NOAA research and services meet the needs of our stakeholders by seeking regular feedback from the research community, operational users, and stakeholders. NOAA scientists and our external partners work together to improve the quality of people's lives and to meet our nation's economic, social, and environmental needs.

In January of 2005, NOAA released *Research in NOAA: Toward Understanding and Predicting Earth's Environment,* a five-year (FY 2005–2009) plan for integrating

research in NOAA. In this report, we examine how NOAA can better understand, monitor, and predict the behavior of Earth's complex natural systems, by working with federal and State agency partners to establish regional observing systems, and working with the international community to build an integrated Global Earth Observing System of Systems (GEOSS). GEOSS will build on the existing Integrated Ocean Observing System (IOOS) and Global Ocean Observing System (GOOS). The integrated observing and modeling system will, in large part, be defined by and be responsive to local needs.

The five-year plan establishes how, in the near-term, NOAA's research enterprise will deliver improvements to existing forecasting tools. Additionally, NOAA is developing new observation systems, models, and other assessment tools that will advance environmental forecasting and management in the long-term. This plan (available at *http://nrc.noaa.gov/Docs/NOAA_5-Year_Research_Plan_010605.pdf)* identifies outcomes for the near-term and research milestones we will use to measure progress towards achieving those outcomes. The five-year plan also describes how we prioritize research within NOAA, who our partners are, and the mechanisms by which we conduct research.

All NOAA research is targeted for application. There are two forms of applications:

(1) Information Services: This research is designed to aid decision-making, management, public safety, and environmental and economic sustainability.

(2) Research to Operations: This research is designed to better serve the public by improving NOAA forecasts, and developing new tools and developing new services.

ASSESSING USER NEEDS FOR INFORMATION SERVICES IN THE GREAT LAKES

NOAA's research and extension programs have an established presence within coastal and Great Lakes communities, and we work with our stakeholders to ensure research meets user needs and is accessible to users. As examples, I will describe Sea Grant Extension, Great Lakes Environmental Research Laboratory workshops, and NOAA Remote Sensing Applications in the Great Lakes.

Sea Grant Extension

The National Sea Grant College program serves as a unifying mechanism within NOAA to engage top universities in conducting scientific research to support NOAA's mission. Sea Grant works in every coastal and Great Lakes state to conduct applied research, extension, education, and communication designed to foster science-based decisions about the use and conservation of our aquatic resources. The goal of these activities is to achieve a sustainable environment and encourage the responsible use of America's coastal, ocean, and Great Lakes resources.

Sea Grant's integrated research, education and outreach programs provide resources to address problems identified by coastal residents and businesses, and local, regional, State and federal agencies. Through the Great Lakes region's eight Sea Grant programs (IL–IN, MI, MN, NY, OH, PA, WI and Lake Champlain), NOAA is able to mobilize significant independent science and advice from the academic community in the Great Lakes, on the complete range of issues faced by the region.

To address regional Great Lakes challenges and ensure that the public remains well-informed of regional science and policy developments, Sea Grant has numerous extension agents throughout the region, and two extension agents co-located with GLERL. Through these regional extension agents and the use of modern communications and education tools, the Great Lakes Sea Grant Network ensures that NOAA research immediately gets into the hands of coastal managers, industry, and local officials that require this information for decision-making. Tools such as local advisory groups with broad representation, facilitated community meetings, the inclusion of outreach activities with every research project conducted, and technology transfer allow Sea Grant extension agents to take the 'pulse' of the user communities on a daily basis and assess their needs. This feedback helps steer NOAA research priorities and research information services. The result is a well-informed society that is able to protect lives and livelihoods, and ensure public safety.

The Sea Grant program also provides resources to researchers and academics allowing them to team up and provide information to the public. As one example, Sea Grant works to educate the community to promote healthy choices with regard to PCB (polychlorinated biphenyl) contamination in fish. For each of the Great Lakes and a majority of their tributaries, there is a fish advisory in place to safely limit consumption of contaminated fish. High-risk groups such as pregnant women, chil-

dren, and women of child-bearing age should limit consumption of PCB-contaminated fish. Sea Grant provides easily-accessible fish advisory information on PCBs in English, Korean, Spanish, and Polish. Wide distribution of these materials has reached many of the 534,000 people comprising non-English-speaking audiences in Illinois and Indiana. All four translations are included in the "ABCs of PCBs" publication, so that a single version can serve a variety of audiences. These materials are provided in hard copy at all Sea Grant workshops and are distributed to the appropriate communities. The "ABCs of PCBs" is also available free of charge on the IL–IN Sea Grant web site (*http://www.iisgcp.org/products/iisg0206.pdf*).

In another example, Pennsylvania, Ohio and New York Regional Sea Grant programs, with additional input from Environment Canada, have developed an extensive education and outreach campaign related to Avian Botulism on the Great Lakes. Public workshops have been conducted on this problem, alternating annually between Pennsylvania and New York. These workshops have served to keep agencies and stakeholders aware of fish and bird kills occurring on the Great Lakes and have resulted in increased research funding on the subject.

Great Lakes Environmental Laboratory Workshops

Communicating with user communities has been integral in setting research priorities at GLERL. For example, in August, 2003, a Great Lakes regional workshop was held at GLERL to assess the region's ecological forecasting needs. Recognizing that making predictions useful to decision-makers is the heart of the ecological forecasting concept, the workshop's preliminary needs assessment challenged workshop participants to think broadly about the ecological forecasting needs of the coastal constituencies. A December, 2004, report produced from the workshop identified stakeholders' needs for 24 ecological forecasts, and GLERL has set nearly all of its research priorities to meet these needs. As discussed in more detail below, operational systems are now in place to provide ecological forecasts for waves, water levels, circulation, and water temperature. Research is ongoing at GLERL to develop the remaining operational forecasting capabilities.

In November, 2005, GLERL teamed up with the Great Lakes Beach Association, the U.S. Geological Survey (USGS), and Environmental Protection Agency (EPA) to host a Beach Health Workshop in conjunction with the Great Lakes Beach Conference. A primary goal of the conference was to identify concerns and information needs of beach managers and public health officials. Another goal was to define research priorities to address recreational water quality issues in the Great Lakes that lead to beach closures for public health. Finally, the workshop helped forge new cooperation between federal agencies and State, tribal, and local groups concerned with beach health.

The overarching questions for this workshop were: How can NOAA, EPA, and USGS research programs help State and local agencies meet their recreational water quality goals, related specifically to beach closures? And, what tools do the beach managers actually need? The workshop allowed our agencies to ask key questions of a diverse group of stakeholders. With attendees from across the region, we were able to gather information to aid in developing effective strategies to meet the research needs of the Great Lakes Beach Health community. Key findings included:

- A need for more comprehensive and standardized training material for beach managers;
- Better communication networks between State, local and federal agencies;
- More accessibility to real-time beach closing data; and
- A need for a regional data network.

By creating a stronger communication network with the beach health community, NOAA is opening the door for better information management, quicker delivery of available tools and technology, and more efficient resource sharing strategies. The GLERL Center for Great Lakes and Human Health web site is being updated to become a central location for health departments, State agencies, beach managers and multiple user groups to check beach conditions throughout the Great Lakes Basin, and learn about current forecasting technologies being developed. This web site will become a "hub" for federal, State, and local agencies to obtain information on beach closures.

In addition, GLERL has been working very closely with EPA Region V, USGS, and the Great Lakes Beach Association in developing a strong communication network between local, State, and federal agencies. We participate in monthly or bimonthly conference calls and distribute information on the BeachNet listserv (*http://www.great-lakes.net/glba/beachnet.html*). BeachNet is an e-mail discussion list that seeks to facilitate communication between people interested in the improve-

ment of recreational beach water quality in the Great Lakes basin. GLERL is also working with the Great Lakes Human Health Network to disseminate information on current research and forecasting models being developed by GLERL researchers. As the technology is transferred, we plan to host training workshops for beach managers to learn to use forecasting models, in coordination with the Great Lakes Human Health Network. The Great Lakes Sea Grant Network is another means that GLERL is utilizing to increase communication and disseminate information on beach closures.

NOAA Remote Sensing Applications in the Great Lakes

NOAA makes data from its Geostationary Operational Environmental Satellites (GOES) and Polar-orbiting Operational Environmental Satellites (POES) fully and freely available for Great Lakes research and operations. This information is available in near real-time to any person or institution (academic, private sector, etc.) that has an antenna capable of receiving the data directly from NOAA's satellites. This data is also available in near real-time on the Internet (*http://www.ssd.noaa.gov*). Additionally, archived satellite data for retrospective analyses are available through the Comprehensive Large Array-data Stewardship System (CLASS), an electronic library of NOAA environmental data (*http://www.class.noaa.gov/nsaa/products/welcome*). To build on current satellite contributions to the Great Lakes region, NOAA's future GOES–R Series and NPOESS (National Polar-orbiting Operational Environmental Satellite System; a partnership with the Department of Defense and the National Aeronautics and Space Administration) will continue these detection capabilities. These satellite data are used by the National Weather Service (NWS) and the private sector to assist in weather forecasting and to protect lives and property in the region.

Another example of meeting user needs with satellite data is NOAA's CoastWatch Program, which processes near real-time satellite data, and makes it available to federal, State, & local marine scientists, coastal resource managers, and the general public. This nationwide program, initially established through NOAA's Coastal Ocean program in 1987, includes two components: (1) central operations and (2) regional nodes. Central operations, managed by NOAA's National Environmental Satellite, Data, and Information Service (NESDIS), coordinates the processing, delivery, quality control and storage of data products. Six regional nodes are located around the country, hosting equipment and personnel to provide near real-time data distribution and regional scientific expertise to the local user community. The Great Lakes regional node is located at GLERL. Together, central operations and the regional nodes provide for the distribution pathway for CoastWatch data and products. The CoastWatch Great Lakes regional node makes a variety of data and products available to the public on their web site (*http://coastwatch.glerl.noaa.gov/cwdata/*). CoastWatch data available on this site includes surface environmental analyses; surface temperature contours; satellite imagery; and in situ data including air temperature and pressure, wind and wave conditions, water level, bathymetry, and weather/meteorological information. One popular CoastWatch web site was developed in collaboration with the Great Lakes Sea Grant Network and Michigan State University (*http://www.coastwatch.msu.edu/*). This site provides up-to-the-minute surface water temperatures for all five Great Lakes—a tremendous resource for commercial and recreational fishers. Lake, regional, and port image charts are updated four times daily and can help recreational and industrial anglers save fuel by pinpointing optimal areas for fishing. Nearly 808,000 Great Lakes surface water temperature images were downloaded from this site over six months during the 2003 fishing season. Through the National Ice Center, a collaborative program among NOAA, the U.S. Coast Guard, and the U.S. Navy, the maritime industry is provided with critical information regarding the extent of sea ice coverage, which is a major navigational hazard for commercial and recreational interests. This information is also available via the Internet at *http://www.natice.noaa.gov/products/gl-ches/index.htm*.

TRANSITION OF RESEARCH TO OPERATIONS

NOAA is committed to maximizing the value of its research to society and to meet mission objectives thereby ensuring the successful transition of research to operations. Ensuring successful transitions is allowing NOAA to provide the best, most up-to-date information and services to our stakeholders and users. Below I will highlight some examples of successful transitions from research to operations programs. I would like to highlight here some of the administrative work we have been doing to clarify and aid in this process.

Over the past year, NOAA has taken significant steps to ensure that the transition of research to operations is streamlined. These steps include:

- Formation of a Transition Board (March, 2005);
- Development of a Policy on Transition of Research to Operations (signed May, 2005);
- Development of implementation procedures the new transition policy (December, 2005); and
- Identification of ongoing NOAA research projects for transition (February, 2006).

The Policy on Transition of Research to Application (available at *http://www.corporateservices.noaa.gov/?ames/NAOs/Chap_216/naos_216_105.html*) was developed in response to the recommendations of a recent NOAA-wide research review by a working group of the NOAA Science Advisory Board. The policy provides a mechanism for systematically reviewing all research annually to identify research to be transferred. The Policy applies to all NOAA research, whether conducted in house or externally, and will facilitate the transition of best available science and cutting-edge technologies from NOAA research to operational status within NOAA.

NOAA's Great Lakes research programs such as GLERL and Sea Grant provide for cutting edge research that leads to the successful transfer of research to operations. Below are some examples of research to operations successes in the Great Lakes region.

Great Lakes Water Level Information and Forecasts

Maritime commerce on the Great Lakes is significant. In 2004, 43.48 million metric tons of cargo passed through the St. Lawrence Seaway, representing a cargo value of $7 billion. Water levels, currents, meteorological and other data are critical for safe and economically efficient commercial Great lakes shipping. Vessels in the 1,000-foot class forfeit 267 tons of cargo for each inch of reduced draft. Regardless of the cargo type, revenue is significantly affected when ships "light-load" to avoid grounding when accurate water levels are not available. NOAA provides the information required by the Great Lakes shipping community through the 52 National Water Level Observation Network (NWLON) stations on the Lakes, the Soo Locks Physical Oceanographic Real-Time System (PORTS®), and accurate water-level forecasts.

The Great Lakes NWLON stations are a part of NOAA's National Ocean Service's National Water Level Program. The Great Lakes NWLON provides real-time water level data to mariners that is updated every six minutes and is available via the Internet (*http://glakesonline.nos.noaa.gov/*) or though voice modem. NOAA has also integrated meteorological data from the National Weather Service buoys on the Lakes into the NWLON voice modem access, so that mariners have a single point of access for critical water level and meteorological information.

PORTS®, a program of NOAA's National Ocean Service, supports safe and cost-efficient navigation by providing ship masters and pilots with accurate real-time water level, currents, meteorological, salinity, air gap (bridge clearance), and other information required to avoid groundings and collisions. PORTS® real-time data is available via the web (*http://140.90.121.76/d_ports.html*) and telephone voice access (301–713–9596 for Great Lakes station information). The Soo Locks PORTS® provides decision support information required to make the critical transit between Lakes Superior and Huron.

Both the NWLON and PORTS® systems provide critical environmental data to U.S. port authorities and maritime shippers allowing them to make sound decisions regarding loading of tonnage (based on available bottom clearance), maximizing loads, and limiting passage times, without compromising safety. They are also critical to environmental protection, since marine accidents can lead to hazardous material spills that can destroy ecosystems and the tourism, fishing, and other industries.

While NOAA's PORTS® and NWLON programs work to provide real-time data and information about water levels in the Great Lakes, research conducted at GLERL provides models that are used to provide monthly forecasts of Great Lakes water levels for 6–12 months into the future. Incorporating NOAA's temperature and precipitation outlooks along with detailed watershed runoff and evaporation models, GLERL's latest 12 month forecasts have proven accurate within two centimeters. These forecasts, which are available at *http://www.glerl.noaa.gov/wr/ahps/curfcst/curfcst.html*, are important to the shipping and fishing (both commercial and recreational) industries for planning purposes.

NOAA forecasts can also be received by ships and boats via NOAA Weather Radio All-Hazards, and through the Digital Marine Weather Dissemination System (DMAWDS), a system the National Weather Service (NWS) operates in the Great Lakes for the specific purpose of disseminating NOAA forecasts to commercial ship-

pers. DMAWDS provides graphic displays of NWS model data for the Great Lakes on a personal computer. Data available for display include barometric pressure, air and sea temperature, wind, and wave height. Data are obtained through the DMAWDS bulletin board, which requires a password for entry. DMAWDS access is available to ships participating in the Voluntary Observing Ships (VOS) program. Through the VOS program, observations are taken by deck officers, coded in a special format known as the ships synoptic code, and transmitted in real-time to NWS. The VOS program operates at no cost to the vessel, with communications charges, observing equipment and reporting supplies furnished by the National Weather Service. To participate, vessels can contact a Port Meteorological Officer; these individuals are located at some NWS offices and serve as liaison for commercial navigation interests.

Great Lakes Coastal Forecasting System

In April, 2006, NOAA announced the completion of the Great Lakes Operational Forecast System (GLOFS) for lakes Superior, Huron, and Ontario. This system, first implemented in Lakes Erie and Michigan in October, 2005, is a NOAA automated model-based prediction system aimed at providing improved predictions (guidance) of water levels, water currents and water temperatures in the five Great Lakes (Erie, Michigan, Superior, Huron and Ontario) for the commercial, recreation, and emergency response communities. This system is an excellent example of how NOAA is meeting its mission responsibility through research projects that were developed in NOAA laboratories and are now being transferred to operational use. This forecast system, which is built on 15 years of solid research and testing, will benefit all who use the Great Lakes—be it for recreational or commercial purposes. In addition to supporting critical economic uses, the GLOFS also will enhance efforts to promote public safety by providing better navigational and coastal information to civil authorities and coastal managers involved in search and rescue missions and other emergency response operations.

NOAA's Center for Operational Oceanographic Products and Services (CO–OPS) maintains the GLOFS in an operational environment 24 hours a day, seven days a week providing accurate information needed by this diverse user population in their day-to-day use of the lakes. GLOFS generates hourly "nowcast" guidance (analyses) for present conditions and four times daily forecast guidance (out to 30 hours) of total water level, current speed and direction, and water temperature for each of the Great Lakes. The GLOFS predictions will enable users to increase the margin of safety and maximize the efficiency of commerce throughout the Great Lakes. Both the nowcasts and the forecasts use information generated by a three-dimensional hydrodynamic model that includes real-time data and forecast guidance for winds, water levels, and other meteorological parameters to predict water levels, currents, and temperatures at thousands of locations throughout the five lakes. Key products include data and animated map plots of water levels, water currents, and water temperatures; these products are available at *http://tidesandcurrents.noaa.gov/ofs/glofs.html*.

Ecosystem Forecasting

NOAA conducts scientific research directed towards creating new tools and approaches for management and protection of coastal ecosystems. To anticipate and minimize how stresses from human and natural causes will affect ecological processes, NOAA is developing ecological forecasting tools which predict the effects of biological, chemical, physical, and human-induced changes on ecosystems and their components. These tools include research on understanding ecological processes, conceptual models of ecosystem function, and statistical and process-driven prediction models. As these tools are developed in the research environment, NOAA scientists identify, consult, and collaborate with user groups representing the ultimate operators and beneficiaries to determine the most useful operational parameters, products, and delivery methods. This often requires the involvement of the operational branches of NOAA (National Ocean Service, National Weather Service, National Environmental and Satellite Data Service, and/or National Marine Fisheries Service) to plan for routine application and dissemination of ecological forecasts. As previously described, public workshops are conducted to identify user needs and services are developed accordingly. This model has been successfully applied by GLERL for forecasts of Great Lakes ice conditions, water levels, circulation and thermal structure, and waves, and is in the process of being applied for beach closures, harmful algal blooms, hypoxia/anoxia, and fish recruitment.

Great Lakes Height Modernization

Height Modernization is a program within NOAA's National Geodetic Survey (NGS) that provides accurate height information by integrating Global Positioning

System (GPS) technology with existing survey techniques. For years, GPS has been used to determine accurate positions (latitude and longitude), but now, by following Height Modernization standards, specifications and techniques, GPS can efficiently establish accurate elevations for all types of positioning and navigational needs.

Post-glacial rebound is causing water from the upper Great Lakes to move into the lower reaches of the lakes. NOAA is working with Canada and several states to conduct GPS surveys to monitor the effects of post-glacial rebound on the Great Lakes region. The goal of this collaborative effort is to maintain accurate height relationships between U.S. and Canadian water level gauges to provide valuable information on how this phenomenon will affect water levels. Establishing GPS Continuously Operating Reference Stations (CORS) at water level gauges is part of this effort. A GPS survey organized under the auspices of the International Joint Commission's Great Lakes Coordinating Committee was conducted in 2005, and will provide a more complete picture of vertical change throughout the region. Updated accurate elevations from this survey are being processed and, when published, will provide vital data to coastal managers, planners, local governments, and others.

Harmful Algal Blooms

The rapid proliferation of toxic or nuisance algae is called a harmful algal bloom (HAB). HABs are scientifically complex and economically significant and can occur in marine, estuarine, and freshwaters. HAB toxins can cause human illness, halt the harvesting and sale of fish and shellfish, alter marine habitats, and adversely impact fish, endangered species, and other marine organisms.

HABs are conservatively estimated to exceed $1 billion in economic damage over the next several decades while a single HAB event can cause millions of dollars in damages through direct and indirect impacts on fisheries resources, local coastal economies, and public health and perception. In the Great Lakes, NOAA scientists have documented HAB toxin levels that were 10 times higher than the World Health Organization recreational standards and much higher than drinking water standards in some areas. This can result in human health problems.

NOAA is working with its federal partners to organize HAB research around a suite of complementary and interconnected programs and activities that involve a mix of extramural and intramural research, long-term regional ecosystem-scale studies supported by short-term targeted studies, collaborations between academic and federal scientists, and multiple partnerships with federal, State and tribal managers. An excellent example of this approach is the collaboration between the extramural ECOHAB (Ecology and Oceanography of Harmful Algal Blooms) and MERHAB (Monitoring and Event Response for Harmful Algal Blooms) research programs of the National Ocean Service and NOAA's intramural research laboratories. ECOHAB is a multi-agency partnership between NOAA's Center for Sponsored Coastal Ocean Research (CSCOR) and the National Science Foundation, U.S. Environmental Protection Agency, National Aeronautics and Space Administration, and the Office of Naval Research.

GLERL has been conducting research on HABs for over a decade. The purpose of this research is to assess the causes and consequences of the blooms and to develop bloom forecasting capabilities. This research aims to understand the processes regulating HAB dynamics and provide stakeholder products to help mitigate the impacts of HABs. NOAA modeling expertise is assuring successful development, validation, and demonstration of HAB forecasts to support more effective ecosystem management. These forecasts provide one type of HAB research product that assists coastal managers in better managing our resources and protecting coastal population from potential detrimental effects through the integration of biology, chemical and physical oceanography, and weather information and products.

Sea Grant extension agents, located in every coastal and Great Lakes state, facilitate the flow of HAB information within local and regional communities. In addition, Sea Grant has supported research focused on the physiology and behavior of individual HAB species and toxins, causes of HABs, and predicting or detecting the occurrence of HABs and their toxins.

The National Ocean Service MERHAB program in the Lower Great Lakes is an eight campus multi-disciplinary effort to develop monitoring strategies for HABs in Lake Erie, Lake Ontario and Lake Champlain watersheds. This project is also examining the basic science of cyanobacteria and toxin formation. In most cases, cyanobacteria (blue-green algae) are the building blocks for HABs. Proliferations of blue-green algae are often triggered by increases in available nitrogen or phosphorus in the environment. By increasing our basic understanding of cyanobacteria (i.e., basic nitrogren:phosphorus ratios, nutrient uptake rates, growth rates), we should be able to help local managers better predict when conditions are right for

bloom formation. Assistance is provided to government and local monitoring agencies through the various campus toxin analysis services.

GREAT LAKES REGIONAL COLLABORATION

On May 18, 2004, President Bush signed an Executive Order that described the Great Lakes as a "national treasure" and sought to improve restoration efforts at the regional and federal levels. The Executive Order established a regional collaboration and promoted agency coordination through a cabinet-level Great Lakes Interagency Task Force. The Department of Commerce is represented on this Interagency Task Force by the Undersecretary of Commerce for Oceans and Atmosphere and NOAA Administrator, VADM Conrad C. Lautenbacher.

In December, 2004, this regional collaborative effort was officially launched in Chicago with the creation of the Great Lakes Regional Collaboration of National Significance (GLRC), a unique partnership of key members from Federal, State, and local governments, tribes, and other stakeholders. NOAA is very supportive of this effort. In addition, NOAA is one of the 11 agencies on the Regional Working Group and has an expert on each of the eight strategy teams developed as part of the GLRC. Underpinning the foundation for collaboration in the Great Lakes is the President's U.S. Ocean Action Plan of December 17, 2004, which calls on federal agencies to work together with their partners in State, local and tribal authorities, as well as with the private sector, our international partners and other interests, to make our oceans, coasts, and Great Lakes cleaner, healthier, and more productive. The U.S. Ocean Action Plan specifically calls on the new ocean governance structure established by Executive Order 13366 and supports the Great Lakes Interagency Task Force and Great Lakes Region Collaboration.

The GLRC strategic planning process builds upon extensive past efforts and works toward a common goal of restoring and protecting the Great Lakes ecosystem for this and future generations. "A Strategy to Restore and Protect the Great Lakes" (Strategy) was released on December 12, 2005. Earlier, a draft strategy was released for public comment and public hearings on the draft strategy were held throughout the Great Lakes region. The final strategy proposes a forward-looking vision to restore and protect the Great Lakes for the benefit of all.

As part of the Administration's response to the Strategy, the Great Lakes Task Force released a list of Near-Term Action items that could be initiated over the next two years at present funding levels. NOAA is taking the lead on several items that pertain to the 'Information and Indicator' section of the Strategy. The Great Lakes Task Force list of Near-Term Action items identified NOAA as the lead on continued implementation of the U.S. contribution to GEOSS and IOOS in the Great Lakes and coordination of existing Great Lakes National Status and Trends monitoring with other agencies. NOAA's FY 2007 budget request includes $1.5 million for a Great Lakes Habitat Restoration Program and associated Great Lakes Restoration Office for the mobilization of NOAA's restoration assets to restore Great Lakes aquatic resources and to serve as a focal point for NOAA's restoration efforts in the region. The program will support restoration projects that achieve significant improvement in habitat function and provide community-wide human use benefits, while ensuring appropriate monitoring and feedback. Working with our partners, results will be used to apply lessons learned to other science-based restoration efforts throughout the Great Lakes basin.

CONCLUSION

Mr. Chairman, this concludes my testimony. I thank you for the opportunity to discuss how NOAA meets user needs through information services and through transition of research to operations, and about NOAA's role in Great Lakes regional collaboration. I would be happy to answer any questions you or other Members of the Committee may have.

Mr. EHLERS: Thank you, very much for your testimony and for your work. I know NOAA is a major agency, little appreciated. It's ironic that the Department of Commerce, which everyone associates with business, has a budget that is 71 percent devoted to science, and much of it is NOAA—more than half of the Department's budget is NOAA. I also find it ironic that an organization with the name of NOAA is in charge of helping people survive floods, even though it's spelled a little differently than the original Noah.

I will take just a break here a moment. I wanted to recognize a special guest. We talked before about Healing the Waters, and the importance of the work of the Wege Foundation. I am pleased that we have been joined by Peter Wege, and also by Ellen Satterlee, the Chief of Staff for the Wege Foundation, and also Terry McCarthy.

Peter, let's—this is unusual. I have to say that Mr. Wege—and I have known him for many years—has always been a supporter of environmental restoration. And at this point he has become sort of the godfather of the environmental movement. And that's intended in a good way. But every time I meet with Mr. Wege, he has more ideas of how we can protect the Great Lakes. And it's a pleasure to have you here.

Mr. WEGE: Thank you. I got a lot more coming.

Mr. EHLERS: Thank you. You will be pleased to know that my wife has now purchased a Prius. I can't purchase it. Someone representing the State of Michigan, I can't buy a Japanese car.

Okay. Next we are pleased to proceed to Ms. Ballard.

STATEMENT OF MS. CATHERINE CUNNINGHAM BALLARD, CHIEF, COASTAL AND LAND MANAGEMENT UNIT, DEPARTMENT OF ENVIRONMENTAL QUALITY, STATE OF MICHIGAN

Ms. BALLARD: Representative Ehlers, I want to thank you for the opportunity to testify today, and also say it's an honor to me to be able to present these comments to you.

My name is Cathie Cunningham Ballard. And I'm here today to represent the Michigan Department of Environmental Quality where I serve as chief of the land coastal and land management unit. In my position, I have responsibility for managing State's coastal resources and implementing the State's coastal zone management program. This requires addressing numerous issues that impact the coast including, but not limited to, habitat conservation, erosion, invasive species, and working closely with local governments to address community development and land use issues.

I'm going to—I'm really pleased that you have held this oversight hearing or briefing now to discuss the important link between science and resource management. My testimony today will focus on three topics. One, the Coastal States Organization's effort to bring together the science and management community to identify research needs. Recommendations for implementation for the Great Lakes Regional Collaboration, and activities that the House Science Committee can undertake to improve the delivery of relevant science into the coastal management decision-making process.

As you know, the Coastal States Organization represents the interests of the governors of the 35 coastal states and territories on issues related to coastal, Great Lakes, and ocean management. As the governor's appointed member of the Coastal States Organization, I have been able to participate in CSO's Science to Management initiative.

The purpose of the Science to Management initiative is to bring together coastal scientists and managers to bridge communication between the two communities, to share scientific findings, and also to identify coastal managers' research needs. The initiative began in 2003 when the CSO sent a survey to about 230 state coastal

managers in the Great Lakes. It represented diverse interests, such as coastal management, fisheries, wetlands, water quality, research and coastal hazards. In the survey, coastal managers were asked to identify what their top priority issues that they would be facing in the next three to five years. Respondents were nearly unanimous in identifying land use, the impacts of land use. And that was 98 percent that were surveyed. 94 percent was habitat change. And I think it was really interesting when they identified what the top research need was. It was to identify what the impacts of land use is on those coastal habitats. We know there is fragmentation. And a lot of—how we are developing our land is having a big influence on those coastal habitats.

The survey went on to identify a number of research needs. They are in my testimony. I won't identify all of those. But one thing they did do is also held a two-day workshop. And one of the days was to—they brought together researchers, scientists, and people who were doing studies on the Great Lakes, along with the resource managers to kind of have that discussion. Second day they brought in the Great Lakes Observation System, people working on that to identify how coastal managers' needs could be incorporated into the gloss.

The second would be the Great Lakes Regional Collaboration. I have been a coastal manager for 19 years. And I have to say this is a first time I can remember this people coming together to talk about the strategy for the Great Lakes and restoration. So it—really commend the people who worked on that. I know from participating, some of the groups, they are—just synthesizing all of that information to be able to prioritize those recommendations was quite an effort.

I would like to offer the following steps or things as a coastal manager that I would recommend. One, you have already done that through the introduction of the implementation plan. And I think that is really helpful because it will allow us to show some success and be a catalyst for getting additional funding.

I think it's important to maintain and expand the communication networks that were set up during the process. I think the process itself had a unifying effect on coastal managers and Great Lakes managers.

Also, I would urge you to use existing programs where you can to the full advantage to implement the Strategy. You have a number of organizations that have been working very hard and very well over the past years. And I would—rather than, you know, creating a lot of new programs, I would look to where can you implement the Strategy using those, because I think especially with limited resources, that's going to be important.

Also, increase short- and long-term monitoring. I think there is a perception that we have a lot more data than what we really do have. And as you said earlier, it's hard to measure where you are going if you don't really know what the current status is. And also if we do set up these monitoring strategies, it's going to allow us to document success which, again, will be a catalyst for increasing funding.

Among the states, there is a real strong need for consistent and—consistent data among the states and in the region if we are

going to do ecosystem management. I also would urge you to focus on the nearshore and tributary areas. Those are our most productive, also diverse coastal habitats, and also very vulnerable to human impacts.

And also interpretation to communicate science to managers. As we do set up these observation systems, there is so much data coming out of these. We really need someone who is going to be able to interpret that data and disseminate it to coastal managers. I have heard it called the fire hose of data that's coming at us. So that will be important.

And also I think it's going to be important to incorporate ecological and biological information to those. Right now they are kind of set up to do more of the chemical and physical. So I would like to see more biological data, because that would help us as coastal managers.

I'm probably a little long because I'm probably getting—to assist in carrying out the Strategy, I would encourage the Committee to work with the Coastal States Organization. It's a great way to hit all of the coastal management community. They are housed in Washington. Gina Carter has been working with Chad. Also, to continue periodic oversight hearings on coordination of federal research dollars to answer coastal management questions. Insert fiscal appropriation bill language which directs the Great Lakes to develop an implementation plan, which you have already done. And then, I guess, partner with the states and other constituents in hoping to enact H.R. 5100 and secure some funds to implement as well.

[The prepared statement of Ms. Ballard follows:]

PREPARED STATEMENT OF CATHERINE CUNNINGHAM BALLARD

Mr. Chairman and Members of the Subcommittee, I want to thank you for the opportunity to testify. My name is Cathie Cunningham Ballard. I am before you today representing the Michigan Department of Environmental Quality where I serve as the Chief of the Coastal and Land Management Unit. In my position, I have responsibility for managing the state's coastal resources and implementing the state's Coastal Zone Management Program. This requires addressing numerous issues that impact the coasts including, but not limited to, habitat conservation, erosion, invasive species, and working closely with local governments to address community development and land use.

In addition to my role with the State, my passion for the coasts and science extends into my personal interests. For example, I serve as President of the Michigan Chapter of the American Planning Association and Chair of the Land Use and Water Quality Committee of the Coastal States Organization. I am also a member of the Board of Directors of the Land Information and Access Association, a nonprofit organization that encourages public participation and access to geo-spatial information and technology. Just recently, I was appointed to the Ocean Studies Board of the National Academy of Sciences Committee charged with review of the Ocean Research Priorities Plan, developed by the Joint Subcommittee on Ocean Science and Technology.

Introduction

I am delighted that you have elected to hold this oversight hearing to discuss the important link between science and wise decision-making in managing the Great Lakes' coastal resources. My testimony today will focus on three topics: 1) The Coastal States Organization's effort to bring together the science and management community to identify research needs; 2) key successes and next steps for regional initiatives such as the Great Lakes Regional Collaboration; and 3) activities the House Science Committee can undertake to improve the delivery of relevant science into the coastal management decision-making process.

Coastal States Organization Science to Management Initiative

As a Governor-appointed member of the Coastal States Organization (CSO), I have the pleasure of working closely with my colleagues from around the Nation. As you know, CSO represents the interests of the Governors of the thirty-five coastal states and territories on issues related to coastal, Great Lakes, and ocean management. These managers around the country work diligently with dwindling resources and mounting pressures to ensure our coasts remain viable and vibrant components of our nation's ecosystems and economy.

As the Chair of the Land Use and Water Quality Committee, I actively participate in the CSO initiative we call *Science to Management.* The purpose of the *Science to Management Initiative* is to bring together the coastal scientists and managers to bridge communication between the two communities, share scientific findings, and identify managers' research needs to improve decision-making.

The Initiative began in 2003 with a survey of 230 state coastal managers representing diverse interests in coastal zone, fisheries, wetlands, water quality, research and hazards. In the survey, coastal managers were asked to identify the top issues they will face in the next five years. The respondents nearly unanimously agreed that land use (98 percent) and habitat change (94 percent) were the top issues confronting coastal managers.

The survey went on to query the managers' needs related to research, technology, and information on land use and habitat. For example, Great Lakes coastal managers identified the following needs:

Land Use

- Research Need: Biological and Socio-economic analyses of various land use options on coastal habitats
- Information Need: Geo-spatial data for GIS
- Technology Need: Customized GIS

Habitat Change

- Research Need: Cumulative impact assessments
- Information Need: Trends analysis and ability to document changes
- Technology Need: Best management practices for habitat restoration

Following the survey, CSO hosted focus groups at a regional level to collect more specific information on coastal managers' research needs. In April 2005, CSO held two workshops in the Great Lakes, one on the topic of land use and another on managers' needs from the Great Lakes Observation System. Issues that came to the forefront during those workshops included shoreline erosion and sediment management, aquatic invasive species, and water quality. During the workshops, the participants identified specific needs and priority products to meet those needs. For shoreline erosion and sediment management, for example, the managers requested research to support their capacity to:

- Calculate erosion-recession rates
- Determine sediment quality, supply, and transport
- Document rip currents
- Access real-time wind and wave observations in the near-shore to respond to erosion and recreation issues
- Document the impact of public and private shoreline structures (e.g., breakwaters, groins, etc.) on hydrology and biology
- Better understand lake level dynamics and assess impacts of federal and State regulations on lake levels

These are only a sample of the significant gaps in the state of Great Lakes knowledge and data collection that came to light during these workshops. For additional information and State needs, I refer you to *http://www.great-lakes.net/coastalstates/* for the presentation and meeting workbook, and *http://www.great-lakes.net/coastalstates/ppt/summary01.pdf* for the final report.

It is important that the work conducted and needs identified via the CSO *Science to Management Initiative* not just sit on the shelf but serve as a vital step toward expanding the dialogue between the management and science communities. These needs and recommendations can be turned into action by directing research dollars towards answering the managers questions, incorporating the managers' needs into on-going Great Lakes land use, habitat, and restoration strategies and initiatives such as the Great Lakes Regional Collaboration, and ensuring that those respon-

sible for shaping the development of the Great Lakes Observation System take into consideration the needs of coastal managers as they make data collection and resource allocation decisions.

Great Lakes Regional Collaboration

The Great Lakes Regional Collaboration (GLRC) has been a cooperative and unifying activity for the Great Lakes science, management, business, and advocacy community. In my nineteen years of coastal management, this was the first time that all the levels of government and private stakeholders came together to craft a comprehensive Strategy for restoring and protecting the Great Lakes. As Chief of a state program with a long and productive record of protecting and restoring coastal habitats, improving coastal water quality, and promoting sustainable use of Great Lakes coastal resources, it is heartening to see a rising level of energy and interest among such a broad base of stakeholders.

In commenting on the Strategy, I want to say that I appreciate the inclusive approach used in developing it, and also want to commend everyone involved who worked so hard to synthesize the information that was collected and prioritized the many recommendations proposed. The strengths of the Strategy are that it builds upon and reinforces existing efforts, provides a set of common and consensus-based goals for protection and restoration, focuses attention on the critical nature of the near-shore and tributary areas, identifies concrete activities for action, and recommends the funding needed to address the challenges facing the region.

The Collaboration partners have presented the region, and the Nation, with an unprecedented opportunity to take action now to protect and restore this national treasure. While all of the Collaboration partners face budgetary constraints, and restoration of the Great Lakes will necessarily occur over many years, it is vital that definitive action commence soon to advance the goals of the Collaboration. Whether and how this Strategy is implemented will be a measure of our success for generations to come.

I offer the following as steps and actions to consider as we move forward:

- Develop an Implementation Plan. An implementation plan is needed to prioritize the actions listed in the Strategy. A priority list will assist government and private partners in determining how to allocate existing resources, and provide a framework for targeting new funding. The implementation plan should be scalable so that, as new funds are appropriated, it is clear which projects will be funded first. The implementation plan should also identify how the Environmental Protection Agency, the National Oceanic and Atmospheric Administration, and other federal agencies will allocate their resources and technical assistance to help achieve the Strategy goals.
- Maintain and Expand Communication Networks. The Strategy catalyzed the establishment of communication networks in the region. These communication networks should be maintained and expanded to bring in new partners and stakeholders. Communication helps encourage partners to buy in to the Strategy and its recommendations. Buy-in will be crucial for ensuring the partners apply their resources toward achieving the Strategy objectives.
- Increase Short- and Long-term Monitoring. Monitoring is an essential component of the Strategy, and is a means of improving our basic understanding of the Great Lakes as well as a tool for tracking progress and measuring the Strategy's effectiveness. Among the states, there is a strong need for consistent and sustained collection of data and increased understanding of emerging environmental trends.
- Focus on the Nearshore, and Tributary Areas. The tributaries to the Great Lakes and nearshore areas are among the most biologically productive and diverse coastal habitats. They also are highly vulnerable to anthropogenic impacts. The Strategy highlights the influence of nearshore activities on the health and integrity of Great Lakes ecosystems. Consequently, recommendations benefiting the nearshore and tributary areas should be foremost among implementation priorities.
- Interpret and Communicate Science to Coastal Managers. There is a perception that coastal managers are managing resources with the best available science. This is not the case. In fact, many Great Lakes states often do not have access to the type of data or resources available to coastal ocean states. In Michigan, for example, we don't have LIDAR images of our coasts. LIDAR provides coastal resource managers with three dimensional images of shoreline bathymetry. That tool is crucial in the management of coastal erosion, sand dune protection, and forecasting capabilities. There is a need to increase coordination between resource managers and the science community, develop

mechanisms that direct science and federal research dollars towards managers' priorities, and to deliver relevant scientific findings in useful formats.

- Ensure the Great Lakes Observation Systems also address biological and ecological parameters. The Regional Association should continue to include coastal managers in setting research and funding priorities. It will also be critical to find a way to interpret and disseminate the data that is collected. Resource managers are not equipped to use the fire-hose of raw data that will be collected by these new systems.
- Finally, there will have to be new funding to implement the GLRC recommendations. Even when existing programs are used, the Strategy will only be a success if new and considerable resources are applied.

Recommendations for the House Science Committee

To assist in carrying out the Strategy and ensure that relevant science is available to coastal managers, the House Science Committee may consider the following actions:

- Work with the states and Coastal States Organization in strengthening communication channels between the science and management communities;
- Continue periodic oversight hearings on (1) the coordination of federal research dollars to answer coastal management questions, and (2) implementation of the Strategy;
- Insert in a fiscal appropriation bill language that directs the Great Lakes to develop an implementation plan which prioritizes activities under the Strategy and is scalable based upon available and new resources;
- Partner with the states and other constituents to enact H.R. 5100 and secure new funds to implement the Strategy.

Conclusion

In conclusion, Mr. Chairman, I want to thank you again for this opportunity to testify on a topic of great importance to the Great Lakes coastal management community. I would be pleased to answer any questions you or others on the Subcommittee may have.

BIOGRAPHY FOR CATHERINE CUNNINGHAM BALLARD

Catherine Cunningham Ballard holds a B.S. in Resource Development from Michigan State University, where she also attended graduate school. She is Chief of the Michigan Coastal Management Program, Michigan Department of Environmental Quality. As the Program Chief, Ms. Ballard develops policy and distributes funds for protecting, restoring, and promoting appropriate, sustainable use of Michigan's Great Lakes coastal resources. Ms. Ballard has a strong interest in land use and growth management issues at the State and national level.

Ms. Ballard was recently appointed to the Ocean Studies Board of the National Academy of Sciences Committee charged with review of the Ocean Research Priorities Plan, developed by the Joint Subcommittee on Ocean Science and Technology. She also recently joined the Advisory Board of the Cooperative Institute for Coastal and Estuarine Environmental Technology, a partnership between NOAA and the University of New Hampshire. Ms. Ballard is President of the Michigan Chapter of the American Planning Association, on the Executive Committee and Chair of the Coastal Water Quality and Land Use Committee, Coastal States Organization, on the Board of Directors for the Land Information Access Association, a non-profit that encourages public participation and access to geo-spatial information and technology. She also serves on the Advisory Committees of the Great Lakes Water Studies Institute and Great Lakes Nonprofit Institute at Northwestern Michigan College, Board of Directors of the Michigan Lighthouse Project and Michigan Lighthouse Fund, and Alumni Board of Directors, College of Agriculture and Natural Resources, Michigan State University. Recent past service includes participation in a NOAA Coastal Services Center Blue Ribbon Panel. In 2003, Ms. Ballard received the "Outstanding State Official" Award from the Michigan Association of Regions.

Mr. EHLERS: Thank you, very much.

Dr. Steinman.

STATEMENT OF DR. ALAN D. STEINMAN, DIRECTOR, ANNIS WATER RESOURCES INSTITUTE, GRANT VALLEY STATE UNIVERSITY

Dr. STEINMAN: Good afternoon, Mr. Chairman. Thank you for the invitation to appear before you and testify with regard to restoration activities in the Great Lakes today.

My name is Alan Steinman. I'm the Director of the Annis Water Resources Institute located in Muskegon, Michigan. And it's a part of Grand Valley State University. On behalf of the University, I welcome you.

Prior to moving to Michigan, I was intimately involved with the restoration of the Florida Everglades, having served as the Director of the Lake Okeechobee Restoration Program for the South Florida Water Management District. My current position, I oversee an academic institution that's involved in a variety of restoration projects in the Great Lakes. And I was personally involved in Great Lakes Regional Collaboration having served on three of the strategy teams.

I want to preface my responses by saying that as a scientist and as administrator at a public university, and economically depressed state, I fully understand the importance of prioritizing our actions based upon existing resources. However, given the national and global importance of the Great Lakes, I believe a more appropriate question to be asking us is what three recommendations should be implemented, not what could be implemented based on existing resources. However, I am a pragmatist. And in the spirit of answering the questions as posed, in my opinion, the top three priorities for Great Lakes restoration are, one, controlling the introduction of aquatic invasive species; two, protecting the nearshore and coastal waters of the Great Lakes, and three, addressing the problems associated with nonpoint source pollution.

What can we do with existing resources? To aquatic invasive species, we need to take a long, hard look at whether ocean shipping in the Great Lakes makes economic sense. And if the answer is no, whether this policy should be altered.

For protecting nearshore and coastal waters, we can, one, promulgate and enforce appropriate regulatory and incentive-based programs to control the sources throughout the Great Lakes. And, secondly, implement an information and education program for the general public.

And for nonpoint source pollution, we can implement a basinwide phosphorus ban and lawn fertilizer in all regions where soil tests indicate that additional phosphorus is not necessary.

What can be done if we had more resources? For aquatic invasives, we need to develop a comprehensive monitoring system throughout the Great Lakes to detect the introduction, establishment and spread of new invasives. And, secondly, we need to invest in research to determine the anticipated, and more importantly, the unanticipated impacts of these species.

For coastal health, we need to replace and upgrade our sanitary infrastructure. This is a real problem Great Lakes where many of our systems are old and failing.

And for nonpoint source pollution, we need to restore our wetlands and repairing buffers which serve as the kidneys for the

Great Lakes, and develop and implement comprehensive nutrient management plans on our farms.

The Collaboration is still in its infancy. As a consequence, it is—it has not yet led to more informed resource management planning decisions. But the foundation is in place for it to do so in the future. I'm a strong proponent for making sure science has a place at the decision-making table—something I'm sure you appreciate. However, my experiences during the Everglades restoration process convinced me that, one, decisions will be made irrespective whether scientists are in the room or not. And, secondly, how the science is presented to the policy-makers makes an enormous difference on whether the scientifically-based recommendations are implemented. The Collaboration has the potential to be a critical driver in melding science and policy, but it needs time to develop and mature.

With respect to your third question, strategy does not presently help me prioritize my work, but it has the potential to do so in the future. Because the recommendations from each strategy team were based on key problems already facing the Great Lakes, my own research agenda, and many of my colleagues were already being driven by these issues. As the strategy evolves, and funding streams are identified, it's inevitable that priorities will shift to reflect those realities and the available funding.

I think it's absolutely essential that the federal agencies not implement the Strategy in a top-down fashion. This type of approach will result in enormous delays at best, and complete failure at worse. My assessment is based on experience in South Florida where during the initial phases of the comprehensive Everglade restoration plan, the U.S. Army Corp. of engineers adopted a top-down command and control approach to the restoration effort. They encountered enormous resistance by local communities, municipalities and agencies. This ultimately resulted in costly delays if the politics were worked out. The strategy teams and Collaboration must be inclusive. Leadership roles should not be exclusive to federal partners, and should include state agencies, NGO's, and academics in these positions as well. And the information must be distributed in an honest and transparent manner.

Based on my experience with the Collaboration on the Everglades, the biggest challenges, implementing the Strategy will be eight-fold. First, we need to generate the credible peer review science on which to base actions. Fortunately we have much of this information already in hand. Second, we need to manage the information that's generated—the fire hose as Cathie refers to it. Third, we need to adopt a holistic approach. Fourth, we need to obtain the public buy-in. Fifth, we need to secure long-term, dedicated funding. Six, we need to build an adaptive framework into this process. Seven, we need to develop a meaningful evaluation and accountability process. And, finally, we need to avoid turf battles.

My expectations for the Strategy over the next year are modest. I hope that we will see the development of a formal process with an organizational structure. And strategy teams will be prioritizing their actions, identifying mechanisms to procure the necessary funding, developing a series of conceptual models to determine how their goals align within the Great Lakes as a whole, and among the

other strategy teams, and laying a common ground work with our elected officials to engage their support.

In summary, I hope these examples and lessons learned, which were based on "my personal experience" and that of many other people involved in restoration throughout this country, will help place this issue in a broader, more pragmatic context, and be of use to you and your subcommittee. Thank you again for the invitation to testify today.

[The prepared statement of Dr. Steinman follows:]

PREPARED STATEMENT OF ALAN D. STEINMAN

Good afternoon. My name is Alan Steinman. I am the Director of the Annis Water Resources Institute (AWRI) located in Muskegon, Michigan, about 30 miles to the west of this building, on the shoreline of the Great Lakes. The Institute is part of Grand Valley State University (GVSU). Mr. Chairman, Members of the Subcommittee, I thank you for the invitation to appear before you and testify with regard to restoration activities in the Great Lakes.

Prior to moving to the Great Lakes region, I was involved intimately in the restoration of the Everglades, having served as the Director of the Lake Okeechobee Restoration Program for the South Florida Water Management District. In my current position, I oversee an academic institution that is involved in a variety of local and regional restoration projects dealing with some of the most pressing water resource issues facing the Great Lakes, including contaminated sediments, impacts of land use change on coastal resources, nonpoint source pollution, and invasive species.

I was directly involved in the Great Lakes Regional Collaboration by serving on two strategy teams: 1) nonpoint source pollution, where I chaired the nutrient work group; and 2) sustainable development, where I served on the water uses work group. In addition, faculty members at AWRI served on the aquatic invasive species and habitat conservation strategy teams as part of the regional collaboration effort.

My written testimony today addresses questions focusing on the Great Lakes Regional Collaboration (GLRC). My responses are based on my personal experience with the Collaboration and my on-the-ground experience of implementing large-scale restoration efforts in south Florida.

1) What are the top three recommendations in the GLRC Strategy that you believe could be implemented with existing resources? What scientific research, scientific information, or science-base products are required to support the implementation of these three recommendations? Would your answers be different if funding was increased?

As a scientist and administrator at a public university in an economically depressed state, I understand the importance of prioritizing actions based upon existing resources. However, given the national and global importance of the Great Lakes, I must premise my remarks with the observation that I believe it is far more important to ask this panel what top three recommendations **should** be implemented, not **could** be implemented. I am a pragmatic individual, and fully understand that resources are limited, but I also believe it is a fundamental mistake to prioritize restoration actions based on what our current resources allow, as opposed to prioritizing based on the most critical needs, and then developing strategies to acquire the necessary funds.

With that caveat in mind, the top three priorities for Great Lakes restoration in my opinion are 1) controlling the introduction of aquatic invasive species; 2) protecting the nearshore and coastal waters of the Great Lakes; and 3) addressing the problems associated with nonpoint source pollution. I briefly discuss each of these priorities, and associated recommendations based on currently available funding.

Aquatic Invasive Species:

The proliferation of aquatic invasive species in the Great Lakes is changing the way that energy and materials cycle throughout the system. There is an enormous wealth of peer-reviewed scientific literature to support this finding, and the implications are staggering. In addition to the changes in the ecology of the Great Lakes, the economic losses in the Great Lakes basin from aquatic invasives were estimated

in 2005 at ~$5 billion/yr.[1] This largely reflects costs associated with changes in our recreational and commercial fisheries, as well as the costs of controlling zebra mussels and sea lampreys.

Many of these introductions have occurred through ballast water. Clearly, action needs to be taken to control ship-mediated introduction of aquatic invasive species. A recent study conducted by John Taylor, a colleague of mine from the Seidman College of Business here at Grand Valley State University,[2] concluded that a cessation of ocean shipping on the Great Lakes would result in a transportation cost penalty of ~$55 million/yr. Given that the economic losses to the Great Lakes associated with aquatic invasive species are estimated to be two orders of magnitude larger than the transportation cost penalty, one question that should be discussed is whether ocean shipping in the Great Lakes continues to make economic sense, and if the answer is no, should the policy be changed?

Protecting Nearshore and Coastal Waters:

The protection of nearshore and coastal waters is critical for two reasons. First, from an ecological perspective, these areas serve as an important buffer, protecting the open waters of the Great Lakes from impairments originating from the land. These nearshore and coastal areas, such as coastal wetlands, embayments, drowned river mouth systems, and estuaries, serve as kidneys of the Great Lakes, in the sense that they filter out pollutants before they reach our open waters. Second, these coastal areas are heavily used by humans for recreation. When they are impaired, our society suffers economic, recreational, and spiritual losses.

Ultimately, we need to replace and upgrade our sanitary infrastructure. However, this is a very expensive program, and local dollars are clearly insufficient to meet the needs. I view this recommendation as a "should"; what **can** be done with existing resources is identify the sources of these pollutants impacting coastal health, promulgate and enforce appropriate regulatory and incentive-based programs to control the sources, and implement an information and education strategy for the general public. New technologies are being developed right now by scientific communities in the Great Lakes to improve our abilities to track these sources to their origins. Continued funding of these research and development programs, as well as incentives for public-private partnerships to commercialize these techniques, is absolutely critical if this recommendation is to succeed.

Nonpoint Source Pollution (NPS)

Nonpoint source pollution comes from diffuse sources; it flows off of lawns, impervious surfaces, and farms, and now contributes more pollution to our nation's waterways than point source pollution (that coming from discrete sources, such as pipes).[3] There are five nonpoint source pollutants of particular concern in the Great Lakes: nutrients, contaminants, pathogens, sedimentation, and altered flow regimes.

The recommendations in the GLRC Strategy dealing with NPS all require the infusion of new dollars to restore wetlands and riparian buffers, reduce soil loss, develop and implement nutrient management plans on farms, and improve the hydrology of select watersheds. These are critical implementation projects, but again fall in the **"should"** category; it is important that they be developed in a coordinated and logical fashion. In the interim, a basin-wide phosphorus ban in lawn fertilizer in all regions where soil tests indicate that additional phosphorus is not needed, could be implemented quickly, at minimal cost, and begin the process of reducing NPS pollution in the Great Lakes.

2) Has the GLRC led to more informed resource management planning decisions? What kinds of scientific information are now being taken into account in those decisions because of the GLRC? To what extent has the GLRC helped foster new or stronger collaboration between scientists and policy-makers? What is your role in strengthening the relationship between scientists and policy-makers?

The GLRC is still in its infancy. The process of having over 1,500 people, from diverse sectors and backgrounds, working together to draft a Strategy for the long-term sustainability of the Great Lakes was, in itself, an incredibly informative experience. Has it led to more informed resource management planning decisions? From

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[1] Pimental, D. 2005. Aquatic nuisance species in the New York State Canal and Hudson River systems and the Great Lakes basin: an economic and environmental assessment. *Environmental Management* 35:1–11.

[2] Taylor, J.C. and J.L. Roach. 2005. Ocean shipping in the Great Lakes: Transportation cost increases that would result from a cessation of ocean vessel shipping. Grand Valley State University, Grand Rapids, MI.

[3] Carpenter, S.R., N.F. Caraco, D.L. Correll, R.W. Howarth, A.N. Sharpley, and V.H. Smith. 1998. Nonpoint pollution of surface waters with phosphorus and nitrogen. *Ecol. Appl.* 8:559–568.

my vantage point, no—not yet. But the foundation is in place for the GLRC to make that happen in the future. The Strategy can be thought of a skeleton, to which some flesh and blood have now been added. However, the animation of the Strategy is yet to come.

I believe there has been a growing recognition that collaboration between scientists and policy-makers is a win-win situation. It is critical that scientists present information to policy-makers in an understandable and real-world fashion; however, it is also incumbent on policy-makers that they understand scientific information is imperfect and often fraught with uncertainty. The GLRC has the potential to be a critical driver in this process, but the Collaboration needs time to develop and mature.

There are many new initiatives in Michigan that are working on the scientist–policy-maker collaboration. For example, the Water Resource Fellows[4] that was started last year at Michigan State University was designed to shape water policy in Michigan and evaluate the role of science in that process. Michigan Sea Grant is funding projects based on an Integrated Assessment approach,[5] whereby existing scientific information is assessed through a formal decision-making process to answer policy or management questions.

In addition, many of the projects conducted at the Annis Water Resources Institute[6] at GVSU are designed explicitly to deliver scientifically-defensible alternatives to decision-makers, so that they can make the best informed decisions possible. Examples include a watershed-based interactive tool (WIT) for local decision-makers, educators, and stakeholders of the Lower Grand River Watershed that shows how everyday activities influence water quality in the region.[7] This tool incorporates information from management plans, as well as materials on the natural history of the Lower Grand River Watershed (LGRW), interactive maps of the LGRW, general watershed concepts, lesson plans for watershed education, and information on how everyday activities can affect water quality in the LGRW. The WIT also can help local units of government and non-profit entities in writing their own nonpoint source management plan. This type of tool helps us address two of the top priorities affecting the Great Lakes: nearshore ecological health and nonpoint source pollution. AWRI is also involved in addressing how best to control phosphorus in our aquatic ecosystems. Phosphorus is a key element responsible for algal blooms. Recently, the frequency of these blooms, and in particular, potentially toxic cyanobacterial blooms, has been increasing in the Great Lakes basin.[8] Our studies have explored ways to reduce phosphorus from the watershed, as well as in-lake management strategies.[9] Finally, legacies of contaminated sediment continue to plague the ecological health in portions of the Great Lakes. In Muskegon County alone, we have two Areas of Concern. Studies at AWRI, identifying the toxic chemicals and their degree of toxicity, have been instrumental in helping catalyze the remediation of Tannery Bay in White Lake and Ruddiman Creek in Muskegon Lake.[10]

I am a strong proponent of making sure science has a place at the decision-making table. My experiences in south Florida with the Comprehensive Everglades Restoration Plan (CERP) convinced me that 1) decisions will be made irrespective of whether scientists are in the room or not, and 2) how the science is presented to policy-makers makes an enormous difference in whether the scientifically-based recommendations are implemented. As a consequence, I work closely with my local, State, and federal elected officials to keep them updated on key findings, and stay engaged in these initiatives.

3) Does the Strategy effectively reflect your needs and help you to prioritize your work? Are there additional actions EPA and other federal agencies should be taking to help implement the GLRC?

Not at present, but it has the strong potential to do so in the future. Because the formation of the Strategy teams and the recommendations from each team were predicated on the largest perceived problems facing the Great Lakes, both my own research agenda and that of staff at AWRI already were driven by these issues, and I suspect this was the case for most other scientists in the region. As the Strategy

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[4] *http://www.environment.msu.edu/water/*
[5] *http://www.miseagrant.umich.edu/ia/index.html*
[6] *http://www.gvsu.edu/wri/*
[7] *http://www.gvsu.edu/wri/isc/index.cfm?id=C8931AA2-EA91-B9B9-8DB821BC1ACF8A05*
[8] *http://www.glerl.noaa.gov/res/Centers/HumanHealth/hab/EventResponse/*
[9] Steinman, A., R. Rediske, and K.R. Reddy. 2004. The reduction of internal phosphorus loading using alum in Spring Lake, Michigan. *Journal of Environmental Quality* 33:2040–2048.
[10] *http://www.epa.gov/glnpo/sediment/whitelake/index.html*

evolves, and funding streams are identified, it is inevitable that priorities will shift to reflect those realities.

It is absolutely essential that the federal agencies not implement the Strategy in a purely top-down fashion. This type of approach will result in enormous delays at best, and in complete failure at worst. My assessment is based on experience in south Florida, where during the initial phases of CERP, the U.S. Army Corps of Engineers adopted a top-down, command-and-control approach to the restoration effort, and encountered resistance by local communities and agencies. This ultimately resulted in costly delays as the politics were worked out. The Strategy Teams must be inclusive, leadership roles should not be exclusive to federal partners (i.e., include State and local agencies, NGOs, academics in those positions, as well), and information must be distributed in an honest and transparent manner. Information control is a form of power, and failure to disseminate information erodes the collegiality and trust that will be essential if these teams are to implement the recommendations in a thoughtful and meaningful manner.

4) What are the biggest challenges you see in implementing the Strategy, particularly in terms of meeting science and information needs?

As noted in my written testimony of May, 2004 to the Committee on Transportation and Infrastructure, Subcommittee on Water Resources and Environment, the biggest challenges associated with implementing the Strategy are very similar to those encountered with other large-scale ecosystem restoration projects. Successful restoration programs must address more than the science of the system, although that is clearly an essential component. Based on my experience, the biggest challenges are the following:

1) Generating the credible, peer-reviewed science on which to base actions
2) Knowledge management
3) Adopting a holistic approach
4) Obtaining public buy-in
5) Securing long-term dedicated funding
6) Building an adaptive framework into the process
7) Developing a meaningful evaluation and accountability process
8) Avoidance of turf battles

Credible, Peer-Reviewed Science: There is often an innate distaste from funding agencies, elected officials, and the public for more "studies." Understandably, people want to see tangible action, dirt turned, and on-the-ground results. However, it is critical that these activities be predicated on scientific results that have withstood the rigors of peer-review. The up-front investment in this scientific information, assuming that the experimental design, scientific analysis, and conclusions are vetted and peer-reviewed, will pay dividends many times over in the long-run by minimizing the likelihood that ineffective or inappropriate actions will be taken.

Knowledge Management: There is a wealth of information currently being generated in the Great Lakes basin. Some of it is coordinated, but much of it is not. Major challenges associated with this issue include (1) prioritizing what information is most essential for the restoration effort (conceptual models can help kick-start this process); (2) developing and implementing the appropriate database management system; (3) maintaining and updating the database; and (4) making the database user-friendly.

Holistic Approach: Large-scale restoration efforts often require a team of experts to successfully implement a project. For example, one of the recommendations to control nonpoint source pollution is to restore hundreds of thousands of acres of wetlands. Determining the best location for restoration requires that hydrologists, chemists, producers, modelers, and ecologists collaborate to identify the optimum soil type, flow patterns, and biotic sensitivity. In addition, planners and engineers are needed to integrate the sites with existing infrastructure and to design the projects. Real estate experts and lawyers may be needed to conduct and finalize the land transactions. Clearly, the public must be behind the project as well, or success is unlikely (see below).

Public Buy-in: Ultimately, ecosystem restoration projects that do not have the approval and backing of the general public are doomed to failure. Getting public support is more than just including them in the early planning stages of a proposed project; it involves communicating with them in a language they can understand,

outlining the entire restoration process, and providing honest input on both the uncertainties of success[11] and the cost estimates associated with the project.

Long-Term Dedicated Funding: Ecosystem restoration projects come in all shapes and sizes, and with varying price tags. However, large projects, which transcend multiple jurisdictions and involve many disciplines, such as in south Florida or in the Great Lakes, are expensive. To maintain momentum and sustain interest in the project, especially when projects are controversial and litigation is a threat, it is critical that the partners recognize that funding sources are not ephemeral.

Adaptive Management: No project goes according to plan. Ecosystems are notoriously stochastic in their responses, so it is particularly important that flexibility be built into the restoration plan. Adaptive management involves assessing the data collected during the restoration process, comparing how the system is responding to the anticipated results, and fine-tuning the restoration activities to meet the restoration goals.

Evaluation and Accountability: Large-scale restoration projects attract considerable attention because of their visibility, funding requirements, and need to balance competing demands for the resources at stake. It is critical that a rigorous evaluation process be established to assess the success of the project and to provide accountability to the public and scientific community at-large.

Turf Battles: Given the number of parties already established in the region, it will be a tremendous challenge to foster a cooperative, collaborative environment. Federal and State governmental agencies have largely driven the process to date; it is essential that these entities reach out to academic institutions, NGOs, local officials, tribal governments, and other entities.

5) What outcomes do you expect to see one year from now as a result of implementing the GLRC Strategy?

My expectations are modest, to be quite honest. My hope is that we would see the development of a formal process, with an organizational structure, to the GLRC Strategy. Assuming this structure parallels what has been developed to date, these Strategy Teams would be prioritizing their actions, identifying mechanisms to procure the necessary funding, developing a series of conceptual models to determine how their goals align within the Great Lakes as a whole and among other Teams, and laying a common groundwork with elected officials and engaging their support.

Summary

The Great Lakes ecosystem provides an enormous number of services and functions to the region. It is currently facing a variety of stresses and pressures, which should be addressed through a comprehensive, coordinated ecosystem restoration plan. Although ecosystem restoration is still far from being an exact science, there are certain elements whose inclusion is strongly recommended in order to ensure the greatest chance of success. These include involving the public in a substantive way, basing restoration activities on sound science, being inclusive during plan development and implementation, retaining a flexible approach, and building accountability into the process.

I hope that the examples and lessons learned presented here, which are based on my personal experience and that of many other dedicated people, will help place this issue in a broader and more pragmatic context, and be of use to you and the Subcommittee. Thank you again for the invitation to appear today.

Mr. EHLERS: Well, thank you, very much for your testimony. Dr. Scavia.

STATEMENT OF DR. DONALD SCAVIA, PROFESSOR AND ASSOCIATE DEAN, SCHOOL OF NATURAL RESOURCES & ENVIRONMENT; DIRECTOR, MICHIGAN SEA GRANT, UNIVERSITY OF MICHIGAN; SCIENCE ADVISOR TO THE HEALING OUR WATERS GREAT LAKES COALITION

Dr. SCAVIA: Mr. Chairman, thank you for the opportunity to testify with you today. As you mentioned earlier, I am a professor of

[11] Peterson, G.D., S.R. Carpenter, and W.A. Brock. 2003. Uncertainty and the management of multi-state ecosystems: an apparently rational route to collapse. *Ecology* 84:1403–1411; and Steinman, A.D., K.E. Havens, and L. Hornung. 2002. The managed recession of Lake Okeechobee, Florida: integrating science and natural resource management. *Conservation Ecology* 6(2):17. [online] URL: *http://www.consecol.org/vol6/iss2/art17.*

natural resources at the University of Michigan, and Michigan Sea Grant Director. But today I'm representing the Healing Our Waters Coalition. The Coalition is dedicated to the protection and restoration of the Great Lakes. And represents 85 national, regional, State and local organizations. And I serve as a senior science advisor to the Coalition's steering committee.

Mr. EHLERS: Could I ask you to pull your mic a little bit closer to your mouth?

Dr. SCAVIA: Sure. Before joining the faculty at the University of Michigan, I served in NOAA as a research scientist and research manager for 29 years. Providing me with a national perspective on the significance of the Great Lakes—something you are battling day-to-day—the need for restoration strategy, and the role science can play in restoration.

My testimony today focuses on four areas. One, the need to act now to protect the natural resources. The, second, to set priorities identified by State and academic scientific communities. Third, the need for strong science-based for the restoration. And, fourth, the critical role for an independent voice that the Great Lakes universities can provide.

A significant portion of my testimony derives directly from the white paper that has been endorsed by over 60 leading scientists across the Great Lakes basin. This paper, a Prescription for Great Lakes Ecosystem Protection and Restoration (Avoiding the Tipping Point of Irreversible Changes), is included as part of my written testimony.

This paper points out that the Great Lakes may be nearing a tipping point. Beyond which, the ecosystems may move into a new state, one that is less desirable from a recreational, commercial and esthesic perspective. And, more importantly, one from which it may be very difficult, if not impossible, to recover.

Similar concerns have been raised by ocean environments in a document (inaudible). However, the Great Lakes are probably more vulnerable than the oceans because they are relatively closed and evolutionarily younger, ill-prepared systems, ill-prepared to deal with these large fluctuations and stress. As mentioned earlier, this food web destruction is a particular point—case in point for the tipping point. The NOAA documentation of the loss of the bottom dwelling animal Diporeia is a really important case here. This dramatic decline is likely to lend to the invasions of the zebra and quagga muscles. And may be one of the clearest warning signs that the lakes are moving into a regime (inaudible) muscles and high populations and prevent any substantial recovery. In fact, Dave Jude, a colleague of mine from the University of Michigan told me just this week that for the first time he has found enormous numbers of quagga muscles in Lake Michigan at depths where only a few or none had been found before. At 100 meter depths he pulled up between 600 to 700 pounds of quagga muscles in just a ten minute bottom trawl. So many members of the fish community depend on Diporeia, but their replacement with this lower food quality muscles may result in a tipping of the entire ecosystem towards a whole new food web structure of far less value to society.

However, the problem with tipping points, particularly ecological tipping points, is that you can't be sure if you have reached it until

you have gotten there. So we really urge precautionary approach to avoid the tipping point and act now.

The Subcommittee asked us to identify three top recommendations for the Collaboration. In our view, the top three, like Al's, are, one, to stop introduction to new invasive species. Two, to restore the nearshore ecosystems, including the watersheds, tributaries, and connecting rivers and straits to increase the ability of the Great Lakes' ecosystems to mitigate stress. And, three, to reduce the loads of nonpoint source pollution.

My written testimony provides rationale for these three priorities. But the short version for invasive species is that prevention is about the only really effective way of dealing with the issue. Once invasive species establish significant populations in the Great Lakes, there is little that can be done to control them or their impacts.

The rationale for focusing on reference to restore watersheds, tributaries and the nearshore is that it will never be possible to completely eliminate the stresses. So we need to help the lakes help themselves by restoring the natural ability to cope with and self-mitigate stress. That buffering system, focusing on the watersheds and nearshore has been lost in many places, and it needs to be restored.

The focus on pollution from the resources is critical. These sources, particularly land-based ones, are not now accurately addressing the regulatory processes, and are key destructions of ecosystems (inaudible).

The Subcommittee also asked us to identify scientific research information and products that are required for implementation. While investing in long-range basic research is important, and such investments in the Great Lakes significantly lag behind those in the marine environments, these investments need to complement science that directly supports restoration.

We recommend a science plan with three broad complements—integrative assessment, monitoring, and restoration innovation. Integrated assessments are designed to harvest the decades of monitoring the research output, integrate and synthesize that information, and deliver the results in ways that are accessible to decisionmakers. These assessments not only draw on talents and subject matter of experts, but also engage the broader stakeholder communities in defining boundaries, integrating traditional knowledge, and identifying socially acceptable options. The results are peer reviewed and subject to public comment, but the process should be supported by funds independent of those with vested interests in any particular solution.

This approach has been actually effective in a number of areas, including the causes and consequences of hypoxia in the Gulf of Mexico, an assessment that was mandated by your Hypoxia Research and Control Act that led to a federal-State-tribal Action Plan for reducing nutrient loads to the Gulf of Mexico.

We have made integrative assessment a priority for Michigan Sea Grant. And are hoping other programs, including federal programs, model it.

The second priority is monitoring, which, of course, is essential for identifying emerging issues and tracking restoration. Most man-

agers and scientists now have raised the notion of adaptive management, where adjustments in approaches are made as restoration proceeds. Without effective monitoring geared towards tracking progress at the right scales, adaptive management is not possible. Effective monitoring in this context must be done in scales that are relative to local and State decision-makers, as well as federal policy-makers. Therefore, priority should be placed on the nearshore terrestrial and aquatic regions, and support the State agencies and academic community to add detail—spatial detail to the traditional lake and regional-scale federal efforts.

The third component is restoration innovation. Invest in new ways to deal with existing and emerging threats and new cost effective technologies for restoration, including new ways to detect threats, new ecosystem forecasting tools, new restoration technologies, and ways to reduce uncertainties with future integrated assessments.

It's easy to identify these needs; their solutions are much harder to predict, and are best sought after investing in nurturing the skills and talents of Great Lakes scientists, particularly through the universities.

The Subcommittee also asked to identify the biggest challenge implementation. And I think we have all said the same thing, it's the money. We need money for implementation. I would like to suggest a significant rule of thumb, that ten percent of the investment in restoration ought to go to the science base to support that restoration.

I would like to close with a comment on the particular role of universities. This might appear a bit self-serving from where I sit now, but I hope my 20 years in federal service balances that to some extent.

During the 1960s, '70s and '80s, the Great Lakes community was well supported and provided important complimentary science to the agency science. I know this first hand because I worked in a Great Lakes federal lab between 1957 and '90. During that time, academic research and modeling played important roles in guiding nutrient (inaudible) and reduced algal overgrowth and increased water clarity; sea lamprey controls that allowed rebounds in fish population, habitat protection that is leading to the recoveries of native species, like Lake Superior lake trout and bald eagles.

However, at a time when the need for science-based support for management policy decisions of the Great Lakes is more—most important, the research community is in decline. An aging work force is now being replaced by young scientists. Old and outdated scientific tools and facilities are not being upgraded. Funding for federal and State science agencies are not keeping up with inflation. And critically important funding for the Great Lakes academic community is becoming scarce, resulting in a significant loss of Great Lakes researchers from our universities. We simply need more support from the academic community. To be most effective, academic work needs to be independent, based on competition and peer review, and well-funded. There are existing federal programs that do that in ways that are connected to the federal and State sciences, but handmaiden to it. Those include NOAA's Center for Sponsored Coastal Ocean Research, Great Lakes Sea Grant pro-

grams, EPA's Science to Achieve Results programs. These programs have missions that complement each other and the federal labs. They have established processes for engaging the academic community and administering grants. However, they need more funding and more encouragement to expand their programs into the Great Lakes.

In closing, Mr. Chairman, I would like to thank you for the opportunity to address your subcommittee. Thank you for your leadership on this endeavor. But most particularly thank you for keeping science on the table. It's really important. Without strong science-based restoration, it would be less effective and more costly to the taxpayers. Thank you.

[The prepared statement of Dr. Scavia follows:]

PREPARED STATEMENT OF DONALD SCAVIA

Mr. Chairman, Members of the Subcommittee, I thank you for this opportunity to testify before you today on this issue of critical national importance. My name is Don Scavia, and I come here in several capacities: I am Professor of Natural Resources and Environment and Associate Dean at the University of Michigan, and Director of Michigan Sea Grant.

I also represent the Healing Our Waters Great Lakes Coalition. The coalition is dedicated to the protection and restoration of the Great Lakes, and represents 85 national, regional, State, and local organizations, including Great Lakes conservation organizations such as the Alliance for the Great Lakes, Great Lakes United, and the Ohio Environmental Council; national conservation organizations like Ducks Unlimited, Trout Unlimited, the Sierra Club, and the Audubon Society; and educational institutions such as Shedd Aquarium and the Brookfield Zoo. I serve as Science Advisor to the Coalition's Steering Committee.

Before joining the faculty at UM, I served in NOAA as a research scientist and research manager for 29 years, providing me with a national perspective on the significance of the Great Lakes, the need for the restoration strategy, and the role science can play in that restoration.

My testimony today focuses on four areas: 1) the need to act now to protect these national treasures; 2) a set of priorities identified by scientific community in their white paper: "A Prescription for Great Lakes Ecosystem Protection and Restoration," 3) the need for a strong science base for restoration, and 4) the critical role for an independent voice that Great Lakes universities can provide.

It is critical to act now

The view from the majority of the science community is that we know enough now to take action. There are indeed important science needs, but they should not create a rationale for inaction. Making a substantial investment in the Great Lakes restoration and protection now will ensure that the economic and ecological health of the Great Lakes region is strong and healthy. This is not only of great importance to the region, but also to the Nation. Delaying that investment will make future actions far more costly and could result in irreversible damage to this national and global treasure.

A significant portion of my testimony draws directly from the white paper: *Prescription for Great Lakes Ecosystem Protection and Restoration: Avoiding the Tipping Point of Irreversible Changes,*[1] *which I include as part of my testimony. The paper was written by eight scientists and endorsed by over 60 other leading scientists from every state in the Great Lakes basin.*

The authors and endorsers of the white paper point out that Great Lakes ecosystems may be nearing a tipping point—beyond which the lake ecosystems would move to a new state, one that is less desirable from a recreational, commercial, and aesthetic perspective and, more importantly, one from which it will be very difficult, if not impossible, to recover. The problem with ecological tipping points, though, is that you cannot be sure you have reached it until it is too late. Thus, we urge a precautionary approach to avoid passing that critical point.

[1] *http://www.restorethelakes.org/PrescriptionforGreatLakes.pdf*

In another consensus report (Scientific Consensus on Marine Ecosystem-Based Management)[2] over 200 scientists cautioned against reaching thresholds beyond which altered marine ecosystems may not return to their previous states. In that report, they also state that because the tipping point for these irreversible changes may be impossible to predict, increased levels of precaution are prudent. While the same ecological principles cited for the world's oceans apply to the Great Lakes, the lakes may be even less able to cope with stress than typical coastal marine environments because the Lakes are relatively closed and evolutionarily younger systems ill-adapted to large fluctuations.

Symptoms of stress

There is widespread agreement among scientists that the Great Lakes are exhibiting symptoms of stress from toxic chemicals, invasive species, excess nutrients, shoreline modifications, change in land use, hydrologic alterations, and climate change. While most of these stresses are not new, more than ever we are seeing symptoms of ecosystem breakdown—in other words an ecosystem nearing its "tipping point"—caused by the combinations of these stresses that overwhelm natural buffering capacities that enable ecosystems to be resilient. Large areas in the lakes are undergoing rapid changes where these combinations of persistent and new stresses are interacting to trigger synergistic ecosystem degradation. Rapid ecological responses to new stresses that may interact with each other and with remnant features of past responses to older stresses, have exhibited sudden and unpredicted changes in the past five to 10 years, to an extent that is unique in Great Lakes' recorded history. The new stresses have complicated past and current efforts to remediate earlier harmful phenomena, such as:

- Extirpation or major declines in important native species (such as lake trout and deepwater ciscoes) due to over fishing and invasive species (such as sea lamprey predation on lake trout, and competition with deepwater ciscoes by invasive alewives and rainbow smelt);
- Declines in other valued and important native aquatic species (including certain plankton, unionid clams, and certain native fish species) caused by altered food webs and introductions of aquatic invasive species (e.g., zebra and quagga mussels, round gobies and predatory zooplankton such as *Bythotrephes cederstroemi* and *Cercopagis pengoi* (two species of water fleas);
- Widespread reproductive failures of keystone, heritage, and other (both native and introduced) fish species, including lake trout, sturgeon, lake herring, coaster brook trout, and Atlantic and Pacific salmon caused by toxic contamination and loss of habitat, including loss of over 90 percent of wetlands along the Huron/Erie corridor;
- Approximately 50 percent of the threatened and endangered birds are wetland dependent species, and no wonder given the estimated 60 percent loss of wetlands in the Great Lakes watershed;
- Toxic contamination of fish threatens not only the species themselves, but also other wildlife and people, resulting in fish consumption advisories throughout the Great Lakes and inland lakes and rivers;
- General reduction in water quality, increased toxic algal blooms, Type E botulism in fish and waterfowl, and contamination of drinking water;
- Fouling of coastlines and near-shore areas from sewage overflows and contaminated runoff, resulting in beach closings, and loss of habitat for fish and waterfowl;
- Elimination of the rooted plant community and disruption of food webs in Sandusky Bay and Cootes Paradise in Hamilton Harbour, due to sediment and other pollutant loads.

Critical food-web disruptions are a particular case in point with regard to the tipping point. These disruptions date back to at least the invasion of the sea lamprey and the cascade of loss of native fishes and invasions of alewife, rainbow smelt, and a host of others.

However, more recent dramatic disruptions include the now well-documented rapid disappearance of the once abundant benthic invertebrate, *Diporeia,* from large areas of all the lakes except Superior. These dramatic declines are likely linked quite closely with the zebra and quagga mussel invasion, and may be one of the clearest warning signs of a tipping point where the Lakes may be moving into a

[2] *http://compassonline.org/files/inline/EBM%20Consensus%20Statement_FINAL_July%2012_v12.pdf*

new regime where these mussels maintain high populations, and prevent any substantial recovery of *Diporeia,* the once primary diet of important fish. In fact, Dave Jude—my colleague at the University of Michigan told me just this week that for the first time he has found enormous numbers of quagga mussels in Lake Michigan at depths where only few or none were found before. At a 100-meter depth, he pulled up between 600 and 700 pounds of quagga mussels in just a 10 minute bottom trawl tow. So many members of the fish community have historically depended on *Diporeia* that lacking this critical food source is another clear indicator of the ecosystem reaching a tipping point.

Restoration Priorities

The Great Lakes Regional Collaboration ("GLRC") has done an outstanding job of identifying the major stresses, and their recommendations for addressing them come just in time. The Collaboration is truly an historic event in two important respects. First, it is the first time that all levels of government and virtually all private stakeholders have come together to draft and support a single Great Lakes restoration plan, the "Great Lakes Regional Collaboration Strategy." Over 1,500 people participated in the drafting of the final plan, including representatives from cities, counties, State agencies, tribal representatives, federal agencies, Congressional staff, businesses, conservation organizations, university scientists, and concerned citizens. Many of the scientists who drafted the "Prescription paper" as well as members of the Great Lakes Healing Our Waters Coalition actively participated in the Collaboration.

The GLRC Strategy sets a second precedent: it is the most comprehensive Great Lakes restoration and protection plan in history. It documents virtually all of the problems besetting the Great Lakes; it recommends concrete solutions; it identifies programs to implement those solutions; and it recommends the funding needed for those programs to succeed. This level of consensus is unprecedented. And unlike so many other plans that have come before it, this isn't just the plan for any one stakeholder or any one lake. It has received input and endorsement from the scientific community, agencies, public interest organizations, businesses, and recreationists. And, it comes as a result of the president's May 2004 Executive Order. Importantly, many of the GLRC recommendations build upon and strengthen successful existing efforts.

The GLRC is a critical first step in forming a permanent institutional mechanism to guide restoration efforts and to facilitate coordination among public agencies, research institutions, and stakeholder organizations to reach consensus on specific priority actions and integrated measures of progress. It is important to also recognize, however, that these international waters require strong coordination and cooperation with Canada. So, the next step in planning should integrate GLRC efforts with those of the Great Lakes Fishery Commission, International Joint Commission, and environmental and resource programs of Great Lakes states and provinces.

The GLRC recommendations are important because the aim to reduce ecosystem stresses. However, it will never be possible to eliminate them completely, and even then it will likely take decades to achieve. So we must, at the same time, and perhaps with more urgency work to restore the Lakes' natural buffering capacity by increasing its resiliency—or ability to cope with stress. *The consensus of the authors and endorsers of the "Prescription paper" is that the most important way to increase that resiliency is to restore the terrestrial and aquatic environments of the nearshore regions and connecting rivers and straights.*

One key priority, however, that cannot be addressed through a primary focus on restoring this nearshore resiliency is the effort to stop invasive species from entering the Lakes. This can only be done through comprehensive, basin scale efforts. In this case, prevention is far more effective than restoration because removal of established invasive species, or restoration from their impacts are almost impossible.

A focus on the nearshore region—Over time, the combined effects of the suite of stresses have overwhelmed the ecosystem's self-regulating mechanisms. In the past, healthy nearshore communities and tributaries helped reduce the impact of many stresses on or entering the lakes. We now recognize that these nearshore and tributary areas constitute a buffer zone and add to the lakes' ability to rebound from stress, and without healthy buffers, the lakes' health is much more vulnerable. For this reason, it is of critical importance to ensure that the nearshore and tributary areas receive the most significant and urgent restoration attention.

Specific geographic areas where stresses have contributed or are likely to contribute to the degradation of the nearshore/tributary areas should be targeted first. These areas may well include those locations already identified as Areas of Concern by the International Joint Commission (expanded geographically to ensure they include all the major sources of stress) as well as nearshore/tributary areas that are

now showing symptoms or vulnerability to multiple sources of stress. And this may require increased institutional focus (including increased emphasis within LaMP efforts) on these nearshore areas. This also has the added advantage of restoring urban coastlines, which in many instances have the most potential for restoration and is consistent with the Great Lakes Cities-St. Lawrence Cities Initiative "urban revitalization" agenda. The goal should be to reestablish the natural states critical to nearshore and tributary communities so they can once again perform their stabilizing function, or, if that is not feasible, enhance critical elements that play a role in stabilizing the communities. Many of the GLRC recommendations, if implemented properly, will provide this needed emphasis on near-shore (e.g., recommendations related to the AOCs, wetlands, coastal health, nonpoint source pollution).

With this focus on the nearshore and connecting rivers and straights, the Prescription paper proposes the following four major components that must be combined to develop a successful ecosystem restoration effort:

- *Restore*—Restore critical elements of the *ecosystem's self-regulating mechanisms.* To the extent possible, reestablish natural attributes of critical nearshore and tributary communities so they can once again perform their stabilizing function. Where full restoration of natural attributes is not possible, improve desirable aspects through *enhancement* of important functions.
- *Remediate*—As outlined in the GLRC report, remediate abusive practices that create *sources of stress.* Reduce or eliminate physical habitat alterations, pollution loadings, pathways for invasive species, and other stressors or their vectors into the lakes.
- *Protect*—Protect the functioning portions of the ecosystem from *impairment.* Preserve those portions of the ecosystems that now are healthy, and those that can be restored or enhanced, through sustainable development practices within the Great Lakes basin.
- *Measure*—Building on existing efforts, measure ecosystem health through a set of agreed-upon integrative indicators that can serve to assess current conditions and monitor the progress of restoring the lakes. This final component is also key element of the three-pronged approach to the recommended plan for science in support of restoration outlined below.

Science Priorities

While investments in long-range, basic research is important, and such investments in the Great Lakes lag significantly behind those of coastal and marine environments, these investments in the future need to be complemented with science that directly supports the urgent needs for restoration. I should note, however, that thoughtful research can be both basic and useful as Donald Stokes outlined clearly in his book, *Pasteur's Quadrant*.[3] I recommend a science plan with three broad components: Integrated Assessment, Monitoring, and Restoration Innovation.

Integrated Assessment—Decades of research and monitoring have produced vast quantities of data and information on Great Lakes conditions, processes, and functioning. However, much of this information is inaccessible or not organized and synthesized in ways most useful to local, State, and federal decision-makers. Providing this information, along with its level of certainty, in credible and timely ways *on issues identified by decision-makers* is an essential element of science support for restoration and protection.

Integrated Assessment (IA) is a formal approach to synthesizing and delivering relevant, independent scientific input to decision-making through a comprehensive analysis of *existing* natural and social scientific information in the context of a policy or management questions. These assessments not only draw on the talents of subject matter experts, but also engage the broader stakeholder community in defining boundaries, integrating traditional knowledge, and identifying socially-acceptable solution options. The IA results are peer reviewed and subject to public comment, and the process should be supported by funds independent of those with vested interests in any particular solution option. IA takes the following structured approach:

1. Define the policy relevant question around which the assessment is to be performed. This is done in conjunction with managers and policy-makers

[3] Stokes, D.E. 1997. *Pasteur's Quadrant. Basic Science and Technological Innovation.* Brookings. Washington, DC. 180 Pg.

such that the analysis is directed toward solving specific policy or management needs.

2. Document the status and trends of appropriate environmental, social, and economic conditions related to the issue. This is a value-independent description of current conditions and, to the extent possible, the historical trends in those properties.
3. Describe the environmental, social, and economic causes and consequences of those trends. This often includes simulation, statistical, and other explanatory models and analyses. Again, these descriptions are fact-based although subject to analysis and interpretation.
4. Provide forecasts of likely future conditions under a range of policy and/or management actions. This can be quantitative forecasts from models or other trend analysis tools. These are subject to considerable scientific evaluation and interpretation.
5. Provide technical guidance for the most cost effective means of implementing each of those management options. These efforts are designed to provide those who are responsible for implementation the menu of approaches available to them, along with some evaluation of their potential for success and cost-effectiveness.
6. Provide an assessment of the uncertainties associated with the information generated for the above steps and outline key monitoring, research, and modeling needs to improve future assessments in this area. This assessment of uncertainties is often a guide to future research needs.

Such approaches have been very useful, for example, in assessments of the impacts of climate variability[4] and the causes and consequences of hypoxia in the Gulf of Mexico[5] (called for in the Harmful Algal Bloom and Hypoxia Research and Control Act), as well as a key element of the new science program for Michigan Sea Grant.[6] The Gulf of Mexico Hypoxia IA, for example, led to a federal-State-tribal Action Plan for reducing nutrient loads to the Gulf, the primary anthropogenic driver of hypoxia.

Monitoring—extremely important. This effort should build on ongoing efforts such as the development and application of State of the Lakes Ecosystem Conference (SOLEC) indicators. However, major negative changes in the ecosystem are occurring while many of the indicators that governments have traditionally used to measure Great Lakes health (water clarity, ambient water pollution levels, and certain contaminant levels in wildlife) actually show improvement. Because nonlinear changes may confound expected relationships between sources of stress and the lakes' response, traditional indicators alone may not be adequate descriptors of ecosystem health and may not be useful in predicting future conditions. While some type of consensus on indicators is desirable, given the dynamic nature of the system and our understanding of it, flexibility must also be included in their development and use.

Monitoring is essential to not only identify emerging issues, but importantly in the context of restoration, to track progress. Most managers and scientists now embrace the notion of adaptive management where adjustments in strategies are made as restoration proceeds. But, without effective monitoring systems, geared toward tracking progress at the right scales, adaptive management is not possible. A key issue for an effective monitoring network in this context is the ability for rapid detection of change on scales relevant to local and State decision-makers, as well as federal policy-makers. Therefore, a priority should be placed on the nearshore terrestrial and aquatic ecosystem in concert with the geographic focuses of restoration. This requires close coordination of State and tribal agencies and the academic community to add higher spatial resolution to the Lake- and region-scale efforts of the federal agencies.

Restoration Innovation—While we have enough information to proceed now with restoration, the task is long term and we need investments in new ways to deal with existing and emerging threats, as well as to find the most cost-effective technologies for identifying threats and restoration approaches. Such innovations could include: new ways to detect and monitor threats to ecosystem structure and functioning; improved methods for synthesizing and integrating information to provide useful forecasts of the impacts of management action or inaction; technologies for restoring

[4] *http://www.usgcrp.gov/usgcrp/nacc/default.htm*
[5] *http://www.nos.noaa.gov/Products/pubs_hypox.html*
[6] *http://www.miseagrant.umich.edu/ia/index.html*

wetlands, coastal habitats, and contaminated sites; methods to value ecosystem goods and services; assessments of the social causes and impacts of ecosystem change; and means to reduce uncertainties in Integrated Assessments.

While the needs for such innovations can be identified, their solutions are hard to predict, and are best sought through investing in, and nurturing, the skills and talents of Great Lakes scientists, including through academic programs.

The Role of Universities

A strong and effective science program supporting restoration and protection of the Great Lakes needs the innovation, expertise, and independent voice of the academic community. During the 1960s, 70s, and 80s, the Great Lakes academic community was well-supported and provided an important complement to the science conducted in the federal and State labs. I know this first hand because I worked in a Great Lakes federal lab from 1975–1990. Working together, and with State agencies and environmental NGOs, these communities identified and analyzed the most important issues of the time—fisheries decline, eutrophication, and chemical contamination. Academic institutions contributed expertise in fisheries biology, food-web structure, ecosystem dynamics, biogeochemistry, ecosystem modeling, and engineering to these successes through cooperation and participation in activities and programs under the auspices of the bi-national Great Lakes Water Quality Agreement and Great Lakes Fisheries Convention, for example.

Through both applied research and research that improved our fundamental understanding of the Lakes' physical and ecological dynamics, academic research and modeling played historically important roles in critical resource management and policy decisions:

- Reducing phosphorus inputs to reduce algal growth and improve water clarity;
- Sea lamprey control;
- Reductions in industrial pollution;
- Reduction in contaminants such as DDT and PCBs;
- Reduced occurrences and magnitude of chemical spills and discharge of objectionable and nuisance materials that form scums, sludge, and odors;
- Confinement and removal of contaminated sediment;
- Growing recoveries of some native species, such as the lake trout in Lake Superior and the bald eagle throughout the Great Lakes.

And these efforts have had significant impacts. In many places, nutrient control reduced algal overgrowth and increased water clarity, sea lamprey control allowed a rebound in fish populations, reduced industrial pollution resulted in declines of DDT and PCBs in fish and wildlife by as much as 90 percent, confinement and removal of contaminated sediment are progressing, and populations of native species, such as the lake trout in Lake Superior and the bald eagle throughout the Great Lakes are making substantial recoveries.

In spite of this progress, and as outlined above and in the GLRC report and the "Prescription paper," the Great Lakes are exhibiting a multiplicity of nagging and emerging issues that are impeding further ecological and economic recovery. Just when we need more research and monitoring to assist sound, science-based management and policy decisions, the Great Lakes research community is in decline. An aging work force will soon retire taking with it historical knowledge and perspective because of limited ability to hire young scientific replacements. Old and outdated scientific tools, facilities, and vessels are not being upgraded to address the complex problems of today. Funding for both federal and State science agencies are not keeping up with inflation and funding to the Great Lakes academic community is scarce, resulting in a significant loss of Great Lakes researchers from Great Lakes academic institutions.

Academics can and should play strong, even dominant, roles in Integrated Assessment, in assisting in and interpreting results from monitoring programs, in identifying and clarifying emerging issues, and in providing innovative solutions to both long-standing and new issues. Academics can be viewed as knowledgeable and interested parties in this management, but not constrained by the mission and viewpoints of their home organization. To be most effective, their work needs to be independent, based on competition and peer review, and well-funded. There are existing models for federal programs that can provide that support in ways that are connected to and integrated with federal and State science, but not handmaiden to it. These include EPA's Science to Achieve Results (STAR) program, NOAA's Center for Sponsored Coastal Ocean Research (CSCOR), and the Great Lakes Sea Grant programs. Each of these programs has a distinct mission that complements the oth-

ers, as well as those of the federal labs. They have established processes for interacting with the academic community and administering effective extramural grant programs. They require increased funding and encouragement to continue to expand their programs in the Great Lakes, focused on supporting restoration and protection needs.

It is important to build upon proven models of academic-governmental partnerships like Sea Grant and NOAA's CSCOR with well-funded, objective, and independent academic research that has strong linkages to resource management and policy needs. These programs can supply the people and new technologies for problem-solving, technology transfer, and the communication of science to policy-makers and the public.

Summary and Conclusion

I would like to recap some of the key concepts from the above as responses to specific questions provided for this hearing:

1. *What are the top three recommendations in the GLRC Strategy that you believe could be implemented with existing funding? What scientific research, scientific information, or science-based products are required to support the implementation of these three recommendations? Would your answers be different if funding could be increased?*

The top three recommendations, as outlined above, are 1) focus on restoring the nearshore ecosystems—including watersheds and tributaries and the connecting rivers and straights—to increase the ability of the Great Lakes ecosystems to mitigate stress, 2) stop introductions of new invasive species, and 3) reduce the loads of nonpoint source pollution. These are priorities for both existing and increased funding; however, little more can be done at existing funding levels.

The key science priorities are 1) support for Integrated Assessments that harvest the decades of monitoring data and research output, integrate that information with stakeholder perspectives and considerations, and synthesize and deliver the results in ways that are accessible to decisions-makers as they consider the key management and policy actions underpinning restoration; 2) support for increased monitoring nearshore regions by states and Universities at the higher spatial and temporal resolution needed to track progress and support adaptive management at relevant restoration scales; and 3) support for "restoration innovation"—creation of new technologies, methodologies, and processes for cost-effective restoration over the next decade.

2. *Has the GLRC led to more informed resource management planning decisions? What kinds of scientific information are now being taken into account in those decisions because of the GLRC? To what extent has the GLRC helped foster new or stronger collaboration between scientists and policy-makers? What is your role in strengthening the relationship between scientists and policy-makers?*

The simple answer to the first part of this question is "no." The GLRC focused on developing a Strategy for the future, and not on informing today's specific resource management planning decisions. While the GLRC has fostered new and stronger collaborations among decision-makers and opinion leaders from a wide array of sectors, including some from the science community, it is too soon to know if these new collaborations will make a difference. The stage has been set by the Collaboration, though, and I am hopeful.

My role in strengthening the relationships between scientists and policy-makers, as Michigan Sea Grant Director, has been to work with decision-makers in Michigan's Departments of Natural Resources and Environmental Quality to identify key Great Lakes restoration issues that need science support, and solicit proposals from the academic community to conduct Integrated Assessments for them. Sea Grant and key partners will fund several IA projects this next funding cycle, both to address those needs and to serve as a model for other funding programs interested in strengthening the relationship between scientists and policy-makers. We would like to see federal grant programs focused in the same way.

3. *Are there additional actions EPA and other federal agencies should be taking to help implement the GLRC?*

As mentioned above, the GLRC was an important first step in forming permanent institutional mechanisms to guide restoration and to facilitate coordination among public agencies, research institutions, and stakeholder organizations. It is important for EPA and the other U.S. federal agencies to also recognize that Great Lakes protection and restoration require strong coordination and cooperation with Canada. I am sure the U.S. agencies recognize this. So, the next step in planning and imple-

mentation would be to integrate GLRC efforts with those of the Great Lakes Fishery Commission, International Joint Commission, and environmental and resource programs of Great Lakes states and provinces.

4. What are the biggest challenges you see in implementing the Strategy, particularly in terms of meeting science and information needs?

The biggest challenges for implementation are 1) ensuring adequate funding for implementing the GLRC Strategy recommendations, and 2) identifying appropriate leadership and coordination among federal agencies, and allowing for honest engagement of the full stakeholder community.

I understand the overall estimates for funding are quite significant, but it is time for Great Lakes restoration to receive support commensurate with its national importance and at least comparable to other large-scale regional restoration efforts. This is particularly true when one compares, not only the range of stresses that impact the Great Lakes, but their enormous size compared to other regional restoration initiatives. It is also important to ensure appropriate funding for the science priorities outlined above for supporting the restoration effort. A rule of thumb that can make sense is to provide 10 percent of restoration costs for science support.

The overall restoration task is daunting and requires effective leadership from the Federal Government (preferably one agency); however, top-down approaches (whether for implementing restoration or for conducting supporting science) will not work. Setting specific goals, priorities, and responding to science needs requires full participation of Federal, State, and local governments; NGOs; Universities; and the private sector. It is not yet clear, that the GLRC has mechanisms in place to do that.

5. What outcomes do you expect to see one year from now as a result of implementing the GLRC Strategy?

Frankly, I do not expect too much in one year. It is very early in the process and developing the Strategy was a major undertaking that engaged the broadest spectrum of U.S. participants. However, I fear that the lack of any significant new funding in the President's budget may set the stage that prevents holding the Collaboration together. Everyone participated in good faith, and many compromises were made to form solidarity behind the Strategy. Without significant movement and funding toward implementation, I am not sure much will be accomplished.

Closing

In closing, Mr. Chairman, I would like to thank you and the Subcommittee for your leadership in scheduling this hearing and maintain the momentum for Great Lakes restoration. I particularly would like to thank you for keeping science on the table. Without a strong science base, restoration will be less effective and more costly to the taxpayers.

I would also like to thank you for inviting me to participate in this hearing. The Great Lakes science academic community looks forward to working with you and all of our Collaboration partners to continue this important work, because it is only through concerted, coordinated action that we will realize our mutually-held goal of a cleaner, healthier Great Lakes.

I would be happy to answer any questions that you may have.

BIOGRAPHY FOR DONALD SCAVIA

Dr. Scavia is the Research Associate Dean and Professor of Natural Resources and Environment at the University of Michigan, Director of the Michigan Sea Grant Program, and Interim Director of the Cooperative Institute for Limnology and Ecosystem Research. He is Associate Editor for journals of the Ecological Society of America and the Estuarine Research Federation, on the Advisory Board for the North American Nitrogen Center and the Science Committee for NSF's Collaborative Large-scale Engineering Analysis Network for Environmental Research, and has served on the Boards of Directors for the American Society of Limnology and Oceanography and the International Association for Great Lakes Research.

As the Chief Scientist of NOAA's National Ocean Service between 2002 and 2005, Dr. Scavia was responsible for the quality, integrity, and responsiveness of NOS's science programs, and for ensuring that NOS's operations and resource management are based on solid science and technology. Before becoming the NOS Chief Scientist, Dr. Scavia was Director of the National Centers for Coastal Ocean Science and Director of NOAA's Coastal Ocean Program, where he managed coastal and Great Lakes research programs in NOS laboratories, monitoring and assessment offices, and extramural research.

Between 1975 and 1990, Dr. Scavia was a research scientist with NOAA's Great Lakes Environmental Research Laboratory in Ann Arbor, Michigan, focusing on modeling and empirical studies on nutrient cycling, bacteria and phytoplankton production, food-web dynamics, and biological-physical coupling at all scales.

Dr. Scavia holds Bachelor's, Master's, and Doctorate degrees in Environmental Engineering from Rensselaer Polytechnic Institute and the University of Michigan. He has published over 60 articles in the primary literature and led development of dozens of interagency scientific assessments and program development plans.

NATURAL RESOURCES AND ENVIRONMENT
UNIVERSITY OF MICHIGAN

April 19, 2006

Honorable Vernon J. Ehlers
U.S. House of Representatives
Washington, DC 20515

Dear Representative Ehlers:

In accordance with the Rules of the House of Representatives, I disclose the sources of Federal funding, as follows:

Grant Title	Source	Award Period	Funding
Michigan Sea Grant Omnibus Award	NOAA	3/1/05 – 9/2/09	$5,391,550
Developing Regional-Scale Stressor-Response Models for Managing Eutrophication in Coastal Marine Ecosystems (with Howarth)	EPA	6/9/03 - 6/8/06	$744,882
CHRP: Watershed-Estuary-Species Nutrient Susceptibility	NOAA	7/1/05 - 6/30/10	$2,500,000
Great Lakes COSEE	NSF/NOAA	7/1/05 - 6/30/07	$2,500,000
Ecofore 06: Forecasting the Causes & Impacts of Lake Erie Hypoxia	NOAA	Pending	$2,520,576
Inventory of navigation-related non-indigenous species	FWS	8/8/05 – 8/31/06	$5,000
Assessment of potential spread of tunicates in U.S Waters	NOAA	7/1/08 – 6/30/06	$70,000
Building a cohort of Great Lakes research investigators	NOAA	7/1/05 – 6/30/07	$375,325
Building a cohort of Great Lakes research investigators	USGS	11/1/05 – 10/31/07	$193,300

Sincerely,

Donald Scavia
Professor and Associate Dean

University of Michigan School of Natural Resources and Environment
Dana Building, 440 Church Street, Ann Arbor, MI 48109-1041

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DISCUSSION

Mr. EHLERS: Thank you, very much. I really appreciate your testimony. And I notice virtually all of you asked for more science and better understanding of science in the Congress. None of you, however, mentioned plans to run for Congress. And let me emphasize how important that is. I was the first research physicist elected after 220 years of the United States Congress. That's a lousy record for the academic community. And so think about it. You can regard it as a capstone on a career, or a way to launch yourself into the presidency. Wouldn't hurt to have a scientist as a president, too. But I'm not going to live forever.

Mr. WEGE: Why don't you run, Vernon?

Mr. EHLERS: But I won't live forever. So we start recruiting some replacements and some additions.

Thank you. Excellent testimony. Very good. I have some questions for you. And I appreciate—on this first one, I would like a quick answer from each one of you. We have—we are all excited about the Collaboration, the results of the Collaboration, the Healing of Our Waters Program, the introduction of this bill. There is great happiness and excitement in the Great Lakes community, and in the environmental community about these. But we all have to recognize the bill hasn't passed yet, it's going to take a lot of hard work to get it there—and time, I might add. And then getting the money is going to be tough. So my first question is, what near-term progress can we make on restoration with current science, current legislation and current funding? What can we do right now? And it's open—I would like answers from all five of you, but I would like a volunteer to start it off.

THE RESTORATION OF SCIENCE LEGISLATION AND FUNDING

Mr. GULEZIAN: I can start. There is a tremendous amount that we can do with the current resources that we have. When the Federal Interagency Task Force took stock of the investment that the federal agencies get for the Great Lakes, we came up with a number of about a half a billion dollars a year. That's not a paltry sum. If that—if that funding is directed effectively, if we can take some of the lessons that we learned from the Collaboration, I think that there is a good ability to make a lot of progress. And we are beginning to see that now.

With the Legacy Act, for example, we have completed three projects. There is another one that's about to start. But in addition to doing contaminated sediment clean-up, we are also looking at the kind of habitat restoration that would need to be done in those areas of concern. Now, we can't do that with the Legacy Act funds, but there are funds from other agencies that can be brought to bear. And we are having discussions with other agencies to do just that. So that's an example of how we can do a better job of utilizing and realigning our existing resources.

Mr. EHLERS: Very good. Good comment.

Dr. Brandt.

Dr. BRANDT: Yeah. I think one of the important things will be to build on the success of this Collaboration. This is the first time when you have 1,500 people from all different sorts of agencies

working together and have a consensus, I think that's something new in the Great Lakes. And it's something—it's going to be a challenge to continue that—sort of that spirit and level of excitement.

I think things are already happening. I will just give two examples. One is that there has been—really has been an increase in the collaboration amongst the federal agencies. I think the development of the regional working group, which was created by the Executive Order, where as the highest ranking officer in the region for the 11 agencies, we meet regularly once a week phone calls on all sorts of activities, research, observing systems. And we coordinate regularly. We even had an example where we had a rapid response to a snake head that was found off of Chicago. And we got all of the federal agencies together. I put my ship on snake head alert, that we could get to Chicago within six hours. We did this in a one-hour conference call. And within two days we confirmed that that was an isolated release. We could not have done that without this regular meeting of the regional working group.

I think another—second example relates to the International Joint Commission Council of the Great Lakes Research Managers. As you mentioned, the coordination of efforts needs to include a candidate. The Council of Great Lakes Research Managers in the last two years, largely at the inspiration of the Regional Collaboration, have developed procedures to put together a coordination strategy for research on the Great Lakes. That's international, across states, across federal agencies. We are working on that strategy. And the next biennial report we will have that adopted by the International Joint Commission. I think the International Joint Commission recognized the need for that Collaboration, largely spear-headed by this Executive Order. And I think that is under way.

Those two efforts of enhanced collaboration address a lot of the issues that were talked about in the JAO report with 140 different programs. We are now collaborating at a level that we had not before. And that will increase efficiency, particularly in research and science.

Mr. EHLERS: That's good new, news, too. Sometimes I think what we need is a Great Lakes czar. But not with the intent of having a czar who is going to tell people what to do, rather a czar who is going to bring people together on the right issues, and make sure that we are all working together. And someone who would help to develop the priorities and advise the administration and Congress. There are so many different agencies and actors. And I don't want to stop any of them. But I want to make sure it's all coordinated so we get the best bang for the buck. Thank you.

Ms. Ballard.

Ms. BALLARD: Congressman Ehlers, I think just holding the funding for existing programs that you have—as you know, the Coastal Zone Management Program is really a very inexpensive national program. I think if we get 60 million dollars a year to run the entire program, we are doing pretty good. Michigan's share of that next year is about 2.8 million. About half of that is passed through to coastal communities to address coastal management issues at the local level. And I would say about a fifth of that goes into research. I'm just thinking in the past year, we have done in-

ventories of critical nesting areas along the shoreline. That has been about a three, four year program that we have been doing that. Doing assessments of coastal wetlands in the Saginaw Bay area. Dr. Uzarski from Grand Valley, Dr. Tim Burton from Michigan State, and Denny Albert had been doing baseline assessments for the past two or three years. When the Michigan legislature changed our submerged lands regulations to allow beach grooming due to low water levels, because we had that baseline data, we have been able to document the impacts. And I have to say they have been pretty dramatic. Already, just with one year of beach grooming, we are seeing a loss of diversity of species; we are seeing a lot more lower populations of other species, too. So without those baseline research that we had funded, we probably would not have been able to document the impacts on such a short amount of time.

We have also funded studies to document the impacts of shoreline structures on offshore. What we are finding is sometimes we are getting scour offshore, and we are actually creating zebra muscle habitat by having a cobble substrait there. Also working with Michigan State to do dune modeling, so we can determine the impacts on shore lines. What's going to happen if we permit certain activities. So just with that 2.8 million Michigan sees, we have been able to fund all of that research.

I also want to say with coastal resource managers saying that land use is impacting water quality, it's fragmenting habitats. I think the CZM program is one of the only programs that is funding local comprehensive environmental planning, and watershed planning. We have the 319 program that's funded through EPA that also does that. But for regular, environmental planning, we are it. And over the past four years we have invested about 4.5 million dollars in coastal management—or local master plans, zoning ordinances, and development of GAS's—decision-making support tools. A lot of bang for the buck.

Mr. EHLERS: Thank you. What's striking about something like that, 60 million dollars, of course, sounds like a huge amount of money. That's 20 cents per capita in the United States. And talking about getting big bang for 20 cents—I think that's pretty good.

Dr. Steinman.

Dr. STEINMAN: Mr. Chairman, I mentioned three things that we could do with existing resources—briefly to restate them. One is, we need to take a look at ocean shipping and whether it makes economic sense. There was a recent study done by a colleague of mine here at Grand Valley State University, identifying the fact that currently economic losses—the transportation cost penalty of having shipping on the Great Lakes is approximately 55 million dollars per year. But the economic losses associated with invasive species are estimated to be about five billion dollars a year. So you have two orders of magnitude difference. We need to look at that policy and see whether it makes sense or not.

Secondly, we need to develop appropriate regulatory and incentive-based programs for dealing with protecting our nearshore and coastal waters.

And then with nonpoint source pollution, look at the phosphorus—possible phosphorus ban in lawn fertilizer. I do want to also add to that that I think there is an obligation on a part of the

scientists here, and also on our elected officials, to make sure that they understand how that information—scientific information is presented. We need to present the information in an understandable and transparent fashion to our elected officials, whether it's at the local, State or federal basis. But it's also incumbent on our elected officials to recognize that this information isn't perfect, there is uncertainty in the information that we present; and we can't be paralyzed in that process. So developing that educational capacity is going to be an important factor in us moving forward in the future.

Mr. EHLERS: Thank you.

Finally, Dr. Scavia.

Dr. SCAVIA: I have three very, very different suggestions. One is, I like the idea of a Great Lakes czar in some fashion, particularly the way you described it. It was interesting when I looked at the GAO reports and other reports about, there is not enough coordination in the Great Lakes. I actually see it quite differently. I think there is an abundance of coordination in the Great Lakes region. There is maybe too many different pieces of coordination. It would be nice to have some way to actually organize all of the organizers and get some priorities—I think that would be a way forward.

Second one is very different. That is, there are programs in place for dealing with nonpoint source pollution, wetlands, buffer creations, and they are all funded through the Farm Bill. I would just be hopeful that in the next round of the Farm Bill, which may actually be a funding opportunity well in advance of what we want to do in the Great Lakes Restoration Bill, we can try to find a way to better direct Farm Bill resources to the region focusing on wetland restoration, nonpoint source pollution.

And the third brings back this idea of mitigated assessment, and harvesting existing information. Over the past year-and-a-half, I worked with agencies like Cathie's and Michigan DNR to get them to identify problems that they were dealing with, that they were just stymied with because they did not have enough information to make a decision. Or they knew what they wanted to do but there wasn't enough ammunition behind what ought to happen. And based on that discussion, we realized that the information that they need is out there. It's just not analyzed, synthesized, peer reviewed, and made available in the right way. So I think we can actually go on Congress by putting in place the programs and funding the activities to bring the scientists and the scientific information to the table for those decision-makers.

Mr. EHLERS: Thank you, very much.

Just a question specifically for Mr. Gulezian. Can you please detail what you see as EPA's role in implementing the Great Lakes Regional Collaboration Strategy? In particular, EPA plays a key role that is critical to the success of the collaborational process. And do you envision the EPA to continue to take that strong leadership role in implementing the strategy or are there other actors within the administration who should be involved or perhaps who want to be involved but shouldn't be? I appreciate your comment.

EPA'S ROLE IN IMPLEMENTING THE GREAT LAKES REGIONAL COLLABORATION STRATEGY

Mr. GULEZIAN: Under the President's Executive Order, EPA's administrator was identified as the lead of the federal Interagency Task Force. And it's through the Task Force that the Federal Government participates in the Collaboration. The Federal Government is continuing to participate in the Collaboration, and EPA will continue to lead and coordinate that effort. So I really think that EPA is sort of at the point as a coordinator of the federal resources that can be brought to bear to work with with the Collaboration. Which isn't to say that we are the lead agency for all of the actions, but it's very much a coordinating role to move the Federal Government's participation in the actions forward, and to keep the Collaboration itself alive and healthy.

Mr. EHLERS: And in a sense, that gets back to my earlier comment about having the Great Lakes czar. Someone has to provide the leadership. And if the administration has designated the EPA, then we want to make sure the EPA does it.

Mr. GULEZIAN: I would like to mention that EPA's administrator, Steve Johnson, is maintaining a very high level of involvement in Great Lakes activities. We have regular briefings with him. And he has been a strong participant in the Collaboration activities.

Mr. EHLERS: So developing the Collaboration report was a consensus process, a collaborative effort. And I guess my question is, what—and a lot of people played an active role. Would you see a place for others to continue taking a very active role as being appropriate in this, or do you think it has to primarily reside with the EPA?

Mr. GULEZIAN: No, I think it's very important for the other federal agencies to be involved from the federal level. And also as part of the Collaboration, there has been to be continuing strong involvement from the State governments, from the municipalities, from the tribes, and also from all of the non-governmental entities that were a part of the Collaboration. So I think it really has to move forward in very much the same form in which it was—it was created.

I mentioned that a framework for implementation of the Collaboration was agreed to by the Executive Committee of the Collaboration in March. And that contemplates continuing efforts of all of the governmental partners, and continuing involvement and input and collaboration from the non-governmental partners as well. At this point the governmental partners are identifying key actions that we want to work on together, where we can use our existing resources to move on some of the priority actions that are identified in the Strategy. And my guess is there will probably be a strong element related to wetland restoration, and probably also to response to invasive species. And the expectation is that the partners will work together on that and can solve more broadly and involve the public on those activities as well. And also hold itself accountable to those activities that are—that are committed to in the near-term.

Mr. EHLERS: Thank you, very much. All of you heard that interchange. I—don't feel obligated to respond or comment. But I want

to give you the opportunity to any one of you who wants to add something to that. Feel free to interject something.

I would be happy to listen to the audience afterwards, okay?

No one else seems to want to interject anything in that.

THE ROLE OF SCIENTIFIC DATA AND PROGRAM MANAGERS

EPA and NOAA, both have programs that put science in the hands of the resource managers. Ms. Ballard expressed concern, this is not happening to the degree that it should. And I'm wondering whose responsibility it is, no matter what the agency, to see that the science gets into the hands of the managers who need it? I hope I'm not paraphrasing what you said, Ms. Ballard.

Ms. BALLARD: No, but I could respond. I say since the Collaboration has started, I think there has been outreach. I know with the Sea Grant, we have been involved in the integrative assessments, identifying issues. I know we have extended an invitation to your staff to attend the CZM. We have a Great Lakes regional meeting where all of the coastal zone management managers from the Great Lakes get together once a year. We have extended that invitation to have someone from GLERL attend, and also somebody from GLOFS so we can continue the discussion and how to incorporate resource management needs into the observation systems. So I think there has probably been more communication with the research community more broadly than we have had in a while. And I think it's some of the relationships that came out of the Collaboration.

Mr. EHLERS: Any other comment on that?

Mr. GULEZIAN: I guess I would just like to say that it's really a shared responsibility of the researchers and of the managers. EPA has a conference every two years called the State of the Lakes Ecosystem Conference. And it's a conference where university researchers, researchers and scientists from the State, federal, tribal agencies get together to characterize the overall health of the Great Lakes system through a review of indicators and indicator data. So it's primarily a science-based conference.

One feature that we added to it two solicks (phonetic) ago, was a manager session where we invited federal agency heads in the region, and State department heads to attend. It was relatively poorly attended by the managers. We had a few there, but not what we would have liked. So there really has to be a commitment on both sides from the managers and from the scientists for it to happen.

Mr. EHLERS: Thank you.

Anyone else?

Dr. SCAVIA: When I was in NOAA, one of the things I did was run the National Science Program, National Grant Program, and struggled with this question for a long time. We were trying to find the best ways to integrate the scientists and the managers, and did not do that very well—very difficult to do at that scale. Having now transitioned to the State level, and running Michigan's Sea Grant Program, I see it from a very different perspective. I think what really needs to be done is to go beyond looking at sort of big collections of lots of managers and lots of scientists to sort of talk about what all needs are, and to establish a process, a routine and regular process where managers and scientists get together to talk

about specific problems and specific crises—identifying the specific needs. And that doesn't just happen. I think there is actually a process that you have to put in place—it needs to operate at at least the State, if not the local level—to actually help direct the larger scale, national—the national programs. So I really do think it needs a process and needs to be talked about—talking about specifics.

Mr. EHLERS: Okay.

Dr. Brandt.

Dr. BRANDT: If I can just add a little bit. I do believe it's the federal scientists, it is their responsibility to make sure that their research results are used. And I think that—and it is a challenge. And there are a number of mechanisms to do this. And I think that is good. There is no one mechanism. Sea Grant extension is probably, in my view, one of the best examples where folks actually living in the communities and assessing the needs of those communities. Or focused workshops where you are focusing on beach closures and bringing the beach managers in. But even in that case, as was mentioned earlier, it's difficult. We have to take advantage of ongoing meetings because resources are limited for a lot of the folks that are in the field. They can't go to a group meeting. We also have limited resources. We can't sends our scientists to every community. So I think there is a number of processes to be worked out. They are probably issue focused sort of things—land use, for example, is a good one. But I think it's a two-way street. And as Gary mentioned in some ways we want to make sure our research is used, but we also want to listen to that community so that the research that we are doing will be useful in the future. So we need to hear what they really need, and how it can best be made available to them.

Mr. EHLERS: Okay. Thank you for those contributions.

I have been a strong supporter of the Sea Grant program, as you know, and tried to increase the funding. Probably my greatest contribution there—although I think largely on NOAA's—on some—was to get the lakes—Great Lakes considered fully. I insisted on that. And there was a lot of push back. I said, well, that's okay. Then if you don't like that, I will introduce legislation to change the name from the Great Lakes to the Great Seas—in which case you would automatically be able to apply for all these. That's sort of in the category of change—creating Lake Champlain as a—but anyway, it seems to have worked. It's still very shortly funded. But at least you are considered part of the action. Any coastal work, any Sea Grant work, Great Lakes is eligible as well.

It's time to start wrapping this up. Last question for the witnesses. I just want to direct it to Dr. Steinman. In your written statement, you explained in your experience in Florida "how the science is presented to policy-makers makes an enormous difference in whether the scientifically-based recommendations are implemented." Can you expand on that a bit, give us some examples of effective ways to present the science?

THE IMPORTANCE OF PRESENTING COMPREHENSIVE SCIENCE TO POLICY-MAKERS

Dr. STEINMAN: Well, it's usually easier to give an example of how ineffectively presenting what the results are. Unfortunately, we don't have that many successes down there. But I would—an example that I think is very illustrative. We had an incident in early 2000 where Florida was undergoing its worst drought in recorded history. As a consequence, the lake levels in Lake Okeechobee were reaching historic lows. And there had been obligations made to the sugar cane farmers, which is a two billion dollar a year industry in South Florida, that they would be made whole with respect to their water. In getting the water out of the lake, over the dyke, to the farms, was an enormous challenge. They brought in pumps half the size of this room in order to do that at the cost of millions of dollars.

Now, when we talked about the strategy—the risk assessment in trying to bring the lake down in order to restore it before nature took over, we had identified a variety of science-based predictions. Some was based on NOAA's climate prediction center; some of it based on our own meteorologists as to what the impacts might be. When we went forward and presented that to our governing board, because they make the policy as to what the science should be, they were very confused. Some of these climate-based models are very sophisticated, very computationalley intensive. And they clearly did not understand some of the implications associated with that. As a consequence, we ended up in a very, very difficult position, both in terms of the policies for South Florida, in terms of making sure there was sufficient water available to all of the users and sectors in there. And, I think, in retrospect the science could have been presented in a much more transparent fashion, and the decision-making process might have been more effective in the long run. And that also goes back to my earlier responses to you about how important it is, how incumbent it is on scientists to present the information to the decision-makers in a way that they understand it. But that's not just a matter of us going in front of the decision-makers and elected officials and espousing what our thoughts are. We have to work with them along the way. There is a lot of work that's done behind the scenes in making sure that we talk to our elected officials and they understand these issues before it becomes a crisis. We need to hold their hands, if you will, if you will pardon that phrase, throughout this process so they understand, so nobody is blind-sided in that process.

Mr. EHLERS: Thank you. It's certainly appropriate comments. And it has been my experience as well in my career. And I often act as interpreter between scientists and the Congress. But I have also run classes for scientists on how to lobby the Congress. And I can assure you that it's not appropriate to walk in the door and say, I am a scientist. And I am here to tell you what to do. Which is called the arrogant approach, but it's surprisingly often used. But I appreciate your comments in that regard.

I appreciate all of your participation, very good ideas, comments. It's time to draw the hearing to a close. Something that is never done in a congressional hearing, a briefing, is to entertain ques-

tions from the audience, but I know there are a few. And so what I'm going to do is close out the hearing, and then proceed informally to take questions from a few people for a short time. If any of you have any questions.

So the Committee briefing is adjourned.

(Briefing concluded at 2:50 p.m.)

Mr. EHLERS: I will now ask those members of the audience who wanted to ask the questions—we had one over there. Do you still have your question?

JAN SHEAR: Well, actually, it was more a comment——

Mr. EHLERS: Could you identify yourself?

JAN SHEAR: My name is Jan Shear. I am a volunteer for Clean Water Action here in Grand Rapids.

Mr. Gulezian was talking about the implementation, I think, of the Collaboration decisions. And I think I understood the process to be that government is now—or the government entities are now getting together to come up with how to implement them. Then you would bring in the other entities. And I—I just have a couple concerns with that approach. One of which is that I think you may lose the opportunity to—for some efficiencies in the process of implementation by not including the other members of the party from the beginning in the implementation process.

And I also think that psychologically you use the opportunity to, to implement things more quickly. As everybody says, well, why didn't they include me, I could have told them, you know, such-and-such won't work, or that this will work better or whatever. And then I think you get into problems in the implementation. That was the only comment that I had.

Mr. EHLERS: Thank you for your comment.

Mr. Wege. For the record, Peter Wege.

MAKING THE GREAT LAKES A RESERVOIR

Mr. WEGE: I would like to make a couple statements. One is, I have always—I have been pushing this for a long time—that there are lakes around in New York City, private lakes, regular lakes in the Adirondacks that are supplying water to New York. Wouldn't it be a great idea to have a Federal Government, a Canadian government and all of the states surrounding the Great Lakes to declare the Great Lakes a reservoir? Now just think what that would do. You would—you would immediately get the rust buckets from Russia out of here, out of the—from coming into the Great Lakes. And just have the lakes, have the original boats that are on the lakes right now. But that's—that's what—that canal, that Erie Canal, and all of the other things that brought in more stuff—as this group knows—brought in all of the species and so forth that caused actually billions of dollars to clean up if we are going to do that. But just think of what that would do. Immediately it would become a reservoir. And then you would have all of the laws to take care of the streams coming in. We have been working on the Muskegon River for over three years now. We are going to have a book out on it on what we are doing up there. And it could be a model for the rest of the rivers that are going into the Great Lakes from Michigan, anyhow. And then think of all of the rivers that are going in from the eight states and Canada that are polluting the

Great Lakes in some cases. Some of them are cleaned up, but some—a lot of them aren't. So I'm just throwing that out for what it's worth. And maybe if you could consider it, if the scientists could consider it in some of the—we have 17 colleges and universities now in the Econo College forum that would certainly get behind you and help you out on research or doing whatever you would like to have them do. And it wouldn't cost you very much either. I think we could do that. That's just a couple ideas I think would help the Great Lakes, okay?

Mr. EHLERS: Thank you, very much. Very interesting idea. You would have to make it clear that this is a reservoir intended for the neighboring lakes and not for Arizona and a few other states.

Mr. WEGE: That's right.

Mr. EHLERS: You would have to be careful on how you use the word reservoir.

Mr. WEGE: The eight states of Great, and the two provinces of Canada.

CONCERN FOR THE GREAT LAKES ENVIRONMENT

MARY SCHMIDT: My name is Mary Schmidt. I actually met you last summer at the public hearing. I just retired from National Tennessee and moved to Western Michigan. And I think I, like most of the people that I have come in contact with, absolutely—we moved here because we loved the Great Lakes. But we had no idea—I certainly had no idea of the really fragile state of the ecosystem here. And as I am—and I spent the summer going to hearings and learning about this. And as I have continued to travel around the country, I'm amazed at even within Michigan the lack of awareness around what a crisis that it is. And coming out of the business world, you know, I have always—I retired after 24 years with the health care corporation—that you have to have a burning platform to drive change. And I give you great, great—I love your passion. I just am so excited that—the legislation that you have introduced.

My concern is to get the funding and to get it passed. People around this country have to recognize how critical it is and how important fresh water is actually to their health. And as I have looked at all of the work that has been done over the last several years around the issue of the Great Lakes, and all of the wonderful collaboration, one of the apparent opportunities to bring another to the table strikes me in terms of health care. Because I—I haven't seen a lot of health care executives at the table or at these hearings. And, yet, when you think about our communities, you know, it is hospitals, it is the health care world that is responsible for our short-term and long-term health. And I just wonder if, perhaps, there is an opportunity, albeit they have—believe me having come from that world, and I spent the last 14 years calling on CEOs of hospitals—that they have got a lot of issues, as well you know on their plate right now. But I think there might be an opportunity, certainly when we start thinking about educating the public, that there might be an opportunity to really use an organization—organizations that are in each of our communities to both educate and really energize the public around the correlation between fresh water and healthy lives. And so I just throw that out there because

I think that the issue of funding is going to really require us getting, you know, the communities at large aware of really the crisis situation that we are in. And not just here in the Great Lakes. As I am digging more and more around the country, you know, fresh water is a very, very scarce resource. So I just wanted to throw that out. And, again, a huge thank you for all that you have done in this area. It's very, very exciting.

Mr. EHLERS: Thank you for your comments. I have always found it striking that, you know, I'm very proud that we have always led the world in having clean, pure drinking water. And we are losing that. And I find it fascinating that communities say they can't afford to get rid of combined sewer overflow, or to keep their systems up, the public just won't vote for it. At the same time, this nation is spending over eight billion dollars a year on bottled water. What an irony. Spending eight billion on bottled water, which is not much better than we get out of the tap when we live near the Great Lakes. So I appreciate your comments.

Yes, sir?

BOB STEGMEIER: And maybe the water is not as good when it comes out of the tap.

INVASIVE SPECIES

My name is Bob Stegmeier. I am involved in the Conservation League of America. And I have been in your districts forever. As this briefing came along, I thought, what are the, you know, what are the most important things? And before I came here, they were, one and two or two and one, I'm not sure which. Get that barrier in the Chicago River properly protected, properly built so that it—you know, it does its job to keep the Asian carp out of the Great Lakes. The thought came to me is, that ought to almost have terrorist, you know, designation, whether it be a terrorist or just somebody who, you know, wasn't quite all there. But that's either number one or number two.

And the second is, to me, and I saw—I heard it here from almost everybody—close the door on the invasive species coming in through the Great Lakes shipping. I mean, Peter had the idea of making a reservoir. That would keep the shipping out. Mr.—Dr. Steinman says it's—is the shipping worth it? It sounds like the shipping is not worth it. But we can close the door—the door ought to be closable, and it ought to be closable now and soon. And then—the coastal, all the other problems that I hear here are certainly there. But the invasive species just comes one after another after another. Thank you. And for your effort and Bill 5100, thank you.

Mr. EHLERS: Well, thank you for your comments. An amusing note here. Some years ago when I first introduced the bill to control invasive species, I was visited by an executive in the shipping industry who explained to me how—what we were proposing was so expensive it would really make it difficult for them to do business. And I said, okay, you have convinced me. I will drop the bill. Instead, I will put in the bill saying that you pay for the damage caused by the invasive species. So he had a direct correlation to it. Well, no, we can't afford that. I said, exactly. That's my point. But thank you for your comment.

Yes, sir?

GREG MONN: Representative Ehlers, I want to thank you—I'm sorry, I'm Greg Monn (phonetic). I'm the chair of the Statewide Public Advisory Council for the 14 areas of concern here in Michigan. And I represent White Lake as the area of concern, but I also want to thank Peter for his support for the Muskegon River Watershed as he mentioned. I'm a board member there.

But we have a handout over here that talks about some of the legislative priorities that we perceive three, as well as some of the success stories, as Al had talked about, Lemon Creek (sic) is one of the Great Lakes Legacy Act clean-ups, as well as (inaudible) bay—that was cleaned up (inaudible) Lake. Not necessarily with—it was before the Legacy Act was passed.

But one of the things is to ensure that there is adequate federal and State funding for working in the areas of concern. Most of the money that is spent here in Michigan comes through the Federal Government. And recently in Michigan that was increased. And we see dramatic changes within the state program just with the doubling of the staff that's there. Things are picking up. There is criteria available now here in Michigan. We need to ensure that. The current resources dwindled potentially. The effort of the Great Lakes, we need to applaud your efforts to bring that attention to it along with the Regional Collaboration.

What's more critical, and what I see in the question I want to pose to the Committee is that there is adequate support for local decision-makers within the community—public advisory councils. What I would call, I think Al talked about a little bit and some of the other speakers, grass roots efforts. They are the speakers; they are the communities that recognize that the canary in the coal mine is dying. We see those things immediately, as well as the science that backs it up.

The third thing is that mandate to coordinate all of the federal programs and State programs. I think EPA is starting that process for the last couple years—but bringing all those different programs. I think there was about 11 different agencies. And I thought I made a note of somewhere around 140 programs that are involved that way, that aren't necessarily focused coordinated and communicated between that. And the question I bring is the stewardship effort. When we talk about prevention, that seems to be still one of the main stays, or one of the name sakes, base things of people—if we had that growing up.

When I think about 1970, I went to the first event—graduated from high school—that was a long time ago—with Earth Day. You know, I had no idea. Rivers were on fire throughout the United States, throughout the Great Lakes. Do we have to wait until those kinds of things happen again to bring public reaction, to bring public—and I want to understand what emphasis there amongst all of the programs that we talked about so far today that brings stewardship ethic along with it. If not, really more so is being predominant emphasis, predominant program that these programs relate to. And I would throw that out. It's a difficult question, but it's worthy of discussion, I think. Thank you.

Mr. EHLERS: Thank you, very much. And I would say that, you know, it was easy back in the old days when you have sewage flow-

ing down the river or river and fire, it's easy to get the public excited. Now we are talking about contamination that you can't see, particularly chemical contamination. You can't see mercury. You can't see the toxics, the PCVs in the water. And so the danger is real, if not worse than it was before. And you have to somehow factor—back to the comments of Dr. Steinman, you have to educate the public to these dangers as well as educating the legislative leaders to it. And it's not easy. But it's something we can do. I see no other hands up—one last one. You will be the last one. Okay?

PUBLIC INVOLVEMENT

KIM SPRING: Thank you, very much. My name is Kim Spring. I'm a community organizer for Clean Water Action here in Grand Rapids. And we serve on the steering committee for Healing Our Waters, but I'm not the person that normally attends those meetings. But I'm very curious to know—I read on the press release that—as well as the sponsors, there were 25 other congressional members supporting this legislation. What can our members do here in Michigan, that gives 170,000 members just here in Michigan, to bridge the gap between the elected officials who aren't on-board yet, and what the people of Michigan want, which is clean water and a healthy Great Lakes ecosystem? How can we help with our members to bring some more people on board from the Michigan delegation?

Mr. EHLERS: I wouldn't worry as much about Michigan as I would some other states. So if you are in other states, you know, the standard thing is simply to get your members to write their legislators, Senators, and Members of Congress. And ask them to co-sponsor the bill. And I don't remember the Senate number, but the House number is easy—5100. I deliberately worked—it's not easy to get a special number, but I had my office staff yelling at me.

Ms. O'CONNELL: 2545.

Mr. EHLERS: So the Senate, 2545. And the House, 5100. And the more co-sponsors we have, the better off we are. And once we get above the magic number of 218 in the House—that's the majority to get it passed—suddenly you get a lot of attention. So any of you can help. Whether you are Trout Unlimited or Clean Water Action or whatever. Get people to write their member of Congress to endorse—to co-sponsor 5100.

Thank you very, very much for attending. I would dearly love to have the names—because we had so many good comments—I would like to have the names of everyone who is here. We do have a sign up sheet over here. If you have a card, you can just drop it off instead of signing up. Otherwise, sign up or just write your name on a piece of paper and leave it on the table so that we can keep you informed of further developments if something else comes up. Thank you again for your deep interest in this. I deeply appreciate it. So good night.

[Proceedings adjourned at 3:10 p.m.]

Appendix:

Additional Material for the Record

Prescription for Great Lakes Ecosystem Protection and Restoration (Avoiding the Tipping Point of Irreversible Changes)

DECEMBER 2005

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OVERVIEW

There is widespread agreement that the Great Lakes presently are exhibiting symptoms of extreme stress from a combination of sources that include toxic contaminants, invasive species, nutrient loading, shoreline and upland land use changes, and hydrologic modifications. Many of these sources of stress and others have been impacting the lakes for over a century. These adverse impacts have appeared gradually over time, often in nearshore areas, in the shallower portions of the system, and in specific fish populations. Factors such as the size of the lakes, the time delay between the introduction of stress and subsequent impacts, the temporary recovery of some portions of the ecosystem, and failure to understand the ecosystem-level disruptions caused by the combination of multiple stresses have led to the false assumption that the Great Lakes ecosystem is healthy and resilient.

Because it has taken the Great Lakes four centuries of exposure to these human-induced stresses to get to this point, some argue we have decades to control these and other sources of stress and promote the lakes' recovery.[1] From this perspective, protecting the Great Lakes is not particularly urgent and action can wait until we conduct more studies, while taking small corrective measures when the opportunity or need arises. However, if not addressed with great urgency, the Great Lakes system may experience further—and potentially irreversible—damage.

In large areas of the lakes, historical sources of stress have combined with new ones to reach a tipping point, the point at which ecosystem-level changes occur rapidly and unexpectedly, confounding the traditional relationships between sources of stress and the expected ecosystem response. There is compelling evidence that in many parts of the Great Lakes we are at or beyond this tipping point. Certain areas of the Great Lakes are increasingly experiencing ecosystem breakdown, where intensifying levels of stress from a combination of sources have overwhelmed the natural processes that normally stabilize and buffer the system from permanent change.[2]

Although the specific episodes of ecosystem breakdown have been unpredictable and alarming, few Great Lakes researchers are surprised by these occurrences. A number of papers were published in the 1980s describing stresses in various areas of the Great Lakes, including Lake Erie and shallow embayments in lakes Michigan, Huron, and Ontario. These papers described the symptoms of the Great Lakes ecosystem under distress, and laid the foundation for a conceptual ecological framework for understanding the changes that were occurring at that time. Rapport et al. (1985) discussed ecosystem self-regulating mechanisms (such as responses to invasive species) and the process by which stresses can give rise to early warnings, coping mechanisms, and ultimately lead to ecosystem breakdown if the overall stress is sufficiently prolonged and/or intense. The ecosystem adaptation syndrome discussed in the paper can be used to help formulate a systematic ecosystem approach to environmental management of the Great Lakes. This ecosystem breakdown concept helps explain the scope, intensity, and speed of the ecosystem changes that have occurred in the Great Lakes since the 1980s.

Examples of ecosystem breakdown or major changes in the lakes include: (1) persistence of the anoxic/hypoxic zone in the central basin of Lake Erie and other stresses in the eastern and western basins; (2) continued symptoms of impairment (including eutrophication) in Saginaw Bay and Green Bay; (3) well-documented rapid disappearance of the once abundant amphipods in the genus *Diporeia* in sediments of large areas of all the lakes (except for Lake Superior), and concomitant food web disruptions; (4) recent declines in growth, condition and numbers of lake whitefish in Lake Michigan and portions of Lake Huron; and (5) elimination of the macrophyte (i.e., rooted plant) community and simplification of the benthic food web, in Sandusky Bay on Lake Erie and Cootes Paradise in Hamilton Harbour on Lake Ontario, due to sediment and other pollutant loads.

The major cause of ecosystem breakdown is the severe damage that has been done to the Great Lakes' self-regulating mechanisms. In the past, healthy nearshore communities and tributaries helped reduce the impact of many stresses on or entering the lakes. Over time, the combined effects of a whole suite of stresses from a variety of human-induced sources have overwhelmed the ecosystem's self-regulating mechanisms. This diagnosis suggests that it is appropriate and necessary to address mul-

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[1] Great Lakes Interagency Task Force, Report to the President on the Implementation of the Great Lakes Executive Order, undated, available at: *http://www.epa.gov/glnpo/collaboration/final_rttp_10282005.pdf*

[2] This is analogous to discussions of resilience and catastrophic change in ecosystems as presented in Scheffer et al. (2001), whereby assuming alternative stable states are available, sufficient perturbation in any ecosystem can shift it to an alternative (and potentially "unwanted") stable state.

tiple sources of stress in order to reverse the trend toward widespread ecosystem breakdown. The following is a list of Great Lakes management objectives based on this diagnosis.

- *Restore*

  Restore critical elements of the *ecosystem's self-regulating mechanisms.* To the extent possible, re-establish natural attributes of critical nearshore and tributary communities so they can once again perform their stabilizing function. Where full restoration of natural attributes is not possible, improve desirable aspects through *enhancement* of important functions.[3]

- *Remediate*

  Remediate abusive practices that create *sources of stress.* Reduce or eliminate physical habitat alterations, pollution loadings, pathways for invasive species, and other stressors or their vectors into the lakes.

- *Protect*

  Protect the functioning portions of the ecosystem from *impairment.* Preserve those portions of the ecosystems that now are healthy, and those that can be restored or enhanced, through sustainable development practices within the Great Lakes basin.

- *Measure*

  Building on existing efforts, measure ecosystem health through a set of agreed-upon integrative indicators that can serve to assess current conditions and monitor the progress of restoring the lakes.

The conceptual model here indicates the importance of immediate and sustained action. It advocates using the principles of ecosystem-based management to restore and protect the Great Lakes. Without such action, the lakes could potentially suffer irreversible and catastrophic damage.

SYMPTOMS

Many of the changes the Great Lakes have experienced in response to sources of stress have been documented for decades. Examples of symptoms and sources of stresses to the lakes include:

- Extirpation or major declines in important native species (such as lake trout and deepwater ciscoes) due to overfishing and effects from aquatic invasive species (such as sea lamprey predation on lake trout, and competition with deepwater ciscoes by introduced alewives and rainbow smelt);
- Widespread reproductive failures of keystone, heritage, and other (both native and introduced) fish species, including lake trout, sturgeon, lake herring, coaster brook trout, and Atlantic and Pacific salmon;
- Fouling of coastlines, resulting in beach closings and loss of habitat for fish and waterfowl;
- Toxic contamination of fish, which threatens the health of people, wildlife, and some fish species themselves, and results in fish consumption advisories throughout the Great Lakes and inland lakes and rivers;
- Loss of coastal wetlands, including over 90 percent of the pre-settlement wetlands along the Lake Huron/Lake Erie corridor;
- More recent introductions of aquatic invasive species (e.g., zebra and quagga mussels, round gobies and predatory zooplankton such as Bythotrephes cederstroemi and Cercopagis pengoi (two species of water fleas)) leading to declines in valued/important native aquatic species (including certain plankton, unionid clams and certain native fish species);
- Decreased populations of benthic organisms in many locations, causing decreased health in lake whitefish and with the potential to impact other species; and
- General water quality degradation, associated algal blooms, Type E botulism in fish and waterfowl, and contamination of drinking water (e.g., Johnson et

[3] Establishment of restoration goals obviously needs to acknowledge ecological constraints (e.g., the presence of numerous invasive species—including introduced fish—that are currently important components of food webs) as well as consider other human use objectives (e.g., maintenance of sport fisheries that include introduced species) (see, for example, discussions in Kitchell et al., 2000; Mills et al., 2003; Sproule-Jones, 2003).

al., 1998; Beeton et al., 1999; IJC, 2000; IJC, 2002; IJC, 2004; Whelan and Johnson, 2004).[4]

Historically, these and other symptoms were attributed to six major anthropogenic or human-induced sources of stress to the ecosystems in each lake.[5] The symptoms may appear stepwise like a chain reaction or self-organize in a complex, ecologically degraded manner. Listed in no particular order are those anthropogenic sources of stress: (1) **overfishing** (i.e., extracting larger quantities of fish than the system can sustain naturally); (2) **nutrient loading** (i.e., addition of phosphorus and nitrogen in excess of natural levels, usually via human waste and urban and agricultural runoff); (3) the release of **toxic chemicals** (e.g., mercury, polychlorinated biphenyls (PCBs) and other chlorinated hydrocarbons), including many that are both persistent and bioaccumulative;[6] (4) increased sediment loading as well as other sources of stress associated with **land use practices** (e.g., physical changes including alteration of vegetative land cover, wetland filling, modification of shorelines); (5) introduction of invasive (nonnative) **exotic plant and animal species** (e.g., purple loosestrife, sea lamprey, and zebra mussel); and (6) **hydrologic alterations** in tributary and connecting waterways, diversion and/or alteration of flows through the construction of dams, channels, and canals, alteration of natural drainage patterns (e.g., leading to increased surface water runoff and stream flows in urban areas with increased imperviousness).

Many of the symptoms of stress on the Great Lakes are attributable to a combination of these six sources of stress. Fouling of coastlines and near-shore areas arises from sewage overflows and contaminated runoff. Historically, valued species of fish declined in number or disappeared as a result of overfishing and, to varying degrees, invasive species, lost habitat connectivity, and toxic chemicals. Presently, invasive species and concomitant food web changes as well as lost connectivity of tributary spawning habitat play a larger role in affecting fish populations. Toxic chemical contamination in fish, which also threatens the health of humans and fish-consuming wildlife, is a direct result of historical and current toxic chemical releases. The loss of coastal wetlands stems from changes in land use practices and hydrologic alterations. Changes in water quality are caused directly by toxic chemical, nutrient, microbial and sediment pollution, as well as through actions of some invasive species (e.g., zebra mussels). Invasive species are the most likely principal source of food web disruptions now occurring in the Great Lakes, and are implicated in reproductive failures of some fish species (e.g., walleyes, lake trout, yellow perch, and lake herring) (McDonald et al., 1998; Fielder and Thomas, 2005).[7]

It should be noted that superimposed on these primary stresses are the broader, large-scale changes in global and regional climate. A recent analysis of the potential global warming and regional climate change impacts to the Great Lakes region included declining lake levels and the duration of winter ice, jeopardizing reproduction of some fisheries, and general lake warming that could negatively impact coldwater fish species, favor invasions of warm water nonnative species, and expand the duration of summer stratification and increase the potential for hypoxia ("dead zones")

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[4] In some cases, policies designed to address these stresses have been effective. Most notably, the passage in the United States of the *Clean Water Act* in 1972 and subsequent amendments initiated the National Pollutant Discharge Elimination System for point sources and resulted in billions of dollars in investments by Federal, State, and local governments to upgrade, improve, and extend wastewater collection and treatment systems directly tributary to the Great Lakes; similar scale investments were made in Canada. The ban on the use and manufacturing of certain toxic chemicals, and strict protections put on others, has helped allow key indicator species (eagles, herring gulls) to return to health. However, even with substantial investments over the past three decades, wastewater treatment plants and sewer systems are in need of substantial new capital expenditures for major repairs, upgrades and, in some cases, replacement, and it is clear that local funding alone will not be adequate to the task. In addition, though a subject of research and policy focus for a number of years, nonpoint source pollution—including urban runoff, agricultural runoff, air deposition, and contaminated sediments—continues to be a significant contributor of pollutants to Great Lakes waters.

[5] Although we often speak of a "Great Lakes ecosystem," in most cases each lake basin has its own ecosystem, further divided into sub-basin ecosystems.

[6] In addition to chemicals that have been of longstanding concern in the Great Lakes, increasing attention is being directed at chemicals of emerging concern, including those found in products such as pharmaceuticals, personal care products, and flame retardants. Some of these and other chemicals may act as endocrine disruptors or otherwise alter regulatory systems in biota, and potentially add to the stress caused by toxic chemicals of principal focus in the region.

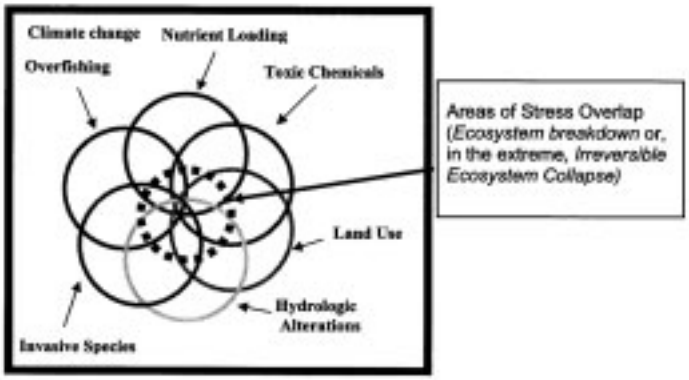
[7] One example of reproductive effects on salmonids involves the action of the enzyme thiaminase, which transforms the essential vitamin thiamine. In a recent study, lake trout fed diets with substantial amounts of thiaminase (either in bacterial form or with alewives (an introduced species with naturally elevated levels of the enzyme)) produce eggs more susceptible to embryonic early mortality syndrome (Honeyfield et al., 2005).

(Kling et al., 2003). These findings were generally consistent with earlier predictions for the Great Lakes in a scenario with a doubling of atmospheric carbon dioxide levels, although the researchers emphasized that the many complex interactions could lead to varied responses in individual ecosystems (e.g., thermal habitat changes in deep stratified lakes vs. shallow lakes and streams) (Magnuson et al., 1997). In addition to these potential compounding factors in the lakes proper, earlier ice breakup and earlier peaks in spring runoff will change the timing of stream flows, while increases in heavy rainstorms may cause more frequent flooding with potential increases in erosion, and additional water pollution from nutrients, pesticides, and other contaminants. While it is difficult to know how these changes will interact with the other six classes of stress identified above, there is little doubt that global warming will add yet another source of stress to the already perturbed Great Lakes ecosystem.

DIAGNOSING THE DISEASE

The Great Lakes ecosystem and the major human-induced sources of stress on it can be portrayed as a series of overlapping circles in a Venn Diagram, as shown in Figure 1.[8] For areas where stresses act singly or jointly but not at intense levels, an ecosystem may change adaptively to an unhealthy state of diminished vigor and unpleasant aesthetics but not suffer major transformation to a disorganized critical state. Such a contrast could be analogous to a person feeling sick and redirecting vital efforts to recover at home rather than being taken to a crisis center for surgery or other intensive care. In an ecosystem in which only one stress acts intensely, positive (or reinforcing) or synergistic feedback loops can emerge, leading to a runaway or catastrophic breakdown process. However, such feedback loops are more likely to occur as the adverse effects of a number of stresses interact. The probability of disastrous ecosystemic breakdown appears to increase with the number of stresses acting on and interacting in the ecosystem. Thus, in this conceptual model, the probability of breakdown is likely to be highest at the center of the Venn Diagram where all types of stress act and interact to varying degrees. The prevention of this type of ecosystem breakdown should be the focus of attention in any restoration and protection efforts.

Figure 1.



The magnitude (intensity), shape, and degree of overlap of the stresses have varied over time and space. For example, **overfishing** began in the late 1800s and continued into the 20th Century, while **invasive species** had significantly effected the ecosystem by the middle of the 20th Century. Other stresses have had significant effects more locally, such as **nutrient loading** in Green Bay, Saginaw Bay, and the western and central basins of Lake Erie, and **toxic chemicals** in the basin's industrial complexes such as along the Niagara, Detroit and Fox rivers (although due in part to diffuse loadings, many contaminants long ago become more widespread

[8] The locations of stresses on the diagram is somewhat arbitrary, as the model is limited to working with stresses that are represented in two dimensions. It is possible that two or more stresses might interact in stronger ways (and others less coherently) that can be represented in the diagram.

throughout the lakes themselves). In order to address these areas of overlap, there remains the need to better understand the salient features of these areas.

Conceptual Understanding of Ecosystem Stress Adaptation

The nearshore areas are important in the ecosystemic self-organization of the Great Lakes. Before the significant impact of humans (i.e., following European settlement), the nearshore areas were in equilibrium with surrounding areas. There was a healthy abundance and diversity of organisms interacting to various degrees with surrounding areas (from wetlands to offshore), and loads of nutrients and other constituents from land could be assimilated and/or transferred between communities without major disruptions to the functioning ecosystem. With development and industrialization in the Great Lakes, land use changes, increased pollution, and other factors have increased stress on these nearshore areas.

As the types and intensity of stress increased, two things happened. First, inflowing nutrients were shunted to the open waters of nearshore areas where photosynthetic energy fixation then erupted as plankton blooms. The blooms resulted in the loss of many valued, native species of nearshore communities and an increase in other species, native and nonnative, that favor open waters. Second, the entire ecosystem, including community abundance and composition, became unstable and began to undergo wider and more frequent fluctuations. Increased loadings of sediments from watershed runoff, toxic chemical inputs, oxygen depletion (following increased nutrient loads), hydrological alterations and other sources of stress created a hostile environment to bottom dwelling, pollution-sensitive species and to the eggs of most Great Lakes fishes (Rapport et al., 1985; Steedman and Regier, 1987). Some of these changes were concomitant with or followed upon earlier changes to the upper portions of the food web due to a combination of introduction of aquatic invasive species (such as the sea lamprey, rainbow smelt and alewives) and overfishing, leading to extirpation or significant depletions of open water species such as lake trout and deepwater ciscoes (Eshenroder and Burnham-Curtis, 1999).

More recently, the invasion of zebra mussels in Lake St. Clair in 1988 and later arrival of quagga mussels have altered this nutrient flow dynamic in the Great Lakes yet again. Extensive colonization by zebra mussels in nearshore areas of the lower lakes has resulted in the reduction of nutrient and energy supplies to the open waters (Hecky et al. 2004). The extreme filtering capacities of zebra mussels for plankton has transferred energy from the water column to the nearshore benthic areas, and diminished the transport of nutrients via currents to the deeper waters. Also, quagga mussels colonize deeper waters and out-compete other organisms for food resources directly. The increased nearshore retention of nutrients along with clearer water has led to an increase in undesirable species of algae. Organic material filtered by mussels is transformed into biodeposits (pseudofeces and feces) that while serving in part as a food source for some organisms, are not utilized as a food source by many other benthic organisms (see below). In addition, the zebra mussels themselves are undesirable prey for most native Great Lakes fish species, but are readily consumed by invasive round gobies. The introduction and spread of zebra and quagga mussels has not only led to declines in native mussels (Nalepa et al., 1996) and other benthic species (see, for example, Nalepa et al., 1998; Dermott, 2001; Lozano et al., 2001), but has also facilitated the spread of other invasive species (Ricciardi, 2001).

With sufficient cumulative stress (including habitat loss, nutrient loadings, oxygen depletion, and invasive species), the capability of once healthy, resilient, and diverse coastal communities to buffer against natural and human perturbations can be overwhelmed. In essence, the health-sustaining system of the Great Lakes is seriously weakened. Once the resilient capabilities are exceeded the ecosystem organization abruptly and catastrophically changes, resulting in ecosystem breakdown. Under extreme circumstances where the suite of stresses become severely intense, the ecosystem adaptive responses in some cases move into another phase dominated by species that can tolerate and benefit from those sources of stress. The presence of surface scum, mats of fungi, strands of filamentous algae, and surface blooms of toxin-producing algae create this new phase in the water column. This surface association has appeared seasonally in certain bays and in the shallow waters of the Great Lakes, but has had adverse affects on both the nearshore and open water communities.

Scientists throughout the world are documenting the actual and expected damage that the loss of such ecosystem resiliency can cause. In March, 2005, the United Nations issued a final draft of a report endorsed by 1,200 of the world's leading scientists called the Millennium Ecosystem Assessment Synthesis Report (United Nations, 2005). One of the report's conclusions follows:

> *There is* established but incomplete *evidence that changes being made in ecosystems are increasing the likelihood of nonlinear changes in ecosystems (including accelerating, abrupt, and potentially irreversible changes), with important consequences for human well-being.* Changes in ecosystems generally take place gradually. Some changes are nonlinear, however: once a threshold is crossed, the system changes to a very different state. And these nonlinear changes are sometimes abrupt; they can also be large in magnitude and difficult, expensive, or impossible to reverse. (Emphasis in original, endnote omitted) (United Nations 2005)

The Millennium Ecosystem Assessment Synthesis Report conclusions are repeated in a "Scientific Consensus Statement for Marine Ecosystem-Based Management" recently adopted by over 200 scientists (Scientific Consensus 2005). The scientists signing the Consensus Statement on marine environments (as do the scientists endorsing this prescription paper) emphasize the need for a holistic, ecosystem-based management approach, including the dangers of managing only individual sources of stress or specific species:

> *Ecosystems can recover from many kinds of disturbance, but are not infinitely resilient.* There is often a threshold beyond which an altered ecosystem may not return to its previous state. The tipping point for these irreversible changes may be impossible to predict. Thus, increased levels of precaution are prudent as ecosystems are pushed further from pre-existing states. Features that enhance the ability of an ecosystem to resist or recover from disturbance include the full natural complement of species, genetic diversity within species, multiple representative stands (copies) of each habitat type, and lack of degrading stress from other sources. (Emphasis in original.) (Scientific Consensus, 2005)

While the same ecological principles cited for the world's oceans apply to the Great Lakes, the lakes may be less able to cope with stress than typical coastal marine environments. Ecosystems that have evolved in relatively unstable environments, such as those in the intertidal ocean communities that are exposed to frequent tidal movements and that have great diversity of species, are more likely to resist and/or recover from moderate human-induced stress. In contrast, the Great Lakes ecosystem is a relatively young (<12,000 years), mostly oligotrophic system that has evolved in a relatively stable environment with a more limited number of species. The lakes represent a more closed system than coastal ocean waters, and respond more slowly to contaminant loadings (with longer hydraulic flushing times than coastal areas). Because of these differences, the lakes may be rapidly altered by even moderate stresses such as changes in water quality, system hydrology, or the introduction of invasive species (Rapport and Regier, 1995). Thus, action to avoid the tipping point for irreversible ecosystem changes in the Great Lakes may be even more urgent than for coastal marine environments.

Great Lakes Ecosystem Response to Loss of Resiliency

In the Great Lakes, nonlinear changes are no longer a future threat—these types of changes are taking place now. While in some areas some indicators of ecosystem health have continued to improve over the past decade, other large areas in the lakes are undergoing rapid changes where combinations of effects of old and new stresses are interacting synergistically to trigger a chain reaction process of ecosystem degradation. The rapidness of this chain-reaction process, seen over the past five to fifteen years and involving sudden and unpredictable changes, is unique in the Great Lakes' recorded history. Some of the most significant changes observed include the radical food web disruptions occurring in Lakes Michigan, Huron, Erie, and Ontario; the reoccurrence of the anoxic/hypoxic zone in the central basin and other impairments (such as blooms of *Microcystis* cyanobacteria in the western basin) in Lake Erie; and ongoing problems related to invasive species and other impairments in Lake Ontario. A profile of components of these potentially devastating ecosystem responses follows.

Profiles of Ecosystem Breakdown

Food Web Disruptions

Invasions of aquatic nonnative species in the Great Lakes have been a concern since the mid-twentieth century when sea lamprey, combined with other sources of stress, decimated populations of lake trout in the Upper Great Lakes. Facilitations between a series of invasive introductions have resulted in a synergistic effect leading to significant alterations of critical ecosystem processes in the Great Lakes. For example, reductions in lake trout and other predator species due to sea lamprey predation in Lakes Michigan and Huron paved the way for explosive increases in the

populations of other invaders (e.g., alewife and rainbow smelt) which, in turn, competed with and preyed upon native forage species (Holeck et al., 2004).

More recently, researchers have documented a dramatic decline in abundances of the amphipod *Diporeia* in sediments of Lake Michigan. *Diporeia* is a critical component of the food web, important in the diets of many fish species. Historically, it has been the dominant food source for species such as slimy and deepwater sculpin, bloater, and lake whitefish. In the early 1980s average abundances of *Diporeia* in bottom sediments from Lake Michigan were as high as 12,200 individuals/m^2. However, *Diporeia* numbers began declining by the early 1990s, and by 2000 became severely depleted from sediment samples from Lake Michigan in much of the southern and northern portions of the lake, in some cases disappearing altogether (Nalepa et al., 1998; GLERL, 2003).

Populations of other macroinvertebrates have declined significantly in Lake Michigan as well. Oligochaete worms and fingernail clams showed declines in parallel with those of *Diporeia* in nearshore areas from 1980–1993 (Madenjian et al., 2002). While researchers have not been able to establish a direct link, they have associated the decline of *Diporeia* with increases in the abundance of the nonnative zebra mussel in Lake Michigan beginning in 1989. *Diporeia* and other benthic organisms depend on diatoms and detritus from other phytoplankton as a primary source of food, the same source of energy that zebra mussels utilize (Nalepa et al., 1998). Recent research indicates that the loss of amphipods is having serious consequences for the fish of Lake Michigan, including whitefish (Pothoven et. al., 2001), sculpin and bloater (Hondorp at al. 2005), and alewife (Madenjian et al., 2002). Evidence also indicates that similar food web disruptions are occurring or have already occurred in Lakes Huron, Erie and Ontario (e.g., Nalepa et al., 2003; Dermott and Kerec, 1997; Lozano et al., 2001).

Lake Erie: Re-emerging Problems and New Threats

For the Lake Erie ecosystem, cautious optimism about restoration was expressed in the early 1990s as the result of reductions in phosphorus loadings, improved dissolved oxygen levels in the bottom waters of the central basin, and increased fish populations (Markarewicz, 1991). However, while improvements have continued by some measures (e.g., increased water clarity, establishment of rooted aquatic plants), other impairments have persisted and/or increased in intensity in recent years. For example, recent data indicate that since the early 1990s springtime phosphorus concentrations have increased, summertime dissolved oxygen levels in Lake Erie's central basin have decreased, and walleye numbers have begun to decline (IJC, 2004). Lake Erie nutrient loads and cycling, oxygen demand, dissolved oxygen levels and related issues have been the subject of a number of studies in recent decades, and it has been recognized that a combination of factors (including physical factors such as thickness of the bottom water layer, or hypolimnion) can affect deeper water dissolved oxygen levels.[9] Because of the number of factors involved, it is likely that no single factor explains the more recent periods of hypoxia (low oxygen conditions) in the central basin. Factors that could be influencing the persistent development of central basin summertime hypoxia include climate change and altered weather patterns (e.g., changes in temperatures and timing and intensity of storm events), changes in nutrient loadings (in particular from nonpoint sources—some data show increased phosphorus loadings from Ohio tributaries in the past decade), and altered internal cycling of phosphorus in response to the presence of zebra and quagga mussels (e.g., IJC, 2004; U.S. EPA and Environment Canada, 2004).

Avian botulism is another feature of the stress complex in Lake Erie (with cases also observed in Lakes Ontario and Huron), leading to episodic summertime die-offs of fish and fish-eating birds. The die-offs (which have included freshwater drum and birds such as common loons *(Gavia immer)* and red-breasted mergansers *(Mergus serrator)*) are linked to the generation of a neurotoxin produced by the anaerobic bacterium *Clostridium botulinum.* While the mechanisms leading to the outbreaks remain to be confirmed, the botulism toxin has been found in dreissenid mussels and invasive round gobies (a principal predator of zebra mussels), leading to the hypothesis that round gobies are transferring the toxin from zebra mussels to organisms higher in the food web (Domske, 2003; Ricciardi, 2005).

Another stress in Lake Erie is the return of blooms of the blue-green algae (or cyanobacteria) *Microcystis.* In addition to being a low quality food for other aquatic species, these algae can produce the microcystin toxin, which at sufficient levels can be harmful to fish, wildlife and humans. *Microcystis* are selectively expelled during

[9] See for example Kay and Regier (1999) (and related papers in the State of Lake Erie volume) and Charlton (1987), Rosa and Burns (1987) and other papers in the same issue of the *Journal of Great Lakes Research.*

feeding by zebra mussels, and thus zebra mussel colonization appears to be facilitating the re-emergence of these problem blooms (Vanderploeg, 2002). Another problem is the increasing frequency of algal mat development in nearshore areas (in particular in the eastern basin) by the filamentous green alga *Cladophora.* Blooms of this alga, which impair recreation and otherwise detract from beach aesthetic value, are linked to nearshore hypoxia/anoxia (U.S. EPA and Environment Canada, 2004).

Yet another significant potential threat to the ecosystem of Lake Erie and the other lakes is the presence of Asian carp in waters near the lakes. Several of these species have been imported to the southern U.S. to control unwanted organisms found in aquaculture facilities, and in some cases have escaped into the wild. While several individual Asian carp have been caught in Lake Erie, there are no established populations in Lake Erie or any of the other Great Lakes. However, at least two of the species have migrated up the Mississippi and Illinois Rivers and are within several miles of Lake Michigan. If the fish (which are planktivores and can range up to 40 kg) manage to breach barriers (such as the electric barrier on the Des Plaines River in Illinois), enter the Great Lakes, and become established, they could cause significant impacts on the ecosystem through competition with other fish that feed on plankton (U.S. EPA and Environment Canada, 2004).

Other emerging or ongoing symptoms of stress in Lake Erie include the continued presence of invasive species (including round gobies and quagga mussels), rising water temperatures, limited shallow water habitat due to hydromodified shorelines on the southern shore (in particular in the western basin), continuing presence of toxic chemicals (e.g., PCBs and persistent pesticides) leading to fish consumption advisories, and findings of pharmaceuticals, hormones and other chemicals of emerging concern in the Detroit River (IJC, 2004; U.S. EPA and Environment Canada, 2004).

Ongoing Impairments in Lake Ontario

Lake Ontario is also continuing to struggle with multiple sources of stress. While *Diporeia* declines have been reported since the 1990s following invasion by zebra mussels, as previously noted, the invasive quagga mussels have contributed to further alterations of the benthic community over broader areas in the lake. Other species that have invaded Lake Ontario in the past 10–15 years, with the potential to out-compete other native species, include the amphipod *Echinogammarus ischnus,* the New Zealand mud snail *(Potamopyrgus antipodarum),* and the predatory zooplankton *Cercopagis pengoi* (or fishhook water flea). The combination of a number of stresses over the past two decades (including oligotrophication, invasion by zebra and quagga mussels, fishery management practices, and climate change) has significantly altered the Lake Ontario fish community, with declines in alewife, native sculpin and whitefish, and increases in some native species associated with lamprey control (Mills et al., 2003). In addition, as with the other Great Lakes, numerous fish consumption advisories remain in place for Lake Ontario, including for PCBs, dioxins, mirex/photomirex and mercury (U.S. EPA, 2005; Ontario MOE, 2005).

PRESCRIPTION FOR RECOVERY

A number of management efforts (at local, state, national, and binational levels) directed at protecting and restoring the Great Lakes over the past three-plus decades have been developed and implemented, and there have been a number of successes. Sea lamprey control efforts starting in the 1950s have been relatively successful at controlling populations of this species, which has taken a significant toll on populations of lake trout and other native fish. Binational efforts following the signing of the Great Lakes Water Quality Agreement (GLWQA) in 1972 resulted in lowering of phosphorus loads to the lakes and improvements in a number of water quality indicators (in particular in the more heavily (nutrient) impacted lower lakes). Subsequent efforts under the GLWQA directed at toxic chemical contamination in Areas of Concern (AOC) (through Remedial Action Plans (RAPs)) have made some progress in addressing contaminated sediments, with two of 43 AOCs delisted. Implementation of Lakewide Management Plans (LaMPs) has also proceeded in recent years, with a number of efforts underway through the LaMP process in each lake to address numerous beneficial use impairments.[10] Other efforts have been ongoing over the past decade to address specific problems in the lakes or basin, such as the Canada-U.S. Binational Toxics Strategy (addressing mostly persistent, bioaccumulative, toxic (PBT) chemicals) and the Great Lakes Panel on Aquatic Nuisance Species. In addition, the development of indicators of ecosystem health has

[10] For Lake Huron, the lakewide effort is the Lake Huron Binational Partnership, which is not nominally a LaMP.

been conducted through the State of the Lakes Ecosystem Conference (SOLEC) process.

The complexity of the jurisdictional management for the Great Lakes has long been recognized, involving management by two federal governments, eight states and two provinces, Native American and First Nation tribes, municipalities, as well as institutions such as the International Joint Commission, the Great Lakes Fishery Commission, and the Great Lakes Commission offering policy and management guidance. Challenges in implementing programs to protect the Great Lakes have been highlighted in recent reports, including a 2003 U.S. General Accounting Office (GAO) report. The report noted there were 148 federal (U.S.) and 51 state programs funding work on environmental restoration within the Great Lakes basin; a smaller number of federal programs (33) were focused specifically on the basin. The report also noted the lack of any overarching approach to coordinate program activities in support of Great Lakes restoration, as well as the lack of a coordinated monitoring program to determine basinwide progress toward meeting restoration goals (U.S. GAO, 2003).

Indeed when faced with a particularly damaging human perturbation in the Great Lakes, our corrective response has generally been to focus on a particular cause of stress and not on the integrated sources of stress that allowed it to occur. For example, when excessive nutrients and associated algal blooms impaired Lake Erie, we focused on the major point sources of phosphorus that fed the algae and lead to oxygen depletion. For a short period, we dampened down that perturbation. However, now that similar degraded conditions have reappeared, we are uncertain if such conditions are due to insufficient control of excessive nutrients, are caused by invasive species, or the result of a combination of stress sources not effectively addressed when the problems were first identified. Compounding the issue, the Great Lakes ecosystem's adaptive responses, transforming into undesired, unhealthy states, seem to be increasing in a dramatic way, in particular due to the uncontrolled introduction of new invasive organisms that out-compete native species whose natural habitat has been severely degraded in a number of areas. In spite of some efforts at addressing invasive species introductions (such as ballast water exchange requirements in the *Non-Indigenous Aquatic Nuisance Species Prevention and Control Act of 1990,* which do not affect the large majority of ships entering the Great Lakes declaring "no ballast on board" but which in fact may contain residual ballast water), the rate of introduction of new aquatic invaders has remained high over the past 15 years, averaging over one new species every eight months since 1970 (Ricciardi, 2001).

Two broad approaches for addressing Great Lakes problems by the policymaking and management communities are treating each symptom, or treating the disease. In addressing each perturbation individually, for example, one would look for approaches to control the spread of zebra or quagga mussels, approaches for reducing polluted runoff, and strategies for addressing existing contaminants and chemicals of emerging concern. Conversely, the Great Lakes community can address the unacceptable adaptive changes in the lakes by focusing attention on the multiple sources of stress that have led to wide-scale disruption of essential nearshore/tributary processes. While recognizing the difficulty in addressing a number of individual stresses (e.g., many years of efforts at suppressing sea lamprey populations), we believe focusing on the multiple sources of stress will lead to the best possible policymaking for and management of the Great Lakes ecosystem.

As we focus on multiple sources of stress, several critical ecosystem objectives should be maintained: (1) restore and enhance the self-regulating mechanisms of the Great Lakes by focusing on the health of key geographic areas. This includes major tributaries and key nearshore areas; (2) to the extent possible, remediate existing and prevent major new perturbations (e.g., stop the introduction of new invasive species and pollutants); (3) protect existing healthy elements by adopting sustainable land and water use practices in the basin that maintain the long-term health of the Great Lakes ecosystem and associated benefits; (4) better monitor ecosystem health and the progress of restoration and protection efforts.

Steedman and Regier (1987) outlined and defined a set of components for Great Lakes ecosystem rehabilitation and those definitions have been modified to formulate the following suggested four primary management objectives for the Great Lakes.

1. Restore and Enhance Critical Nearshore Areas, Tributaries, and Connecting Channels

The ecosystem-based conceptual model should be applied to identify specific geographic areas where the combination of individual sources of stress have contributed or are likely to contribute to the degradation of the nearshore/tributary

areas. These are areas where ecosystem breakdown is occurring or is likely to occur, and where action is most likely to restore resiliency to the Great Lakes. These consensus-targeted areas for coordinated restoration and protection efforts may well include those locations already identified as Areas of Concern by the International Joint Commission (expanded geographically to ensure they include the major sources of stress) as well as nearshore/tributary areas that are now showing symptoms or vulnerability to multiple sources of stress. This may require increased institutional focus (including increased emphasis within LaMP efforts) on these nearshore areas. The goal should be to reestablish the natural states critical to nearshore and tributary communities so they can once again perform their stabilizing function, or, if that is not feasible, enhance critical elements that play a role in stabilizing the communities.

2. Remediate Basinwide Sources of Stress

Some of the major stress sources need to be managed through systematic, basinwide approaches. Impacts of stress are often lakewide, if not basinwide, and the remedies are not linked to a limited geographical area. Basinwide stress reduction recommendations include:

- Support research on control of existing invasive species (e.g., round gobies, zebra and quagga mussels), and to the extent they are identified, implement any control measures.
- Prevent the introduction of new invasive species.
- Mitigate existing negative impacts and prevent significant future human alterations of tributary hydrology and Great Lakes shoreline structure. This can include promoting connectivity of habitat (such as wetlands or free-flowing rivers) important for many species.
- Reduce loadings of nutrients, sediments/dredged material, toxic chemicals, and microbial pollution to the Great Lakes and tributaries from all sources, including addressing continued development pressures and potential for increases in polluted runoff.

Actions such as these will be critical in preventing new perturbations as well as enabling the recovery process. Addressing nonnative species introductions is a key issue. Unlike chemical pollution (except in extreme cases of local pollution), nonnative species, if established, can be extremely difficult to control and have the potential to engineer the ecosystem to a significantly altered state.

3. Protect Healthy Functioning Elements

Sustainable development practices within the Great Lakes basin are required to preserve those portions of the ecosystem that now are healthy, and those that can be restored or enhanced. Recovery of healthy nearshore communities and tributaries, once begun, must be maintained; the conditions that caused the impairments in the first place must be addressed. Watershed-based approaches to land use management provide the best opportunity to minimize negative impacts on the surface water and groundwater essential to the sustainability of the Great Lakes ecosystem. Actions should support and expand activities that employ holistic, watershed-based approaches to land and water use decisions.

4. Monitor Ecosystem Health

Monitoring the ecosystem response through an agreed-upon set of integrative indicators will be an extremely important part of any Great Lakes restoration effort. This effort should build on ongoing efforts such as the development and application of SOLEC indicators. Major changes in the ecosystem are occurring while many of the indicators that governments have traditionally used to measure Great Lakes health (water clarity, ambient water pollution levels, and certain contaminant levels in wildlife) are actually improving. Because nonlinear changes, such as those the Great Lakes are currently experiencing, may confound expected relationships between sources of stress and the lakes' response, traditional indicators may not be adequate descriptors of the health of the ecosystem and may not be useful in predicting future conditions. While some type of consensus on indicators is desirable, given the dynamic nature of the system and our understanding of it, flexibility must also be included in the development and use of indicators.

Certain features of the ecosystem appear to be particularly responsive to the seven sources of stress (including climate change) identified above. Emblematic species such as certain fish-eating birds and populations and reproductive health of key fish species (such as lake trout, lake herring, walleye, yellow perch, and lake sturgeon) as well as wetland sub-ecosystem complexes should clearly be

part of any monitoring program. In addition, monitoring should include a strong human health component, in particular involving tribal/First Nation communities and other populations heavily dependent on Great Lakes fisheries and other resources. There have been varying degrees of research on integrative indicators of ecosystem integrity with most effort focused on emblematic species and wetland complexes. Some evidence suggests smaller organisms at the bottom of the food chain respond more quickly to change, and thus monitoring micro- and macro-invertebrates might well reveal the earliest signs of ecosystem disruption and/or recovery (Odum, 1985).

A key issue for any monitoring network is the ability for rapid detection and identification of new threats, in particular aquatic invasive species. This is particularly important given the difficulty in controlling invaders once established, and the significant economic costs and ecological disruption nonnative species can cause (Pimentel et al., 2000). Use of predictive tools based in part on an understanding of existing invasions can assist in monitoring for potential invasive species (Ricciardi, 2003).

SUMMARY

The health of the Great Lakes ecosystem is in jeopardy. While a number of remediation and other activities have been pursued through the years to address Great Lakes problems, additional actions are urgently needed to restore system elements, particularly in critical nearshore/tributary zones where a chain reaction of adaptive responses to a suite of stresses may be leading to catastrophic changes: ecosystem breakdown and potentially irreversible ecosystem collapse. Without at least partial restoration of these areas, the negative symptoms being observed in the Great Lakes will likely intensify and could degrade irreversibly. Concurrently, actions are needed to control or eliminate sources of basinwide threats to the essential biological, physical, and chemical components of the Great Lakes' ecosystem stability and health. Finally, large areas of the Great Lakes basin waters remain relatively healthy and productive and they provide a wide range of benefits to the people of the region. Protecting the remaining areas from further stress is significantly more cost-effective than attempting restoration after damage has occurred. In summary,

- Historically, when faced with a particularly damaging ecosystem impact, policy responses have focused on particular symptoms and not on the integrated sources of stress that cause these symptoms.
- To increase the effectiveness of policy and on-the-ground restoration, sources of stress and, especially, interactions between those sources need to be explicitly considered.
- One way to prioritize efforts is to focus on specific geographic areas that have experienced ecosystem breakdown and develop efforts to address the multiple sources of stress that have contributed to these impacts.
- Some major sources of stress to the Great Lakes have broad implications and need to be addressed basin-wide since the sources (and their impacts) are not always limited to single locations.
- Watershed-based approaches offer the best opportunity to protect existing basin waters by establishing sustainable land and water use development practices.

LITERATURE CITED

Beeton, A.M., C.E. Sellinger, and D.E. Reid, 1999. An Introduction to the Laurentian Great Lakes Ecosystem. In W.W. Taylor and C.P. Ferreri, Eds., *Great Lakes Fishery Policy and Management: A Binational Perspective.* Michigan State University Press, pp. 3–54.

Charlton, M.N. 1987. Lake Erie oxygen revisited. *Journal of Great Lakes Research* 13:697–708.

Dermott, R., 2001. Sudden disappearance of the amphipod *Diporeia* from eastern Lake Ontario, 1993–1995. *Journal of Great Lakes Research* 27:423–433.

Dermott, R., and D. Kerec. 1997. Changes to the deepwater benthos of eastern Lake Erie since the invasion of Dreissena: 1979–1993. *Canadian Journal of Fisheries and Aquatic Sciences* 54:922–930.

Domske, H.M., 2003. Botulism in Lake Erie Workshop Proceedings, Co-sponsored by New York Sea Grant, Ohio Sea Grant, and Pennsylvania Sea Grant, April 3, 2003, Buffalo, NY.

Eshenroder, R.L. and M.K. Burnham-Curtis. 1999. Species succession and sustainability of the Great Lakes fish community. In W.W. Taylor and C.P. Ferreri, Eds., *Great Lakes Fishery Policy and Management: A Binational Perspective.* Michigan State University Press. pp. 145–184.

Fielder, D.G. and M.V. Thomas, 2005 (in press), Fish Population Dynamics of Saginaw Bay, Lake Huron, 1998–2004. Michigan Department of Natural Resources Fisheries Research Report.

Great Lakes Environmental Research Laboratory (GLERL), 2003. Decline in Lake Michigan Bottom Life, brochure, available at: *http://www.glerl.noaa.gov/pubs/brochures/dipoflyer/dipo.html*

Hecky, R.E., R.E.H. Smith, D.D. Barton, S.J. Guilford, W.D. Taylor, M.N. Charlton, and T.E. Howell. 2004. The Nearshore Phosphorus Shunt: A Consequence of Ecosysyem Engineering By Dreissenids in the Laurentian Great Lakes. *Canadian Journal of Fisheries and Aquatic Sciences* 61:1285–1293.

Holeck, K.T., E.L. Mills, H.J. McIsaac, M.R. Dochoda, R.I. Colautti, and A. Ricciardi, 2004. Bridging Troubled Waters: Biological Invasions, Transoceanic Shipping, and the Laurentian Great Lakes. *Bioscience* 54:919–929.

Hondorp, D.W., S.A. Pothoven, S.A., and S.B. Brandt, 2005. Influence of Diporeia Density on Diet Composition, Relative Abundance, and Energy Density of Planktivorous Fishes in Southeast Lake Michigan. *Transactions of the American Fisheries Society* 134:588–601.

Honeyfield, D.C., Hinterkopf, J.P., Fitzsimons, J.D., Tillitt, D.E., Zajicek, J.L., and Brown, S.B. (2005). Development of thiamine deficiencies and early mortality syndrome in lake trout by feeding experimental and feral fish diets containing thiaminase. *Journal of Aquatic Animal Health* 17:4–12.

International Joint Commission (IJC), 2000. 10th Biennial Report on Great Lakes Water Quality, International Joint Commission, July 2000. Available at: *http://www.ijc.org/php/publications/html/10br/en/indexen.html*

IJC, 2002. 11th Biennial Report on Great Lakes Water Quality, International Joint Commission, September 2002, Available at: *http://www.ijc.org/php/publications/html/11br/english/report/index.html*

IJC, 2004.12th Biennial Report on Great Lakes Water Quality, International Joint Commission, September 2004, Available at: *http://www.ijc.org/php/publications/html/12br/english/report/index.html*

Johnson, B.L., H.E. Hicks, D.E. Jones, W. Cibulas, A. Wargo, and C.T. De Rosa, 1998. Public Health Implications of Persistent Toxic Substances in the Great Lakes and St. Lawrence Basins. *Journal of Great Lakes Research* 24:698–722.

Kay, J.J., and H.A. Regier, 1999. An ecosystemic two-phase attractor approach to Lake Erie's ecology. In: M. Munawar, T. Edsall & I.F. Munawar, Eds., *State of Lake Erie (SOLE)—Past, Present and Future.* Ecovision World Monograph Series, Backhuys Publishers, Leiden, The Netherlands, pp. 510–533.

Kitchell, J.F., S.P. Cox, C.J. Harvey, T.B. Johnson, D.M. Mason, K.K. Schoen, K. Aydin, C. Bronte, M. Ebener, M. Hansen, M. Hoff, S. Schram, D. Schreiner, and C.J. Walters, 2000. Sustainability of the Lake Superior Fish Community: Interactions in a Food Web Context. *Ecosystems* 3:545–560.

Kling, G.W., K. Hayhoe, L.B. Johnson, J.J. Magnuson, S. Polasky, S.K. Robinson, B.J. Shuter, M.W. Wander, D.J. Wuebbles, D.R. Zak, R.L. Lindroth, S.C. Moser, and M.L. Wilson, 2003. *Confronting Climate Change in the Great Lakes: Impacts on Our Communities and Ecosystems,* Union of Concerned Scientists, Cambridge, Massachusetts and Ecological Society of America, Washington, D.C.

Lozano, S.J., J.V. Scharold, and T.F. Nalepa. 2001. Recent Declines in Benthic Macroinvertebrate Densities in Lake Ontario. *Canadian Journal of Fisheries and Aquatic Sciences* 58:518–529.

Madenjian, C.P., Fahnenstiel, G.L., Johengen, T.H., Nalepa, T.F., Vanderploeg, H.A., Fleischer, G.W., Schneeberger, P.J., Benjamin, D.M., Smith, E.B., Bence, J.R., Rutherford, E.S., Lavis, D.S., Robertson, D.M., Jude, D.J., Ebener, M.P., 2002. Dynamics of the Lake Michigan Food Web, 1970–2000. *Canadian Journal of Fisheries and Aquatic Sciences* 59(4):736–753.

Magnuson, J.J., Webster, K.E., Assel, R.A., Bowser, C.J., Dillon, P.J., Eaton, J.G.., Evans, H.E., Fee, E.J., Hall, R.I., Mortsch, L.R., Schindler, D.W., Quinn, F.H., 1997. Potential Effects of Climate Changes on Aquatic Systems: Laurentian Great Lakes and Precambrian Shield Region. *Hydrological Processes* 11(8):825–871.

Makarewitz, J.C. and P. Bertram. 1991. Evidence for the Recovery of the Lake Erie Ecosystem. *Bioscience* 41:216–223.

McDonald, G.J., D. Fitzsimond, and D.C. Honeyfield, Eds. 1998. Early Life Stage Mortality Syndrome in Fishes of the Great Lakes and Baltic Sea. Proceedings of American Fisheries Society Symposium 21, American Fisheries Society, Bethesda, Maryland.

Mills, E.L., J.M. Casselman, R. Dermott, J.D. Fitzsimons, G. Gal, K.T. Holeck, J.A. Hoyle, O.E. Johannsson, B.F. Lantry, J.C. Makarewicz, E.S. Millard, I.F. Munawar, M. Munawar, R. O'Gorman, R.W. Owens, L.G. Rudstam, T. Schaner, and T.J. Stewart. 2003. Lake Ontario: Food Web Dynamics in a Changing Ecosystem (1970–2000). *Canadian Journal of Fisheries and Aquatic Sciences* 60:471–490.

Nalepa, T.F. 1998. Dramatic changes in benthic macroinvertebrate populations in southern Lake Michigan. *Aquatic Nuisance Species Update* 4(3):1.

Nalepa, T.F., D.J. Hartson, G.W. Gostenik, D.L. Fanslow, and G.A. Lang, 1996. Changes in the Freshwater Mussel Community of Lake St Clair: From Unionidae to Dreissena Polymorpha in Eight Years. *Journal of Great Lakes Research* 22:354–369.

Nalepa, T.F., D.J. Hartson, D.L. Fanslow, G.A. Lang, and S.J. Lozano. 1998. Declines in Benthic Macroinvertebrate Populations in Southern Lake Michigan, 1980–1993. *Canadian Journal of Fisheries and Aquatic Sciences* 55(11):2402–2413.

Nalepa, T.F., D.L. Fanslow, M.B. Lansing, and G.A. Lang, 2003. Trends in the Benthic Macroinvertebrate Community of Saginaw Bay, Lake Huron, 1987 to 1996: Responses to Phosphorus Abatement and the Zebra Mussel, Dreissena Polymorpha. *Journal of Great Lakes Research* 29:14–33.

Odum, E.P. 1985. Trends to be Expected in Stressed Ecosystems. *Bioscience* 35:419–422.

Ontario Ministry of the Environment (MOE), 2005. Guide to Eating Ontario Sport Fish, 2005–2006.

Pimentel, D., Lach, L., Zuniga, R., and Morrison, D. 2000. Environmental and Economic Costs of Nonindigenous Species in the United States. *Bioscience* 50:53–65.

Pothoven, S.A., T.F. Nalepa, P.J. Schneeberger, and S.B. Brandt, 2001. Changes in diet and body condition of lake whitefish in southern Lake Michigan associated with changes in benthos. *North American Journal of Fisheries Management* 21:876–883.

Rapport, D.J., H.A. Regier and T.C. Hutchinson. 1985. Ecosystem Behavior Under Stress. *The American Naturalist* 125:617–640.

Rapport, D.J. and H.A. Regier. 1995. Disturbance and stress effects on ecological systems. In B. Patten and S.E. Jörgensen, Eds. *Complex Ecology: The Part-whole Relation in Ecosystems.* Prentice Hall, Englewood Cliffs, New Jersey, pp. 397–414.

Ricciardi, A. 2001. Facilitative Interactions Among Aquatic Invaders: Is an 'Invasional Meltdown' Occurring in the Great Lakes? *Canadian Journal of Fisheries and Aquatic Sciences* 58:2513–2525.

Ricciardi, A., 2003. Predicting the Impacts of an Introduced Species From Its Invasion History: An Empirical Approach Applied to Zebra Mussel Invasions. *Freshwater Biology* 48:972–981.

Ricciardi, A. 2005. Facilitation and synergistic interactions among introduced aquatic species. In: H.A. Mooney, R.N. Mack, J. McNeely, L.E. Neville, P.J. Schei, J.K. Waage, Eds. *Invasive Alien Species: A New Synthesis.* Island Press, Washington, D.C., pp. 162–178.

Rosa, F. and N.M. Burns. 1987. Lake Erie Central Basin Oxygen Depletion Changes From 1929–1980. *Journal of Great Lakes Research* 13:684–696.

Scheffer, M., S. Carpenter, J.A. Foley, C. Folke, and B. Walker. 2001. Catastrophic Shifts in Ecosystems. *Nature* 413:591–596.

Scientific Consensus. 2005. Scientific Consensus Statement on Marine Ecosystem-Based Management. Released March 21, 2005, at House Ocean Caucus Luncheon, Washington D.C. Communication Partnership for Science and the Sea. Available: *http://compassonline.org/files/inline/EBM%20Consensus%20Statement_FINAL_Mar%2021%2005_up.pdf.* (May 2005).

Sproule-Jones, M. 2003. *Restoration of the Great Lakes: Promises, Practices, Performances.* Vancouver: UBC Press, 160 pp.

Steedman, R.J., and H.A. Regier. 1987. Ecosystem Science for the Great Lakes: Perspectives on Degradative Transformations. *Canadian Journal of Fisheries and Aquatic Sciences* 44, Supplement 2:95–130.

United Nations. 2005. Millennium ecosystem assessment synthesis report. United Nations Environment Programme (UNEP), Millennium Ecosystem Assessment Secretariat. Available: *http://www.millenniumassessment.org/en/Products.Synthesis.aspx.* (May 2005).

U.S. Environmental Protection Agency and Environment Canada, 2004. Lake Erie LaMP 2004 Report, prepared by Lake Erie LaMP Workgroup.

U.S. Environmental Protection Agency, 2005. National List of Fish Advisories database, available at: *http://epa.gov/waterscience/fish/advisories/*

U.S. General Accounting Office (GAO—now Government Accountability Office), 2003, Great Lakes: An Overall Strategy and Indicators for Measuring Progress Are Needed to Better Achieve Restoration Goals, GAO–03–515, April 2003.

Vanderploeg, H. 2002. The zebra mussel connection: Nuisance algal blooms, Lake Erie anoxia, and other water quality problems in the Great Lakes, Great Lakes Environmental Research Laboratory flyer, revised September 2002.

Whelan, G.E. and J.E. Johnson. 2004. Successes and failures of large scale ecosystem manipulation using hatchery production: the Upper Great Lakes experience. In M.J. Nickum, P.M. Mazik, J.G. Nickum and D.D. MacKinlay, Eds. *Propagated Fish in Resource Management.* American Fisheries Society, Symposium 44, Bethesda, Maryland, pp. 3–32.

ADDITIONAL GENERAL REFERENCES

Beeton, A.M. 1966. Indices of Great Lakes Eutrophication. Great Lakes Research Division, University of Michigan, Publication 15, Ann Arbor, Michigan.

Beeton, A.M., and W.T. Edmondson. 1972. The Eutrophication Problem. *Journal of the Fisheries Research Board of Canada* 29:673–682.

Cook, P., J.A. Robbins, D.D. Endicott, K.B. Lodge, P.D. Guiney, M.K. Walker, E.W. Zabelo, and R.E. Peterson. 2003. Effects of aryl hydrocarbon receptor-mediated early life stage toxicity on lake trout populations in Lake Ontario during the 20th century. *Environmental Science and Technology* 37:3864–3877.

Dobson, T., H.A. Regier, and W.W. Taylor. 2002. Governing Human Interactions With Migratory Animals, With a Focus on Humans Interacting With Fish in Lake Erie: Then, Now, and in the Future. *Canada-United States Law Journal* 28:389–446.

Edwards, C.J., and H.A. Regier, editors. 1990. An ecosystem approach to the integrity of the Great Lakes in turbulent times. Great Lakes Fishery Commission, Special Publication 90–4, Ann Arbor, Michigan.

Gladwell, M. 2000. *The Tipping Point: How Little Things Can Make a Big Difference.* Little, Brown and Company, Boston, MA.

Hecky, R.E., R.E.H. Smith, D.R. Barton, S.J. Guildford, W.D. Taylor, M.N. Charlton, and T.H. Howell. 2004. The Nearshore Phosphorus Shunt: Consequences of Ecosystem Engineering by Dreissenids in the Laurentian Great Lakes. *Canadian Journal of Fish and Aquatic Sciences* 61:1285–1293.

Holsen, T.M., M. Cohen, T.J. Holsen, and A. Corso. 2004. The Ann Arbor Statement: Actions to Improve Atmospheric Transport and Deposition Science, resulting from Great Lakes Binational Toxics Strategy Long Range Transport Workshop: The Atmospheric Pathway of Toxic Substances in the Great Lakes, Sept. 16–17, 2003, Ann Arbor, MI.

Hubbs, C.L., and K.F. Lagler, 2004. *Fishes of the Great Lakes Region, Revised Edition,* revised by G.R. Smith, University of Michigan Press, Ann Arbor, MI, 276 pp.

Kay, J.J., and H.A. Regier. 1999. An ecosystem two-phase attractor approach to Lake Erie's ecology. In M. Munawar, T. Edsal, and I.F. Munawar, Eds., *State of Lake Erie (SOLE)—Past, Present and Future.* Ecovision World Monograph Series, Backhuys Publishers, Leiden, The Netherlands, pp. 511–533.

Koestler, A., and J.R. Smythies, Eds. 1976. *Beyond Reductionism.* Hutchinson, London.

Loftus, K.H., and H.A. Regier, Eds. 1972. Proceedings of the Salmonid Communities in Oligotrophic Lakes (SCOL) Symposium. *Journal of the Fisheries Research Board of Canada* 29:613–986.

Margalef, R. 1968. *Perspectives in Ecological Theory.* University of Chicago Press, Chicago.

Odum, E.P. 1969. The Strategy of Ecosystem Development. *Science* 64:262–270.

Regier, H.A. and W.L. Hartman. 1973. Lake Erie's Fish Community: 150 Years of Cultural Stress. *Science* 180:1248–1255.

Regier, H.A. and J.J. Kay. 1996. An Heuristic Model of the Transformations of the Aquatic Ecosystems of the Great Lakes-St. Lawrence River basin. *Journal of Aquatic Ecosystem Health* 5:3–21.

Regier, H.A., T.H. Whillans, W.J. Christie, and S.A. Bocking. 1999. Over-Fishing in the Great Lakes: The Context and History of the Controversy. *Aquatic Ecosystem Health and Management* 2:239–248.

Reynoldson, T.B., and A.L. Hamilton. 1993. Historic changes in populations of burrowing mayflies *(Hexagenia limbata)* from Lake Erie based on sediment tusk profiles. *Journal of Great Lakes Research* 19:250–257.

Schneider, J.C., and J.H. Leach. 1979. Walleye Stocks in the Great Lakes, 1800–-1975: Fluctuations and Possible Causes. *Great Lakes Fisheries Commission Technical Report* 31:1–51.

Selye, H. 1974. *Stress Without Distress.* J.P. Lippincott, Philadelphia, Pennsylvania.

Van Oosten, J. 1930. The Disappearance of the Lake Erie Cisco—A Preliminary Report. *Transactions of the American Fisheries Society* 60:204–214.

Vallentyne, J.R. 1974. The algal bowl. Canada Department of Environment, Miscellaneous Publication 22, Ottawa, Ontario.

Vanderploeg, H.A., Nalepa, T.F., Jude, D.J., Mills, E.L., Holeck, K.T., Liebig, J.R., Grigorovich, I.A., and Ojaveer, H. 2002. Dispersal and Emerging Ecological Impacts of Ponto-Caspian Species in the Laurentian Great Lakes. *Canadian Journal of Fisheries and Aquatic Sciences* 59:1209–1228.

Verduin, J. 1964. Changes in Western Lake Erie During the Period 1948–1962. *Verh. Internat. Verein. Limnol.* 15:639–644.

Vollenweider, R.A. 1968. Scientific fundamentals of the eutrophication of lakes and flowing waters with particular reference to phosphorus and nitrogen as factors in eutrophication. OECD, Technical Report DAS/CSI/68, Paris.

Vollenweider, R.A. 1990. Eutrophication: conventional and non-conventional considerations and comments on selected topics. Pages 77–134 in R. De Benardi, G. Giussani, and L. Barbanti, Eds., *Scientific Perspectives in Theoretical and Applied Limnology.* Memorie dell'Istituto Italiano di Idrobiologia Dott. Marco de Marchi. Verbania Pallanza, Italy.

Vollenweider, R.A., M. Munawar, and P. Stadelman. 1974. A Comparative Review of Phytoplankton and Primary Production in the Laurentian Great Lakes. *Journal of the Fisheries Research Board of Canada* 31:739–762.

Acknowledgments

The development of this white paper (including meetings and discussions among the authors and other scientists) was made possible through the generous support of the Wege Foundation and the Joyce Foundation. The views expressed in the paper are those of the authors, and do not necessarily represent the views of the financial supporters.

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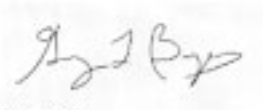

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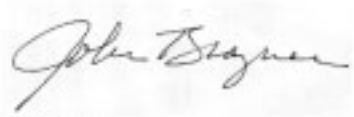

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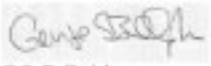

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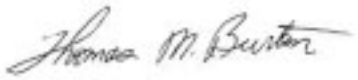

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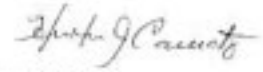

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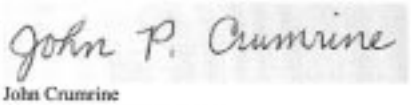

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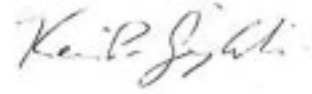

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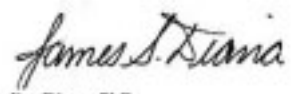

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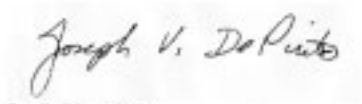

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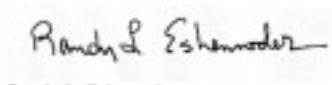

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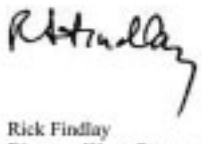

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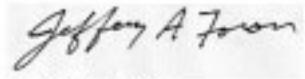

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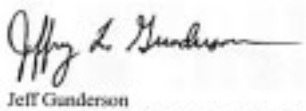

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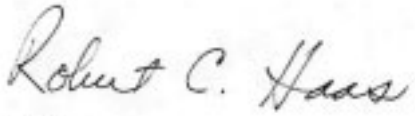

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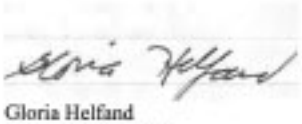

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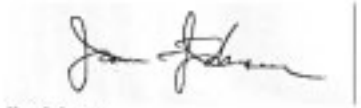

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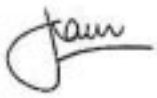

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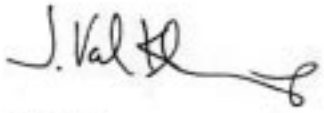

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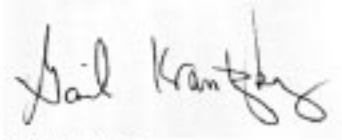

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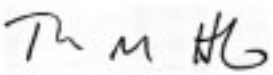

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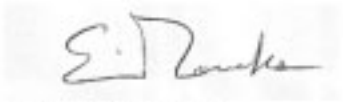

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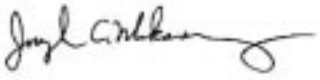

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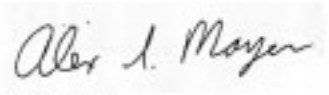

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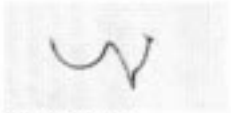

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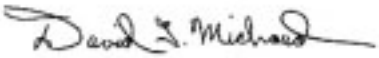

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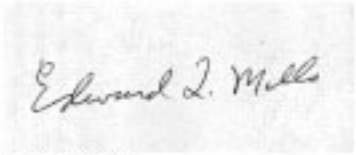

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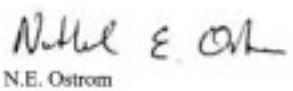

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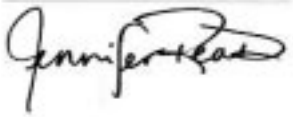

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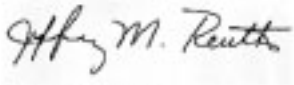

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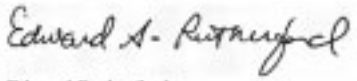

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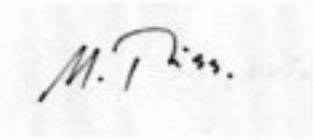

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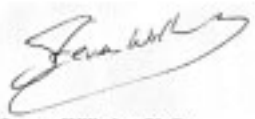

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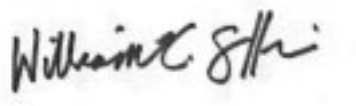

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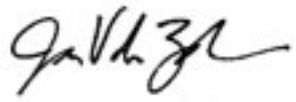

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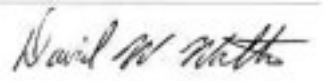

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