CILER
ANNUAL REPORT

Cooperative Institute for Limnology and Ecosystems Research (CILER)

NA07OAR4320006 — Year One
July 1, 2007 to March 31, 2008

Edward Rutherford, Interim Director
Christine A. McAllen, Administrator
CILER/University of Michigan
2038a Dana Building
440 Church Street
Ann Arbor, MI 48109-1041
734 -763-3010
www.ciler.snre.umich.edu

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

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Cooperative Institute for Limnology and Ecosystems Research
CILER

Edward Rutherford, Interim Director
Christine A. McAllen, Administrator
University of Michigan
Ann Arbor, Michigan

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Executive Summary

The Cooperative Institute for Limnology and Ecosystems Research (CILER) was established in 1989, with the objective of fostering University and NOAA partnerships in the Great Lakes region. Since its inception, CILER has supported over 140 grants that have totaled more than $13,499,651. Activities conducted under the old CILER ended in 2006. The new CILER 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) in the Great Lakes in July, 2007.

CILER currently conducts research that falls under 6 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.

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 activities for the first year of the new cooperative agreement and covers the period from July 1, 2007 to March 31, 2008. During this period CILER administered 14 projects, with the majority being in the Great Lakes Forecasting research theme (Table 1, Figure 1).

The total funding level for the first year of the cooperative agreement was $2,020,568.

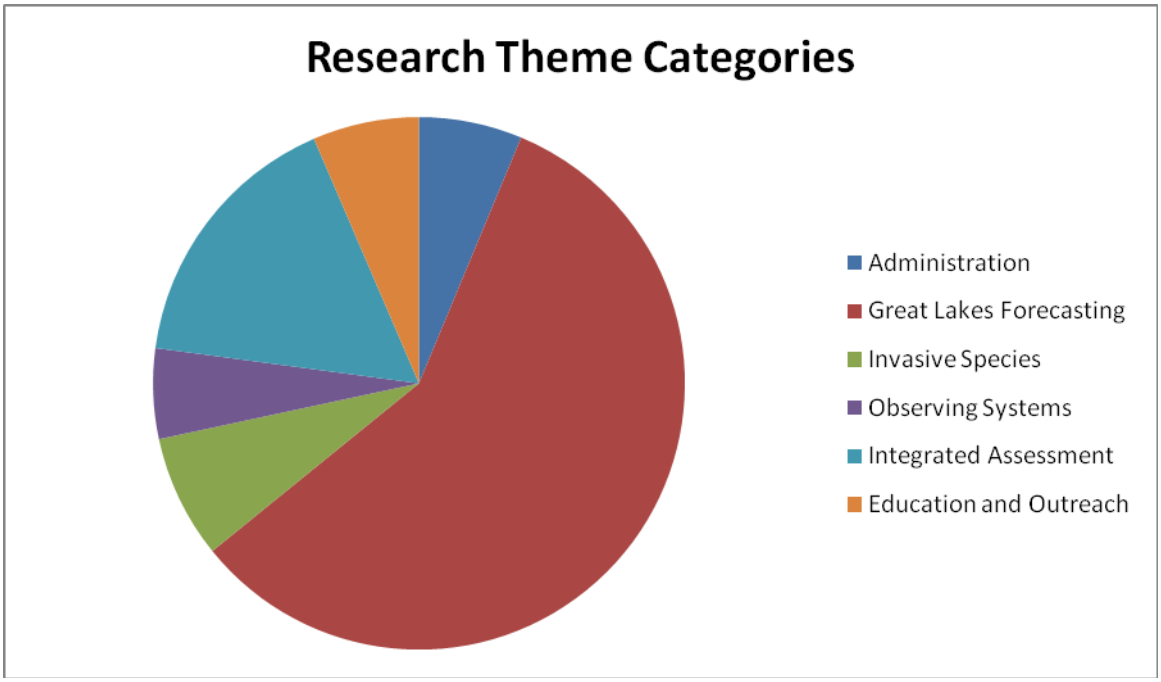

Figure 1. Funding distribution for CILER by theme area from 07/01/07 to 03/31/08.

Table 1. Breakdown of funding by Task awarded to CILER for the current Cooperative Agreement, NA07OAR4320006 for the period July 2007 through March 31, 2008.

Task	Research Theme	#Projects	Funding ($)	%Funding
II	Theme I: Great Lakes Forecasting	8	$1,169,851	58%
II	Theme II: Invasive Species	2	$131,096	6%
II	Theme III: Observing Systems	2	$96,094	5%
II	Theme IV: Protection and Restoration of Resources	0	0	0%
II	Theme V: Integrated Assessment	1	$287,757	14%
II	Theme VI: Education and Outreach	1	$113,250	6%
Totals		14	$1,798,048	89%

The following are highlights of some of the accomplishments achieved in the major research themes.

THEME I: GREAT LAKES FORECASTING

Little is known about the complex set of processes that result in eutrophication, excessive algal growth and presence of fecal signatures in Great Lakes ecosystems. Significant progress was made on a project to characterize sources, ecological systems, and potential health risks of fecal contamination and algal growth in Saginaw Bay, Lake Huron. Research surveys investigated the microbiological quality of algal debris, muck and water in the swash zone of Saginaw Bay. The sampling indicated high levels of fecal contamination in waters containing suspended algae, and in the solid material on shore, suggesting that both human fecal sources and bovine sources are impacting the water quality.

A model of current transport in near-shore waters was developed and calibrated by CILER and NOAA scientists to predict dynamics, fate and transport of E. coli in the water column.

THEME II: INVASIVE SPECIES

Ongoing research is exploring the utility of salinity-based treatments of potential invasive species in ballast tanks of ships entering the Great Lakes. Data were compiled and analyzed to identify the probable entry routes of invaders entering the Great Lakes from estuarine ports from the US and Canada. Salinity tolerance experiments were conducted to identify species in coastal port regions that pose a high risk of range expansion, and to determine effectiveness of brine treatments for killing potential invaders.

THEME III: OBSERVING SYSTEMS

The Great Lakes CoastWatch program provides data to monitor algal blooms, sediment plumes, ice cover, and water temperatures; to support predictive models of wave height and currents; and for use in education and recreation. Significant progress was made to develop and improve the operational programs that receive, process, analyze and archive Coastwatch data, and make Satellite images available to Google Earth.

Public access to habitat conditions and species in remote areas of national marine sanctuaries is significantly enhanced through implementation of real time video and audio capability. Equipment towers were purchased and are being assembled for deployment in the Thunder Bay Marine Sanctuary in Thunder Bay, Lake Huron. Additional funds are being sought to monitor fisheries resources in the sanctuary through linked acoustics and video transmissions.

THEME V: INTEGRATED ASSESSMENT

Hypoxia formation in Lake Erie's Central Basin is tied to hydrology and land use practices in surrounding watersheds, lake dynamics, climate variation and invasive species. To develop models of these processes, data on nutrient loadings and discharges from Lake Erie tributaries were summarized and entered into basin runoff models and assessment tools to be used in forecasting scenarios of changes in climate and land management practices. The basin runoff models were calibrated for five major Lake Erie watersheds. A one-dimensional model of lake currents and temperature was calibrated and will be used to provide input to a hypoxia model. Ecological models are being developed and calibrated to predict food web and species response to hypoxia formation. Data aquired during the International Field Year on Lake Erie (IFYLE) are being analyzed to populate the ecological models.

THEME VI: EDUCATION AND OUTREACH

The Center for Excellence in Great Lakes and Human Health has built strong collaborations with water quality managers at state and local levels. Workshops were held to assess stakeholder needs. A significant need was identified to train the public in algal identification, monitoring techniques, and risk communication. Workshops were held to communicate results of research conducted by NOAA in this area.

Recent and On-going CILER Initiatives in Research

In addition to these successful efforts in specific research areas, CILER also co-led efforts on research proposals in the invasive species and ecosystem forecasting research themes. This resulted in a successful proposal to NOAA CSCOR to develop a regional ecosystem forecasting model to support adaptive management of the Laurentian Great Lakes in a dreissenid-dominated environment. The research supports NOAA's efforts in ecosystem forecasting of invasive species impacts on aquatic food webs and fisheries. CILER scientists will participate in this effort through modeling of fish population dynamics and response to food web changes

imposed by nutrient loadings or fisheries harvest. The project was awarded this year but will start in FY 09 due to availability of funds.

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 planning for NOAA-GLERL's new building to open October 2008. CILER scientists and administrators co-hosted the celebration of NOAA's 200th anniversary at the Shedd Aquarium in Chicago, IL, in September 2007. Regional stakeholders and NOAA science partners participated in a round-table discussion of science needs for the Great Lakes. CILER scientists also will co-host 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 administrative personnel during the first year of the new 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 will start as CILER Director on Aug. 1 2008, and will have a joint appointment in UM-SNRE. Dr. Burton's expertise and leadership in ecological toxicology will greatly enhance NOAA's capabilities in this area, and his experience with research administration and cooperative institutes will be invaluable. In addition to hiring Dr. Burton, Christine McAllen was hired as administrative specialist for CILER. Ms McAllen has extensive experience with administration and financial operations both within the university and the private sector.

As part of the new CILER award, we hired a technician to update and revamp the CILER website. The new website (www.ciler.snre.umich.edu) highlights the consortium of the new Cooperative Institute and better showcases ongoing and new CILER initiatives. This project has required input and effort from multiple CILER staff, in order to compile appropriate information, data, and material.

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. Meetings of the Executive Board and Council of Fellows of the new CILER are scheduled for Fall 2008.

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

ADMINISTRATION AND RESEARCH ENHANCEMENT

GREAT LAKES OCEAN SCIENCE BOWL

CILER and NOAA personnel organized and led the 11th annual regional competition (Great Lakes Science Bowl) for the National Ocean Science Bowl. The competition was held Feb 9, 2008 at the University of Michigan School of Natural Resources and Environment, and attracted high school teams from around the Great Lakes.

NOAA/UM GREAT LAKES SEMINAR SERIES

Principal Investigators: Edward Rutherford, University of Michigan, Stephen Brandt, Great Lakes Environmental Research Laboratory;

GLERL and CILER continued their partnership in co-sponsoring a joint seminar series. In order to increase collaborations between NOAA and its partner universities in the new CILER, we sponsored an exchange program whereby GLERL or UM-CILER scientists would visit the nine partner universities in the new CILER, and scientists at the partner universities would speak at GLERL. Speakers listed below have contributed seminars, or committed to giving seminars, as part of the joint seminar series during FY08. In addition, four scientists gave seminars for the CILER director search.

Table 2. Speakers participating in the NOAA-UM Great Lakes Seminar Series, FY08.

Speaker	Affiliation	Title
Dr. Steve Bortone	**Univ Minnesota, Minnesota Sea Grant**	An approach to Establishing Aquatic Organisms as in situ Environmental Bioindicators of Natural Hazards
Dr. David Schwab	**NOAA GLERL**	Observations and numerical model simulations of the Grand River plume in Lake Michigan.
Dr. Haejin Han	**University of Michigan**	Nutrient loading to Lake Michigan – a mass balance assessment
Dr. Jessica Head	**Environment Canada**	Genetic and molecular approaches for assessing health of Great Lakes birds
Dr. Meng Xia	**North Carolina State University**	3-dimensional modeling of nearshore hydrodynamics in Pamlico Sound

Dr. Jay Austin	**Univ Minnesota-Duluth**	Sea ice climate interactions
Dr. Carlo DeMarchi	**UM-CILER**	Understanding Present and Future State of the Great Lakes: Current Hydrology and Pollution Loads Modeling Projects at CILER
Dr. Hongyan Zhang	**UM-CILER**	Ecological Modeling of the Lower Trophic Levels of Lake Erie
Dr. Craig Stow	**NOAA GLERL**	Applications of Bayes theory to analysis of fish population dynamics
Dr. Joseph Koonce	**Case Western Reserve**	To Be Decided
Mr. Steve Ruberg	**NOAA GLERL**	To Be Decided
Dr. Allen Burton	**Wright State University**	Assessment of Aquatic Ecosystem Impairment: Issues and Approaches
Dr. Michael Hansen	**Univ. Wisconsin - Stevens Pt**	A Perspective on Lake Trout in Oligotrophic Lakes of North America: Restoration in the Laurentian Great Lakes versus Suppression
Dr. Steve Wilhelm	**Univ. Tennessee**	Viruses, Cyanobacteria and a Dead Zone: Taking Molecular Toys on Your Summer Vacation in a Laurentian Great Lake
Dr. Edward Rutherford	**Univ. Michigan**	Influence of habitats, food webs and invasive species on Great Lakes fisheries

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: CLIMATE IMPACTS ON GREAT LAKES ECOSYSTEMS

Principal Investigators: *Cynthia Sellinger, GLERL*

Michael Quigley, GLERL

Doran Mason, GLERL

Jeffery Reutter, CILER, Ohio Sea Grant Director

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

Thus far, we've formed a steering committee to refine the venue and focus of the workshop. The workshop is planned to take place in August 2008 in Ann Arbor, Michigan.

Publications

None

Presentations

None

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

Principal Investigators: *Edward Rutherford, CILER*

Stephen Brandt, GLERL

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 coastal marine ecosystems with an emphasis on fish ecology.

-Apply this knowledge to better understand the causes, effects, and solutions to problems such as eutrohication, toxic contaminants, nonindigenous species invasions, habitat modification, and climatic variation. A comparison across the Chesapeake Bay and Great Lakes will provide further insight.

Accomplishments

Analysis was completed on effects of hypoxia on bioenergetic growth potential for striped bass and bay anchovy in the Chesapeake Bay, and on foraging and distribution of yellow perch in Lake Erie. These efforts were submitted as manuscripts (below).

Publications

Manuscripts in press or in review:

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

2. Roberts, J.J., T.O. Höök, S.A. Ludsin, S.A. Pothoven, H.A. Vanderploeg, and S.B. Brandt. *in review*. Hypoxia effects on yellow perch foraging and distribution in central Lake Erie. *Journal of Experimental Marine Biology and Ecology*.

Presentations

1. Ludsin, S.A. 2008. Hypoxia alters species distributions and interactions: implications for food webs and fisheries. Department of Zoology, Southern Illinois University, Carbondale, IL (**invited seminar**)

2. Ludsin, S.A. 2007. Hypoxia alters species distributions and interactions: implications for food webs and fisheries. Department of Earth, Ecological, and Environmental Sciences, University of Toledo, Toledo, OH (**invited seminar**)

3. Ludsin, S.A. 2007. Hypoxia alters species distributions and interactions: implications for food webs and fisheries. Department of Biology, University of Akron, Akron, OH (**invited seminar**)

4. Zhang, X., L. Bahner, R. Wood, E. Houde, E. Annis, L. Harding, R. Kelsey, **S.** Ludsin, and S. Brandt. 2007. Modeling the temporal and spatial variability in bay anchovy habitat suitability in Chesapeake Bay. Estuarine Research Foundation, Providence Rhode Island (contributed presentation).

PROJECT TITLE: EFFECTS OF HYPOXIA ON PELAGIC FOOD WEBS

Principal Investigators: *Doran Mason, GLERL*
Edward Rutherford, CILER

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

We are developing a pair of individual-based bioenergetics models for juvenile white (*Litopenaeus setiferus*) and brown shrimp (*Farfantepenaeus aztecus*). These bioenergetics models will be used to predict the effects of current and future freshwater diversions in coastal Louisiana on the growth and survival of juvenile white and brown shrimp. Growth and survival rates of juvenile shrimp are affected by water temperature and salinity (Zein-Eldin and Aldrich 1965; Saoud and Davis 2003) which can both be affected by freshwater diversions such as the Caernarvon river diversion on the Mississippi River (Lane et al. 2007). Outputs from hydrodynamics and hydrology models will be used to simulate temperature and salinity patterns in an estuary for a series of freshwater diversion scenarios. Temperature and salinity output from the hydrodynamics and hydrology models will be used as inputs to the shrimp bioenergetics models. The statically coupled models will be used to predict shrimp growth, survival and production under different freshwater diversion scenarios.

Initial versions of white and brown shrimp bioenergetics models have been developed and calibrated using published and unpublished field data. The bioenergetics models were based upon the Wisconsin bioenergetics model (Hewitt and Johnson 1992) in which the change in weight each time step (dW/dt) was determined as:

$$\frac{dW}{dt} = [CON - (R + F + E)] \cdot \frac{Cal_{prey}}{Cal_{shrimp}} \cdot W$$

where CON = the specific consumption rate; R = routine metabolism; F = egestion; E = excretion; Cal_{prey} = caloric density of prey (cal g^{-1} wet weight prey); Cal_{shrimp} (cal g^{-1} wet weight. shrimp) and W = weight of the shrimp (g wet weight). Consumption and the loss terms were all in units of g prey g^{-1} shrimp d^{-1}. We have found that there are several model parameters for which the values for shrimp have not been determined or are somewhat uncertain. In order to better estimate these model parameters we have been using Bayesian inference using the program WINBUGS to

estimate these unknown or uncertain model parameters. At this point, we are nearing completion of the model parameterization process. We are currently in the process of obtaining model output from a hydrodynamics model for Barataria Bay. Since July, we have met twice with Rozas and Minello to identify project objectives, review initial versions of the bioenergetics models and identified areas where the model needs improvement.

These models will also be used to evaluate habitat quality for these commercially important species along the northern Gulf of Mexico coast.

Publications

None

Presentations

None

References

Hewett, S.W. and B.L. Johnson. 1992. A generalized bioenergetics model of fish growth for microcomputers. University of Wisconsin Sea Grant Institute, Madison, Wisconsin. UW Sea Grant Tech. Rep. WIS-SG-92-250. 79 pp.

Lane, R.R., J.W. Day Jr., B.D. Marx, E. Reyes, E. Hyfield, and J.N. Day. 2007. The effects of riverine discharge on temperature, salinity, suspended sediment and chlorophyll *a* in a Mississippi delta estuary measured using a flow-through system. Estuarine, Coastal and Shelf Science 74: 145-154

Saoud, I.P. and D.A. Davis. 2003. Salinity tolerance of brown shrimp *Farfantepenaeus aztecus* as it relates to postlarval and juvenile survival, distribution, and growth in estuaries. Estuaries 26:970-974

Zein-Eldin, Z.P. and D.V. Aldrich. 1965. Growth and survival of postlarval *Penaeus aztecus* under controlled conditions of temperature and salinity. Biological Bulletin 129:199-216

PROJECT TITLE: 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

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) Conduct model-data comparison in the Bering Sea model only
2) Conduct model-data comparison in the Chukchi-Beaufort sea model
3) Configure a pan Bering-Chukchi-Beaufort sea model

Publications

Hu, H. and J. Wang, 2008. Modeling the ocean circulation in the Bering Sea. *Ocean Modeling* (under revision)

Wang, J., H. Hu, K. Mizobata, and S. Saitoh, 2008. Modeling seasonal variations of sea ice and ocean circulation in the Bering Sea. (submitted to *J. Geophys. Res*.)

Wang, J., J. Zhang, E. Watanabe, M. Ikeda, B. Wu, and K. Mizobata, 2008. Dipole Anomaly drove the 2007 Arctic sea ice minimum. (submitted to ***Science-***Brevia)

Presentations

Invited:

Wang, J. Model-data fusion studies in the Beaufort-Chukchi seas. Pacific Arctic (Country) Group (PAG) Model-Data Fusion Workshop, Ottawa, October, 2007.

Wang, J. Model-data fusion studies in the Beaufort-Chukchi seas. US-China Arctic IPY Cruise Planning, D.C., October, 2007

Wang, J. Model-data fusion study in the Bering Sea using CIOM. Pacific Arctic (Country) Group (PAG) Model-Data Fusion Workshop, Sanya, China, Feb. 18-20, 2008.

Oral:

Wang, J., K. Mizobata, and H. Hu: Development of the Beaufort-Chukchi seas Coupled Ice-Ocean Model (CIOM). 2008 Alaska Marine Symposium, Jan. 20-24, Anchorage.

Wang, J., Dipole Anomaly determined from the 20th century GCM simulation. The 2008 Ocean Science Meetings, Orlando, FL, March 2-5.

Hu, H and Wang, J., Modeling the Bering Sea ice and ocean circulation. The 2008 Ocean Science Meetings, Orlando, FL, March 2-5.

Mizobata, K. and J. Wang. Modeling Beaufort and Chukchi seas ice and ocean circulation. Pacific Arctic (Country) Group (PAG) Model-Data Fusion Workshop, Sanya, China, Feb. 18-20, 2008.

Poster:
Hu, H and Wang, J., Modeling the Bering Sea circulation and the cold pool. 2008 Alaska Marine Symposium, Jan. 20-24, Anchorage.

Mizobata, K., J. Wang, and H. Hu: Sensitivity study of the Beaufort-Chukchi seas ice-ocean circulation. 2008 Alaska Marine Symposium, Jan. 20-24, Anchorage.

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: *Stephen Brandt, GLERL*
Doran Mason, GLERL
Edward Rutherford, CILER

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: Between July 30 and August 7, 2007, a cruise was completed using the LUMCON RV Pelican. Four people from GLERL participated: Stephen Lozano, Craig Stow (both GLERL PIs), Melissa Clouse (CILER staff), and Jennifer Metes (CILER Summer Fellow). The cruise consisted of three long North-South transects (stations C, I, and E) and a square-wave transect consisting of seven short transects. Diel (24 hour) sampling occurred at the middle of the three North-South transects. Trawls were only conducted at inshore, middle, and offshore sites of the three long transects. Forty-one trawls were conducted (all but one were bottom trawls, as our brand new midwater trawl did not work), collecting 51 different

species. The most abundant fish species caught were striped anchovy, Atlantic croaker, Atlantic bumper, Gulf butterfish, Spanish sardine, Atlantic cutlassfish, longspine porgy, sand seatrout, least puffer, blackwinged sea robin, Atlantic thread herring, hardhard catfish, moonfish, and spot. Fish acoustics were recorded for the long transects (both day and night), square wave transects, and trawls, totaling 63 different operations.

2. Data processing:

a) Fish diets: As of April 25, 2008, 2997 diets from 45 species of fish have been processed: The most abundant species are: Atlantic bumper (n=487) fed primarily on copepods, shrimp larvae, crab zoea and megalopae, and gastropods; Atlantic croaker (597) fed primarily on nematodes and polychaetes; Atlantic cutlassfish (191) primarily fed on fish, squid, and shrimp larvae; Gulf butterfish (164) primarily fed on copepods, amphipods, and shrimp larvae; longspine porgy (180) primarily fed on nematodes, polychaetes, gastropods, and amphipods; sand seatrout (300) primarily fed on shrimp larvae, crab megalopae, fish, and squid.; striped anchovy (295) primarily fed on copepods, shrimp larvae, crab zoea and megalopae, bivalves, and nematodes. Other species are: Almaco jack (22), Amberjack (2), Atlantic spadefish (1), Atlantic thread herring (63), Banded drum (21), Bay anchovy (30), Bay whiff (13), Bermuda chub (2), Blackcheek tonguefish (20), Blackear bass (2), blackedged cusk eel (11), Blue runner (31), Blackwing searobin (69), Cobia (6), Codlet (13), Crested cusk eel (2), Dusky flounder (23), Dwarf sand perch (14), Fringed flounder (15), Grey triggerfish (26), Hardhead catfish (4), Harvestfish (1), King mackerel (5), lane snapper (33), least puffer (10), Lizardfish (12), Moonfish (51), Moray eel (4), Pinfish (11), red snapper (45), remora (1), round scad (12), scaled sardine (27), sennet (2), shoal flounder (1), spot (131), Spanish sardine (42), and threadfin shad (5).

b) Acoustic data: Physical and biological data (water temperature, dissolved oxygen, salinity, chlorophyll a, and relative fish biomass) collected during 2007 cruise have been integrated into matrix data files, and are ready for use in statistical analyses, graphing, and modeling studies planned for the upcoming year.

c) Growth Rate Potential (GRP) model: we have been researching values of parameters used in GRP model from literature. Preliminary results of GRP model of bay anchovy showed that GRP is a good habitat indicator for bay anchovy.

3. Data analysis: Using spatial analysis techniques, we have explored how hypoxia can influence the horizontal and vertical distribution of pelagic fish. We used physical (water temperature, dissolved oxygen, salinity), lower tropic level (zooplankton biomass), and relative fish biomass information collected simultaneously and continuously along fifteen transects during 2003, 2004, and 2006 cruises. As expected, we observed low fish biomass in the hypoxic areas, with fish

aggregating next to these areas. Vertically, we observed fish aggregated immediately above hypoxia only during severe hypoxia. The relationship between fish biomass and zooplankton biomass was significantly correlated during mild hypoxia, but was decoupled during severe hypoxia. Consistent to other coastal systems such as Chesapeake Bay and the Neuse River Estuary, our findings ultimately suggest that hypoxia may negatively affect habitat quality for zooplanktivores in the northern Gulf of Mexico.

Publications

1. Zhang, H., Ludsin, S., Brandt, S., Mason, D., Adamack, A., Zhang, X., Roman, M., Boicourt, W., Kimmel, D., Pierson, J. *in preparation*. Influence of hypoxia on pelagic fish distribution in the northern Gulf of Mexico. Targeting Marin Ecology Progress Series.

2. Clouse, M. et al. *in preparation.* Feeding habits of seven fish species from the northern Gulf of Mexico.

Presentations

None.

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

Principal Investigators: *Craig Stow, GLERL*

Stephen B. Brandt, GLERL

Thomas E. Croley II, GLERL

Julianne Dyble, GLERL

Gary L. Fahnenstiel, GLERL

Thomas F. Nalepa, GLERL

Steven A. Pothoven, GLERL

Henry A. Vanderploeg, GLERL

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 accomplish this goal, we will conduct research in the field and the laboratory to study how these stressors interact to influence Saginaw Bay's fisheries and water quality. The information from these studies will be used to guide the development of several mathematical models that will help identify useful management options.

Mathematical models will help researchers to organize what is known about the behavior of stressors in Saginaw Bay and to identify the important processes about which very little is known. Additionally, the models will allow scientists to conduct simulated experiments, such as reducing phosphorus input to the Bay, to evaluate the logical outcome alternative management actions.

Another objective is the development of an "Adaptive Integrative Framework" so that our models and field studies will be used interactively to inform one another. As an important component of this Adaptive Integrative Framework, our research will be conducted in coordination with local stakeholder groups under the guidance of representatives from the Michigan Departments of Natural Resources (DNR) and Environmental Quality (DEQ). This interactive environment will help the public understand the goals and difficulties involved in effectively studying and managing Saginaw Bay. In turn our research will be informed and guided by local knowledge and an enhanced appreciation of the ecosystem services that the public considers most important.

Accomplishments

A series of workshops was held to plan research activities and field surveys, and to introduce stakeholders to the research project. Progress was made in sampling

watersheds, assembling databases, updating models, and modeling river flows and nutrient loadings from tributary watersheds. A list of research activities includes:

PI Workshop December 2007
Watershed Sampling began January 2008
Assembly of Comprehensive Database is underway
Updating of Existing Model is underway
Planning for 2008 Field Survey is underway
Watershed modeling, nutrient accounting is underway

Publications
None.

Presentations:
Resource Manager Workshop held in Bay City, MI April 2, 2008

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

Principal Investigators: *Stephen B. Brandt, GLERL*

Joan Rose, MSU

Overview and Objectives

Recent concerns about excessive algal growth and "muck" in the Saginaw Bay area as well as the presence of fecal signatures and the potential human health concerns call for an in-depth scientific investigation of the complex set of processes that result in eutrophication and the algae and muck-related issues in Saginaw Bay. The muck is decomposing mats of algae that have detached from the bottom of the bay and have been washed to shore by wind and water circulation patterns. No standard exists for "muck" but in the future, in order to address the need for such a standard, more sampling for characterization is needed. A comprehensive environmental sampling plan should be developed to better characterize sources, potential health risks and management strategies.

There are very limited data on the fecal signature of the muck. While the beach water quality continues to be monitored for *E. coli* according to the requirements of the State, this information does not always address the source of the contamination

or define the risk under unique exposure scenarios. This includes exposure to the muck itself or the sand, or shallow waters. We proposed to focus efforts on the Saginaw Bay issues including algae, muck, and benthic grazers such as zebra mussel using a combination of field sampling, modeling and quantitative risk assessment.

Research Objectives: To develop and implement a comprehensive environmental sampling plan to characterize sources, ecological systems, potential health risks and management strategies in a large complex watershed. This project will use new tools and models previously developed and will address coastal shoreline issues along Lake Huron.

Specific Tasks and Outcomes

1. We will compile and collect existing datasets on landuse, bathymetry, sources and loading into the bay as well as data to address historical (1970s' and 1980's) and future scenarios under climate change to understand the dynamics of Saginaw Bay under the influence of different stressors (fall 2007).
2. We will sample the muck to better characterize the fecal signatures and sources (fall 2007 and summer 2008).
3. To address health risks we will be testing water, sediment and muck with routine indicators, pathogens as well as alternative indicators (e.g., cow and bird markers). Summer 08 and fall 08.
4. To characterize sources better, we will use source tracking techniques over a range of time periods and spatial locations. Fall 07 to summer 08.
5. To address questions and concerns about children's exposure to the sand and muck, we will sample the water and sediment at different depths. Summer 08.
6. We will sample for major nutrients (including phosphorus and nitrogen including their total and dissolved components), temperature and other stressors to improve management decisions and to allow us to quantify the important processes that contribute to eutrophication and algal blooms in the Saginaw Bay. Fall 07, summer 08 and fall 08.
7. In an effort to better understand sources and loading and mixing in the near-shore region of the bay, we will also focus our efforts on the Saginaw River (sampling at the mouth of the river, tracer studies on the river etc) Spring-Summer 2008.
8. We will work with Michigan Department of Community Health on "Water Watch", self-reporting illness survey. We will join the State team to sample the environment.

Accomplishments

MICROBIOLOGICAL QUALITY OF SAGINAW BAY

During the summer of 2007, we investigated the microbiological quality of the algal debris, muck, and water in the swash zone of the Saginaw Bay. The Saginaw Bay was examined using a variety of fecal bacterial indicators and viruses with the intent to evaluate and develop protocols for DNA extraction and testing to improve microbial source tracking. Included in the analysis were *Escherichia coli*, *Enterococci*, the *esp* sewage marker from the *Enterococci faecium*, coliphage, *Clostridium perfringens*, human and cow Bacteroides marker, and the human adenovirus.

Following the approved methods in the QA/QC plan for the water quality and environmental microbiology lab of MSU, samples were analyzed for *Escherichia coli*, *Enterococci*, the *esp* sewage marker from the *Enterococci faciem*, coliphage, *Clostridium perfringens*, human and cow Bacteroides marker, and the human adenovirus. The sampling on Saginaw Bay indicated high levels of fecal contamination in waters containing suspended algae (muck) and in the solids material on the shore. There is strong evidence that both human fecal sources and to a lesser extent bovine sources are impacting the water quality.

Increased efforts to inform the public of potential health risk and the importance of good hygiene are needed should an individual come into contact with the muck, sediments, or water.

Near-shore Fate and Transport Models:

We continue to refine our biology module and our coupled near-shore transport modeling based on the Princeton Ocean Model in collaboration with NOAA scientists (Dr. David Schwab and Dr. Dima Beletsky). Results of detailed three-dimensional simulations based on improved inactivation formulations (taking into account the full three-dimensional circulation) were presented at the AGU Joint Assembly in Mexico in a special session on coastal processes. Sensitivity analyses were performed to isolate the important factors that contribute to inactivation in the surf zone. Comparisons with ADCP data for the 2006 season showed that the hydrodynamic model is describing the long-shore and cross-shore components well. Results of these detailed analyses (in particular the dynamics of *E. coli* fate and transport in the water column) will be communicated to a journal soon. The biology module will be useful in modeling the extensive field data collected near Grand Rapids in summer 2007.

Watershed Modeling for the Grand River Watershed (MDEQ's *E. coli* database):

Our watershed models for the Grand River watershed are being tested using MDEQ's *E. coli* database with nearly six years of data. These models will provide loading / boundary condition data for the Grand Haven beach models developed at GLERL. We plan to communicate the results of our watershed modeling to a journal in fall 2008. We also made progress in conducting laboratory experiments using a large flume in the engineering building at MSU to understand questions related to sediment resuspension and deposition.

Publications

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

1. ** 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.
2. ** 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)
3. *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*** (in review, 2008)
4. *M.S. Phanikumar, R. Navaneethakrishnan and Mark M. Meerschaert, Fractional Transient Storage Models for Streams, ***Water Resources Research*** (in review, 2008)
5. +P. Thupaki, M.S. Phanikumar, D.J. Schwab, D. Beletsky, R.L. Whitman and J.B. Rose, Sensitivity Analysis of Factors Influencing the Fate and Transport of Fecal Indicator Bacteria in the Surf Zone of Lake Michigan, ***Journal of Geophysical Research - Oceans*** (in preparation)

Presentations

1. P. Thupaki, M.S. Phanikumar, D.J. Schwab, R.L. Whitman, M.B. Nevers and D.A. Shively, J.B. Rose, Sensitivity Analysis of Factors Influencing the Fate and Transport of Fecal Indicator Bacteria in Southern Lake Michigan, ***EOS*** Paper # OS23G-03, American Geophysical Union Joint Assembly, Acapulco, Mexico, 22-25 May 2007.
2. Phanikumar, M.S., C. Shen, T.T. Fong and J.B. Rose, The Transport of

Biological Tracer P22 in Surface Water, IAGLR Meeting, State College, PA, Session on Oceans and Human Health (2007)

3. Ali Boehm and M.S. Phanikumar*, From Genomes to Plumes: Linking Coastal Processes to Human and Ecosystem Health (Sessions I and II), American Geophysical Union Joint Assembley, Acapulco Mexico, 22-25 May 2007
4. Phanikumar, M.S., Chaopeng Shen, Pramod Thupaki and Joan B. Rose, Modeling the Fate and Transport of Indicator Bacteria in the Grand River Watershed, ***Ottawa County Water Quality Public Forum***, November 19, 2007
5. Chaopeng Shen, Pramod Thupaki, M.S. Phanikumar, and Joan B. Rose, The Transport of Suspended Sediment and Indicator Bacteria in the Grand River Watershed, ***NOAA All-PI National meeting*** , October 22, 2007, Muskegon, MI
6. J.B. Rose and M.S. Phanikumar, Water Pollution Studies for the Lower Grand River, Michigan, ***Ottawa County Water Quality Public Forum***, November 19, 2007, West Olive, MI.
7. J.B. Rose, Source Tracking and Water Quality Issues, ***Michigan Environmental Health Association Annual Educational Conference***, March 13, 2008, Bay City, MI.

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

Principal Investigators: *Stephen B. Brandt, GLERL*

Joan B. Rose, MSU

Overview and Objectives

The Great Lakes are the largest supply of freshwater in the world, and are the Nation's single most important aquatic resource from an economic, geographic, international, ecological, and societal perspective. Human health can be explicitly tied to water quality, and despite major advances in the last several decades, the water quality of the Great Lakes remains at risk due to population growth and stresses along the shore line, increased use, climate impacts and emerging contaminants. From a human health perspective, the Great Lakes are the only

coastal waters in the Nation used as a source of drinking water. Microbial contaminants remain a threat and need more attention now and in the future.

The Great Lakes Strategy (2002) provided a vision for the Great Lakes that a) the basin will be a healthy natural environment for wildlife and people, and that the waters will be safe for drinking and swimming, and fish will be safe to eat. To meet these goals, the major pathways need to be identified from source to loading, to transport for waterborne infectious microbial pathogens, including exposure via both drinking water and recreational use.

NOAA has a significant role in research and application at the intersection of meteorology, microbiology, coastal processes and their impact on human health.

The overall purpose of this research is to:

1) Conduct research, apply new technologies and develop new capabilities to provide public-domain forecasting models of drinking water, beach closings, and harmful algal bloom toxins.

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Accomplishments

No progress has been made at the time of this report because of delays in hiring a postdoctoral fellow.

Publications

None.

Presentations

None.

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: 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

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

The traffic and ballast water discharge records of coastwise shipping between estuarine ports of the United States, Canada, and the Great Lakes region was compiled and analyses are underway.

A list of high-priority ports on the U.S. east and Gulf coats was developed by SERC for compiling associated environmental information needed to assess ecological compatibility between and among those ports and the Great Lakes. Work to locate, review, and compile appropriate environmental information for each port was initiated in February 2008 and is on-going.

Planning for salinity tolerance experiments to identify species in U.S. east and Gulf coastal port regions that pose a high risk of range expansion was completed and associated fieldwork will start in April 2008.

Experiments to 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) were completed and results have been written into a paper submitted for publication (see below).

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. Under review. Concentrated sodium chloride 'brine' solutions as an additional treatment for preventing the introduction of non-indigenous species in the ballast tanks of NOBOB vessels. Submitted to Environmental Toxicology & Chemistry.

Presentations

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

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

Principal Investigators: *Thomas Nalepa, GLERL*
David Reid, GLERL
Edward Rutherford, 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, CILER and NOAA scientists sampled several sites in the Huron-Erie corridor from Port Huron through the Detroit River and into western Lake Erie. Bottle traps and plankton net tows were deployed at the sites, and samples were analyzed in the laboratory. No Hemimysis specimens were found at any of the sites.

Publications

none

Presentations
none

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: GREAT LAKES COASTWATCH RESEARCH ASSISTANT FOR NOAA COASTWATCH PROGRAM ELEMENT

Principal Investigators: *George Leshkevich, GLERL*
Edward Rutherford, 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.

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

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).

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.

PROJECT TITLE: ADVANCED NETWORKING FOR COASTAL OBSERVATIONS

Principal Investigators: *Edward Rutherford, CILER*
Steven A. Ruberg, GLERL
Doran M. Mason, GLERL

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 implantation of a high bandwidth network portion. Implementation of the fisheries component is now being pursued through other grant sources. The funding for 2008 has not yet been provided possibly delaying the implementation of the project until 2009. State historic society permission is currently on hold until further information is provided.

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**.**

THEME IV: PROTECTION AND RESTORATION OF RESOURCES

There are no current CILER funded projects in this research theme.

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 2006: FORECASTING THE CAUSES, CONSEQUENCES AND REMEDIES FOR HYPOXIA IN LAKE ERIE

Principal Investigators: Don Scavia, University of Michigan, and Stuart Ludsin, NOAA/Great Lakes Environmental Research Laboratory

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 Many activities in the Watershed Team are being conducted and completed concurrently. Phosphorus (P) loading data is 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.

P loading efforts

Monthly and daily river export load series for the Raisin, Maumee, Sandusky, 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.

Lake Erie total phosphorus loading estimates for 2003-2005 have been completed. In January, the Watershed Team and the Hypoxia Team agreed that the Intensive Years to be modeled would be 2005, 1976, and 2007. Daily loadings at 26 spatial nodes were needed on a calendar year (CY) basis. Because all previous estimates had been made on a water year (WY, October - September) basis, the 2005 estimates were completed for both WY and CY. A database of historic Great Lakes Total Phosphorus Loading has been acquired from the International Joint Commission (IJC) and this information combined with archived tributary data is being used to reconstruct the 1976 loadings at the same level of spatial detail as that for the 2005 loadings. Detailed point source load estimates for total phosphorus in 1997 and 2002 have been de-archived and provided for SWAT modeling. Collection of point source and tributary data for 2006 and 2007 is ongoing.

N and P budgets

Net anthropogenic phosphorus input (NAPI) budgets are mostly completed for all 25 Lake Erie watersheds in Canada (CA) and U.S. for 2002 and for U.S. watersheds for 1987, 1992, and 1997. NAPI budgets include P fertilizer, atmospheric P deposition, net trade of P in food and feed, and P import in dishwasher detergent. Alternative P budgets have also been constructed and consider different

P input components including P fertilizer, animal P manure, atmospheric P deposition, human P excretion (including P input from septic, sludge, and point discharge), P dishwasher detergent, P input from industrial sources, and P in harvested crops. These alternative budgets were completed for all Lake Erie watersheds (CA and U.S.) for 2002, for only the U.S. watersheds for 1997. Budgets for 1987 and 1992 will be completed after we obtain data on industrial P discharges for those years from the IJC. Currently, we are trying to estimate N budgets using the net anthropogenic nitrogen input (NANI) method for 1987, 1992, and 1997 for only the U.S. watersheds and for 2002 for all watersheds (including U.S. and CA). This will be completed by May.

Modeling efforts

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, 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). 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 have transitioned from data gathering and reformatting to inputting data into SWAT models and setting initial model parameter values. Data gathering and reformatting

for model input have been largely completed over recent months. Data obtained include reference watershed boundaries, digital elevation models, stream networks, stream discharge time series, land cover, soil types, climate time series (precipitation, temperature, wind speed, relative humidity, solar radiation), agricultural management data, point source dischargers, reservoir and pond characteristics, and atmospheric N deposition. Data processing and reformatting have been completed for most of these data types. All 7 SWAT models have been created and at least have the subwatershed delineation completed. The Raisin model is parameterized and is currently being calibrated. Other models are in various stages of data input and parameterization. All watershed models have also been recently upgraded to the ArcSWAT 2.0 interface using ArcGIS 9.2.

HYPOXIA: A 1D version of the Princeton Ocean Model was applied to Lake Erie to model vertical thermal structure. The model is driven with momentum and heat fluxes calculated from standard meteorological observations at Cleveland using overland-overlake correction for wind speed. The model was calibrated with 1994 data and evaluated with 2004-2005 temperature observations at mid-lake location. Next, the model was run for a 1972-2005 period to provide input for a water quality model, and to study inter-annual variability in thermocline depth and sharpness (vertical temperature gradients).

Using the output of the 1D temperature profile model, the level 1 hypoxia model, developed in the previous year, was applied for a period of 1987-2005, the continuous period where data had been acquired for boundary conditions and calibration. This is a 1D (vertical) model aimed at identifying the relative importance of the establishment of temperature profile and associated hypolimnion volume due to hydrometeorological factors (i.e., wind, solar radiation) on the timing, duration, and magnitude of hypoxia in the central basin. The model generates a thermal and mixing profile for the central basin and estimates the dissolved oxygen profile. Kinetic formulations include a layer specific deoxygenation rate in the water column and sediment oxygen demand effective in the bottom layer. The model performs well when compared to epilimnion and hypolimnion average dissolved oxygen concentrations. However, smaller scale variations in the dissolved oxygen data are not captured well. This suggests that other processes are significantly influencing the oxygen dynamics.

This year, we have also developed the next level of hypoxia model. This model utilizes the same 1-dimensional thermal model, but includes a limnological model to better represent eutrophication mechanisms in the lake. Model processes include phytoplankton growth, respiration, and decay, nutrient (phosphorus) uptake and

limitation, light limitation, as well as feedback from the sediments. This model is currently being applied for 1987-2005.

We have also been reviewing the literature on estimation of modeling uncertainty in an effort to develop a methodology for quantifying model uncertainty for use in this project. Initial efforts are underway to apply a parameter estimation or optimization algorithm to the level 1 model. This approach will allow us to assess the optimal parameter values and compare to expected values. This can help determine which processes are important, but not being represented in model. Additionally, the parameter estimation framework will allow us to estimate parameter uncertainty.

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. 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.

In applying our models, we build directly on the efforts of other project components (i.e., we will use the output from Watershed and Hypoxia forecasting models as input for our models). Thus, the thrust of our model application efforts will occur towards the end of the project (i.e., after other project components have generated watershed and hypoxia forecasts).

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).

To date, we have developed bioenergetics growth rate potential models for rainbow smelt, yellow perch and walleye. We have applied these models 1) using physical, chemical and biological data collected during 2005 IFYLE cruises in central Lake Erie and 2) using preliminary output from 1-dimensional hypoxia models. We have also initiated a retrospective statistical analysis to explore how hypoxia may have impacted key Lake Erie fish species in the past. Finally, we are currently actively searching for three post-doctoral fellows who will facilitate the further development and application of our ecological models.

Publications

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.

Croley, T. E., II, J. F. Atkinson, and D. F. Raikow, 2007. Hydrologic-hydraulic-ecologic resource sheds. Proceedings of Water Resources Management 2007 Conference, Honolulu, Hawaii, International Association of Science and Technology for Development, Calgary, Canada, August 20-22, 2007, 6 pp.

Presentations

Bosch, N.S. and J.D. Allan. 2008. An analysis of catchment nutrient inputs compared to riverine exports. International Joint Commission workshop – Loading from landscapes and coastal margin effects: Developing a framework to evaluate consequences of land management strategies. Oregon, OH.

Brandt, S., D. Schwab, and T. E. Croley II, 2007. Nearshore Water Quality: Linkages between Watersheds and Offshore Processes, International Joint Commission Workshop on 'Nearshore Processes,' Dearborn, Michigan, November 19-20.

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.

Croley, T. E., II, and T. S. Hunter, 2007. Great Lakes Hydrology Modeling with the Advanced Hydrologic Prediction System, Michigan Technological Institute, Houghton, Michigan, October 8.

Croley, T. E., II, 2008. Great Lakes Hydrologic Modeling, Hydrology Laboratory, NWS Office of Hydrology, Ann Arbor, Michigan, March 6.

Croley, T. E., II, 2007. GLERL's Hydrology Program, GLERL-NCEP-NWS-NOS Meeting, Ann Arbor, Michigan, November 28.

Dolan, D, R.P. Richards, and K. McGunagle. 2008. Total Phosphorus Loading to the Great Lakes. Landscapes and Loadings Workshop, Council of Great Lakes Governors, Maumee, OH, March 18. Presented by R. Peter Richards.

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. (50 min presentation) The Chinese Academy of Sciences Research Center of Eco-Environmental Sciences, Beijing, Jan.5.

He, C., T. E. Croley, C. DeMarchi. 2008. Modeling Spatial Distribution of Nonpoint Source Pollution in the Great Lakes Watersheds. The Association of American Geographers Annual Meeting, Boston, April 15-20.

He, C., and T. E. Croley II, 2007. Integration of GIS and Distributed Large Basin Runoff Model for Modeling Nonpoint Source Loadings in the Great Lakes Watersheds, International Congress on Modelling and Simulation, Session 47: Nutrient Modeling Techniques to Support Water Quality Management, Christchurch, New Zealand, December 10-13.

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.

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. 2008. Record Setting Phosphorus Loads from Agricultural Watersheds in Ohio. USDA Water Quality Conference, Sparks, NV, February 6.

Richards, R.P., D.B. Baker, and J.P. Crumrine. 2008. Water Quality Trends in Lake Erie Watersheds. Western Lake Erie Basin Partnership Roundtable, Toledo, OH, February 20.

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.

Roberts, J.J., T.O Höök, S.A. Ludsin, S.A. Pothoven, and H.A. Vanderploeg. 2008. Bioenergetics model to explore the effects of hypoxia on yellow perch habitat quality in Lake Erie's central basin. Oral presentation at the International Association for Great Lakes Research 51st Annual Conference on Great Lakes Research, Peterborough, ON. May 20.

Rucinski, D.K., D. Beletsky, J.V. DePinto, D. Scavia, D. Schwab. 2007. Model analysis of climate effects on dissolved oxygen in the central basin of Lake Erie. Oral presentation at the International Association for Great Lakes Research 50th Annual Conference on Great Lakes Research, University Park, PA. June 1.

Rucinski, D.K., D. Beletsky, J.V. DePinto, D. Scavia, D. Schwab. 2008. Long-Term Application of a Climate-Driven Dissolved Oxygen Model 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.

Rucinski, D.K., D. Beletsky, J.V. DePinto, D. Scavia, D. Schwab. 2007. 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.

Sellinger, C., and T. E. Croley II, 2008. GLERL's Hydrology Program, NOAA-USGS Committee on Hydrology Meeting, Silver Springs, Maryland, January 16.

Sharpley, Andrew and R. Peter Richards. 2008. Adaptive Management and Water Quality: Is there anything to be learnt from outside the U.K.. Agriculture, Water Management, and Climate Change, Bath, England, March

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: *Stephen B. Brandt, GLERL*

Joan Rose, MSU

Overview and Objectives

To ensure the development of useful and timely research, tools and technology, involving stakeholders in determining research priorities is essential. 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, 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

CEGLHH's outreach program has been focused on building strong collaboration and coordination with local water quality and public managers at state and local levels. This has led to the development of partnerships with drinking water operators, local health departments, and beach managers in various Great Lakes states. In FY07, CEGLHH's Michigan Sea Grant Outreach Coordinator, Sonia Joseph, co-hosted three stakeholder needs assessment workshops with the GLSGN to identify and assess stakeholder Harmful Algal Bloom research, technology, and informational needs, which in total had participation from 145 Great Lakes stakeholders from various backgrounds including public health, drinking water, beach management, academia, U.S. and Canadian federal, state, county, and city

governments, and community members. Positive feedback was received on workshop evaluations and there was press coverage on two workshops.

One of the needs identified from the workshops was training on algae identification, monitoring techniques, and communicating risk to the public. On March 4, 5, & 6, 2008 Joseph co-hosted one day training workshops on Harmful Algal Blooms with Minnesota Sea Grant and the Minnesota Pollution Control Agency in the cities of Sauk Centre, Mankato, and St. Paul. The first of its kind in the Great Lakes, these workshops served to train natural resource and health managers, lake associations, and local government officials on algal ecology, blue-green algae identification, monitoring and analytical techniques, health and animal health risks, and communicating and engaging the media and public. Workshop participants received resource guides and algae identification materials. Workshop evaluations were extremely positive and articulated the necessity of such a training. Television news media was present at two of the three workshops and five newspapers featured articles on the trainings. The Sauk Centre workshop had 30 participants, 24 participants were present at the Mankato workshop and the March 6 workshop in St. Paul, Minnesota had 28 attendees. In addition the St. Paul workshop was webcast and had 159 computers link to the webcast, which included participants from various states throughout the country. Participants were from 23 of 87 Minnesota counties and included 18 state agency; 16 lake associations; 5 each municipality, county department, and watershed district; 2 soil and water conservation district; 2 academic; 1 vet and 1 community health end user.

CEGLHH has continued to work closely with Ottawa County on research and outreach. Joseph met with Grand Haven City Council and the Ottawa County Board of Commissioners to discuss Grand River Field Experiments which included the release of Rhodamine-WT dye. There were numerous newspaper articles highlighting the summer experiments, which assisted in raising public awareness. On July 30, 2007, CEGLHH and Michigan Sea Grant met with Ottawa County's Water Quality officials to give updates on Grand River research progress and 2007 summer plans. On November 30, 2007, CEGLHH, MSU, and Ottawa County hosted a second Water Quality Forum to bring together the Ottawa County residents, employees, and decision makers to give updates on the state of water quality, new and ongoing water quality projects and programs occurring in the county as well as identify emerging issues. Approximately 100 people attended the Forum and there was immense interest in all the water quality projects and the development of CEGLHH's beach models.

During the October 3-5, 2007 Great Lakes Beach Association Annual Meeting, Joseph served as chair of the Predictive Models Session as well as co-organizing and co-

hosting the "Beach Health Research Needs: Continuing the Communication" meeting (with USGS) to assess and determine if research needs identified during the 2005 Beach Health Research Needs Workshop are still a priority for beach managers. Evaluations and feedback from the meeting determined that beach health research needs are still the same, there are emerging issues such as cladophora occurring on beaches, and funding seems to be a limiting factor in beach management. As a result formation of a Beach Health Steering Committee has been planned to continue to move forward on addressing beach manager needs.

Additional accomplishments include:

~ CEGLHH exhibit at NOAA 200th Anniversary Event at Shedd Aquarium in September 2007.

~ Event planning and co-organized NOAA Oceans and Human Health Initiative All-PIs meeting in Muskegon, Michigan in October 2007.

~ In March 2008, Joseph received the 2007 GLERL Director's Award for Excellence and Individual Achievement.

Publications

NOAA Center of Excellence for Great Lakes and Human Health = 2-page Brochure

Grand River Field Experiments = 2- page Brochure

Presentations

Joseph, S. NOAA's Grand River Beach Forecasting Research and Model Development. Ottawa County Water Quality meeting. Ottawa County Government Building, West Olive, MI. July 30, 2007

Joseph, S. Update on Center of Excellence for Great Lakes and Human Health Research and Outreach. Great Lakes Sea Grant Network Meeting. EPA GLNPO, Chicago, IL. Sept 16-19, 2007.

Joseph, S. Assessing Stakeholder Needs through Harmful Algal Bloom Workshops. NOAA Oceans and Human Health Initiative All-PI meeting, Muskegon, MI. October 22-24, 2007.

Joseph, S. Overview and Update on NOAA's Grand River Beach Forecasting Research. Ottawa County Water Quality Forum. Ottawa County Government Building, West Olive, MI. November 19, 2007.

Joseph, S. Update on NOAA Center of Excellence for Great Lakes and Human Health
Research and Outreach. Michigan State University Extension Southeast Region County Extension Directors Meeting, Gran Blanc, MI. November 20, 2007.

Joseph, S. Harmful Algal Blooms in the Great Lakes. Harmful Algal Bloom Training Workshop. Gerard's Restaurant, Sauk Centre, MN. March 4, 2008

Joseph, S. Are There Human Health Risks from HABs? Harmful Algal Bloom Training Workshop. Gerard's Restaurant, Sauk Centre, MN. March 4, 2008

Joseph, S. Harmful Algal Blooms in the Great Lakes. Harmful Algal Bloom Training Workshop. Best Western Conference Center, N. Mankato, MN. March 5, 2008

Joseph, S. Are There Human Health Risks from HABs? Harmful Algal Bloom Training Workshop. Best Western Conference Center, N. Mankato, MN. March 5, 2008

Joseph, S. Harmful Algal Blooms in the Great Lakes. Harmful Algal Bloom Training Workshop. Minnesota Pollution Control Agency, St. Paul, MN. March 6, 2008

Joseph, S. Are There Human Health Risks from HABs? Harmful Algal Bloom Training Workshop. Minnesota Pollution Control Agency, St. Paul, MN. March 6, 2008

Joseph, S. CEGLHH's Beach Forecasting Research in the Grand River. Michigan Environmental Health Association Annual Education Conference, Bay City, MI. March 13, 2008.

APPENDIX 1: Count of Publications by CILER staff by category, FY2002 – FY2008.

	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

APPENDIX 2: Employee Count by category from FY2002 to FY2008, by year.

Summary of Joint Institute Staff by Head Count 2002-2003

Category	Number	B.S.	M.S.	Ph.D.
Research Scientists	1			1
Visiting Scientists	0			
Postdoctoral Research Fellows	1			1
Research Support Staff	14	7	6	
Administrative	3	1	1	
High School Students	3			
Undergraduate Students	15			
Graduate Students	6			
Totals	43	8	7	2

Summary of Joint Institute Staff by Head Count 2003-2004

Category	Number	B.S.	M.S.	Ph.D.
Research Scientists	0	0	0	0
Visiting Scientists	0	0	0	0
Postdoctoral Research Fellows	0	0	0	0
Research Support Staff	7	3	3	0
Administrative	4	2	1	0
High School Students	3	0	0	0
Undergraduate Students	14	0	0	0
Graduate Students	4	2	2	0
< 50% NOAA Support	14	4	4	3
Totals	46	11	10	3
Located at NOAA Lab	33-GLERL			
Obtained NOAA employment	0			

Summary of Joint Institute Staff by Head Count 2004-2005

Category	Number	B.S.	M.S.	Ph.D.
Research Scientists	0	0	0	1
Visiting Scientists	0	0	0	0
Postdoctoral Research Fellows	3	0	0	3
Research Support Staff	7	2	5	0
Administrative	4	2	1	1
High School Students	2	0	0	0
Undergraduate Students	20	0	0	0
Graduate Students	21	13	5	0
< 50% NOAA Support	10	4	4	2
Totals	57	21	15	7

Located at NOAA Lab	41-GLERL	
Obtained NOAA employment	0	

Summary of Joint Institute Staff by Head Count 2006-2007

Category	Number	B.S.	M.S.	Ph.D.
Research Scientists	7	0	0	7
Visiting Scientists	0	0	0	0
Postdoctoral Research Fellows	4	0	0	4
Research Support Staff	8	3	5	0
Administrative	5	2	1	2
High School Students	2	0	0	0
Undergraduate Students	11	0	0	0
Graduate Students	14	9	5	0
Totals	51	14	11	13
Located at NOAA Lab	41-GLERL			
Obtained NOAA employment	0			

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			