G. Allen Burton, Director
Thomas H. Johengen, Associate Director
Heather Hazzard, Administrator
CILER/University of Michigan
G110 Dana Building
440 Church Street
Ann Arbor, MI 48109-1041
734-763-3010
www.ciler.snre.umich.edu

ANNUAL REPORT:
COOPERATIVE INSTITUTE FOR LIMNOLOGY & ECOSYSTEMS RESEARCH
CILER
# Cooperative Institute for Limnology and Ecosystems Research – CILER

G. Allen Burton, Director  
Thomas H. Johengen, Associate Director  
Heather Hazzard, Administrator  
University of Michigan  
Ann Arbor, Michigan  

Annual Report for NA12OAR4320071  
Year One (9 months): July 1, 2012 - March 31, 2013  

## Table of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>From the Director</td>
<td>3</td>
</tr>
<tr>
<td>CILER’s Vision and Mission</td>
<td>5</td>
</tr>
<tr>
<td>Executive Summary</td>
<td>6</td>
</tr>
<tr>
<td>Administrative Summary</td>
<td>8</td>
</tr>
<tr>
<td>Executive Board-Management Council-Council of Fellows</td>
<td>10</td>
</tr>
<tr>
<td>Funding Distribution by Theme and Institution</td>
<td>13</td>
</tr>
<tr>
<td>Research Project Reports by Theme</td>
<td>16</td>
</tr>
<tr>
<td>Appendix 1: Publication Count</td>
<td>66</td>
</tr>
<tr>
<td>Appendix 2: Employee Count</td>
<td>67</td>
</tr>
<tr>
<td>Publications</td>
<td>68</td>
</tr>
</tbody>
</table>
From the Director

It has been a busy nine months at CILER, as we have worked to close out efforts that started under the old cooperative institute, and start up activities of the new institute.

Many of these new activities are focused on interdisciplinary efforts to better monitor and forecast the changing conditions in the Great Lakes region. This has been a good year to focus on such activities, due to the extreme changes in weather conditions that have ranged from the large drought of the summer of 2012 to the large amount of snow and rain associated with the winter of 2013. Through our partnership with the Great Lakes Environmental Research Lab, we continue to work on ways to better track and report on these changing conditions.

CILER researchers have also been busy developing better models to forecast changes in ecosystem conditions in the Great Lakes. Much like the extreme changes in weather, the Great Lakes have undergone profound alterations in their ecology due largely to invasive species. To understand both why these changes have occurred and to help forecast likely conditions into the future, CILER researchers are looking at food web connections and the role of invaders in altering energy flow between key trophic levels.

In addition to looking at effects of existing invasives, CILER researchers have also been engaged on the issue of the Asian carp. This group of fishes has received a lot of attention over the last year, as the Great Lakes community has grappled with the potential ecological risk of this likely invader. CILER has assisted on this effort by using existing information to predict what the Asian carp might do if it becomes established in the Great Lakes.

On other fronts, CILER continues to work to improve educational opportunities for students. We have done this by successfully holding a 14th year of our Great Lakes Summer Student Fellowships, with continued strong support from the Great Lakes Environmental Research Lab. CILER also successfully held a request for proposal for a post-doctoral fellow. We had a tremendous response, with many exceptional applicants submitting excellent proposals to do important work in the Great Lakes region. We are happy to announce that with the support of the University of Michigan, we were able to fund not just one but two full time postdoctoral fellows who will work with academic and GLERL researchers to address critical issues facing the Great Lakes.
Finally, I want to highlight the continued growth and interest in Great Lakes research. As one example, the University of Michigan launched a Water Center in the Fall of 2012. The impetus of this was simple – the Great Lakes are the largest source of surface freshwater in the world and we need to understand it better to manage it well.

Much of the continued interest in the region related to Great Lakes research comes from NOAA’s continued interest in issues that are critical to these water bodies. We thus look forward to the opportunity to continue to capitalize on the strong partnerships that have been an essential hallmark of CILER from its inception.

G. Allen Burton  
Director – Cooperative Institute for Limnology and Ecosystems Research
CILER’s Vision

To enhance the quality of the Great Lakes and its related ecosystem services, through a partnership of universities, NOAA scientists, and other stakeholders.

CILER’s Mission

- Advance our understanding of, and ability to predict, complex ecosystem processes, responses, and dynamics in the Great Lakes.
- Identify and characterize emerging areas of concern for the Great Lakes ecosystem, with applications to all coastal ecosystems.
- Provide a forum for better linking ecosystem responses, sustainable ecosystem services, and decision-making in the Great Lakes.
- Translate research into productive outcomes for stakeholders in the region through outreach and education.
- Improve effectiveness of education and expand research training opportunities for students and postdoctoral fellows.

CILER’s Goals

- Advance the science of Great Lakes ecosystem forecasting by integrating physical, chemical, and biological components to allow for more effective responses and management of invasive species, climate change, habitat alteration, and contaminants.
- Facilitate the translation of research into more effective decision-making and public education.
- Support NOAA’s mission and strategic goals.
- Facilitate research in the Great Lakes region.
- Mentor and train the next generation of scientists through research and educational opportunities.
Executive Summary

The Cooperative Institute for Limnology and Ecosystems Research (CILER) was first established in 1989, with the objective of fostering University and NOAA partnerships in the Great Lakes region. As a Center of Excellence at the School of Natural Resources and Environment at the University of Michigan, CILER has been working for more than 24 years on research issues that are critical to the Great Lakes region. A major part of this effort has focused on partnering with NOAA researchers to help augment and advance research activities.

In addition to these research activities, CILER has a long history of education and outreach efforts. These activities include formal programs such as the Great Lakes Summer Student Fellows Program, in which we provide research and educational opportunities to promising young undergraduate and graduate students to engage on important research projects.

Freshwater Resources and the North American Great Lakes

The North American Great Lakes region is characterized by expansive wilderness areas, productive agricultural lands, and numerous stream, riverine, and lake environments. The habitats of the region range from sand dunes to coastal marshlands, and from forests to rocky shorelines. Perhaps the most defining feature of the region is the Great Lakes themselves, which are arguably one of the nation’s greatest natural resources. The five Great Lakes combined contain more than 22,000 km³ of freshwater, and comprise the largest single body of freshwater in the world, containing 20% of the Earth’s surface freshwater supply and 90% of the surface freshwater in the United States.

The Great Lakes region is also home to almost 40 million U.S. and Canadian residents and houses some of the nation’s major metropolitan and manufacturing areas. This combination of large urban populations and abundant natural resources has often resulted in overexploitation of ecosystems and environmental degradation. Today, fewer than half of the region’s original forest and wetland areas remain. Important fishery resources, such as lake trout, yellow perch, and walleye, are vulnerable to overexploitation. Human activities have facilitated the introduction of numerous terrestrial and aquatic non-native species into the region, and are currently threatening native populations and impair ecosystem functions. Clearly, careful management of these natural resources, including both protection of remaining aquatic resources and restoration of disturbed aquatic ecosystems, is of vital importance.

Several community-wide efforts (e.g., Great Lakes Regional Collaboration, Healing our Waters coalition, The Nature Conservancy Biodiversity Assessment) have identified the most critical threats to natural resources in the basin, and developed recommendations to help protect and restore Great Lakes resources. Some of the key recommendations from these efforts are: 1) stop the introduction of additional invasive species into the region; 2) augment habitat conservation and species management; 3) protect nearshore water and coastal areas to preserve water quality and recreational opportunities; 4) remediate and restore areas of concern; 5)
decrease non-point sources of pollution; and 6) reduce toxic pollutant releases in the region (Great Lakes Regional Collaboration Strategy 2005). These recommendations were paralleled subsequently in Federal legislation on Great Lakes restoration, and were supported and refined in the white paper, “Prescription for Great Lakes Ecosystem Protection and Restoration: Avoiding the Tipping Point of Irreversible Changes.” This paper was endorsed by more than 200 scientists from both within and outside the Great Lakes basin.

CILER Research – An Overview

For the first nine months of the new cooperative, CILER has worked to achieve a research portfolio that combines new research efforts with the continuation of past projects that have high importance to NOAA and to the Great Lakes region. For the latter, CILER continues with its efforts on CoastWatch, which provides up-to-date remotely sensed data for ice classification and ocean colors that help support managers and decisionmakers in the Great Lakes region. This effort is an important and longterm partnership between CILER and NOAA-GLERL to provide reliable and critical data on Great Lakes conditions. CILER also continues to support the Great Lakes Synthesis, Observations, and Response System (SOAR). This program focuses on coordinating and integrating regional coastal observations that support national and regional priorities, especially those related to Great Lakes restoration. Through these activities, CILER supports NOAA’s efforts to improve decision support tools related to phosphorous loading and hypoxia as well as helping to improve ecological forecasting of harmful algal blooms.

Some of the newer CILER efforts have been focused on invasive species modeling, including trying to forecast potential food web effects and resulting economic impacts of Asian carp invasion into the Great Lakes. The new Cooperative Institutes has also helped with developing a new emergency response protocol for both human-made and natural disasters in the Great Lakes region. The need for this type of product became evident after the Enbridge oil spill that occurred in the Kalamazoo River in July of 2010. Through this effort, CILER and the NOAA Great Lakes Regional Collaboration were able to work together to rapidly respond to lessons learned in the aftermath of this environmental disaster by working on a protocol that would lead to improved responses to future such incidences.

CILER Education and Outreach – An Overview

For over a decade, CILER has been co-hosting a Summer Fellows program with NOAA. This effort, the Great Lakes Summer Fellows Program, attracts highly qualified undergraduate and graduate students to NOAA and university facilities to do research on a range of topics. For the 2013 program, we received more than 100 applications for 10 positions. This cohort of summer
student fellows has a diversity of backgrounds and come from a range of Great Lakes’ universities. Most of these students will start their fellowship in early May and will present their research findings at a mid-summer colloquium to be held at GLERL.

Under the new Cooperative Agreement, CILER has continued the Longterm Fellows program. To date we have fully funded one fellow to work at the University of Toledo with Dr. Carol Stepiesn on a project to develop a rapid DNA test of water samples to identify the potential presence of invasive fish species. We also have funding in hand to support a longterm fellow at the University of Wisconsin-Madison, to work with Dr. Chin Wu.

As in years past, CILER and GLERL continue to partner on an annual seminar series that brings in research and education and outreach experts from around the Great Lakes region and other coastal areas throughout the U.S. We have expanded this program through enhanced listserves, such as the Great Lakes Information Network. Attendee participation through these venues has increased significantly over the past year, especially after including e-mail lists from other university partners, and University of Michigan departments besides the School of Natural Resources and Environment. We are also working on larger seminar events that bring in a range of people to discuss pressing issues in the Great Lakes region.

Finally, during the first year of this new cooperative agreement, CILER held a request for proposals for a Great Lakes postdoctoral position. This newer CILER program provides salary and research support for a post-doctoral fellow who will work closely with a CILER Management Council or Council of Fellows member on a project of mutual interest. All CILER Management Council and Council of Fellows members were eligible to participate in the program, with the position being selected based on review by the Management Council and based on research needs. The goal of this program is to enhance training and research opportunities for postdoctoral fellows and to provide opportunities for Council investigators to engage in new research projects that help support CILER’s new missions in the Great Lakes region.

**Administrative Summary**

The primary role of CILER administration is to support research carried out under the auspices of the Cooperative Institute. Two of the most important administrative tasks are to facilitate financial elements of the consortium and to support the development, implementation, and coordination of our multi-university, regional research programs. Financial and research administration is a key component to the success of the institute. To help with elements of program management, CILER hired a 0.25 FTE person, Larissa Sano, to assist with implementing CILER’s administrative and research missions. Dr. Sano comes to CILER with a background in aquatic ecotoxicology and brings an extensive knowledge of both CILER and University of Michigan operational procedures to this position.
Communication between the administrator and the investigators is ongoing and vital to ensuring the longevity of the cooperative institute. New systems are currently being developed to enhance the financial capability of monitoring future projections. This will give the investigators more notice on potential budget issues and constraints and can avoid pitfalls. A stronger working relationship has been cultivated with SNRE administration and human resources. The new CILER administration is committed to continuous improvements and growth.
Executive Board - Management Council - Council of Fellows

Executive Board
The Executive Board makes recommendations concerning CILER’s administration, budget, future cooperative agreements, and Management Council members. The Board last met in January 2013.
The members of the Executive Board include:
Al Powell (Director, NOAA Center for Satellite Applications and Research), Russell Callender (Director, NOAA National Centers for Coastal Ocean Science), Marie Lynn Miranda (Dean, UM-SNRE), Volker Sick (Associate Vice-President for Research, UM), Allen Burton (CILER Director, ex-officio) and Marie Colton (GLERL Director, ex-officio).

CILER Management Council
The Management Council provides reviews and recommendations of the scientific direction of the CI, and includes directors of the Great Lakes Sea Grant programs, with additional representation by NOAA and university scientists. This Council will meet in June 2013. Members include:

Jim Ammerman, Director, N Y Sea Grant Program, State University New York-Stony Brook
Jim Diana, Director, Michigan Sea Grant Program, University of Michigan;
Jeff Gunderson, Director, Minnesota Sea Grant Program, University of Minnesota
Lucinda Johnson, Director, Natural Resources Research Institute, University of Minnesota
Val Klump, Director, Great Lakes Water Institute, University of Wisconsin – Milwaukee
Doran Mason, Research Ecologist & CILER Program Manager, NOAA-GLERL
Brian Miller, Director Illinois-Indiana Sea Grant, Purdue University;
Steve Ruberg, Group Leader, Marine Instrumentation Lab, NOAA-GLERL
Edward Rutherford, Research Fishery Biologist, NOAA-GLERL
Jeff Reutter, Director Ohio Sea Grant, The Ohio State University
Al Steinman, Director, Annis Water Resources Resources Institute, Grand Valley State University
Craig Stow, Aquatic Ecosystem Modeler, NOAA-GLERL
Henry Vanderploeg, Research Ecologist and Lead of Ecosystem Dynamics Group
NOAA-GLERL
Jan Stevenson, Department of Zoology, Michigan State University; Professor,  
Chin Wu, Professor, Civil and Environmental Engineering, University of Wisconsin – Madison  

Additional information about the members of the Management Council can be found at http://ciler.snre.umich.edu/content/management-council.  

Council of Fellows  
The new Council of Fellows include over 30 Great Lakes academic and federal researchers willing to mentor and rotate postdoctoral fellows through their laboratory programs every 1 to 2 years.  

Joe Atkinson, Professor, State University of New York - University at Buffalo  
Jay Austin, Asst. Professor, Univ. of Minnesota-Duluth’s Large Lakes Observatory  
Niladri Basu, Asst. Professor, University of Michigan’s School of Public Health  
Stuart Batterman, Professor, University of Michigan’s School of Public Health  
Dima Beletsky, Associate Research Scientist, CILER  
Bopi Biddanda, Res. Scientist, Grand Valley State Univ., Annis Water Resources Inst.  
John Bratton, Deputy Director, GLERL  
Brad Cardinale, Asst. Professor, SNRE, University of Michigan  
Hunter Carrick, Professor, Central Michigan University  
Steve Colman, Professor, Univ. of Minnesota-Duluth’s Large Lakes Observatory  
Jim Cotner, Professor, University of Minnesota  
Drew Gronewold, Hydrologist, GLERL  
Nathan Hawley, Oceanographer, GLERL  
Thomas Höök, Asst. Professor, Purdue University  
Tom Johengen, Associate Director, CILER  
Donna Kashian, Asst. Professor, Wayne State University  
Peter Lavrentyev, Professor, University of Akron  
Brent Lofgren, Physical Scientist, GLERL  
Nancy Love, Professor, University of Michigan  
Rex Lowe, Professor, Bowling Green State University  
Stuart Ludsin, Asst. Professor, Ohio State University  
Phanikumar Mantha, Assoc. Professor, Michigan State University  
Peter McIntyre, Asst. Professor, University of Wisconsin-Madison  
Guy Meadows, Professor Michigan Technological University  
Cheryl Murphy, Asst. Professor, Michigan State University  
Scott Peacor, Assoc. Professor, Michigan State University  
Lutgarde Raskin, Professor, University of Michigan  
Jen Read, Executive Director, Great Lakes Observing System
Carl Ruetz III, Assoc. Professor, Grand Valley State Univ., Annis Water Resources Inst.
Paul Seelbach, Eco. Hlth. & Restor. Branch Chief, USGS-Great Lakes Science Center
Carol Stepien, Director, Lake Erie Research Center, University of Toledo
Robert Sterner, Professor, University of Minnesota
Cary Troy, Asst. Professor, Purdue University
Mike Wiley, Professor, SNRE, University of Michigan

For information on individual Fellows can be found on CILER’s website: http://ciler.snre.umich.edu/content/council-fellows, with a link to their online profiles, which includes their affiliations, contact information, and research interests.
**Funding Distribution**

This report details project activities through the first nine months of the new cooperative agreement, covering the period through March 31, 2013. The total funding level through this period (9 months) is $3,898,127.

![Funding Distribution Pie Chart]

**Figure 1.** Funding distribution for CILER by theme through 03/31/13.
Table 1. Breakdown of funding by Theme awarded to CILER for the current Cooperative Agreement, NA12OAR4320071, through March 31, 2013.

<table>
<thead>
<tr>
<th>Task</th>
<th>Research Theme</th>
<th>Funding ($)</th>
<th>Funding (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Administration</td>
<td>$217,945</td>
<td>5.6%</td>
</tr>
<tr>
<td>II</td>
<td>Theme I: Great Lakes Observing and Forecasting Systems</td>
<td>$1,669,143</td>
<td>42.8%</td>
</tr>
<tr>
<td>II</td>
<td>Theme II: Invasive Species</td>
<td>$306,331</td>
<td>7.9%</td>
</tr>
<tr>
<td>II</td>
<td>Theme III: Ecological Risk Assessment</td>
<td>$996,586</td>
<td>25.6%</td>
</tr>
<tr>
<td>II</td>
<td>Theme IV: Protection and Restoration of Ecosystem Resources: Linking to Human Dimensions</td>
<td>$651,623</td>
<td>16.7%</td>
</tr>
<tr>
<td>II</td>
<td>Theme V: Education and Outreach</td>
<td>$56,500</td>
<td>1.4%</td>
</tr>
<tr>
<td></td>
<td>Totals</td>
<td>$3,898,127</td>
<td>100%</td>
</tr>
</tbody>
</table>
Table 2. Breakdown of subcontract funding by institution:

<table>
<thead>
<tr>
<th>Institution</th>
<th>Funding Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grand Valley State University</td>
<td>$10,000</td>
</tr>
<tr>
<td>Michigan State University</td>
<td>$148,445</td>
</tr>
<tr>
<td>Michigan Technological University</td>
<td>$177,370</td>
</tr>
<tr>
<td>Palm Island Environmental</td>
<td>$118,240</td>
</tr>
<tr>
<td>Penn State University</td>
<td>$20,000</td>
</tr>
<tr>
<td>Purdue</td>
<td>$60,000</td>
</tr>
<tr>
<td>State University of New York</td>
<td>$138,400</td>
</tr>
<tr>
<td>University of Illinois</td>
<td>$131,971</td>
</tr>
<tr>
<td>University of Minnesota-Duluth</td>
<td>$106,238</td>
</tr>
<tr>
<td>University of Toledo</td>
<td>$63,000</td>
</tr>
<tr>
<td>University of Wisconsin-Madison</td>
<td>$73,312</td>
</tr>
<tr>
<td>University of Wisconsin-Milwaukee</td>
<td>$59,200</td>
</tr>
<tr>
<td>University of Wisconsin</td>
<td>$85,943</td>
</tr>
<tr>
<td>Wayne State University</td>
<td>$30,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$1,222,119</strong></td>
</tr>
</tbody>
</table>
**THEME I: GREAT LAKES OBSERVING AND FORECASTING SYSTEMS**

**PROJECT TITLE: INTRODUCING SHARED SOFTWARE INFRASTRUCTURE INTO THE CLIMATE MODELING CURRICULUM**

*Principal Investigators:* Allen Burton (CILER), Christiane Jablonowski (Atmospheric, Oceanic & Space Sciences, University of Michigan)

*NOAA Technical Contacts:*
Cecelia DeLuca (NOAA Earth System Research Laboratory, NOAA Environmental Software Infrastructure and Interoperability (NESII) group)

**Overview and Objectives:**
Earth system models for future projections of the weather and climate system put strong demands on the modeling infrastructure. Next-generation models will for example require greater computing capabilities, transparent software designs with exchangeable model components, self-explanatory descriptions of data and models, online gateways and portals for data exchanges, and shared online workspaces for both tight and loose science collaborations. Such challenges demand a highly versatile and interdisciplinary workforce. In particular, atmospheric modelers need to be trained not only in the science aspects of Atmospheric General Circulation Models (GCMs), but also in computational techniques that allow them to work effectively with the most modern computational infrastructure for the climate and weather sciences.

The University of Michigan serves as a key partner in NOAA’s Global Interoperability Program (GIP). Our role in this collaboration is twofold. We are an educator for the future generation of atmospheric modelers by further developing a new graduate-level climate modeling course at UM and organizing an international summer school at the National Center for Atmospheric Research (NCAR). We are also a communicator who provides feedback on the shared software infrastructure under development in GIP.

In this project we will further develop the new hands-on driven course ‘The Art of Climate Modeling’ at the University of Michigan that was taught for the first time from September through December 2010. It trains students in the use of NCAR’s Community Atmosphere Model (CAM) and explores how the GIP supported computational tools aid the model developments, evaluations and collaborations. We provide feedback on the ease of use, quality, enhancements, and usability of the shared modeling infrastructure under development in the GIP program. In addition, we will contribute to the development of new interoperable software tools by formulating requirements for shared workspaces that are linked to the Earth System Grid and NOAA’s Live Access Server (LAS). Furthermore, we will organize the Dynamical Core Model Intercomparison Project (DCMIP) & Summer School on ‘Future-Generation Non-
Accomplishments:
During the reporting period 7/1/2012-3/31/2013 I organized the multidisciplinary two-week summer school and Dynamical Core Model Intercomparison Project (DCMIP) that was held at NCAR in Boulder, CO, from 7/30-8/10/2012. The event brought together graduate students, postdocs, atmospheric modelers, expert lecturers and computer specialists to create a stimulating, unique and hands-on driven learning environment. It led to an unprecedented student-run model intercomparison project, and thereby trained the future generation of scientists engaged in global atmospheric model developments. Special attention was paid to the role of emerging non-hydrostatic global atmospheric models. The summer school and model intercomparison project promoted active learning, innovation, discovery, mentorship and the integration of science and education. We hosted 18 dynamical cores (some of them remotely) that represent a broad spectrum of the modeling approaches in the international weather and climate modeling community.

The participants of DCMIP prototyped new cyberinfrastructure tools and shared workspaces during the workshop. The cyberinfrastructure supports data (located on a NOAA Earth System Grid Federation server), searchable metadata for models and data, remote visualization and analysis capabilities through NOAA’s Live Access Server (LAS), a communication platform for participants (Wiki functionality) and adheres to standards like the netCDF data format (CF-compliant). The entry points for DCMIP and the 2012 summer school activities are:
http://earthsystemcog.org/projects/dcmip/
http://earthsystemcog.org/projects/dcmip-2012/

Publications:
Presentations:

- Jablonowski, C., Model Evaluations: How to think about and what to expect from dynamical core and GCM tests, Dynamical Core Model Intercomparison Project (DCMIP) Summer School on Future-Generation Non-Hydrostatic Weather and Climate Models, National Center for Atmospheric Research, Boulder, CO. USA, July 30 - August 10, 2012
- Jablonowski, C., Model tuning: Review of possible filtering operations and diffusive mechanisms in dynamical cores, Dynamical Core Model Intercomparison Project (DCMIP) Summer School on Future-Generation Non-Hydrostatic Weather and Climate Models, National Center for Atmospheric Research, Boulder, CO. USA, July 30 - August 10, 2012

Outreach Activities:
The project is centered around educational activities. The DCMIP summer school taught a group of about 40 multi-disciplinary students, postdocs and young researchers how today’s and future atmospheric models are or need to be built and (2) hosted about 15 dynamical core model developers at NCAR for a hands-on student-run model intercomparison project. Three additional modeling groups participated remotely. The project introduced new cyberinfrastructure tools to the GCM community that enabled the participants to share and discuss the scientific results via a newly developed shared
workspace. The latter connects data and information with web services like online data visualization software.

**Relevant websites:**
2012 Dynamical Core Model Intercomparison Project: 
http://earthsystemcog.org/projects/dcmip-2012/
THEME I: GREAT LAKES OBSERVING AND FORECASTING SYSTEMS

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

Principal Investigators: Allen Burton (CILER)
NOAA Technical contacts: George Leshkevich (NOAA-GLERL)

Overview and Objectives:
To address critical coastal environmental problems, the National Oceanic and Atmospheric Administration, National Environmental Satellite, Data, and Information Service has established the NOAA Ocean Remote Sensing (NSORS) Program. Within NSORS, CoastWatch is a NOAA-wide program designed to provide a rapid supply of up-to-date, coordinated, environmental (remotely sensed, chemical, biological, and physical) information to support Federal and state decision makers and researchers, who are responsible for managing the Nation’s living marine resources and ecosystems. NOAA CoastWatch focuses on specific regional priorities, such as unusual environmental events (e.g. harmful algal blooms), accumulating algal biomass, mapping wetland change (e.g. change detection), and mapping ice cover/ice thickness (e.g. hazard mitigation).

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 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 agency’s such as the U.S. Coast Guard and National Weather Service.

Regional products delivered in an untimely fashion or in a unusable format, whether to land or ship-based users, defeats the objectives and goals of the program. Therefore, the development of tools to effectively and efficiently deliver these products to regional users in near real-time and in a useable format is of great importance. This will foster additional research applications by regional data users employing the processed satellite data such as, detection and tracking of thermal fronts and analysis of circulation patterns and upwelling (fish recruitment studies) and modeling and forecasting Great Lakes parameters (Great Lakes Forecasting System).
The goal of the CoastWatch Great Lakes program is to develop and deliver environmental data and products for near real-time monitoring of the Great Lakes to support environmental science and decision making. One of the objectives of the continuing CoastWatch program is to provide access to near real-time and retrospective satellite observations and derived products of the Great Lakes for Federal, state and local decision making and supporting research. Communications requirements and data distribution are accomplished electronically via the Internet (CoastWatch Great Lakes web site).

Additional (future) products include turbidity, ocean color (chlorophyll, DOC, SM), and ice mapping. Additional activities to be performed include participation in field data collection, research on new algorithm development of the remotely sensed data, assist in development of project reports and scientific presentations, and provide the necessary computer system and software support to facilitate these activities.

**Accomplishments:**

1. **Monitor, develop and/or improve the operational program to receive, process, analyze, and archive the CoastWatch data:**
   - Finished new CW server (CWOPS) hardware and operation system installation.
   - Installed and tested the THREDDS data server, TOMCAT web server, LAS server, and Ferret.
   - All GLSEA files (1994-2003) have been converted from .gif format to ascii format. All GLSEA files (2004-2006) have been converted from .dat format to ascii format.
   - Moved all data from old server (SPARKY) to new server.
   - Finished moving all AVHRR, GLSEA (asc) files to monthly folder on new server.
   - Finished the RADARSAT-2 operational program moving from SPARKY (old server) to CWOPS (new server).

2. **Maintain and improve the CoastWatch Great Lakes Node web server, design and develop the web site:**
   - Updated the Gallery section on CoastWatch Great Lakes web page.
   - Updated What's New section in CW website to show the operational satellite switch between GOES-13 and GOES-14.
   - Updated What's New section in CW website to show official date for decommissioning NOAA-17.

3. **Design, modify, and develop the software to analyze and process the CoastWatch data:**
* Wrote the Unix script to copy and move data from old server or CD, DVD to new server, also move the data to monthly folder.
* Wrote the Unix script to validate the AVHRR and GLSEA data after moving to monthly folder in new server.
* Wrote and modified the IDL program to process the RADARSAT images for ice classification project.

4. Participate in CoastWatch related research and preparation of presentations for meetings:
* "Great Lakes CoastWatch Update" presentation at CW meeting 2012.
* “Great Lakes CoastWatch Summary” presentation for EMU Limnology Class, Dec. 6, 2012

5. Assist in the mentorship of a Great Lakes summer fellow:
* Assist summer fellow to convert the files from .gif or .dat format to ascii format.
* Assist summer fellow to install and test the THREDDS data server, TOMCAT webserver, LAS server, and Ferret.

Publications:

Presentations:
Leshkevich, G. and S. Liu, Great Lakes CoastWatch Update, CoastWatch Node Managers Meeting, Kona, HI, April, 2012. (Included here as CoastWatch NMM was held early during 2012 but represents full year).


Outreach Activities:
None to report to date.

Relevant Websites:
Coast Watch Website: [http://coastwatch.glerl.noaa.gov](http://coastwatch.glerl.noaa.gov)
THEME I: GREAT LAKES OBSERVING AND FORECASTING SYSTEMS

PROJECT TITLE: LARVAL DISPERSAL, HABITAT CLASSIFICATION, AND FOOD WEB MODELING

Principal Investigators: Allen Burton (CILER), Dmitry Beletsky (CILER)
NOAA Technical contacts: Ed Rutherford (NOAA-GLERL)

Overview and Objectives:
Invasive species are one of five key NOAA-identified stressors of native biodiversity and ecosystem function in the Laurentian Great lakes. In the context of on-going management and policy discussions, it is thus critical to forecast species invasions and their costs, and to predict the effectiveness and costs of potential management responses to these invasions. By integrating ecology and economics at a landscape scale, we will be able to communicate forecasts in terms of introduction pathways, which are the most appropriate targets for cost effective management, especially where preventing new invasions is the goal. We thus propose to use ecological models and GIS databases to support a NOAA CSCOR proposal (D. Lodge, PI) entitled “Forecasting spread and bioeconomic impacts of aquatic invasive species from multiple pathways to improve management and policy in the Great Lakes.”

To forecast what portions of the Great lakes are most vulnerable to invasions, we will use abiotic data layers to develop an environmental classification that groups areas of environmental similarity as a surrogate descriptor of biotic patterns, because abiotic data are available with more extensive spatial coverage than biological data. All GIS variables and classifications will be freely available as an output of the project and will provide a new spatial framework for a variety of applications of management interest.

We will hold an expert workshop to elicit information on model input and uncertainties and to report preliminary results of simulations for Lakes Michigan and Erie. We will revise and report simulations for lakes Michigan and Erie, and run simulations for Superior, Ontario, and Huron, while incorporating uncertainty in model parameters and under different invasion and management scenarios.

Products will include: maps and predictions of invasive species larval dispersal in four of five Great Lakes; developed databases and eco-regional habitat classifications for environmental niche modeling; Ecopath/Ecosim food web models and predictions of invasive species impacts on Great Lakes food webs and fisheries.

Accomplishments:
Modeling Natural Dispersal of Invasive Species Larvae:
Dispersal of two AIS (ruffe and limnoperna) in Lake Michigan is studied with a 3D particle transport model. The model is developed by David Schwab (University of Michigan) and is described more fully in Michalak et al. (2013). Particles are assumed to be passive and neutrally buoyant. Advection fields for the particle transport model are obtained from the 1998-2007
currents modeled by Beletsky and Schwab (2008). We are predicting larval transport from ballast release point located along the longitudinal transect (to determine safest ballast exchange locations), ports, and major tributaries. Release time and maximum drift duration are species specific. Simulated Ruffe larvae were released at surface daily during spring-summer (March-August) and tracked for 30 days while Limnoperna larvae were released daily during summer-fall (June-November) and tracked for 70 days. Settlement at coast is targeted initially and is currently being expanded to cover nearshore areas. For ballast releases, both species show a tendency to drift eastward (reflecting prevailing surface currents) and colonize more or less the same area on Lake Michigan’s east coast but due to seasonal and drift duration differences Limnoperna is expected to survive/spread better; 62% of Limnoperna particles reached shore versus only 20% for ruffe. For port releases, settlement rates (percentage of particles reaching shore in time allowed) were similar between Limnoperna and Ruffe (82 vs 89%) but Limnoperna spreads over a much larger area. Ruffe spread is very localized near source ports while Limnoperna spreads much more around east coast (mostly due to drift from Chicago and Milwaukee).

Bioeconomic Models of Invasive Species Impacts on Food Webs:
We have modeled Asian Carp impacts on the Lake Erie food web using the Ecopath with Ecosim (EwE) food web software. Our colleagues at Univ. Notre Dame and Resources for the Future provided measures of uncertainty of Asian carp impacts by asking experts to estimate variance in production, consumption, diet and equilibrium biomass of Asian carp once they are established. We incorporated this uncertainty into the EwE model framework, and have successfully linked a regional economic model developed by collaborator D. Finnoff (Univ. Wyoming) to our EwE model. by combining Structured Expert Judgment into to assess uncertainty in the simulated potential impacts of Asian carp on food web of Lake Erie. Preliminary results of our work have been presented at conference meetings (IAGLR 2012, American Fisheries Society, 2012; ICAIS 2013) and will be presented again at IAGLR 2013. Lake Michigan EwE model is being finalized and soon will be used to estimate impacts of invasive species, including Asian carps, ruffe, killer shrimp, golden mussel, and northern snakehead. We are working on a manuscript to predict Asian carp impacts on food webs in Muskegon Lake, Lake Erie and Lake Michigan. EwEs for Saginaw Bay and main basin of Lake Huron are developed and calibrated. The impacts on fish production of Dreissena, alewife and nutrient loading on Lake Huron food webs were estimated individually and combined. The results will be presented at the IAGLR 2013 meeting. We have met with Drs. Tom Stewart (Ontario Ministry of Natural Resources) and Lars Rudstam (Cornell University) and colleagues to discuss collaborative modeling of invasive species impacts on the Lake Ontario food web using EwE.

Habitat Classification and GIS data layers:
We have developed environmental data layers for Great Lakes coastal, nearshore and offshore areas to support a Great Lakes habitat classification and environmental niche models of invasive species distribution and relative abundance. Some of the habitat layers were derived from existing models of lake ice, waves, water temperature, bathymetry, circulation, while other
layers (chlorophyll a, Cladophora) were produced by collaborators at Ontario Ministry of Environment, Canada’s Dept. of Environment, Michigan Tech Research Institute and University of Michigan. When completed, the habitat data layers will be posted at the University of Michigan IFR GIS web site (http://ifrgis.snre.umich.edu/projects/CSCOR/cscor.shtml), on a server hosted by USGS-GLSC. Our core partners for habitat classification are at University of Michigan SNRE (Catherine Riseng), IFR (Kevin Wehrly), Nature Conservancy (Scott Sowa, Lindsay Chadderton, Gust Anns, Mary Khoury), USGS-GLSC (Jim McKenna and Chris Castiglione), and elsewhere (Lizhu Wang, IJC). This group has held webinar meetings for habitat classification each month, and a classification workshop at NOAA GLERL in Dec. 2012. We anticipate finishing the habitat classification and a technical report by June 2014.

Publications:

Presentations:


Beletsky, D. Modeling thermal structure and circulation in the Great Lakes. GIS Day 2011 Modeling Symposium, University of Notre Dame, December 2, 2011, South Bend, IN.


Outreach Activities
None to date.

Relevant websites
CSCOR Great Lakes Aquatic Habitat Classification: http://ifrgis.snre.umich.edu/projects/CSCOR/cscor.shtml
THEME I: GREAT LAKES OBSERVING AND FORECASTING SYSTEMS

PROJECT TITLE: GREAT LAKES RESTORATION INITIATIVE CLIMATE PROJECT

Principal Investigators: Allen Burton (CILER)
NOAA Technical contacts: Jennifer Day (NOAA – Great Lakes Regional Collaboration); Brent Lofgren (NOAA-GLERL)

Overview and Objectives:
NOAA has received funding through the FY11 GLRI allocation to implement a comprehensive NOAA climate program in the Great Lakes aimed at providing community outreach and technical assistance for assessing climate change and hazards risks and vulnerabilities. This position will provide assistance to two areas of work being conducted under this project.

This project will provide the science plan necessary to coordinate the science across NOAA and the region with respect to climate to ultimately meet the goals of improved forecasts that facilitate restoration and protection of critical natural resources, help guide management decisions, and support sustainable economic development in the region.

Objectives and Goals
Climate Funding Opportunities Compilation – This position will research and complete a report on funding opportunities available to the region in both January and June 2012. Informal Regional Climate Science Plan. This position will work with Brent Lofgren, GLERL, to develop this plan which will be used as a guide book for future NOAA and Great Lakes Regional Collaboration Team work on climate. Anticipated delivery: June 2012

Accomplishments
In the context of ice-climate study, anomalous ice cover in the Great Lakes was investigated in association with atmospheric teleconnection patterns (Bai et al., 2012). As an extreme event study, a record-breaking low ice cover in the Great Lakes in the winter of 2011/2012 was explained as a result of combined effects of a strong North Atlantic Oscillation and La Niña in the winter (Bai et al. 2013a). An ice-lake coupled model for Lake Erie was configured based on the Princeton Ocean Model (Fujisaki et al., 2012). A simulation through 2003-2012 reproduced seasonal/interannual variation of ice extent and thermal structure in the lake compared with the observations (Fujisaki et al., 2013).
The other model accomplishments are based on the Unstructured Grid Finite Volume Coastal Ocean Model (FVCOM): FVCOM coupled with the NPZD biological model was applied to Lake Michigan with operationally-used numerical grids, reproducing the ‘doughnut’-shape spring bloom in 1998 (Luo et al., 2012). Another physical model with FVCOM covers the entire Great Lakes at a relatively coarse resolution (Bai et al., 2013b). This five-lake model is a base for the future coupling with ice and ecosystem models.

Two 1-D lake models, Lake, Ice, Snow, and Sediment Simulator (LISSS) model (Subin et al. 2011) and NOAA Great Lakes Environmental Research Laboratory (GLERL) lake model (Lofgren 2004), were newly incorporated into Climate extension Weather Research and Forecast (CWRF) model. Along with the original Hostetler based lake model rooted from Common Land Model (CoLM) and NCAR Land Surface Model (LSM) in CWRF, there are three 1-D lake models in the coupled CWRF-LAKE modeling system with different physical representations, assumptions, advantages and deficits. The coupled system allows us to comprehensively evaluate key physical processes in the lake and atmospheric interactions and to intensely study the impacts of lakes on regional climates.

Initial evaluations on three lake models implemented in CWRF indicate that their skills are slightly different in simulating diurnal and seasonal cycles of lake surface temperatures and lake ice durations. But their simulated regional climatic effects of lakes are substantial, especially during winter season. Moreover incorporating dynamic lake models largely improves the CWRF performance over the regions nearby large and deep lakes, such as the North American Great Lakes Basin.

Publications


• Xu, Min, Xin-Zhong Liang, Brent Lofgren, and Arthur Samel, 2013: Regional climatic effects of Great Lakes simulated by coupled CWRF and lake models.

**Presentations:**

Xu, Min, Xin-Zhong Liang, and Brent Lofgren, 2012: the simulation of lake effects on regional climate by cwrf, the NOAA-GLERL workshop on Methods of Projecting the Hydrologic Impacts of Climate Change, Muskegon, MI, Aug. 2012

Xu, Min, Xin-Zhong Liang, and Brent Lofgren, 2012: Comparison of Two Lake Models Implemented in CWRF. In: 55th Annual Conference of International Association for Great Lakes Research, May 13-17, 2012, Cornwall, ON Canada.


Wang, J., and X. Bai. Teleconnection patterns associated with severe and mild ice cover in the Great Lakes. 55th Annual Conference of the International Association for Great Lakes Research, Cornwall, Ontario, Canada, May 14-17, 2012.

**Outreach Activities:**
None to date.

**Relevant Websites:**
NOAA Technical Memorandum GLERL-155 (2006-2011 data) is available
THEME I: GREAT LAKES OBSERVING AND FORECASTING SYSTEMS

Funded projects, with no activity to date:

PROJECT TITLE: IMPROVING RUNOFF ESTIMATES IN THE GREAT LAKES BASIN

PROJECT TITLE: HOW WILL THE GREAT LAKES WATER LEVELS RESPOND TO CLIMATE CHANGE: YEAR 3: REGIONAL MODELING FOR APPLICATION TO DECISION-MAKING

PROJECT TITLE: HYDRODYNAMIC MODELING AND OBSERVATION IN SUPPORT OF GLRI DECISION SUPPORT TOOLS

PROJECT TITLE: MODELING SEA ICE-OCEAN-ECOSYSTEM CHANGES, AND GREAT LAKES ICE MODELING, MEASUREMENT, AND CLIMATE CHANGE

PROJECT TITLE: HYDRODYNAMIC MODELING AND CONTAMINATED SEDIMENT IN MANISTIQUE RIVER, MI

PROJECT TITLE: GREAT LAKES OBSERVING PROGRAM
THEME II: INVASIVE SPECIES

PROJECT TITLE: ASSESSING RISK OF ASIAN CARP INVASION AND IMPACTS ON GREAT LAKES FOOD WEBS AND FISHERIES

Principal Investigators: Allen Burton (CILER), Hongyan Zhang (CILER), Dmitry Beletsky (CILER), Lori Ivan (CILER)
NOAA Technical contacts: Edward Rutherford (NOAA-GLERL), Doran Mason (NOAA-GLERL), Andrew Gronewold (NOAA-GLERL)

Overview and Objectives:
Bighead (Hypophthalmichthys nobilis) and silver (H. molitrix) carp (Asian carps) threaten to invade the Great Lakes and disrupt aquatic food webs and fisheries through their consumption of lower trophic levels. In river and lake ecosystems in North American, Asia and Europe, the introductions of Asian carps have resulted in the decline of many native fish species, with planktivorous fish and fish with planktivorous stages being particularly affected (e.g Arthur et al. 2010; Pegg et al. 2009).

Impacts of Asian carps on aquatic food webs are potentially complex, and require spatially-explicit models of trophic interactions to assess direct and indirect influences. A spatially-explicit modeling approach such as those we propose below allows a more detailed look at the effects of Asian carps on key members of the food web, and allows for the inclusion of density-dependent feedbacks (e.g., lower survival of age-0 fish, but higher growth and reproductive output by older survivors) which may help species compensate for the effects of an Asian carp invasion.

Our objectives are to:
1. Predict in which Great Lakes habitats Asian carps can successfully grow, survive and reproduce.
2. Predict Asian carp’s impacts on food webs, key fish species and fisheries in different Great Lakes environments.
3. Survey the Chinese literature for relevant information on Asian carps’ energetics, vital rates and ecology

Outcomes: At the end of the two-year project, this work will expand on the results of Cooke and Hill (2010) and help identify regions in Lakes Huron, Michigan and Erie that could support Asian carps. Our individual-based model and food web model will identify the species and fisheries that likely will be impacted by Asian carps.

Accomplishments:
Both the Saginaw Bay IBM and Lake Michigan Atlantis model were configured and finalized.

Dr. Ivan continued the development of the IBM model and presented a preliminary version of the model in August to the American Fisheries Society meeting. After this presentation, it was agreed to modify the model to simplify the lower food web component of the model to allow for interactions amongst prey groups. Further, it was suggested by the audience that Asian carp be allowed to consume larval fishes as is indicated by diets analyses of carps in the Illinois and Mississippi Rivers. In preparation for another presentation, Dr. Ivan modified the code to incorporate literature relationships for hatching and spawning, as well as the removal of dead individuals, in an effort to make the model multigenerational. She finalized the movement subroutine such that movement is realistic for all species for winter, summer and spawning. Previous simulations revealed a flaw in the vulnerabilities of prey to predators; new size-based vulnerabilities were therefore used. Further, the code, especially in the initialization subroutine, was simplified to improve readability. The general framework of the IBM is therefore complete. This framework will be easily transferable to Lakes Michigan and Erie. Next, the Saginaw Bay model will be calibrated and we will run simulations for Saginaw Bay. Dr. Ivan began incorporating Lake Huron data into the model and will finalize the biological and physical data for the Lake Huron model and begin calibration in the next three months. Finally, she will complete a draft manuscript for Saginaw Bay to be submitted to co-PIs for review. Co-PIs have already read and made comments on a draft of the introduction and methods section of this manuscript, which will facilitate the submission process on completion of the model simulations. Dr. Ivan will also continue to develop the offshore IBM model for Lake Huron community model. She has developed the framework for the physical environment of offshore Lake Huron and has included parameters for two new fish species to be used in the Lake Huron community, lake trout and lake whitefish.

Dr. Zhang has implemented external nutrient loading into the Lake Michigan Atlantis model. Further, she has incorporated spawning migrations and the resting egg life stage into the model framework. She has also run some preliminary simulations with and without Asian carps. She has maintained a good communication with Dr. Fulton’s group (the Atlantis model developer) and solved many technical problems with help from them; she also helps to improve the Atlantis model wiki website. Next, the Atlantis model for Lake Michigan will be calibrated and we will run scenario simulations for this lake. Dr. Zhang will also begin the configuration of the Atlantis model for Lake Erie and Lake Huron. Finally, she will begin to draft a manuscript on the Lake Michigan Atlantis outputs. Two specialists, Lacey Mason and Jason Breck, will
generate current fields for the Atlantis model from the hydrodynamics model output being finalized by Dr. Beletsky and described next.

Existing hydrodynamic model output from 1998-2007 run was used to produce climatology of 3D currents and temperature in Lake Michigan. We also continued working on calibration and validation of hydrodynamic model of Lake Huron using 1991-1996 and 2008-2010 observations with the goal to improve initial climatology developed for this lake. Finally, hydrodynamic model of Lake Erie was calibrated and validated using 2004, 2005 and 2007 observations. Meteorological forcing functions were generated for select years during 2004-2012 in preparation of additional model runs for Lake Erie in order to produce climatological circulation and temperature fields in this lake.

Publications:
None to date.

Presentations:

Outreach Activities:

Ivan and Zhang presented the IBM and Atlantis Ecosystem Model to international students participating in an exchange program between Eastern Michigan University and HUAZ University in Wuhan, China. Fishes of the Great Lakes. Ann Arbor MI, July 2012.

**Relevant Websites:**
Asian Carp Risk Assessment: [http://www.regions.noaa.gov/great-lakes/?page_id=787](http://www.regions.noaa.gov/great-lakes/?page_id=787)
THEME III: ECOLOGICAL RISK ASSESSMENT

PROJECT TITLE: OCEANS AND HUMAN HEALTH: HARMFUL ALGAL BLOOM FORECASTING

Principal Investigators: Allen Burton (CILER), Tom Johengen (CILER)

Overview and Objectives
The NOAA Center of Excellence for Great Lakes and Human Health (CEGLHH) is a multi-disciplinary, multi-institutional research center that is developing tools to predict water quality in the Great Lakes. Focus areas for the Center include ecological forecasting, nearshore transport, drinking water, beach closings, and harmful algal blooms. The proposal will describe research activities related to Beach Forecasting, Harmful Algal Bloom Forecasting, Microbial Monitoring and Forecasting, and Outreach. Also, we will continue to conduct field sampling and experimental work to: 1) determine whether significant amounts of the HAB toxin, microcystin, is entering the drinking water supplies of residents on two Lake Erie Islands, and 2) elucidate what are the main drivers determining the timing and extent of bloom development, and its subsequent movements through the western and central basins of Lake Erie. We will use both historical and our current evolving environmental data sets to construct statistical models delineating factors regulating phytoplankton and Microcystis abundance patterns throughout western Lake Erie. We will develop and evaluate ‘user friendly’ models (i.e. incorporating readily-obtained hydrological-meteorological variables) for predicting Microcystis biomass Current beach monitoring, which uses the persistence model of using yesterday’s E. coli measurements to determine today’s beach bather water quality is not effective in predicting swimming conditions today. In some cases, the persistence model has been shown to be inaccurate more than 50% of the time. Nowcast models using statistical regression methods improve correct prediction of swimming conditions by 20 to 30% or more over the current technology. This swimming information is provided by the afternoon of the same day. Forty-eight hour forecasting incorporates process modeling (river and lake dynamics) as well as forecasted variables (rainfall, wind velocity and direction, and wave height) to enable beach managers to better inform the public of beach water quality, assist in the development of remediation projects to reduce bacterial sources to beaches, and provides families data for recreational planning. Beach water quality nowcast and forecast models can be useful screening tools in determining where human health threats may be impacting recreational beaches.
Accomplishments

1. Harmful Algal Bloom Forecasting (Lead: Tom Johengen)
   A) Field Monitoring
   • Conducted field sampling program for western Lake Erie and Saginaw Bay, Lake Huron. For western Lake Erie we conducted 18 sampling trips and a total of 85 samples. Each sample was analyzed for nutrients, phytoplankton composition, extracted algal pigments, and toxins. For Saginaw Bay we conducted 3 sampling trips including a total of 12 samples.
   • Data has been entered into the program’s database and is being shared with our Partners conducting statistical modeling, as well as, with NOS staff running the operational Lake Erie HABS Bulletin.

   B) HABS modeling and data analysis (Lead: Dave Millie)
   • Funding for the current sub-award has just been received by the PI as of the end of April, so no prior activity to report. Proposed statistical analysis and phytoplankton composition analyses will proceed as planned.

2. Beach Water Quality Forecasting (Lead: David Rockwell)
   • Continued analysis to identify appropriate parameters to use as independent variables for the Virtual Beach water quality forecast, including: gathering water quality records, obtaining the required independent variables, developing a statistical model relating water quality to the independent variables, implementing a system for routine operation of the model in nowcast and forecast mode as well as dissemination to users, and evaluation of the accuracy of the system.
   • The forecast is currently being applied to Memorial and Metro Park Beaches, Macomb County, MI, Bay City State Recreational Area beach, Bay County MI, and North Beach Park and Grand Haven State Park Beaches, Ottawa County.
   • Continued meetings to help coordinate Beach Health activities between EPA, USGS, NOAA, and CDC via video/phone conferencing and bi-annual face to face meetings.
   • Worked with appropriate state and local Beach Health agencies, Sea Grant, and the Great Lakes Beach Association to make sure that the beach decision support tools result in a product that will be useful for both nowcasting and forecasting of conditions at Great Lakes beaches.
   • Conducted monthly meetings of the Beach Health Interagency Coordination Team to provide updates on project activities and to seek input for future priorities.

3. Fecal indicator bacteria monitoring and forecasting (Lead: Drew Gronewald)
   A) Watershed modeling:
• Developed a preliminary pollutant fate and transport models for the Clinton River watershed which is currently providing loads for the hydrodynamic model on the lake side.
• Completed the development of the rainfall-runoff modeling will require geospatial analysis and coding in order to assimilate land use-derived pollutant loading rates for the Clinton River watershed, and tools have been developed to expand into other sites, including: Saginaw Bay, Grand Haven, and Fox River.

**B) Field monitoring:**
• Expanded in-house FIB analysis capability including hiring and training of additional staff; purchased equipment to conduct sample preparation and analysis.
• Coordinated with Macomb County Public Health Department regarding their regulatory sampling collection and analysis.
• Coordinated with USGS regarding laboratory procedures, waste management, and rainfall event sample collection.
• Conducted pilot deployment of a vADCP in the natural channel of the Clinton River for approximately three months.
• Initiated our FIB monitoring program, including: collected samples on 25 occasions, including 5 rainfall events. Collected FIB samples, Temp, and conductivity at 17 sites which including two river sites and 15 lake sites on both public and residential properties within the Clinton River watershed, . Nutrient samples were collected at 4 of these sites as a preliminary assessment of water quality correlation to FIB concentrations.

**Publications**
None to date.

**Presentations**
None to date.

**Outreach Activities**

*Outreach and Education Coordination (Lead: Sonia Joseph Joshi)*
• Disseminated weekly Lake Erie Harmful Algal Bloom Experimental Forecast Bulletin to the now 470 subscribers of Bulletin during 2012 sampling season.
• Conducted planning for a feedback assessment stakeholder workshop on the Lake Erie Harmful Algal Bloom Experimental Forecast Bulletin to be held July 2013 in Ohio.
• Assisted in the coordination and administration for Center of Excellence for Great Lakes and Human Health’s funding received from the Great Lakes Restoration Initiative, including: drafting and submitting statements of work and
quarterly reports, participating in monthly Great Lakes Restoration Initiative conference calls for NOAA, and participating in the NOAA Focus Area Leads conference calls.

- Ongoing development of new communications products, including: development of two new fact sheets, updated the Center of Excellence website, and planning for a workshop. Of particular note is the website for Lake St. Clair bacterial monitoring, has been revamped to be more user-friendly and to provide easier access and interpretation of our sampling data. Building on the website we will begin planning for a public unveiling of the website as well as a stakeholder meeting next quarter to solicit feedback on the website. The stakeholder survey for feedback on the website will be distributed next quarter as well to ensure our communication products for the bacterial sampling data is delivered in a format and layout that is useful to our end users.

**Relevant Websites**
HABS Bulletin and Microsystin toxin data disseminated at:
http://www.glerl.noaa.gov/res/Centers/HABS/sampling_data.html

FIBS Monitoring Results and Model Development Website to be publically launched next quarter through the NOAA-GLERL Center for Excellence for Great Lakes and Human Health.
THEME III: ECOLOGICAL RISK ASSESSMENT

PROJECT TITLE: 2012 MONITORING ACTIVITIES FOR THE LAKE HURON CSMI AND LAKE MICHIGAN LONG-TERM ECOLOGICAL RESEARCH PROGRAMS

Principal Investigators: Allen Burton (CILER), Thomas Johengen (CILER)
NOAA Technical contacts: Henry Vanderploeg (NOAA-GLERL), Gary Fahnenstiel (NOAA-GLERL, now University of Michigan), Craig Stow (NOAA-GLERL)

Overview and Objectives:
NOAA-GLERL and CILER are participating in the multi-agency Year of Lake Huron 2012 Program sponsored through the EPA Coordinated Science and Monitoring Initiative (CSMI). Federal and State partners coordinating within this CSMI effort include: EPA-GLNPO, NOAA-GLERL, USGS Great Lakes Science Center, Environment Canada, Department of Fisheries and Oceans Canada, Michigan DNR, Michigan DEQ, Michigan SeaGrant, Great Lakes Observing System, and CILER. The focus of this proposed project is to help determine spatial distribution of all elements of the food web in the vicinity of Thunder Bay National Marine Sanctuary, to characterize the composition, abundance, and long-term trends of the benthic community throughout the lake, and to determine role of Saginaw Bay acting as a nearshore shunt for P removal. The work is divided into 4 subprojects.

1. Benthic Survey
GLERL has been involved in assessing trends in benthic populations (including zebra and quagga mussels) in Lake Huron since 2000. Lake-wide surveys have been conducted under various programs in 2000, 2003, and 2007. All data collected in the former two years have been published in a NOAA Technical Memorandum (Nalepa et al. 2007a), and trends assessed and summarized in a journal article (Nalepa et al. 2007b). All data collected in 2007 have been processed and placed into spreadsheets, but summary articles have not yet been published.

A complete resampling of the same historic benthos sites will be completed in 2012. All field collections will be completed in 2012. Laboratory analysis will be completed during 2013, approximately 9 months after sample collections are completed. Data analysis will be completed by the end of 2013 and results shared among all agency participants through workshops, presentations, and a project report.

2. Spatial Study of Lower Food Web
We propose to do the same intense spatial work off Alpena that is presently being done off of Muskegon, MI under the NOAA-GLERL LTER, to characterize the spatial distribution of the food web. This sub-project will involve 3 cruises (April, July, September) along a transect at Alpena using plankton survey system, acoustics, net tows, and Tucker trawl to examine horizontal and vertical distribution of plankton, larval fish, fish, and Mysis and to relate them to dreissenid-driven changes in phytoplankton abundance and distribution and light climate, which has altered horizontal spatial distribution of planktivorous fishes and changed in diel vertical migration of fishes and zooplankton.

All field collections will be completed in 2012. Laboratory analysis will be completed during 2013, approximately 9 months after sample collections are completed. Data analysis will be completed during 2013 and results shared among all agency participants through workshops, presentations, and a project report. Preparation and submission of final manuscripts will likely occur in early 2014.

3. Sediment Core Study of Phosphorus Deposition

The nearshore shunt hypothesis posits that dreissenid mussels have increased phosphorus retention in shallow nearshore areas via particle filtration and deposition in the sediment. Recent work using a simple mass balance model indicates that the proportion of the phosphorus load retained in the sediments of Saginaw Bay, a large shallow nearshore arm on Lake Huron, increased with the mussel invasion (Cha et al in revision). Our modeling results indicate that total phosphorus export from the inner bay decreased from an overall mean of 624 (± 69) tonnes yr⁻¹ pre-invasion to 247 (± 82) tonnes yr⁻¹ post-invasion.

To confirm these model results we propose the collection of 10 sediment cores in Saginaw Bay and the main body of Lake Huron to examine if analogous changes in the rate of phosphorus sedimentation are discernible. All field collections will be completed in 2012. Laboratory analysis of nutrient content will be completed within 2012. Radiometric dating will be completed approximately 12 months after sample collections and delivery of dried sub-sections. Data analysis will be completed during 2013 and results shared among all agency participants through workshops, presentations, and a project report. Preparation and submission of final manuscripts will likely occur in early 2014.

4. Communities on Hard Substrates with emphasis on the role of Dreissena

With the aid of Sanctuary divers, three sites on hard substrates in Thunder Bay will be sampled in May, July, late August for benthos and collection of live mussels for experiments to determine the impact of their feeding and nutrient excretion.
We will determine feeding and nutrient excretion by quagga mussels in Lake Huron in shallow water using mussels collected on natural reefs in Thunder Bay and in deep water using mussels sledded off of soft substrate.

5. Benthic Surveys for Lake Michigan
The benthos is an important sentinel of change and at same time is an important force affecting the rest of the ecosystem: replacement of native benthos by rapidly expanding mussel populations has resulted lowered concentration of phytoplankton during all seasons, shunting of P and C from the pelagic to benthic realms, and increasing water clarity as well as a number of other direct and indirect effects on the total ecosystem that are explored here and in other subprojects. This subproject focuses on describing mussel trends, condition, and filtering, and nutrient cycling to understand and predict mussel carrying capacity and impact on Lake Michigan’s ecosystem.

In 2012, we will complete taxonomic analysis (oligochaetes and chironomids) of the 2010 samples, and pick, count, and ID organisms in all the 2011 samples. Once the 2011 data set is completed, we will help produce a manuscript assessing trends in the total benthic community between 1992-93 and 2010-2011.
We will also revisit and sample sites in the southern basin of Lake Michigan in 2012 to capture the potential population stabilization or decline of dreissenid mussels. We will collect benthos during late summer (August) in the southern basin to continue assessing population abundance there and their impact on the food web during CY2012.

Accomplishments
1. Benthic Survey
A complete resampling of approximately 100 historically maintained benthos monitoring sites was completed during 2012 over several research cruises. Approximately one-third of the samples have been processed.

2. Spatial Study of Lower Food Web
Two spatial food-web cruises were conducted in Lake Huron during the project reporting period to characterize the horizontal and vertical distribution of plankton, larval fish, and adult fish. All of the plankton survey system and acoustic fish data have been processed (see Supplemental Material for example data sets). All corresponding water quality (nutrients and chlorophyll) samples have been analyzed and entered into a project database.

3. Sediment Core Study of Phosphorus Deposition
Sediment cores were collected in summer 2012. Radiometric data of core sections has been completed under the subcontract with Wayne State University. Data is being
finalized and a final report will be delivered next quarter. All phosphorus analysis has been completed on the cores and a database has been shared with all NOAA and CILER PI’s. Data will be further analyzed once the core section data is finalized.

4. Communities on Hard Substrates with emphasis on the role of Dreissena
Three sampling surveys were conducted to characterize the benthos community structure on hard substrate at six locations within Thunder Bay, Lake Huron. Those samples are being analyzed by as part of a Master’s Thesis project for Lauren Eaton.

Three mussel feeding and excretion experiments were completed during the project reporting period. Two sets of experiments were done using mussels and water collected from a shallow, hard-substrate site and one set of experiments was done using mussels and water collected from a deep, soft-substrate site. All laboratory analyses have been completed for the feeding and excretion experiments and the data are being further analyzed for future publication.

5. Benthic Surveys for Lake Michigan
A complete resampling of approximately 40 historically maintained benthos monitoring sites was completed during 2012 over several research cruises. Approximately one-half of the samples have been processed.

Publications
None to date.

Presentations
Preliminary field results of spatial study on lower food web were presented to EPA GLNPO GLRI managers in April 2013.

A special session on, Tracking and Understanding Changes in the Lake Michigan’s Emerging Food Web, has been developed for the upcoming June 2013 IAGLR conference.

Outreach Activities
Several radio and newspaper interviews were given by project PI’s in regards to the spatial food web study and multi-agency coordinated effort organized within the CSMI.

Relevant websites
None to date.
Fig. 1. Photo showing deployment of the plankton survey system from the R/V Laurentian to conducting a spatial survey of water quality and plankton distributions in Lake Huron.
Fig. 2. Daytime results collected from the plankton surveys tows during the spatial survey cruise in Lake Huron on September 25, 2012.
Fig. 3. Nighttime results collected from the plankton surveys tows during the spatial survey cruise in Lake Huron on September 25, 2012. Zooplankton counts and biomass show a clear redistribution throughout the water column during the nighttime.
 THEME III: ECOLOGICAL RISK ASSESSMENT

Funded projects, with no activity to date:

PROJECT TITLE: THE EFFECTS AND IMPACTS OF HYPOXIA ON PRODUCTION POTENTIAL OF ECOLOGICALLY AND COMMERCIALLY IMPORTANT LIVING RESOURCES IN THE NORTHERN GULF OF MEXICO
PROJECT TITLE: LAKEWIDE ASSESSMENT OF LAKE ONTARIO BENTHIC MACROINVERTEBRATE COMMUNITIES
THEME IV: PROTECTION AND RESTORATION OF ECOSYSTEM RESOURCES: LINKING TO HUMAN DIMENSIONS

PROJECT TITLE: NOAA EMERGENCY RESPONSE PROTOCOLS

Principal Investigators: Allen Burton (CILER)
NOAA Technical contacts: Jennifer Day (NOAA-Great Lakes Regional Collaboration)

Overview and Objectives:
During the Enbridge oil spill response, NOAA Line Offices were aware in a rudimentary way of each other’s roles and responsibilities with respect to environmental disaster response. However, initial attempts at notification and collaboration were disorganized due to a lack of existing coordination protocols. A diverse service portfolio, such as that provided by NOAA, requires a highly organized response to maintain effective coordination; including information sharing, resource sharing, coordinated briefing services, and a consistent information flow. To accomplish this, a set of response protocols will be established that set guidelines for cross-Line Office coordination and support.

This project utilizes qualitative research to determine how NOAA can integrate its work across many different missions and line offices when an ecological emergency occurs in the region. It is important to understand how the various parts of NOAA contribute understanding of the fundamental physical, chemical, biological, ecological, social, and economic processes operating in the Great Lakes region and the critical socio-economic drivers and feedback shaping natural resource use in the region when emergency response and natural resource restoration are pursued.

FY2013 Objective: Create a reference document containing NOAA strategies and responsibilities for quick and coordinated response to man-made and natural disasters by Q4 2012.

Accomplishments:
In March 2013, the Great Lakes Regional Collaboration Team (GLRCT) through CILER released a Guide to Integrated NOAA Response and Communication Protocols for Man-Made and Natural Disasters in the Great Lakes. This document offers information, tools, and guidelines to improve collaboration among Line Offices during emergency response events and facilitate a unified NOAA response that optimally utilizes agency resources and capacities. The process of creating the Guide was in itself collaborative, convening persons from across
Line Offices to educate one another about individual responsibilities, address concerns, identify communication gaps, and brainstorm tangible ways to respond as OneNOAA in the event of an emergency. The resulting Guide covers NOAA’s integrated response to an oil spill, hazardous chemical release, maritime accident, large-scale fire event, large-scale and/or high-impact weather event, or radiological release. It was designed to be flexible and account for the dynamic nature of technology, inter-Line Office relationships, and individuals who hold critical positions in response activities. The GLRCT is pleased to be the first regional team to produce a document of this kind, and we hope that it can serve as a resource for other regional collaboration teams across NOAA.

Publications:

Presentations:
Presentation on content made to the following groups:
1. NOAA Great Lakes Environmental Research Lab
2. NOAA Great Lakes Regional Collaboration Team
3. Regional Coordinators and Regional Team Leads for the seven additional NOAA Regional Teams
4. Deputy Assistant Administrators from each of the NOAA Line Offices

Outreach Activities:
A new regional working group has been created to discuss the need for involving Regional Collaboration Teams in larger NOAA emergency responses.

Relevant Websites:
THEME IV: PROTECTION AND RESTORATION OF ECOSYSTEM RESOURCES: LINKING TO HUMAN DIMENSIONS

PROJECT TITLE: IMPLEMENTATION OF THE GREAT LAKES SYNTHESIS, OBSERVATIONS, AND RESPONSE SYSTEM (SOAR)

Principal Investigators: Allen Burton (CILER), Thomas Johengen (CILER)

NOAA Technical contacts: Steven Ruberg (NOAA-GLERL)

Overview and Objectives:
The implementation of the Great lakes Synthesis, Observations and Response System program (SOAR) is designed to coordinate and integrate regional coastal observations that support national and regional priorities including Great Lakes restoration. SOAR activities include the deployment and support of on-water and remote sensing platforms where observations from these systems are used to create database products for assessment and decision support. The project will provide an up-to-date (including real-time data) web presence to support accountability, management and restoration activities. The system will provide up to date information on ecosystem health to maintain high quality drinking water and bathing beaches through observations, data management, and forecast model development.

Observations of environmental parameters will be used to develop decision support tools to determine success of remedial actions, provide warnings to regional managers regarding phosphorous loads, hypoxia and harmful algal blooms, and support future remedial action decisions. These decision support tools include: real-time observing system components (buoys) deployed at Maumee Bay, Saginaw Bay, Muskegon and Cleveland, a web-based data management system, synthesized remote sensing products for predicting HABs, and coupled physical-chemical-biological models for Green Bay, Saginaw Bay, Maumee Bay and the St. Lawrence River AOCs. Instrumentation deployed in AOCs will provide observations of hypoxia, soluble reactive phosphorous and support detection of harmful algal blooms.

1. Development of Decision Support Tools
Observations of environmental parameters will be used to develop decision support tools to determine success of remedial actions, provide warnings to regional managers regarding phosphorous loads, hypoxia and harmful algal blooms, and support future remedial action decisions. Instrumentation deployed will provide observations of hypoxia, soluble reactive phosphorous and provide detection of harmful algal blooms.

2. Remote Sensing Product Development for Early HAB Detection
The University of Toledo and Blue Water Satellite Inc. will lead an effort to perform early season satellite HAB monitoring in Lake Erie to understand incipient HAB bloom formation and to understand factors that may contribute to early bloom formation to assist in improving the ability to provide early warning for bloom onset. Because of the low ice cover that has
occurred over the winter of 2011-2012, there is a very strong opportunity to both observe from satellite and potentially sample for confirmation any early season blooms in 2012.

Accomplishments

1. Development of Decision Support Tools

In 2012 we deployed two instrumented moorings in Western Lake Erie that incorporated the following: Wetlabs CYCLE-P nutrient analyzer, Turner Designs C6 fluorometer, Wetlabs Ecopar, and YSI 6600 multi-parameter sonde. Instrumentation was serviced approximately every month (see Supplemental Material; Table 1, Fig. 1 and Fig. 2). Discrete samples were collected weekly or bi-weekly for laboratory analysis to evaluate the accuracy and consistently of the in-situ instrument measurements. All laboratory analysis for the 2012 sample collections has been completed. Data are being analyzed for initial presentation at the June 2013 IAGLR conference.

2. Remote Sensing Product Development for Early HAB Detection

During the reporting period, the University of Toledo led a project to analyze up to 60 cloud free remote sensed images using MODIS, LANDSAT, and WorldView2 satellite images between 4/1/12-7/15/12. In addition, three sampling trips were conducted of 30 stations per trip to provide corresponding ground-truth data against which to compare analyze remote sensed data. The sampling effort was able to quantify a significant surface HABS bloom in late summer but that was limited in its spatial extent and duration. Further data analysis is ongoing.

Publications:

In Prep., manuscript to describe the interaction of internal waves and the entrainment of hypoxic water into locations of water intakes in the central basin of Lake Erie.

Presentations:
Multiple talks and a special session have been submitted for the 2013 IAGLR conference to be held on June 2-6.

Outreach Activities:
Data from RECON buoys was displayed on the Real-time Coastal Observation Network web display and data management system, as well as the GLOS DMAC web portal to be made available for access by GLRI managers, municipal water managers, beach managers, and researchers.
Data from moored instruments and mobile platforms is being analyzed and protocols are being established with GLOS DMAC to receive and display the data.

**Relevant Webcontent:**
A new application’s programmer has just been hired who will work on developing target types of data synthesis and forecasting products. Two stakeholder needs assessment workshops are being developed to facilitate identifying the scope and format of those products.

**Supplemental Materials (Data tables and figures):**
Table 1. Summary of deployment periods for two instrumented moorings in western Lake Erie with the number of successful days of data returned by each of the instruments.

<table>
<thead>
<tr>
<th>Site (days)</th>
<th>Date Deployed (days)</th>
<th>Duration (days)</th>
<th>Wetlabs Cycle P (days)</th>
<th>Turner C6 (days)</th>
<th>YSI (days)</th>
<th>Wetlabs PAR (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>THL</td>
<td>5-11-12</td>
<td>31</td>
<td>31</td>
<td>31</td>
<td>31</td>
<td>No data</td>
</tr>
<tr>
<td>TL2</td>
<td>5-11-12</td>
<td>42</td>
<td>42</td>
<td>35</td>
<td>42</td>
<td>42</td>
</tr>
<tr>
<td>THL</td>
<td>6-11-12</td>
<td>32</td>
<td>No data</td>
<td>No data</td>
<td>32</td>
<td>na</td>
</tr>
<tr>
<td>TL2</td>
<td>6-22-12</td>
<td>35</td>
<td>35</td>
<td>35</td>
<td>35</td>
<td>na</td>
</tr>
<tr>
<td>THL</td>
<td>7-13-12</td>
<td>29</td>
<td>29</td>
<td>29</td>
<td>29</td>
<td>na</td>
</tr>
<tr>
<td>TL2</td>
<td>8-1-12</td>
<td>36</td>
<td>36</td>
<td>36</td>
<td>36</td>
<td>na</td>
</tr>
<tr>
<td>THL</td>
<td>8-17-12</td>
<td>31</td>
<td>31</td>
<td>31</td>
<td>31</td>
<td>31</td>
</tr>
<tr>
<td>TL2</td>
<td>9-6-12</td>
<td>60</td>
<td>No data</td>
<td>No data</td>
<td>60</td>
<td>na</td>
</tr>
<tr>
<td>THL</td>
<td>9-17-12</td>
<td>53</td>
<td>53</td>
<td>30</td>
<td>53</td>
<td>na</td>
</tr>
</tbody>
</table>
Fig. 1. Continuous in situ SRP measurements in western Lake Erie at the Toledo Channel Marker Light#2 mooring location from May – October, 2012.

Fig. 2. Continuous in situ Chlorophyll measurements in western Lake Erie at the Toledo Channel Marker Light#2 mooring location from May – October, 2012.
THEME IV: PROTECTION AND RESTORATION OF ECOSYSTEM RESOURCES: LINKING TO HUMAN DIMENSIONS

Funded projects, with no activity to date:

**PROJECT TITLE: IDENTIFYING LAND USE TIPPING POINTS THAT THREATEN GREAT LAKES ECOSYSTEMS**
THEME V: EDUCATION AND OUTREACH

CILER supports several activities that fall under the theme of Education and Outreach. Several of these activities are funded through Task 1 funding, including the Great Lakes Summer Student Fellows Program, the Longterm Fellows program, the CILER postdoctoral program, and the CILER-GLERL Great Lakes Seminar series. The year-to-date efforts of these projects are presented as follows:

TASK 1: 2013 GREAT LAKES SUMMER STUDENT FELLOWS PROGRAM

As part of its efforts to educate and train a new generation of research scientists, the Cooperative Institute will continue to administer the current Great Lakes Summer Student Fellows Program geared toward undergraduate and graduate students. The objective of this program is to train promising young scientists under the mentorship of a Great Lakes researcher. In turn, the program provides students the opportunity to work on a substantive research issue in the Great Lakes that supports CILER’s and NOAA’s research missions in the region. CILER will continue to build upon the success of the current program by continuing to promote it throughout the Great Lakes region to other institutes.

We offered 10 fellowship positions for the 2013 program. We advertised the program through our CILER communications network, which includes distribution to the CILER Council of Fellows, the CILER Management Council, the Great Lakes Information Network, and NOAA and university listserves. Similar to the last year’s program, we used an online web-based application to help streamline the process. For this year’s program, we also utilized the University of Michigan’s CTools platform. This allowed CILER administration to upload all applications to a safe and secured location and to allow all mentors (including NOAA employees) to view the application material. This seemed to enhance the ability to manage all of the application material and to streamline the review process. We exceeded our timeline, by reviewing and selecting fellows one week earlier than originally planned.

In terms of the program, we received 100 applications for the 10 positions. Most applicants were well qualified for the positions, and many positions had numerous competitive applicants. This year’s fellows and their projects are as follows:
2013 Great Lakes Summer Student Fellows  
Sponsored by UM-CILER and NOAA-GLERL

Kyle Beadle (University of Michigan), buoy dynamics analysis. Kyle will be working with Steve Ruberg on an analysis of buoy dynamics under various wave conditions, using Real-time Coastal Observation Network (ReCON) buoys that provide continuous observations of chemical, biological, and physical parameters.

Bryan Comer (SUNY College of Environmental Science and Forestry), hydrology and GIS analysis. Bryan will be working with Lauren Fry (CILER) and Drew Gronewold (GLERL) to assist NOAA-GLERL’s hydrological modeling team by conducting a quantitative assessment of the representation of the Great Lakes in hydrological and climatic sciences peer-reviewed literature.

Bridget Faust (University of Minnesota – Twin Cities), climate adaptation forum coordination. Bridget will be working with Heather Stirratt (NOAA-NWS) on coordinating efforts to address near-, mid-, and long-term management decisions in the Great Lake region to address climate adaptation.

Kiefer Forsch (Rutgers University), foodweb modeling. Kiefer will be working with Hongyan Zhang (CILER), Lori Ivan (CILER), Ed Rutherford (GLERL), and Doran Mason (GLERL) on using an ecosystem-based model to study the spatiotemporal impacts of remediation actions on the Lake Erie food web.

Nathan Kelly (Valparaiso University), hydrologic modeling. Nathan will be working with Lauren Fry (CILER) and Drew Gronewold (GLERL) to help advance the deployment of the National Weather Service’s Community Hydrologic Prediction System throughout Great Lakes watersheds by assisting with model calibration, simulations, and validation.

Aaron Letterly (University of Illinois at Urbana-Champaign), will be working with George Leschevich on improving satellite remote sensing products for the Great Lakes by contributing to the development of a long-term SST database using nighttime AVHRR thermal data and employing a developed compositing method to process the long-term satellite AVHRR data.
Heather Lucier (University of Michigan), physical oceanography. Heather will be working with Nathan Hawley (GLERL) on developing a program to help archive more than 25 years of data collected by acoustic Doppler current profilers, with potential application for other oceanographic observation instrumentation.

Thomas Makled (University of Michigan – Dearborn), invasive species database application. Thomas will be working with Rochelle Sturtevant (GLERL) to synthesize information on regulation and management of nonindigenous species in the Great Lakes for inclusion in the GLANSIS database.

Lisa Schneider (University of Hamburg), foodweb modeling and forecasting. Lisa will be working with Hank Vanderploeg (GLERL), Jia Wang (GLERL) and Mark Rowe (GLERL) to advance foodweb forecasting in the Great Lakes by linking a water quality and lower food web model (CE-QUAL-ICM) to a Finite Volume Coastal Ocean (FVCOM) hydrodynamic model.

David Wells (University of Michigan – Dearborn), fisheries and foodweb dynamics. Dave will be working with Ed Rutherford (GLERL) on evaluating the impacts of invasive species on Great Lakes fisheries and food webs by helping with intensive diel surveys in Lake Michigan.

------------------------------------------------------------------------------------------------------------

**TASK 1: 2013 LONGTERM FELLOWS**

**FELLOWSHIP #1: COMPARATIVE GENETICS OF INVASIVE FRONTS VERSUS ESTABLISHED POPULATIONS OF BIGHEAD AND SILVER ASIAN CARP**

*Principal Investigators:* Allen Burton (CILER), Carol Steprien (University of Toledo)

**Overview and Objectives**

Little is known about the fundamental population genetic variability underlying the spread of the invasive bighead (*Hypopthalmichthys nobilis*) and silver carp (*H. moitrix*) (referred herein collectively as Asian carp), which pose an invasive threat for the Great Lakes. Asian carp are large, voracious, and prolific planktivorous filter-feeders that were intentionally introduced to the southern U.S. for algae control in catfish farms, and then escaped in the 1970s to spread northward. They are now at the threshold of entering the Great Lakes watershed in several areas, including Lake Michigan near Chicago, IL and Lake Erie via the marshlands connecting the Wabash and Maumee Rivers around Ft. Wayne, IN.
Cheng et al. (2008) identified 16 polymorphic nuclear microsatellite loci for bighead carp, of which 11 were found to be polymorphic in silver carp, which will be used here for assaying their variation in North America. This funded project will analyze the genetic structure, diversity, and composition of three expansion sites and three longer-established sites for populations of bighead and silver carp. Expansion fronts will include (1) northward extent of the Illinois River (near southern Lake Michigan), (2) the Wabash River (the population approaching the Maumee River system near Fort Lakes), and (3) a site to be determined based upon the degree of threat to invade the Great Lakes.

The goals of this project are to use environmental (e) DNA from water samples and Next-generation sequencing (NGS) analysis to assay the presence/absence and relative abundances of all fish species (native and non-native). The assay includes all existing invasive species, as well as potential invaders. The eDNA water samples will be ground-truthed by statistical comparison with species and relative abundances from traditional sampling (netting and electrofishing) taken at the same time on the same dates. Specific project outcomes are:

1. Design and evaluate an inexpensive, easy-to-use assay for managers and other sciences to assess water for presence and abundance of high-risk invasive fish species using diagnostic eDNA markers
2. Help stop the introduction of new aquatic invasive species (AIS) in the Great Lakes through enhanced surveillance (e.g., ballast water and harbor samples) to facilitate rapid response actions
3. Develop technology and sampling methodology to use eDNA testing to control and reduce the spread of AIS already in the ecosystem and expedite critical management information

Thus far, we pinpointed the most informative small (<100bp) diagnostic sequence regions from two mitochondrial genes (barcode COI and cytochrome b) and the nuclear RAG1 gene to be used to identify and distinguish among 200 fish species. These gene regions contain diagnostic single nucleotide polymorphisms (SNPs) that will identify each species, and additionally will yield diagnostic haplotypes to elucidate relative variability within biological populations in the Great Lakes. We currently are testing primers that exclusively amplify these target marker sequence regions across all 200 fish species. Next-generation sequencing (NGS) assays and bioinformatic statistical algorithms will be used to determine the relative abundances of the target diagnostic sequence products from three genes for all fish species. By using 3 gene regions, we have built in redundancy to improve our estimates. In summer-fall 2012, Ohio DNR took water samples at their sampling sites across Lake Erie and rivers for us, which are stored at -80C in our laboratory. At those locations, the Ohio DNR netted and electrofished, thus providing us with identities and relative abundances to groundtruth our eDNA assay. A projected utility of this test will be to estimate fish species abundances using eDNA. We will be
comparing the relative abundances of species-specific molecular markers from water samples against fish population abundance estimates from traditional fish sampling methods (e.g., gillnets and electrofishing) to pioneer the use of eDNA for in estimating fish abundances.

Future work will examine the longevity of the target molecular markers in controlled laboratory and in situ environments. We will experimentally ascertain the effects of temperature and time after fish removal on the detection capabilities and performance of our assay.

Accomplishments
Carson Prichard was awarded the 2013 IAGLR Scholarship ($2,000) for his work on this project.

Publications
None to date.

Presentations
Prichard, Carson G., Blomquist T., Willey, James C., Sigler, V., & Stepien, Carol A. “Development of a Rapid eDNA test for Invasive Fish Species”, poster presentations given at:
(1) Ohio Fish and Wildlife Management Association annual meeting, February 2013, Ohio State University, Columbus, OH.
(2) Joint Ohio-West Virginia Chapters American Fisheries Society annual meeting, March 2013, Marshall University, Huntington, WV.
(3) International Conference on Aquatic Invasive Species, April 2013, Niagara Falls, ON.

Stepien, Carol A. Invited research seminar presentations on “Invasion Genetics: Tracing Pathways, eDNA, and Temporal Changes Across Aquatic Ecosystems”.
(1) Abu Dhabi Environmental Agency, January 22, 2013, Abu Dhabi, United Arab Emerites
(2) Department of Biological Sciences, University of Warsaw, January 25, 2013, Warsaw, Poland
(3) Department of Zoology, University of Tasmania, February 28, 2013, Tasmania, Australia
(4) Department of Zoology, University of Melbourne, March 5, 2013, Melbourne, Australia
(5) Victoria Museum, March 4, 2013, Melbourne, Australia

Outreach Activities:
Research presentation by Carson Prichard to undergraduate students of chapter of Beta Beta Beta National Biology Honorary Society at Hillsdale College in Michigan. April 16, 2013.

Relevant Websites:
http://www.utoledo.edu/nsm/lec/research/glgl/index.html
**Task 1: 2013 CILER Postdoctoral Fellows Program**

This program provides salary and research support for a post-doctoral fellow who will work closely with a CILER Management Council or Council of Fellows member on a project of mutual interest. The program is administered as a Task IC activity, because it will be a competitively awarded position based on funds that are not associated with a specific research project. All CILER Management Council and Council of Fellows members are eligible to participate in the program.

This year’s program was advertised as part of a larger University of Michigan post-doctoral program (see [http://graham.umich.edu/pdf/water-postdoc-rfp.pdf](http://graham.umich.edu/pdf/water-postdoc-rfp.pdf) for the RPF). We had applicants develop proposals in conjunction with a University or Federal researcher. Applications were then reviewed and the top 8 candidates were forwarded to the CILER Management Council for review and rankings. We were fortunate to be able to leverage funding from the new University of Michigan Water Center in order to support two positions. Based on these rankings, we awarded the following two post-doctoral candidates fully funded positions:

Ashley Baldridge who will begin her fellowship in 30-September 2013. She will be based at NOAA-GLERL, where she will work with an interdisciplinary group of researchers to understand how increasing water temperatures (and phenological shifts) may affect the dynamics between native and invasive species in Lake Michigan. Ashley’s postdoctoral work is co-funded by CILER and by the University of Michigan Water Center.

Peter Levi who will begin his fellowship in the late fall of 2013. He will be based at the University of Wisconsin - Madison, where he will work in Peter McIntyre’s lab. With his postdoctoral fellowship, Peter will assess how stream restoration affects the provisioning of ecosystem services in different sites in the Great Lakes basin. Peter’s position is fully funded through CILER.

**Task 1: 2013 CILER-GLERL Great Lakes Seminar Series**

As part of its efforts to achieve its scientific vision and its education and outreach missions, CILER proposes to continue sponsoring and coordinating a joint CILER-GLERL Seminar Series. This series brings in regional, national, and international researchers to talk about pertinent new and emerging scientific issues to GLERL, the University of Michigan, and to other universities and sites within the Great Lakes
region. These events will facilitate collaborations between researchers, provide an educational opportunity for NOAA and university scientists, and serve as an outreach forum for stakeholders and the general public to attend.

To date, we have brought in two speakers as part of this seminar series:

Dr. Kevin Strychar who came to NOAA-GLERL on 4-April 2013 to speak on Avian botulism, invasive carp, Cryptosporidium, & Giardia: Better management strategies using real-time underwater instruments. Dr. Kevin Strychar is a marine microbiologist with a specialty in climate science. His research focuses on the biological implications of climate change, such as the effects of warming temperatures on the spread of both invasive species and aquatic-born diseases and pathogens. Dr. Strychar is an Associate Professor at the Anis Water Resources Institute at Grand Valley State University in Muskegon MI.

Dr. Clare Robinson who came to NOAA-GLERL on 21-February 2013 to speak on The influence of groundwater-lake interactions on nearshore water quality in the Great Lakes. Abstract: Pollution of the near-shore waters of the Great Lakes is an increasingly serious problem due to rapid urbanization, the intensification of agriculture and industry and increasing pollutant toxicity. While the contribution of surface water inputs to nearshore water pollution is generally well characterized, the groundwater pathway is often poorly understood. Predicting groundwater-derived pollutant loading rates is complex as loading is controlled not only by the specific pollutant sources, groundwater flow paths but also by biogeochemical processes occurring near the groundwater-lake interface. Lake hydraulics (seasonal lake-level variations, waves, seiches) cause dynamic water exchange across the groundwater-lake interface and this leads to the creation of important biogeochemical zonations (pH and redox) that strongly control the fate of discharging pollutants. Field data is presented from a sandy beach on Lake Erie that examines the effect of waves on the transport and accumulation of heavy metals in beach groundwater and subsequent heavy metal discharge to nearshore waters. The implications of dynamic groundwater-lake interactions on nutrient and bacteria transport from groundwater to near-shore waters will also be discussed. Dr. Robinson is an Assistant Professor in the Department of Environmental Engineering at the University of Western Ontario.

Finally, to better coordinate research efforts between the University of Michigan and NOAA-GLERL, we are co-sponsoring a big event on campus to highlight issues associated with low Great Lakes water levels. This event will be held 30-May 2013 and will include a webcast option to allow for regional outreach to a broad audience (see http://sustainability.umich.edu/events/low-great-lakes-water-levels-understanding-
causes-and-potential-consequences for details). The University of Michigan is providing the facilities and webcast support, and the event will feature researchers from both NOAA-GLERL and the University of Michigan. Depending on the feedback about this event, we hope to plan more of these multi-speaker panel events in the future.
THEME V: EDUCATION AND OUTREACH

PROJECT TITLE: PENN STATE UNIVERSITY SEA BASS 2012: A MARINE BIOACoustICS SUMMER SCHOOL

Principal Investigators: Allen Burton (CILER), Jennifer Miksis-Olds (Pennsylvania State University)
NOAA Technical contacts: Doran Mason (NOAA-Great Lakes Regional Collaboration)

Overview and Objectives:
Marine bioacoustics is an interdisciplinary field that includes biologists, engineers, oceanographers, and ecologists. The integration of knowledge from these different disciplines has led to the study of marine animal sound production, sound reception, vocal communication, response to both natural and human events, and the interaction of marine animals within the ecosystem. Given these diverse backgrounds, there is currently no single educational program in the country with the resources to provide background on the variety of topics in the field of marine bioacoustics.

The goal of the SeaBASS (Marine BioAcoustics Summer School) program is to provide opportunity for graduate students interested in pursuing careers in marine bioacoustics to develop a strong foundation in both marine animal biology and acoustics, foster technical communication across disciplines, and develop professional relationships within the field. SeaBASS was structured after the successful PASS (Physical Acoustics Summer Session) that has been offered in alternate years for over two decades. SeaBASS was designed to support 30 graduate students and 10 expert lecturers. A week long curriculum was created where invited lecturers within the field of marine animal bioacoustics (academic, private, and management) provided half day seminars that described fundamental aspects of underwater sound and marine animal behavior, summarized the present state of the field, identified current obstacles and challenges, and discussed important “hot topics” areas.

Accomplishments:
SeaBASS was hosted by the Applied Research Laboratory at The Pennsylvania State University. The week long summer session took place June 17-22, 2012 at the Penn State Conference Center in State College, PA. Selection of student participants was through an open application process. The application process was online (http://www.arl.psu.edu/education_seabass.php), and preference was given to US
citizens. Thirty-one graduate student applicants were admitted to the program from 64 eligible applications. Applications were received from graduate students in 13 countries, and course attendees were accepted from six different countries (USA & Puerto Rico, Italy, United Kingdom, Greece, Canada, and Austria).

NOAA funds contributed support for conference facility fees and travel grants to graduate student applicants based upon need and qualifications. Twenty three travel grants were awarded to defray costs of graduate student travel. Invited lecturers provided their time at no cost. Additional sponsors of the SeaBASS program included the Applied Research Laboratory at Penn State, the Office of Naval Research, Bureau of Ocean Energy Management (BOEM), and the Acoustical Society of America (ASA).

Upon completion of the program, students were asked to complete a survey of the program and their experience. Based on a scale of 1-5, where 1 is poor and 5 is excellent, the students responded as follows:

<table>
<thead>
<tr>
<th>5. Please rate the following aspects of the program on a scale of 1-5, where 1 is extremely poor and 5 is excellent.</th>
<th>Poor</th>
<th>Below Average</th>
<th>Average</th>
<th>Good</th>
<th>Excellent</th>
<th>N/A</th>
<th>Rating Average</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application process</td>
<td>0.0% (0)</td>
<td>0.0% (0)</td>
<td>0.0% (0)</td>
<td>11.5% (3)</td>
<td>73.1% (19)</td>
<td>15.4% (4)</td>
<td>4.88</td>
<td>26</td>
</tr>
<tr>
<td>Number of participants</td>
<td>0.0% (0)</td>
<td>0.0% (0)</td>
<td>0.0% (0)</td>
<td>19.2% (5)</td>
<td>76.9% (20)</td>
<td>3.8% (1)</td>
<td>4.80</td>
<td>26</td>
</tr>
<tr>
<td>Length of program</td>
<td>0.0% (0)</td>
<td>0.0% (0)</td>
<td>3.8% (1)</td>
<td>30.8% (6)</td>
<td>61.5% (10)</td>
<td>3.8% (1)</td>
<td>4.60</td>
<td>26</td>
</tr>
<tr>
<td>Length of sessions</td>
<td>0.0% (0)</td>
<td>0.0% (0)</td>
<td>11.5% (3)</td>
<td>42.3% (11)</td>
<td>42.3% (11)</td>
<td>3.8% (1)</td>
<td>4.32</td>
<td>26</td>
</tr>
<tr>
<td>Topics covered</td>
<td>0.0% (0)</td>
<td>0.0% (0)</td>
<td>0.0% (0)</td>
<td>30.8% (8)</td>
<td>65.4% (17)</td>
<td>3.8% (1)</td>
<td>4.68</td>
<td>26</td>
</tr>
<tr>
<td>Activities</td>
<td>0.0% (0)</td>
<td>3.8% (1)</td>
<td>3.8% (1)</td>
<td>38.5% (10)</td>
<td>50.0% (13)</td>
<td>3.8% (1)</td>
<td>4.40</td>
<td>26</td>
</tr>
</tbody>
</table>

Students also provided the following feedback about the program:

*The week was totally awesome and I wish I could come back!!! How about a SeaBASS II for*
alumni?

All of the instructors were fantastic and I learned so much from this experience.

Thank you for organizing this course. It was an amazing opportunity to gain experience with underwater bioacoustics.

Thank you to Jen and Susan for organising this amazing week, I can’t imagine how many hours of effort it required; nor can I begin to show how valuable of an experience it was for me. Thank you to the lecturers for giving up their time - it was honestly appreciated by us all. I hope one day to be able to donate my time to teach on such a course (fingers crossed!).

Thank you so much for putting this on. It will be many years before another conference stack up to this one!

With only enthusiastic and intelligent students, as well as incredibly knowledgeable presenters, I can honestly say that I learned more in one week than I did in either of my first two quarters of graduate school.

**Publications:**
None to date, but see website below for specific details from the summer school.

**Presentations:**
None to date.

**Outreach Activities:**
A key outcome from the SeaBASS program is the continued effort to keep the participants actively engaged in a network of researchers. The SeaBASS program allowed for extended interaction and discussion by students with each other and with leaders in the field of marine bioacoustics to define current and future research priorities and directions in the field. Evidence of the connections and collaborations made during SeaBASS 2012 is demonstrated by a SeaBASS student initiated, online networks on Facebook (30 members) ([https://www.facebook.com/groups/192730237521891/](https://www.facebook.com/groups/192730237521891/)). This is in addition to the SeaBASS 2010 networks on Facebook ([http://www.facebook.com/#!/group.php?gid=133952333289137&v=wall&ref=ts](http://www.facebook.com/#!/group.php?gid=133952333289137&v=wall&ref=ts)) and LinkedIn ([http://www.linkedin.com/groups?mostPopular=&gid=3186754](http://www.linkedin.com/groups?mostPopular=&gid=3186754)). Subscribers have been using the online resources to exchange research ideas, seek feedback, solicit
Matlab help, exchange information on upcoming conferences, and explore research funding opportunities.

**Relevant Websites:**
SeaBASS BioAcoustics Summer School website, including agenda and program:

http://www.arl.psu.edu/education_seabass.php
APPENDIX 1: Publication Count by year and Grand Total to date for both previous and under the new Cooperative Agreement.

Peer-Reviewed Publications

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CILER</td>
<td>16</td>
<td>8</td>
<td>7</td>
<td>10</td>
<td>10</td>
<td>12</td>
<td>19</td>
<td>14</td>
<td>36</td>
<td>15</td>
<td>8</td>
</tr>
<tr>
<td>Lead</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NOAA</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>7</td>
<td>3</td>
<td>4</td>
<td>33</td>
<td>24</td>
<td>10</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>Lead</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>12</td>
<td>10</td>
<td>3</td>
<td>6</td>
<td>13</td>
<td>29</td>
<td>38</td>
<td>0</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>Lead</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>21</td>
<td>22</td>
<td>21</td>
<td>13</td>
<td>19</td>
<td>29</td>
<td>81</td>
<td>76</td>
<td>46</td>
<td>42</td>
<td>19</td>
</tr>
</tbody>
</table>

Non-peer Reviewed Publications

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CILER</td>
<td>7</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>3</td>
<td>123</td>
<td>67</td>
<td>N/A</td>
</tr>
<tr>
<td>Lead</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NOAA</td>
<td>4</td>
<td>6</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>64</td>
<td>30</td>
<td>N/A</td>
</tr>
<tr>
<td>Lead</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>11</td>
<td>11</td>
<td>56</td>
<td>N/A</td>
</tr>
<tr>
<td>Lead</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>11</td>
<td>7</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>7</td>
<td>0</td>
<td>17</td>
<td>198</td>
<td>153</td>
<td></td>
</tr>
</tbody>
</table>
## APPENDIX 2: Employee Count.

**Summary of Joint Institute Staff by Head Count 2012-2013 (Includes subcontracts)**

<table>
<thead>
<tr>
<th>Category</th>
<th>Number</th>
<th>B.S.</th>
<th>M.S.</th>
<th>Ph.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research Scientists</td>
<td>22</td>
<td>0</td>
<td>0</td>
<td>22</td>
</tr>
<tr>
<td>Visiting Scientists</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Postdoctoral Research Fellows</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Research Support Staff</td>
<td>13</td>
<td>3</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>Administrative</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Undergraduate Students</td>
<td>9</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Graduate Students</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td><strong>Totals (≥ 50% support)</strong></td>
<td>29</td>
<td>4</td>
<td>7</td>
<td>18</td>
</tr>
<tr>
<td><strong>Totals (≤ 50% support)</strong></td>
<td>10</td>
<td>5</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Located at NOAA Lab</td>
<td>19-GLERL</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obtained NOAA employment</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Publications


Rockwell, D.C.; K.B. Campbell; G.A. Land; D.J. Schwab; G. Mann; R. Wagenmaker. 2013. Beach water quality decision support system. NOAA Technical Memorandum GLERL-156. NOAA, Great Lakes Environmental Research Laboratory, Ann Arbor, MI, 64 pp.


