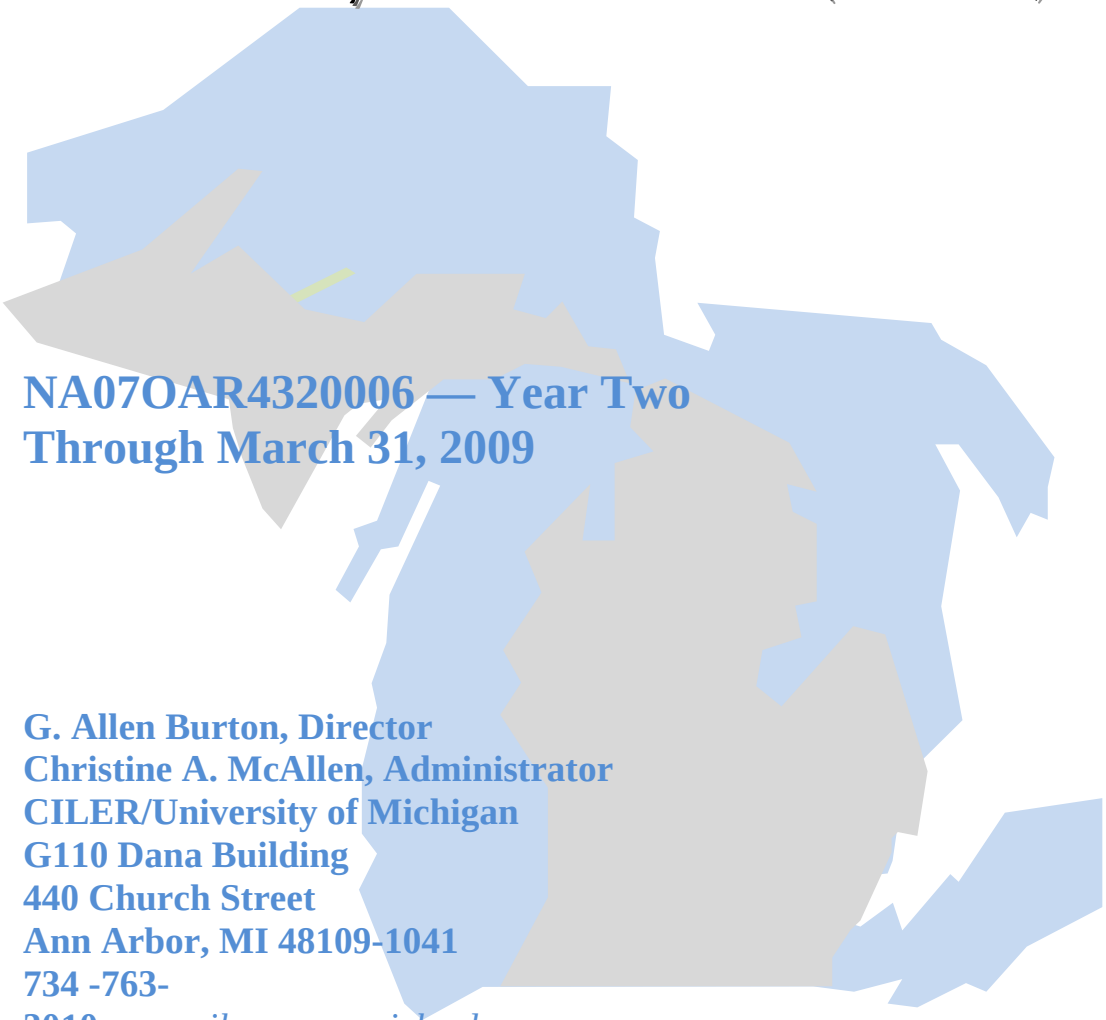
2008-2009
ANNUAL REPORT

Cooperative Institute for Limnology and Ecosystems Research (CILER)



NA07OAR4320006 — Year Two
Through March 31, 2009

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Cooperative Institute for Limnology and Ecosystems Research - **CILER**

Annual Report for NA07OAR4320006
Year Two: Through March 31, 2009

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Cooperative Institute for Limnology and Ecosystems Research (CILER)

G. Allen Burton, Director
Christine A. McAllen, Administrator
University of Michigan
Ann Arbor, Michigan

ANNUAL REPORT for NA07OAR4320006
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Executive Summary

The Cooperative Institute for Limnology and Ecosystems Research (CILER) was originally established in 1989, with the objective of fostering University and NOAA partnerships in the Great Lakes region. The renewal of the CILER Cooperative Agreement went into effect in July of 2007. This agreement was awarded to the University of Michigan (host institution) and nine partner universities (Michigan State University, University of Toledo, Grand Valley State University, University of Minnesota Duluth, University of Wisconsin, University of Illinois at Urbana Champaign, Ohio State University, State University of New York at Stony Brook, Penn State University). Since the renewal of this new agreement has been in effect, CILER supported 30 project grants that total over $4.2 million in research funding.

The past year was a transition year for CILER and their host NOAA facility, the Great Lakes Environmental Research Laboratory (GLERL). In August 2008, Dr. G. Allen Burton began as the new Director of CILER, and then in January 2009, Dr. Marie Colton, assumed duties as Acting Director of GLERL.

CILER currently conducts research that falls under five of the six different research themes: 1) ecosystem forecasting; 2) invasive species; 3) coastal observing systems; 4) protection and restoration of resources; 5) integrated assessments, and; 6) education and outreach. Research conducted under the ecosystem forecasting theme aims to develop forecasts for physical hazards, water levels, and harmful algal blooms, and fish recruitment and production. Research in the second theme, invasive species, focuses on the prevention, monitoring, detection, and control of invasive species, and on a better understanding of the range of their ecosystem impacts. Research in the third theme, coastal observing systems, focuses on providing observing system data and platforms, data management and communications, and data products and

forecasts needed for effective environmental management, and for monitoring and understanding ecosystem responses to natural and anthropogenic conditions. The fourth theme, protection and restoration of resources, supports research to protect, restore, or enhance priority coastal land and water habitats throughout the basin. Research projects in the fifth theme, integrated assessments, generate policy-relevant and synthetic efforts to help guide long-term resource use in the basin. Finally, research conducted under the education and outreach theme facilitates education and outreach activities for NOAA in the Great Lakes region.

The Regional Ocean Sciences Bowl was hosted again by CILER for 16 high school teams in the Great Lakes. This exciting competition continues to grow and consisted of a weekend competition at the University of Michigan. The winning team participates in the national competition in Washington DC in May 2009. CILER organized their eleventh Summer Student Fellows Program, which supports 24 undergraduate and graduate students (10 international). Over 250 applications were received from this national and international competition. Students participate on research projects with NOAA scientists within the Great Lakes.

CILER's Mission

CILER's overarching missions are to:

- To meet the needs for ecosystem and human systems research in the regions that are reflected in NOAA's mission and objectives. CILER will foster this mission by serving as a center of excellence for scientific, education and outreach in the Great Lakes basin, and a portal to the universities of the region.

- To fully engage participants from universities throughout the Great Lakes region that carry out research, education, and outreach in order to help address NOAA's highest priorities in the Great Lakes region.

- To engage in research that improves understanding of the fundamental physical, chemical, biological, ecological, social, and economic processes operating in the Great Lakes region and identifying the critical socio-economic drivers and feedback shaping natural resource use and conservation.

- To improve forecasts that facilitate restoration and protection of critical natural resources, help guide management decisions, and support sustainable economic development in the region.

- To disseminate scientific information for the general public, highlight NOAA research initiatives in the region, and provide training opportunities for students, teachers, and the general public.

Summary of Research Activities

This report details project activities through the first two years of the new cooperative agreement with updates covering the period through March 31, 2009. During this period CILER administered 30 projects, with the majority being in the Great Lakes Forecasting research theme (Table 1, Figure 1). The total funding level for the first two years of the cooperative agreement is $4,234,378.

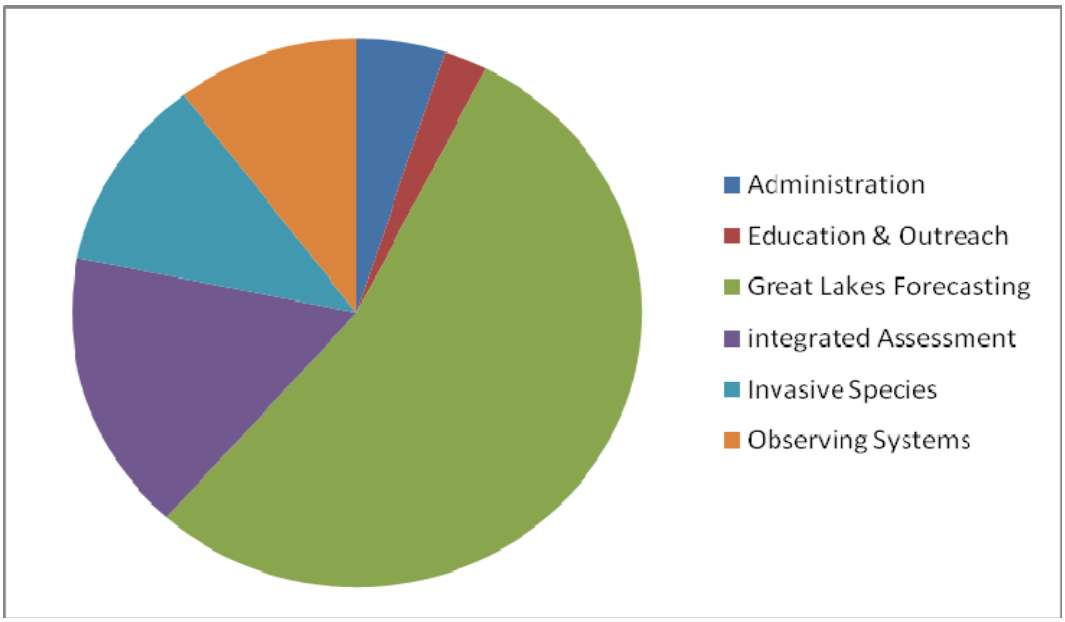

Figure 1. Funding distribution for CILER by theme through 03/31/09.

Table 1. Breakdown of funding by Theme awarded to CILER for the current Cooperative Agreement, NA07OAR4320006, through March 31, 2009.

Task	Research Theme	#Projects	Funding ($)	%Funding
II	Theme I: Great Lakes Forecasting	17	$2,412,799	57%
II	Theme II: Invasive Species	5	$507,346	12%
II	Theme III: Observing Systems	6	$463,662	11%
II	Theme IV: Protection and Restoration of Resources	0	0	0%
II	Theme V: Integrated Assessment	1	$739,542	17%
II	Theme VI: Education and Outreach	1	$111,029	3%
Totals		30	$4,234,378	100%

Table 2. Breakdown of funding by Theme awarded to CILER for the current Cooperative Agreement, NA07OAR4320006, through March 31, 2009. These funds are used to cover 50% of Director's and Administrator's salary, as well as travel expenses related to annual meeting and consortium coordination.

Task	Research Theme	#Projects	Funding ($)	%Funding
I	Administration	1	$223,867	5%

Table 3. Breakdown of subcontract funding by institution:

Case Western Reserve University	$42,041
Duke University	$50,192
E2 Engineering	$75,000
Grand Valley State University	$39,499
Heidleberg University	$29,841
LimnoTech	$85,772
Michigan State University	$296,689
Michigan Technological University	$5,000
Ohio State University	$50,099
Purdue	$203,826
Smithsonian	$102,640
State University of New York	$30,011
University of Minnesota	$23,300
University of Wisconsin	$83,929
University of South Florida	$15,175
Upstate Freshwater Institute	$5,000
Wayne State University	$69,258
Western Michigan University	$53,800
Total	**$1,261,072**

Administrative Activities

CILER research staff and administrators worked with NOAA partners to plan for new facilities and assess stakeholder needs. CILER staff assisted NOAA administrators in the planning and move of the NOAA-GLERL's new building which opened in January 2009. CILER scientists co-hosted a workshop by NOAA in August 2008 to assess research and forecasting needs of stakeholders to adapt to climate change in the Great Lakes.

Significant changes were made in the administration of CILER during the second year of CILER. A joint search was conducted for a permanent CILER director by the University of Michigan School of Natural Resources and Environment (UM-SNRE) and NOAA GLERL. Dr. Allen Burton of Wright State University was chosen to serve as permanent director of the new CILER. Dr. Burton started as CILER Director on Aug. 1 2008, and has a joint appointment as Professor in UM-SNRE. Dr. Burton's expertise and leadership in ecological toxicology and risk assessment should greatly enhance NOAA's capabilities in this area. He began working closely in January with Dr. Marie Colton, Acting Director of GLERL.

Council of Fellows/Executive Board

Under the new CILER, membership of the Executive Board will expand to include administrative representatives from the partner universities and senior NOAA leadership. The Council of Fellows for the new CILER provides review of the scientific direction of the new CILER, and will include directors of the Great Lakes Sea Grant programs, with additional representation by NOAA and university scientists. The Executive Board, whom approves the membership of the Council of Fellows, is comprised of senior NOAA managers, Vice President of Research from the 9 participating universities, the Dean of SNRE, and GLERL Director. Meetings of the Executive Board and Council of Fellows of the new CILER are scheduled for summer 2009. These important administrative support elements (and the CILER/NOAA Memorandum of Agreement) were not implemented during the past year due to the departure of Dr. Steve Brandt as GLERL Director and the transition of Dr. Marie Colton into her new role as Acting Director. Now that the transition is complete and both administrative and budgetary issues have been addressed, these elements can be implemented.

Members of the Executive Board and Council of Fellows for the old CILER are listed below. These boards last met in March and April, respectively in 2005.

Membership of the old CILER Executive Board

Stephen Forrest, Vice President for Research, University of Michigan
J. Ian Gray, Vice President for Research, Michigan State University
Rosina Bierbaum, Dean, School of Natural Resources & Environment, UM
Alexander MacDonald, OAR Deputy Administrative Assistant
Stephen B. Brandt, Director, Great Lakes Environmental Research Lab.

Membership of the old CILER Council of Fellows

James Diana, Professor and Associated Dean, SNRE
Brian Eadie, Scientist, NOAA-GLERL
Val Klump, University of Wisconsin - Milwaukee
Peter F. Landrum, Scientist, NOAA-GLERL
David Reid, Scientist, NOAA-GLERL
Jeffrey Reutter, Ohio State University, Ohio Sea Grant Program
David Schwab, Scientist, NOAA-GLERL
William Taylor, Michigan State University, Michigan Sea Grant Program
Henry Vanderploeg, Scientist, NOAA-GLERL

THEME I: GREAT LAKES FORECASTING

CILER activities that fall under the theme of Great Lakes Forecasting include research focusing on developing forecasts for physical hazards, water levels, and harmful algal blooms, and fish recruitment and production.

PROJECT TITLE: FISH ECOLOGY AND ECOSYSTEM FORECASTING OF THE GREAT LAKES AND CHESAPEAKE BAY

Principal Investigators: *Stephen Brandt*

Allen Burton, CILER

Overview and Objectives

Fishery managers in the Great Lakes and coastal marine systems need to be able to make predictions as they attempt to manage fisheries in ecosystems that are constantly changing. Problems such as habitat loss, eutrophication, non-indigenous species invasions, and climate change all pose challenges to making the predictions that are needed in fishery management scenarios. For example, in the Great Lakes, recent changes in the benthic community, particularly the invasion by Dreissena mussels and subsequent decline of Diporeia, have been tied to changes in planktivorous fish distribution and abundance. The invasion of the predatory zooplanktors, Bythotrephes longimanus and Cercopagis pengoi may be affecting fish diet selectivity and zooplankton availability. Changes in forage fish abundance, condition, and distribution may be affecting predator fish (Pacific salmon, lake trout) condition and distribution in Lake Huron. Changes in lake whitefish condition and distribution are affecting commercial fishery harvests in Lakes Ontario, Huron, and Michigan. In Lake Erie, low productivity and forage fish abundance may be contributing to low harvests of walleye in the lake. In the Chesapeake Bay, eutrophication and introduced bacteria have affected Morone spp. fisheries, and the harmful parasite MSX that is devastating oyster fisheries may be an introduced species.

The objectives of this project are to:
-Improve our knowledge and understanding of food web processes and dynamics and their relationship to environmental quality and living resources in Great Lakes and the Chesapeake Bay with an emphasis on fish ecology.

-Apply this knowledge to better understand the impact of hypoxia on fishes. A comparison across the Chesapeake Bay and Great Lakes will provide further insight.

Accomplishments

1. Two consecutive searches were conducted to hire a Post Doctoral Scientist for this project and interviews are underway.
2. The main ongoing accomplishment is the publication of a dedicated issue of the Journal of Experimental Biology and Ecology on "The Impact of Hypoxia on Living

Resources" where over 20 papers will be published. The Principal Investigator is serving as a co-editor of the issue.

3. A number of analyses and manuscripts were completed on effects of hypoxia on distribution, predator-prey interactions and bioenergetic growth potential for striped bass and bay anchovy in the Chesapeake Bay and yellow perch and walleye in Lake Erie. Most of this work has been submitted and is now in press (see list below).

Publications

1. Costantini, M., S.A. Ludsin, D.M. Mason, X. Zhang, W.C. Boicourt, and S.B. Brandt. 2008. Effect of hypoxia on habitat quality of striped bass (Morone saxatilis) in Chesapeake Bay. Canadian Journal of Fisheries and Aquatic Sciences 65:898-1002.

2. Pothoven, S. A., Vanderploeg, H. A., Ludsin, S. A., Hook, T. O. & Brandt, S. B. 2009. Feeding ecology of emerald shiners and rainbow smelt in central Lake Erie. J. Great Lakes Res. ***In Press.***

3. Roberts, J.J., T.O. Höök, S.A. Ludsin, S.A. Pothoven, H.A. Vanderploeg, and S.B. Brandt. 2009. Effects of hypolimnetic hypoxia in Lake Erie's central basin on foraging and distribution of yellow perch. Journal of Experimental Marine Biology and Ecology. ***In Press.***

4. Vanderploeg, H.A., S.A. Ludsin, J.F. Cavaletto, T.O. Höök, S.A. Pothoven, S.B. Brandt, J.R. Liebig and G.A. Lang. 2009. Lake Erie dead zone: zooplankton refuge from visual predation or habitat compressor and planktivory accelerator? – It depends on zooplankton species and dissolved oxygen concentration. Journal of Experimental Marine Biology and Ecology. ***In Press.***

5. Ludsin, S.A., X. Zhang, S.B. Brandt, M.R. Roman, W.C. Boicourt, D.M. Mason, and M.Costantini. 2009. Hypoxia-avoidance by planktivorous fish in Chesapeake Bay: implications for food web interactions and fish recruitment. Journal of Experimental Marine Biology and Ecology. ***In Press.***

6. Brandt, S.B., M.Gerkin, K. Hartman, E. Demers. 2008. Effects of hypoxia on food consumption and growth of juvenile striped bass (Morone saxatilis). Journal of Experimental Marine Biology and Ecology. ***In Press.***

7. Vanderploeg, H.A., S.A. Ludsin, S.A. Ruberg, T.O. Hook, S.A. Pothoven, S. B. Brandt, G.A. Lang, J.R. Liebig,and J.F. Cavaletto . 2009. Hypoxia affects spatial distributions and overlap of pelagic fish, zooplankton and phytoplankton in Lake Erie. Journal of Experimental Marine Biology and Ecology. ***In Press.***

Presentations

1. Brandt, S.B., M. Costantini, S.A. Ludsin, D.M. Mason, and H.A. Vanderploeg. 2008. Spatially-explicit growth predictions to assess habitat quality of walleye during hypoxia in Lake Erie. Oral presentation at the International Association for Great Lakes Research 51st Annual Conference on Great Lakes Research, Peterborough, ON. May 20.

PROJECT TITLE: CLIMATE IMPACTS ON GREAT LAKES ECOSYSTEMS

Principal Investigators: *Doran Mason, GLERL*

Michael Quigley, Margaret Lansing, GLERL

Sonia Joseph, CEGLHH

Jeffery Reutter, CILER, Ohio Sea Grant Director

Allen Burton, CILER

Overview and Objectives

BACKGROUND

The Great Lakes, being the largest surface freshwater source in the world, not only provides drinking water for over 40 million people, but is the home for hundreds of diverse species. Economically viable, the Great Lakes provide a pathway for commercial shipping, hydropower production and recreation. Now that the world is entering a period of unusually rapid climate change, stakeholders need to know how these changes will affect their daily and long-term lives on the Great Lakes.

NOAA is congressionally mandated to research and provide products on the changing climate to the public. GLERL has researched climate change impacts on the Great Lakes water resources since the 1980s. This proposal is the first step in applying NOAA's climate research to understanding the impacts that climate change will have on Great Lakes ecosystems.

PROJECT DESCRIPTION

The proposed activity is to conduct a public workshop resulting in knowledge of products and services the public and private sectors need to mitigate the impacts of climate change on their daily lives. Specifically, the workshop's focus is to:

1) Assess the state of the climate change science in the Great Lakes and globally;
2) Assess the research direction for NOAA—mission relevant; and,
3) Assess the types of products and services needed by Great Lakes user communities.

WORK PLAN

Project funds are requested to hold a four-day workshop. The first day, open to the public, will consist of invited speakers that will talk about a range of subjects, some of which are: 1) evidence for climate change and human impact on the process, 2) climate impacts on ecosystems; 3) NOAA's climate research and products; 4) climate impacts on the Great Lakes water resources; 5) a summary of our ability to predict the impacts of climate change, and 6) strategies for the mitigation of climate changes. The second day will consist of facilitated public input on the various topics. The third and fourth days will consist of facilitated discussions by the invited experts and others on how to develop present and future products and services and engage Great Lakes managers and users to maximize the value of the products and services.

Accomplishments

The Climate Change workshop "Impact of Climate Change on the Great Lakes Ecosystem - A NOAA Science Needs Assessment Workshop to Meet Emerging Challenges" was held July 29-31, 2008.

Hosted by:

NOAA Great Lakes Environmental Research Laboratory (GLERL)
Cooperative Institute for Limnology and Ecosystems Research (CILER)
Great Lakes Sea Grant Network
NOAA Great Lakes Regional Team

Workshop Location:

School of Natural Resources and Environment
University of Michigan Central Campus
Ann Arbor, Michigan

Day 1 (Tuesday, July 29, 2008; 8 AM – 5 PM) featured a series of scientific presentations / Q&A's on the current state of knowledge of present and expected future impact of climate change on the Great Lakes ecosystem, with prime focus on effects in coastal waters and connecting channels.

Day 2 (Wednesday, July 30, 2008; 8 AM – 5 PM) featured a series of stakeholder presentations / Q&A's outlining key issues and concerns in confronting anticipated impacts of climate change on the Great Lakes ecosystem meeting new challenges in managing, protecting or restoring resources.

Day 3 (Thursday, July 31, 2008; 8 AM – 3PM) featured a set of 6 concurrent Breakout Sessions that will address science and stakeholder issues divided among the Key Theme areas defined above.

Publications

NOAA Technical Memorandum GLERL -147 *(in review)* M. Quigley, S. Joseph, L. Chaimowitz, R. Sturtevant, D. Mason, C. Sellinger, J. Wang, and C. DeMarchi. "Impact of Climate Change on the Great Lakes Ecosystem - A NOAA Science Needs Assessment Workshop to Meet Emerging Challenges – Summary Report", July 29 - 31, 2008.

Presentations

Note: All July 29th and 30th presentations and panels were held in Rm. 1040 Dana Building, School of Natural Resources and Environment, University of Michigan Central Campus, Ann Arbor, MI

8:45 AM	Science Panel #1: Physical Environment - Seasonal Warming/Cooling, Vertical Temperature Profiles and Ice Extent/Duration Session Chair – Dr. Jia Wang, Ice Climatologist, NOAA/Great Lakes Environmental Research Laboratory
8:45 AM	Dr. Xuezhi Bai, Research Investigator, University of Michigan School of Natural Resources and Environment / Cooperative Institute for Limnology and Ecosystems Research, *Interannual Variability of Lake Ice and Internal Climate Teleconnection Patterns* (Co-Author: Wang, J.)
9:00 AM	Dr. Eric Anderson, National Research Council Post Doctoral Fellow, NOAA Great Lakes Environmental Research Laboratory, Hydrodynamic Modeling and Forecasting in the Great Lakes (Co-Authors: Schwab, D.J, Holtschlag, D.J and G.A. Lang)
9:15 AM	Dr. Jia Wang, Ice Climatologist, NOAA/Great Lakes Environmental Research Laboratory, Projections of the Great Lakes Climate in the 21st Century and Coupled Lake-Ice Modeling
9:45 AM	Break
10:00 AM	**Science Panel #2: Water Quantity** – Lake Levels and Flows in Connecting Channels Session Chair – *Ms. Cynthia Sellinger, NOAA/Great Lakes Environmental Research Laboratory*
10:00 AM	Dr. Thomas E. Croley II, Senior Research Hydrologist, NOAA/Great Lakes Environmental Research Laboratory - Great Lakes Sensitivity to Paleo Climate Change

10:15 AM	Ms. Cynthia Sellinger, Hydrologist, NOAA/Great Lakes Environmental Research Laboratory - The Rise and the Fall of Great Lakes Water Levels
10:30 AM	Dr. Brent Lofgren, Physical Scientist, NOAA/Great Lakes Environmental Research Laboratory - *Modeling to Address Open Questions on the Future of Great Lakes Climate*
10:45 AM	Q&A / Discussion
11:00AM	**Science Panel #3: Watershed Hydrology** Session Chair – *Dr. Carlo DeMarchi, Research Investigator, Cooperative Institute for Limnology and Ecosystems Research*
11:00 AM	Dr. Norman Grannemann, U.S. Geological Survey, Great Lakes Program Coordinator, Changes in Ground Water Conditions from Possible Changes in Climatic Conditions in the Great Lakes Basin
11:15 AM	Dr. Veronica Webster Griffis, Department of Civil and Environmental Engineering, Michigan Technological University, Potential Impacts of Climate Change on Flood Frequency and Other Surface Water Phenomena
11:30 AM	Dr. Chansheng He, Department of Geography, Western Michigan University, Climate Change and Non-Point Source Pollution in the Great Lakes Basin: Opportunities and Challenges (Co-Authors: Croley, T.E. II and C. DeMarchi)
12:00 PM	Lunch – Catered buffet SNRE Commons
1:00 PM	**Science Panel #4: Water Quality and Human Health** Session Chair – *Ms. Sonia Joseph, Outreach Coordinator, Center of Excellence for Great Lakes and Human Health / Michigan Sea Grant*
1:00 PM	Dr. Michael Murray, Staff Scientist, National Wildlife Federation, Great Lakes Natural Resources Office, Climate Change, Water Quality and Human Health: Some Research and Policy Questions
1:15 PM	Dr. Donna Kashian, Research Investigator, Cooperative Institute for Limnology and Ecosystems Research Climate-induced Changes in Organic Material Influences Contaminant Exposure in Aquatic Systems

1:30 PM Dr. Carlo DeMarchi, Cooperative Institute for Limnology and Ecosystems Research, Potential Impacts of Climate Change on Pathogen and Pesticide Contamination of Coastal Water (Co-Authors: Croley, T.E II, Hunter, T.S. and H. Chansheng)

2:00 PM **Science Panel #5: Fish Recruitment and Productivity**
Session Chair – *Dr. Doran Mason, Research Ecologist, NOAA/Great Lakes Environmental Research Laboratory*

2:00 PM Dr. Edward S. Rutherford, Associate Research Scientist, School of Natural Resources and Environment, University of Michigan, Impact of Climate Change on Salmon Recruitment in the Great Lakes

2:15 PM Dr. Henry Vanderploeg, Research Ecologist, NOAA/Great Lakes Environmental Research Laboratory, Climate Change, Physical-Biological Coupling, and the Resource Mismatch Hypothesis for Plankton and Fish (Co-Authors: Cavaletto, J.F., Liebig, J.R., Ludsin, S.A., and Madenjian, C.P.)

2:30 PM Dr. Doran Mason, Research Ecologist, NOAA/Great Lakes Environmental Research Laboratory, Climate change: Implications for Fish Growth Performance in the Great Lakes (Co-authors: Brandt, S.B, McCormick, M.J., Lofgren, B., Hunter T. and J.A. Tyler)

3:00 PM Break

3:15 PM **Science Panel #6: Aquatic Invasive Species**
Session Chair – *Dr. Rochelle Sturtevant, Great Lakes Regional Extension Educator, Michigan Sea Grant*

3:15 PM Dr. Cindy Kolar, Assistant Program Coordinator, Invasive Species Program U.S. Geological Survey USGS Research on Invasive Species and Climate Change in the Great Lakes

3:30 PM Dr. Henry Vanderploeg, Research Ecologist, NOAA/Great Lakes Environmental Research Laboratory, Surprising Synergies Between Invasive Species and Climate Impacts (Co-Authors: Pothoven, S.A., Fahnenstiel, G.L. and Nalepa, T.F.)

MODELING SEA ICE-OCEAN-ECOSYSTEM RESPONSES TO CLIMATE CHANGES IN THE BERING-CHUKCHI-BEAUFORT SEAS WITH DATA ASSIMILATION OF RUSALCA MEASUREMENTS

Principal Investigators: *Jia Wang, GLERL*

Dmitry Beletsky, CILER

Allen Burton, CILER

Overview and Objectives

This proposed study is to use the combination of an IARC high-resolution (4-km) Coupled Ice-Ocean Model (CIOM, Wang et al. 2002, 2004, 2005; Wu et al. 2004) and Princeton Regional Ocean Forecast (and Hindcast) System's (PROFS) data-assimilation methodologies to improve our understanding of ocean and sea ice circulation in the Bering-Chukchi-Beaufort (BCB) seas, driven by ocean tides, Alaska Stream (AS) and Alaska Coastal Current (ACC) inflow/outflow, freshwater discharge, and synoptic wind stress. We propose to implement the data assimilation approach based on PROFS to cover the Bering Sea, Chukchi Sea, and part of the Beaufort Sea. That will allow assimilations of existing and on-going hydrographic data and moorings across the Bering Strait in addition to those data in the Chukchi Sea and Bering Sea. Importantly, PROFS' Lagrangian assimilation scheme will also assimilate the Argo data (http://www.argo.ucsd.edu/). Particularly the developed PROFS approach will allow CIOM to assimilate hydrographic data measured during the period (2007-2012) when the RUSALCA's moorings will be deployed near Bering Strait. A high-resolution coupled atmosphere-ice-ocean global climate model (from Japan) will provide the BCs to both CIOM and PROFS. Then, a series of sensitivity simulations with CIOM combined with PROFS will be conducted to examine in 1) AS inflow 2) Response to a change in position of the Aleutian Low, 3) Both positive and negative phases of AO (Arctic Oscillation) and PDO (Pacific Decadal Oscillation) to identify the similarity and difference of the ice-ocean response to AO and PDO, and 4) Response to Arctic Dipole Anomaly (DA) to investigate the DA's impact on SST, sea ice concentration (retreat) in the Alaska Arctic water due to the enhanced Bering Inflow. In return, the modeling results will be discussed with those PIs with RUSALCA field observation projects and an optimal sampling strategy will be designed to better coverage.

A 3-D, 9-compartment, Physical-Ecosystem Model (PhEcoM), coupled to CIOM, will be used to study the ice-ocean-ecosystem dynamics in the same region. The data from RUSALCA nutrient and plankton moorings will be used for conducting independent data analysis to also validate this model, and for assimilation by PROFS .

This model will be used to test our proposed hypotheses: 1) North-south connection/advection of nutrients and planktons, 2) West-east seesaw of plankton blooms due to a change of location of the Aleutian Low, and 3) On-shelf nutrient supply by mesoscale eddies for sustainable "Green Belt" booms. Therefore, this proposed study using PhEcoM-CIOM-PROFS will have a broad impact on 1) the ice-ocean-ecosystem dynamics that explains the high primary productivity region, along the Green Belt (i.e., along the Bering Slope), seasonal blooms and the interannual variability in the BCB seas, and 2) ice edge variability due to climate changes and the impacts on primary and secondary productivity.

Accomplishments

1) Complete model-data comparison in the Bering Sea model only for a seasonal cycle
2) Complete model-data comparison in the Chukchi-Beaufort sea model for a seasonal cycle
3) Conduct a pan Bering-Chukchi-Beaufort seas model

Publications

Deal, C.J., M. Jin, and J. Wang, 2008. The significance of water column nitrification in the southeastern Bering Sea, *Chinese Journal of Polar Science : Special Issue of Pacific Arctic Group (PAG) Model-Data Fusion Studies in the Arctic Ocean and Subpolar Seas, 19(2), 185-192.*

Hu, H. and J. Wang, 2008. Modeling the ocean circulation in the Bering Sea, *Chinese Journal of Polar Science : Special Issue of Pacific Arctic Group (PAG) Model-Data FusionStudies in the Arctic Ocean and Subpolar Seas, 19(2), 192.*

Jin, M., J. Wang, K. Mizobata1, H. Hu, and K. Shimada, 2008. Observations and modeling of the ice-ocean conditions in the coastal Chukchi and Beaufort Seas. *Acta Oceanologica Sinica*, 27(3), 79-87.

Jin, M., C. Deal, J. Wang, 2008, A coupled ice-ocean ecosystem model for 1-D and 3-D applications in the Bering and Chukchi Seas, *Chinese Journal of Polar Science: Special Issue of Pacific Arctic Group (PAG) Model-Data Fusion Studies in the Arctic Ocean and Subpolar Seas, 19(2), 212-217.*

Mizobata, K., S.-I. Saitoh, and J. Wang, 2008. Summer biological enhancement in relation to the mesoscale eddy at the shelf break in the vicinity of the Pribilof Islands. *Deep Sea Res.* II, 55: 1717-1728, doi:10.1016/j.dsr2.2008.03.002.

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Presentations

Invited:

Wang, J., 2008. Modeling sea ice and ocean circulation in the Bering Sea, Hokkaido University T/S Oshoro-Maru, July 16, Alaska

Wang, J., 2008. Dipole Anomaly drove the 2007 Arctic sea ice minimum, Dutch Harbor Museum, Alaska (outreach to local community), July 17.

Wang, J. 2008. Climate change and the changing role of freshwater and sea ice. US-Canada
GEO Workshop. Oct. 28-30, Arlington, VA

Wang, J., Arctic Dipole Anomaly drove the 2007 Arctic sea ice minimum: Implication to ecosystems in the North Atlantic, NW Atlantic GLOBEC Workshop, New Hampshire, Oct, 2008

Oral:

Wang, J., 2008. Dipole Anomaly drove the 2007 Arctic sea ice minimum, International Symposium on Arctic Research, Tokyo, Japan, Nov. 4-6, 2008.

Poster:

Wang, J., 2008. Ice-ocean-ecosystem modeling in the Bering, Chukchi, and Beaufort seas, NOAA Climate Observation Division 6th Annual System Review, September 3-5, Silver Spring, D.C.

PROJECT TITLE: IMPROVED UNDERSTANDING AND FORECASTING OF VIRAL AND BACTERIAL SOURCES AND TRANSPORT IN THE GREAT LAKES

Principal Investigators: *Joan Rose, Mantha Phanikumar, MSU*

Allen Burton, CILER

Overview and Objectives

During years 1-4, The MSU team has made excellent progress supporting the Center Goals on water and health in the Great Lakes. We have published and presented work on the following:

i. Drinking water safety in the Great Lakes
ii. Microbial contaminant transport and risks associated with Great Lakes beaches and coastal contamination
iii. The role of algal mats and sediments as reservoirs of fecal pollutants
iv. Applications of new tools and techniques for describing water quality and health.

We have focused on pathogen virus and parasite risks as well as the building and validation of microbial source tracking tool kit. Geographically we have focused on beaches along the eastern shore to the south tip of Lake Michigan, the Grand River Watershed and this last year we focused on monitoring in the Saginaw Bay.

Beach and Watershed Modeling

We have completed most of our studies along the Grand River and beaches along the Indiana shoreline. Recognizing the need for datasets that allow us to separate physical and biological processes in our models, we conducted field experiments in the Burns Ditch area along the Indiana shoreline during summer 2008. The experiments were conducted in collaboration with scientists from USGS, Wisconsin, USGS Indiana, MSU, EPA and NOAA. A tracer study was conducted and detailed spatial snapshots of the dye plume were observed using moving boat measurements. Continuous time series data were obtained for the tracer and E. coli at the beaches while recording meteorological parameters using weather stations equipped with data loggers. We also deployed (thanks to the divers from the USGS Science Center) a string of thermistor chains and six Acoustic Doppler Current Profilers (ADCPs) for a period of three months from depths ranging from 2 m to 20 m. Examination of the data collected from all the instruments showed that high-quality datasets were obtained for all important parameters for summer 2008.

We completed the testing of our biology module for the Princeton Ocean Model (POM) in 2008 based on *E. Coli* and hydrometerological data collected in the previous years (2004-2007). We made a detailed comparison of *E. Coli* predictions from POM with observed data and completed a journal paper that is being submitted to Environmental Science and Technology in January 2009 (Thupaki et al., 2009). We have been currently working on the following:

1. Multiple publications based on the summer 2008 data
2. Further development and detailed testing of our Saginaw Bay model for both pathogens and Harmful Algal Blooms (models based on both FVCOM and POM). Efforts will be made to conclude this task and write papers in 2009. The biology module developed for the Indiana beaches will be used for describing pathogens in the Saginaw Bay area.
3. Hydrological Modeling of *E. coli* in Michigan watersheds. We have completed the development of a process-based watershed model that describes the fate and transport of biological agents in overland flow, stream channel networks and in the vadose and fully saturated regions. The model is being tested using the MDEQ *E. coli* database in the Grand River watershed. Several publications based on this research will be communicated in 2009.

Accomplishments

We accomplished specifically and are completing our work for 2008:

1. Development of qPCR techniques for fecal pollution indicators and pathogens, to be used for rapid assessment and microbial source tracking. We now have protocols for E.coli, E.coli 0157H7, Enterococci, Enterococci *esp,*Bacteroides total, human, cow, adenoviruses cow and human, enteroviruses cow and human
2. Examined the role of algal blooms in maintaining fecal indicators and pathogens in Saginaw Bay. Assessment of the muck and impact on water quality.
3. Hydrological Modeling of *E. coli* in Michigan watersheds. We have completed the development of a process-based watershed model that describes the fate and transport of biological agents in overland flow, stream channel networks and in the vadose and fully saturated regions. The model is being tested using the MDEQ *E. coli* database in the Grand River watershed. Several publications based on this research will be communicated in 2009.
4. We have begun development of the Saginaw Bay model for both pathogens and Harmful Algal Blooms (models based on both FVCOM and POM). Efforts will be made to conclude this task and write papers in 2009. The biology module developed for the Indiana beaches will be used for describing pathogens in the Saginaw Bay area.

Publications

Journal Publications:

The following papers are either published (**), in review (*) or ready to be communicated (+)

1. **M. Wong, L. Kumar, T.M. Jenkins, I. Xagoraraki, M.S. Phanikumar and J.B. Rose, Evaluation of Public Health Risks at Recreational Beaches in Lake Michigan via Detection of Enteric Viruses and a Human-Specific Bacteriological Marker, ***Water Research***, doi: 10.1016/j.watres.2008.11.051 (2009) 43:1137-1149
2. +S. Singh, C. Shen, M.S. Phanikumar and J.B. Rose, Sediment –Water Partitioning of Bacterial Fecal Indicators and Coliphage Virus in Parks and Beaches along the Grand River and Lake Michigan, USA, ***Water Research***, (to be submitted in April 2009)
3. +P. Thupaki, M.S. Phanikumar, D.J. Schwab, D. Beletsky and R.L. Whitman, Budget Analysis of *Escherichia coli* in the Nearshore Region of Lake Michigan, ***Environmental Science & Technology*** (manuscript ready to be submitted in April 2009)
4. *C. Shen and M.S. Phanikumar, Numerical Solution of Fractional Stream Transient Storage Models, ***Advances in Water Resources*** (in review, 2009)
5. ** C. Shen, M.S. Phanikumar, T.T. Fong, I. Aslam, S.L. Molloy and J.B. Rose, Evaluating Bacteriophage P22 as a Tracer in a Complex Surface Water System: The Grand River, Michigan, ***Environmental Science & Technology***, Vol. 42, doi: es200702317t (2008) February 29, 2008.
6. ** Phanikumar, M.S., I. Aslam, C. Shen, D.T. Long and T.C. Voice, Separating Surface Storage from Hyporheic Retention in Natural Streams Using Wavelet Decomposition of Acoustic Doppler Current Profiles, ***Water Resources Research***, Vol. 43, No. 5, W05406, doi: 10.1029 / 2006WR005104 (May 2007)
7. *C. Shen, N. Jie and M.S. Phanikumar, Estimating Longitudinal Dispersion in Rivers Using Acoustic Doppler Current Profilers, ***Advances in Water Resources*** (2009, in review)
8. Knoll, L.B., Sarnelle, O., Hamilton, S.K., Kissman, C.E.H., Wilson, A.E., Rose, J.B., Morgan, M.R. 2008. Invasive zebra mussels (*Dreissena polymorpha*) increase cyanobacterial toxin concentrations in low-nutrient lakes. CJFAS March 2008, pp 448-455.

Proceedings / Presentations

1. Phanikumar, M.S., Grand River Modeling:Water Quality and Land Use, ***Ottawa County Water Quality Public Forum***, November 2008
2. Baas, D.G., Long, D.T., and Phanikumar, M.S., Identifying Seasonal Trends In Dissolved Phosphorus In a Mixed Land Use Watershed Using a Mixed Linear

Model Approach, Paper # 272-6: T139. Sources, Transport, Fate, and Toxicology of Trace Elements in the Environment II), ***2008 Joint Meeting, Geological Society of America***), Houston, Texas, 7 October 2008

3. Rose, JB, Michigan Environmental Health Association's (MEHA) Annual Education Conference, "Monitoring for Microbial Risks in Groundwater" and "Source Tracking and Water Quality Issues" Bay City, Michigan March 11-14, 2008.
4. Rose, JBKeynote Speaker, MSU Water Forum, Potential Impacts of Climate Variability and Change on Water Quantity and Quality in the Great Lakes Region "Climate Change and Impacts on Water Quality in the Great Lakes Region" MSU, E. Lansing, MI, April 28
5. Rose, JB, Michigan Water Environment Association, Lab Seminar, "What's New in the Tool Box for Water Quality Testing?" Lansing, MI, April 29
6. Rose, JB. Third Annual Water Quality Forum, County of Ottawa, November 1

PROJECT TITLE: EFFECTS OF HYPOXIA ON PELAGIC FOOD WEBS

Principal Investigators: *Allen Burton, CILER*
Doran Mason, GLERL
Edward Rutherford, GLERL
Hongyan Zhang, CILER UM
Aaron Adamack, CILER UM

Overview and Objectives

As a direct consequence of eutrophication, there has been an alarming increase in the spatial and temporal extent of low oxygen bottom waters in estuarine and coastal waters. Although hypoxia is prevalent in many US coastal systems, such as Chesapeake Bay and the Laurentian Great Lakes, most prominent has been the advancement of hypoxia in the northern Gulf of Mexico (NGOMEX). The temporal and spatial extent of hypoxia in the NGOMEX has increased as a result of excessive nitrogen inputs from the Mississippi River. Despite this increase in hypoxia, the trophic consequences of low oxygen waters on pelagic communities remain poorly understood. Given the economic importance of the Gulf of Mexico commercial fisheries (about 20% of the U.S.'s total domestic fishery landings representing about $991 million) and recreational fishing (generating ~30% of the nation's saltwater fishing expenditures and supporting nearly 25% of the nation's recreational saltwater jobs), it is imperative that knowledge of the ecosystem effects of hypoxia in NGOMEX be increased.

The objectives are to:

- Conduct high-resolution mapping of the NGOMEX pelagic food web (including bacteria, phytoplankton, microzooplankton, mesozooplankton, and fish) in relation to hypoxia;
- Integrate these ecosystem measurements through a variety of models designed to assess the effects of hypoxia on NGOMEX pelagic food webs and production;
- Quantify habitat suitability for economically and ecologically important fishes; and
- Provide tools to forecast food-web interactions, habitat suitability, and fish production in relation to hypoxia.

High-resolution mapping of the major ecosystem components of the NGOMEX will be conducted. Automation of sampling, analysis, and classification of pelagic organisms using new technologies offers a practical, cost-effective way to intensify survey efforts in the NGOMEX so that ecosystem components are sampled at the fine-scale and broad-scale resolutions necessary to understand the effects of hypoxia. This approach will yield information on phenomena that would have been missed by a fixed or

bottom-focused sampling regime, and enhance the functionality of monitoring and observations. Mapping results will be incorporated into spatially-explicit bioenergetics-based growth rate potential, size-spectrum, dynamic optimization, food-web, and statistical models to provide managers with essential information for improved ecosystem-based management of the NGOMEX, including information to quantify and forecast the ecological consequences of changes in hypoxia on the living resources of the NGOMEX. The results of this research will be highly integrated into NOAA operations and strategic planning through direct NOAA involvement, tightly integrated with other programs in the region and elsewhere, and broadly disseminated to resource managers and the scientific community through the WWW, presentations at meetings, Sea Grant Extension and peer-reviewed publications. Undergraduates, graduate students, postdoctoral scholars, and teacher interns will be involved in all aspects of this research.

Researchers from CILER focus on the fish component of the living resources and food web model construction and simulations.

Accomplishments

1. Field cruise: We carried out our annual research cruise from Aug 1-14, 2008 using the Louisiana Universities Marine Consortium's (LUMCON) RV Pelican. The cruise was split into two halves with several people from GLERL and CILER participating on all or part of the cruise: Stephen Lozano, Craig Stow (both GLERL PIs), Aaron Adamack (CILER Research Fellow), and Melissa Clouse (CILER staff) participated on both parts of the cruise while University of Michigan graduate student James Roberts (employed by CILER), and CILER summer fellows Alyson Flood, Katie Bush, and Andrew Layman participated on the first half of the cruise.

During our previous cruises, we have had problems with getting our mid-water trawl to deploy properly. Thus, the primary focus of the first part of the cruise was to test several different methods for sampling pelagic fish in the mid-water portion of the water column. We spent the first three days tested several different deployment configurations for the mid-water trawl, a vertical gillnet, and an acoustic imaging system (DIDSON acoustic camera) in order to better sample the mid-water portion of the water column. We determined that the best method for sampling pelagic fish in the mid-water portion of the water column was to use the DIDSON acoustic camera.

The secondary goal of the first part of the cruise was to identify potential sampling sites for the second half of the cruise. Unfortunately, the cruise was interrupted part way through the first half of the cruise by tropical storm Edouard

which forced us to return to port. The activity of the storm completely altered the physical structure of the water column which resulted in our spending the last two days of the first half of the cruise surveying the region around stations C and D trying to find locations with bottom-layer hypoxia that we could sample during the second half of our cruise.

For the second part of the cruise, we surveyed three North-South transects (transects C, D, and F) and two-diel surveys (at stations C8 and C9 for the first and stations D3A, D4A, and D4). We conducted a bottom trawl and surveyed the water column using the DIDSON at the beginning and end of transect C but did not use the trawl or DIDSON on transects D and F. Along the length of each transect, we used fisheries acoustics and SCANFISH to examine the distribution of fish, zooplankton, temperature, salinity and dissolved oxygen along the transects. For the two diel surveys, we carried out trawls and DIDSON surveys every 4-6 hours at each station. In total, we completed 31 bottom trawls during the second half of the cruise, collecting 40 species of fish and invertebrates. The 5 most abundant species collected in ascending order were: Atlantic bumper, Atlantic cutlassfish, sand seatrout, striped anchovy, and Atlantic croaker.

2. Data processing:

a) Fish diets: We processed 1346 diets from 39 species of fish: The most abundant species were: Atlantic croaker (331) fed primarily on nematodes and polychaetes; striped anchovy (270) primarily fed on copepods, shrimp larvae, crab zoea and megalopae, bivalves, and nematodes; Atlantic cutlassfish (246) primarily fed on fish, squid, and shrimp larvae; sand seatrout (115) primarily fed on shrimp larvae, crab megalopae, fish, and squid; and Atlantic bumper (104) fed primarily on copepods, shrimp larvae, crab zoea and megalopae, and gastropods; Other species are: amberjack (1), bay anchovy (10), batfish (1), barracuda (2), banded drum (14), blackedged cusk eel (10), blue runner (2), blackcheek tonguefish (26), gulf butterfish (7), blackwing sea robin (72), dusky flounder (7), filefish (2), flounder larvae (2), grey triggerfish (1), harvestfish (1), hardhead catfish (1), king mackerel (1), least puffer (17), mackerel sp. (1), Atlantic moonfish (13), needlefish (2), pinfish (2), longspine porgy (1), red drum (1), red snapper (25), scombridae (5), scaled sardine (19), snapper larvae (1), Spanish mackerel (4), spot (23), Spanish sardine (1), smooth puffer (1), Atlantic threadfin herring (1), and tripletail (1).

b) Acoustic data: more than 80 acoustics casts were carried out during 2008 cruise. The longest transects have been processed, while the rest will require an additional month of work.

3. Data analysis: Growth rate potential (GRP) models have been widely used to assess ecosystem capacity, qualify habitat quality, and examine the response of fish to stress factors. We have developed a GRP model which is being used to investigate the impacts of hypoxia on forage fish production. We are currently determining whether the model can be used to successfully predict habitat quality in the northern Gulf of Mexico. The model uses water temperature, dissolved oxygen, zooplankton biomass and fish biomass data that were collected during the 2003, 2004 and 2006 cruises. Model results clearly show that hypoxic zones (<2.0 mg $O_2 l^{-1}$) are low-quality habitats. For most of transects, especially those that were sampled during 2006, a year with severe hypoxia, the locations that were predicted by the GRP model to have good habitat quality were also observed to have high fish biomass. The opposite was true low quality habitats. While the initial model results were good, additional analysis suggests that the sigmoidal dissolved oxygen functional response needs further modification to improve predictions for years with mild hypoxia. Model error analysis shows that when variation level of parameters values is low (2%), growth rate potential is linearly correlated to the model parameters; however this linearity is reduced when the variation in model parameter values is increased. Based on these results, we feel that our use of "species borrowing" from closely related species for GRP modeling is appropriate.

4. Communications:

An All-PI project meeting was held on February 12 – 13, 2009 at Silver Spring, MD. Four people from GLERL and CILER presented at the meeting, Doran Mason, Hongyan Zhang, Aaron Adamack, Melissa Clouse.

A meeting to discuss the analysis of the data collected using the DIDSON acoustic camera was held in Baton Rouge, LA on February 24, 2009 at Louisiana State University (LSU). The meeting attendees were Aaron Adamack (CILER), Doran Mason (GLERL), Stuart Ludsin (Ohio State University) and Kevin Boswell (LSU).

Publications

1. Zhang, H, Ludsin, S.A., Mason, D.M., Adamack, A.T., Brandt, S.B., Zhang, X., Kimmel, D.G., Roman, M.R., Boicourt, W.C. *In press*. Hypoxia-driven changes in the behavior and spatial distribution of pelagic fish and mesozooplankton in the Northern Gulf of Mexico. Journal of Experimental Marine Biology and Ecology.
2. Zhang, H, et al. *In preparation*. GRP model: detection of hypoxia impacts on the distribution of the pelagic fish in the northern Gulf of Mexico. Targeting on Marine Ecology Progress Series.
3. Clouse, M. et al. *in preparation.* Summer feeding habits of Atlantic bumper in the northern Gulf of Mexico.

4. Clouse, M. et al. *in preparation*. Trophic relationships among common fish species in the northern Gulf of Mexico during summer.

Presentations

1. Adamack, A.T. 2009. Developing an Ecopath model for the Northern Gulf of Mexico. Project meeting. Silver Spring, MD. Feb. 12-13
2. Adamack, A.T., Boswell, K.M. 2009. DIDSON Talk. Project meeting. Silver Spring, MD. Feb. 12-13
3. Clouse, M. 2009. Feeding habits and trophic relationships of dominant fishes. Project meeting. Silver Spring, MD. Feb. 12-13
4. Mason, D.M. 2009. Model of fish movement in the northern Gulf of Mexico. Project meeting. Silver Spring, MD. Feb. 12-13
5. Zhang, H., Ludsin, S.A., Mason, D.M., Adamack, A.T., Brandt, S.B., Zhang, X., Kimmel, D.G., Roman, M.R., Boicourt, W.C. 2009. Hypoxia-driven changes in the behavior and spatial distribution of pelagic fish and mesozooplankton in the Northern Gulf of Mexico. Project meeting. Silver Spring, MD. Feb. 12-13

PROJECT TITLE: FORECASTING BEACH CLOSINGS, HARMFUL ALGAE BLOOMS AND WATER QUALITY IN THE GREAT LAKES

REPORTING PERIOD: JANUARY 20, 2009 – MARCH 30, 2009

Principal Investigators: *Stephen Brandt*

Allen Burton, CILER

Overview and Objectives

The Great Lakes are an important resource for recreational activities that involve full body contact with water, such as swimming, water-skiing, sailboarding and wading. Apart from the risks of accidental injuries, the major human health concern for recreational waters is microbial contamination by bacteria, viruses, and protozoa. The Great Lakes Water Quality Agreement calls for recreational waters to be substantially free from bacteria, fungi, and viruses. These microbial organisms of fecal origin have the potential to cause relatively mild illnesses (e.g., gastroenteritis) to more serious illnesses (e.g., hepatitis, typhoid fever) from a single exposure.

Some bacteria in beach waters can pose a serious threat to human health. Great Lakes beaches are monitored for safe conditions. Beach closings are based on the levels of fecal indicator microorganisms in the water column. The common indicators including fecal coliform bacteria, *E. coli* and enterococci have been used to address advisories and closures. Unfortunately, *E.coli* assay requires a 24-hour incubation. Because of this delay, people unknowingly swim in contaminated water or are turned away from safe water. **Forecasting methods need to be developed to improve the Nation's beach closing policies and thereby reduce the human health threat and improve tourism and coastal economics.**

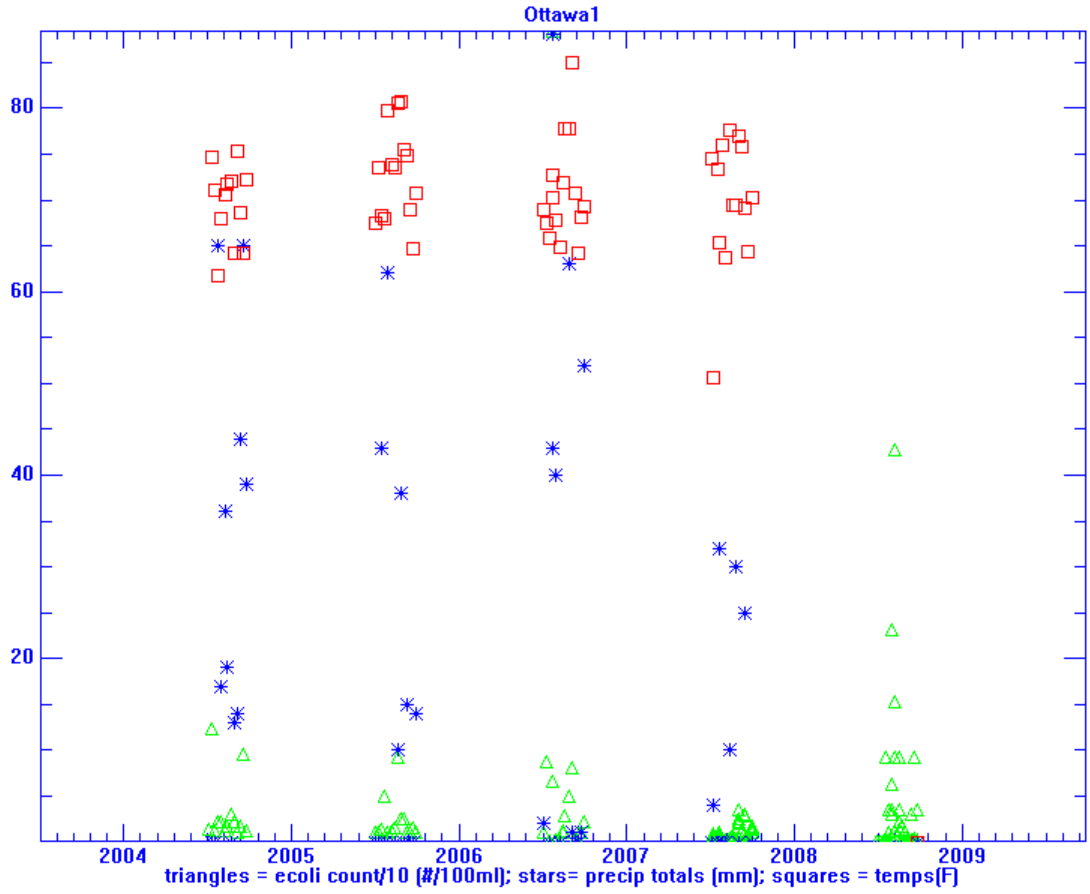
This project will examine the physical and biological processes affecting beach conditions and closings in an effort to develop a generalized model to statistical forecast beach water quality conditions and thereby reduce the risks to human health. Land-use and meteorological processes and events in the watershed determine the sources and loadings of bacteria to the lakes. Ecosystem processes, particularly hydrodynamics determine the fate and probability of transport of this material to beaches. Defining and forecasting these relationships using statistical approaches will be the primary research focus. Data on wave heights, rainfall, wind conditions and river flows will be evaluated for statistical forecasting of Michigan Great Lakes beach. Data on beach closing will be obtained from Michigan State University as part of the NOAA OHH center. There will be strong coordination with local water quality managers at state and local levels and with the NOAA center's beach coordinator throughout the project.

Accomplishments

This project formally began on January 20, 2009. To date we have:

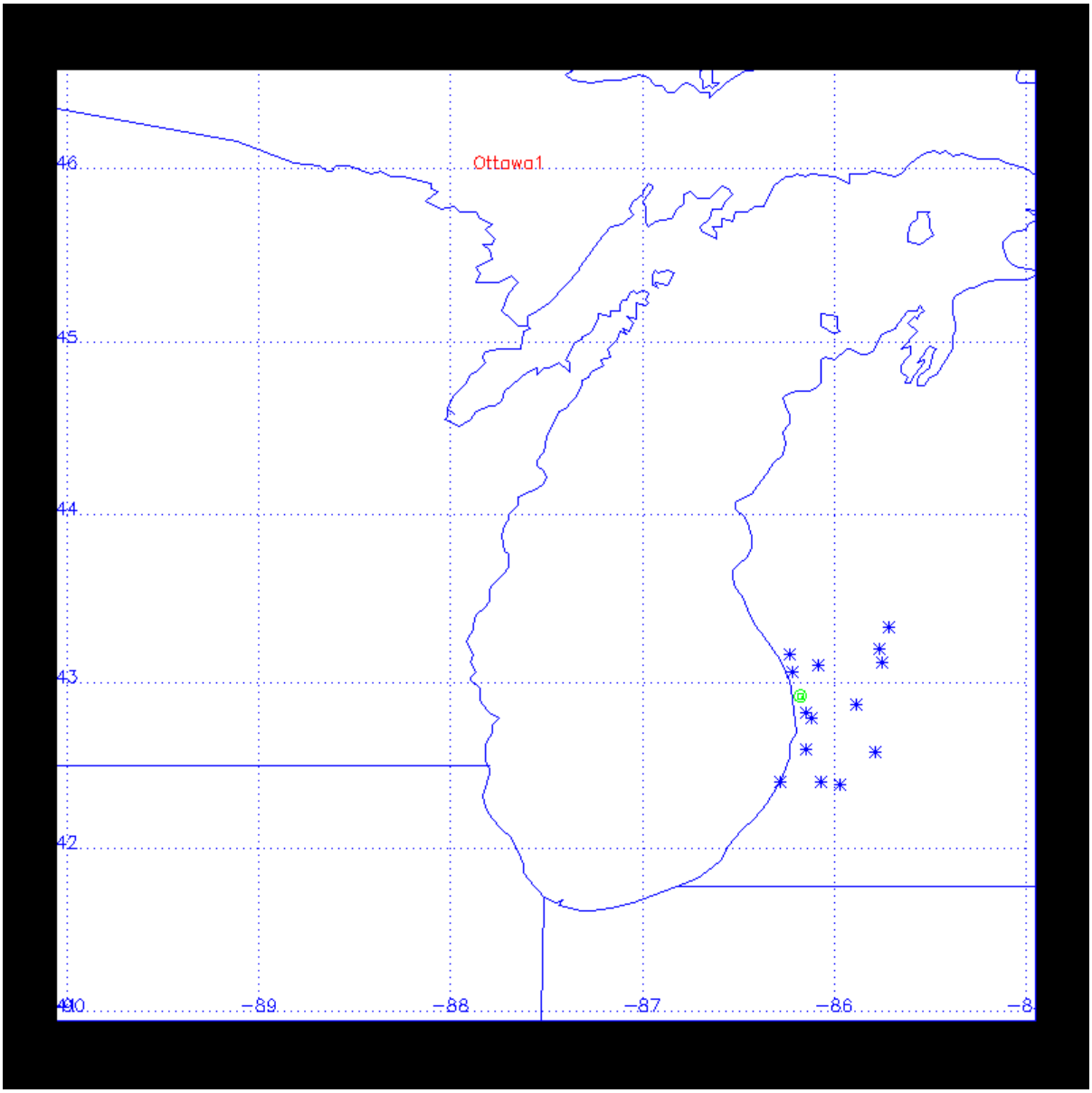
1) Hired a Faculty Research Assistant (FRA) as of March 15th 2009.
2) For this reporting period (March 15th – March 31st 2009) the FRA has:
   a) Procured software and hardware necessary for statistical analysis; and
   b) Obtained all hydrological, meteorological, and biological data for all Michigan beaches across the 4 Great Lakes. Wind, wave, and current data will be received shortly.
   c) Communicated with scientists at the Center of Excellence for Great Lakes and Human Health (CEGLHH) to indentify the initial pilot area for the statistical analysis. Since the Center is particularly interested in the Grand River area on Lake Michigan, it was decided to use this area to create the first statistical model.
   d) Developed a preliminary IDL forecasting model.
   e) Figure 1 depicts one of several sites along the Grand River area. Data for Ecoli Count is plotted along with daily averaged temperature and precipitation.

Figure 1—Physical and Biological Data Sets for Kouw Park.



There are several beaches along this stretch of Lake Michigan. This site, a public beach, (one of six) is located on Lake Michigan at Kouw Park in Ottawa County in Port Sheldon Township; latitude = 42.88203 and longitude = -86.2139. The Ecoli Count data was sampled by the Ottawa County Health Department and is archived in the EPA's STORET database. The precipitation and temperature data was obtained from NOAA's National Climatic Data Center data base. Figure 2 shows the spatial location of the site, denoted by a '@' surrounded by the location of meteorological stations, denoted by '*', in the area.

Figure 2—Site Location.



3) Literature searches and raw data analysis is presently underway to determine the temporal and spatial relationships between the data in order to develop a viable statistical model. Preliminary thoughts are: 1) there is a possible time-lag between the Ecoli sampled data and the precipitation event, and 2) since precipitation has a gamma distribution, a non-linear statistical model may be more appropriate.

Publications

None

Presentations

None

PROJECT TITLE: ENVIRONMENTAL DATA SET RECOVERY AND MIGRATION

Principal Investigators: *John Fenton, GLERL*
Allen Burton, CILER

Overview and Objectives

Problem Statement:

Over the past 30 years GLERL and CILER environmental research data has been archived on various types of media from 9-track and 8mm tapes to currently using DAT tapes and large capacity hard drives. If these data sets are to remain accessible to future GLERL and CILER researchers, it's critical to migrate the older media formats to modern archiving technologies. GLERL has a large number of data tapes in 9 track and 8mm format that were written by now obsolete methods which can only be read by our 20 year old VAX system which we still have on hand. Eventually, this old system will stop functioning and/or the skills for using it will be lost.

Performance Measures:
The project will be successful if the following tasks are completed:

- Development of catalog of targeted dataset archive library
- Successfully migrate older tape archive datasets to modern storage media in a readable format

Milestones:
Month 2 – catalog all tape archives targeted for migration
Month 4 – develop migration methods and procedures
Month 6 – complete migration of targeted dataset archives to modern storage media

Accomplishments

A computer archive of NOAA/GLERL environmental data and research material circa 1984-1992 was extracted from legacy storage media and copied to modern disk drive storage, preserving valuable Great Lakes research and data at risk of being permanently lost or inaccessible on aging magnetic tapes.

About 35 gigabtyes of Great Lakes related data and research, originally stored on GLERL's mainframe computer, was successfully recovered from over 250 reel-to-reel magnetic tapes and is now preserved for future research and reference.

Publications

N/A

Presentations

N/A

PROJECT TITLE: VISUALIZATION OF HYDRODYNAMIC MODEL OUTPUT

Principal Investigators: *David Schwab, GLERL*
Allen Burton, CILER

Overview and Objectives

GLERL is embarking on a new approach to hydrodynamic modeling using unstructured grids rather than traditional rectilinear grids. The procedures we have used to visualize horizontal and vertical slices of hydrodynamic model output such as temperature, water level, currents, etc. are based on the assumption that the output fields are available on a structured, rectilinear grid. The new unstructured approach stores model output as a single vector with each element of the vector corresponding to the value of the output field at a particular node in the unstructured grid. A separate geometry file stores the locations of each node in space. This new modeling approach will require changes to our visualization programs to accommodate the unstructured grid. The objective of this project is to develop a computer program to view and analyze output files from unstructured grid hydrodynamic models.

Accomplishments

Under this project, Raisa Beletsky completed the following tasks:

- Developed computer programs to map unstrctured grid hydrodynamic model output in a geographic context
- Developed interactive viewing software using the IDL programming language.
- Created static graphics for web-based viewing.
- Created animated graphics from series of single-frame maps.

Publications

The principal output from this project was a computer program for visualizing unstructured grid hydrodynamic model output and its corresponding documentation.

Presentations

Several informal project presentations were made to the hydrodynamic modeling group at various stages of development of the visualization program.

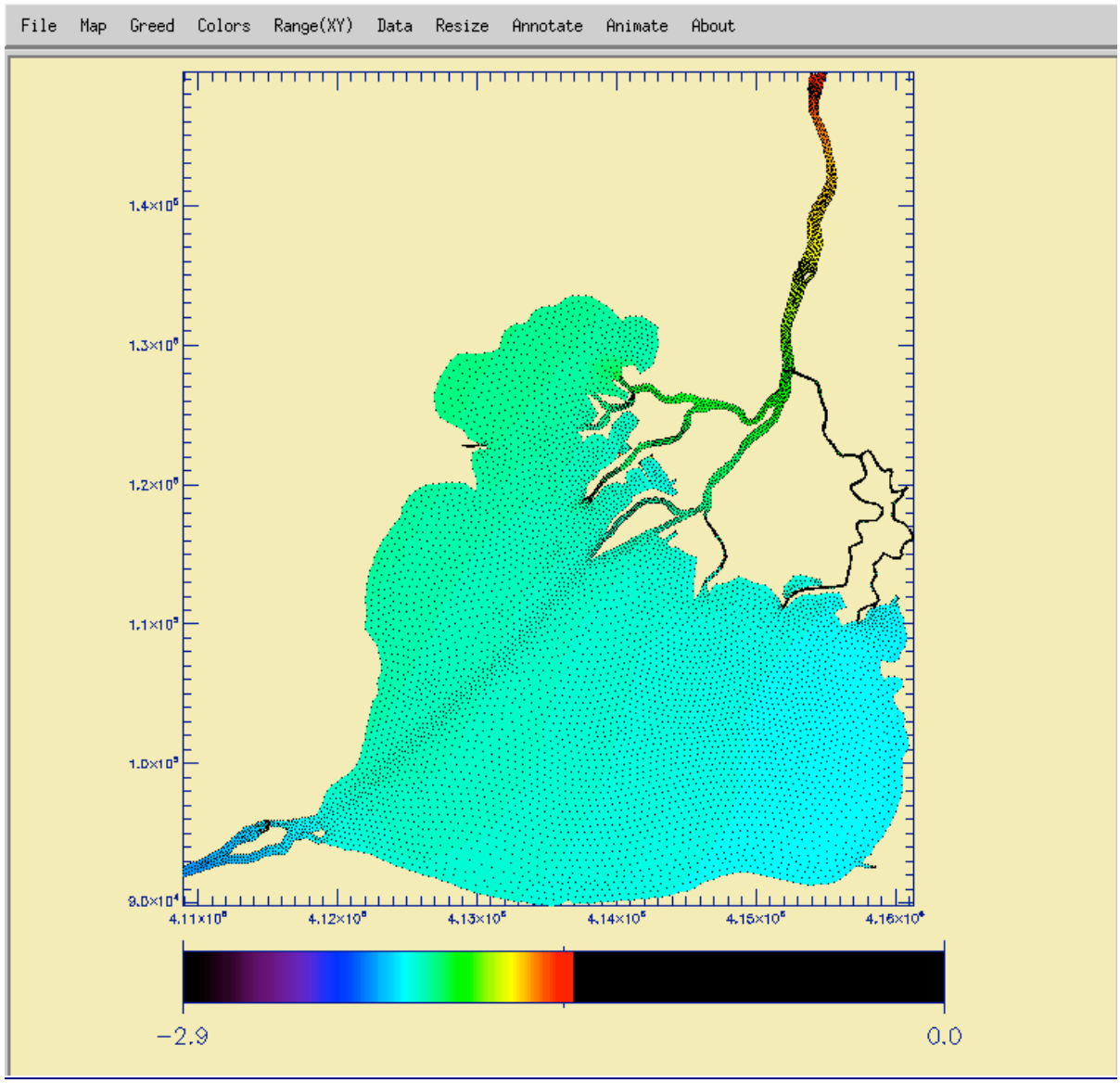


Figure 1. Sample screenshot from visualization program

PROJECT TITLE: LAKE ERIE HYDRODYNAMIC MODELING

Principal Investigators: *Dmitry Beletsky, CILER*
David Schwab, GLERL
Allen Burton, CILER

Overview and Objectives

The motivation for this project is to lay the groundwork for studying the relative roles of physical, chemical, and biological factors on the ecology of Lake Erie at a variety of space and time scales. Lake Erie was chosen as the target lake for several reasons including population density, availability of long term data sets, a variety of physical, chemical, and biological forcing functions (including invasive species), and a wide variety of impacts including water quality (hypoxia/anoxia), fisheries, and biological community structure. We believe that a reasonable initial approach would be to identify sources for and begin gathering data on the biological, chemical, and physical environment in Lake Erie. The data would be organized in a format that would be conducive to interdisciplinary analyses. The next step would be to develop a linked hydrodynamic/ecological model of Lake Erie including relevant physics (tributaries, advection, resuspension, etc.) and lower food web ecology. This project is intended to support the development of the Lake Erie hydrodynamic model which will eventually form the basis for the linked hydrodynamic/ecological model.

Recently, a 2 km hydrodynamic model of Lake Erie was developed based on the GLERL version of the Princeton Ocean Model (POM). Daily tributary inflows and hourly meteorology were assembled for the year 1994, 2004 and 2005 and complete hydrodynamic model simulations were accomplished. Comparison of model results with observations showed that the model was not able to simulate the observed step-function like vertical thermal structure in the central and eastern basins. The consequences of this problem for modeling hypoxia/anoxia and for coupling ecological models with the physical model in Lake Erie are very significant since the vertical distribution of dissolved oxygen as well as nutrients and biota in the central basin closely follow the vertical temperature profile and the development of a sharp thermocline in the lake in summer inhibits vertical mixing of epilimnetic and hypolimnetic waters. At the same time, the 2007 field year brought in a new set of data on thermal structure evolution. Therefore, we propose to run the model for 2007 to help interpret the field observations as well as to continue testing the hydrodynamic model.

Accomplishments

Meteorological data from 12 land stations around Lake Erie and 3 meteorological buoys were assembled, edited and interpolated to create gridded 2 km forcing functions for hydrodynamic model. Flow data from 22 major tributaries are being prepared for 2007 hydrodynamic model run.

Publications

Schwab, D.J., D. Beletsky, J. DePinto, and D. M. Dolan. 2009. A hydrodynamic approach to modeling phosphorus distribution in Lake Erie. *J. Great Lakes Res.* 35, 50-60.

Presentations

Beletsky, D., and D. Schwab. 2008. Modeling thermal structure in Lake Erie. ECOFORE/CHRP All-PI Workshop. December 11-12, 2008, Ann Arbor, MI.

Beletsky, D., and D. Schwab. 2008. Modeling thermal structure in Lake Erie. IAGLR 2008. May 19-23, 2008, Peterborough, ON.

PROJECT TITLE: AN INTEGRATED APPROACH TO MONITORING AND FORECASTING HARMFUL ALGAL BLOOMS (HABS) IN THE GREAT LAKES

Principal Investigators: *Juli Dyble, GLERL*
Donna Kashian, CILER
Allen Burton, CILER

Overview and Objectives

Harmful algal blooms (HABs) are a significant concern for ecosystem and human health in the Great Lakes. Blooms can reduce the aesthetic qualities of a water supply and cause complaints about taste and odor in drinking water; the decomposition of blooms can result in hypoxia or anoxia in the bottom water resulting in fish kills and benthic invertebrate mortality; and blooms can produce toxins that have direct detrimental impacts on human and animal health (Hawkins et al 1985, Teixera et al. 1993, Kuiper-Goodman et al. 1999). *Microcystis aeruginosa* is the dominant bloom-forming, toxic cyanobacterium occurring in the Great Lakes. *Microcystis* has (again) become a dominant component of the summer phytoplankton in both Saginaw Bay and western Lake Erie after being a relatively minor component during the late 1980s and early 1990s. The toxin of highest concern in the Great Lakes in the hepatotoxin microcystin and recent studies have measured up to 5 μg/L intracellular microcystin (Dyble et al, 2008), exceeding the recommended limit for microcystin in drinking water (1 μg/L; World Health Organization 1998). These microcystin concentrations are of particular concern because they are found close to a public water supply intake in the bay. Since the Great Lakes are such a highly utilized resource for both recreation and drinking water, the ability to predict the location of HAB blooms, especially in relation to drinking water intakes and recreational beaches, would allow protection of human and ecosystem health.

The most commonly used method for detecting HAB blooms is to do ship-based sampling on transects followed by microscopy-based detection methods (including cell counts). This process is time and resource intensive in terms sample analysis and ship time. Due to limits in time and resources, the spatial and temporal frequency of sampling is generally not sufficient to provide timely warning about the presence of HAB bloom at a drinking water intake or recreational beach, thus potentially threatening human health. For example, in order to detect a bloom at a drinking water intake, there would need to be monitoring daily or every other day near the intake pipe in order to detect the presence of toxic cells. Once detected, drinking water treatment needs to be increased in order to adequately remove the toxins and it is beneficial to have advanced warning in order to prepare for this. Even if sampling could somehow be conducted with sufficient enough frequency, processing the samples quickly enough to be responsive to a developing bloom

would take a significant amount of time. Thus, there is a significant need for a HAB forecasting system that can predict the presence of blooms at significant points of interest.

We propose an integrated system of detection and modeling in order to develop a HAB forecasting model for the western basin of Lake Erie. This system would incorporate satellite imagery for the detection of blooms, a particle tracking model utilizing the hydrodynamic circulation of the basin, in situ measurements for HAB cells to determine the effectiveness of the predictive model, and public outreach to inform beachgoers and recreational water users of the presence of HAB blooms. Each of these components has been in development over the few years and this will be the first effort to incorporate them into a forecasting system.

Accomplishments

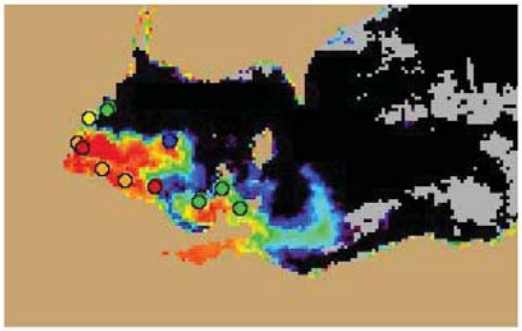
We were very successful this year in developing a HAB Bulletin for western Lake Erie in close collaboration with R. Stumpf, M. Tomlinson, T. Wynne (NOAA/NOS/CCMA, Silver Spring, MD). Using MERIS satellite imagery, Wynne et al. (2008) has documented that surface reflectance at 681nm may be a useful indicator of *Microcystis* concentrations in the Great Lakes and the NOAA-NOS team (Silver Spring, R. Stumpf lead) has developed an algorithm for determining cyanobacterial cell concentrations from surface reflectance. Data from the MERIS imagery was then used as input data into a Lagrangian particle tracking model with 2D horizontal transport that also allows for wind-induced movement of cells. This model was incorporated with the Great Lakes Forecast System developed by D. Schwab (GLERL), D. Beletsky (CILER) and colleagues. Satellite imagery was monitored on a weekly basis by Stumpf's group and when there were significant cyanobacterial blooms present, their location and approximate densities were input into this tracking model in order to predict the movement of the bloom. In order to test the accuracy of these predictions, small boats were used to go out and sample transects across the regions where the blooms were first detected by satellite imagery and where they were predicted to be transported to. Samples were collected for chlorophyll *a* and cell counts of *Microcystis* and this information was also included in the HAB bulletin. The weekly bulletin was sent out to researchers and managers in the regions around western Lake Erie.

EXPERIMENTAL
Lake Erie Harmful Algal Bloom Bulletin
4 September 2008
National Ocean Service
Great Lakes Environmental Research Laboratory
Last bulletin:

Conditions: A *Microcystis aeruginosa* bloom has been identified in western Lake Erie from the Maumee River mouth eastward, along the south shore.

Analysis: A *Microcystis aeruginosa* bloom was identified on August 26, 2008 through the use of MERIS imagery. The bloom was confirmed through sampling on August 28, 2008 and extends from the Maumee Bay eastward and along the southern shore of western Lake Erie. Concentrations range from very high to low, with the greatest concentration at the Maumee Bay in the far SW corner of the basin (41.7919N, -83.3925W) along the southern shoreline almost to the Bass Islands (41.6602N, -83.0780W). Satellite chlorophyll levels have exceeded 40 ug/L. A cyanobacteria bloom is also present in Sandusky Bay, however the majority of the bloom was primarily comprised of *Planktothrix spp.* and some *Anabaena spp.* *M. aeruginosa, Anabaena spp.* and *Planktothrix spp.* are known to produce toxins. Strong winds and thunderstorms are expected through Friday, which may cause the bloom to disperse, become mixed within the water column or possibly concentrate along the southern shore of Lake Erie. Further sampling is recommended.

-Tomlinson, Wynne



Imagery shows the spectral shape at 681 nm from September 2, 2008, where colored pixels indicate the likelihood of *Microcystis* (with red being most likely). *Microcystis* concentration sampling data from August 28, 2008 are shown as red circles (very high), orange circles (high), yellow circles (medium) green circles (low) and blue circles (very low) and purple circles (not present).

Wind conditions from South Bass Island, OH

Lake Erie: Strong northeasterly winds (10-20 knots) are expected through tonight, and are expected to shift southwesterly on Friday. Northwesterly winds of 5-15 knots are expected Saturday and Sunday, with a decrease in storm activity.

Please note:
1. MERIS Imagery was distributed by the NOAA Coastwatch Program and provided by the European Space Agency
2. Cell counts were collected by the Great Lakes Environmental Research Laboratory
3. The wind data is available throught the National Data Buoy Center

(HAB bulletin put out by R. Stumpf, M. Tomlinson, T. Wynne – NOAA/NOS/CCMA)

Publications

- Tomlinson, M.C., T.T. Wynne, R.P. Stumpf, J. Dyble, G.L. Fahnenstiel, and P.A. Tester. Accepted. Using remote sensing to aid in the detection and monitoring of *Microcystis aeruginosa* in western Lake Erie and Saginaw Bay, USA. *Proceedings of the XII International Conference on Harmful Algae*
- Wynne, T., Stumpf, R., Tomlinson, M., Warner, R., Tester, P., Dyble, J. and G. Fahnenstiel. 2008. Relating spectral shape to cyanobacteria blooms in the Laurentian Great Lakes. *International Journal of Remote Sensing* 29:3665-3672.
- Wynne, T.T., Stumpf, R.P., Tomlinson, M.C., Dyble, J. Characterizing a cyanobacterial bloom in western Lake Erie, *in prep*.

Presentations

- Wynne, T.T., Schwab, D.J., Stumpf, R.P., Tomlinson, M.C., Dyble, J., Fahnenstiel, G.L., "Cyanobacterial Monitoring System for Lake Erie", *International Association of Great Lakes Research*, May 08
- Dyble, J., *Eastern Michigan University, Ypsilanti, MI,* "Harmful Algal Blooms", invited seminar, 26 Sept 08

PROJECT TITLE: SPATIALLY-EXPLICIT, HIGH-RESOLUTION MAPPING AND MODELING TO QUANTIFY HYPOXIA EFFECTS ON THE LIVING RESOURCES OF THE NORTHERN GULF OF MEXICO

Principal Investigators: *Allen Burton, CILER*
Doran Mason, GLERL
Edward Rutherford, GLERL
Hongyan Zhang, CILER UM
Aaron Adamack, CILER UM

Overview and Objectives

As a direct consequence of eutrophication, there has been an alarming increase in the spatial and temporal extent of low oxygen bottom waters in estuarine and coastal waters. Although hypoxia is prevalent in many US coastal systems, such as Chesapeake Bay and the Laurentian Great Lakes, most prominent has been the advancement of hypoxia in the northern Gulf of Mexico (NGOMEX). The temporal and spatial extent of hypoxia in the NGOMEX has increased as a result of excessive nitrogen inputs from the Mississippi River. Despite this increase in hypoxia, the trophic consequences of low oxygen waters on pelagic communities remain poorly understood. Given the economic importance of the Gulf of Mexico commercial fisheries (about 20% of the U.S.'s total domestic fishery landings representing about $991 million) and recreational fishing (generating ~30% of the nation's saltwater fishing expenditures and supporting nearly 25% of the nation's recreational saltwater jobs), it is imperative that knowledge of the ecosystem effects of hypoxia in NGOMEX be increased.

The objectives are to:

- Conduct high-resolution mapping of the NGOMEX pelagic food web (including bacteria, phytoplankton, microzooplankton, mesozooplankton, and fish) in relation to hypoxia;
- Integrate these ecosystem measurements through a variety of models designed to assess the effects of hypoxia on NGOMEX pelagic food webs and production;
- Quantify habitat suitability for economically and ecologically important fishes; and provide tools to forecast food-web interactions, habitat suitability, and fish production in relation to hypoxia.

High-resolution mapping of the major ecosystem components of the NGOMEX will be conducted. Automation of sampling, analysis, and classification of pelagic organisms using new technologies offers a practical, cost-effective way to intensify survey efforts in the NGOMEX so that ecosystem components are sampled at the fine-scale and broad-scale resolutions necessary to understand the effects of hypoxia. This approach will yield information on phenomena that would have been missed by a fixed or

bottom-focused sampling regime, and enhance the functionality of monitoring and observations. Mapping results will be incorporated into spatially-explicit bioenergetics-based growth rate potential, size-spectrum, dynamic optimization, food-web, and statistical models to provide managers with essential information for improved ecosystem-based management of the NGOMEX, including information to quantify and forecast the ecological consequences of changes in hypoxia on the living resources of the NGOMEX. The results of this research will be highly integrated into NOAA operations and strategic planning through direct NOAA involvement, tightly integrated with other programs in the region and elsewhere, and broadly disseminated to resource managers and the scientific community through the WWW, presentations at meetings, Sea Grant Extension and peer-reviewed publications. Undergraduates, graduate students, postdoctoral scholars, and teacher interns will be involved in all aspects of this research.

Researchers from CILER focus on the fish component of the living resources and food web model construction and simulations.

Accomplishments

Field cruise: We carried out our annual research cruise from Aug 1-14, 2008 using the Louisiana Universities Marine Consortium's (LUMCON) RV Pelican. The cruise was split into two halves with several people from GLERL and CILER participating on all or part of the cruise: Stephen Lozano, Craig Stow (both GLERL PIs), Aaron Adamack (CILER Research Fellow), and Melissa Clouse (CILER staff) participated on both parts of the cruise while University of Michigan graduate student James Roberts (employed by CILER), and CILER summer fellows Alyson Flood, Katie Bush, and Andrew Layman participated on the first half of the cruise.

During our previous cruises, we have had problems with getting our mid-water trawl to deploy properly. Thus, the primary focus of the first part of the cruise was to test several different methods for sampling pelagic fish in the mid-water portion of the water column. We spent the first three days tested several different deployment configurations for the mid-water trawl, a vertical gillnet, and an acoustic imaging system (DIDSON acoustic camera) in order to better sample the mid-water portion of the water column. We determined that the best method for sampling pelagic fish in the mid-water portion of the water column was to use the DIDSON acoustic camera.

The secondary goal of the first part of the cruise was to identify potential sampling sites for the second half of the cruise. Unfortunately, the cruise was interrupted part way through the first half of the cruise by tropical storm Edouard which forced us to return to port. The activity of the storm completely altered the physical structure of the water column which resulted in our spending the last two days of the first half of the cruise surveying the region around stations C and D trying

to find locations with bottom-layer hypoxia that we could sample during the second half of our cruise.

For the second part of the cruise, we surveyed three North-South transects (transects C, D, and F) and two-diel surveys (at stations C8 and C9 for the first and stations D3A, D4A, and D4). We conducted a bottom trawl and surveyed the water column using the DIDSON at the beginning and end of transect C but did not use the trawl or DIDSON on transects D and F. Along the length of each transect, we used fisheries acoustics and SCANFISH to examine the distribution of fish, zooplankton, temperature, salinity and dissolved oxygen along the transects. For the two diel surveys, we carried out trawls and DIDSON surveys every 4-6 hours at each station. In total, we completed 31 bottom trawls during the second half of the cruise, collecting 40 species of fish and invertebrates. The 5 most abundant species collected in ascending order were: Atlantic bumper, Atlantic cutlassfish, sand seatrout, striped anchovy, and Atlantic croaker.

Data processing:

a) Fish diets: We processed 1346 diets from 39 species of fish: The most abundant species were: Atlantic croaker (331) fed primarily on nematodes and polychaetes; striped anchovy (270) primarily fed on copepods, shrimp larvae, crab zoea and megalopae, bivalves, and nematodes; Atlantic cutlassfish (246) primarily fed on fish, squid, and shrimp larvae; sand seatrout (115) primarily fed on shrimp larvae, crab megalopae, fish, and squid; and Atlantic bumper (104) fed primarily on copepods, shrimp larvae, crab zoea and megalopae, and gastropods; Other species are: amberjack (1), bay anchovy (10), batfish (1), barracuda (2), banded drum (14), blackedged cusk eel (10), blue runner (2), blackcheek tonguefish (26), gulf butterfish (7), blackwing sea robin (72), dusky flounder (7), filefish (2), flounder larvae (2), grey triggerfish (1), harvestfish (1), hardhead catfish (1), king mackerel (1), least puffer (17), mackerel sp. (1), Atlantic moonfish (13), needlefish (2), pinfish (2), longspine porgy (1), red drum (1), red snapper (25), scombridae (5), scaled sardine (19), snapper larvae (1), Spanish mackerel (4), spot (23), Spanish sardine (1), smooth puffer (1), Atlantic threadfin herring (1), and tripletail (1).

b) Acoustic data: more than 80 acoustics casts were carried out during 2008 cruise. The longest transects have been processed, while the rest will require an additional month of work.

Data analysis: Growth rate potential (GRP) models have been widely used to assess ecosystem capacity, qualify habitat quality, and examine the response of fish to stress factors. We have developed a GRP model which is being used to investigate the impacts of hypoxia on forage fish production. We are currently determining whether

the model can be used to successfully predict habitat quality in the northern Gulf of Mexico. The model uses water temperature, dissolved oxygen, zooplankton biomass and fish biomass data that were collected during the 2003, 2004 and 2006 cruises. Model results clearly show that hypoxic zones (<2.0 mg $O_2 l^{-1}$) are low-quality habitats. For most of transects, especially those that were sampled during 2006, a year with severe hypoxia, the locations that were predicted by the GRP model to have good habitat quality were also observed to have high fish biomass. The opposite was true low quality habitats. While the initial model results were good, additional analysis suggests that the sigmoidal dissolved oxygen functional response needs further modification to improve predictions for years with mild hypoxia. Model error analysis shows that when variation level of parameters values is low (2%), growth rate potential is linearly correlated to the model parameters; however this linearity is reduced when the variation in model parameter values is increased. Based on these results, we feel that our use of "species borrowing" from closely related species for GRP modeling is appropriate.

Communications:

An All-PI project meeting was held on February 12 – 13, 2009 at Silver Spring, MD. Four people from GLERL and CILER presented at the meeting, Doran Mason, Hongyan Zhang, Aaron Adamack, Melissa Clouse.

A meeting to discuss the analysis of the data collected using the DIDSON acoustic camera was held in Baton Rouge, LA on February 24, 2009 at Louisiana State University (LSU). The meeting attendees were Aaron Adamack (CILER), Doran Mason (GLERL), Stuart Ludsin (Ohio State University) and Kevin Boswell (LSU).

Publications

Zhang, H, Ludsin, S.A., Mason, D.M., Adamack, A.T., Brandt, S.B., Zhang, X., Kimmel, D.G., Roman, M.R., Boicourt, W.C. *In press*. Hypoxia-driven changes in the behavior and spatial distribution of pelagic fish and mesozooplankton in the Northern Gulf of Mexico. Journal of Experimental Marine Biology and Ecology.

Zhang, H, et al. *In preparation*. GRP model: detection of hypoxia impacts on the distribution of the pelagic fish in the northern Gulf of Mexico. Targeting on Marine Ecology Progress Series.

Clouse, M. et al. *in preparation.* Summer feeding habits of Atlantic bumper in the northern Gulf of Mexico.

Clouse, M. et al. *in preparation*. Trophic relationships among common fish species in the northern Gulf of Mexico during summer.

Presentations

Adamack, A.T. 2009. Developing an Ecopath model for the Northern Gulf of Mexico. Project meeting. Silver Spring, MD. Feb. 12-13

Adamack, A.T., Boswell, K.M. 2009. DIDSON Talk. Project meeting. Silver Spring, MD. Feb. 12-13

Clouse, M. 2009. Feeding habits and trophic relationships of dominant fishes. Project meeting. Silver Spring, MD. Feb. 12-13

Mason, D.M. 2009. Model of fish movement in the northern Gulf of Mexico. Project meeting. Silver Spring, MD. Feb. 12-13

Zhang, H., Ludsin, S.A., Mason, D.M., Adamack, A.T., Brandt, S.B., Zhang, X., Kimmel, D.G., Roman, M.R., Boicourt, W.C. 2009. Hypoxia-driven changes in the behavior and spatial distribution of pelagic fish and mesozooplankton in the Northern Gulf of Mexico. Project meeting. Silver Spring, MD. Feb. 12-13

PROJECT TITLE: NEARSHORE TRANSPORT: MODELING, OBSERVATIONS, AND BEACH CLOSURE FORECASTING

Principal Investigators: *Dmitry Beletsky, CILER*
David Schwab, GLERL
Allen Burton, CILER

Overview and Objectives

The Great Lakes respond very quickly to atmospheric forcing and other loadings (Klump et al., 1995). Consequently water quality managers and other planning and decision entities are increasingly calling for up-to-the-minute data on present water quality conditions or forecasts of these data that can be used to adjust or respond to quickly developing activities with environmental implications. Examples include the forecast of short term water quality conditions for the withdrawal of water for drinking water supply; short range predictions of potentially dangerous conditions at water supply intakes; the forecast of beach closings and openings from bacterial contamination from combined sewer overflow (CSO) discharges (Burton et al., 1987; Sherer et al., 1992); the knowledge of the trajectory of materials from dangerous spills; short range prediction of the impact of shoreline activities at one site or another shoreline site; and the forecasting of upwelling and downwelling events and the associated nutrient and bacterial redistributions required for toxic plankton blooms.

For these and other reasons, the Great Lakes Forecasting System (GLFS, Bedford and Schwab, 1994; Schwab and Bedford, 1994) has been developed to provide short-range operational (regularly scheduled) predictions of such conditions for the open waters of the Great Lakes. Variables predicted include the three-dimensional velocity field, the three-dimensional temperature field, the water level distribution and the wind wave height, length, period, and direction, and resuspension, transport, and deposition of bottom sediments based on wave and current conditions (Lou et al., 2000). The Princeton Ocean Model (Blumberg and Mellor, 1987) serves as the base model for the forecast system. The system has undergone extensive testing. As a result of these testing activities, we concluded that the whole lake circulation features could be forecast with reasonable accuracy out to 12-24 hours.

This proposal is a part of the research program that focuses on point source loadings of *E. coli* (EC) into coastal environments from particular rivers, its transport and impact on beach closures in the Great Lakes. The **objective** of this project is to develop a nested grid modeling system for Indiana Dunes National Lakeshore, Lake Michigan based upon a fully three-dimensional hydrodynamic model to provide temperature

and advection fields for forecasting E. coli and Enterococci concentrations along the coasts impacted by a specific plume (ultimately pathogens).

Accomplishments

A nested grid 3D hydrodynamic modeling system was developed for the for Indiana Dunes National Lakeshore area in southern Lake Michigan. The grid includes four major tributaries and extends from Gary, IN to New Buffalo, MI. The Princeton Ocean Model was run first for the whole lake in 2004 and 2005, boundary conditions were extracted and the fine-resolution (100 m) model was run again. Results were compared with current observations in the vicinity of Burns Ditch. We also used 3D particle transport model to simulate Burnes Ditch plume propagation and compared model results with 2005 field observations.

Publications

Beletsky, D. and D.J. Schwab. 2008. Climatological circulation in Lake Michigan. *Geophys. Res. Letters.* 35, L21604, doi:10.1029/2008GL035773.

Presentations

Beletsky, D., D. Schwab, and M. McCormick. 2008. Near-shore circulation modeling in southern Lake Michigan. The 12th Workshop on Physical Processes in Natural Waters, September 2-5, 2008, Incline Village, NV.

Beletsky, D., D. Schwab, and M. McCormick. 2008. Nested grid circulation modeling in southern Lake Michigan. IAGLR 2008. May 19-23, 2008, Peterborough, ON.

Beletsky, D., D. Schwab, and M. McCormick. 2008. Evaluation of a 3D circulation model to predict bacterial contamination at Great Lakes beaches. 2008 Ocean Sciences Meeting, 2-7 March 2008, Orlando, FL.

Schwab, D., D. Beletsky, and G.Lang. 2008. A real time system for prediction of coastal circulation at Great Lakes beaches. 2008 Ocean Sciences Meeting, 2-7 March 2008, Orlando, FL.

PROJECT TITLE: BEACH QUALITY FORECASTING COORDINATOR

Principal Investigators: *David Schwab, GLERL*

Allen Burton, CILER

Overview and Objectives

The NOAA Center of Excellence for Great Lakes and Human Health (CEGLHH) is a multi-disciplinary, multi-institutional research center that is developing tools to predict water quality in the Great Lakes. Focus areas for the Center include ecological forecasting, nearshore transport, drinking water, beach closings, and harmful algal blooms. CEGLHH is currently seeking a Beach Quality Forecasting Coordinator to coordinate on-going efforts of CEGLHH and other agencies with the purpose of developing and implementing a generalized approach to beach quality nowcasting and forecasting. Specific responsibilities for the Coordinator include:
1. Inventory and document ongoing activities related to beach quality forecasting such as

- USGS Project SAFE
- USGS Ohio beach nowcasting
- Lake County Illinois Swimcast
- Great Lakes Information Network Beachcast
- NOAA/GLERL research on process-based beach quality modeling
- EPA AMI bacterial exposure project

2. Develop a generalized process for beach quality nowcasting, forecasting, and product delivery. The process should include a protocol for identifying appropriate parameters to use as independent variables, gathering water quality records, obtaining the required independent variables, developing a statistical model relating water quality to the independent variables, implementing a system for routine operation of the model in nowcast and forecast mode as well as dissemination to users, and evaluation of the accuracy of the system. The coordinator might not be the person carrying out all these activities, but would be responsible for coordinating the required activities, documenting the protocol, and ensuring that the protocol could be applied and sustained at any new beaches.

3. Work with EPA, USGS, NOAA, Sea Grant, appropriate state and local agencies, and the Great Lakes Beach Association to make sure that the end result is a product that will be useful for both nowcasting and forecasting of conditions at Great Lakes

beaches. The product should also be transferable to other beaches and operationally sustainable.

In addition, the Coordinator will be expected to possess existing knowledge on methods for predicting recreational water quality at beaches and the processes needed to develop data sets capable of providing useful explanatory variables for model development.

Accomplishments

Hired David Rockwell for Beach Water Quality Forecasting Coordinator.

- Great Lakes Restoration Initiative

  NOAA plan for Beach Water Quality Forecasting Program proposal for Gt. Lk. Restoration Initiative. Proposal for 3.4 M over two years

  Areas of interest including Saginaw Bay River and Bay AOC, Milwaukee Wisconsin AOC, Clinton River AOC, St. Louis River Duluth Minnesota AOC, Rochester Embayment, Rochester NY AOC, and Presque Isle Erie PA AOC, Huntington Beach is near the Cuyahoga River AOC.

  NOAA Beach Proposal for GLRI funds (attachment 1).

- Beach Model Data Base Spreadsheet (attachment 2) identifies ~100 Great Lake Beaches where predictive models have been developed. These beaches use EPA's Beach ID number in the USGS Great Lakes Beach Analysis Tool Utilizing Geographic Information Systems.

- Formed the Great Lakes Beach Health Interagency Coordination Team comprised of three members from USEPA, USGS, and NOAA and held first joint meeting April 14, 2009.

  Membership;
  USEPA: Holly Wirick, Richard Zdanowicz, and Dr. Richard Zepp
  USGS: James Morris, Sandra Morrison, and Norman Grannemann
  NOAA: Richard Wagenmaker, Sonia Joseph, and Dr. David Schwab
  Beach Quality Forecasting Coordinator: David Rockwell

  Norman Grannemann <nggranne@usgs.gov>, Sonia Joseph <Sonia.Joseph@noaa.gov>, James Morris <jrmorris@usgs.gov>, Sandra Morrison <smorrison@usgs.gov>, David Schwab

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Publications

None

Presentations

Poster: National Beach Conference Huntington Beach California, April 20-22, 2009

Towards 48 Hour Beach Forecasting Models for the Great Lakes.

D. Rockwell, D. J. Schwab, S. Joseph, and R. Wagenmaker with collaborators J. Morris, S. Morrison, N. Grannemann, H. Wirick, R. Zdanowicz, and R. Zepp.

EPA Recreational Waters Research Forum April 23, 2009
Session 3. Compliance monitoring and predictive modeling

Invited Talk

A Real-time System for Prediction of Nearshore Circulation and Pathogen Transport at Great Lakes Beaches.

D.J. Schwab and D. Rockwell

American Public Health Association annual meeting November 7-11, 2009
"Water and Public Health: the 21st Century Challenge" in Philadelphia,

Session: Your Oceans and Your Health: Public Health Surveillance, Prediction, Prevention and Preparedness

Invited Talk:
Beach Water Quality Forecasting in the Great Lakes: Using Ocean Observing Systems to Predict Public Health Issues.

D. Rockwell, D.J. Schwab, and S. Joseph

PROJECT TITLE: MODELING GREAT LAKES ICE AND REVEALING LINKAGE BETWEEN LAKE ICE AND CLIMATE PATTERNS

Principal Investigators: *Jia Wang, GLERL*
Dmitry Beletsky, CILER
Allen Burton, CILER

Overview and Objectives

Lake ice cover is an important predictor of regional climate. Lake ice extent also modifies the circulation patterns and thermal structure because: 1) wind stress drag is different in magnitude over water surface than over ice surface; 2) the albedo over ice vs. water differs, and 3) heat and moisture exchange between the atmosphere and the lake water can differ significantly (as much as an order of magnitude difference) in magnitude with and without lake ice, thus leading to striking difference in evaporation in wintertime due to wind mixing.

The Great Lakes ice severity conditions are determined by surface air temperature (SAT), water temperature, heat flux, and water heat storage that is directly proportional to water depth. These factors are associated with global (hemispheric) and regional climate patterns, such as the Arctic Oscillation (AO) or the North Atlantic Oscillation (NAO), and Pacific-North America (PNA) pattern.

The Great Lakes are located at the edge of the Icelandic Low, far away from the action center. Thus, although being influenced by the Icelandic Low whose intensity is associated with AO/NAO (+/-AO means a stronger/weaker Icelandic Low), ice cover may not have a statistically significant relationship with AO/NAO. A similar doubt/hypothesis is also applied to the PNA pattern. Based on previous research (Wang et al. 1994; Mysak et al. 1996), the PNA pattern may have a marginally significant impact on ice cover in the Great Lakes, because the Great Lakes are located between the Alberta High and the SE-US Low.

The objective of this study is to use generalized statistical analyses of the NCEP/NCA reanalysis and climate GCM products and historical sea ice observations including recent satellite measurements to analyze the statistical relationship between lake ice cover and climate indices in both spatial and temporal spaces. Generalized relationship between lake ice cover, lake levels, and atmospheric circulation patterns will be concluded. The second objective is to develop and test ice model of Lake Erie.

Accomplishments

A coupled ice-lake model of Lake Erie was developed based on POMGL and CIOM and tested during 2003-2004 winter. Model results compared favorably with observations.

The impacts of ENSO and AO on Great Lakes ice cover were investigated using lake ice observations for winters 1963-2008 and NCEP reanalysis data. It is found that both ENSO and AO have impacts on Great Lakes ice cover. During El Niño events, the Great Lakes tend to be warmer-than-normal and have less ice cover. Strong El Niño events are often associated with least ice cover. The impacts of La Niña events on the Great Lakes ice cover are insignificant. The Great Lakes tend to have less ice cover during +AO and more ice cover during -AO. The combination and interference of these two forcings complicate the relationship between Great Lakes ice cover and ENSO/AO. When a winter is simultaneously during El Niño and +AO, the combined effects lead to mild winter. When a winter is during La Niña and -AO, the combined effects lead to severe winter. When a winter is simultaneously during El Niño and –AO, ice conditions on the Great Lakes depend on strengthen of these two forcing. When a winter is simultaneously during La Niña and +AO, as the impacts of La Niña events on the Great Lakes are insignificant, the Great Lakes is dominated by +AO, leading to mild winter. These two states reinforce the asymmetric response of Great Lakes regional climate to ENSO. The combination and interference of effects of both ENSO and AO should be considered to predict ice cover variability on the Great Lakes.

Publications

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PROJECT TITLE: IFYLE – THE INTERNATIONAL FIELD YEARS ON LAKE ERIE PROGRAM – WEBSITE AND DATABASE DEVELOPMENT AND MANAGEMENT

Principal Investigators: *Margaret Lansing, GLERL*
Nathan Hawley, GLERL
Allen Burton, CILER

Overview and Objectives

The three primary objectives of the IFYLE program are to:

- Quantify the spatial extent of hypoxia across the lake, and gather information that can help forecast its timing, duration, and extent;
- Assess the ecological consequences of hypoxia to the Lake Erie food web, including phytoplankton, bacteria, microzooplankton, mesozooplankton, and fish;
- Identify factors that control the timing, extent, and duration of HAB (including toxin) formation in Lake Erie, as well as enhance our ability to use remote sensing as a tool to rapidly map HAB distributions in the lake.

Accomplishments

The data base is fully operational. Management of the database is satisfactory; the database design has insured simple, trouble free functionality.

http://www.ifyle.org/

Data base submissions are added iteratively. All data/ submissions are entered immediately.

http://www.ifyle.org/whats_new.html

Publications

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PROJECT TITLE: WATER QUALITY AND FISH PRODUCTION IN COASTAL ECOSYSTEMS

Principal Investigators: *Stephen Brandt*
Allen Burton, CILER

Overview and Objectives

Project Background

Fishery managers in the Great Lakes and coastal marine systems need to be able to make predictions as they attempt to manage fisheries in ecosystems that are constantly changing and under multiple stressors. Problems such as habitat loss, hypoxia, harmful algal blooms, eutrophication, nonindigenous species invasions, and climate change all pose challenges to making the predictions that are needed in fishery management scenarios. For example, in the Great Lakes, recent changes in the benthic community, particularly the invasion by D*reissena* mussels and subsequent decline of *Diporeia*, have been tied to changes in planktivorous fish distribution, abundance and production. The invasion of the predatory zooplanktors, *Bythotrephes longimanus* and *Cercopagis pengoi* may be affecting fish diet selectivity and zooplankton availability. Changes in forage fish abundance, condition, and distribution may be affecting predator fish (Pacific salmon, lake trout) condition and distribution in Lake Huron. Changes in lake whitefish condition and distribution are affecting commercial fishery harvests in Lakes Ontario, Huron, and Michigan. In Lake Erie, low productivity and forage fish abundance may be contributing to low harvests of walleye in the lake and there is evidence that watershed loadings and water quality have direct impact on fish recruitment. In the Chesapeake Bay and the Gulf of Mexico, eutrophication has caused dead zones that may affect the pelagic food webs, and, ultimately fish behavior, growth, distribution and production. Many of these same stressors also affect water quality and human health through their influence on drinking water and recreational water use. How can management balance these impacts?

Objectives

Our overall objective is to improve our knowledge and understanding of the relationship between water quality and fish production as driven by nutrient loading, physical forcing and invasive species. Focusing research on forecasting fish growth and production will lead to a better understanding of the causes, effects, and solutions to problems such as eutrophication, toxic contaminants, nonindigenous species invasions, habitat modification, and climatic variations.

Approach

Overall, this program combines modeling and field programs and will largely be a comparison of results from different coastal ecosystems including the Great Lakes, Gulf of Mexico, Chesapeake Bay, the Adriatic Sea, Lake Kinneret and other coastal ecosystems. Most of the field work has been completed although additional field sampling will occur in the Great Lakes in 2009. This program will work closely with other major programs including IFYLE, The Center of Excellence for Great Lakes and Human Health, ECOFORE, the NGOMEX, and the Multiple Stressors Program.
In the Great Lakes, sampling has largely been completed and occured seasonally in conjunction with other ongoing GLERL/CILER research projects and at stations where historical data sets are available. Special emphasis in the analyses will be placed on evaluating fisheries in Lake Erie and how physical (water currents, temperature, hypoxia, harmful algal blooms) and biological (productivity, prey concentration and types) parameters affect the production of these fisheries. Forage fish abundance and distribution will be examined relative to water depth, water temperature, and abundance of various prey such as *Diporeia*, zooplankton, and *Mysis*. Fish were sampled during day and night using a variety of sampling techniques including bottom and midwater trawling and fisheries acoustics. Diet information will be related to prey availability to determine selectivity and importance of major prey items. Diet information will also be used as inputs into bioenergetic models. These models will help assess fish consumption relative to prey production. Spatially-explicit bioenergetics models will help to determine what factors (i.e., temperature, fish density, prey types) are affecting fish growth in the Great Lakes. The models will also be used to help predict how changes in the Great Lakes food web may be affecting predator and forage fish production and growth. Additional modeling will occur in the Saginaw Bay, Lake Huron and Western Lake Erie to evaluate the effects of multiple stressors on fish and water quality conditions and their relationships to human health.

To develop forecasting models in coastal marine systems, we will utilize the wealth of physical, chemical, and biological data, collected in Chesapeake Bay during 1995-2000 as part of the Trophic Interactions in Estuarine Systems (TIES web site) project (funded as part of the National Science Foundation's Land Margin Ecosystem (LMER) program) and ongoing field program in the Gulf of Mexico. In so doing, we primarily seek to provide ecological forecasts to agencies involved in Chesapeake Bay and Gulf of Mexico fisheries management, but fully envision that the products and approaches developed herein will benefit management in a broad class of estuaries. The comprehensive data products and forecasting tools being produced require an interdisciplinary synthesis of physical, chemical, and biological data collected at numerous spatial and temporal scales with a variety of technologies (e.g., acoustics, CTDs, OPCs, ADCPs, remote sensing). A variety of analytical techniques, including spatially explicit bioenergetics modeling, spectral analysis, multivariate statistical modeling, and network analysis will be employed to aid this effort. We plan to continue quantifying the spatio-temporal distribution of pelagic fish biomass (e.g., bay

anchovy, striped bass) in both ecosystems, as well as continue exploring the role of habitat (e.g., temperature, dissolved oxygen, prey availability) and water quality in explaining fish distributions and potential growth rates. These efforts ultimately would enhance our ability to provide ecological forecasts of how anthropogenic factors such as eutrophication can influence growth rate and habitat use of fishes in coastal systems.

This project will also examine the response of pelagic fishes (primarily sardines and anchovy) to the Po River outflow into the Adriatic Sea. Field programs will use fisheries acoustics to examine the spatial distribution of fishes across the Po River Front. Like many coastal environments throughout the world, the watersheds of the Adriatic Sea are regions of rapid population growth and changing land-use patterns. Changes in the coastal ecosystems of Croatia, Italy, and Slovenia are making the coastal zone more susceptible to environmental hazards, more costly in which to live, and of less value to the regional economy. The overall goal of this program is to cultivate a regional approach to environmental monitoring and forecasting in the Northern Adriatic Sea that will help mange coastal fisheries and tourism.

Predictive models developed for all four ecosystems will be compared to determine what predictive factors are common to the ecosystems. We will also analyze similarities and dissimilarities in the effects of changes such as eutrophication, Hypoxia, nonindigenous species invasions, habitat modification, and climatic variations on the Great Lakes and a coastal marine environment. These data will help provide information on the applicability of predictive models across ecosystems, and provide a broader context for the assessing the effects of anthropogenic changes in aquatic ecosystems.

Accomplishments

Two consecutive searches were conducted to hire a Post Doctoral Scientist for this project and interviews are underway.

The main ongoing accomplishment is the publication of a dedicated issue of the Journal of Experimental Biology and Ecology on "The Impact of Hypoxia on Living Resources" where over 20 papers will be published. The Principal Investigator is serving as a co-editor of the issue.
A number of analyses and manuscripts were completed on effects of hypoxia on distribution, predator-prey interactions and bioenergetic growth potential for striped bass and bay anchovy in the Chesapeake Bay, yellow perch and walleye in Lake Erie and pelagic fishes in the Gulf of Mexico. Most of this work has been submitted and is now in press (see list below).

We completed our final research cruise in the Gulf of Mexico during August, 2008.

The Principal Investigator convened an all-pi meeting of the scientists working on NGOMEX – (Impact of Hypoxia on Living Resources in the Gulf of Mexico) in Washington D.C. on Feb. 12-13, 2009. At that meeting, there was a series of presentations on data collected and we compiled a list of manuscripts, authors, timetables, responsibilities and data needs for the project.

Publications

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Borme D.[1] , Tirelli V. [1,*], Brandt S.B. [2], Fonda Umani S. [3], Arneri E. [4] Diet of *Engraulis encrasicolus* (L.) in the northern Adriatic Sea (Mediterranean): ontogenetic changes and feeding selectivity. Journal of Plankton Research (***submitted***)

Presentations

Brandt, S.B., M. Costantini, S.A. Ludsin, D.M. Mason, and H.A. Vanderploeg. 2008. Spatially-explicit growth predictions to assess habitat quality of walleye during hypoxia in Lake Erie. Oral presentation at the International Association for Great Lakes Research 51st Annual Conference on Great Lakes Research, Peterborough, ON. May 20.

Brandt, S. B. 2009. NGOMEX Program description and objectives. Invited presentation to: Northern Gulf of Mexico Hypoxia Workshop. Silver Spring, Md. Feb. 12-13, 2009.

Brandt, S. B. 2009. Growth rate potential modeling of fish habitat quality. Invited presentation to: Northern Gulf of Mexico Hypoxia Workshop. Silver Spring, Md. Feb. 12-13, 2009.

ADAPTIVE INTEGRATED FRAMEWORK (AIF): A NEW METHODOLOGY FOR MANAGING IMPACTS OF MULTIPLE STRESSORS IN COASTAL ECOSYSTEMS

Principal Investigators: *Craig Stow, GLERL*
Julianne Bressie, GLERL
Gary L. Fahnenstiel, GLERL
Thomas F. Nalepa, GLERL
Steven A. Pothoven, GLERL
Henry A. Vanderploeg, GLERL
Allen Burton, CILER

Overview and Objectives

Saginaw Bay has a long history of anthropogenic impacts that have compromised many of the ecosystem services that humans value. Current stressors influencing the Bay include excess nutrient inputs, invasive species (dreissenid mussels), and climate change effects (declining water levels). The combined effect of these stressors has resulted in nuisance and harmful algae production and changed the balance of the recreational fishery. This goal of this project is to develop an interactive working relationship with resource managers in the Saginaw Bay watershed and conduct research that will provide guidance to address the most important management concerns.

To help accomplish this goal we held a workshop of Bay-area resource managers in Bay City, MI on April 2, 2008. The purpose of the workshop was to assess management priorities so that we could design research to address some of the key unknowns that impede effective management decision-making. In response to what we learned in this workshop, and in a limited field survey in 2008, we developed a field sampling program with supporting experimentation to be conducted in 2009. These plans were conveyed to the management community in a second workshop at the new GLERL facility on April 9, 2009. Representatives from Senator Stabenow's office, as well as Rob Magnien and Larry Pugh from NOAA's Center for Sponsored Coastal Ocean Research (our funding source) also attended the workshop.

2008-09 Accomplishments and Activities

- PI Workshop October 2008
- Resource Manager Workshop April 2009
- Watershed Sampling conducted from January-December 2008
- Assembly of Comprehensive Database is ongoing
- Update of Existing Model, SAGEM2, a linked hydrodynamic – lower food web eutrophication model that includes sub-models for dreissenids and attached algae (i.e., Cladophora) ongoing.
  - ✓ Model code running, being tested to verify no bugs. We plan to apply to the 1990's data to evaluate ability to simulate observed plankton dynamics.
- Duke University student hired to develop Bayesian network model (Saginaw Bayes).
- 2008 Field Survey Results:
  - ✓ sampled May, July, Sept (13 stations – 10 inner, 3 outer bay)
  - ✓ Chlorophyll *a*
  - ✓ Nutrients (TP, TDP, SRP, NH4, NO3, Cl, Si, PON, POC, DOC)
  - ✓ Secchi depth
  - ✓ temperature profile (CTD)
  - ✓ microcystin concentrations (at 5 Master stations)
  - ✓ dreissenid densities (in September)
  - ✓ collected zooplankton and microzooplankton at Master stations – not yet processed.
- Watershed modeling, nutrient accounting activities included:
  - ✓ Generation of watershed characteristics databases at 500m resolution;
  - ✓ Completed calibration of the Distributed Large Basin Runoff Model hydrology at 500m resolution of Kawkawlin-Pine, AuGres-Rifle, and Pigeon-Wiscoggin for 1948-1964.
  - ✓ Completed verification of DLBRM hydrology at 500m resolution of Kawkawlin-Pine, AuGres-Rifle, and Pigeon-Wiscoggin for 1999-2006.
  - ✓ Completed recalibration of DLBRM hydrology at 500m resolution for 1999-2006 of Kawkawlin-Pine, and Pigeon-Wiscoggin; initiated for AuGres-Rifle;
  - ✓ Completed calibration of DL:BRM hydrology at 500m resolution of Saginaw River for 1999-2006 (Saginaw River watershed is too large for being recalibrated at this resolution also for 1948-1964);
  - ✓ Inclusion of point sources in DLBRM (Discharge, Temperature, Total Suspended Solids, Biological Oxygen Demand, Dissolved Oxygen, Organic Phosphorous, Soluble Reactive Phosphorous, Organic Nitrogen, Nitrate, Ammonia, and Fecal Coliforms);
  - ✓ Inclusion of BOD dynamics in the DLBRM
  - ✓ Modeling of Total Suspended Solids and Total Phosphorous Loads in the Saginaw River tributaries by regression.
  - ✓ Planning of 2009 sampling campaign of the Kawkawlin, Pine, Rifle, and AuGres Rivers.

- ✓ Multiple databases of DEM, land use, soil, and hydrography compiled for the Saginaw Bay watersheds
- ✓ Generated input variables for the DLBRM at 1x1, 2x2, and 4x4 square km resolutions.
- ✓ Derived nutrient loadings (N and P) from animal manure and fertilizer applications for the study watersheds for 1987, 1992, 1997, and 2002.
- ✓ Produced monthly estimates for the revised universal soil loss equation (RUSLE) for Saginaw Bay watersheds.

- Hydrodynamic Modeling Efforts Included:
  - ✓ Lake-wide 3D hydrodynamic model of Lake Huron run for 1993 on 2 km grid in baroclinic mode. Modeled currents saved hourly to validate water quality model circulation.
  - ✓ 3D nested grid modeling system developed for inner bay on200 m grid. The model was run for summer of 1993 using Lake Huron model currents, temperatures at open boundary conditions.
  - ✓ 2008 physical measurements collected for hydrodynamic model validation. Several ADCPs. thermistor chains deployed in inner and outer Bay in summer 2008, some continuing in winter-spring 2008-2009.
- Statistical analyses of MI-DNR survey data included:
  - ✓ Obtained trawl and gill net data from the Michigan DNR
  - ✓ Data manipulation and organization
  - ✓ Completed statistical analysis of Michigan DNR trawl and gill net survey data for spatial and recruitment patterns of yellow perch and walleye in Saginaw Bay
  - ✓ Analyzed yellow perch and walleye gill net and trawl CPUE time series using dynamic factor analysis (DFA)
  - ✓ Spatial patterns in yellow perch and walleye in Saginaw Bay
  - ✓ Patterns in cohort CPUE for yellow perch and walleye
  - ✓ Recruitment dynamics for yellow perch and walleye analyzed
  - ✓ Preliminary stages of manuscript prep & additional analysis
  - ✓ Completed statistical analysis of Michigan DNR trawl and gill net survey data for understanding trends in fish community structure in Saginaw Bay
  - ✓ Analyzed fish community gill net and trawl CPUE time series using dynamic factor analysis
  - ✓ Compared results of DFA for gill net and trawl survey data
  - ✓ Preliminary stages of manuscript prep
- Development of yellow perch and walleye individual-based model (IBM) included:
  - ✓ Communicated with developers of the physical and lower trophic food web model at Limnotech on spatial and temporal structure of the model framework and model coupling
  - ✓ Developed preliminary model framework

- ✓ Mined literature for functions and parameters required for model function
- ✓ Many simplified subroutines coded into IDL, including foraging, growth, and mortality
- ✓ Initial parameters set for several subroutines required for model function, including foraging, growth, and mortality
- ✓ Developed an individual-based ecogenetic model of yellow perch energy allocation
- ✓ Coding and model structure have been completed
- ✓ All subroutines have been tested to ensure model function
- ✓ Final testing for model accuracy yet to be completed

- Collection of angler fishing survey data began July 2008.
- Analysis of Michigan beach use pilot survey completed.
- Saginaw Bay session scheduled for IAGLR 09.
- 2009 Field Survey began in April – will continue into October.

Publications

Croley II, T.E. and C. He. 2008. Ch.9. Spatially Distributed Watershed Model of Water and Materials Runoff. In: Ji, W. (ed). Wetland and Water Resource Modeling and Assessment: A Watershed Perspective. CRC Press, New York, p.99-112.

Croley, T. E., II, D. F. Raikow, C. He, and J. F. Atkinson, 2008. Hydrological Resource Sheds. *Journal of Hydrologic Engineering (SCI)* Vol.13 (9):873-885.

He, C. and T.E. Croley II. 2008. Ch.10. Estimating Nonpoint Source Pollution Loadings in the Great Lakes Watersheds. In: Ji, W. (ed). Wetland and Water Resource Modeling and Assessment: A Watershed Perspective. CRC Press, New York, p.115-127.

He, C. C. DeMarchi, and T.E. Croley II. 2008. Modeling Spatial Distributions of Nonpoint Source Pollution Loadings in the Great Lakes Watersheds by Using the Distributed Large Basin Runoff Model. Proc. Papers of American Water Resources Association GIS and Water Resources V, San Mateo, California, March 17-19.

Schertzer, W.M., R.A. Assel, D. Beletsky, T.E. Croley II, B.M. Lofgren, J.H. Saylor, and D.J. Schwab. 2008. Lake Huron climatology, inter-lake exchange and mean circulation. *Journal of Aquatic Ecosystem Health & Management*, 11(2), 144–152.

Stow, C.A., E.C. Lamon, T. K. Kratz, and C. E. Sellinger. 2008. Lake level coherence supports common driver. *Eos*,89: 389-390.

Presentations

He, C. and T. E. Croley. 2008. Resource Shed and Its Applications in the U.S. Great Lakes Watersheds. The Chinese Academy of Sciences Research Center for Eco-Environmental Sciences, Beijing, Nov.6.

He, C. and T. E. Croley. 2008. Resource Shed and Its Applications in the U.S. Great Lakes Watersheds. Lanzhou University, Lanzhou, P.R. China, Oct.29.

He, C. and T. E. Croley. 2009. Defining and Applying Hydrological Resource Shed in the Great Lakes Watersheds. Department of Geography, East Carolina University, Greenville, NC. Feb.18.

He, C., and C. DeMarchi , 2009. Modeling Spatial Distributions of Point and Nonpoint Source Pollution Loadings in the Great Lakes Watersheds by Using the Distributed Large Basin Runoff Model. Proceedings of the World Academy of Science, Engineering and Technology's ICGIS 2009 - International Conference on Geographic Information Systems, Paris, France, June 24-26, 2009.

He, C., C. DeMarchi, and T.S. Croley II, 2008. Modeling Spatial Distributions of Nonpoint Source Pollution Loadings in the Great Lakes Watersheds by Using the Distributed Large Basin Runoff Model. In *Proceedings of the AWRA 2008 Spring Specialty Conference*, San Matteo, CA, March 17-19, 2008 (*CD*).

He, C., T. E. Croley, and C. DeMarchi. 2008. Modeling Nonpoint Sources Pollution Loadings in the U.S. Great Lakes Basin. Shaanxi Normal University, Oct.24.

He, C., T.E. Croley, and C. DeMarchi.2008. Application of Distributed Large Basin Runoff Model and Resource Sheds in the U.S. Great Lakes Watersheds. The Chinese Academy of Sciences Research Center of Eco-Environmental Sciences, Beijing, Jan.5.

Johengen, T.H., C. DeMarchi, T.E. Croley II, and C. He, 2008. Sediment and Nutrient Load Simulation for the Saginaw Bay AIF. International Association for Great Lakes Research's 51st Annual Conference, May 19-23, 2008, Peterborough, Ontario.

Perspectives on Muck and Beach Fouling in the Great Lakes. Bay City State Recreational Area, Saginaw Bay Coastal Initiative Speaker Series, April 2009. Craig Stow, Juli Bressie, Kim Peters, Diana Dziekan.

Project Overview presented to MDNR, Fisheries Division Lake Huron Basin Team, May 2008. Tammy Newcomb.

THEME II: INVASIVE SPECIES

CILER activities that fall under the theme of Invasive Species include research focusing on the prevention, monitoring, detection, and control of invasive species, and on a better understanding of the range of their ecosystem impacts.

PROJECT TITLE: PORT DISTRIBUTION OF HEMIMYSIS ANOMALA – ONE OF THE NEWEST GREAT LAKES INVADERS

Principal Investigators: *Thomas Nalepa, GLERL*

David Reid, GLERL

Allen Burton, CILER

Overview and Objectives

In 2006, the bloody red shrimp, the mysid *Hemimysis anomola* was discovered in Muskegon MI, and has since expanded to northern Lake Erie and Lake Ontario. The mysid is an omnivore, and has potential to further disrupt the lower food web of the Great Lakes. The distribution of *Hemimysis* is not well known, but is thought to occur along ports where ships offload cargo and ballast.

The objectives of this research are to document the spread of *Hemimysis* in central and southern Lake Michigan, Saginaw Bay Lake Huron, and the Huron-Erie corridor. In all ports where *Hemimysis* is found, estimates will be made of *Hemimysis* age structure, size, and reproductive state.

Accomplishments

In fall 2007, project scientists sampled locations in lakes Michigan and Huron with habitat suitable for *Hemimysis* colonization. Bottle traps and plankton net tows were deployed at the sites in the offshore area near Muskegon, Michigan, Traverse City, Charlevoix, Saginaw Bay, and along the Huron-Erie corridor (St. Clair River, Lake St. Clair, and the Detroit River). Samples were initially examined in the field and then returned for more thorough laboratory analysis. No *Hemimysis* were found at any of the sites.

NOAA established a comprehensive website http://www.glerl.noaa.gov/hemimysis/index.html) to provide information in various forms (a brochure, scientific factsheet, a research plan, sampling protocols), a reporting mechanism for the public, and to provide a central record of distribution reports as they came in. Results from the surveys conducted under this project were added to the Reporting section of that website.

By mid-2008 it became apparent that *Hemimysis* is already widely distributed in the Great Lakes, having been found at multiple locations in lakes Ontario, Erie, Michigan,

and Huron. Given the widespread distribution, a plan to notify the shipping industry to avoid ballasting in "hot spots" was abandoned as not worthwhile.

In late 2008, the distribution records and reporting mechanism were transferred to the USGS NAS (Nonindigenous Aquatic Species Database, Gainesville, FL.) website/database: http://nas.er.usgs.gov. With the transfer of findings to this data base, this project was terminated.

Publications

none

Presentations

none

PROJECT TITLE: ASSESSMENT OF COASTWISE TRAFFIC PATTERNS AND MANAGEMENT OF AQUATIC NONINDIGENOUS SPECIES RISK ON NOBOBS AND COASTWISE VESSELS OF THE GREAT LAKES AND EAST COAST OF THE UNITED STATES AND CANADA

Principal Investigators: *Greg M. Ruiz, SERC*

Scott Santagata, SERC

Thomas H. Johengen, CILER

David F. Reid, GLERL

Allen Burton, CILER

Overview and Objectives

In this project we expand upon previous work on NOBOB Salinity Tolerance (NOBOB-S): Eradicating aquatic nuisance species from the residual ballast water of NOBOB vessels using salt solutions, to explore the efficacy of salinity-based treatments of residual organisms (especially low-salinity tolerant organisms) in ballast tanks, including those in NOBOB condition. The focus is on coastal organisms in Great Lakes and other coastal estuarine habitats of the North American Atlantic coast that are interconnected via coastwise shipping patterns. We are using detailed analyses of coastwise traffic to guide us in a risk assessment of the potential for transfer of low salinity organisms between these ecosystems/habitats. These data and assessments are required to make informed predictions and recommendations for the best combination of management strategies of ballast water exchange and brine exposures for preventing the secondary coastal spread of nonindigenous species into the freshwater and estuarine habitats of the United States. Factors will include salinity tolerances, coastwise and Great Lakes shipping patterns, and environmental compatibility between Great Lakes and U.S. east coast ports.

Objectives:

1. Quantify the traffic and ballast water discharge patterns of coastwise shipping between estuarine ports of the United States, Canada, and the Great Lakes region.
2. Characterize the salinity and biota of ballast water entering the Great Lakes from coastwise traffic.
3. Test the efficacy of full salinity exposure to prevent the transfer of low salinity organisms by ships in coastwise trade.

4. Test the efficacy of brine solutions for preventing the introduction of ANS into the Great Lakes, with emphasis on environmentally tolerant fish (gobies) and invertebrate species (peracarids).
5. Create a predictive model based on their environmental tolerances, abundance, and life history characteristics that discriminates between those species that have been successful versus unsuccessful at spreading among low salinity habitats along the eastern US and the Great Lakes Region.

Accomplishments

Coastwise Traffic Analysis

Data on vessel traffic and ballast water discharge records of coastwise shipping between estuarine ports of the United States, Canada, and the Great Lakes region, contained in the National Ballast Information Clearinghouse (NBIC) were compiled and analyzed by SERC.

The most significant ports that supply ballast water to the Great Lakes region were identified based on NBIC records:

Houston, TX; Baton Rouge, LA; Baltimore, MD; Long Island Sound (COTP Zone), Port Everglades, FL; Portland, ME; New York, NY; Wilmington, DE; Albany, NY; Claymont, DE; and Philadelphia, PA.

Of these ports with significant ballast water transport into the Great Lakes, those considered predominantly or significantly low salinity (Houston, Baton Rouge, Baltimore, Philadelphia-Claymont, Wilmington, and New York (Hudson River) were further investigated and port environmental profiles were developed for use in risk analyses during 2009.

The GloBallast Risk Assessment model provided by Canada DFO was initiated and staff are learning how to manipulate it.

Brine Treatment – Lab Experiments

Experiments to explore the efficacy of high-concentration sodium chloride (brine) solutions as a rapid-acting biocide for treating non-compliant NOBOB residuals was completed. We tested the efficacy of concentrated sodium chloride brine solutions as an additional treatment for eradicating halotolerant taxa often present in the ballast tanks of NOBOB ships. The lowest brine treatments (30 ppt for 1 h) caused 100% mortality in several species of cladocerans and copepods collected from oligohaline habitats. However, several brackish-water peracarid crustaceans, including some that

can also survive in freshwater, required higher brine concentrations and longer exposure durations (45-60 ppt, 3-24 h). The most resilient animals were widely-introduced peracarid crustaceans that generally prefer mesohaline habitats, but do not tolerate freshwater (required brine treatments of 60-110 ppt for 3-24 h). Brine treatments (30 ppt) also required less time to cause 100% mortality for eight taxa than treatments using 34 ppt seawater. Based on these experiments and published data, we proposed appropriate treatment strategies for ballast tank biota often associated with NOBOB vessels entering the Great Lakes region. We estimate the lethal dosage of brine for 95% of the species in our experiments to be 110 ppt (95% confidence limits of 85-192 ppt) when the exposure time is 1 h and 60 ppt (95% confidence limits of 48-98) when the exposure duration is 6 h or longer.

Salinity tolerance lab experiments to identify species in selected high-risk U.S. Gulf coast ports were completed and the results are being reviewed.

Shipboard Brine Treatment Experiments

Calibration of instruments (YSI 6600 multiparameter sondes) for shipboard brine treatments with moored conductivity-temperature sondes to track the dispersion of brine added as a treatment to tanks were completed.

One shipboard experiment on a ballasted ship was completed. Six instruments were moored in a ballast tank used for testing treatment with brine. The experiment took place from Dec 1 – 6, 2008. Instruments were programmed to record water depth, conductivity, salinity, temperature, and dissolved oxygen at 5-minute intervals.

The instrument time series in Figure 1 captures the initial filling with freshwater on Dec 1 around 15:00, the addition of approximately 0.5 m of NaCl brine on Dec 3 around 17:30, and a final discharge of the tank on Dec 6 at 16:00.

Figure 2 shows records for the first six hours, starting with brine addition, from multiple sensors located in different positions throughout the tank. There were distinct differences in the distribution and mixing of brine within the tank, both horizontally and vertically, reflecting incomplete mixing and density-driven stratification.

The vertical stratification remained throughout the vopyage, but the horizontal gradients changed over time (Figure 3). The records from the sondes near the tank bottom at positions 81AB-Low and 81AE-Low were essentially the same, indicating that the brine spread and mixing was the same at both locations. However, the record from the sonde at position 81AC-Low was quite different, with high salinity water only gradually reaching the sonde position until an event during 12/5 caused a sudden jump of ~10 ppt at that position, followed by continued gradual increase. We believe the position of this sonde was effectively blocked from efficient horizontal brine flow

and mixing by the internal tank structure, in particular, the bottom longitudinals, which allowed only minimal cross-tank communication through drainage holes at the very bottom of the tank until some forcing event, likely increased pitch and role, provided the energy to push the brine to that position.

Figure 1: Time series of water depth in the treated ballast tank. Increase in depth late on 12/3 reflects addition of ~0.5 m of brine.

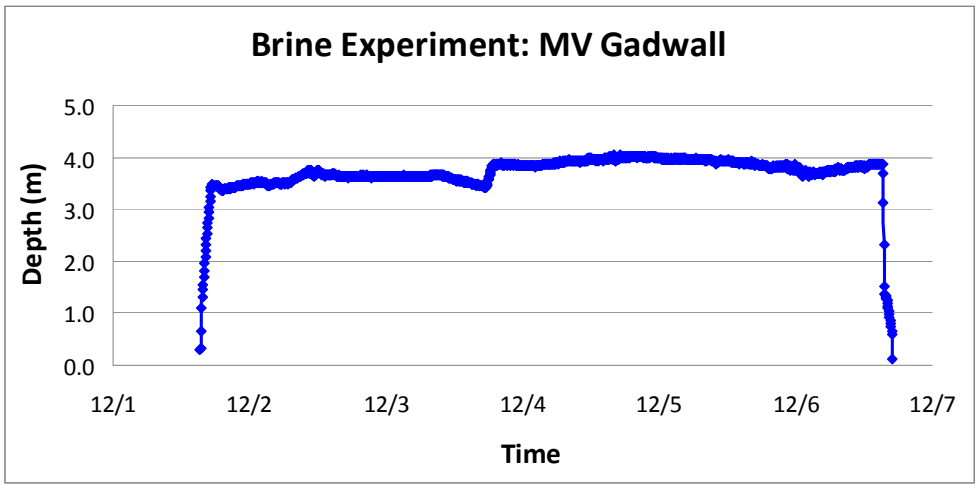


Figure 2: Time series of estimated salinity (ppt) recorded at five-minute intervals on 12/3 during the first six hours at various locations across the treated ballast tank.

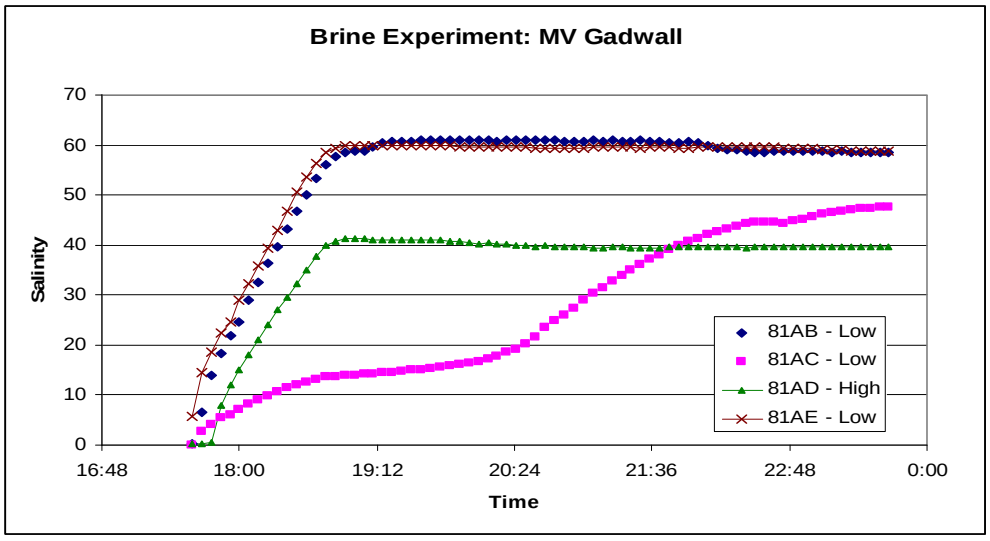
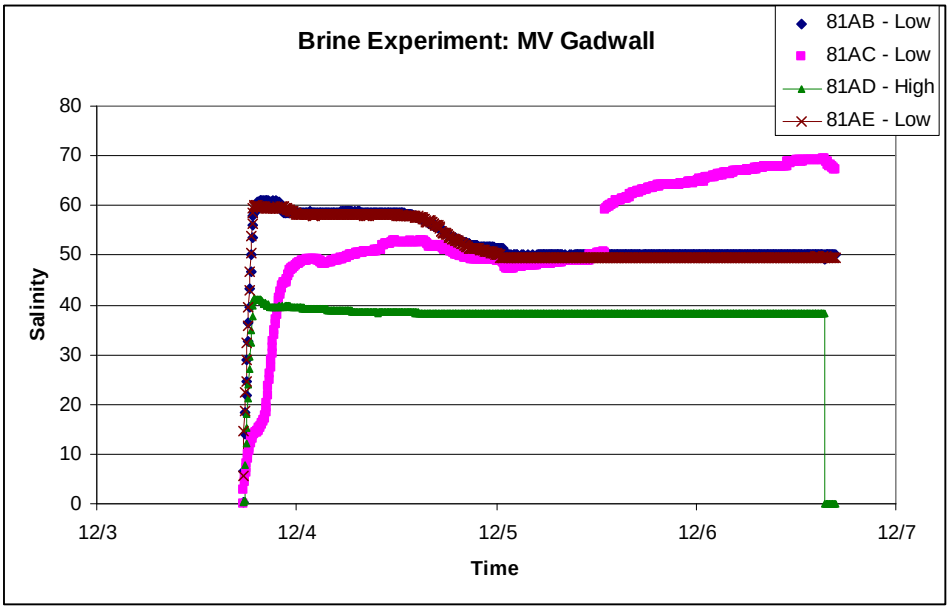


Figure 3: Time series of estimated salinity (ppt) recorded at five minute intervals over the entire duration of the voyage, up to discharge.



Addition shipboard tests will be conducted during CY2009.

Publications

Santagata S., K. Bacela, D.F. Reid, K. Mclean, J.S. Cohen, J.R. Cordell, C. Brown, T.H. Johengen , and G.M. Ruiz. 2009. Eradicating ballast-tank organisms with sodium chloride treatments. Environmental Toxicology & Chemistry, Vol. 28, No. 2, pp. 346–353.

Presentations

Santagata, S. et al. (2007). Effect of osmotic shock as a management strategy for reducing the transfer of nonindigenous species among low-salinity ports by commercial ships. Invited presentation at a ballast water management workshop organized by the U. S. Coast Guard, Chicago, IL.

Santagata, S. et al. (2007). Effect of osmotic shock as a management strategy for reducing the transfer of nonindigenous species among low-salinity ports by commercial ships. Invited seminar given at Bowdoin College, Brunswick, Maine.

PROJECT TITLE: STATUS AND TRENDS IN BENTHIC MACROINVERTEBRATES IN THE GREAT LAKES

Principal Investigators: *Thomas Nalepa, GLERL*

Allen Burton, CILER

Overview and Objectives

This research project monitors trends in benthic macroinvertebrate populations in Lakes Michigan and Huron. Changes in the abundance and composition of benthic populations provide a measure of environmental response to anthropogenic influences such as nutrient enrichment and invasive species. Specific objectives are thus to determine and assess changes in benthic populations over the long term. The original program was initiated in 1980 at 40 sites in the southern basin of Lake Michigan, and samples have been collected at these same sites for two consecutive years every five years since. Because population changes in some taxa (i.e., zebra mussel *Dreissena polym*orpha, quagga mussel *Dreissena buge*nsis, and *Diporeia*) were occurring so rapidly in the late 1990s, the monitoring program was expanded in 1998 and samples are now collected every year at these 40 sites. To determine trends in *Dreissena* and *Diporeia* over the entire lake, samples were collected in late summer at 160 sites located throughout the lake in 1995, 2000, and 2005. In Lake Huron, samples were collected at 75 sites in the main basin in 2000, 2003, and 2007, and at 33 sites in Georgian Bay and North Channel in 2002 and 2007.

Accomplishments

Efforts in 2008 focused on counting and identifying organisms found in previously-collected samples, tabulating and analyzing data, and writing manuscripts. More specifically, organisms found in samples collected in Lake Michigan and Lake Huron in 2007 were counted. For the former lake, this consisted of counting *Dreissena* and *Diporeia* in 120 samples (3 replicates at each of 40 sites), and for the latter lake this consisted of counting and sorting all organisms in 324 samples (3 replicates at 108 sites). Lake-wide data collected in Lake Michigan in 1994/95, 2000, and 2005 was organized, cross-checked, and published in a NOAA data report. A manuscript based on these data was completed and published.

The survey of *Dreissena* and *Diporeia* at 40 sites in the southern basin of Lake Michigan was completed in fall 2008 and organisms will be counted in 2009.

Publications

Nalepa, T. F., Fanslow, G. L., Lang, G. A., Lamarand, D. B., Cummins, L. G., and Carter, G. S. 2008. Abundances of the amphipod *Diporeia* spp. and the mussels *Dreissena polymorpha* and *Dreissena rostriformis bugensis* in Lake Michigan in 1994-1995, 2000, and 2005. NOAA Technical Memorandum GLERL-144. NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI.

Nalepa, T. F. and Dermott, R. 2008. Abundances of the benthic amphipod *Diporeia* spp,, Indicator 123. State of the Lakes Ecosystem 2008 (SOLEC). U. S. Environmental Protection Agency and Department of the Environment Canada.

Nalepa, T. F., Fanslow, D. L., Lang, G. A. Transformation of the offshore benthic community in Lake Michigan: recent shift from the native amphipod *Diporeia* spp. to the invasive mussel *Dreissena rostriformis bugensis*. Freshwater Biology 54:466-479.

Nalepa, T. F., Pothoven, S. A., and Fanslow, D. L. Recent changes in benthic macroinvertebrate populations in Lake Huron and impact on the diet of Lake Whitefish (*Coregonus clupeaformis*). Aquat. Ecosystem Health & Manag. 12: 2-10.

Presentations

Nalepa. T. F. 2008. Transformation of the offshore benthic community in Lake Michigan: the dramatic shift from *Diporeia* spp. to quagga mussels in 12 years. Inland Seas Education Association Invited Lecture, Traverse City, MI, March, 2008.

Nalepa, T. F. and Rockwell, D. A. 2008. Status of *Diporeia* spp. and dreissenids in the upper Great Lakes. Great Lakes Fishery Commission Annual Meeting, Invited Presentation, Niagara Fall, ON, March, 2008.

Nalepa, T. F. 2008. A chronological perspective on ecological impacts of dreissenids in the Great Lakes: some expected and unexpected outcomes. 51st Conference on Great Lakes Research, Peterborough, ON, May, 2008.

Vanderploeg, H.A., Nalepa, T.F., Fahnenstiel, G.L., Pothoven, S.A., Liebig, J.R., Dyble, J., and Robinson, S. 2008. Dreissenids as nearshore and offshore engineers: predicting direct and indirect effects of mussels on pelagic and benthic food webs. 51st Conference on Great Lakes Research, Peterborough, ON, May, 2008.

Nalepa, T. F. 2008. Aquatic invasive species and recent food web disruptions in the Great Lakes. Inland Seas Education Association, Invited Lecture, Aquatic Invasive Species Course, Traverse City, MI, July, 2008.

Nalepa, T. F. 2008. Expansion and food web implications of quagga mussels in the Great Lakes. Annual Conference of Michigan Community College Biologists, Muskegon, MI, Oct.25, 2008.

Nalepa. T. F. 2008. An overview of the spread and ecological impacts of the quagga mussels with possible implications of its recent discovery in the Colorado River Basin. Colorado River Basin Science and Resource Management Symposium, Scottsdale, AZ. Nov. 18-20, 2008.

PROJECT TITLE: STATUS MACROINVERTEBRATES IN THE LAKE ONTARIO

Principal Investigators: *Stephen Lozano, GLERL*
Allen Burton, CILER

Overview and Objectives

This project focuses on documenting changes in Lake Ontario and extends monitoring efforts that in began over a decade ago. Historical records of benthic macroinvertebrates are documented during lake wide surveys in 1964 and 1972. The current monitoring program was initiated in 1994 at 51 sites located throughout the lake. Samples have also been collected in 1997, 19998, 1999, and 2002. All organisms collected in samples from the 1997-1999 sites were counted and identified, but only the native amphipods *Diporeia* and the invasive mussel *Dreissenia* were counted in samples collected from the lake-wide survey in 2002.

In 2002, emphasis has been placed on obtaining detailed temporal data on *Diporeia* and *Dreissena* because populations of both taxa are changing rapidly, and both are considered to be keystone species in Lake Ontario. *Diporeia* was formerly the most abundant species in offshore waters of Lake Ontario and served as a major pathway by which energy was cycled from the lower (phytoplankton) to the upper food web (fish). However, populations have dramatically declined over the past 10-15 years and large areas are now completely devoid of this organism. On the other hand, dreissenid mussels have increased, with zebra mussels first colonizing the nearshore region, followed by quagga mussels colonizing the offshore region and currently displacing zebra mussels in nearshore regions.

Besides providing data to assess population trends of macroinvertebrates in Lake Ontario, this project will also provide data that will help evaluate the ecological consequences of these population trends. As noted, *Diporeia* is not longer found in large areas of both lakes, and fish that once fed heavily on *Diporeia* must now seek alternative food sources. Combined with data from other studies that examine fish diets, data from this project will help evaluate food availability and selectivity in fish. These data will also be used for whole lakes simulation models.

This project will initially focus on counting and identifying organisms in samples that will be collected In 2008. Samples will be collected at 58 monitoring sites in throughout Lake Ontario.

Accomplishments

Two cruises were completed in 2008. The first cruise occurred during the week of August 18 to 21, 2009, when 46 benthic sites were visited. We were able to collected mud at 44 sites. An additional 3 sites were visited in September 23, 2009. Benthic organisms were picked from all 44 samples from the August cruise. The three samples from September will be completed in June 2009. There were 28,037 invertebrates in the samples, 67% of which were dreissenids (Table 1). Amphipods were found at 13 sites. Only 5 sites had greater than 2 organisms. The greatest number of amphipods were found at station 55 which had a depth of 192 meters.

Publications

None.

Presentations

None. One will be give in May at the Great Lakes Conference in Toledo, OH, May 2009.

Table 1. Benthic invertebrates from 42 sites in Lake Ontario collected in August 2009.

Long.	Lat.	Station	Substrate	Depth - m	**Amph.**	**Worms**	**Sphaerids**	**Midges**	**Dreissenids**	**Mysis**	**Clams**
-79.67	43.34	2	Mud/Silt	60	0	127	2	31	1212		
-79.62	43.27	3	Mud/Silt	24	1	229	0	11	648	0	0
-79.54	43.47	6	Sand	62	0	352	3	100	1028	0	0
-79.40	43.59	9	Mud/Silt	58	1	352	3	122	400	1	0
-79.49	43.39	14	Mud/Silt	98	33	52	0	104	0	11	0
-79.36	43.27	16	Mud/Silt	66	0	143	1	103	47	0	0
-79.29	43.38	19	Mud/Silt	107	19	73	4	25	0	0	0
-79.01	43.30	22	Mud/Silt	11	0	618	42	16	39	0	58
-79.13	43.44	24	Mud/Silt	120	0	18	25	35	1	6	0
-79.02	43.61	26	Clay	120	2	7	2	5	3	0	0
-78.86	43.78	28	Sand	65	12	140	0	19	427	0	0
-78.46	43.89	31	Rock	20	0	7	0	0	177	0	0
-78.44	43.78	32	Sand	78	0	107	0	29	926	0	0
-78.81	43.60	33	Mud/Silt	138	1	14	3	7	0	0	0
78.76	43.46	34	Mud/Silt	136	0	283	0	38	676	0	0
-78.73	43.36	35	Mud/Silt	28	0	565	0	8	133	0	70
-78.39	43.49	36	Mud/Silt	140	0	23	3	1	11	0	0
-77.99	43.38	38	Sand	19	0	130	0	13	1	0	0
-78.00	43.49	39	Mud/Silt	154	0	34	27	0	26	1	0
-78.01	43.59	40	Mud/Silt	190	0	24	0	0	1	10	0
-78.03	43.72	41	Mud/Silt	128	7	10	1	2	0	0	0
-78.04	43.84	42	Rock	65	0	107	0	121	1088	0	0
-78.05	43.95	43	Sand	19	1	272	0	9	5	0	0
-77.78	43.82	45	Sand	80	0	81	0	9	860	0	0
-77.44	43.77	49	Rock	48	n/s	n/s	n/s	n/s	n/s	n/s	n/s
-77.71	43.43	52	Mud/Silt	125	0	48	12	4	418	3	0
-77.44	43.44	55	Mud/Silt	192	36	10	3	3	7	3	0
-77.59	43.28	57	Mud/Silt	13	0	176	2	12	216	0	185
-77.16	43.79	61	Sand	54	0	150	3	33	1028	0	0
-77.00	43.87	62	Rock	10	n/s	n/s	n/s	n/s	n/s	n/s	n/s
-77.02	43.73	63	Mud/Silt	87	0	187	17	0	440	3	0
-76.93	43.52	64	Mud/Silt	214	0	20	1	0	2	4	0
-76.79	43.41	67	Sand	71	0	342	0	0	2640	0	0
-76.71	43.61	69	Mud/Silt	185	0	13	6	0	6	13	0
-76.53	43.55	72	Mud/Silt	113	0	111	125	0	807	0	1
-76.29	43.63	73	Sand	40	0	282	0	78	40	0	20
-76.52	43.75	74	Mud/Silt	69	0	159	15	7	463	1	0
-76.36	43.84	75	Sand	32	3	133	3	12	350	0	41
-76.41	43.96	77	Mud/Silt	29	0	139	4	6	0	0	39
-76.61	44.14	80	Mud/Silt	19	0	26	0	101	117	0	31
-76.81	44.07	82	Mud/Silt	27	0	96	0	3	67	0	6

-76.73	43.89	84	Sand	37	2	326	1	0	1340	0	2
-78.31	43.92	91	Sand	22	0	223	45	140	109	0	26
-77.22	43.33	94	Sand	54	0	182	0	7	1248	0	0
-79.45	43.23	1318	Mud/Silt	26	0	305	0	46	137	0	0
-79.06	43.74	1330	Sand	61	1	288	0	26	1616	0	0

PROJECT TITLE: NOAA AQUATIC INVASIVE SPECIES POSTDOCTORAL RESEARCH PROGRAM

Principal Investigators: *David F. Reid, GLERL*
Allen Burton, CILER

Overview and Objectives

This project established a pilot partnership between NOAA and the University of Michigan-CILER to support and manage a NOAA Aquatic Invasive Species Postdoctoral Research Program.

The objective of this pilot program is to engage a competitively selected post-doctoral research scientist in biological invasion research, introduce him/her to the mission and organizational culture of NOAA, and foster new biological invasion research activities within NOAA.

Accomplishments

Six potential Host NOAA and Partner Institution were identified and commitment letters received.

An Advisory Panel was formed.

An Announcement of Opportunity was prepared and is in final draft form.

Publications

N/A

Presentations

N/A

THEME III: OBSERVING SYSTEMS

CILER activities that fall under the theme of Observing Systems include research focusing on providing observing system data and platforms, data management and communications, and data products and forecasts needed for effective environmental management, and for monitoring and understanding ecosystem responses to natural and anthropogenic conditions.

PROJECT TITLE: ADVANCED NETWORKING FOR COASTAL OBSERVATIONS

Principal Investigators: *Steven A. Ruberg, GLERL*

Doran M. Mason, GLERL

Allen Burton, CILER

Overview and Objectives

There is an increasing demand in the scientific research community for real-time biological information and a requirement within NOAA's National Marine Sanctuary program for real-time video to make sanctuaries more accessible. We will focus on the solution to two problems - NOAA Sanctuary public access limitations and the availability of real-time observations of marine biota abundance and distributions.

The National Marine Sanctuary Program, administered by NOAA's National Ocean Service, manages and protects specially designated areas of the nation's oceans and Great Lakes for their habitats, ecological value, threatened and endangered species, and historic, archeological, recreational and esthetic resources. The Thunder Bay National Marine Sanctuary maintains stewardship over one of the nation's most historically significant collection of shipwrecks. Located in the northeast corner of Michigan's lower peninsula, the sanctuary contains hundreds of shipwrecks. Preserved by the cold, fresh water of Lake Huron, these submerged cultural resources are time capsules linking us to our collective maritime past. The sanctuary seeks to ensure that divers and non-divers of all ages share in the discovery, exploration and preservation of Thunder Bay's historic shipwrecks. The majority of sanctuary visitors experience these archeological resources at the Great Lakes Maritime Heritage Center, the TBNMS visitor's center, but are unable to have the sense of being "fully present" that is experienced by the diving public. An approach to sanctuary access must be taken that will provide better access for a larger number of users at the TBNMS, other national marine sanctuaries, and other institutions.

A viable solution to the problem of access to remote areas of national marine sanctuaries is through the implementation of a real-time video and audio capability. Current methods of video transfer depend on lossy and complicated compression methods that impact video quality. The use of advanced digital video transport methods can provide an improved video transfer mechanism but requires at least 20 Mb/s of system bandwidth to implement. GLERL currently has the capability to collect high bandwidth environmental data using the Real-time Environmental Coastal Observations Network (RECON); the RECON project (www.glerl.noaa.gov/res/recon)

was initiated after the successful completion of the HPCC funded "Wireless Environmental Observations" project. The existing RECON system is limited in bandwidth capacity to approximately 1.0 Mb/s and so will be upgraded during the execution of this project.

Accomplishments

All buoy and Thunder Bay Island tower components have been purchased and assembly is proceeding on schedule. The fisheries acoustics funding was cut by the NOAA HPCC in 2007 leaving the implementation of a high bandwidth network portion. Funding for 2008 was not provided by NOAA HPCC. Currently awaiting word on 2009 funding. State historic society permission is currently on hold until the impact of the tower installation on Thunder Bay Island can be assessed.

Publications

Ruberg, Muzzi, Brandt, Gray, Downing, Lane Miller, Constant, A Wireless Internet-Based Observatory: The Real-time Coastal Observation Network (ReCON). Proceedings of the MTS/IEEE Oceans 2007 Conference, September 30 – October 5, Vancouver, BC**.**

Presentations

Ruberg, Muzzi, Brandt, Gray, Downing, Lane Miller, Constant, A Wireless Internet-Based Observatory: The Real-time Coastal Observation Network (ReCON). Proceedings of the MTS/IEEE Oceans 2007 Conference, September 30 – October 5, Vancouver, BC**.**

PROJECT TITLE: GREAT LAKES COASTWATCH RESEARCH ASSISTANT FOR NOAA COASTWATCH PROGRAM ELEMENT

Principal Investigators: *George Leshkevich, GLERL*

Allen Burton, CILER

Overview and Objectives

CoastWatch is a nationwide National Oceanic and Atmospheric Administration (NOAA) program within which the Great Lakes Environmental Research Laboratory (GLERL) functions as the Great Lakes regional node. In this capacity, GLERL obtains, produces, and delivers environmental data and products for near real-time observation of the Great Lakes to support environmental science, decision making, and supporting research. This is achieved by providing Internet access to near real-time and retrospective satellite observations, in-situ Great Lakes data, and derived products to Federal, state, and local agencies, academic institutions, and the public via the Great Lakes CoastWatch web site (http://coastwatch.glerl.noaa.gov). The goals and objectives of the CoastWatch Great Lakes Program directly support NOAA's statutory responsibilities in estuarine and marine science, living marine resource protection, and ecosystem monitoring and management. Great Lakes CoastWatch data are used in a variety of ways including monitoring of algal blooms, plumes, ice cover, and water temperatures, two and three dimensional modeling of Great Lakes physical parameters (such as wave height and currents), damage assessment modeling, research, and for educational and recreational activities.

This project focuses on research and applications development utilizing CoastWatch imagery and imagery from new satellite sensors such as synthetic aperture radar (SAR) for ice classification and mapping and ocean color sensors such as the Sea Viewing Wide Field-of-View Sensor (SeaWiFS) and/or MODIS for ocean color (chlorophyll) products. These products will enhance the CoastWatch Great Lakes product suite by developing regional products and applications for the Great Lakes, and will contribute to the operational responsibilities of sister agencies such as the U.S. Coast Guard and National Weather Service. One of the objectives of the CoastWatch Great Lakes program is to provide access to near real-time and retrospective (two weeks) satellite observations and derived products of the Great Lakes for Federal, state and local decision making, supporting research and public use. Communications requirements and data distribution are accomplished electronically via the Internet.

Accomplishments

1. Monitor, develop and/or improve the operational program to receive, process, analyze, and archive the CoastWatch data. eg. Write the operational program to make the AVHRR image available for Google Earth.

-Completed the GLSEA 1024x1024 operational program (including IDL and Unix script).
-Google Earth (KLM) programming complete - Waiting for operting system upgrade for Google Earth implementation.

2. **Maintain and improve the CoastWatch Great Lakes Node web server, design and develop the web site**, eg., make gallery section on web page, check the images and links on web site.

-Created image gallery page for CW Great Lakes web site.
-Need to continue development of the image gallery page.
-Install and in process of testing Thredds/LAS server for possible use on the CoastWatch Great Lakes web site.

3. **Design, modify, and develop the software to analyze and process the CoastWatch data**, eg., write programs to create kml and png files for Google Earth, write programs to create turbidity product when the new algorithm becomes available.

-Wrote the IDL program for Ice overlay on GLSEA 1024x1024.
-Wrote the IDL program to subsize the GLSEA (from 1024 to 512) for research project.
-Modified the IDL program to process RARDARSAT image for ice classification project.
-Created GLSEA asscii file (new format).
-Waiting for operting system upgrade for Google Earth implementation
-Wrote program to calculate ice concentration data (by lake) from the NIC ice charts and post data and graphics on the CoastWatch Great Lakes web site
-Test program to derive turbidity from AVHRR Ch.1 and Ch. 2 data

4. **Participate CoastWatch related research and prepare the presentation for meetings.**

-Prepared presentations for meetings and conferences (such as: CoastWatch Node Manager Meeting 2007, Making a Great Lake Superior 2007 Conference, IAGLR 2007).
-Help prepare presentations for the 2008 CoastWatch Node Managers Meeting, IAGLR 2008 and 2009.

5. **Assist in the mentorship of a Great Lakes summer fellow**.

-Wrote the IDL program to interpolate the MODIS true color imagery (the west end of Lake Erie) for Yellow Perch project animation.

6. **Document CoastWatch software, including path designations and data source input/output. Construct flow chart depicting data and code relationships.**

-Create flow chart and documentation for documenting the operational process of the Great Lakes CoastWatch site. Needs to be continued (completed).

Publications

Nghiem, S.V. and G.A. Leshkevich, 2007. Satellite SAR Remote Sensing of Great Lakes Ice Cover, Part 1. Ice Backscatter Signatures at C-Band. *Journal of Great Lakes Research*, 33(4):722-735.

Leshkevich, G.A. and Son V. Nghiem, 2007. Satellite SAR Remote Sensing of Great Lakes Ice Cover Part 2. Ice Classification and Mapping. *Journal of Great Lakes Research*, 33(4):736-750.

Ruberg, S., S. Brandt, R. Muzzi, N. Hawley, T. Bridgeman, G. Leshkevich, J. Lane, and T. Miller, 2007. A Wireless Real-Time Coastal Observation Network, *Eos*, Transactions, American Geophysical Union, Vol. 88, No.28. pg. 285-286.

Leshkevich, G.A. and S.V.Nghiem. 2006. Algorithm Development for Operational Satellite SAR Classification and Mapping of Great Lakes Ice Cover. Proceedings: OceanSar2006, St. Johns, Newfoundland, Oct. 22-26.

Presentations

Leshkevich, G.A. and S. Liu. Environmental Monitoring of the Great Lakes Using CoastWatch Data. 50th Conference on Great Lakes Research (IAGLR'07), State College, PA, May 31, 2007.

Leshkevich, G.A. and S.V. Nghiem. Algorithm Development for Remote Sensing of Great Lakes Ice Cover Using Multiple Satellite Sensors. 50th Conference on Great Lakes Research (IAGLR'07), State College, PA, May 31, 2007.

Leshkevich, G.A. CoastWatch Great Lakes Node Summary. CoastWatch Review Panel (multi agency). Annapolis, Maryland, June 13-14, 2007.

Leshkevich, G.A. and S. Liu. CoastWatch Great Lakes Node Operations Report. CoastWatch Node Meeting. Annapolis, Maryland, June 12-14, 2007.

LESHKEVICH, G.A.[1], and LIU, S.[2]
[1]NOAA/Great Lakes Environmental Research Laboratory, and [2]CILER, 2205 Commonwealth Blvd., Ann Arbor, MI 48105. CoastWatch Great Lakes Program Update: 2008. 51st Conference on Great Lakes Research, Trent University, Peterborourgh, Ontario, Canada, May 19-23, 2008.

LESHKEVICH, G.A.[1], and LIU, S.[2]
[1]NOAA/Great Lakes Environmental Research Laboratory, and [2]CILER, 4840 South State Road, Ann Arbor, MI 48108. CoastWatch Great Lakes Program Update: 2009. 52nd Conference on Great Lakes Research, University of Toledo, Toledo, Ohio, May 18-22, 2009.

PROJECT TITLE: NEW MODIS ALGORITHM FOR RETRIEVAL OF CHLOROPHYLL, DISSOLVED ORGANIC CARBON, AND SUSPENDED MINERALS IN THE GREAT LAKES

Principal Investigators: *George Leshkevich, GLERL*

Robert Shuchman (Michigan Tech Research Institute)
Dmitry Pozdnyakov and Anton Korosov (NANSEN International Environmental and Remote Sensing Centre, St. Petersburg, Russia)
Chuck Hatt (MTRI)
Thomas Johengen, CILER/UM
Allen Burton, CILER

Overview and Objectives

It has previously been found that the ocean ratioing algorithms for the retrieval of chlorophyll from satellite data do not work well in time or space for the Great Lakes. A fundamentally different algorithm for the retrieval of color producing agents (CPAs) from satellite data has been developed by the Altarum Institute (formerly the Environmental Research Institute of Michigan (ERIM)and currently MTRI) and the Nansen International Environmental and Remote Sensing Center (NIERSC) of St. Petersburg, Russia and tested on Lake Michigan. The algorithm operates on either SeaWiFS or MODIS data and produces estimates of chlorophyll (chl), dissolved organic carbon (doc), and suspended minerals (sm). The algorithm has undergone a preliminary validation using both dedicated and historical *in situ* water chemistry measurements. The algorithm presently underestimates the amount of chlorophyll, however, the algorithm successfully observes the correct seasonal trends of all three color producing agents. The present shortcoming of the algorithm lies in the fact that the hydro-optical model used in the algorithm was generated 20 years ago for Lake Ontario waters .

This proposal addresses a proposed collaboration between MTRI, NIERSC, GLERL, and CILER to further develop the algorithm so that meaningful estimates of chl, doc, and sm can result from MODIS satellite data for all of the Great Lakes, especially Lake Erie which is optically more complex. Historical radiometric observations with coincident *in situ* water chemistry collected by GLERL in Lake Michigan have been used to update the hydro-optical model presently used in the algorithm. Optical measurements and coincident water samples taken on Lake Erie in the summer of 2005 have allowed the development of a hydro-optical model for Lake Erie and enhanced the main hydro-optical model as will the in situ measurements made on Lake Superior during 2007. The algorithm will then be tested with MODIS satellite data acquired coincident with field sampling. GLERL's extensive archive of chl, doc, and sm data collected throughout the Great Lakes will serve as validation values for the new

improved algorithm. The anticipated results (objective) of this proposed collaborative investigation will be a validated robust algorithm (or algorithms) for the retrieval of CPAs from all of the Great Lakes.

Proposed Work: Process optical data taken on Lake Superior during 2007 and include data taken on Lakes Ontario and Erie to modify/update the hydro-optical model. Run some MODIS images using the updated hydro-optical model to test algorithm performance. Test and validate new hydro-optical model for Lake Erie, Lake Michigan, Lake Superior and on other Great Lakes if in situ data is available.

Deliverables: The anticipated results of this proposed collaborative investigation will be a validated robust algorithm (or algorithms) for the retrieval of CPAs from all of the Great Lakes and a journal article (or articles) documenting the algorithm and results

Accomplishments

Data for Lakes Superior, Ontario, and western Lake is being incorporated into the hydro-optical model. Data for Lakes Michigan, Huron, Erie, and additional data for Lake Ontario has been measured and is being processed and should soon be incorporated into the hydro-optical model.

Publications

Publications can proceed when the model is completed and tested.

Presentations

Development of a Robust Hydro-optical Model for the Great Lakes for the Extraction of Chlorophyll, Dissolved Organic Carbon and Suspended Minerals from MODIS Satellite Data. 51st Conference on Great Lakes Research, Trent University, Peterborourgh, Ontario, Canada, May 19-23, 2008.

Robert Shuchman[1], George Leshkevich[2], Charles Hatt[1], Dmitry Pozdnyakov[3], Anton Korosov[3], and Josberger, E.[1] 1Michigan Tech Research Institute, Ann Arbor, MI 2National Oceanic and Atmospheric Administration, Great Lakes Environmental Research Laboratory, Ann Arbor, MI Nansen International Environmental and Remote Sensing Center, St. Petersburg, Russia. **Further Steps Towards a Chlorophyll, Dissolved Organic Carbon, and Suspended Mineral Remote Sensing Algorithm for All Laurentian Great Lakes. .** 52nd Conference on Great Lakes Research, University of Toledo, Toledo, Ohio, May 18-22, 2009.

PROJECT TITLE: OPTICAL PROPERTIES OF THE GREAT LAKES

Principal Investigators: *George Leshkevich, GLERL*
David O'Donnell (Upstate Freshwater Institute)
Thomas Johengen, CILER
Allen Burton, CILER

Overview and Objectives

This research project focuses on measurement and quantification of the optical properties of the Great Lakes. During 2007 measurements of the optical properties of Lakes Ontario and western Lake Erie were made with a suite of surface and profiling instruments along with concurrent water samples. In collaboration with the Upstate Freshwater Institute (a nonprofit organization), GLERL, and CILER, plans are for measurements in Lakes Michigan and Huron during 2008. These measurements not only document optical properties of the lakes (during mid-season), they are important for hydro-optical model development to be used for satellite retrieval of major color producing agents (chlorophyll, CDOM, SM).

Proposed Work: Analyze measurement data collected in 2007/2008 on Lakes Ontario and western Erie for optical properties and make and analyze measurements on Lakes Michigan, Huron and Erie for optical properties.

Deliverables: Optical properties including but not limited to scatter, backscatter, absorption, water leaving radiance, remote sensing reflectance, and coincident measured water samples including chlorophyll, CDOM, DOC, suspended mineral, etc.for the lakes measured (Ontario, Erie, Michigan, Huron) in the MODIS and SeaWiFS ocean color bands. In addition, a journal article (or articles) will be written and submitted describing and documenting the optical properties of the lakes measured based on the measurements made.

Accomplishments

Measurements of optical properties along with coincident measured water samples including chlorophyll, CDOM, DOC, suspended mineral were made on Lakes Michigan, Huron, Erie, and Ontario during 2008.

Publications

In process of development.

Presentations

O'DONNELL, D. M.1, QUARING, G. F.1, SPADA, M. E.1, STRAIT, C. M.1, EFFLER, S. W.1 and LESHKEVICH, G. A.2, 1 Upstate Freshwater Institute, P. O. Box 506, Syracuse, NY 13214, 2 NOAA/GLERL, 2205 Commonwealth Blvd., Ann Arbor, 48105. **Spectral Measurements of Absorption, Beam Attenuation and Backscattering Coefficients, and Remote Sensing Reflectance in Lake Ontario and Lake Erie** 51st Conference on Great Lakes Research, Trent University, Peterborourgh, Ontario, Canada, May 19-23, 2008.

O'Donnell, D.M., Quaring, G.F., Strait, C.M., Effler, S.W., and Leshkevich, G.A. 1 Upstate Freshwater Institute, P. O. Box 506, Syracuse, NY 13214, 2 NOAA/GLERL, 4840 South State Road, Ann Arbor, 48108. **Spectral Measurements of Absorption, Beam Attenuation and Backscattering Coefficients, and Remote Sensing Reflectance in Four Laurentian Great Lakes.** 52nd Conference on Great Lakes Research, University of Toledo, Toledo, Ohio, May 18-22, 2009.

PROJECT TITLE: GLOS – IMPLEMENTATION OF THE GREAT LAKES OBSERVING SYSTEM

Principal Investigators: *Thomas Johengen, CILER*
Steve Ruberg, GLERL
David J. Schwab, GLERL
Allen Burton, CILER

Overview and Objectives

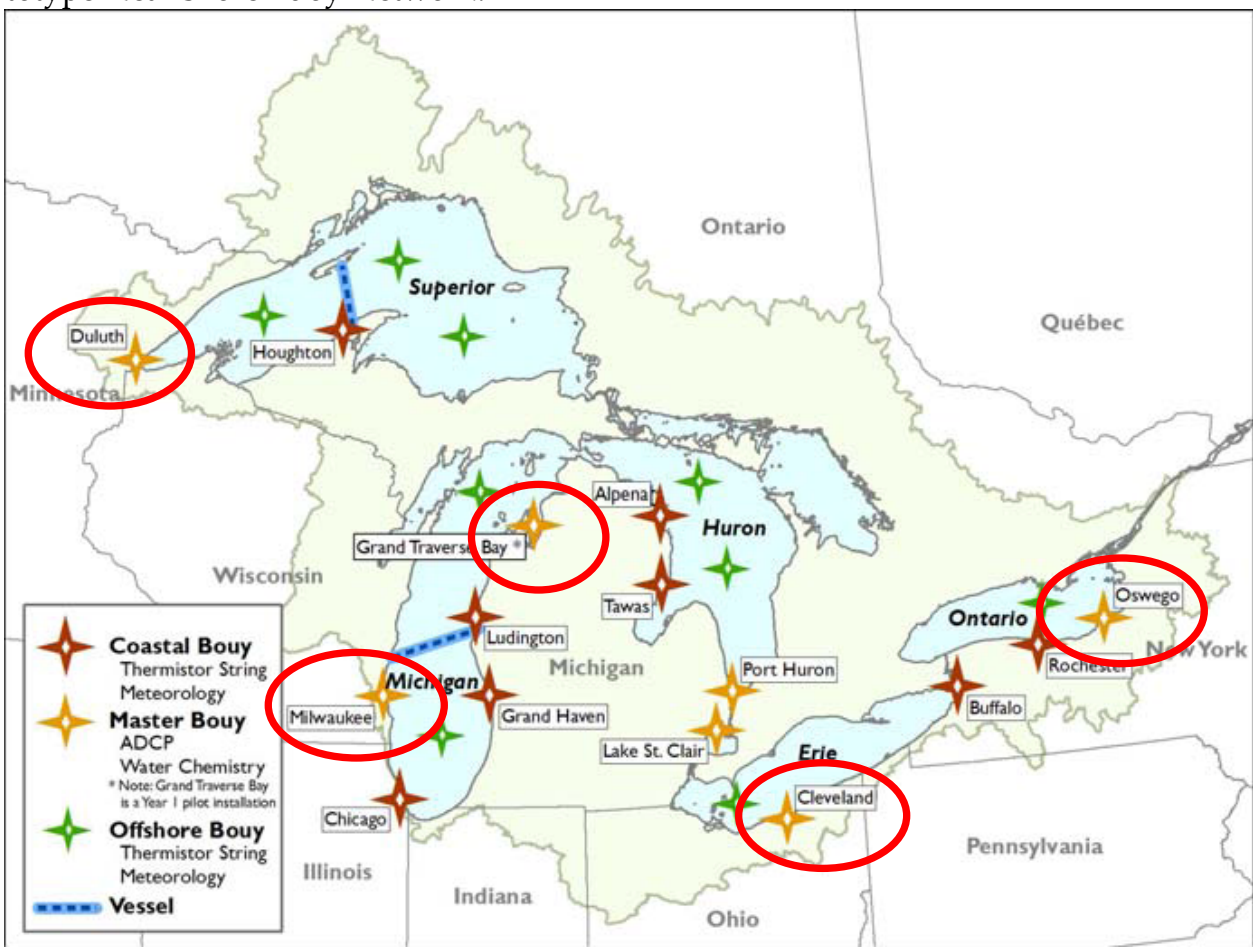
The multi-year GLOS Implementation proposal is designed to systematically improve the observing, monitoring and modeling framework across the Great Lakes to meet existing and emerging information needs. Each year of the multi-year proposal adds more strategic pieces to this effort, each of which is designed to provide specific benefits to distinct user communities. The primary activity for year one was to develop and operate prototype nearshore buoys on lakes Superior, Michigan, Erie and Ontario to collect meteorological, wave information and vertical lake temperature observations.

The focus of this work is on developing new products for four priority issue areas that affect the health, well-being and economic viability of the region, these being: climate change impacts; ecosystem and food web dynamics; protection of public health; and navigation safety and efficiency. Critical information needs for these priority areas are being addressed by implementation of an array of integrated observations including new moorings and additional sensors to measure temperature and current profiles. AUV/glider technologies would be initiated to collect critical transect information. A cross-lake ferry would be instrumented to collect repetitive observations of surface chemistry.

Accomplishments

The prototype buoy deployment project initiated a region-wide effort to begin assessing thermal structure of the lakes, which will improve understanding of the changes in water balance as a consequence of climate variability and potential change. This latter effort began a process of standardizing moorings across the five Great Lakes and Lake St. Clair which will help define the most cost efficient strategy for monitoring and modeling changes in heat storage of the lakes. In addition, the prototype buoy deployments provide important information for use by municipal water system managers to help them protect public drinking water supplies. In years two and three, the standard buoy design will be implemented to include 14 nearshore buoys deployed in close proximity to major municipal water intakes. The spatial distribution around each of the Great Lakes of this network will provide input to heat storage and upwelling models which will foster better understandings of climate change impacts on fishery resources and food web dynamics for each lake.

Prototype Near shore Buoy Network:



Lake Superior, Duluth, MN
PI: Jay Austin, University of Minnesota, Duluth

We received funding through a subcontract to accomplish the following tasks:

- Update our current meteorological buoy to provide surface meteorological data in real time;
- Add a thermistor string to allow subsurface temperatures from the surface to 30m depth to be reported in real-time
- Provide a real-time web presence which would allow interested public parties to access the buoy data, both graphically and in tabular form

All of these goals were met. We deployed the buoy on 16 June, 2008 in approximately 50m of water, near the intake of the Duluth (MN) water supply, and recovered the buoy on 28 October, providing data over nearly the entire 134 day span. Communication problems in the last week of the deployment caused us to lose this last week or real-time data, and we concluded that this problem was due to a problem with the cell-phone service provider as opposed to a problem with our equipment. The

buoy reported shortwave and longwave radiation, air temperature and relative humidity, wind speed and direction, and water temperatures at 10 depths from 1m to 29m.

In the lab, we had a dedicated account which interrogated the buoy logger once every 10 minutes, downloaded new data from the buoy, did some basic quality control on the data, archived the data, and produced graphical output which was placed on a web page which the public could access. While the fact that we were constantly upgrading the software which accomplished this meant that data was not necessarily available in real time for the entire 130+ day span of the deployment, by the last half of the deployment the system ran without intervention.

Lake Michigan, Grand Traverse Bay, MI
PI: Guy Meadows, University of Michigan

In response to the severe cut in funding available for the GLOS Open Water Subsystem, the University of Michigan's Marine Hydrodynamics Laboratories agreed to share with GLOS the costs of the design, fabrication and deployment of an environmental monitoring buoy as a third node in the Grand Traverse Bay Observing System. The buoy is currently near completion, having been tested in the laboratory as well as a local lake and will be deployed as soon as the ice leaves Grand Traverse Bay. The mooring is already in place just north of Old Mission Point and is ready to accept the buoy. The buoy will measure wind speed and direction, water and air temperature, relative humidity as well as wave height, period and spectra. The directional wave package was designed by the MHL as a cost effective sensor for monitoring buoys. With the expectation of funding cuts for next year, the MHL has been working on gaining the support of local communities to expand the Grand Traverse Observing System into Little Traverse Bay.

This section should contain an update on the progress (activities and results) made during the semiannual period of performance that allows the reader to understand key accomplishments and progress toward milestones, objectives and goals in reference to the time line described in the proposal/project plan. Progress should be reported in relation to each milestone and objective in the work plan. Briefly outline the priorities for the next funding period.

Lake Michigan, Milwaukee, WI
Pi's: Val Klump, Harvey Bootsma, Tom Hansen
Great Lakes WATER Institute, University of Wisconsin-Milwaukee

The WATER Institute is implementing the Great Lakes Urban Coastal Observing System (GLUCOS) in the Milwaukee area. In 2008 they deployed four Pioneer buoys

— battery operated for up to 4 weeks at a time — in the lake off Bradford beach to collect water quality information for managers and beach goers, and to study thermal bar dynamics, as part of an effort to achieve "Blue Wave" clean beach certification for the popular Milwaukee attraction.
They also deployed the larger solar-powered Endurance — a 2m discus buoy — to collect near surface meteorological data, gas data (aqueous and atmospheric CO_2 and O_2) and data on temperature, pH, conductivity and algal fluorescence. This buoy was in continuous operation from April through November of 2008.

In August and September, WATER Institute scientists merged a Pioneer buoy with a 48 bottle sampler in an adaptive sampling experiment which essentially automated what microbiologists do every day. It was set to sample at an optimal time after a storm event based on the same data inputs used by humans to determine sampling routine.

In addition to buoy deployments, the WATER Institute has a monitoring system on the Lake Express ferry (Milwaukee to Muskegon) that includes: CO_2, oxygen, algal fluorescence, and temperature sensors. They are also experimenting with tracking fish activity by mounting an inexpensive fish finder sonar on a bottom station with upward looking sonar so they can track weeks of data of fish activity.

To facilitate real-time data acquisition from their various platforms, the WATER Institute has deployed both low-power 900MHz radios, as well as 802.11 2.4 GHz wireless networks. These have worked very well in the near-shore coastal zone that is the focus of GLUCOS.
As the data is telemetered to shore, it is immediately posted to a MySQL database housed at the WATER Institute. A web page for use by scientists and researchers allows immediate display of data visualization graphs, as well as downloads directly to the user's desktop with Excel or other data analysis software.
Scientists and staff at the WATER Institute are compiling comprehensive and detailed documentation on the buoy system, including everything from details of moorings and buoy physical construction to electronics schematics and software flowcharts.
Finally, GLOS funding has been instrumental in bringing a new version of the WATER Institute's public data display website, WATERBase, nearer to completion, with an expected launch in the spring of 2009. The new web site has a geospatial interface allowing users to literally "zoom in" to their area of interest and see real-time data displays.

Lake Ontario, Oswego Harbor
PI: Gregory Boyer, SUNY ESF

Funds were transferred too late in the year to make significant progress on the Oswego Harbor master buoy. However, in preparation for an early 2009 deployment, agreements were reached with the City of Oswego, the H.C. White Maritime Museum, New York Sea Grant Extension and the Upstate Freshwater Institute on location, housing and infrastructure support needed for the master buoy. This will include a public data display, education and outreach activities and online access to the information for the local K-12 schools. Use of an existing buoy in Oneida Lake provided an opportunity, through collaboration with New York Sea Grant, to develop a web-site designed for end-users. Additional observation activity/experience that will be leveraged in 2009 occurred at a hut-installation located at the Thousand Island Biological Station on Governors' Island near Clayton NY. Water near the edge of the shipping channel was pumped through both standard water quality sensors, and experimental sensors for gasoline, hydrocarbons and cyanobacteria to identify potential sources for drinking water taste and odor issues. The gasoline and hydrocarbon sensor is an experimental, membrane-based sensor of interest to the interest to the Coast Guard and New York Department of Environmental Conservation in support their supporting oil spill response activities and for monitoring ballast water discharge in their efforts to protect against the introduction of invasive species.

Activity One Issues: There were some challenges associated with transferring funds to the partner institutions that were identified and resolved. We do not anticipate any problems this coming year.

ADDITIONAL GLOS ACTIVITIES CONDUCTED BY NOAA GLERL

(not funded through CILER – but part of overall project)
PI: Steve Ruberg, NOAA-GLERL

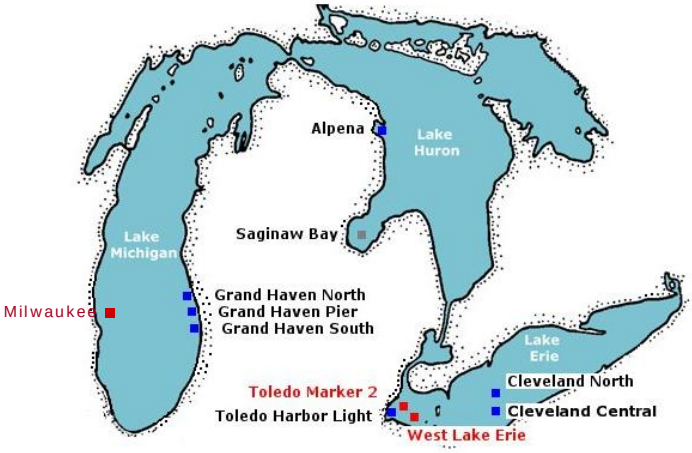


Figure 1. Locations of ReCON system on buoys and navigation structures in 2008 (stations still active on November 3rd in red, inactive locations in blue, planned station in gray). Primary research ReCON buoys were located at Cleveland supporting drinking water quality and bio-acoustic research, Western Lake Erie addressing HABs forecast development, Grand Haven in collaboration with a rip current model verification, and at the Thunder Bay National Marine Sanctuary. Remaining systems shown were used for NWS forecast verification.
See www.glerl.noaa.gov/res/recon for all system data and plots.

Proposed Work for 2008

- Deploy one buoy at Cleveland, OH in support of hypoxia forecasting related to drinking water safety. The ReCON buoy provided real-time observations of waves, currents, oxygen, and temperature profiles along with meteorological parameters.
- Deploy a fixed station on Lake Michigan at Grand Haven pier. Supports GLERL/NWS rip current model validation and rip current warning validation project providing real-time observations of meteorology and horizontal currents along pier.
- Deploy the Thunder Bay National Marine Sanctuary (TBNMS) buoy on the Montana shipwreck providing imagery and physical measurements supporting DNR lake trout and whitefish sampling.
- Deploy Turner Designs chlorophyll and phycocyanin sensors in collaboration with Juli Dyble and Greg Boyer, SUNY on Western Lake Erie for harmful algal blooms (HAB) research.

Accomplishments for 2008

Cleveland Buoy – Hypoxia Forecasting for Water Intakes

Minor buoy problems could not be repaired due to vessel problems, and MIL personnel retirement, illness, and month long research cruise. The ReCON system is heavily dependent on personnel and vessels. This needs to be considered if we intend on improving our observing reliability.

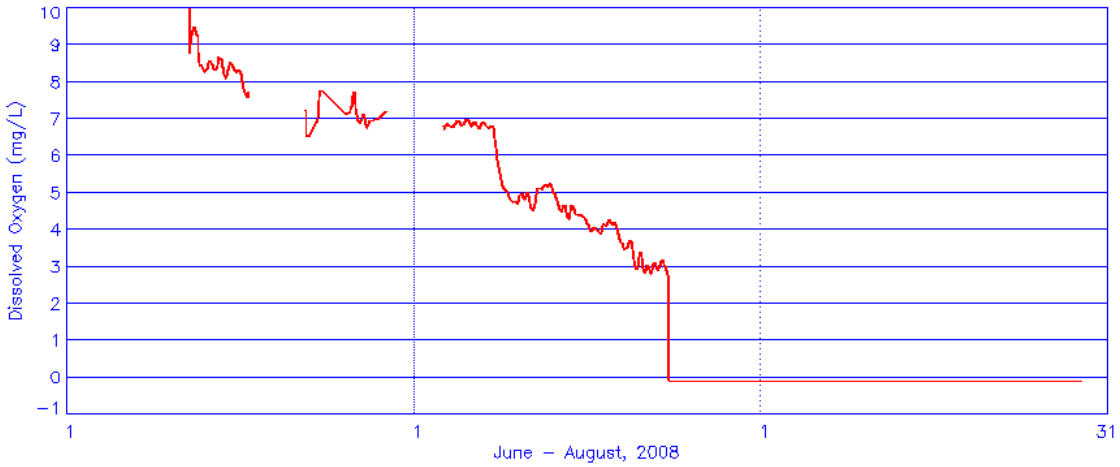


Figure 2. Real-time plot of decline in oxygen 15 miles north of Cleveland. This data was used to alert the Cleveland water district to allow changes in water processing techniques. Sensor failure experienced at the end of July.

Lake Michigan, Grand Haven Pier site.

A ReCON system was deployed at Grand Haven, MI in collaboration with NWS marine forecasters providing rip current warning validation and GLERL near pier current model validation. The piers at Grand Haven have been scene of drownings and near-drownings due to the acceleration of currents in the vicinity of these structures.

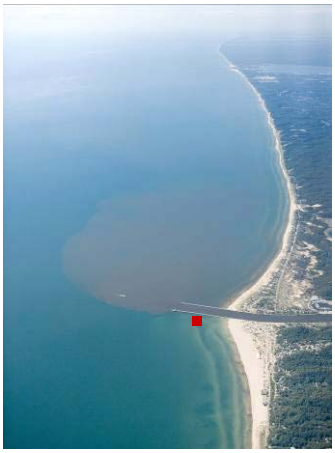


Figure 3. On the left, data acquisition and communications system on Grand Haven pier. On the right, location of the horizontal ADCP used to measure currents to validate rip current model. ReCON meteorology was provided by the Muskegon station.

Lake Huron Buoy at the Thunder Bay National Marine Sanctuary (TBNMS)

The TBNMS buoy was located approximately eight miles from the Sanctuary headquarters in the outer part of Thunder Bay providing physical observations of water temperatures, waves, currents, winds and air temperatures in support of the Sanctuary's mission. The system was used to transmit streaming video from the Montana shipwreck to the Marine Heritage Center auditorium, Figure 4.

Figure 4. Underwater webcam capable of pan, tilt, zoom and providing streaming video. The camera is located on the Montana shipwreck

Western Lake Erie Buoy

The RECON system located in Western Lake Erie provided meteorological conditions and observations from Chlorophyll / Phycocyanin sensors supporting the issue of the first HABs bulletin. The sensors are deployed in pairs to allow discrimination between Chlorophyll *a* and Phycocyanin measurements.

Figure 5. MODIS Satellite image from October 7, 2007 showing algal bloom in western and central Lake Erie.

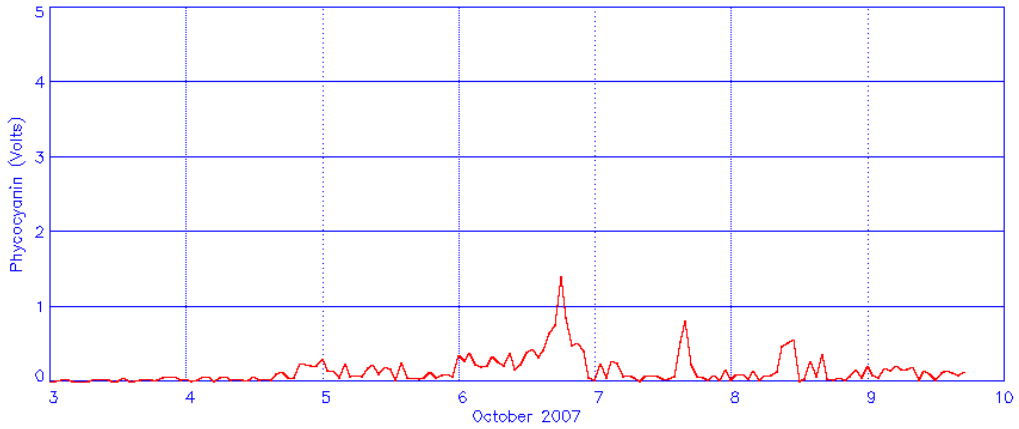


Figure 6. Phycocyanin sensor spikes on October 6-8, 2007 indicating a potential algal bloom at Toledo Harbor Light #2 at the end of the Toledo shipping channel in the Western Basin of Lake Erie.

The western basin site was also used in a continuation of studies related to understanding the role of episodic hypoxia events on benthic in collaboration with the University of Toledo's Lake Erie Center.

Publications

Consi, T.R., Anderson, G., Barske, G., Bootsma, H., Hansen, T., Janssen, J., Klump, V., Paddock, R., Szmania, D., Verhein, K. and Waples, J.T. (2008). Real Time Observation of the Thermal Bar and Spring Stratification of Lake Michigan with the GLUCOS Coastal Observatory. Proceedings of the MTS/IEEE Oceans 2008 Conference, Quebec City, Canada, Sept. 14-18.

RUBERG, S.A., E. Guasp, N. HAWLEY, R.W. MUZZI, S.B. BRANDT, H.A. VANDERPLOEG, J.C. LANE, T.C. MILLER, and S.A. CONSTANT. Societal benefits of the real-time coastal observation network (ReCON): Implications for municipal drinking water quality. Marine Technology Society Journal 42(3):103-109 (2008).

Presentations

Thomas SP, Pavlac MM, Oakes RL, Hassett JP, Farrell, JM, **Boyer, GL.** Developing a Land-based Monitoring Station on the Saint Lawrence River. The St.Lawrence Seaway - Gateway to the Great Lakes: Unlocking 50 years of benefits and impacts conference, May 5, 2009

Consi, T.R. An Urban Coastal Observatory: Design, Implementation and Results, ONR-MTS 2008 Buoy Workshop, Bay St. Louis, MS

RUBERG, SA, Muzzi, Brandt, Gray, Downing, Lane Miller, Constant. A Wireless Internet-Based Observatory: The Real-time Coastal Observation Network (ReCON). Proceedings of the MTS/IEEE Oceans 2007 Conference, September 30 – October 5, 2007, Vancouver, BC.

MUZZI, R.W., S.A. RUBERG, J.C. LANE, T.C. MILLER, and S.A. CONSTANT. Real-time coastal observation network: Five year update on communications, power, and data access. ONR/MTS/WHOI Buoy Workshop 2008, Bay St. Louis, MS, March 4-6, 2008 (2008).

RUBERG S.A., R. W. Muzzi, S. B. Brandt, J. C. Lane, T. C. Miller, S. Constant. ReCON - Regional Data Exchange, October 29, 2007, Ottawa, ON

RUBERG, SA. "Recent Advances in Limnology and Oceanography", Univ. of Wisconsin - Milwaukee Bio/Sci 611, February 28, 2008.

RUBERG SA. Cyberinfrastructure for Environmental Observations, Univ. of Michigan Graham Environmental Sustainability Institute Workshop, March 26-27, 2008

RUBERG, SA. ReCON Presentation to NOAA Program Planning Representatives, Silver Spring, MD, February 2, 2009

PROJECT TITLE: OBSERVATORY FOR SUBMERGED SINKHOLE ECOSYSTEMS IN THUNDER BAY NATIONAL MARINE SANCTUARY, LAKE HURON: HABITAT EXPLORATION, LIFE INVENTORY AND HYDROLOGIC MODELING

Principal Investigators: *Thomas Johengen, CILER*
Steve Ruberg, GLERL
Allen Burton, CILER

Research Collaborators

Steven A. Ruberg, NOAA-GLERL (*Physico-Chemical Mapping and Instrumentation*), Mark Baskaran, Wayne State U (*Groundwater Discharge*), Bopiah Biddanda, GVSU (*Aquatic Ecology*), Tyrone Black, Michigan DEQ (*Karst Geology*), Nathan Hawley, NOAA-GLERL (*Oceanography*), Tom Johengen, U Michigan (*Nutrient Chemistry*),Val Klump (*Groundwater Analyses*), UW-Milwaukee, Stephen C. Nold, UW-Stout (*Molecular Ecology*), Ivar Babb, Rob Paddock (*ROV Technology*), NURC/UW-Milwaukee, Jeff Gray and Russ Green, TBNMS (*Sanctuary Support, Outreach and Diving*).

Overview and Objectives

Introduction

Summer and fall 2008 data collection efforts have given way to sample processing and data analysis. We will resume field data collection in spring 2009. We obtained sensor measurements and collected samples at near shore El Cajon and Middle Island sinkhole system and the offshore Isolated sinkhole system during the summer and fall. Sensor observations and diver observations have given us insight into the physical, biological, and chemical characteristics of the sinkholes. Sample processing continues to reveal to us the way life in these extreme systems behaves as well as provided hopeful insights into the potential value of these organisms for use in pharmaceutical applications. We have also begun to publish some of our results in scientific journals.

Tasks Scheduled Summer and Fall 2008

Map the underwater habitat (ROV and diver mapping), evaluate the variable physico-chemical conditions for one year (continuous time-series exploration), measure the rate of groundwater discharge (Ra, Rn tracers and stable oxygen isotopes), quantify ground water and sediment pore water nutrient chemistry (colorimetry and ion chromatography), identify the carbon composition of benthic mats and sediments (stable carbon isotopes in sediment cores), describe the fine-scale vertical organization

of the microbial mats (epifluorescence microscopy, molecular characterization), identify metazoan sinkhole inhabitants (light microscopy and molecular characterization), and study mat growth (light/dark growth experiments). The proposed study is expected to provide a clear working picture of the bathymetry, physico-chemical conditions, hydrologic processes, variety and distribution of life in a range of submerged sinkhole ecosystems in this Laurentian Great Lakes Basin.

Accomplishments

Nutrients

Nutrient samples were collected by Tom Johengen's Lab from all three sinkhole locations during three different surveys. The goal was to sample the groundwater end member as well as comparative control (lake water) samples at each of the sinkhole sites. Samples will be analyzed for a variety of nutrients including nitrogen, phosphorous and silicon as well as other ions such as chloride, sulfate, bromide and fluoride. Chemical analyses will help to define the signatures (i.e. source and strength) of the groundwater input and will be examined in terms of its potential influence on observed levels of photosynthesis and chemosynthesis present within the sinkhole basins. Samples analyses have not been completed due to an early shutdown of the laboratory in preparation for a building move. The new laboratory is scheduled to be operational by the end of March 2009 and sample analyses will commence immediately. We have also split samples among project participants to enhance the number of anions and cations that we can measure on the sample to help in the interpretation of source water and degree of mixing within the sinkhole basins.

Ecosystem ecology

Bopi Biddanda's Lab focused on sinkhole ecosystem ecology, characterizing the chemical, physical and hydrographic features measuring water, benthic mat and sediment metabolism providing insight into the food web linkages between sinkhole ecosystems and the lake. Collectively we developed methods to describe the abundance, diversity and activities of the sinkhole microbial communities. Although the purple benthic mat consisted mostly of *Oscillatoria*-like cyanobacteria, microscopic examination (and molecular level phylogenetic analyses by the Nold Lab) has revealed the presence of active nematodes, tardigrades, arthropods, and various protozoa – confirming that the mats are a complex and dynamic consortia of microbial producers and protozoan+metazoan consumers. An interesting scientific finding was that the ^{14}C-bicarbonate uptake studies of production processes showed that sinkhole ecosystems are variably supported by oxygenic photosynthesis, anoxygenic photosynthesis, and chemosynthesis along a depth gradient of decreasing sunlight. Further stable isotope

studies showed that the local benthic food web is tightly linked to carbon input from the groundwater. Additional microscopy of biological samples and analyses of carbon and nutrient content of water samples collected during 2008 remain to be performed.

Microbial ecology

Steve Nold's Lab is providing an understanding of microbial ecology by characterizing the fine-scale vertical organization of microbial and multi-celled animal communities inhabiting the sinkholes and determining the source of organic carbon in sinkhole sediments. We collected and thin-sectioned sediment cores from Middle Island Sinkhole and analyzed the gene sequences of the microbial inhabitants. These data were recently submitted for publication (**Rich archaeal and eukaryal diversity in a lacustrine submerged sinkhole ecosystem,** Stephen C. Nold, Heidi A. Zajack, and Bopaiah A. Biddanda, submitted to *Microbial Ecology*). We also extracted and separated the membrane phospholipids of sinkhole inhabitants. These samples are currently at the Soil Science Department at the University of Wisconsin-Madison awaiting analysis. The sample backlog at UW-Madison is substantial, and the analytical instrumentation needs upgrading before running these samples. A recent phone call to the technician performing these analyses suggested that the samples will be run sometime this summer. Eventually, they will be separated by gas chromatography and individual lipids will be analyzed by isotope ratio mass spectrometry for ^{13}C content. These data will provide a comprehensive view of microbial community composition, including the metazoan and bacterial inhabitants. By illuminating patterns of ^{13}C incorporation into individual membrane lipids, these data will also link metazoans to their food source (presumably the cyanobacterial phototrophs in this ecosystem). The source of organic carbon in sinkhole sediments was discovered by collecting sediment, phytoplankton, cyanobacterial mat, sedimenting carbon, and dissolved inorganic carbon samples from Middle Island sinkhole. We analyzed the ^{13}C and ^{15}N content of each carbon pool using isotope ratio mass spectrometry. Nearly all (>90%) of the carbon in sinkhole sediments originates from the sedimenting phytoplankton rather than the overlying cyanobacterial mat. A manuscript has been composed for publication (**Lacustrine submerged sinkhole sediments are a sink for organic carbon,** Stephen C. Nold, Michael J. Bellecourt, Bopaiah A. Biddanda, Scott C. Kendall, Steven A. Ruberg, T. Garrison Sanders and J. Val Klump, to be submitted to *Biogeochemistry*) and is awaiting one final figure before submission. Two more manuscripts are in preparation, one describing bacterial diversity in Middle Island sinkhole, and another describing the diversity and activity of cyanobacteria in this habitat (see below). Upcoming analyses will focus on the diversity and abundance of microbes inhabiting Isolated Sinkhole, a deep (93 m) feature offering an aphotic environment possibly supported solely by chemosynthesis.

Groundwater Isotopic Analyses

Mark Baskaran's Lab collected a suite of water samples in around the three vents. Radioisotopes and stable isotopes of oxygen and hydrogen were analyzed in these water samples. We found the radium isotopes give the groundwater a unique isotopic signature with 100 times radium in the sinkhole groundwater than in the surrounding lake water. We will be able to quantify the amount of submarine groundwater discharge into the lake using this unique signature. The analysis of stable isotopic oxygen indicated that the sinkhole water is highly depleted in oxygen isotopic composition. The hydrogen isotopic composition also indicates similar depletion. When the analysis is completed on additional radium isotopes we anticipate obtaining the velocity of the movement of sinkhole water into the lake using isotopic activity ratios. We also anticipate obtaining the vertical and horizontal diffusion rates of sinkhole water using the concentration gradient of radium isotopes.

In addition, long diver collected cores were obtained from the Middle Island sinkhole and are being dated using Pb-210 and Cs-137 geochronologies by Val Klump at the University of Wisconsin Milwaukee WATER Institute. Preliminary results indicate that sediment accumulation rates are considerably higher than for the depositional regions of the lake as a whole, indicating either the sinkhole is operating as a significant trap, focusing material from a wider area, and/or that productivity is high leading to high rates of deposition.

Analysis of sinkhole waters by Val Klump shows that these waters are very high in dissolved methane (400-1000 nmol L^{-1}), a bi-product of anaerobic metabolism of organic matter. Analysis of organic carbon and total nitrogen content, as well as stable isotopic composition of the Middle Island core sediment is continuing. Nitrogen remineralization appears to be significant, with as much as 60% of the total deposition being recycled back into the overlying water. Estimates of the isotopic composition of this recycled fraction indicate that it is isotopically light ($\delta^{15}N$ ~ -0.2 ‰) relative to surface sediments ($\delta^{15}N$ ~ +1.25 ‰), in keeping with the preferential remineralization of ^{14}N relative to ^{15}N (β_{obs} = 1.00164).

Pharmaceutical Analyses

Sediment and microbial mat samples are also being analyzed for potential use in treating a wide variety of diseases. Cyanobacterial mat samples from the Middle Island sinkhole provided to David Sherman's Lab at the University of Michigan were analyzed by a multidisciplinary team of investigators at the UofM's Life Sciences Institute, Argonne National Laboratory and the University of Chicago. The team of researchers reported the discovery of a new target against the deadly human pathogen anthrax that could provide access to effective antibiotic therapies. The bacterium that causes anthrax, a bioterror agent that again came to notoriety during the 2001 "anthrax

scare", has been the subject of intensive research to develop effective vaccines, and new drugs to rapidly treat infection.

Physico-chemical Mapping and Instrumentation

Project lead investigator Steve Ruberg, along with Rob Paddock of the University of Wisconsin Milwaukee WATER Institute and Scott Kendall of the Annis Water Resources Institute collected imagery and chemical and physical mapping data at all three sinkhole locations using remotely operated vehicles. Bathymetric maps have now been produced of all three sinkhole locations. Visualization maps of dissolved oxygen, pH, temperature, and conductivity will be produced for all three sinkhole systems. Observations obtained during the summer and fall research cruises are leading to insights valuable to our understanding of these unique environments which may lead to additional investigations. Preliminary observations indicate that groundwater at the nearshore Middle Island sinkhole has a lower conductivity than the offshore Isolated system. A possible explanation is that groundwater exiting into the deeper Isolated sinkhole (93m) flows through the Silurian geologic formation known to hold more halite deposits while the shallower Middle Island system is flowing through the higher level Devonian formation. The higher salt content of the deeper formation can be attributed to the evaporation of seawater captured in rock layers of the Silurian period during the Paleozoic era. The additional exploration of a karst feature further east at a depth of 109 m showed no obvious signs of recent venting activity and no changes in water temperature or increased conductivity indicative of groundwater flow where observed.

ROV observations have led to a better understanding of the sources of groundwater in the Middle Island system. Our initial conclusion that the bowl-shaped Alcove was the primary source of groundwater is now being re-evaluated with the discovery of multiple sources around the base of the Arena walls.

In addition, Nathan Hawley deployed twelve instrumented moorings near the Middle Island and Isolated sinkholes to determine how groundwater ionic composition and physical parameters such as temperature and flow rate vary with local climate and lake conditions over the course of a nine month multi-sensor deployment. These instrument packages will be retrieved in May 2009.

Scientific Products

Products: The project was chosen as a "Signature Project" during 2008 by NOAA-OE and, together with NOAA's Thunderbay National Marine Sanctuary, we have published 2 peer-reviewed articles (*MTJS* 2008 and *Eos*-AGU 2009), distributed audio-video educational project CDs to school teachers and participated in live web casts to

schools and the public. Learn more about this project by viewing the Web Page at http://oceanexplorer.noaa.gov/explorations/08thunderbay and our live web cast at http://www.oceanslive.org (choose "Underwater Sinkholes" under archives).

Research Articles:

Publications

Biddanda, Nold, Ruberg, Kendall, Sanders, and Gray. 2009. Submerged sinkhole ecosystems in the Laurentian Great Lakes: a new biogeochemical research frontier. *Eos.*

Ruberg S., S. Kendall, B. Biddanda, T. Black, W. Lusardi, R. Green, T. Casserley, E. Smith, S. Nold, T. G. Sanders, G. Lang, S. Constant. (Winter 2008/2009). Observations of the Middle Island Sinkhole in Lake Huron: A Unique Hydrogeologic and Glacial Creation of 400 Million Years. *Marine Technology Society Journal.*

In Review:

Stephen C. Nold, Heidi A. Zajack, and Bopaiah A. Biddanda. Rich archaeal and eukaryal diversity in a lacustrine submerged sinkhole ecosystem. Submitted to *Microbial Ecology.*

Stephen C. Nold, Michael J. Bellecourt, Bopaiah A. Biddanda, Scott C. Kendall, Steven A. Ruberg, T. Garrison Sanders and J. Val Klump. Lacustrine submerged sinkhole sediments are a sink for organic carbon. To be submitted to *Biogeochemistry*

Planned:

Stephen C. Nold, Heidi A. Zajack, Joseph B. Pangborn, Rick Rediske, and Bopaiah A. Biddanda. Lake Huron sinkholes host enormous bacterial diversity. To be submitted to *Aquatic Microbial Ecology*.

Stephen C. Nold, Heidi A. Zajack, Joseph B. Pangborn, Scott C. Kendall, and Bopaiah A. Biddanda. Cyanobacterial identity and activity in Lake Huron sinkholes. To be submitted to *Journal of Plankton Research*.

Sanders, T.G. and B. A. Biddanda (In Prep): Food web linkages in and around submerged sinkhole ecosystems of Lake Huron.

Biddanda, B. A. and S. C. Kendall et al. (In Prep): Production processes in sub-lacustrine sinkhole ecosystems.

Presentations

Laguna Bacalar Symposium, Bacalar, Quinatan Roo, Mexico, January 2009 (Biddanda and Kendall)

American Society of Limnology and Oceanography, Nice, France, January 2009 (Nold)

Forthcoming:
NABS, Grand Rapids, MI, May 2009 (Sanders)
International Association of Great Lakes Research, Toledo, OH, May 2009 (Klump)

Invited Seminars:

Montana State University, Bozeman, October 2008 (Nold)
Wayne State University Seminar, November 7, 2008 (Ruberg)
Seminar, Kellogg Biological Station, MSU, February 13, 2009. (Biddanda)

Outreach and Education Presentations and Products

Immersion Presents Lake Huron Sinkholes Exploration (Ruberg, Biddanda), September 2008

Seminar, Faculty Research colloquium, College of Liberal Arts and Sciences, GVSU (October 24, 2008) (Biddanda)

Guest lecture in undergraduate class Introduction to Natural Resource Management, GVSU (October 29, 2008) (Biddanda)

Wayne State University Seminar, November 7, 2008 (Ruberg)

Dive into Lake Huron Sinkholes: An Educational CD for K-5th grade students (2008). (Biddanda and Kendall)

Ocean Exploration Professional Development Workshop for Science Teachers, Shedd Aquarium, Chicago, IL. April 18 (Ruberg)

Submerged Sinkholes of Lake Huron: an Educational Outreach CD for K-12th Grade Students (2009). This revised and updated version contains teacher resources that include classroom audio Power Point presentations, activities,and other materials that brings sinkhole research into the classroom. Copies of CDs are available for distribution. (Biddanda and Kendall)

Classroom presentation of the educational and outreach CD to visiting K-12 students (>500) at AWRI-GVSU during 2008 (Dr. Janet Vail, GVSU)

THEME V: INTEGRATED ASSESSMENT

CILER activities that fall under the theme of Integrated Assessment include research to generate policy-relevant and synthetic efforts to help guide long-term resource use in the basin.

PROJECT TITLE: ECOFORE: FORECASTING THE CAUSES, CONSEQUENCES AND REMEDIES FOR HYPOXIA IN LAKE ERIE

Principal Investigator: Don Scavia, University of Michigan

Allen Burton, CILER

Overview and Objectives

The overall objective of this project is to create, test, and apply models to forecast how these stresses influence hypoxia formation and ecology of Lake Erie's Central Basin, with an emphasis on fish production potential. These models will integrate the multiple factors that interact to create hypoxia on Lake Erie, such as surface water flow, phosphorus input, lake dynamics, climate variation, fish movement patterns and fish and Dreissenid biology and physiology. The forecasts will be conducted within an Integrated Assessment (IA) framework, which is a formal approach to synthesizing existing natural and social scientific information in the context of a natural resources policy or management question.

Accomplishments

WATERSHED TEAM

Many activities in the Watershed Team are being conducted and completed concurrently. Nutrient (TP, NO2+NO3, TKN, TN, TSS, and SRP) loading data are being compiled and summarized to be used as model inputs for the Hypoxia Team. Watershed nitrogen (N) and P budgets are being created to better understand N and P sources over time as well as to aid in forecasting scenarios. The Distributed Large Basin Runoff Model (DLBRM) and the Soil and Water Assessment Tool (SWAT) are be parameterized and calibrated to be later used in climate and land management practice change forecasting scenarios.

Nutrient loading efforts

Monthly and daily river export load series for the Raisin, Maumee, Sandusky, Vermilion, Cuyahoga, and Grand Rivers have been completed for the period of record. Missing data have been filled in, and the complete time series have been posted to the project website.

Daily Lake Erie nutrient loading estimates for CY2005 at 26 spatial nodes have been completed with the exception of atmospheric estimates which are pending data from Environment Canada. CY1976 nutrient loads have been reconstructed from archived historical data with the exception of unmonitored area estimates. Collection of point source and tributary data for 2006 and 2007 is still ongoing as many data sources are still unavailable.

N and P budgets

For all watersheds of the Lake Erie Basin in the U.S., historical N and P budgets were completed for agricultural census years from 1934 to 1974 at every decennial, and from 1974 to 2002 at every five years. Similar to the NAPI budgets, Nitrogen budget was estimated using net anthropogenic N inputs approach. NANI was constructed by quantifying all known anthropogenic N inputs (fertilizer, crop fixation, atmospheric deposition, imports of N in crop and animal products), outputs (volatilization of N from applied manure and fertilizer and crop senescence, and exports of N in food and feed) as well as the net balances between inputs and outputs, resulting in an estimate of net anthropogenic N inputs (NANI).

In addition, we developed relationships between watershed P inputs and river TP exports for the selected watersheds of the Lake Erie Basin (Huron, Raisin, Maumee, Sandusky, Cuyahoga, and Grand in OH) for 5 agricultural census years from 1978 to 2002 to figure out how the input: export relationship has changed over time and how the changes in relationships would be linked to the re-occurrence of the Hypoxia in Lake Erie.

Multiple databases of land use, soil, digital elevation model (DEM), hydrography, and agricultural management practices have been acquired, processed, and analyzed to develop dynamic input parameters for the DLBRM and the revised universal soil loss equation (version 2) (RUSLE2) for the 6 watersheds on the U.S. side (Grand-OH, Cuyahoga, Sandusky, Maumee, Huron-MI, and Raisin). We have acquired and processed multiple databases of land use, soil, digital elevation model (DEM), and hydrography for the Grand River –Ontario. A computer program was written to spatially link the Ontario soil attribute database with the polygon database for extracting the soil input parameters. Input parameters for the DLBRM were derived. We are currently working to derive the N and P loading input for the DLBRM on the Grand River –Ontario.

We have also built basic model application databases (daily meteorology, land use, soils, elevation, and hydrography) for all 17 US Lake Erie watersheds and are working on the same for the Grand (Ontario) and we completed DLBRM daily calibrations for five Erie watersheds: Huron, Raisin, Maumee, Sandusky, and Grand (Ohio). We are now calibrating the DLBRM for the remaining 12 US Erie watersheds. We estimated sediment and nutrient transport for two non-Erie watersheds and are doing the same now for the Maumee watershed on Lake Erie. We are now adding transport mechanics to the DLBRM. We developed automatic near real time "Resource Shed" processing for 18 watersheds, including the five Erie watersheds mentioned previously. Resource shed maps for the last 31 days are available daily and will soon be accessible via the WWW.

SWAT models are being developed for the same 7 Lake Erie watersheds being modeled by DLBRM – Huron, Raisin, Maumee, Sandusky, Cuyahoga, Grand (in Ohio), and Grand (in Ontario, Canada). Primary SWAT modeling efforts are currently parameterizing and calibrating the individual models. Data gathering and reformatting for model input has been completed over recent months except for some

Canadian data to be used for the Grand (in Ontario) watershed. All 7 SWAT models have been delineated with DEMs, stream channels, sub-basin boundaries, and impoundments. The Raisin and Huron models are completely parameterized and are being calibrated. Other models are in various stages of parameterization. All watershed models have also been recently upgraded to the ArcSWAT 2.1.4a interface using ArcGIS 9.2.

HYPOXIA TEAM

Our level 2 hypoxia model was developed and applied for the period 1982-2005. The goal of this model is to expand on the level 1 model (focused primarily on thermal structure) to assess how the relative role of growth and decay processes in the lower foodweb affect hypoxia. The level 2 model maintains the 1-dimensional vertical domain. This framework incorporated basin phosphorus and carbon loads, available light (including phytoplankton self-shading), and the mixing and temperature structures from the 1D thermal model. The model estimates phytoplankton biomass, zooplankton biomass, autochthonous detritus, and dissolved oxygen by quantifying nutrient uptake and cycling in the water column. The application was calibrated for 2005 observations, and confirmed using data from 1982-2004.

A 2 km hydrodynamic model of Lake Erie was developed (based on the Princeton Ocean Model) with a goal to calculate lake-wide circulation and thermal structure in 2004 and 2005. Daily inflows at 22 major tributaries and hourly meteorological data at 12 land stations and 3 meteorological buoys were assembled, edited and interpolated to create gridded forcing functions for the hydrodynamic model. Complete 3D hydrodynamic model simulation was accomplished for both years and model results are now being compared with observations of temperature and currents. This modeling work has demonstrated the potential importance of nearshore-offshore gradients of important biogeochemical materials, making the exchange of material between the nearshore and offshore an important aspect to be considered in our level 3 modeling.

Our level 3A model is currently being developed to incorporate the 3-dimenstional hydrodynamic output for 2004 and 2004. The model will integrate the level 2 lower food web model into the 3-dimensional domain. The goal of this application is to assess how the food web impacts on dissolved oxygen resources vary spatially, particularly in near shore regions. The level 3A model is preliminarily applied for 2004 and 2005. We have also begun developing the code for our level 3B model, which will be a complex hypoxia model, incorporating Dreissenids and nearshore lower food web dynamics that may be different from offshore dynamics. This model will be linked to the same 3D hydrodynamic model as is being used for the level 3A model.

Additionally, we have continued to assess and incorporate uncertainty in our modeling applications. We have conducted preliminary, exploratory analyses of our level 1 model using PEST (a parameter estimation and optimization software) and WinBUGS (a Bayesian reference software). These analyses are intended to assess the variability of the calibration terms in the model.

ECOLOGICAL EFFECTS

The Ecological Effects team is developing a suite of models to explore how hypolimnetic hypoxia impacts ecological interactions and fisheries production in the central basin of Lake Erie. We are using a parallel modeling approach including: 1) Empirical, statistical models; 2) Bioenergetics models (Growth rate potential models [GRP] and Individual-based models [IBM]); and 3) Foodweb models (Ecopath with Ecosim and CASM [Comprehensive Aquatic Simulation Model]). Our ultimate goal is to apply these models to forecast how fish production in Lake Erie would be affected by potential, future nutrient loading scenarios and hypoxia dynamics.

During the initial phase of the project, we primarily work to develop and parameterize ecological models. To accomplish this goal, we rely on a variety of existing data: physical measures (temperature, water clarity, oxygen concentration), fisheries harvest data, annual fisheries-independent stock assessments, hydro-acoustic estimates of fish biomass, benthic macroinvertebrate surveys, zooplankton surveys (from optical plankton counter, net collections and pump samples), and fish samples (midwater and bottom trawl caught fish allowing for quantification species-specific vertical distributions and diet contents). Most of these data were collected through the IFYLE (International Field Years on Lake Erie) program and state/provincial agency-based monitoring efforts. Most of the data which we use for model development and parameterization have been previously collected and analyzed (primarily through IFYLE-related efforts). However, some previously collected data require compilation, processing and analyses before they can be used for model development and parameterization. To this end, we have analyzed biological data (zooplankton, benthic macro-invertebrate, and fish) and compiled historical fisheries and fisheries-independent data (including manual data entry from paper copies).

In applying our models, we build directly on the efforts of other project components (i.e., we use output from Watershed and Hypoxia forecasting models as input for our models). As these other project components have realized model outputs, our modeling efforts have ramped up. During 2008, we hired three postdoctoral research associates (Arend [Purdue; Bioenergetics modeling and CASM], Hosack [Ohio State; Empirical analyses], and Zhang [NOAA-GLERL and U. Michigan; EcoPath]).

Empirical analyses

We are exploring the effects of hypoxia on commercial catch rates of walleye using both commercial and fishery independent data in Lake Erie. Hypoxia, as estimated by the 1-D model, positively correlates with annual catch rates of walleye. Monthly analyses, however, show that catch rate and harvest response to hypoxia varies by region. Spatial data available from IFYLE 2005 shows that hypoxia is constrained to the central basin, and fishery independent survey data suggests that the probability of walleye occurrence exhibits unimodal relationships with respect to bottom dissolved oxygen and temperature. Ongoing work investigates how spatial IFYLE abiotic data relates to walleye distribution and the distribution of a primary prey species, rainbow smelt. We are continuing these analyses and in the future will use similar data sets to

consider how spatial distributions and harvest of yellow perch and other species respond to hypoxia.

Bioenergetic models

To date, we have developed bioenergetics growth rate potential models for emerald shiner, rainbow smelt, round goby, yellow perch, and walleye. We have applied these models 1) using physical, chemical and biological data collected during 2005/2007 IFYLE cruises in central Lake Erie and 2) using output from 1-dimensional hypoxia models. Analyses based on output from 1-dimensional hypoxia models suggest that hypoxia effects on habitat quality vary inter-annually and differentially affect various species and life-stages. In addition, we are in the process of incorporating dynamic behavior and movement into growth rate potential models. In the near future, we will start development of individual-based bioenergetics models for rainbow smelt, walleye and yellow perch. These models will build on growth rate potential models and on-going individual-based modeling efforts for walleye and yellow perch in other systems.

Foodweb models

CASM is a bioenergetics foodweb model useful for considering how stressor impacts on certain portions of a food-web may cascade to influence various other components. CASM Lake Erie (CASM-LE) is being developed and applied to evaluate how hypoxia impacts may cascade through the foodweb of Lake Erie's central basin. The impacts of hypoxia are somewhat different than many other stressors (e.g., contaminants) and this has required a restructuring of CASM. For instance, CASM-LE includes 3-layer vertical structure and allows foodweb constituents to move vertically. Further, CASM-LE includes a transect of vertically-structured foodweb compartments, moving from nearshore to offshore (thereby allowing for horizontal migration in response to hypoxia). We are using a variety of information to develop foodweb connections, initial model biomasses and physio-chemical conditions in CASM-LE (e.g., physical, chemical and biological data from IFYLE; literature values; agency reports). We have developed initial structure for the CASM-LE foodweb and will shortly begin model simulations.

Ecopath with Ecosim (EwE) is a suite of food web models that is designed to address ecological questions, to evaluate ecosystem effects of fishery management, to explore management policy options, and to evaluate effect of environmental changes, etc. Our Ecopath model will be focused on the central basin of Lake Erie, and aims to evaluate the impacts of hypoxia on the lake ecosystem structure and function, and to explore water quality management and fisheries management scenarios. Our EwE team has been compiling and analyzing data since December 2008 to modify an existing Ecopath model for Lake Erie developed by Johnson and Zhu to investigate the effects of invasive species on the Lake Erie food web. Our EwE team has consulted lower trophic level experts regarding merging taxa into functional trophic groups in Ecopath. We estimated biomass of the lower trophic-level groups based on literature review and data sources including IFYLE field studies and the LEPAS (Lake Erie Plankton

Abundance Study at Ohio State University). Currently, we are modeling 41 age/size groups of fish in our Ecopath model: biomass estimated from IFYLE trawl and acoustic data, and from surveys by state and provincial agencies. Our EwE team also is working with Lake Erie fisheries managers to design relevant management simulations and to ensure the final EwE model is a useful management tool.

Coordination and application

We are working to ensure that our models and simulations are highly relevant for Lake Erie fisheries managers and that our collective analyses provide insight regarding tradeoffs between nutrient loading and fisheries production. We are engaging with managers via presentations at stakeholder meeting, personal conversations, and distribution of project literature (including series of questions for managers). While we are developing a multitude of models which have unique advantages and disadvantages. An ultimate goal of our efforts is to be able to compare model predictions. While this may not always be feasible (given the differential forms of our models), when possible we are facilitating model comparisons by initially structuring models in a similar manner. For instance, we have communicated during CASM-LE and EwE development to ensure that the foodweb connections of these models are similar.

Publications

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Roberts, J.J., T.O. Höök, S.A. Ludsin, S.A. Pothoven, H.A. Vanderploeg, and S. B. Brandt. In press. Effects of hypolimnetic hypoxia on foraging and distributions of Lake Erie yellow perch. Journal of Experimental Biology and Ecology.

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Presentations

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Brandt, S.B., M. Costantini, S.A. Ludsin, D.M. Mason, and H.A. Vanderploeg. 2008. Spatially-explicit growth predictions to assess habitat quality of walleye during hypoxia in Lake Erie. International Association for Great Lakes Research, Peterborough, Ontario
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DePinto, J.V. "Nearshore phosphorus cycling and algal growth in the western basin of Lake Erie. Invited talk at the Western Lake Erie Basin Conference, Oregon, OH (March 10-11, 2009).
DePinto, J.V.1, Vanderploeg, H.A.2, and AUER, M.T. 2008. Cladophora and open-water "desertification": Do Dreissenids play a role? Paper presented at the 51th Annual Conference on Great Lakes Research, Trent University, Peterborough, ON (May 19-June 23, 2008).
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He, C. and T. E. Croley. 2008. Resource Shed and Its Applications in the U.S. Great Lakes Watersheds. Lanzhou University, Lanzhou, P.R. China, Oct.29. 60 min.
He, C. and T. E. Croley. 2008. Resource Shed and Its Applications in the U.S. Great Lakes Watersheds. The Chinese Academy of Sciences Institute of Geodesy and Geophysics, Wuhan, Nov.3, 65 min.
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Ludsin, S.A., T.O. Höök, D. Rucinski, J.V. DePinto and D. Scavia. 2008. Historical exploration of hypoxia effects on fish recruitment and production in Lake Erie. Oral presentation at the International Association for Great Lakes Research 51st Annual Conference on Great Lakes Research, Peterborough, ON. May 20.
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Ludsin, S.A. 2009. Hypoxia in Lake Erie: implications for food webs and fisheries. The Great Lakes: Adapting to a Wave of Change Conference, Michigan State University, East Lansing
Ludsin, S.A. 2008. Hypoxia alters species distributions and interactions: implications for food webs and fisheries. Stone Laboratory Guest Lecture Series, Put-In-Bay, Ohio
Ludsin, S.A. 2008. Hypoxia alters species distributions and interactions: implications for food webs and fisheries. Department of Zoology, Southern Illinois University, Carbondale, IL
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Ludsin, S.A., T.O. Höök, D.K. Rucinski, J.V. DePinto, and D. Scavia. 2008. Historical exploration of hypoxia effects on fish recruitment and production in Lake Erie. International Association for Great Lakes Research, Peterborough, Ontario
Modelling and Simulation, Session 47: Nutrient Modeling Techniques to Support Water Quality Management, Christchurch, New Zealand, December 10-13.
Richards, R. P. 2008. Food, Fertilizer, Fish, and Fouled Beaches: Water Quality in the Maumee River and the Western Basin of Lake Erie, 1975 to Present. Lake Erie Center, Maumee, OH, October 16.

Richards, R.P. 2008. Record Setting Phosphorus Loads from Agricultural Watersheds in Ohio. USDA Water Quality Conference, Sparks, NV, February 6.
Richards, R. P. 2008. Testimony on Lake Erie Phosphorus Loadings. U.S. House of Representatives Committee on Transportation and Infrastructure, Subcommittee on Water Resources and Environment. Port Huron, Michigan, May 12.
Richards, R. P. 2009. Trends in sediment concentrations and loads in Northwest Ohio tributaries to Lake Erie, 1975-2008. Western Lake Erie Basin Conference, March 10.
Richards, R.P., D.B. Baker, and J.P. Crumrine. 2007. Increased Dissolved Phosphorus Loading to Lake Erie from Agricultural Watersheds. Great Lakes Protection Fund Project Workshop, Tiffin, OH, December 18.
Richards, R.P., D.B. Baker, and J.P. Crumrine. 2008. Trends in Dissolved Reactive Phosphorus in Lake Erie Tributaries. Landscapes and Loadings Workshop, Council of Great Lakes Governors, Maumee, OH, March 19.
Richards, R.P, D.B. Baker, and J.P. Crumrine. 2008. Trends in Dissolved Reactive Phosphorus in Lake Erie Tributaries. Millennium Network Conference, Windsor, ON, April 29.
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Rucinski, D.K., D. Beletsky, J.V. DePinto, D. Scavia, D. Schwab. 2008. Development and Application of 1D Eutrophication Models for the Central Basin of Lake Erie. Oral presentation at the International Association for Great Lakes Research 51th Annual Conference on Great Lakes Research, Peterborough, Ont. May 20.
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Lake Erie. Oral presentation at the International Association for Great Lakes Research 51th Annual Conference on Great Lakes Research, Peterborough, Ont. May 20.
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Zhang, H., Rutherford, E.S., Mason, D.M., Adamack, A.T., Johnson, T., and Zhu, X. 2009. Ecopath with Ecosim and Ecospace: Hypoxia impacts on the fisheries of Lake Erie. Pre-Lake Erie Committee meeting. London, Ontario.

Awards

Best Professional Paper: Indiana American Fisheries Society Annual Meeting, Indianapolis. (K. Arend, T. Höök, S. Ludsin, D. Rucinski, J. DePinto, and D. Scavia.)

Thesis Defended (M.S.)

Regression Analysis of Total Phosphorus Loading for the Maumee River, Water Years 2003-2005, by Charlie Piette, University of Wisconsin-Green Bay, December, 2008.

THEME VI: EDUCATION AND OUTREACH

CILER activities that fall under the theme of Education and Outreach focus on facilitating education and outreach activities for NOAA in the Great Lakes region.

PROJECT TITLE: OUTREACH AND EDUCATION COORDINATION FOR THE NOAA CENTER OF EXCELLENCE FOR GREAT LAKES AND HUMAN HEALTH

Principal Investigators: *Joan Rose & Sonia Joseph, MSU*

Allen Burton, CILER

Overview and Objectives

To ensure the development of useful and timely research, tools and technology, involving stakeholders in determining research priorities is essential. The NOAA Center of Excellence for Great Lakes and Human Health (CEGLHH) uses a multidisciplinary approach to translate scientific information and research into materials to aid health officials, local governments, and communities in making sound environmental decisions. In order to translate scientific materials into a concise, easily understood format and identify community needs, outreach is critical. Using Michigan Sea Grant as a model, CEGLHH's Outreach Coordination serves two roles, identifying and assessing user needs (related to Great Lakes and human health) and disseminating scientific information, technology, and research materials to aid health officials, local governments, and communities in making sound environmental decisions.

Accomplishments

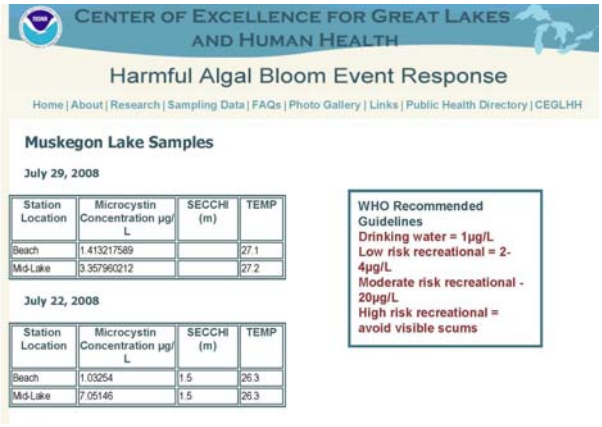
IAGLR Great Lakes and Human Health Session

Michigan Sea Grant Outreach Coordinator for CEGLHH, Sonia Joseph, co-chaired the Great Lakes and Human Health session at the 2008 International Association for Great Lakes Research Annual Conference. The Great Lakes and Human Health session had 40 participants.

Volunteer Student Sampling Program launched for Harmful Algal Bloom Monitoring

Weekly lakewide summer monitoring of two inland lakes that are tributaries of Lake Michigan was organized and launched during in June 2008. The Volunteer Student Sampling Program is the first of its kind for NOAA GLERL and for the western Michigan area. Summer students volunteers were trained by CEGLHH scientists in water sample collection, and Summer Interns based at GLERL processed and analyzed samples for the toxin Microcystin. Sample results from the weekly monitoring program were posted on the CEGLHH HAB Event Response Website: http://www.glerl.noaa.gov/res/Centers/HABS/index.html. The Muskegon

County Health Department developed a notification letter on the sampling program and the sampling results for local governments. Michigan Sea Grant has begun plans to expand the Volunteer Student Sampling Program in 2009 to different locations in Michigan to train students on sampling, analysis, and data relevance.


CENTER OF EXCELLENCE FOR GREAT LAKES AND HUMAN HEALTH

Harmful Algal Bloom Event Response

Home | About | Research | Sampling Data | FAQs | Photo Gallery | Links | Public Health Directory | CEGLHH

Muskegon Lake Samples

July 29, 2008

Station Location	Microcystin Concentration µg/L	SECCHI (m)	TEMP
Beach	1.413217589		27.1
Mid-Lake	3.357960212		27.2

July 22, 2008

Station Location	Microcystin Concentration µg/L	SECCHI (m)	TEMP
Beach	1.03254	1.5	26.3
Mid-Lake	7.05146	1.5	26.3

WHO Recommended Guidelines
Drinking water = 1µg/L
Low risk recreational = 2-4µg/L
Moderate risk recreational - 20µg/L
High risk recreational = avoid visible scums

Impact of Climate Change on the Great Lakes Ecosystem - A NOAA Science Needs Assessment Workshop to Meet Emerging Challenges

Co-organized the "Impact of Climate Change on the Great Lakes Ecosystem - A NOAA Science Needs Assessment Workshop to Meet Emerging Challenges" on July 29-31, 2008 at the University of Michigan in Ann Arbor, MI. The purpose of the workshop was to bring together NOAA and Great Lakes scientists and stakeholders to discuss the state of Great Lakes science pertaining to climate change and develop research priorities to address potential climate change impacts based on stakeholder needs. Michigan Sea Grant Outreach Coordinator Sonia Joseph facilitated the Water Quality and Human Health scientific panel and breakout session as well as organized the entire needs assessment breakout session on the final day of the workshop. Approximately 80 stakeholders from the US and Canadian federal, state, county, and city governments, drinking water, land use planning, coastal zone management, energy industry, and non-profit organizations participated in this workshop.

Ottawa County Water Quality Forum

Joseph continued to work with Al Vandenberg, Ottawa County Administrator and Michigan Sea grant colleagues Dan O'Keefe, and Chuck Pistis to organize Ottawa County's Third Water Quality Forum on November 14, 2008. With close to 100 participating in this year's Forum, we expanded the program to be a full day, with a session pertaining to Beach Health/Quality issues in the County as well as an Emerging Issues session with presentations on Pharmaceuticals in Water and Harmful Algal Blooms.

Publications

None

Presentations

Joseph, S., D. Schwab, C. Stowe, J. Bressie. March 19, 2009. Water Quality Forecasting in the Grand River and Saginaw Bay. Michigan Environmental Health Association Annual Meeting (Traverse City, MI)

Joseph, S. Sea Grant in the Great Lakes. NOAA Great Lakes Marine Forecasters Annual Meeting (Ann Arbor, Michigan).

Joseph, S., J. Bressie, G. Fahnenstiel. January 10, 2009. Blue Green and Green Algae in the Great Lakes: Perspectives and Implications for Fouling of Commercial Fishing Nets. Michigan Fish Producers Association Annual Meeting (Traverse City, Michigan)

Joseph, S., J. Rose, D. Schwab, M. Phanikumar. December 18, 2008. Beach and Drinking Water Quality Forecast Development. Monitoring Microbes in the Great Lakes Workshop (Romulus, Michigan).

Joseph, S., J. Rose, D. Schwab, M. Phanikumar. November 18, 2008. Coastal Cities and Impact of Pathogens = A Great Lakes Perspective. Coastal Cities Summit Meeting (St. Petersberg, Florida).

Joseph, S., J. Bressie, G. Fahnenstiel. November 14, 2008. Harmful Algal Blooms. Ottawa County Water Quality Forum III (West Olive, Michigan)

Joseph, S., D. Schwab. June 4, 2008: Presentation: Center of Excellence for Great Lakes and Human Health- Research and Outreach. 2008 Society of American Indian Government Employees (SAIGE) Annual Conference (Traverse City, Michigan)

APPENDIX 1: Count of Publications by CILER staff by category, FY2003 – FY2009.

	CILER Lead Author			**NOAA Lead Author**			**Other Lead Author**		
	2002-2003	2003-2004	2004-2005	2002-2003	2003-2004	2004-2005	2002-2003	2003-2004	2004-2005
Peer Reviewed	16	8	7	5	2	4	0	12	10
Non-Peer Reviewed	7	1	2	4	6	1	0	0	0
Total	23	9	9	9	8	5	0	12	10

	CILER Lead Author			**NOAA Lead Author**			**Other Lead Author**		
	2005-2006	2006-2007	2007-2008	2005-2006	2006-2007	2007-2008	2005-2006	2006-2007	2007-2008
Peer Reviewed	10	10	12	7	3	4	3	6	13
Non-Peer Reviewed	1	0	6	0	2	1	0	0	0
Total	11	10	18	7	5	5	3	6	13

	CILER Lead Author			**NOAA Lead Author**			**Other Lead Author**		
	2008-2009	2009-2010	2010-2011	2008-2009	2009-2010	2010-2011	2008-2009	2009-2010	2010-2011
Peer Reviewed	19	0	0	33	0	0	29	0	0
Non-Peer Reviewed	0	0	0	0	0	0	0	0	0
Total	19	0	0	33	0	0	29	0	0

APPENDIX 2: Employee Count by category from FY2007 to FY2009, by year.

Summary of Joint Institute Staff by Head Count 2007-2008

Category	Number	B.S.	M.S.	Ph.D.
Research Scientists	7	0	0	7
Visiting Scientists	0	0	0	0
Postdoctoral Research Fellows	3	0	0	3
Research Support Staff	14	6	8	0
Administrative	5	2	1	2
High School Students	0	0	0	0
Undergraduate Students	8	0	0	0
Graduate Students	11	4	7	0
Totals	48	10	16	12
Located at NOAA Lab	46-GLERL			
Obtained NOAA employment	0			

Summary of Joint Institute Staff by Head Count 2008-2009 (Includes subcontracts)

Category	Number	B.S.	M.S.	Ph.D.
Research Scientists	19	0	0	19
Visiting Scientists	0	0	0	0
Postdoctoral Research Fellows	19	0	0	19
Research Support Staff	22	10	12	0
Administrative	3	2	1	0
High School Students	2	0	0	0
Undergraduate Students	22	0	0	0
Graduate Students	27	14	13	0
Totals	114	26	26	38
Located at NOAA Lab	56-GLERL			
Obtained NOAA employment	3			