



## DEPARTMENT OF COMMERCE RESEARCH PERFORMANCE PROGRESS REPORT (RPPR)

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| AWARD INFORMATION   |   |
|---|---|
| 1. Federal Agency:<br>Department of Commerce / NOAA   | 2. Federal Award Number:<br>NA17OAR4320152  |
| 3. Project Title:<br>The Cooperative Institute for Great Lakes Research (CIGLR): A Proposal to the Office of Oceanic and Atmospheric Administration |   |
| 4. Award Period of Performance Start Date:<br>07/01/2017  | 5. Award Period of Performance End Date:<br>06/30/2022  |
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| 16. Submission Date and Time Stamp:<br>07/02/2019   | 17. Reporting Period End Date:<br>03/31/2019  |
| 18. Reporting Frequency:<br><br><input checked="" type="radio"/> Annual<br><input type="radio"/> Semi-Annual<br><input type="radio"/> Quarterly     | 19. Report Type:<br><br><input checked="" type="radio"/> Not Final<br><input type="radio"/> Final |
| RECIPIENT ORGANIZATION  |   |
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## ACCOMPLISHMENTS

### 24. What were the major goals and objectives of this project?

The Cooperative Institute for Great Lakes Research was established in 2017 to accelerate NOAA's mission to conserve and manage natural resources in the Great Lakes. The University of Michigan School for Environment and Sustainability (SEAS) serves as the host and administrative lead for CIGLR. Consisting of a Research Institute and a Regional Consortium, CIGLR is a partnership between NOAA, universities, NGOs, and businesses.

CIGLR's mission is to lead exciting new research, train the next generation of scientists, and turn research into action for safe and healthy Great Lakes communities. The following goals are designed to achieve this mission:

1. Research institute. CIGLR operates a productive research institute that complements NOAA GLERL's workforce with a highly-skilled, permanent group of research scientists, technicians, and staff that is fully integrated in GLERL's scientific enterprise and serves to expand GLERL's research expertise.
2. Regional consortium. CIGLR expands GLERL's intellectual capacity and research infrastructure by building strong partnerships with universities, NGOs, and private-sector partners who share similar research and management goals in the Great Lakes. Consortium partners include 12 universities and 7 private sector organizations that collaborate with CIGLR and NOAA GLERL to conduct research, transition research to operations, and engage with stakeholders. Regional Consortium partners include: Central Michigan University, Cornell University, Grand Valley State University, Lake Superior State University, University of Michigan, Michigan State University, Michigan Technological University, University of Minnesota-Duluth, Ohio State University, University of Windsor, University of Wisconsin-Milwaukee, Wayne State University, Cleveland Water Alliance, Fondriest Environmental, Great Lakes Environmental Center, LimnoTech, Michigan Environmental Council, The Nature Conservancy, National Wildlife Federation.
3. Science translation. CIGLR helps translate NOAA research in the Great Lakes into action-oriented, science-based products that meet the needs of end-user stakeholders like natural resource managers, businesses, public utilities, and citizen users of data.
4. Engagement (ECO Program). CIGLR supports informed decision making by working directly with legislators, resource managers, and other stakeholders to develop the research programs, tools, and information needed for decision making that promotes sustainability in the Great Lakes. We work directly with those who rely on our research tools and products to facilitate the co-production of research outcomes.
5. Career development (ECO Program). CIGLR fosters the development of a diverse, skilled workforce by providing career training for undergraduates, graduate students, and postdoctoral fellows who will become the next generation of NOAA and Great Lakes scientists. We strive to shape a workforce that is not only skilled in NOAA mission-related research priorities, but also one that is rich in diversity in an inclusive environment.

### 25. What was accomplished under these goals?

CIGLR's major research activities for the period are organized by theme. ECO Program accomplishments are summarized in Sections 27, 39, and 43.

#### Theme 1. Observing systems & advanced technology

We deployed buoys on Lakes Michigan, Huron, and Erie to continuously monitor ecosystem parameters and support model development/validation. Episodic hypoxia detected in Saginaw Bay (L. Huron) was the most severe in our observational data record. Remote sensing showed lower HAB areal extent in Lake Erie than the previous year, but higher than 2002-2010. Lake Michigan buoys were programmed to collect meteorological data for meteotsunami research. We completed 24 weekly HAB monitoring cruises in Lake Erie and Saginaw Bay to generate data for stakeholders and HAB/hypoxia forecast models. ESPNiagara was deployed twice in Lake Erie for in situ toxin analysis. We received 2 new ESP units and prepared them for deployment, and worked with MBARI to develop and test a miniaturized 3G ESP that fits in a long-range AUV.

#### Theme 2. Invasive species & food-web ecology

We continued fundamental research on ecosystem processes to better understand food web dynamics and the impacts of invasive species. For the Lake Michigan Long Term Ecological Research program, we conducted benthic surveys at 46 sites, surveyed invasive mussel populations, and collected monthly monitoring measurements. We also conducted benthic surveys and invasive mussel growth experiments as part of the Lake Ontario CSML. We are using genomic techniques to understand invasive mussel impacts on HABs by identifying genetic traits within Microcystis strains that allow it to resist mussel grazing.

#### Theme 3. Hydrometeorological & ecosystem forecasting

We supported the current operational HAB forecast by evaluating, validating, and modifying the Lake Erie HAB Bulletin operated by NOAA NOS and the development of an improved 3D HAB Tracker forecast model. We evaluated a method to incorporate toxin data into the forecasts to produce a probability of exceeding toxin threshold levels. A demonstration version of a Saginaw Bay HAB Tracker was developed.

We developed new models to improve Great Lakes water balance estimates and water level simulations. We created historical datasets that explain observed water level changes and produced the first comprehensive Great Lakes water balance estimate. These new models replace the current Coordinated Great Lakes Regulation and Routing Model. Other water level model development was applied to Lake Champlain, where an FVCOM-based model is being used to forecast floods.

We advanced lake effect snow and ice forecasting by linking hydrodynamic and atmospheric forecast models. Snow water equivalent simulations were improved in comparison with the NWS operational Snow Data Assimilation System (SNODAS). We also developed the Great Lakes FVCOM-CICE model for transition to operations at NOS CO-OPS, providing the first short-term ice forecast

*Attach a separate document if more space is needed for #6-10, or #24-50.*

## ACCOMPLISHMENTS (cont'd)

### 26. What opportunities for training and professional development has the project provided?

The updated CIGLR Employee Handbook includes a section on professional and career development that identifies the expectations, evaluation processes, and resources available to each group of employees: Research Scientists, Postdoctoral Fellows, and Research/Administrative Staff.

For Research Scientists, CIGLR provides support to achieve scholarly publication goals, establish a successful funding record, mentor students, engage in professional service, and develop a public or policy engagement program that complements their research. CIGLR offers professional development opportunities and mentoring to help ensure the success of Research Scientists, including regular meetings with CIGLR leadership, internal review of publications and proposals, mock panels for proposal review, and internal review of promotion portfolios.

Postdoctoral Fellows employed by CIGLR develop and follow an Individual Development Plan (IDP) that includes a statement of career goals, experience and products needed to achieve career goals, an outline of how the fellow will attain them, and a timeline for success. Postdoctoral Fellows develop a research proposal that includes clear hypotheses with testable predictions, with guidance to ensure it is sufficiently detailed to produce a successful research product. Postdoctoral Fellows are also provided the support and resources already described for Research Scientists, and receive coaching on the job application and interview process. During the reporting period, 2 new postdocs developed IDPs and research proposals, while one 2nd-year postdoc received continued career coaching toward fulfilling IDP goals.

Research/Administrative Staff develop an annual goal setting and development plan tailored to their job responsibilities, individual career aspirations, and development needs. Each development plan must include at least one training activity and a science dissemination goal, such as a conference presentation or authoring a manuscript/technical report.

All CIGLR employees have access to professional development resources offered by the University of Michigan, such as grant writing workshops, short courses on topics such as career development and leadership, and statistics and data science workshops. CIGLR and the University of Michigan School for Environment and Sustainability provide financial support to cover fees associated with professional development activities.

During the reporting period, CIGLR supported the following professional development activities

- Research staff, students, and postdocs presented 40 oral or poster presentations at scientific conferences and workshops
- Staff authored 12 peer-reviewed articles
- Staff attended the following training courses/workshops
  - 2019 NOAA Ocean Satellite Data Course (Juneau, AK)
  - WPE Hydro training course at NCAR (Boulder, CO)

### 27. How were the results disseminated to communities of interest?

The Outreach & Communications element of the ECO Program is designed to translate and disseminate CIGLR research outcomes at local, state, regional, national, and international scales to support informed decision making, increase interest in Great Lakes science careers, and promote a culture of Great Lakes stewardship. Our key messages are formulated using input gathered from CIGLR leadership and principal investigators, and modified as needed for target audiences. CIGLR's target audiences include the CIGLR Regional Consortium, NOAA (e.g., GLERL, CIPO, OAR, GLRCT), other NOAA Great Lakes programs (e.g., Sea Grant, GLOS, GLISA), the general public, news media, and stakeholders (e.g., resource managers, industry, government officials).

We work with our Regional Consortium partners, NOAA GLERL, and other NOAA programs to expand our outreach and communications efforts across the Great Lakes basin. Our continued participation in NOAA communications and outreach groups allows us to coordinate our efforts with NOAA programs across the basin, resulting in broader impact, cohesive messaging, and increased visibility for NOAA in the Great Lakes. We are active members of the GLERL Information Services Communications Group, along with the other collocated NOAA programs – GLOS and Michigan Sea Grant. We also participate in monthly meetings of the NOAA Great Lakes Regional Collaboration Team (GLRCT) Communications and Outreach Working Group, composed of representatives from CIs, NOAA Line Offices, Great Lakes Sea Grant Network, and GLOS. We are also connected with the OAR Communications and Outreach Working Group, and participate in their monthly nationwide conference calls.

We estimate that CIGLR's Outreach & Communications efforts have reached more than 800,000 people during this reporting period through the activities described below. CIGLR's primary communication methods include:

- CIGLR website – 126K average hits/month over this period
- Social media – 5K followers across all platforms (Twitter, Facebook, Instagram)
- You Tube – 24 original videos featuring CIGLR research projects, staff profiles, and summer fellow highlights
- Flickr – 1,365 publically-available photos with descriptive captions, in 15 subject-matter albums
- CIGLR Quarterly e-newsletter – 4 produced this period, 584-person distribution list, 40% open rate
- CIGLR Minute videos – 7 produced this period and shared on social media, the CIGLR website, and You Tube
- NOAA OAR Hot Items – 3 articles contributed this period
- News media – 63 news stories featured CIGLR and our research this period

CIGLR's outreach activities center on interactive informational tables at community events and scientific conferences. We had tables at 7 outreach events and reached an estimated 17K people this period. To broaden our outreach across the Great Lakes, we provide Regional Consortium partners with funds to support undergraduate or graduate students who incorporate a public outreach or education component into their work. This period, we funded a journalism student at Michigan State University who wrote a series of news articles on CIGLR research.

In addition to outreach and communications activities within the ECO Program, research projects produce scholarly publications, technical reports, and conference presentations that disseminate results to a scientific audience, as well as informational and data-

*Attach a separate document if more space is needed for #6-10, or #24-50.*

## ACCOMPLISHMENTS (cont'd)

### 28. What do you plan to do during the next reporting period to accomplish the goals and objectives?

As we complete Year 2 research and ECO Program activities, we are preparing for both new and continuing efforts in Year 3. We have submitted 25 research proposals totaling \$5.6M under our Cooperative Agreement for Year 3, including new projects related to the NOAA Omics Roadmap, Lake Erie Coordinated Science Monitoring Initiative, and hydrological modeling within the National Water Model framework to improve the NWS Runoff Risk model. Research projects continuing into their third year of funding include those related to monitoring and forecasting HABs, real-time observing systems, long-term ecological research in Lake Michigan, impacts of invasive mussels, ice forecasting, and Lake Champlain flood forecasting. We expect further expansion in research areas associated with 'omics and biophysical modeling, with the recent hire of two new Research Scientists that specialize in those areas.

We will continue to foster collaborative research and infrastructure sharing with the Regional Consortium, specifically through holding our third annual All Partners meeting, issuing our annual call to partners for programmatic funding, and continuing to make connections between partners and NOAA scientists. The 1.5-day annual meeting includes research update presentations by GLERL, CIGLR, and funded partners, a poster session featuring (at a minimum) all funded students and postdocs, and opportunities for networking and discussion. Our annual call for partner funding proposals includes postdoc fellowships, graduate student fellowships, summits and working groups, rapid response funding, ECO funding, and summer student fellowships.

In the ECO Program, we will continue our ongoing engagement, career training, and outreach and communications activities and implement plans to expand some of our efforts. CIGLR is producing our first annual magazine, titled Ripple Effect, during the next period. The magazine provides a review of research and ECO Program activities from the previous year and communicates research outcomes. We plan to expand our science-policy engagement activities by serving as co-organizers of the annual Healing Our Waters conference, bringing a strong science focus to the already robust policy and engagement expertise of the leads from the National Wildlife Federation. We plan to roll out a new section of the CIGLR website geared for stakeholders that collects and interprets CIGLR research projects in a clear and understandable fashion. In our career training program, we plan to make changes to our summer fellowship program to make it more accessible for minority students, including offering housing and other financial incentives.

## PRODUCTS

### 29. Publications, conference papers, and presentations

CIGLR peer-reviewed publications, non-peer reviewed publications, and presentations from July 1, 2017-March 31, 2019 are included in the attachment Appendix 2 – Products. All peer-reviewed publications since July 1, 2017 will be added to the NOAA Institutional Repository by July 31, 2019 in accordance with the CIGLR Specific Award Condition Handling of Environmental Data or Peer-Reviewed Publications.

Other products during the reporting period include the following websites, which were developed as part of CIGLR projects to provide access to CIGLR data and data products, or utilize CIGLR data/data products:

#### CIGLR parent

- <https://cigl.seas.umich.edu/> - CIGLR website that gives information on our organization, partners, staff, research, programs, job openings, events, fellowships, and more
- <https://cigl.seas.umich.edu/products/> - CIGLR products landing page

#### HABs Monitoring, Forecasting and Genomics for the Great Lakes

- [https://www.glerl.noaa.gov/res/HABs\\_and\\_Hypoxia/habsMon.html](https://www.glerl.noaa.gov/res/HABs_and_Hypoxia/habsMon.html) - current and historical monitoring data for western Lake Erie and Saginaw Bay, including real-time buoy data
- [https://www.glerl.noaa.gov/res/HABs\\_and\\_Hypoxia/habTracker.html](https://www.glerl.noaa.gov/res/HABs_and_Hypoxia/habTracker.html) - experimental Lake Erie Harmful Algal Bloom (HAB) Tracker
- <http://accession.nodc.noaa.gov/0187718> - monitoring data report

#### Environmental Modeling: Integrating Community and Operations

- <http://ufs-dev.rap.ucar.edu/index.html> - A prototype web portal was developed for the Unified Forecast System and released for review

#### Implementation of the GLOS Buoy and Mobile Platform Observing Systems

- <https://glbuoys.glos.us/> - Great Lakes Buoy Portal for the Great Lakes Observing System, allows access to real-time and archived data
- <https://www.ndbc.noaa.gov/> - National Data Buoy Center allows access to real-time and archived data

#### Synthesis, Observations, and Response (SOAR)

- <http://greatlakesremotesensing.org/> - hosts Michigan Tech Research Institute (MTRI) color-producing agent algorithm (CPA-A) derived products for all five Great Lakes
- <http://webserver.mtri.org/wordpress/habsmapping/> - contains harmful algal bloom (HAB) maps for western basin Lake Erie, Green Bay, and Saginaw Bay
- [glopqd.org](http://glopqd.org) - GLOPGD contains historic Great Lakes inherent optical properties (IOP) data

*Attach a separate document if more space is needed for #6-10, or #24-50.*

**PRODUCTS (cont'd)**

**30. Technologies or techniques**

As part of the project "Advancement of Mobile, In-situ HAB Toxin Warning and Genomic Observation for Great Lakes Decision Support Tools," GLERL and CIGLR in collaboration with NOAA National Centers for Ocean Coastal Science (NCCOS), and Monterey Bay Aquarium Research Institute (MBARI) have supported the development of new mobile, in-situ harmful algal bloom (HAB) detection technology that will facilitate toxin forecasting and genomic observations at much improved temporal and spatial scales in support of informed decision making. Engineering advances for the 3rd generation Environmental Sample Processor (3G ESP) include miniaturizing the in-situ sample processing capabilities of the 2G ESP for algal toxin detection and DNA archival to fit into the payload of a Tethys-class long-range autonomous underwater vehicle (LRAUV). The resulting 3G ESP-LRAUV prototype will enable adaptive biological sampling over weeks-long targeted missions. In this project, a major activity during 2018 was a deployment of mobile, autonomous assets designed for microcystin detection in western Lake Erie. In this CIGLR project, MBARI has developed both the 3G ESP and the LRAUV. The marriage of these two technologies provides mobile, autonomous sampling capabilities in aquatic environments, and this project was the first to test the technology in freshwater. The autonomously collected samples have been processed and are currently undergoing high-throughput sequencing at University of Michigan's Core sequencing facility for genetic analysis .

With University of Michigan cost-share funding, CIGLR awarded Consortium partner LimnoTech Rapid Response funds for a project titled "Enhanced monitoring and data management to support meteotsunami research and detection." In response to the need for a more robust monitoring and alert system to detect and mitigate the impact of future meteotsunami events, LimnoTech developed a meteotsunami monitoring network in Lakes Michigan and Erie to detect significant atmospheric conditions that could lead to meteotsunami events. The monitoring network consists of 25 stations that are able to report air pressure observations at one minute intervals to a custom postgres database real-time. NOAA GLERL plans to build a notification system on top of the database, thus creating an early warning system for meteotsunami events in Lakes Michigan and Erie.

**31. Inventions, patent applications, and/or licenses**

See attached.

## PRODUCTS (cont'd)

### 32. Other products

#### MAPS:

- GLANSIS Map Explorer <https://www.glerl.noaa.gov/glansis/mapExplorer.php>
- CoastWatch Great Lakes regional map products <https://coastwatch.glerl.noaa.gov>

#### MODELS (by project):

##### Lake Champlain Hydrodynamic Flood Forecasting System

- WRF-Hydro hydrological model of Lake Champlain-upper Richelieu River basin developed and tested
- FVCOM-based Lake Champlain hydrodynamic model developed and tested

##### Synthesis, Observations, and Response (SOAR)

- Color Producing Agent Algorithm (CPA-A)
- HAB extent and duration time series for Lake Erie and Saginaw Bay
- CIGLR Postdoc Fellowship: Development of a gene-based model of toxin production by *Microcystis aeruginosa* in Lake Erie
- Expanded the LimnoTech Western Lake Erie Ecosystem Model (WLEEM) to have an additional active phytoplankton class, allowing for diatoms, green algae, and two cyanobacteria to be modeled simultaneously
- Produced a Neo4j native graph database that includes comparative *Microcystis* genomics data, environmental sampling data, and isolate strain data

##### Water level forecasts: Improving water level models for shipping and commerce

- Operational Great Lakes water balance model <https://www.glerl.noaa.gov/data/WaterBalanceModel/>
- Great Lakes water level data-handler
- Implementation of the FVCOM-Ice model for the Great Lakes Operational Forecasting System (GLOFS)
- FVCOM-CICE based Great Lakes Operational Forecast System models were developed and validated for all five lakes for transition from research to operations at NOS CO-OPS
- Development of a Coupled Hydrodynamic-Wave Model using FVCOM and WAVEWATCH III
- WaveWatch III model developed and implemented for Lake Erie

#### NEWS ARTICLES (selected from >65 news stories):

##### Cooperative Institute

- Between government shutdowns? Great Lakes researchers struggle to carry on, Great Lakes Echo, 2/7/2019
- Federal shutdown hits UM-affiliated environmental studies, Crain's Detroit Business, 1/23/2019
- Six things to know about the federal government shutdown in Michigan\_Bridge\_1/18/2019

## PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS

### 33. What individuals have worked on this project?

#### CIGLR Administration

Bradley Cardinale, Director, University of Michigan  
Thomas Johengen, Associate Director, University of Michigan  
Mary Ogdahl, Program Manager, University of Michigan

#### CIGLR Research Institute Principal Investigators

Dmitry Beletsky, Research Scientist, University of Michigan  
Ayumi Fujisaki-Manome, Assistant Research Scientist, University of Michigan  
Casey Godwin, Assistant Research Scientist, University of Michigan  
Thomas Johengen, Research Scientist, University of Michigan  
Mark Rowe, Assistant Research Scientist, University of Michigan  
Hongyan Zhang, Assistant Research Scientist, University of Michigan

**PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS (cont'd)**

34. Has there been a change in the active other support of the PD/PI(s) or senior/key personnel since the last reporting period?

Changes in senior personnel during the reporting period include a shift in CIGLR's principal investigators. Dr. Mark Rowe was hired by NOAA GLERL in October 2018 as a Research Physical Scientist to continue biophysical modeling research related to harmful algal blooms and hypoxia. Dr. Hongyan Zhang left CIGLR in March 2019 to open a private consulting firm specializing in aquatic research. Concurrently, CIGLR received support from the School for Environment and Sustainability at the University of Michigan to hire 3 new Assistant Research Scientists to serve as principal investigators in the areas of aquatic ecology, biophysical modeling, and 'omics. Dr. Casey Godwin was hired in June 2018 and is focusing on research involving the effects of nutrient abundance and forms on harmful algal blooms and the influence of hypoxia on the biogeochemical cycling of nutrients and heavy metals in Lake Erie. Recruiting for the other two Assistant Research Scientist positions occurred during December 2018 – March 2019, concluding with the hires of Dr. Rao Chaganti ('omics) and Dr. Michael Fraker (biophysical modeling) who both begin work with CIGLR in the next reporting period.

35. What other organizations have been involved as partners?

Consortium lead investigators (CIGLR Council of Fellows reps)

John Bratton, LimnoTech  
Patrick Doran, Nature Conservancy  
Aaron Fisk, University of Windsor  
Steve Fondriest, Fondriest Environmental  
Donna Kashian, Wayne State  
Val Klump, University of Wisconsin Milwaukee  
Maria Lemos, University of Michigan  
Phani Mantha, Michigan State University  
Dennis McCauley, Great Lakes Environmental Center  
Guy Meadows, Michigan Tech  
Ashley Moerke, Lake Superior State  
Mike Murray, National Wildlife Federation  
Lars Rudstam, Cornell University  
Al Steinman, Grand Valley State University  
Bob Sterner, University of Minnesota Duluth  
Bryan Stubbs, Cleveland Water Alliance  
Don Uzarski, Central Michigan University  
Chris Winslow, Ohio State University  
Tom Zimnicki, Michigan Environmental Council

CIGLR Executive Committee

Bradley Cardinale – Director, CIGLR, University of Michigan (Ex-Officio)  
Carl Gouldman – Director, U.S. IOOS Office, NOAA National Ocean Service  
Deborah Lee – Director, NOAA GLERL (Ex-Officio)  
Brad Orr – Associate VP, Natural Sciences and Engineering, University of Michigan  
Jonathan Overpeck – Samuel A. Graham Dean, School for Environment and Sustainability, University of Michigan  
Steven Thur – Director, National Centers for Coastal Ocean Science, NOAA National Ocean Service

Subawardees

*Attach a separate document if more space is needed for #6-10, or #24-50.*

**PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS (cont'd)**

36. Have other collaborators or contacts been involved?

Significant NOAA collaborators included:

Eric Anderson, GLERL  
Philip Chu, GLERL  
Jennifer Day, GLERL  
Ashley Elgin, GLERL  
Jesse Feyen, GLERL  
Dustin Goering, NWS  
Lucas Harris, GFDL  
Nic Kinsman, NGS  
Deborah Lee, GLERL  
Shian-Jiann Lin, GFDL  
Brent Lofgren, GLERL  
Felix Martinex, NOS  
Doran Mason, GLERL  
Steve Pothoven, GLERL  
Steve Ruberg, GLERL  
Ed Rutherford, GLERL  
Ivanka Stajner, NWS  
Hank Vanderploeg, GLERL  
Jia Wang, GLERL

**IMPACT**

37. What was the impact on the development of the principal discipline(s) of the project?

In support of NOAA Strategic Goals, CIGLR's research is advancing coastal science and promoting adaptive management through the application of novel techniques to understand environmental problems, prepare communities for environmental change, and develop tools for informed decision making. Through collaborations with NOAA GLERL and our Regional Consortium partners, we are at the forefront of coastal forecasting, high-tech observations, and ecosystem health research to serve the communities that rely on the Great Lakes for human health, safety, and commerce.

CIGLR's development of coupled modeling systems is producing coastal forecasts that have improved accuracy and advanced capabilities to predict environmental events. Our core expertise in hydrodynamic modeling using FVCOM has facilitated the integration of physical, chemical, biological, and atmospheric models to create new forecasting products that support more informed decision making by resource managers, other stakeholders, and the public. Biophysical modeling of Lake Erie HABs resulted in the 3D HAB Tracker forecast model, which predicts the size, location, and movement of harmful algal blooms and is currently in transition to operations by NOAA CO-OPS. At the same time, we are developing a HAB toxicity forecast based on the HAB Tracker model to predict the probability of exceeding specified thresholds of microcystin concentration in the western basin of Lake Erie. We have advanced lake effect snow forecasting by coupling hydrodynamic and atmospheric models, exceeding the accuracy of NWS operational output. We have also produced the first-ever short term ice forecast guidance for the Great Lakes by developing the Great Lakes FVCOM-CICE model for transition to operations. Last, we are developing a flood forecasting system for Lake Champlain to meet operational needs of the NWS and US Coast Guard, based the coupling of 3 physical models to simulate hydrodynamics, hydrology, and wind-waves.

We are also developing and deploying advanced-technology observing systems that have not been previously used in freshwater environments, increasing our capacity to develop decision-support tools that provide early warning of environmental hazards. With the first operational deployment of the 2nd Generation Environmental Sample Processor (2G ESP) in 2017, we accelerated our ability to detect algal toxins with autonomous, near-real-time monitoring of harmful algal bloom conditions. In situ toxin assays on board the 2G ESP provide unprecedented temporal resolution of algal toxin levels, enabling resource managers to take action to protect public health before a crisis begins. The recent addition of 2 additional ESP units, plus the development of the mobile 3G ESP, gives us the ability to serve more communities with high-resolution algal toxin data. We are also supporting the development of the first meteotsunami warning system for the Great Lakes by creating a meteotsunami monitoring network composed of atmospheric data sensors throughout Lakes Michigan and Erie.

Advanced monitoring and research techniques are also helping us evaluate the ecosystem impacts of invasive species and generate baseline data for detecting future changes to food web structure. Our long-term record of fine scale food web ecology has contributed



## IMPACT (*cont'd*)

### 38. What was the impact on other disciplines?

The NWS Runoff Risk Advisory Forecast is a decision support tool is designed to help farmers identify the most effective time to apply fertilizers to minimize costs, while safeguarding water quality. However, the impact of this tool on water quality has not been previously evaluated. We are using a watershed model to analyze the different adoption scenarios of RRAF on water quality, with the goal to improve the use of RRAF as a decision tool to reduce nutrient runoff from agricultural fields. Project results will be presented at a stakeholder workshop and a regional meeting focused on implementing the RRAF.

A connection to the agriculture community was also made during a CIGLR summit focused on linking farmland soil health to downstream water quality, thus providing motivation for promotion and adoption of soil health strategies. As an outcome of the summit, CIGLR Regional Consortium Partners leveraged grant funding from Michigan Department of Agriculture and Rural Development to better understand farmer motives for conservation practice adoption and for edge of field monitoring to improve understanding of soil health functions and their relationship to offsite movement of nutrients.

The Lake Erie walleye fishery represents one of the most important freshwater commercial and recreational fisheries in North America, but the effects of environmental change on walleye are not well understood. Furthermore, offshore wind farms within the Great Lakes are being proposed without knowledge of potential impacts to Great Lakes fisheries. A CIGLR Postdoctoral Fellow is using acoustic telemetry to provide decision makers with information on the potential physical and biological impacts of Lake Erie offshore wind farm development on the fishery so that they may recommend appropriate measures to protect critical habitat and preserve self-sustaining fish populations. Results were conveyed to the Walleye Task Group, consisting of government representatives in Canada and the US who provide stock assessment and fishery management advice to policy makers.

With multi-agency partners including USACE, USGS, and Michigan Department of Natural Resources, we evaluated the potential impacts of Asian carp invasion to the Great Lakes food web. Our results are being used to inform bioeconomic models coordinated by the US Army Corps of Engineers, which aim to evaluate costs and benefits of preventing Asian carp introduction or controlling their populations if introduced (GLMRIS Report, [http://glmr.is.anl.gov/documents/docs/glmrisreport/GLMRIS\\_Report.pdf](http://glmr.is.anl.gov/documents/docs/glmrisreport/GLMRIS_Report.pdf)).

Our research on lake effect snow has contributed to improvements to meteorological forecasting and community preparedness for severe winter weather. Simulations of snow water equivalent were notably improved in comparison with the operational analysis of the Snow Data Assimilation System (SNODAS) from the NWS National Operational Hydrologic Remote Sensing Center. We also contributed to the OAR-NWS Hydrometeorology Testbed by adding our FVCOM-CICE operational outputs into the HRRR atmospheric model.

With funding to the Great Lakes Sea Grant Network, we reached out to the education community to develop a group of Mentor Teachers to serve as "Great Lakes Ambassadors" versed in Great Lakes literacy principles and stewardship practices. The Center for

### 39. What was the impact on the development of human resources?

We strive to create a diverse workforce that is skilled in areas related to NOAA's research mission through career training activities that are part of our comprehensive ECO Program. Within our Career Development goal, CIGLR provides career training to students and postdocs who will become the next generation of NOAA and Great Lakes scientists. Supported by a combination of Task IB and University of Michigan cost share funds, in addition to student and postdoc opportunities within Task II research projects, CIGLR's career training activities include the Great Lakes Summer Fellows Program, Graduate Research Fellows Program, graduate student thesis/dissertation or professional projects, and project-funded postdocs and students. During the reporting period, CIGLR supported 15 undergraduate students, 13 graduate students, and 12 postdoctoral research fellows within the CIGLR Research Institute and Regional Consortium.

The Great Lakes Summer Fellows Program has been a cornerstone of our career training program since CIGLR's inception in 1989. Each year this program places highly qualified undergraduate and graduate students with both academic and federal research mentors. Through this program students gain experience working on substantive research issues from a variety of themes pertinent to the Great Lakes and in turn, support CIGLR's and NOAA's research mission within the region. In order to ensure that we are attracting a broad range of student applicants in terms of diversity, geography, and STEM disciplines, CIGLR developed and implemented a recruiting plan that emphasizes reach to under-represented student groups nationwide. The fellowship program includes educational events that help students explore topics ranging from career options across multiple sectors to methods for sourcing funds for graduate school. The summer fellowship program is supported by Task 1B and Task II funds. We supported 9 fellowships in 2018.

CIGLR receives Task IB funding to administer a Graduate Research Fellowship Program that provides career training opportunities to master's or doctoral students that are located at one of CIGLR's Regional Consortium universities. In early 2019, Graduate Research Fellowships were awarded to Jim Hood (Ohio State University), CK Shum (Ohio State University), Harvey Bootsma (University of Wisconsin-Milwaukee), Phanikumar Mantha (Michigan State University), and Peter Dijkstra (Central Michigan University). NOAA GLERL Task IB funds were supplemented with University of Michigan cost share funding to offer a greater number of graduate student opportunities than the 2 typically funded by NOAA GLERL.

In addition to supporting postdoctoral positions through Task II research projects, CIGLR also administers a competitive Postdoctoral Fellowship Program that is supported by University of Michigan cost share funds. In FY19, CIGLR issued a call to our Regional Consortium universities to solicit proposals for four 12-month postdoctoral fellowships. Postdoctoral fellowships were awarded to Allison Steiner (University of Michigan), Jay Martin (Ohio State University), CK Shum (Ohio State University), and Christiane Jablonowski (University of Michigan). University of Michigan cost share funds were supplemented with Task IB funds from NOAA GLERL and NGS to fund additional postdoctoral research opportunities beyond the 2 typically offered by CIGLR.

*Attach a separate document if more space is needed for #6-10, or #24-50.*

**IMPACT (cont'd)**

**40. What was the impact on teaching and educational experiences?**

During the reporting period, CIGLR subawarded a project titled Using a Teacher Mentor Model to Expand the Impact of the Center for Great Lake Literacy's Community of Practice to Illinois-Indiana Sea Grant, with secondary subawards to other Great Lakes Sea Grant programs. In this project, The Center for Great Lakes Literacy (CGLL) developed a group of Mentor Teachers to serve as "Great Lakes Ambassadors" by 1) disseminating Great Lakes learning and stewardship practices, and 2) providing support to CGLL workshop participants for post-workshop implementation of projects, professional development, and/or knowledge dissemination. The CGLL expanded and strengthened their core network of experienced educators and scientists through additional training. Those experienced educators will mentor a cadre of new educators participating in future CGLL events.

Great Lakes Sea Grant programs conducted professional development/mentor training workshops for teachers. During the reporting period, these included:

- Greatest of the Great workshop—Ohio Sea Grant
- Summer Science Workshop 2018—Pennsylvania Sea Grant
- Shipboard Science on the S/V Denis Sullivan—Minnesota Sea Grant and Wisconsin Sea Grant
- CGLL Mentor Workshop—New York Sea Grant
- Genomics for Teachers Workshop—Illinois-Indiana Sea Grant
- Science Teachers Association of New York State Workshop—New York Sea Grant

In addition to this project, CIGLR's education activities are implemented within our ECO Program (Engagement, Career Training, Outreach & Communications). Our education focus is on undergraduates, graduate students, and postdoctoral fellows in the form of hands-on applied research career training related to NOAA's mission (see question 39). We also engage in public education through our ECO Program by translating and promoting NOAA's research in the Great Lakes (see question 27).

**41. What was the impact on physical, institutional, and information resources that form infrastructure?**

One of CIGLR's goals is to build a Regional Consortium that expands NOAA's intellectual capacity, geographic scope, and research infrastructure by building strong partnerships with universities, NGOs, and businesses who share similar research and management goals in the Great Lakes. While our academic Regional Consortium members broaden NOAA's intellectual expertise in the Great Lakes, private organizations help develop applications for NOAA research and engage policy-makers and resource managers in ways that bridge science with public interests. CIGLR's Regional Consortium consists of 12 universities, 4 NGOs, and 3 businesses who partner with NOAA in research and development activities that support NOAA's mission in the Great Lakes.

During the reporting period, CIGLR held an open competition for new partners to join the consortium, in an effort to further expand the expertise and infrastructure resources available to NOAA. Four new partners were selected: Cleveland Water Alliance, Lake Superior State University, Michigan Technological University, and Wayne State University. These institutions were chosen for membership because each brings a critical new element to the Regional Consortium. They join the consortium members named in the CIGLR proposal: Central Michigan University, Cornell University, Grand Valley State University, Lake Superior State University, University of Michigan, Michigan State University, Michigan Technological University, University of Minnesota-Duluth, Ohio State University, University of Windsor, University of Wisconsin-Milwaukee, Wayne State University, Cleveland Water Alliance, Fondriest Environmental, Great Lakes Environmental Center, LimnoTech, Michigan Environmental Council, The Nature Conservancy, National Wildlife Federation.

Each of the Regional Consortium University Partners has signed an MOU with the University of Michigan that allows scientists from NOAA, CIGLR, and other Regional Consortium institutions to use their facilities at 'in-house' costs. These facilities include:

- Field stations and laboratories. CIGLR University Partners collectively manage 15 field stations that are located on all 5 Great Lakes. These stations have wet lab space, analytical facilities, housing for researchers and students, classrooms for teaching and hosting of seminars, and world-class mesocosm facilities for experiments.
- Fleet of research vessels. University Partners own and operate a fleet of 13 research vessels in all 5 Great Lakes, including several of the largest and most well-equipped vessels available (e.g., Agassiz, Blue Heron, W.G. Jackson).
- Monitoring instrumentation. University Partners own and manage 50 buoys, AUVs, ROVs, and gliders that form a large portion of the Great Lakes Observing System (GLOS), in addition to a wealth of water quality instruments, ADCPs, acoustic telemetry, etc.
- Specialized engineering and research facilities. All University Partners have engineering and design labs that specialize in materials design (plastics, metals, glass), development of instrumentation, marine hydrodynamics, and perpetual robotics for autonomous navigation and mapping systems. University Partners also operate a suite of highly specialized laboratory facilities, including numerous labs for remote sensing and GIS, genomics and sequencing, bioinformatics, high-performance computing, marine hydrodynamics, elemental and isotopic analyses, advanced microscopy, geomicrobiology, sedimentology, and fisheries and aquaculture.

*Attach a separate document if more space is needed for #6-10, or #24-50.*

**IMPACT (cont'd)**

**42. What was the impact on technology transfer?**

During the reporting period, CIGLR was involved in the following technology transfer activities that benefit research to applications at NOAA and serve the public for a weather ready nation:

- Funded by the Joint Technology Transfer Initiative (JTTI), the project titled Implementation of the FVCOM-Ice model for the Great Lakes Operational Forecasting System (GLOFS) produced FVCOM-CICE based Great Lakes Operational Forecast System models for transition from research to operations at NOS CO-OPS to provide the first-ever, short-term ice forecast guidance for the Great Lakes.
- Funded by the International Joint Commission, the project titled Water level forecasts: Improving water level models for shipping and commerce utilized NOAA GLERL's Large Lake Statistical Water Balance Model (L2SWBM) to generate a new historical record of the Great Lakes water balance to aid in evaluating changes in Great Lakes water levels. As part of this work, CIGLR developed a package of R scripts for transitioning the water balance model to operations at the US Army Corps of Engineers Detroit District and Environment and Climate Change Canada <https://www.glerl.noaa.gov/data/WaterBalanceModel/>
- Funded by NOAA NCCOS, the project titled Advancement of Mobile, In Situ HAB Toxin Warning and Genomic Observation for Great Lakes Decision Support Tools engaged a nonprofit research institute, Monterey Bay Aquarium Research Institute (MBARI), to develop a new mobile, in situ HAB detection technology to facilitate toxin forecasting and genomic observations at high spatial and temporal resolution in support of informed decision making. Such technology has been previously applied only in marine environments, making it essential to harness outside expertise to transfer this technology to NOAA's freshwater research enterprise. Engineering advances by MBARI include miniaturizing the in situ sample processing capabilities of the 2nd generation Environmental Sample Processor (ESP) for algal toxin detection and DNA archival to fit into the payload of a Tethys-class long-range autonomous underwater vehicle (LRAUV), thus creating the 3rd generation ESP (3G-ESP). The marriage of the 3G-ESP and the LRAUV technologies by MBARI provides mobile, autonomous sampling capabilities in aquatic environments. This project was the first to test the technology in freshwater.
- With University of Michigan cost-share funding, CIGLR awarded Regional Consortium partner LimnoTech Rapid Response funds for a project titled Enhanced monitoring and data management to support meteotsunami research and detection. In response to the need for a more robust means to monitor, detect, and mitigate the impact of future meteotsunami events with an alert system, LimnoTech developed a meteotsunami monitoring network in Lakes Michigan and Erie to detect atmospherically significant events that could lead to meteotsunamis. The monitoring network consists of 25 stations that are able to report air pressure observations at one minute intervals to a custom postgres database in real time. NOAA GLERL plans to build a notification system on top of the database, thus creating an early warning system for meteotsunamis in Lakes Michigan and Erie.

**43. What was the impact on society beyond science and technology?**

As part of the Engagement element of our ECO Program, CIGLR interacts with legislators, resource managers, and other stakeholders to identify their information needs, tailor research to meet those needs, and deliver the products needed for decision making. We reach beyond the academic and science community into society, to support research outcomes that make a difference in people's lives. Our engagement activities promote science-based decision making, protect public health and safety, and improve stakeholder knowledge and attitudes about NOAA research in the Great Lakes.

We work directly with elected officials to provide the information needed to support decisions, respond to constituent concerns, and understand critical research needs in the Great Lakes. Each year we co-host an annual event with the Environmental Law and Policy Center that brings together scientists, stakeholders, and Great Lakes elected officials to share the current state of science, identify critical next steps, and outline funding needs. During the reporting period, CIGLR co-organized the 2019 Science-Policy Confluence Conference, Understanding and Addressing Climate Change Impacts on the Great Lakes. We also co-organized and presented CIGLR research at a Michigan Congressional Roundtable led by the GLRCT, which was attended by staffers from 8 Michigan Congressional districts, 1 Senate office, and the Michigan Governor's office. Other significant legislative engagement activities include

- Co-produced a Great Lakes research fact sheet with the University of Michigan Office of Research, to inform the Michigan delegation about progress on top Great Lakes research priorities
- Participated in Congressional briefings with staffers from 4 offices
- At a Congressman's request, composed a letter describing how CIGLR research benefits his district

Our stakeholder engagement activities facilitate the co-production of research outcomes to develop research products that are useful to society, promoting effective decision making and public education. Stakeholder engagement is focused on research related to conditions that impact human health and economies: HABs, hypoxia, and lake ice/snow. During the reporting period, we engaged 529 stakeholders representing 43 organizations, held 4 stakeholder workshops/focus groups, and presented CIGLR research at 16 stakeholder meetings. These activities are designed to 1) identify and assess user data and information needs for decision making, to help guide research development, and 2) disseminate research tools and forecasts. Significant stakeholder engagement activities during this period include

- We partnered with the Cleveland Water Department to co-design an experimental hypoxia forecast. Ten drinking water treatment plants participated in 9 focus groups to inform the initial design and user interface. Plant operators provided feedback on the need for information on manganese, a heavy metal that is released during hypoxic conditions, causing aesthetic and human health concerns. As a result, we initiated new research to help plant operators anticipate and treat manganese-laden water associated with hypoxia.
- We surveyed 2,559 Ohio residents on public awareness and preferences for nutrient reduction policies. The results are being used

*Attach a separate document if more space is needed for #6-10, or #24-50.*

**IMPACT (cont'd)**

44. What percentage of the award's budget was spent in foreign country(ies)?

0 , During the reporting period, \$5,924 (0.056%) of the \$10,561,141 awarded to CIGLR as of 3/31/19 was spent in foreign countries. The expenditures were on travel, including lodging, food, and ground transportation (car rental) costs incurred by CIGLR research personnel for attending international scientific conferences to present their work. Of the 0.056% spent in foreign countries, 0.023% was spent in France to attend the joint International Association for Great Lakes Research-European Large Lakes Symposium conference in Evian, France; 0.033% was spent in Canada to attend the International Association for Great Lakes Research conference in Toronto, Ontario.

**CHANGES/PROBLEMS**

45. Changes in approach and reasons for change

See attached.

**CHANGES/PROBLEMS (cont'd)**

**46. Actual or anticipated problems or delays and actions or plans to resolve them**

As of the end of the reporting period, CIGLR has received 48 amendments to our parent Cooperative Agreement award. We have requested an extension for 24 of these amendments, all of which were necessary wholly or in part due to delays in the timing of amendment awards. Although the CIGLR Cooperative Agreement is on a July 1 – June 30 annual timeline, we do not receive awards for end-of-fiscal-year submissions until August or September each year. Any subawards within these awards take an additional 30-60 days to become established. The resulting delays to start dates necessitate extended end dates in order to meet project objectives. In addition, 18 of the 24 extended projects received a second year of funding in a subsequent amendment, triggering an extension of the initial year 1 amendment in the University of Michigan system.

One particular project titled Lake Champlain Hydrodynamic Flood Forecasting System, took more than 7 months to be approved and awarded by NOAA (submitted 11/1/17, awarded 6/20/18). Although the University of Michigan allowed hardship spending to uphold project timelines, the amendment end date needed to be extended. Other delays within this project included the unavailability of high-performance computing resources at NOAA GLERL during the December 2018-January 2019 government shutdown and departure of key personnel responsible for thermal structure modeling work. CIGLR hired a replacement modeler in March 2019 and an additional hydrodynamic modeler in April 2019 to accelerate the progress toward project milestones. Another postdoc will begin on the project in September 2019. With these new hires, we expect this project to be back on schedule within the first quarter of the 2019-2020 reporting period.

Appendix 1 – List of Projects contains information on all amendments for which we have requested a no-cost extension.

**47. Changes that had a significant impact on expenditures**

During the reporting period, projects that experienced an impact on expenditures due to staff departures or delays in hiring new/replacement staff include:

- Metagenomic and eDNA approaches for early detection and community impact of Great Lakes invasive species. No activity was initiated under sub-project 2, Implementing Metabarcoding Assays of Invasive and Native Invertebrate Communities in the Great Lakes due to the delayed hiring of a postdoctoral fellow who will lead this research. The new postdoc to fill this role started on May 24, 2019.
- Building Coupled Storm Surge and Wave Operational Forecasting Capacity for Western Alaska. A postdoc was proposed to lead this project, but an extensive national search failed to produce viable candidates. A staff-level position was posted and filled with a highly-qualified candidate on March 1, 2019.
- Developing an operational ESP network for early HAB toxin detection in Lake Erie. A delay in the hire of a NOAA GLERL principal investigator to lead this effort on the federal side set back the hiring of CIGLR technical support staff to help with the project. Dr. Reagan Errera was hired by NOAA GLERL in February 2019, in part to lead the ESP program. CIGLR expects to regain traction on this project in the first quarter of the next reporting period under the leadership of the new GLERL PI.
- Great Lakes Long-term Ecological Research Program. Long-term medical leave (6 months) was taken by a staff person appointed to this project, during which the University of Michigan supported salary and benefits with non-sponsored funds, resulting in unspent salary budget in the project.
- Lake Champlain Hydrodynamic Flood Forecasting System. A postdoctoral fellow appointed to this project departed CIGLR. A search was conducted for a replacement postdoc, but the candidate of choice is unable to begin work until September 2019. In the meantime, two new technical support staff have been hired to help meet project milestones.

**CHANGES/PROBLEMS (cont'd)**

48. Significant changes in use or care of human subjects, vertebrate animals, biohazards, and/or select agents

During the reporting period, 3 studies involving human subjects were conducted by CIGLR researchers: the GLANSIS Website Usability Interview Study, the Saginaw Bay Harmful Algal Blooms Forecast Needs Assessment, and the Environmental Conditions and Public Opinion about Policies for Great Lakes Water Quality Restoration Survey Study. The University of Michigan's Institutional Review Board (IRB) reviewed study methods, including interviews, focus groups, workshops, and surveys. The University of Michigan's IRB determined that the studies were exempt from the formal IRB approval process, because study involvement did not pose any increased risk to participants' safety or well-being. Within study methods, measures were taken by researchers to ensure the confidentiality of personally identifiable information, including anonymous reporting and restricted access to audio recordings and participant contact information. After receiving exempt status, no substantial changes were made to study methods or data collection instruments requiring amendments to the IRB application. Study participants have raised no issues or concerns. All participants gave their informed consent prior to participation in CIGLR research. IRB exemption approval dates are given for the following projects: GLANSIS Website Usability Interview Study, 3/12/2019; Environmental Conditions and Public Opinion about Policies for Great Lakes Water Quality Restoration, 5/30/2018; Saginaw Bay Harmful Algal Bloom Forecast Needs Assessment, 3/11/2019.

49. Change of primary performance site location from that originally proposed

See attached.

**PROJECT OUTCOMES**

**50. What were the outcomes of the award?**

In support of NOAA Strategic Goals, CIGLR's research is advancing Great Lakes science and promoting adaptive management through the application of novel techniques to understand environmental problems, prepare communities for environmental change, and develop tools for informed decision making. Through collaborations with NOAA GLERL and our Regional Consortium partners, we are at the forefront of coastal forecasting, high-tech observations, and ecosystem health research to serve the communities that rely on the Great Lakes for human health, safety, and commerce.

During the first two years of the CIGLR Cooperative Agreement, we have continued long-standing research projects to monitor, observe, and predict critical conditions in the Great Lakes, while venturing into new research areas using advanced techniques and technologies. We continue to serve resource managers the tools and information they need to protect public health and wellbeing, by providing real-time observations, remote sensing images, and predictive models that inform drinking water plant operators when source water may be impacted by harmful algal blooms or low oxygen conditions. At the same time, we are leading the way toward using advanced technology to solve environmental problems, by identifying the genes that allow harmful algae to bloom while other algae are eaten by invasive mussels, and developing underwater robots to measure algal toxins in the water. We are using advanced techniques to build new models that predict algal bloom toxicity and improve forecasts of lake effect snow, ice, and floods. In just two years, we have developed 5 models or technologies for transfer to government operations, published 56 scientific papers and reports, and given 139 research presentations.

We complement our cutting-edge research with programs that engage stakeholders, educate the public, and train the next generation of Great Lakes scientists. As part of the Engagement element of our ECO Program, CIGLR interacts with legislators, resource managers, and other stakeholders to identify their information needs, tailor research to meet those needs, and deliver the products needed for informed decision making. We reach beyond the academic and science community into society, to support research outcomes that make a difference in people's lives. Our engagement activities promote science-based decision making, protect public health and safety, and improve stakeholder knowledge and attitudes about NOAA research in the Great Lakes. During CIGLR's first two years, we engaged 922 stakeholders in research related to conditions that impact human health and economies: HABs, hypoxia, and lake ice/snow. Working directly with 12 public water systems across Lakes Erie and Huron, we helped to protect over 3M people each year by putting NOAA HABs and hypoxia products into action.

We strive to create a diverse workforce that is skilled in areas related to NOAA's research mission through Career Training activities that are part of our comprehensive ECO Program. CIGLR provides career training to students and postdocs who will become the next generation of NOAA and Great Lakes scientists. Through fellowships, thesis/dissertation/professional projects, and research positions, CIGLR has supported 76 students and postdocs during our first 2 years. Another key career training function of CIGLR is to prepare personnel for federal laboratory employment. Two CIGLR employees were hired as permanent federal staff at NOAA GLERL during the first 2 years.

The Outreach & Communications element of the ECO Program is designed to translate and disseminate CIGLR research outcomes to support

**DEMOGRAPHIC INFORMATION FOR SIGNIFICANT CONTRIBUTORS (VOLUNTARY)**

|   |   |
|---|---|
| <p>Gender:</p> <p><input type="radio"/> Male</p> <p><input type="radio"/> Female</p> <p><input type="radio"/> Do not wish to provide</p>  | <p>Ethnicity:</p> <p><input type="radio"/> Hispanic or Latina/o Not</p> <p><input type="radio"/> Hispanic or Latina/o Do not wish to provide</p>  |
| <p>Race:</p> <p><input type="radio"/> American Indian or Alaska Native Asian</p> <p><input type="radio"/> Black or African American</p> <p><input type="radio"/> Native Hawaiian or other Pacific Islander</p> <p><input type="radio"/> White</p> <p><input type="radio"/> Do not wish to provide</p> | <p>Disability Status:</p> <p><input type="radio"/> Yes</p> <p style="margin-left: 20px;"><input type="checkbox"/> Deaf or serious difficulty hearing</p> <p style="margin-left: 20px;"><input type="checkbox"/> Blind or serious difficulty seeing even when wearing glasses</p> <p style="margin-left: 20px;"><input type="checkbox"/> Serious difficulty walking or climbing stairs</p> <p style="margin-left: 20px;"><input type="checkbox"/> Other serious disability related to a physical, mental, or emotional condition</p> <p><input type="radio"/> No</p> <p><input type="radio"/> Do not wish to provide</p> |

*Attach a separate document if more space is needed for #6-10, or #24-50.*