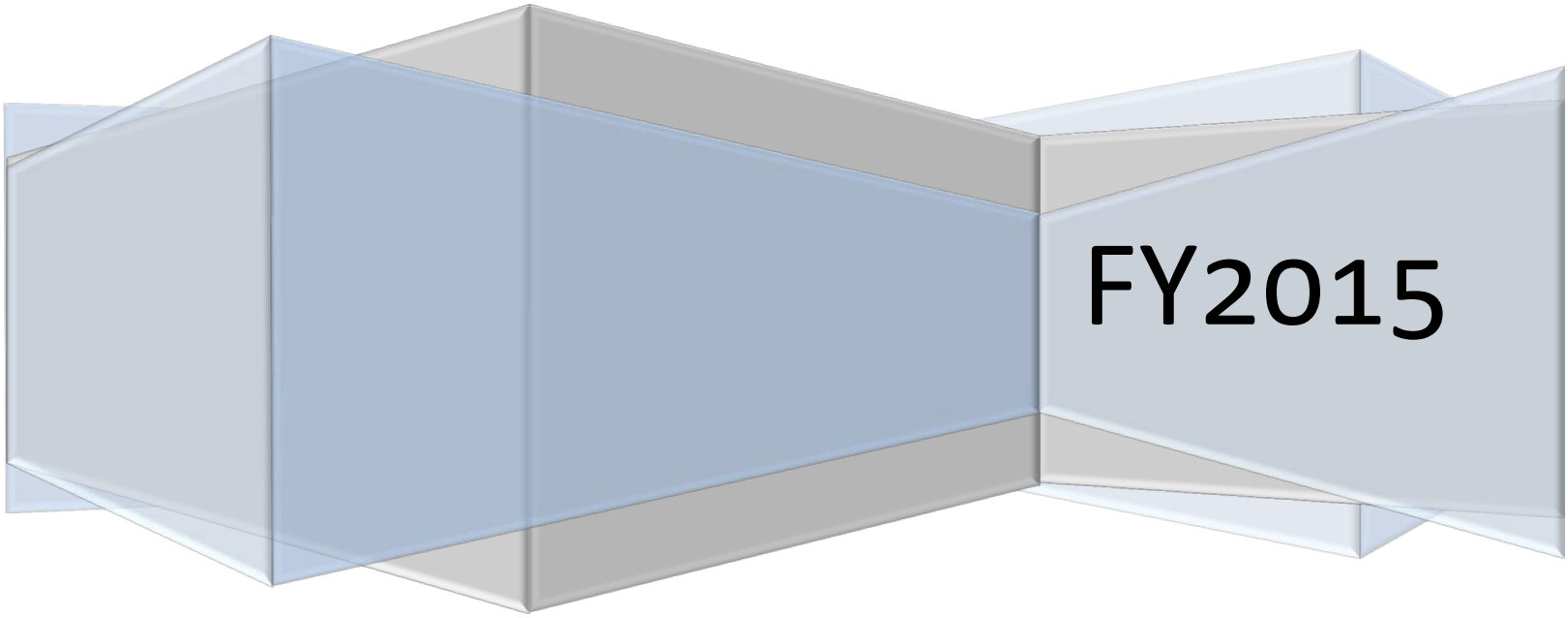
NOAA GREAT LAKES ENVIRONMENTAL RESEARCH LABORATORY

FY2015 PLANNING

SCIENCE AND INFRASTRUCTURE

FINAL



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Internal Science Project Planning

Ecosystem Dynamics

The Ecosystem Dynamics (EcoDyn) branch collects long-term ecological data and conducts targeted fundamental research on ecosystem processes critical to understanding ecosystem structure and function for managing water quality, fisheries, and other ecosystem services in the Great Lakes. Towards this goal, EcoDyn has developed a Long-Term Research (LTR) program that integrates a core set of long-term observations on biological, chemical, and physical variables, with short-term process-based studies for understanding ecosystem change. Such information is essential for the development of new concepts, models, and forecasting tools to explore impacts of various stressors on the ecosystem. EcoDyn contributes across all science branches by providing data and understanding for the development of models and forecasting capabilities, and the application of technologies and vessel use. Herein, we briefly present our plans for FY15. Some of the work is continuing and some of this is work is designed to be completed in 2015. We organize the projects in four general categories: LTR observations, process-based studies, developmental projects, and projects that cut across science branches. It is implicitly understood all process studies are targeted to understand critical processes affecting Great-Lakes LTR sites or ecosystems. It is our ultimate goal to understand the structure and function of Great Lakes food webs, from viruses to fishes, in response to multiple stressors including invasive species, climate change, and nutrient loading. A mix of base and external funds is used for our research.

Much of our research is driven by two major stressors or issues presently impacting the Great Lakes: (1) understanding and forecasting impacts of dreissenid mussels to nutrient cycling and food web dynamics of Lakes Michigan (and Huron); and (2) understanding and forecasting *Microcystis* abundance, distribution, and toxicity. In addition to these issues we are examining potential impacts of other invaders poised to invade the Great Lakes such as Asian carp.

Dreissenid mussels have led to radical cascading impacts to food web structure and function, including offshore starvation of the food web and in the nearshore zone nuisance and harmful algal blooms, the latter which are arguably the most important factors in degradation of beach quality. GLERL, UM, and CMU research now underway indicates that although Lake Michigan has a higher nutrient loading than Lake Superior, its offshore waters are now more oligotrophic than Lake Superior in the following characteristics: (1) clearer water, (2) lower P concentration in offshore waters, (3), lower phytoplankton concentration, and (4) greater importance of picophytoplankton (< 2µm) and the microbial food web.

Microcystis blooms are a hazard to recreational water use and drinking water safety in Lake Erie and shallow regions of the Great Lakes such as Saginaw Bay (Lake Huron) and Green Bay (Lake Michigan). The shutdown of the Toledo, OH, water plant last year due to a localized *Microcystis* bloom emphasized the importance of being able to forecast bloom timing, extent, horizontal and vertical position in the water column and toxicity.

Most of our field efforts—both base and externally funded—will focus on Lake Michigan and Lake Erie. As part of the multi-agency Lake Michigan Coordinated Science and Monitoring Initiative (CSMI) 2015 to monitor and understand the function of Lake Michigan, EcoDyn will be surveying abundance and spatial distribution of dreissenid mussels and other benthos in the southern basin as well as examining the spatial structure of the pelagic food web monthly near Muskegon, MI. EcoDyn has been preparing for

CSMI 2015 for a number of years by developing new sampling methods and partnerships. The core set of LTR variables will continue to be monitored. In Lake Erie we will participate with other branches, other NOAA line offices, and academic partners to describe the abundance, size structure, buoyancy, toxicity and bloom trajectories of *Microcystis* to better predict its hazard to drinking water supplies.

Process work on impacts of invasive mussels will continue so as to define their feeding and nutrient recycling to better understand their impacts to phytoplankton and the Lake Michigan food web.

ECODYN 1.1 Monthly Observations Lake Michigan
(Pothoven)

Key Internal Personnel: S. Pothoven, N. Morehead, D. Fanslow
Key External Partners: J. Elliott - IMSG Contractor, G. Fahnenstiel (Michigan Technological University)

Executive Summary

A major goal of the Ecosystem Dynamics Theme is to maintain a GLERL Long-Term Ecological Research (GLERL-LTER) program that integrates a core set of long-term observations on biological, chemical, and physical variables with process-based studies that will serve as the foundation for developing new concepts and modeling tools to explore impacts of various stressors (e.g., invasive species, climate change, nutrient loading, overfishing) on the ecosystem. Long-term observations also provide a foundation for evaluating changes in ecosystems where there could be a significant time lag between cause and effect; such information is essential for management of an environment (Magnuson 1990). Herein, we will maintain a LTER program for the waters near the Muskegon Field Station where we have a long-term history of observation and process-based studies. GLERL has collected biological (zooplankton, chlorophyll) and water chemistry (nutrients) samples at offshore sites in southern Lake Michigan dating back to the 1970s, with the most extensive and complete data sets dating back to the 1980s.

We will continue our time series of biweekly/monthly (March-December, January-February when possible) measurement of key biological, chemical, and physical core variables at stations M15, M45, and M110 (M designates Muskegon and number designates depth in m) off of Muskegon and occasional measurements at Grand Haven to evaluate regional generality of Muskegon observations. Variables to be examined in 2015 include temperature, chlorophyll, nutrients, zooplankton, *Mysis*, dreissenids, fish diets and condition. In addition, we will continue to sample a subset of core variables from Lake Superior to compare to Lake Michigan.

Budget Summary	
Item	***Total ($)***
Equipment	
Supplies-chemicals, nets, labware, bottles, nets	$15,000
Field Travel *(field work)*	
Science Conference Travel *(conferences e.g. AMS, IAGLR, AGU)*	
Science Meeting Travel *(e.g. working groups, PI meetings)*	$ 1,000
Admin Travel *(e.g. Advisory Board meetings)*	
*** International travel - possible GLFC Windsor-March 2015*	*amount included above*
Contracts/CILER	$86,000
Other (specify)	
Total Amount	$102,000

Staffing and Ship Time	
Federal Staff - Pothoven, Morehead 50%, Fanslow 8%	1.58 FTE
Contract Staff - Elliott	1.00 FTE
Total Staff	**2.58 FTE**
Total Ship Time Days	**100 Laurentian; 30 small boat, 10 5501 or equivalent**

Project Details

Personnel Requirements

GLERL: Pothoven (1.0 FTE), Morehead (0.5), Fanslow (0.08)
Contractor: Elliott (1.0) - IMSG
Collaborator: Fahnenstiel – Michigan Technological University (MTU)/ University of Michigan (UM)

Describe what work is intended to be done

Where the work will take place

a. Lake(s) Michigan (Muskegon to Grand Haven area); Superior (assuming continuation of collaborative efforts by lab beyond this project that were done the last two years at MTU)

When the work will take place

a. March-December; Jan-Feb weather permitting
b. Day and Night
c. How often
   1 week routine measures (nets/water/Mysis/ponars/moorings);
   1 week fish sampling/along with additional water/zoopl collections
   Beach seining—spring (done collaboratively with Little Traverse Bay Bands of Odawa Indians and MI DNR)

How will the work be accomplished?

- What are key processes necessary to accomplish the work? Net tows, trawling, water grabs, CTD
- What are key resources necessary to accomplish the work?
  - Vessels –Need Laurentian 2 weeks/month x 10 months to get work done and allow 1-2 days/week for some weather issues; need small boat 3 days/month for nearshore work/gill nets/mamou net; need to make sure cables are fit and meter wheels and CTD are in working order

    Assuming efforts at MTU beyond this project will continue—Lake Superior large vessel for 1 week plus transit

  - Existing equipment, new equipment & supplies (PSS, ADCP, YSI meters, etc.) CTDs fluorometers; winter mooring fluorometers/thermistors
  - Materials (radioisotopes, special chemicals, standards) formalin, ethanol
  - Marine Instrumentation Laboratory tech resources (preparation of moorings, ADCPs, Nortech meters, YSI meters, cable repairs) assist with thermistor strings/winter

moorings (thermistor strings need to be retrieved in spring and redeployed/ winter fluorometers need to be retrieved in spring, and deployed in the fall)
- IT resources required (new computers, high performance computing time, data storage, specialized computer hardware or software) standard needs
- Editorial, media, graphics, web services, public relations support required

- Identify health and safety issues associated with performing the work (extreme weather, pathogens, rigging, etc.) nothing out of the ordinary hazards associated with this type of work
- How will samples and data be generated and managed? Samples will be generated by collecting samples, and will be managed in the same way samples have been managed for the past several years—logged after counting within a year and data stored in a database for that specific year

Budget Explanation
Pothoven's time to manage/assist with collections and lab work; Morehead for nutrient analysis, Fanslow for CHN analysis, Elliot to collect and analyze samples

Integration
Linked to EcoDyn process work-CSMI efforts

Progress & Project Improvement (if project is continuing / on-going)
Expected short-term (FY15) and longer term (2-5 years) outcomes and milestones?

- Short term: data will be collected and analyzed in a timely fashion (generally within 1 year for critical variables).
  Longer term: Continue long-term monthly observations of core variables (Chl-a, nutrients, benthos, zooplankton, Mysis) in Lake Michigan; modify observations as needed to meet ongoing constituent needs/forecasting needs/relevant issues/changing technology
- Journal articles will be published based on relevant issues/data sets; data has been provided to management agencies (GLFC, MI DNR) and to modelling exercises (Rowe, Glyshaw, Marino, Fahnenstiel)

FY14 progress made on the project as compared to stated milestones and goals

- Continue long-term monthly observations of core variables (Chl-a, nutrients, benthos, zooplankton, Mysis) in Lake Michigan and collect a second year water quality observations at a deep-water site in Lake Superior in cooperation with Michigan Technological University. (Q1-Q4) DONE
- Submit papers on spatial studies in Lake Michigan and Huron (to special JGLR issue if proposal accepted). DONE- Spatial and temporal trends in zooplankton assemblages along a nearshore to offshore transect in southeastern Lake Michigan from 2007-2012 Pothoven and Fahnenstiel—IN PRESS
- Initiate a data management team to develop a framework for ecological data management and sample archiving at GLERL. This was not my milestone, but we archived all zooplankton samples on site and developed a listing of what samples exist, we also summarized all water quality data from 2007-2013 in a single sheet for each year, and are working on doing the same for 1980s and 1990s data

What challenges were encountered during the past year and what is the plan to reduce or eliminate them this year?

- Challenges were due to facility issues (e.g. water main breaks); poor weather conditions (eliminated some spring sampling and resulted in extra weather days), coming within 1 day of a work stoppage for contractors due to issues with KC procurement, issues with transition to Windows 7 that provided down time in the labs—all of these challenges are beyond my control, so I plan to do nothing about any of them.

ECODYN 1.3: MOCNESS in CSMI: Deployment and Gear Efficiency Studies
(Rutherford)

Key Internal Personnel: E. Rutherford, H. Vanderploeg, J. Cavaletto, J. Liebig, A. Yagiela, B. Braymer
Key External Partners: Summer Fellow (CILER), Erich Horgan (Woods Hole Oceanographic Institute), Glenn Zapfe (NOAA NMFS)

Executive Summary

The MOCNESS (Multiple Opening Closing Nets Environmental System Sampler) was purchased to sample fine-scale (m) vertical and horizontal distributions of mesozooplankton, large zooplankton such as *Bythotrephes*, and micronekton including *Mysis* and larval fishes. Recent GLERL studies have shown that there is extreme diel vertical migration of zooplankton, micronekton, and fishes, and their densities are highly concentrated in relatively thin layers associated with thermal structure and phytoplankton concentrations that can be sampled well only by this technology. Precise definition and quantification of spatial structure is critical to understanding food web structure and function for model building. In November 2014, we will configure the MOCNESS and conduct sea trials to get experience deploying the gear. In early April 2016, we will conduct another sea trial to test deployment and gain experience. For each test deployment, we will have experienced MOCNESS operators assisting with the operation. We will use MOCNESS as part of the ECODYN Spatial Structure project to routinely sample the Lake Michigan food web as part of CSMI in 2015.

Budget Summary	
Item	***Total ($)***
Equipment	
Supplies (Ethanol, formalin)	$ 4,000
Field Travel *(field work)* (travel by visiting scientists Horgan and Zapfe)	$ 5,000
Science Conference Travel *(IAGLR conference)* *$1,200 request included in standard allotment*	
Science Meeting Travel *(e.g. working groups, PI meetings)*	$ 100
Admin Travel *(e.g. Advisory Board meetings)*	
*** International travel*	--
Contracts/CILER	
Other (specify)	
Total Amount	$ 9,100
Staffing and Ship Time	
Federal Staff	0.6 FTE
Contract and CILER Staff (Summer fellow)	0.3 FTE
Total Staff	**0.9 FTE**
Total Ship Time Days	**14 days**

Project Details

Personnel Requirements

GLERL*:* Rutherford (lead PI, 0.2 FTE), Vanderploeg (co-PI), Cavaletto, Liebig (research scientists, 0.1 FTE each), Yagiela and Braymer (0.1 FTE each).

CILER Collaborators: summer fellow (0.2 FTE) (Covered under ECODYN 1.5)

Significant Collaborating Scientists: *Erich Horgan, Woods Hole Oceanographic Institute,* 4 days*;* Erich will help set up the MOCNESS, train us and conduct a sea trial; *Glenn Zapfe,* NOAA NMFS Pascagoula Lab: 1 week; Glenn will help train us to operate MOCNESS efficiently).

Describe what work is intended to be done

We will conduct surveys in Lake Michigan to compare the relative efficiency of the MOCNESS for sampling zooplankton, Mysis and fish larvae against sampling efficiency of traditional gears (lift nets, bongo samplers, Tucker trawls). Investigator travel cost is to be approved from program development account. We also will compare gear efficiency during 2 week-long cruises in June and July. On each cruise, we will take replicate samples of zooplankton and fish larvae density at 4 sections of the water column during day and night at the M110 LTR site. These cruises will be operated much like our spatial structure cruises conducted in FY 2010 - FY 2014. Finally, we will operate MOCNESS on monthly spatial structure cruises off Muskegon in Lake Michigan from April-September.

Where the work will take place

a. Lake Michigan
b. LTR stations M15, M45, M110

When the work will take place

a. Gear Efficiency Study: Early April, June, July; MOCNESS Spatial Structure sampling late April, May, June, July, August, and Sept.
b. Day and Night
c. Spatial Structure – monthly from April-Sept. Gear efficiency – April, June, July.

How will the work be accomplished?

- What are key processes necessary to accomplish the work?
- What are key resources necessary to accomplish the work?
  - RV Laurentian – gear efficiency studies (14 work days, 3 weather days; Spatial structure sampling (30 work days included in ECODYN 1.5)
  - Existing equipment, new equipment & supplies (bongo frame, Tucker trawl, neuston net, MOCNESS)
  - Materials (95% ethanol and formalin to preserve fish larvae and zooplankton, respectively)
  - Marine Instrumentation Laboratory tech resources (none)
  - IT resources required (anticipate needing external hard drive)
  - Editorial, media, graphics, web services, public relations support required
- Identify health and safety issues associated with performing the work (extreme weather)
- How will samples and data be generated and managed? Samples will be collected and preserved during research cruises. Samples will be analyzed in the GLERL wet laboratory.

Budget Explanation

- Resources requested include comp time for Rutherford, Liebig and Cavaletto, lab space for analysis of samples, and waste disposal of formalin and ethanol.
- The project will not increase the current GLERL security level which is now considered “low”

- The hire of temporary CILER technician and a summer fellow to support existing staff will be accomplished through ECODYN EX8 NOAA Support of CSMI Lake Michigan 2015

Integration

This project is directly linked to the ECODYN Spatial Studies and Microbes # 1.5.

Progress & Project Improvement (if project is continuing / on-going)

- In FY 15, the expected outcomes are to set up, test and operate the MOCNESS system, and conduct efficiency studies. Other expected outcomes include monthly MOCNESS sampling of the Lake Michigan food web to contribute to ECODYN Spatial Structure study. The expected longer term (2-5 years) outcomes are annual estimates of the vertical structure of the food webs in Lake Michigan and Huron, and annual estimates of bloater and alewife larvae dynamics.
- Results from MOCNESS sampling will contribute to the following journal manuscripts: a gear efficiency study comparing MOCNESS sampling with traditional sampling gears; a study of the fine spatial structure of the lower food web; a paper on compensatory reserve of the Great Lakes lower food web to invasive species.
- FY14 progress made was to purchase the MOCNESS and auxiliary nets.
- The challenges associated with purchasing this equipment have been overcome.

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ECODYN 1.4 Benthic Surveys in Southern Lake Michigan and tracking Dreissenid population dynamics
(Ashley Baldridge)

Key Internal Personnel: A. Baldridge, H. Vanderploeg, S. Pothoven, S. Ruberg, S. Constant
Key External Partners: T. Nalepa (U-M Water Center), L. Burlakova & A. Karatayev (Buffalo State College)

Executive Summary

The goals of this project are to (1) maintain the long-term monitoring program for benthic organisms in southern Lake Michigan, and (2) advance our understanding of Dreissenid population dynamics. The southern region of Lake Michigan has been monitored regularly since 1980. The initial goal was to study the effects of phosphorous abatement on the benthic community. However, this dataset has ended up providing a baseline for community composition pre- and post- invasion of Dreissenid mussels. Continuation of these surveys allows us to track the population dynamics of Dreissenid mussels, follow the continued decline of native amphipods, and also provide monitoring to detect any new invasive benthic species. The long-term nature of this data set also allows for investigation of climate impacts on the Lake Michigan benthic community. In addition to the surveys, I propose to conduct pilot experiments in the lab and field to help us further our understanding of Dreissenid growth, reproduction, and mortality. Ultimately it is our plan to monitor these variables as a function of food concentration in the benthic boundary layer and physical variables that affect it. As part of the sampling along the Muskegon transect we will document the buildup of dead shells necessary for understanding this potential P and Ca sink in collaboration with the mussel feeding and nutrient dynamics subproject.

For FY2015, I am requesting resources to perform new field collections and pilot experiments, as well as catch up on processing benthic samples that were collected in 2013 and 2014. Looking forward, I am planning to conduct an intensive (i.e., identification of all benthic organisms, not just Dreissenids and amphipods) survey in 2016. It is imperative that we are caught up with all samples collected through 2015 by the time the 2016 survey begins.

Budget Summary	
Item	***Total ($)***
Equipment	
Supplies	$ 3,300
Field Travel *(field work)*	$ 1,500
Science Conference Travel *(conferences e.g. AMS, IAGLR, AGU)* *$2,000 request included in standard allotment*	
Science Meeting Travel *(e.g. working groups, PI meetings)*	
Admin Travel *(e.g. Advisory Board meetings)*	
*** International travel*	--
Contracts/CILER (Includes all benefits and overhead)	$ 77,200
Other (specify)	
Total Amount	$82,000

Staffing and Ship Time	
Federal Staff	1.00 FTE
Contract and CILER Staff	1.40 FTE
Total Staff	**2.40 FTE**
Total Ship Time Days *(All ship time integrated with other projects)*	**0**

Project Details

Personnel Requirements

Key Internal Personnel

Baldridge- 1.00 FTE

H. Vanderploeg, S. Pothoven, S. Ruberg, S. Constant will be involved on a consulting basis only (all <0.02FTE)

Collaborators

Kerrin Mabry 0.80 FTE

David Well 0.10 FTE

New CILER Hire (Paul Glyshaw in mind) 0.50 FTE

Significant Collaborating Partners:

T. Nalepa, L. Burlakova, and A. Karatayev. All three have their own support

Describe what work is intended to be done

Where the work will take place

- Lake Michigan
- 40 sites distributed within the southern portion, with a focus on the Muskegon Transect sites (M25, M45, X2)

When the work will take place

- April-Nov
- Day or night (flexible)
- Early, mid, and late season mussel collections at the Muskegon Transect (coordinated with Pothoven). Spring deployment of mussel cages (coordinated with Pothoven/Ruberg/Constant). Summer servicing of cages will be in conjunction with Muskegon Transect sampling cruises and Pothoven has offered his crew for assistance.

How will the work be accomplished?

- What are key processes necessary to accomplish the work?
  - Field collections and cage deployments, followed up by sample processing the lab.
- What are key resources necessary to accomplish the work?
  - All vessel time is integrated with Pothoven's work (ECODYN 1.1)
  - I will make use of existing equipment wherever possible, plus some new equipment and supplies (as listed below in the budget explanation).
- No expected health or safety risks.
- Samples will be processed at GLERL in Ann Arbor with the help of CILER staff. Data will be submitted to the GLERL Data Store server.

Budget Explanation

- Right now and through the end of FY2015, we are processing benthic samples in the lab, which requires manual sorting, measurement, and identification of all mussels and amphipods.
- To quantify the build-up of dead shells, we will measure biomass of empty shells and shell fragments for the Muskegon Transect samples collected in 2013, 2014, and 2015.
- During winter 2015, we will conduct pilot trials in the lab to mark mussels using a fluorescent dye. This will allow us to track individual growth of mussels deployed in the field. We will also design and construct the mussel cages, which will be deployed at M45 in spring 2015.
- In summer 2015, a majority of the Lake Michigan Benthic Survey work has been contracted to researchers Burlakova and Karatayev from Buffalo State College as part of the CSMI for Lake Michigan. Nalepa will oversee all sample collection, which will take place aboard the EPA Lake Guardian. Nalepa will have assistance from Buffalo State College and Cornell researchers for the central and northern portions of Lake Michigan and I (plus one CILER staff) will assist for the southern portion. Initial sample sorting and identification will take place at Buffalo State College and the mussels will be sent to GLERL for scanning and biomass determination.
- To assess mussel condition (i.e., relative body mass for a given size) and reproductive status, we will collect mussels from three sites along the Muskegon Transect at three time points between April-Nov. The mussels will be processed at GLERL.
- Time estimates for work described above:
    - To process the samples already in hand will require 14 months of full time work.
    - To assist with field collections and lab and field experiments will require 2 months full time work.
- Non-federal staffing requirements include continued support for CILER employee, Kerrin Mabry. Kerrin has 0.05 FTE for administrative duties with CILER, and may be involved with assisting other ECODYN projects for 0.15 FTE, which leaves her available for 0.80 FTE for the proposed Benthos work. I also request the hiring of a new temporary full-time CILER employee (1.00 FTE). I have identified Paul Glyshaw (recent SNRE graduate) as a very suitable candidate due to his ample experience with mussel research as a master's student working under Tom Nalepa. Based on **Salary, Fringe, and Indirect** costs quoted by Heather Hazzard, the CILER employee costs will be as follows (**Total= $77,200**):
    - Kerrin Mabry = $52,770
    - David Wells = $2,450
    - New Temp CILER = $20,230
    - Allen Burton = $1,750
- New equipment/supplies that need to be purchased (**Total= $3300**)
    - Mussel growth experiment supplies (Subtotal= $2600)
        - Calcein ($500), fluorescence filter sets ($1200), materials for field cages ($400), mussel food and other husbandry supplies ($250), 500 ft. ground line ($550), misc. supplies ($200)
    - Sample processing and storage (Subtotal= $700)
        - Storage containers ($100), flatbed scanner for imaging mussels ($100), Slides and sample vials ($200), misc. supplies ($300).

Integration

I have already communicated with Pothoven about coordinating efforts to collect mussels for my proposed condition factor and reproductive status work at the same time he will be collecting mussels

for his projects. He will be visiting sites M25, M45, and X2 in spring, summer and fall and has agreed to do additional ponar grabs for me at that time.

I also propose to deploy two mussel cages during summer 2015 so that I may test out equipment and protocols for field growth experiments. For this, I am consulting with Vanderploeg, Constant and Ruberg on equipment design and Pothoven has offered some research crew time (~30 min per trip) to deploy and service the cages while they go out to conduct their routine sampling. Data collected from these caged mussels will be of great benefit to future projects.

Progress & Project Improvement (if project is continuing / on-going)

- In the short term, this project will produce biomass and density estimates for Dreissenid mussels in southern Lake Michigan for 2012-2015. It will also provide the foundation for designing future lab and field experiments (FY2016 and beyond).
- Products include updated biomass estimates for Dreissenids in Lake Michigan, which can be part of a standalone publication associated with a broader ecological question, a technical report, and/or serve as a valuable contribution to other modeling efforts.
- The greatest challenge encountered in the past year is the backlog of samples to be processed. The increased effort in the lab to process samples will alleviate this pressure.

Relevance to NOAA & Public

Question: How is the Lake Michigan benthic community responding to multiple environmental stressors?

- Societal relevance: Dreissenid mussels are a high profile invader throughout North America. They are associated with negative impacts on infrastructure, the lake ecosystem, and possibly human health.
- NOAA and DOC goals: #3.1 (Advance the understanding and prediction of changes in the environment.
- This work is in direct response to the GLERL Priority Science Question: “How will quagga mussel populations change in the coming years and how will the ecosystem respond?”

ECODYN 1.5: Spatial Studies and Microbes: CSMI 2015 Intensive Study
(Vanderploeg)

Key Internal Personnel: H. Vanderploeg, E. Rutherford, D. Mason, S. Ruberg, S. Constant, J. Liebig, G. Lang, J. Cavaletto, D. Fanslow, and N. Morehead.
Key External Partners: Carrick (CMU), Denef (UM)

Executive Summary

As part of Year of Lake Michigan 2010 and Lake Huron 2012, we examined detailed diel spatial coupling seasonally (April, July, and September) of nutrients and the food web from microbes to fishes using a variety of advanced tools. These studies have revealed extreme spatial organization of the lower food web, with larval fishes and zooplankton inhabiting narrow vertical layers between the metalimnion and hypolimnion, and this pattern can vary radically from nearshore to offshore and across seasons. These studies have also shown major changes in the microbial food web (MFW) caused by dreissenid grazing.

In support of the larger CSMI2015 we will be doing temporally intensive spatial studies in Muskegon/Grand Haven region to complement twice a year sampling by EPA and USGS along 8 transects located around Lake Michigan. We have no knowledge of spatial coupling—including diel vertical migration— during the time of early stratification, which is critical for deep chlorophyll layer formation as well as zooplankton and larval fish production. We will examine spatial coupling of the entire food web (microbes to fishes) at this time (May and June) as well as August to augment our standard seasonal sampling (April, July, September) along the Muskegon transect to understand the fate nutrient loading from inshore to offshore from tributaries loading into this region, the largest source of P loading directly into Lake Michigan. We will also augment our studies with 2 glider missions from Muskegon to Milwaukee to characterize cross lake chlorophyll and thermal structure. These and ongoing GLERL studies of hydrodynamics, process research, dreissenid abundance and grazing, MFW abundance and production, and collaborative research will provide us with data necessary for building sophisticated water quality and fisheries models to allow us to prioritize tributaries for P loading control for all of Lake Michigan. We have proposed such model development using GLRI funds in 2016-2017.

Budget Summary	
Item	***Total ($)***
Equipment	$10,000
Supplies *(includes EchoView software)*	$26,000
Field Travel *(field work)*	$ 2,500
Science Conference Travel *(conferences e.g. AMS, IAGLR, AGU)* *$2,500 request included in standard allotment*	
Science Meeting Travel *(e.g. working groups, PI meetings)*	$ 1,000
Admin Travel *(e.g. Advisory Board meetings)*	
*** International travel*	--
Contracts	$ 4,000
Other (specify):	
Total Amount	$43,500

Staffing and Ship Time	
Federal Staff	3.45 FTE
Contract and CILER Staff (Mabrey)	0.95 FTE
Total Staff	**4.40 FTE**
Total Ship Time Days (1 week per month April – September day/night: 30day) plus shakedown (5 days includes MOCNESS)	**35**

Project Details

Personnel Requirements

GLERL: Vanderploeg (0.3 FTE), Rutherford (0.4), Mason (0.3), Liebig (.5), Cavaletto (0.8), Fanslow (0.4), Morehead (0.5), Lang (0.1), Ruberg (0.05); Constant (0.1)

CILER: Mabrey (0.15FTE) and GLRI funded tech under MOCNESS project

Significant Collaborating Partners (externally funded GLRI and other sources): Carrick, Denef

Describe what work is intended to be done

We will be expanding upon our standard spatial cruises along the Muskegon transect that normally occur in April, July, and September to include all months April- September/October. All zooplankton and larval fish sampling will be done using the MOCNESS (see MOCNESS supporting subproject). In addition we propose to support 2 cross-lake glider missions (May and June). As in past efforts we will be doing a long transect from inshore (10-m depth contour) to offshore (110-m depth) at day and night running both PSS and fisheries acoustics. As usual we will be doing day/night sampling at M110 (Muskegon transect, 110-m depth contour) and M45 to describe diel vertical migration (DVM) of fish and zooplankton as well as sampling at M15. Short transects at all stations will provide acoustic information on fish abundance and all PSS variables (see below) to match with MOCNESS collections of zooplankton and larval fishes and with forage fishes made in Pothoven's LTR studies. Vincent Denef and Hunter Carrick will determine abundance and production of the microbial food web (MFW). Any dead time during crepuscular periods will be filled with PSS/acoustics runs. Water samples taken at points along the transect will be used to calibrate PSS sensors and to provide samples for nutrients and MFW components.

These week-long (assuming good weather) spatial cruises and the glider missions will be complimented by long-term research (LTR) studies of Pothoven (described in ECODYN1.1):

- Fish trawling for diet and acoustic identification and sampling for nutrients (1 week)
- LTR nutrients and plankton (1 week)

How will the work be accomplished?

All sampling will be carried out on day/night cruises of the Laurentian on a week sandwiched between the cruises of Pothoven described above. The LOPC must be sent back ASAP to manufacturer for check out of a faulty board and recalibration as well as other sensors checked out. A shakedown cruise well before the first spatial cruise will be necessary to check out LOPC/PSS function and check attack angle of LOPC relative to tow body as we discovered poor agreement between external flow meter and estimates in LOPC tunnel. Do note need for shakedown on MOCNESS in MOCNESS subproject. All scientific staff working on deck should be provided with appropriate cold weather gear for spring months.

Variables sampled include:

- Acoustic abundance of fish
- PSS (CTD, fluorometer, CDOM sensor, turbidity sensor, laser optical plankton counter [LOPC], PAR)
- UV radiation and FluoroProbe (algal composition by in situ spectrofluorometry) vertical profiles
- Zooplankton and larval fish abundance by MOCNESS
- Water samples:
    - Size-fractioned (< 2, 2-20, and > 20 µm) chlorophyll
    - Particulate C, N, and P; TP, TDP
    - MFW –omics (Denef)
    - MFW microscopy (Carrick)

Budget Explanation

CILER Personnel: Mabrey (0.15) to help out on labor intensive spatial cruises.
Equipment service/Repair LOPC and PSS sensors (assuming nothing seriously wrong): $10000
Supplies (lab and field): nutrients, MFW, and PSS supplies ($15K) and two glider missions ($10,000 for batteries)

Supplies/Contracts narrative:
LOPC must be sent back to manufacturer for checkout and repair, because internal flow speed was not recording ($10,000) on last cruise, a serious problem in itself and may indicate other underlying problems. Sensors other than LOPC on PSS will also require checking out. The EcoView software must be renewed annually ($8000). Supplies will cover items necessary for collecting and analyzing nutrient, MFW components, and zooplankton, PSS supplies (hardware and batteries) for a total of $8K; and $10K for batteries for two glider missions. The contract for genetic sequencing will be used to target the 16S rRNA gene for bacterial community composition and the 18S rRNA gene for eukaryotic community composition ($4K). This is to follow up on our mussel grazing studies which showed that mussels are targeting bacteria associated with particles. This will support parallel studies Carrick's study using traditional microscopy that is unlikely to observe this phenomenon

Integration
This study is GLERL's contribution to a multiagency (EPA, USGS, NOAA) and academic, state, tribe, and non-government efforts to describe and understand Lake Michigan in the Coordinated Science and Monitoring Initiative (CSMI) of 2015. This project is a complement to Vanderploeg's externally funded project "ECODYN EX8 NOAA Support of CSMI Lake Michigan 2015". This expanded subproject is an integral part of the LTR program and the expansion in 2015 will provide new important information not available in earlier spatial studies. This project documents all activities that will occur in CSMI, some of which are funded externally. All budget items listed here are those requesting base funds. This subproject will be coordinated with supporting LTR subprojects on nutrients, plankton and fishes of Pothoven (ECODYN 1.1), the mussel survey subproject of Baldridge (ECODYN 1.4), and the mussel feeding and nutrient excretion subproject of Vanderploeg (ECODYN 2.2). In addition, this work will provide information for modeling proposed (pending) for prioritizing tributary P loads to Lake Michigan using GLRI funds in 2016 and 2017.

Progress & Project Improvement (if project is continuing / on-going)
This research is expected to yield insight into how nutrient flows from tributaries and move through the food web from inshore to offshore and provide information necessary for predicting water quality and

larval production and recruitment in nearshore and offshore waters of Lake Michigan. This builds upon experience gained in earlier studies now in manuscript preparation, including a few manuscripts that have been submitted to a special issue of JGLR of which I am guest editor. Also, this study will yield important information on how the plankton and fish communities organize themselves in early spring which is important for understanding the role of interannual variability in weather and climate change on water quality and fisheries production. A series of manuscripts on all components of the food web is expected.

Relevance to NOAA & Public

What science question are we answering?

How do nutrient flows from tributaries and move through the food web from inshore to offshore?
How is the food web spatially organized?
How does nutrient loading and spatial organization of the food web affect water quality and fisheries production?
How does interannual variability in weather or climate change affect the food web of Lake Michigan?

What is the societal relevance?

We cannot predict effects of changes in nutrient loading, weather, or climate on the water quality and fisheries without this information.

Under what NOAA and DOC goals does the work fit?

DOC FY2014-2018 Strategic Plan: Environment: 3.1. Advance the understanding and prediction of changes in the environment through world class science and observations 3.4: Foster healthy and sustainable marine resources, habitats, and ecosystems through improved management and partnerships.
NOAA 5-year research and development plan 2013-2017: under the "Healthy Oceans Goal", this project meets the objective that fisheries, habitat, and biodiversity are sustained within healthy and productive ecosystems.

What part of GLERL's mission or which Strategic Plan milestone does this support?

This research is the culmination of years of preparation first identified as a goal of the ECODYN group in GLERL's strategic plan of 2012. This research is expected to yield insight into how nutrient flows from tributaries and move through the food web from inshore to offshore and provide information necessary for predicting water quality and larval production and recruitment in nearshore and offshore waters as well as forecasting climate impacts on the Great Lakes.

ECODYN 2.2 Mussel Feeding and Nutrient Excretion
(Vanderploeg)

Key Internal Personnel: H. Vanderploeg, J. Liebig, J. Cavaletto
Key External Partners: T. Johengen, A. Burtner, D. Palladino (CILER); V. Denef (UM), H. Carrick (CMU)

Executive Summary

We are examining mussel selective feeding on whole spectrum of seston (from bacteria to microplankton), nutrient recycling, and factors limiting growth of mussels in Lake Michigan to determine their impact on the food web, particularly the MFW and nutrient recycling. Recent work we submitted (under review) has shown that the size structure of phytoplankton and microbial food web (MFW) components have been radically altered by mussels with most production now occurring in the MFW rather than the classic phytoplankton to zooplankton food web. These observations have profound implications to how Lake Michigan functions and has relevance to both water quality and fisheries. In 2014, we used size fractioned chlorophyll analyses, light microscopy, and genetic techniques to characterize impacts of mussels on Lake Michigan seston in controlled laboratory experiments; however, weather and technical problems prevented us from doing experiments in late fall and during early spring, periods critical for understanding impact so we can tie in observed changes in nature observed in the Spatial Studies and Microbes subproject with measurement of effects in the laboratory. Interestingly, we learned with genetic methods that much of the bacterial community grazed by mussels during our summer experiment was associated with particles. This would not have been observable by traditional methods. In addition we need to plan for the next generation of experiments for examining P recycling by looking at our results and planning for future experiments with radioisotopes. Our efforts will focus on data analysis of experiments we have performed as well as conducting experiments in late fall and early spring. In addition this study is examining the inventory of P associated with mussel tissues and shells (live and dead) to determine the inventory of P and N in these compartments.

Budget Summary	
Item	***Total ($)***
Equipment	
Supplies	$ 4,000
Field Travel *(field work)*	
Science Conference Travel *(conferences e.g. AMS, IAGLR, AGU)*	
Science Meeting Travel *(e.g. working groups, PI meetings)*	
Admin Travel *(e.g. Advisory Board meetings)*	
*** International travel*	--
Contracts/CILER: Burtner and Palladino each at 1 months:	$12,500
Other (specify)	
Total Amount	$16,500

Staffing and Ship Time	
Federal Staff	0.80 FTE
Contract and CILER Staff	0.24 FTE
Total Staff	**1.04 FTE**
Total Ship Time Days	**4**

Project Details

We are examining mussel selective feeding on whole spectrum of seston (from bacteria to microplankton), nutrient recycling, and factors limiting growth of mussels in Lake Michigan to determine their impact on the food web, particularly the MFW and nutrient recycling. Recent work we submitted (under review) has shown that the size structure of phytoplankton and microbial food web (MFW) components have been radically altered by mussels with most production now occurring in the MFW rather than the classic phytoplankton to zooplankton food web. These observations have profound implications to how Lake Michigan functions and has relevance to both water quality and fisheries. In 2014, we used size fractioned chlorophyll analyses, light microscopy, and genetic techniques to characterize impacts of mussels on Lake Michigan seston in controlled laboratory experiments; however, weather and technical problems prevented us from doing experiments in late fall and during early spring, periods critical for understanding impact so we can tie in observed changes in nature observed in the Spatial Studies and Microbes subproject with measurement of effects in the laboratory. Interestingly, we learned with genetic methods that much of the bacterial community grazed by mussels during our summer experiment was associated with particles. This would not have been observable by traditional methods. In addition we need to plan for the next generation of experiments for examining P recycling by looking at our results and planning for future experiments with radioisotopes. Our efforts will focus on data analysis of experiments we have performed as well as conducting experiments in late fall and early spring. In addition this study is examining the inventory of P associated with mussel tissues and shells (live and dead) to determine the inventory of P and N in these compartments.

<u>Personnel Requirements</u>

GLERL and CILER staff:

Vanderploeg (0.2FTE) will design and participate in carrying out experiments. The whole team consisting of Vanderploeg, Liebig (0.2FTE), Cavaletto (0.1 FTE), Fanslow (0.2 FTE), Johengen, Burtner, Palladino (0.08 FTE), and Denef will participate in setting up the experiments and immediately processing water from the experiments. Water samples will be collected for Carrick who will describe changes in the MFW in the grazing experiments using flow cytometer and microscopic analyses. Liebig, Burtner, Palladino, and Johengen will be responsible for managing data and reporting out results. Fanslow will do FlowCAM analyses, collect mussels and water and do CHN analyses. Burtner and Palladino are also responsible for carrying out the nutrient cycling experiments run in parallel with feeding experiments and determining P concentration in tissues. Morehead (0.1 FTE) is responsible for determining P concentration in live and in dead mussel shells.

<u>Describe what work is intended to be done</u>

All work is done with mussels and water collected at M45, with the water collected 2-5 mab. Fanslow working with LMFS collects mussels and water during time periods scheduled for Pothoven's monitoring cruises off the Laurentian.

Budget Explanation
The primary costs of this project are supplies ($4K) necessary for carrying out the experiments and personnel costs ($12.5K) to fund CILER techs Burtner and Palladino.

Integration
This project is an integral part of the LTR program and is necessary for understanding and predicting changes in the ecosystem caused by dreissenid mussels. The project combined with the project on mussel biomass (ECODYN 1.4) will help explain the changes in the Lake Michigan foodweb observed in the internally funded and externally funded Lake Michigan CSMI projects.

Progress & Project Improvement (if project is continuing / on-going)
What are the expected short-term (FY15) and longer term (2-5 years) outcomes and milestones?

- In the near-term we will analyze data from completed experiments, conduct new ones, and plan for future studies that will include radioisotopes as well as designing new experiments to understand growth potential of mussels under different food concentration found in nature.

Which journal papers, reports, and products (e.g., forecasts, briefs, models, etc.) will be *developed or improved* upon?

- We will use the information to upgrade our knowledge of the feeding rate and nutrient excretion of mussels.

FY14 progress made on the project as compared to stated milestones and goals

- We carried out two experiments, but weather prevented us from doing 2 we had planned.

What challenges were encountered during the past year and what is the plan to reduce or eliminate them this year?

- Weather prevented collection, try again late this fall and early next spring.

Relevance to NOAA & Public
What science question are we answering?

- What is the role of dreissenid mussels in reengineering nutrient cycling and food web dynamics?
- How have dreissenid mussels impacted water quality and fisheries in the Great Lakes?
- What will be the impact of climate change and dreissenid mussels on Lake Michigan?
- Can we predict the carrying capacity of dreissenid mussels Lake Michigan?

What is the societal relevance?

Dreissenid mussels have radically changed the Great Lakes and we cannot effectively manage them unless we understand their effects.

Under what NOAA and DOC goals does the work fit?

- DOC FY2014-2018 Strategic Plan: Environment: 3.1. Advance the understanding and prediction of changes in the environment through world class science and observations 3.4: Foster healthy and sustainable marine resources, habitats, and ecosystems through improved management and partnerships.

- NOAA 5-year research and development plan 2013-2017: under the "Healthy Oceans Goal", this project meets the objective that fisheries, habitat, and biodiversity are sustained within healthy and productive ecosystems.

What part of GLERL's mission or which Strategic Plan milestone does this support?

- This project is an anchor for ECODYN's LTR project to understand changes in the Lake Michigan ecosystem.

ECODYN 3.1 Black Box Warning: Microcystis Abundance and Buoyancy
(Vanderploeg)

Key Internal Personnel: H. Vanderploeg, S. Ruberg, T. Davis, E. Anderson, D. Fanslow, J. Liebig
Key External Partners: M. Rowe (NRC), T. Johengen (CILER)

Executive Summary

In forecasting HAB trajectories, GLERL and other groups use hydrodynamic models to move neutrally buoyant HAB particles from one location to project HAB location seen in satellite images to a future time. However, this approach is not realistic because *Microcystis* undergoes a diel vertical migration that depends on physiological status (as it affects gas vacuole condition), *Microcystis* colony size (Stokes Law sinking and floating), and water column stability. Larger colonies undergo a larger migration than smaller colonies as their gas vacuole shrink during the day as the colonies photosynthesize carbohydrates. Under quiescent conditions full migratory potentials will be realized and *Microcystis* will float up and harvest light at the surface and sink down later during the day. Vertical position will affect growth rate (and competition with other algae that do better under low-light and high mixing regimes) and the ability of the satellite to determine Microcystis abundance. Biophysical models have been developed for diel vertical distribution of *Microcystis* for various mixing scenarios in some reservoir systems and compared to vertical distribution of *Microcystis* colonies (Medrano et al. 2013). Nakamura et al. (1993) using an apparatus analogous to the Critter Cam in our lab, showed vertical migration rates of large colonies (~mm/s) can be 500 × rate of small colonies (~ 2µm/s), a range much wider than the assumed velocities of the Medrano et al. simulations.

Therefore, practical trajectory models depend on being able to rapidly determine abundance, size structure, and vertical distribution of the Microcystis community and specify its buoyancy. We propose to use FlowCAM and FluoroProbe to rapidly report out Microcystis abundance, size structure, and vertical distribution for the trajectory model in western Lake Erie. Moreover, we will develop practical methods to measure buoyancy of Lake Erie Microcystis colonies using the Critter Cam with the ultimate goal of rapidly assaying buoyancy and the factors that regulate it.

To determine vertical migration rates of different sized colonies in the lab, the Critter Cam will be used. This will require setting the system up again and relearning and upgrading software for 2-D motion analysis (< $10K). We propose that a computer savvy Summer Fellow take on this task of set up and making initial measurements of cultured and natural colonies.

Budget Summary	
Item	***Total ($)***
Equipment	
Supplies	$ 4,000
Field Travel *(field work)*	
Science Conference Travel *(conferences e.g. AMS, IAGLR, AGU)*	
Science Meeting Travel *(e.g. working groups, PI meetings)*	
Admin Travel *(e.g. Advisory Board meetings)*	
*** International travel*	--
Contracts/CILER	
Other (specify)	
Total Amount	$4,000
Staffing and Ship Time	
Federal Staff	0.95 FTE
Contract and CILER Staff	0.00 FTE
Total Staff	**0.95 FTE**
Total Ship Time Days	**4**

Project Details

Personnel Requirements

Key project personnel

Henry Vanderploeg (20%); Steve Ruberg (5%); Jim Liebig (20%); Dave Fanslow (40%); MIL Tech (10%) (from 1040); Davis, Anderson, Rowe, Johengen (not on 1040 but listed above in exec summary)

Describe what work is intended to be done

In forecasting HAB trajectories, GLERL and other groups use sophisticated hydrodynamic models to move neutrally buoyant HAB particles from one location to project HAB location seen in satellite images to a future time. However, this approach is not realistic because Microcystis undergoes a diel vertical migration that depends on physiological status (as it affects gas vacuole condition), Microcystis colony size (Stokes Law sinking and floating), and water column stability (mixing can overcome buoyancy). Larger colonies undergo a larger migration than smaller colonies as their gas vacuole shrink during the day as the colonies photosynthesize carbohydrates. Under quiescent conditions full migratory potentials will be realized and Microcystis will float up and harvest light at the surface and sink down later during the day. Vertical position will affect growth rate (and competition with other algae that do better under low-light and high mixing regimes) and the ability of the satellite to determine Microcystis abundance. Biophysical models have been developed for diel vertical distribution of Microcystis for various mixing scenarios in some reservoir systems and compared to vertical distribution of Microcystis colonies (Medrano et al. 2013). Nakamura et al. (1993) using an apparatus analogous to the Critter Cam in our lab, showed vertical migration rates of large colonies (~mm/s) can be 500 × rate of small colonies (~ 2µm/s), a range much wider than the assumed velocities of the Medrano et al. simulations.

Therefore, practical trajectory models depend on being able to rapidly determine abundance, size structure, and vertical distribution of the Microcystis community and specify its buoyancy. We propose to use FlowCAM and FluoroProbe to rapidly report out Microcystis abundance, size structure, and vertical distribution for the trajectory model in western Lake Erie. Moreover, we develop practical methods to measure buoyancy of Lake Erie Microcystis colonies using the Critter Cam.

We would propose a similar approach in western Lake Erie and parameterize the model for the Microcystis strains there by examining diel vertical distribution of different sized colonies in the field as well as making observations in the laboratory of floating and sinking rates. To examine diel vertical migration, ship time would be required to take water samples every 4 hours at a "deep-water" site in western Lake Erie on two calm days and 2 average-condition days. This information would be used by the hydrodynamic modelers to improve their trajectory models. It has been suggested that biologically-oriented post-doc work with our hydrodynamic modeler (Anderson) on this problem to speed development of the model and make field and laboratory observations. Likewise we expect for various reasons that larger Microcystis colonies will be more toxic than smaller colonies. To determine vertical distribution of Microcystis abundance and colony size we will use FlowCAM observations to rapidly assess biomass and size distribution. This same technology could be used to rapidly report on Microcystis abundance for the HAB Bulletin along with observations made with the FluoroProbe, which can (fluorometrically) rapidly assess pigment classes in the field and lab. A major effort will be made (Vanderploeg, Fanslow & Liebig) to optimize FlowCAM image processing of Microcystis colonies and relate them to "true" biomass. Work with FlowCAM will be coordinated with other components of the monitoring program. Because of heavy use of the FluoroProbe in the Lake Michigan LTR program and conflicting heavy use in Lake Erie, we purchased another FluoroProbe to be dedicated solely to HAB and laboratory work. Toxicity of different sized colonies would be examined by size fractionation of the floating component in a collected water sample (= Microcystis) or phycocyanin containing component.

To determine vertical migration rates of different sized colonies in the lab, the Critter Cam will be used. This will require setting the system up again and relearning and upgrading software for 2-D motion analysis. We have advertised for a computer savvy Summer Fellow to take on this task of set up and making initial measurements of cultured and natural colonies.

<u>Budget Explanation</u>
$4K will be needed for expendable supplies

<u>Integration</u>
This project will be important for externally supported research to forecast bloom trajectories funded under GLRI.

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ECODYN 4.1 International collaboration and science planning towards predicting invasive species impacts in the Great Lakes
(Doran Mason)

Ed Rutherford (EcoDyn) and Hongyan Zhang (CILER)

Executive Summary

The US has a number of aquatic invasive species from Asia (most notably Asian Carp who are now threatening to invade the Great Lakes) and the threat of future invasions from the continent of Asia is on the rise due to increasing traffic amongst the two continents. Likewise, North American species are currently invading Asian waters. Collaboration between GLERL/CILER and China will contribute greatly to insights into the ecology and biology of invasive species from researchers in the country of origin, identifying potential future invaders and predicting their potential spread, and assessing the potential impacts of these invaders on ecosystem resiliency and sustainability using models and experiments. The Chinese collaborators have expertise with experimental and field studies on Asian Carp useful for model development and calibration, while GLERL/CILER have the expertise in modeling the potential impacts of invasive species. This creates an excellent opportunity for collaboration. Collaborating with researchers from China is vital to creating 'cross-talk" that will enhance our ability to study invasive species from Asia, and provide sound scientific information for managers and policy-makers. To facilitate this interaction with the Chinese, we request funds for two to travel to China (Yangtze River Fisheries Research Institute, Wuhan China) to begin to develop a conceptual model and strategy for long-term collaborations. It is expected that the results of our visit will be used to seek funding sources both in the US and China.

Budget Summary	
Item	***Total ($K)***
Equipment	
Supplies	
Field Travel *(field work)*	
Science Conference Travel *(conferences e.g. AMS, IAGLR, AGU)*	
Science Meeting Travel: China 7 days (2)	$10,150
Admin Travel *(e.g. Advisory Board meetings)*	
***International travel: Wuhan China*	--
Contracts/CILER	
Other (specify):	
Total Amount	$10,150
Staffing and Ship Time	
Federal Staff	0.17 FTE
Contract and CILER Staff	0.15 FTE
Total Staff	**0.32 FTE**
Total Ship Time Days	**0**

Project Details

Personnel Requirements

Doran Mason-Lead PI (8.3%), Edward Rutherford- Supporting PI (8.3%)

Collaborators: Hongyan Zhang (CILER)-Supporting PI

Collaborating Partners: Professor Yan Wang (Zhejiang University), Dr. Daqing Chen (Yangtze River Fisheries Research Institute)

Work is intended to be done

a. One week visit will take place in Wuhan China at the Yangtze River Fisheries Research Institute in FY15
b. Overall purpose is to develop a conceptual model and strategy for long-term collaborations with regard to invasive species and invasive species impacts in Great Lakes and China, and to seek funding for planned projects
c. Continuation of GLERL/CILER ongoing research on the potential impacts of identified likely invaders in the Great Lakes
d. Natural collaboration as China is the origin of many invasive species in the Great Lakes (including Asian Carp), China has many invasive species from the US (e.g., channel catfish and largemouth bass), Chinese collaborators have expertise in experimental and field research with Asian Carp necessary for model development, GLERL/CILER have extensive experience modeling invasive species impacts.

Budget Explanation

Budget is to support travel for two to Wuhan, China. Estimated costs are $225/day per diem (food and lodging) for 7 days for a total of $1,575, $3,000 round trip airfare, $500 for visa application for a total of $5,075 per person. For two people the final cost is **$10,150**.

Integration

This project builds directly upon 3 externally funded projects: 1) GLRI- Assessing risk of Asian carp invasion and impacts on Great Lakes food webs and fisheries, 2) GLRI- Larval dispersal, habitat classification and food web modeling, and 3) NSF- U.S.-China Planning Visits: Catalyzing Collaboration on Forecasting the Potential Impacts of Invasive Species (awarded to University of Michigan). The NSF grant provides travel support for Dr. Zhang for the purpose of developing these collaborations. Dr. Zhang has made one trip to China to meet with collaborators (Spring 2014). The intent is for Rutherford and Mason to join her on the second trip.

Progress & Project Improvement

- Expected short-term outcomes (FY15): conceptual model and strategy for collaborative research on invasive species in China and the Great Lakes.
- Expected long-term outcomes (2-5 years): Joint funded research program that combines experimental, field, and modeling work for quantifying and forecasting impacts of invasive species in the Great Lakes and in inland waters of China.
- FY14 progress: N/A, new project
- Challenges encountered during the past year: N/A, new project

Relevance to NOAA & Public

What science question are we answering?

- The general question is "what are the impacts of invasive species on natural aquatic systems and are they preventable by natural control mechanisms?"

What is the societal relevance?

- Invasive species are a global threat to aquatic ecosystems. Information is needed to decide when or if a non-native species poses a threat to an ecosystem, and if it does, what kind of threat does it pose. This is necessary for making decisions regarding prevention and control, which has budgetary and economic ramifications.

Under what NOAA and DOC goals does the work fit?

- DOC FY2014-2018 Strategic Plan
  - Environment, 3.1 Advance the understanding and prediction of changes in the environment through world class science and observations
  - Environment, 3.4 Foster healthy and sustainable marine resources, habitats, and ecosystems through improved management and partnerships
- NOAA 5-year research and development plan 2013-2017
  - Goal: Healthy Oceans. Objective: Increase our knowledge and understanding of the mechanisms and impacts of environmental changes on marine species and ecosystems
  - Goal: Resilient Coastal Communities and Economies. Objective: *Determine combined effects of environmental stressors on coastal species and ecosystems. Objective: Region-specific, nationwide, operational capability for ecological forecasting*
- Fulfills GLERL's mission to "… conduct innovative research on the dynamic environments and ecosystems of the Great Lakes to inform resource use and management decisions that lead to safe and sustainable ecosystems, ecosystem services, and human communities".

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Integrated Physical and Ecological Modeling and Forecasting

IPEMF 1.1 Lake Circulation and GLCFS: Can HRRR meteorological forcing conditions be used to improve hydrodynamic forecasting skill?

(Eric J. Anderson)

Collaborators: Gregory Lang, Dmitry Beletsky (CILER), Raisa Beletsky (CILER)
Partners: Stanley Benjamin (ESRL)

Executive Summary

This project will evaluate the new NCEP High-Resolution Rapid Refresh (HRRR) model for the Great Lakes, and in particular investigate (1) the hydrodynamic response to the HRRR weather model, (2) transferability to FVCOM-based operational forecasting systems, (3) the ability of HRRR to resolve fine-scale convective processes (e.g. squall lines, meteotsunamis) and over-lake conditions, and (4) the improvement to model skill during storm and non-storm events.

The HRRR model is a rapid update weather model that uses radar and other observations to improve forecasted weather conditions. Currently, the operational forecasting systems (OFS) including GLOFS and the GLCFS do not use radar data as part of the surface marine observations that drive the hydrodynamic simulations. In addition, the existing OFS use hourly, interpolated meteorological observations to determine over-lake conditions and as a result are unable to resolve fine-scale convective processes and some coarse-scale over-water wind conditions (see Beletsky et al., 2013).

Currently, the next generation of the GLCFS is under development using the Finite Volume Coastal Ocean Model (FVCOM), with the first model, Lake Erie Operational Forecasting System (LEOFS), scheduled to transfer from GLERL to CO-OPS for operational implementation by August 2015. The HRRR model has be identified as a candidate for meteorological forcing conditions needed by the FVCOM Lake Erie model (LEOFS); however no study of hydrodynamic response on any body of water has been carried out.

Although the potential for HRRR to improve meteorological outlooks is known, we do not know how well the HRRR resolves over-water conditions for the Great Lakes (at 3km scale) or how hydrodynamic models will respond to the implementation of rapid-update weather forcing. Therefore, in this project we will answer key questions pertaining to the suitability of HRRR for hydrodynamic OFS implementation, improvement to model skill, and potential to resolve extreme phenomena such as meteotsunami events.

Budget Summary	
Item	***Total ($)***
Equipment	-
Supplies	-
Field Travel *(field work)*	-
Science Conference Travel *(conferences e.g. AMS, IAGLR, AGU)*	-
Science Meeting Travel *(e.g. working groups, PI meetings)*	-
Admin Travel *(e.g. Advisory Board meetings)*	-
***Please note here any International travel and the location ($ amount is included in one of the above categories)*	--
Contracts/CILER	$29,000
Other (specify)	
Total Amount	**$29,000**
Staffing and Ship Time	
Federal Staff	0.30 FTE
Contract and CILER Staff	0.33 FTE
Total Staff	**0.63 FTE**
Total Ship Time Days	**0**

Project Details

Personnel Requirements

Anderson – Lead PI, model simulation (20%); Lang- GLCFS comparison and interpolated meteorology (10%)

Collaborators: Dmitry Beletsky (CILER) – Meteorological intercomparison and analysis (8%); Raisa Beletsky (CILER) – HRRR preparation and model post-processing (25%)

Collaborating Partners: Stan Benjamin – NOAA/ESRL

Work intended to be done

Where the work will take place

c. Work will take place (virtually) on Lake Erie, in actuality on GLERL HPC cluster
d. Will cover entire lake at model grid scales between 100m-2km, using the new NCEP/HRRR 3km radar-assimilated weather forecast product

When the work will take place

d. Will take place in spring/summer 2015 (depending on data transfer from ESRL)
e. Day time work (model simulation at any hour)
f. Anticipate modeling 1-5 storm events initially. 1-year simulation if results are promising.

How will the work be accomplished?

- Hindcast output from the HRRR model (covering Lake Erie) will be obtained from Stan Benjamin (ESRL) for at least one year. Meteorological variables will be extracted and

translated into FVCOM format (and supplemented with necessary meteorological variables from other sources). An intercomparison of surface forcing conditions will be carried out (HRRR, GEM, NDFD, NAM, WRF, etc.). The Lake Erie FVCOM model will be simulated for chosen events to evaluate lake response to HRRR forcing. Post-processing analysis of hydrodynamic conditions will be carried out to evaluate model skill. Operational capability and testing will be carried out by testing HRRR output within the GLCFS real-time framework.

- What are key resources necessary to accomplish the work?
  - GLERL HPC cluster (e.g. Wings): estimate 4 nodes for 4-6 hour simulations, 1-3x per week during development/testing, operational testing to be done on Tiger/Panther using 1-3 nodes in parallel to real-time LEOFS (Lake Erie FVCOM) runs.
  - Data storage expected to be <50 GB during project lifetime (on zeus/zebra)
  - Anticipate manuscript preparation/editing/publication fees following the project completion.
- Identify health and safety issues associated with performing the work: None
- Model output will be archived on zeus/zebra servers in NetCDF format and native HRRR format (GRIB2)

Budget Explanation

- I am requesting funding to support two existing CILER staff. Dmitry Beletsky (effort 1 month, $8k) will work with PI Anderson to analyze the HRRR meteorology and compare to other existing weather products (e.g. GEM, NDFD, GLCFS-interp, etc.) to evaluate resolution of over-lake conditions such as convective storms. Furthermore D. Beletsky will oversee R. Beletsky (effort 3 months, $21k) in pre-processing of HRRR data (e.g. translating to FVCOM format, etc.) and post-processing of FVCOM model output for analysis and skill assessment (validation with observations)
- No new GLERL resources are being requested (only existing office usage by CILER scientists, and existing IT resources used by the IPEMF group).
- GLERL security level will not be affected.

Integration

This project is linked to existing GLCFS development and the transfer to NOS/CO-OPS (LEOFS). See project 1.1 GLCFS from FY14.

Progress & Project Improvement (if project is continuing / on-going)

- What are the expected short-term (FY15) and longer-term (2-5 years) outcomes and milestones?
  - FY15 milestone is an (1) evaluation of the HRRR for use in hydrodynamic operational forecasting systems, (2) lake response to HRRR forcing and improvement to model skill
  - Longer term milestone is (1) publication of at least one article on the model results, (2) presentation at >1 scientific conference, and (3) incorporation into the LEOFS operational framework (in appropriate)
- Which journal papers, reports, and products (e.g., forecasts, briefs, models, etc.) will be *developed or improved* upon?
  - Journal publication (>1) and scientific presentation (>1)
  - Enhancement of GLCFS/LEOFS operational model
- FY14 progress: N/A new project

- Challenges encountered this year: HPC downtime and bug fixes to FVCOM code. HPC issues are not expected to be a long-term issue, but if so, we will run model simulations on ESRL/Jet HPC in Boulder. FVCOM code fixes have been implemented; anticipate no additional or only minor bug fixes that should not impact this work.

Relevance to NOAA & Public

What science question are we answering?

- Lake circulation and coastal dynamics is focused on understanding the physical environment of the lakes and connecting channels and addressing water quality problems (chemical pollution and bacterial contamination as well as physical threats to public safety (storms, oil spills, waves, rip currents)) on a localized and lake-wide basis. The length of time for these problems ranges from hours to days. Our research includes the development and use of hydrodynamic (circulation of water in the prediction of currents, water temperature, storm surge, waves, ice cover, and nutrient or bacteria loads.

What is the societal relevance?

- These predictions enable us to forecast events such as beach closures, hazardous material transport pathways, movement of harmful algal blooms, aid in search and rescue operations, navigation (commercial shipping), and recreational boating/swimming. These forecasts provide decision makers with tools to aid in protecting the Great Lakes and the public.

Under what NOAA and DOC goals does the work fit?

- DOC Objective 3.1: Advance the understanding and prediction of changes in the environment through world class science and observations
    - Develop the next-generation environmental modeling system
- DOC Objective 3.2: Improve preparedness, response, and recovery from weather and water events by building a Weather-Ready Nation
    - Improve the accuracy and usefulness of forecasts
- NOAA Weather Ready Nation: Improved predictive guidance
    - Evaluate the impact of ocean-atmosphere coupling on short-range weather forecasts
- NOAA Healthy Oceans: Increase our knowledge and understanding of the mechanisms and impacts of environmental changes on marine species and ecosystems
    - Decrease uncertainty in the forecasts generated from ecosystem models
- NOAA Resilient Coastal Communities and Economies: Region-specific, nationwide, operational capability for ecological forecasting
    - Expand the HAB forecast system to a national scale through the development of a standardized and modular system for data synthesis, analysis, and product creation
    - Transition ecological forecasting from research to operations in selected regions as progress towards a nationwide capability, and focus on topics of immediate concern
- NOAA Integrated Environmental Modeling System: Establish quantified uncertainties for NOAA's predictions and projections

    - Quantify model uncertainty and skill for all NOAA operational models and forecast products
- NOAA Integrated Environmental Modeling System: Advance data integration and assimilation into Earth System modeling
    - Prototype data assimilation methods

What part of GLERL's mission or which Strategic Plan milestone does this support?

- Provide improved analysis tool and high spatial resolution numerical models for operational coastal forecasting in the Great Lakes to maintain safe navigation and enhanced recreational opportunities
- Develop predictive models for algal blooms in Lake Erie, Saginaw Bay, and Green Bay, and for beach water quality at key swimming beaches in all five Great Lakes to protect human health
- Replace Princeton Ocean Model (POM) hydrodynamic code in the Great Lakes Coastal Forecasting System (GLCFS) with Finite Volume Coastal Ocean Model (FVCOM) code to ensure future compatibility with NOAA's operational coastal forecasting systems
- Develop coupled physical/biological model as first step toward a fully integrated ecological modeling system to predict impacts of climate and invasive species on physical and ecological conditions on a multi-decadal, regional scale

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IPEMF 1.3 Lake circulation and physical observations for development of hydrodynamic and HAB forecasting models
(Eric J. Anderson)

Collaborators: Steve Ruberg, Tim Davis, Steve Constant

Executive Summary

This project will provide observations of the physical environment of the western basin of Lake Erie in order to understand the transport of the Maumee River plume and movement of the algal bloom. Observations of currents, temperature, and waves will be used in conjunction with co-located water quality observations at three continuous sampling stations in the western basin to calibrate the Lake Erie FVCOM hydrodynamic model and the HAB Tracker particle model. In addition, drifter releases (3 drifters for 2 releases) will be deployed to track the HAB after formation, supplying additional calibration information for the HAB Tracker.

Presently, no water current information is recorded at the HAB monitoring sites in the western basin, and thus when water quality measurements indicate changes in HAB dynamics it is difficult to determine if these events are due to advection or resuspension processes, or a combination of the two. The current observations proposed in this project will aid in the elucidation of these events and processes as well as the development of the HAB Tracker and operational Lake Erie hydrodynamic model.

Budget Summary	
Item	***Total ($)***
Equipment	-
Supplies	-
Field Travel *(field work)*	-
Science Conference Travel *(conferences e.g. AMS, IAGLR, AGU)*	-
Science Meeting Travel *(e.g. working groups, PI meetings)*	-
Admin Travel *(e.g. Advisory Board meetings)*	-
***Please note here any International travel and the location ($ amount is included in one of the above categories)*	-
Contracts/CILER	-
Other (specify)	
Total Amount	**$0**
Staffing and Ship Time	
Federal Staff	0.35 FTE
Contract and CILER Staff	-
Total Staff	**0.35 FTE**
Total Ship Time Days	**5**

Project Details

Personnel Requirements

Anderson – Lead PI, project management/deployment/analysis (25%); Ruberg – observation management (5%); Constant – mooring preparation (5%)

Collaborators: Tim Davis – HAB monitoring; Tom Johengen (CILER) – HAB monitoring; Andrea Vander Woude (CILER) – HAB remote sensing; Mark Rowe (CILER) – HAB particle modeling

Describe what work is intended to be done

As part of the narrative include:

Where the work will take place

a. Lake Erie
b. Western basin, at the continuous HAB sampling stations

When the work will take place

a. Deployment of ADCPs at HAB sampling stations in June (or when HAB sampling program begins weekly sampling) on ship of opportunity (deploy from one of the weekly cruises)
b. Service ADCPs once per month and retrieval in October
c. Deploy drifter buoys (3 buoys, 2 sets of releases) after HAB formation
d. Work will occur during the day for instrument and drifter deployment
e. Monthly instrument service (ADCP swaps) between deployment and retrieval

How will the work be accomplished?

- What are key processes necessary to accomplish the work?
  a. Preparation of 3 Nortek Aquadopp shallow water ADCPs and mooring (Constant, Anderson, Ruberg)
  b. Deployment/service/retrieval of ADCPs and drifters (Anderson)
  c. Data processing of temperature/ADCP/drifters (Anderson)
  d. Model development (Anderson, Rowe)
- What are key resources necessary to accomplish the work?
  - Vessels: Vessel of opportunity for instrument deployment, service, and retrieval, as part of the weekly HAB sampling cruises in Lake Erie; once per month for June-October (5 ship days)
  - Existing equipment to be used for all deployments:
    - 3 existing Nortek 2MHz Aquadopps and moorings
    - 3 existing drifter supplies and TrackPack/Spot
  - MIL support and mooring preparation for all deployments
- Typical health and safety issues associated with shipboard mooring preparation and instrument deployment/retrieval as currently performed by GLERL
- Data will be archived in NetCDF or appropriate format on zeus/zebra

Budget Explanation

- No additional staff will be necessary to perform the deployments described in this project.
- No new equipment will need to be purchased for these deployments
- 5 ship days are requested as described above (1/month for 5 months)
- GLERL security level will be unchanged.

Integration

This project is directly linked to IPEMF1.1 (GLCFS development and calibration) and external GLRI projects (SOAR – Ruberg; OHH – Anderson; HAB – Davis).

Progress & Project Improvement (if project is continuing / on-going)

Include:

- What are the expected short-term (FY15) and longer term (2-5 years) outcomes and milestones?
    - FY15 milestone is to gather continuous data on currents in Lake Erie for several months including data download and processing.
    - Longer-term milestones are to calibrate the GLCFS Lake Erie FVCOM model in the western basin and validate the HAB particle model development (Rowe)
- Which journal papers, reports, and products (e.g., forecasts, briefs, models, etc.) will be *developed or improved* upon?
    - This work will contribute to publications related to HAB research in Lake Erie; anticipate at least one publication on the HAB particle model. In addition this will aid in the development of the GLCFS Lake Erie hydrodynamic model and the HAB particle tracking model currently being developed via external GLRI projects.

Relevance to NOAA & Public

What science question are we answering?

- Lake circulation and coastal dynamics is focused on understanding the physical environment of the lakes and connecting channels and addressing water quality problems (chemical pollution and bacterial contamination as well as physical threats to public safety (storms, oil spills, waves, rip currents)) on a localized and lake-wide basis. The length of time for these problems ranges from hours to days. Our research includes the development and use of hydrodynamic (circulation of water in the prediction of currents, water temperature, storm surge, waves, ice cover, and nutrient or bacteria loads.

What is the societal relevance?

- These predictions enable us to forecast events such as beach closures, hazardous material transport pathways, movement of harmful algal blooms, aid in search and rescue operations, navigation (commercial shipping), and recreational boating/swimming. These forecasts provide decision makers with tools to aid in protecting the Great Lakes and the public.

Under what NOAA and DOC goals does the work fit?

- DOC Objective 3.1: Advance the understanding and prediction of changes in the environment through world class science and observations
    - Develop the next-generation environmental modeling system
- DOC Objective 3.2: Improve preparedness, response, and recovery from weather and water events by building a Weather-Ready Nation
    - Improve the accuracy and usefulness of forecasts
- NOAA Weather Ready Nation: Improved predictive guidance
    - Evaluate the impact of ocean-atmosphere coupling on short-range weather forecasts
- NOAA Healthy Oceans: Increase our knowledge and understanding of the mechanisms and impacts of environmental changes on marine species and ecosystems
    - Decrease uncertainty in the forecasts generated from ecosystem models

- NOAA Resilient Coastal Communities and Economies: Region-specific, nationwide, operational capability for ecological forecasting
    - Expand the HAB forecast system to a national scale through the development of a standardized and modular system for data synthesis, analysis, and product creation
    - Transition ecological forecasting from research to operations in selected regions as progress towards a nationwide capability, and focus on topics of immediate concern
- NOAA Integrated Environmental Modeling System: Establish quantified uncertainties for NOAA's predictions and projections
    - Quantify model uncertainty and skill for all NOAA operational models and forecast products
- NOAA Integrated Environmental Modeling System: Advance data integration and assimilation into Earth System modeling
    - Prototype data assimilation methods

What part of GLERL's mission or which Strategic Plan milestone does this support?

- Provide improved analysis tool and high spatial resolution numerical models for operational coastal forecasting in the Great Lakes to maintain safe navigation and enhanced recreational opportunities
- Develop predictive models for algal blooms in Lake Erie, Saginaw Bay, and Green Bay, and for beach water quality at key swimming beaches in all five Great Lakes to protect human health
- Replace Princeton Ocean Model (POM) hydrodynamic code in the Great Lakes Coastal Forecasting System (GLCFS) with Finite Volume Coastal Ocean Model (FVCOM) code to ensure future compatibility with NOAA's operational coastal forecasting systems
- Develop coupled physical/biological model as first step toward a fully integrated ecological modeling system to predict impacts of climate and invasive species on physical and ecological conditions on a multi-decadal, regional scale

IPEMF 2.1 Monitoring, Understanding, and Forecasting Over-lake Evaporation
(Drew Gronewold)

Key Internal Personnel: Lofgren, Wang, Anderson, Ruberg, Constant, Muzzi, Clites, Hunter
Key External Partners: Chris Fairall, Dan Wolfe, Stan Benjamin (NOAA-ESRL); J. Smith (CILER); Branko Kerkez (U. Michigan); Peter Blanken (UC-Boulder); Carol Stepien and Jiquan Chen (U. Toledo and MSU); John Lenters (LimnoTech); Northern Michigan University; Vincent Fortin, Chris Spence (Environment Canada)

Executive Summary

In FY2015, NOAA-GLERL will look to continue its contribution to the Great Lakes Evaporation Network (GLEN) by supporting the deployment of vessel-based eddy-covariance instruments, and the deployment of an eddy-covariance buoy. These projects leverage related ongoing monitoring efforts across the Great Lakes, including the use of off-shore lighthouse-based eddy-covariance towers (which NOAA-GLERL supported in FY14).

Budget Summary	
Item	***Total ($)***
Equipment *(eddy-covariance buoy, sensors for existing buoys -in kind from Environment Canada)*	-
Supplies	$2,000
Field Travel *(field work)*	$1,000
Science Conference Travel *($2,500 request for AGU included in standard allotment)*	
Science Meeting Travel *(e.g. working groups, PI meetings)*	$1,000
Admin Travel *(e.g. Advisory Board meetings)*	$1,000
*** International travel*	-
Contracts/CILER - ESRL-CIRES	$30,500
Other (specify)	
Total Amount	**$35,500**
Staffing and Ship Time	
Federal Staff	0.85 FTE
Contract and CILER Staff	1.00 FTE
Total Staff	**1.85 FTE**
Total Ship Time Days	**5**

Project Details

Personnel Requirements

GLERL: Gronewold (10%), Ruberg (5%), Constant, Muzzi (each 5%), Clites (30%), Hunter (30%)
CILER: Smith (30%)
CU-Boulder (through CIRES): Blanken (20%), grad student (50%)
OTHERS: Roughly 10% each

Describe what work is intended to be done

- Maintain real-time telemetry with Stannard Rock, White Shoal, and Spectacle Reef
- Introduce real-time telemetry with Toledo Channel Marker 2
- Install new Irgason flux instruments on Canadian commercial vessel (CU-Boulder)
- Assimilate measurements into model simulations and projections
- Receive at Muskegon and deploy Canadian eddy-covariance buoy (vessel needed)
- Serve on invited panel on hydrology prior to AGU; present five (5) posters across 4 sessions

Budget Explanation: support deployment of equipment on Canadian commercial carrier

Integration: Directly supports projects on estimating lake heat content, improving operational forecasting, improving regional hydrometeorological database, improve over-lake precipitation estimates, and fulfills a critical gap in NOAA's mission. Leverages over $100,000 in (anticipated) support from the Coastal Storms Program in FY2015, and well over $1,000,000 of prior support to the GLEN effort to-date.

Progress & Project Improvement (if project is continuing / on-going)

- Collect continuous spatially-distributed flux measurements along commercial vessel cruise track
- Integrate with existing measurements from buoys and lighthouse-based towers to improve
- evaporation historical record, and estimates of other off-shore hydrological variables
- Will improve parameterization of currently employed 1-D, 2-D, and 3-D lake models
- Will apply lighthouse-based data funded by NOAA-GLERL in FY2014

Relevance to NOAA & Public

- The general public and regional policy makers have a need to understand and predict drivers of water level change across different time scales.
- Part of NOAA's mission is to understand and predict aspects of the Great Lakes hydrological system; over-lake evaporation processes are a gap in that understanding.
- The recently completed IJC-funded International Upper Great Lakes Study identified continuous year-round off-shore evaporation monitoring as a high priority area for continued research

IPEMF 2.2 Lake-scale physical/biological modeling (FVCOM-NPZD Model with River Loading in Lake Michigan)
(Jia Wang)

Haoguo Hu, Hongyan Zhang, Ayumi Manome
Collaborator: Lin Luo (SCSIO, China), Mark Rowe (CILER), Vanderploeg (GLERL)

Executive Summary

We propose to improve FVCOM-NPZD (Luo et al. 2012) to Lake Michigan using the existing configuration, but with the improved FVCOM code using the centered differencing schemes in time integration. After adding river loading/nutrient loading of year 1998 in FY14 (Luo et al. 2014, submitted), we will run a case for a cold year (ENSO neutral year), since 1998 was an El Nino (warm) year. This will allow us to examine the ecosystem response to a warming and a cooling event due to El Nino and ENSO-neutral event, respectively. These hindcasts enable us to simulate Great Lakes circulation and ecosystem in response to a changing climate, which can provide decision makers with our products and tools to aid in protecting the Great Lakes and the public. This project supports ***GLERL Strategic Plan milestone:*** Develop coupled physical/biological models as first step toward a fully integrated ecological modeling system to predict impacts of climate and invasive species on physical and ecological conditions on a multi-decadal, regional scale

Budget Summary	
Item	***Total ($)***
Equipment	
Supplies	
Field Travel *(field work)*	
Science Conference Travel *(conferences e.g. AMS, IAGLR, AGU)*	
Science Meeting Travel *(e.g. working groups, PI meetings)*	$ 1,000
Admin Travel *(e.g. Advisory Board meetings)*	
***Please note here any International travel and the location ($ amount is included in one of the above categories)*	--
Contracts/CILER	$27,000
Other (specify)	
Total Amount Requested	$28,000
Approval Amount Deferred	($ 10,000)
Total Amount Approved	**$--**
Staffing and Ship Time	
Federal Staff	0.30 FTE
Contract and CILER Staff	0.70 FTE
Total Staff	**1.00 FTE**
Total Ship Time Days	**0**

Project Details

Personnel Requirements

Wang-Lead GLERL PI (20%) Haoguo Hu (20%), Hongyan Zhang (10%), Ayumi Manome (10%)
Collaborator: Lin Luo (SCSIO, China), Mark Rowe (CILER), Vanderploeg (GLERL, 10%)

Describe what work is intended to be done

We apply the modified FVCOM model (by Manome) to Lake Michigan only as a test bed, and run a warm case for 1998 (El Nino year) and a cold case for ENSO-neutral (the year to be determined as 2014 or 2015 since the Nino3.4 index in October 2014 was 0.5C (neutral) and NAO index was -0.87, cold NAO even to the Great Lakes). To accomplish the work we need to do the detailed model testing, and validation using GLERL cluster and NOAA Jet Supercomputer System, and process observation data. IT resources are required for high performance computing time and data storage. In scientific paper writing, editorial assistance is needed. For media interview, we also need support in media, graphics, web services, and public relations support required. Model data will be stored and used for analysis and upon request

Budget Explanation

- CILER staffing (non-federal) is requested in the budget to support to support existing CILER staff. Hu will run FVCOM-NPZD on the modification/improvement with Manome, while Zhang will process observation data for model-data verification with Hu.
- No resources will be requested from GLERL.
- The project will not increase the current GLERL security level which is now considered “low”

Integration

This project is directly linked to Vanderploeg’s measurements of food web dynamics near Muskegon in 2005 and the continuation of Luo’s work in Lake Michigan.

Progress & Project Improvement (if project is continuing / on-going)

- Expected short-term (FY15) outcome is that an improved FVCOM-NPZD model can be used for long-term simulation with no significant temperature increase and diffusive miological variables in the water column. The expected longer term (2-5 years) outcome is that FVCOM-NPZD model can be used to other lakes and all five lakes at the same time that is our goal.
- Expected journal papers will be submitted to JGR or JGLR
- In FY14 progress was made on the project as compared to stated milestones and goals: adding riverine-loaded nutrient was finished and a paper was submitted (Luo et al. 2014) to JGLR. Another paper, Rowe et al. (2014) was also submitted to JGLR.
- The challenge encountered during the past year was that we did not have sufficient manpower/time to run the FVCOM-NPZD model, which need more time than a physical only model (such as FVCOM only). We need to focus on the two cases in FY15.

IPEMF 2.3 Project Title: Improving historical estimates and projections of the Great Lakes water budget
(Drew Gronewold)

Key Internal Personnel: Lofgren, Stow, Anderson, Clites, Hunter
Key External Partners: Jim Noel, and others (NOAA-NSSL and NOAA-NWS); Song Qian (U. Toledo); NOAA-GLERL David Holtschlag (USGS); Vincent Fortin, Jacob Bruxer (Environment Canada)

Executive Summary

NOAA-GLERL has, for the past 30 years, been actively developing components of regional hydrometeorological databases and seasonal water budget projection models for use by operational entities (including the USACE and regional hydropower authorities). In FY2015, we plan to focus explicitly on three computer-model related efforts, application of a Bayesian statistical model that assimilates the most recent *in situ* hydrological measurements to develop posterior probability distributions for monthly estimates of all historical water budget components, ii) partnership with NWS to develop a new product for Great Lakes over-lake precipitation estimates, iii) hosting of a mini-workshop for enacting a plan for leveraging NOAA's capabilities for improving regional water budget (including interconnecting channel flow) forecasting.

Budget Summary	
Item	***Total ($)***
Equipment *(eddy-covariance buoy, sensors for existing buoys)*	-
Supplies	-
Field Travel *(field work)*	-
Science Conference Travel *(AMS & IAGLR- additional to standard allotment)*	$ 3,000
Science Meeting Travel *(e.g. working groups, PI meetings)*	$ 5,000
Admin Travel *(e.g. Advisory Board meetings)*	$ 2,000
***Please note here any International travel and the location ($ amount is included in one of the above categories)*	-
Contracts/CILER *(U. Toledo and U. Michigan student help)*	$15,000
Other (specify)	
Total Amount	**$25,000**
Staffing and Ship Time	
Federal Staff	1.10 FTE
Contract and CILER Staff	0.20 FTE
Total Staff	**1.30 FTE**
Total Ship Time Days	**0**

Project Details

Personnel Requirements
GLERL: Gronewold (40%), Stow (10%), Clites (30%), Hunter (30%)
CILER: Qian (10%), students (10%)

Describe what work is intended to be done

- Incorporate off-shore measurements (from lighthouses, vessels, and buoys) into statistical models of Great Lakes water budget to develop new estimates (probability distributions) of monthly water budget components. Leverages IJC-funded effort for Lake Superior only (with USGS) in FY2014.
- Host mini-workshop at GLERL in late January or early February 2015 with USACE, NWS, and NSSL, along with representatives from regional hydropower companies, to discuss improvements in over-lake precipitation estimates and water budget forecasts.
- Hire two (2) UM undergraduate engineering students to improve estimate of gate flow out of Lake Superior (a pressing problem for the international water level coordination committee)
- Prepare for and attend bi-annual meeting of the Coordinating Committee on Great Lakes basic hydraulic and hydrologic data; prepare for and attend other related international water budget and water level forums, meetings, and public presentations
- Prepare for and present research findings at AMS (abstracts accepted) and IAGLR

Budget Explanation

- Funding for Dr. Qian's time, and that of two UM students, as well as travel to mini-workshop and scientific conferences (AMS and IAGLR). Other travel as noted above.

Integration

- Directly supports projects on estimating lake heat content, improving operational forecasting, improving regional hydrometeorological database, improve over-lake precipitation estimates, and fulfills a critical gap in NOAA's mission.
- Leverages over $120,000 in funding support from the USACE for post-doctoral support and interconnecting channel flow monitoring, and over $100,000 from UCAR for post-doctoral support focused on improving regional water budget projections.

Progress & Project Improvement (if project is continuing / on-going)

- Collect continuous spatially-distributed flux measurements along commercial vessel cruise track
- Integrate with existing measurements from buoys and lighthouse-based towers to improve evaporation historical record, and estimates of other off-shore hydrological variables
- Will improve parameterization of all currently employed 1-D, 2-D, and 3-D lake models
- Will leverage successful retrieval of lighthouse-based data in FY2014

Relevance to NOAA & Public

- The general public and regional policy makers have a need to understand and predict drivers of water level change across different time scales.
- Part of NOAA's mission is to understand and predict aspects of the Great Lakes hydrological system
- The recently completed IJC-funded International Upper Great Lakes Study identified a clear need to "close" the Great Lakes water budget through improved quantification of uncertainty in water budget components, and to propagate revised estimates into regional forecasting models.

IPEMF 3.1 Climate change studies
(Brent Lofgren)

Drew Gronewold, Jia Wang, GLERL programmer; Chuliang Xiao (CILER); Mantha Phanikumar (Michigan State U.)

Executive Summary

Regional climate modeling is an approach to projecting the aspects of climate and climate change that are relevant on smaller scales than those addressed by global general circulation models (GCMs). This approach is most valuable in regions where there are particular features that characterize the region but are not (or not adequately) represented by GCMs. The presence of the Great Lakes in our region, with their much higher heat capacity than the surrounding land, is a prime example of this need. We have developed, and continue to develop and apply, models that simulate the climate of our region, and treat the air, land, and lakes all as parts of the climate system. The term "dynamical downscaling" of climate has often been applied to that process. However, that term implies only a summary of some basic atmospheric variables, whereas our approach takes into account a larger suite of interactions among components of the climate system, and an investigation of mechanisms surrounding changes in all of these components.

Budget Summary	
Item	***Total ($)***
Equipment	
Supplies	
Field Travel *(field work)*	
Science Conference Travel *(conferences e.g. AMS, IAGLR, AGU)* *$2,500 request included in standard allotment)*	
Science Meeting Travel *(e.g. working groups, PI meetings)*	$1,500
Admin Travel *(e.g. Advisory Board meetings)*	
*** International travel*	--
Contracts/CILER	
Other (specify)	
Total Amount	$1,500
Staffing and Ship Time	
Federal Staff	0.7 FTE
Contract and CILER Staff	0 FTE
Total Staff	**0.7 FTE**
Total Ship Time Days	**0**

Project Details

Personnel Requirements

Federal

Brent Lofgren 60%--primary oversight of the project, planning, scientific and public communication. In the absence of a GLERL scientific programmer, Dr. Lofgren will undertake all work with developing, running, and analyzing CHARM, as well as running and analyzing climate change scenarios under LBRM and its experimental variants.

Jia Wang 5%--consultation on ice and lake dynamics, coordination with his projects

Drew Gronewold 5%--consultation on hydrologic components, coordination with his projects

Significant Collaborating Partners

Chuliang (Andy) Xiao, CILER—100% funded externally through GLRI, developing and applying a version of the Weather Research and Forecasting (WRF) model focused

Mantha Phanikumar 5% + graduate student 50%, Michigan State U.—externally funded through GLRI, off-line modeling of hydrology and nutrient load under climate change scenarios.

Describe what work is intended to be done

All of the activities in this project will take place in an office setting at GLERL's Ann Arbor building, during regular daytime working hours, other than travel for conferences and working group meetings. This project is computationally intensive, but existing computing facilities will be adequate, including desktop computers and HPC facilities internal and external to GLERL.

Modeling of climate is a means to understanding the processes that are important in climate and climate change. Although the term "climate downscaling" has often been used to describe regional climate modeling activities, the intention of that label limits the usefulness of modeling to a set of summary end products, rather than understanding of a larger array of processes in a more inclusive atmosphere-land-lake system. Progress during 2014 on climate modeling using the Coupled Hydrosphere-Atmosphere Research Model (CHARM) has included publishing a GLERL Tech. Memo that both showed the results of a previous run of CHARM and exposed some known problems to be overcome. This provides a basis for extension of this work during 2015.

The findings of Lofgren et al. (2011) and Lofgren et al. (2013) that temperature-based projections of hydrologic impacts of climate change do not present a complete picture of the drivers of evapotranspiration, have gained traction in the scientific community, especially outside of the Great Lakes basin. However, the Annex to the National Climate Assessment gave very thin lip service to these results, and discussions said that those results were largely dismissed because they showed few actual model runs, despite extensive theoretical justification for the problems. This is being remedied by an additional large ensemble of model runs.

A new sub-project for this year is to produce a short (hopefully less than 20 minutes) educational video tentatively titled "The Job of the Atmosphere—The Great Lakes Region". This will be about how the Sun and other forms of heat exchange drive weather and climate, and how the atmosphere responds to counter some of these effects. It will have emphasis both on the more general characteristics of the midlatitudes of North America and also on the specific influences of the Great Lakes in our region. It will be partially modeled on a presentation that Dr. Lofgren gave to a non-scientific audience in September 2014. Kathe Glassner-Shwayder has expressed interest on working on supporting this project, and

Margaret Lansing has also endorsed this idea. Note that this is intended to be about climate, and potentially serve as groundwork for future episodes addressing climate *change*.

Budget Explanation

- This project requests no funding for non-federal staff, but does request a federal support employee that goes beyond the FTEs available at GLERL, i.e. a new hire. This support employee should be proficient in programming in C, Fortran, and other languages, and preferably have a strong background in numerical methods and, even more specifically, atmospheric and oceanic modeling. It is also requesting a few weeks worth of support from Kathe Glassner-Shwayder. This project will not affect GLERL's security level.

Integration

This project is linked with projects (using FY14 designation): IPEMF 2.1 for interaction on hydrologic modeling components, IPEMF 3.3 for interaction on lake hydrodynamic modeling including ice, IPEMF 4.2 (Great Lakes Evaporation Network) for new data for validation of the models, and IPEMF EX 2 for GLRI-funded activities associated with this project, specifically those from Xiao and Phanikumar.

Progress & Project Improvement (if project is continuing / on-going)

- What are the expected short-term (FY15) and longer term (2-5 years) outcomes and milestones?
  Validation of basic climatic variables in CHARM and WRF using hindcast runs.
  Transfer of CHARM and WRF output to Phanikumar group at MSU.
- Production of an education video on The Job of The Atmosphere.
  Note: Additional support staff would be required to achieve new realizations of regional climate projections using CHARM and WRF in FY15.
- Which journal papers, reports, and products (e.g., forecasts, briefs, models, etc.) will be *developed or improved* upon?
  Revise short-term case-based study using WRF (Xiao, Lofgren and Wang).
  Results of ensemble of LBRM variants driven by many GCMs. (Short summary in peer-reviewed lit, longer version as Tech Memo.)
  Validation of CHARM and WRF in hindcast mode.
  Improve on last year's Tech Memo about CHARM results under climate change scenarios. (Likely FY16)
  Expand to show results of WRF under climate change scenarios. (Likely FY16)
- FY14 progress made on the project as compared to stated milestones and goals
  A climate scenario run of CHARM was analyzed and published as a Tech Memo, including suggestions for improvement.
  WRF is up and running in both weather and climate mode. It has yielded results worth publishing for weather case studies. It was also run for climate scenarios, but the formulation of lake temperature was found lacking.
- What challenges were encountered during the past year and what is the plan to reduce or eliminate them this year?
  The most egregious problem with CHARM's lake vertical diffusion component has been corrected, and now more tuning needs to be done on this component, prior to full climate runs using CMIP5-class GCMs.
  Work will continue on improving the lake temperature formulation of WRF, and we hope that this will lead to full climate runs with a better-validated model.

This project continues to be in need of federal support staff with a significant time commitment in order to have continuity and accumulation of skill over time.

Relevance to NOAA & Public

- What science question are we answering?
  (Specific to climate change studies project) We are working on furthering our understanding of how greenhouse gases affect the coupled atmosphere-land-lake climate system of the Great Lakes basin. The resulting knowledge can then be further transferred to other impacts on ecological and human systems.
- What is the societal relevance?
  (Specific to climate change studies project) The relevance of this research has been demonstrated through extensive interest by groups doing impact research, particularly in the areas of hydrology and fish ecology. However, our eventual goals include, in cooperation with Jia Wang's group, to fill in the lower trophic ecology, which forms an important gap between physics and fish. By using different combinations of GCM drivers, atmospheric models (CHARM vs. CWRF), and surface hydrologic interactions, we are exploring the range of uncertainty in outcomes of these models.
- Under what NOAA and DOC goals does the work fit?
  (IPEMF branch-wide)
  Primary
  DOC Strategic Objective 3.1—Advance the understanding and prediction of changes in the environment through world-class science and observations.
  DOC Strategic Objective 3.4—Foster healthy and sustainable marine resources, habitats, and ecosystems through improved management and partnerships.
  NOAA Objective for R&D (p. 22)—Atmospheric and oceanic observations integrated into Earth system modeling.
  NOAA Objective for R&D (p. 23)—Improved understanding of interactions and processes of key oceanic, terrestrial, and atmospheric components of Earth's climate system.
  NOAA Objective for R&D (p. 23)—Identify the causes of climate trends and their regional impacts.
  NOAA Objective for R&D (p. 24)—Earth system models for seasonal to centennial predictions and projections at regional to global scales.
  NOAA Objective for R&D (p. 26)—Improved observations.
  NOAA Objective for R&D (p. 30)—Increased hydrologic forecast skill for low to high streamflow conditions to match skill afforded by weather and climate predictions.
  NOAA Objective for R&D (p. 30)—Increase our knowledge of the physical and chemical changes in the oceans resulting from atmospheric, oceanic, and land-based forcing.
  NOAA Objective for R&D (p. 34)—Develop integrated models that take advantage of synoptic data at various scales, to inform ecosystem-based management approach.
  NOAA Objective for R&D (p. 39)—Understand the impacts of land-based sources of pollution.
  NOAA Objective for R&D (p. 44)—Exploit emerging data types and observing capabilities to satisfy NOAA's observing requirements and to support new and improved applications, products, and services.
  NOAA Objective for R&D (p. 45)—Leverage advanced technologies to improve data access.
  NOAA Objective for R&D (p. 45)—Leverage advanced technologies to improve data archiving technology.
  NOAA Objective for R&D (p. 45)—Enhance data stewardship.

NOAA Objective for R&D (p. 46)—A framework for linking, coupling, and nesting models.
NOAA Objective for R&D (p. 46)—Advance Earth system modeling development, addressing underlying processes and relationships, seamless connectivity across spatial and temporal scales, and coupling across domains.
NOAA Objective for R&D (p. 47)—Establish quantified uncertainties for NOAA's predictions and projections.

Secondary
NOAA Objective for R&D (p. 25)—Key impacts and vulnerabilities are identified across regions and sectors.
NOAA Objective for R&D (p. 25)—Improved and sustained assessment of risks and impacts.
NOAA Objective for R&D (p. 25)—Climate information, tools, and services are developed and shared broadly to inform society's preparedness and response efforts.
NOAA Objective for R&D (p. 35)—Improved understanding of the economic and behavioral elements of coastal resilience.
NOAA Objective for R&D (p. 36)—Determine combined effects of environmental stressors on coastal species and ecosystems.
NOAA Objective for R&D (p. 38)—Region-specific, nationwide, operational capability for ecosystem forecasting.
NOAA Objective for R&D (p. 38)—Improved water quality testing and monitoring technologies.
NOAA Objective for R&D (p. 38)—Improved understanding of emerging water quality issues, including the sources, environmental fate, and ecological consequences of nanoparticles and microplastics.
NOAA Objective for R&D (p. 40)—Improved impact assessments of changing sea ice.
NOAA Objective for R&D (p. 41)—Improved understanding of what kinds of information the public needs to make actionable decisions.
NOAA Objective for R&D (p. 42)—Improved understanding of how NOAA's stakeholders consume information.
NOAA Objective for R&D (p. 47)—Advance data integration and assimilation into Earth system modeling.

- What part of GLERL's mission or which Strategic Plan milestone does this support?
  This project supports a goal to have multiple realizations of Great Lakes regional climate projections available in FY15. It also contributes toward a goal of, by FY22, developing a comprehensive modeling strategy for GLERL that will include a suite of relevant physical and biological processes.

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IPEMF 3.2: Great Lakes Ice and Climate Studies
(Jia Wang)

Anne Clites, Xuezhi Bai, Haoguo Hu
Collaborators: Leshkevich (GLERL), Beletsky (CILER)

Executive Summary

This project will continue to update ice atlas parameters and statistics for the period 1973-2014/15. After revealing the ice minimum in 2011/2012 ice season (Bai et al., 2014, Dyn. Clim.), the 2013/14 winter reached the second largest ice cover (92% vs record high of 94% in 1979) of the record from 1973-2014 in the Great Lakes, caused by continuous polar vortex intrusions: impacts of diminishing Arctic summer sea ice on mid-latitude Great Lakes region. Therefore, we intend to update the ice atlas and conduct in-depth research linking to Arctic climate teleconnection patterns to the Great Lakes climate and ice cover. In addition, we will continue to measure in situ ice thickness in Lake Erie with USCG helicopter for ground truths collaborating with Leshkevich. We will plan to process ice thickness data recovered from ice profilers during 2010-2011 in Lake Erie with Beletsky to validate coupled ice-lake model. The prediction of ice cover in response to a changing climate on seasonal, interannual, and decadal time scales enable us to provide information to a broader users in search and rescue operations, navigation (commercial shipping), and recreational ice fishing during winter season. These forecasts provide decision makers with tools to aid in protecting the Great Lakes and the public.

Budget Summary	
Item	***Total ($)***
Equipment	
Supplies	
Field Travel *(field work)*	$ 500
Science Conference Travel *(conferences e.g. AMS, IAGLR, AGU)* *$1,000 request included in standard allotment*	
Science Meeting Travel *(e.g. working groups, PI meetings)*	$ 1,000
Admin Travel *(e.g. Advisory Board meetings)*	
***Please note here any International travel and the location ($ amount is included in one of the above categories)*	--
Contracts/CILER	$30,000
Other (specify)	
Total Amount Requested	$31,500
Approval Amount Deferred	($ 10,000)
Total Amount Approved	**$--**
Staffing and Ship Time	
Federal Staff	0.9 FTE
Contract and CILER Staff	0.6 FTE
Total Staff	**1.5 FTE**
Total Ship Time Days	**0**

Project Details

Personnel Requirements

Wang (30%), Clites (50%), Bai (20%), Hu (30%)

Collaborators: Leshkevich (10%, GLERL), Beletsky (10%, CILER)

Describe what work is intended to be done

We will update ice atlas parameters and statistics for the period 1973-2014/15 through quality control process (Clites and Hu), and then using the updated data, we will investigate the mechanisms responsible for the second largest ice cover in 2013/14 winter (92% vs record high of 94% in 1979) of the record from 1973-2014 in the Great Lakes, which might be caused by the diminishing Arctic summer sea ice and its impacts on mid-latitude Great Lakes region. In addition, we will continue to measure in situ ice thickness in Lake Erie with USCG helicopter for ground truths for FVCOMice model verification, collaborating with Manome and Leshkevich. We will plan to process ice thickness data recovered from ice profilers of previous years in Lake Erie by Beletsky to validate coupled ice-lake model. To accomplish the work, IT resources are required data storage. In scientific paper writing, editorial assistance is needed. For media interview, we also need support in media, graphics, web services, and public relations support required.

Budget Explanation

- CILER staffing (non-federal) is requested in the budget to support existing CILER staff. Hu will work with Clites to update the data and do the quality control, since Assel seems to spend time with the family. Bai will work on searching mechanism of the 2013/14 event, which will lead to a journal paper. Leshkevich and Wang will work with the USCG for ice thickness measurements. Beletsky will work with Hu for processing the ice thickness data from ice profilers.
- No resources will be requested from GLERL.
- The project will not increase the current GLERL security level which is now considered “low”

Integration

This project is directly linked to Wang’s FVCOMice project, and many other projects requiring ice dataset. Water level change partially depends on ice cover. Externally, the ice atlas has been widely used by the community for their research and management.

Progress & Project Improvement (if project is continuing / on-going)

- Expected short-term (FY15) outcome is that the ice atlas is updated to the present and posted in the ice data web site. The expected longer term (2-5 years) outcome is that we possess the ice atlas dataset for validating 5-lake FVCOMice. In the climate and ice research, GLERL will be recognized by the Great Lakes and climate communities in the U.S. and abroad.
- Expected journal papers will be submitted to J Clim. Or JGR
- In FY14 progress was made on the project as compared to stated milestones and goals: We did not complete the ice atlas update because Assel took time off due to that his term was finished. Clites spent more time on water level data processing. No drifters were deployed last year since the funding for drifters was pending until winter. Ice profiler data were processed by Beletsky and use for GLIM comparison. In FY14, five papers were published from this project: Bai et al. (2014, Clim. Dyn.), Clites et al. (2014, EOS), and Beletsky et al. (2014, 22nd Ice Symposium

Proceedings), Van Cleave et al. (2014, L&O), and Wang et al. (2014, 22nd Ice Symposium Proceedings)

- The challenge encountered during the past year was that the funding was delayed to the winter time, leaving no time to prepare for the field work. This year, we propose not to deploy drifters and ice profilers.

Relevance to NOAA & Public

The project fit the ***NOAA and GLERL goal: 1)*** Integrated ecological modeling to produce hindcasts and forecasts for proactive management of resources and communities and 2) Accurate and reliable data from sustained and integrated observing systems. Furthermore, this research support ***GLERL Strategic Plan milestone:***

Our research on regional climate projections is based on atmospheric and coupled hydrodynamics-ice ecosystem models. Results are used to predict the physical and ecological conditions of the Great Lakes over the course of yearly seasonal changes to decades. Our research tools are designed to examine the effects of climate on regional air temperature, precipitation, ice cover, and ecosystems.

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IPEMF 3.3 FVCOMice: Improvement/implementation for v3.1.6, testing/improvement/ calibration/ validation for Great Lakes
(Jia Wang)

Ayumi Manome, Xuezhi Bai
Collaborators: Eric Anderson (GLERL)

Executive Summary

In FY14, we have modified the unstable Euler forward schemes to a neutrally-stable centered differencing scheme in ocean and turbulence equations in FVCOMice that was applied to Lake Erie. It is found that diffusive temperature structure and thermocline have been significantly improved and the model is stable with reasonable CFL criterion (Manome and Wang, in prep). We propose to continue to modify FVCOMice numerical scheme for ice dynamics equations, which still uses Euler forward scheme along with the explicit Coriolis force. We also propose to implement the modified FVCOMice to five Great Lakes. Only after the modification with the guidance of numerical theory, can this model be widely used in our NOAA NOS and GLERL community. So, we need to improve, calibrate and validate FVCOMice model in all five lakes in FY15.

Budget Summary	
Item	***Total ($)***
Equipment	
Supplies	
Field Travel *(field work)*	
Science Conference Travel *(conferences e.g. AMS, IAGLR, AGU)*	
Science Meeting Travel *(e.g. working groups, PI meetings)*	$ 1,000
Admin Travel *(e.g. Advisory Board meetings)*	
***Please note here any International travel and the location ($ amount is included in one of the above categories)*	--
Contracts/CILER	$30,000
Other (specify)	
Total Amount Requested	$31,500
Approval Amount Deferred	($ 15,000)
Total Amount Approved	**$--**
Staffing and Ship Time	
Federal Staff	0.4 FTE
Contract and CILER Staff	0.4 FTE
Total Staff	**0.8 FTE**
Total Ship Time Days	**0**

Project Details

Personnel Requirements

Wang-Lead PI (30%), Manome (20%), Bai (20%)
Collaborators: Anderson (GLERL, 10%)

Describe what work is intended to be done

We apply this model to Lake Erie only as a test bed, and at the same time to all five lakes at a time. The model will run for the period of 2003-2012. To accomplish the work we need to do the detailed model code modification, testing, and validation using GLERL cluster and NOAA Jet Supercomputer System. IT resources are required for high performance computing time and data storage. In scientific paper writing, editorial assistance is needed. For media interview, we also need support in media, graphics, web services, and public relations support required. Model data will be stored and used for analysis and upon request

Budget Explanation

- CILER staffing (non-federal) is requested in the budget to support existing CILER staff. Manome will continue to work on the modification/improvement of FVCOMice in Lake Erie, while Bai will apply this model to all five lake using Bai's existing model grids (Bai et al. 2013).
- No resources will be requested from GLERL.
- The project will not increase the current GLERL security level which is now considered "low"

Integration

This project is directly linked to Lofgren's regional climate modeling using WRF, since 5-lake FVCOMice is the backbone mode to be coupled to the regional climate model. The improved FVCOMice will be directly linked to Anderson's GLCFS project in which ice component is needed, just like the present POM-based coupled Great Lakes ice-circulation model (GLIM) in GLCFS. The improved version of FVCOM can be used for the biological modeling as well, collaborating with Vanderploeg. Externally, the improved version can be used by NOS colleagues.

Progress & Project Improvement (if project is continuing / on-going)

- Expected short-term (FY15) outcome is that an improved FVCOMice can be used for long-term simulation with no significant temperature increase in the water column. The expected longer term (2-5 years) outcome is that FVCOMice can be coupled to regional WRF to become a regional coupled climate model.
- Expected journal papers will be submitted to JGR or JGLR
- In FY14 significant progress was made on the project as compared to stated milestones and goals: Modification of the code was 80% finished, and the new code was tested in Lake Erie from 2003-2012 in comparison to IcePOM, and a paper is in preparation; the 5-lake model run was only 30% finished, because of the delay of the modified code. No journal papers were published last year; since we had to sit down to modify the code, which is what the modeling about.
- The challenge encountered during the past year was that we did not have sufficient time to run the 5-lake model, which needs more time than a single lake. This year, we will focus on 5-lake model simulation.

IPEMF 4.1 GLERL-Wide Data Management Project
(Brent Lofgren)

Heather Lucier (currently CILER, proposed to be moved to contract)

Executive Summary
Data management is necessary as an ongoing effort in scientific organizations, and is mandated by NOAA management. The need for enhanced and lab-wide coordinated data management efforts was highlighted by NOAA-wide surveys as well as activities data management activities at other Great Lakes agencies, including the USGS Great Lakes Science Center and the Great Lakes Observing System. We have recognized the need to catalog, document, standardize, and serve internal data products, both old and new, to bring our data standards up to date and ensure availability of all relevant data.

Budget Summary	
Item	***Total ($)***
Equipment	
Supplies	
Field Travel *(field work)*	
Science Conference Travel *(conferences e.g. AMS, IAGLR, AGU)*	
Science Meeting Travel *(e.g. working groups, PI meetings)*	
Admin Travel *(e.g. Advisory Board meetings)*	
***Please note here any International travel and the location ($ amount is included in one of the above categories)*	--
Contracts/CILER	$40,000
Other (specify)	
Total Amount	$40,000
Staffing and Ship Time	
Federal Staff	0.05 FTE
Contract and CILER Staff	0.50 FTE
Total Staff	**0.55 FTE**
Total Ship Time Days	**0**

Project Title GLERL-Wide Data Management Project
Brent Lofgren

Project Details
Personnel Requirements
Federal
Brent Lofgren 5%
Committee members—Hunter, Lang, Hawley, Smith
Collaborators and percentage of time
Heather Lucier 50%

Describe what work is intended to be done

This project will be entirely office-based, at GLERL's Ann Arbor building. This work is a lab-wide initiative that, at least in the long run, supports all projects at GLERL. As such, the science questions, societal relevance, NOAA and GLERL goals, and milestones that it supports all follow from the various projects with which it interacts.

The need for enhanced and lab-wide coordinated data management efforts has been highlighted by NOAA mandates, activities of other Great Lakes agencies such as the USGS Great Lakes Science Center and the Great Lakes Observing System, and a NOAA-wide survey (NOSIA II) that brought up the question, "Do we know what datasets we have in hand?" This pointed to the need to catalog, document, standardize, and serve internal data products to the extent that is appropriate. Relevant mandates at the NOAA level can be found on the NOAA Environmental Data Management web page.

This project's goal will be to successfully steer between the worst effects of these two alternative **undesirable** states: 1. Information on the existence and provenance of GLERL datasets is not collected and made available on a systematic basis, and relevant researchers even within GLERL are sometimes unaware of internal datasets that they might find useful. 2. The work burden for satisfying data management requirements becomes prohibitive and out of proportion to the effort required to generate the data and its general usefulness, and with GLERL's role as a research laboratory rather than a data center.

Some GLERL projects and products, such as the Great Lakes Hydrometeorological Database, the CoastWatch Project and GLSEA dataset, the Great Lakes Hydroclimate Dashboard, and benthic physical datasets generated over time by Nathan Hawley, started with more advanced data management schemes in place. But many other GLERL datasets need more work.

This project will take sensible steps to upgrade the level of data management at GLERL by assigning personnel resources dedicated to this task. We believe that the computing resources that are necessary at this time are already in place. Because many datasets are already in hand, we are abandoning the part of last year's proposal that prioritizes long-term station-based time series over campaign-based data, and will instead take all new datasets that are submitted to the data management system

The following priorities for action remain in place, but because the work on the first three priorities is largely complete for the datasets already in the system, more of the activity for this year will be focused on testing and implementing a THREDDS data server (priority 4):

1. Catalog—Document the existence of datasets.
2. Metadata—Make the strongest practical effort at documenting the method of generating the data. Include the information on where, when, and how it was generated, along with links to peer-reviewed and other literature, and practical considerations of parsing the data.
3. Data format—Particularly for data that will be served to external users, use formats that are standard within the scientific community. This should make them usable off the shelf by standard analysis software such as ArcGIS.
4. Serving—The documentation from the NOAA Environmental Data Management web page is largely geared toward data that will be served to the public, especially through NESDIS's data centers. However, in order to keep the data-related workload within bounds, we will need to be selective about which datasets to make available on servers, with the associated user support that might be necessary.

Budget Explanation

$50,000 is requested to pay for approximately 0.5 FTE for Heather Lucier to be hired as a contractor to continue her duties as technician for the data management project. This will be supplemented by funds from other projects to enable a full 1-year contract.

- Existing computing equipment is adequate for this project. This project does not affect GLERL's security level.

Attach draft 1040 budget sheet

Integration

Ideally, this project is tied in with every project at GLERL. However, participation is optional de facto, so only some projects.

Progress & Project Improvement (if project is continuing / on-going)

- What are the expected short-term (FY15) and longer term (2-5 years) outcomes and milestones?
  Cataloguing, metadata collection, and formatting of datasets will continue.
  Greater emphasis will be placed on serving data via THREDDS server.
  In the long term, this will work toward an increasing number of datasets being stored and served under GLERL's catalog and metadata repository.
- Which journal papers, reports, and products (e.g., forecasts, briefs, models, etc.) will be *developed or improved* upon?
  The product of this project is the data catalog, data and metadata collection, and server.
- FY14 progress made on the project as compared to stated milestones and goals
  Many historical GLERL datasets have been collected, catalogued, and are now on an experimental server environment.
- What challenges were encountered during the past year and what is the plan to reduce or eliminate them this year?
  Participation by scientists, in terms of contributing their data and metadata, is quite optional, and needs more prompting from management to further encourage it.

Relevance to NOAA & Public

- What science question are we answering?
  We are supporting ongoing access to data from all projects and all science questions addressed by GLERL, in addition to those that might be external to GLERL but using GLERL data.
- What is the societal relevance?
  The societal relevance ties into the relevance of all the participating projects.
- Under what NOAA and DOC goals does the work fit?
  Across the board. See the submission for climate change studies, which includes a long list of NOAA Objectives for R&D that are either directly addressed by projects within the IPEMF branch, or at least peripherally touched upon, and there are probably several more that are represented by the datasets from other branches that are supported by this project.
- What part of GLERL's mission or which Strategic Plan milestone does this support?
  Have increasing quantities of GLERL-generated data catalogued, stored, and served centrally.

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IPEMF 4.2 Great Lakes Heat Budget-Water Budget Connections
(Brent Lofgren)

Eric Anderson, Dmitry Beletsky, Drew Gronewold, Brent Lofgren, Craig Stow, and Jia Wang
Xuezhi Bai, Raisa Beletsky, Tim Hunter, Chuliang Xiao, NRC post-doc to be named

Executive Summary

This project will tie together and compare observational datasets and model runs from several models developed and used within the IPEMF branch. It will focus on retrospective simulation of the period of approximately 1984 to present, and key in on the linkages between the lakes heat storage and water budget, with lake evaporation being a key component that is addressed by several of IPEMF's models. These factors also link in to other modes of heat exchange at the surface, including shortwave and longwave radiative fluxes and sensible heat flux. New observational resources, including the Great Lakes Evaporation Network (GLEN) and more widespread distribution of thermistor chains to measure lake temperature profiles, combine with our modeling methods to make this a rich comparison of data generated through different paths.

Budget Summary	
Item	***Total ($)***
Equipment	
Supplies	
Field Travel *(field work)*	
Science Conference Travel *(conferences e.g. AMS, IAGLR, AGU)*	
Science Meeting Travel *(e.g. working groups, PI meetings)*	
Admin Travel *(e.g. Advisory Board meetings)*	
***Please note here any International travel and the location ($ amount is included in one of the above categories)*	--
Contracts/CILER	$22,000
Other (specify)	
Total Amount	$22,000
Staffing and Ship Time	
Federal Staff	0.60 FTE
Contract and CILER Staff Note: Includes NRC post-doc at 1.0 FTE	1.45 FTE
Total Staff	**2.05 FTE**
Total Ship Time Days	**0**

Project Details

Personnel Requirements

Key project personnel, role and approximate percentage of time—Eric Anderson, Drew Gronewold, Brent Lofgren, Craig Stow, and Jia Wang, co-PIs, 10% each; Tim Hunter, technical support for LLTM, 10%

Collaborators and percentage of time Xuezhi Bai, hydrodynamic and ice modeling, 15%; Dmitry Beletsky 5%, consultation on hydrodynamic modeling; Raisa Beletsky 15%, hydrodynamic modeling; Chuliang Xiao, WRF modeling and consultation, 10%
Significant Collaborating Partners: NRC Fellow to be named 100%

Describe what work is intended to be done
This project will be accomplished entirely in an office setting at the Ann Arbor facility, during regular daytime work hours.

This project will draw on various GLERL modeling and data resources that have not previously been used in combination. It will expand on recent work in the IPEMF Branch on quantifying heat storage in the Great Lakes and connecting this to over-lake evaporation and the general water budget of the lakes. It capitalizes on observed meteorological datasets that have long been available, and especially on the more recent advent of eddy covariance-based observations of evaporative and sensible heat fluxes from the Great Lakes Evaporation Network (GLEN), and the currently expanding collection of lake temperature profile measurements from thermistor chains.

We propose to gain a greater understanding of the factors and processes involved in storage of heat in the Great Lakes, the role played by ice cover and its phenology, and by the thermocline and its process of formation and decay. GLERL-based data to be deployed in this effort will include the already-mentioned GLEN and thermistor string networks, along with the GLSEA data for lake surface temperature. External datasets will include station-based meteorological data served by NCDC (as incorporated into the Great Lakes Hydrometeorological Database, this is also housed at GLERL), the North American Regional Reanalysis (NARR, a gridded dataset using data-assimilation techniques to yield estimated historical meteorology), and NSSL's National Mosaic Precipitation, which is in fact international.

These data will be diagnostically analyzed for relationships between lake level and its trends on one hand and drivers such as precipitation, air and water temperature, radiative energy fluxes, and wind speed on the other. In addition, these datasets, particularly NARR, will be used to drive hindcast simulations from the suite of models that exist within the IPEMF Branch: the Large Lakes Thermodynamic Model (LLTM), a simulation of the lakes' thermodynamics and evaporation that treats each lake as a single water column; the Coupled Hydrosphere-Atmosphere Research Model (CHARM) and Weather Research and Forecasting (WRF) model, each of which have an atmospheric model coupled to a lake component that treats the lakes as a horizontal array of 1-dimensional columns with diffusive mixing; as well as the Finite Volume Coastal Ocean Model (FVCOM) and Princeton Ocean Model (POM), each of them 3-dimensional lake dynamics models driven by atmospheric data, and each having a version with advanced treatment of ice cover. Use of these models will augment the observational dataset with more spatial richness in the information about lake surface heat and moisture fluxes, lake thermal structure, lake effect precipitation, and coastal processes.

Such hindcasts can be run to simulate at least the past 30 years. This will encompass some of the most interesting cases of lake levels—initially high levels in the mid-1980s, an abrupt drop in 1997-98, persistent low levels in 1998-2012, and an abrupt rise in 2013-14.
The equipment requirement will be desktop computing systems for all personnel, notably the NRC Fellow, as well as access to GLERL HPC systems and possibly NOAA-wide HPC systems. Modeling output and other data generated by this project will be stored, in the short term, on the participants' own

computing systems and HPC systems. After primary publication and prior to the termination of the project, key output will be migrated to GLERL data archiving and serving facilities.

Budget Explanation

Xuezhi Bai will complete a retrospective run of FVCOM-Ice and interface its results with this project.

- Chuliang Xiao will complete a retrospective run of WRF and interface its results with this project.
- Dima Beletsky and Raisa Beletsky will complete a retrospective run of POM and interface its results with this project.
- This project will not affect GLERL's security level.

Integration

This project draws on modeled data originating from nearly all of the IPEMF branch's projects, specifically those known under the FY14 numbering system as IPEMF 1.1, 2.1, 2.2, 3.1, 3.2, 3.3, and the Great Lakes Evaporation Network, as well as some of the external projects.

Progress & Project Improvement (if project is continuing / on-going)

- What are the expected short-term (FY15) and longer term (2-5 years) outcomes and milestones?
  Comparison, with proper allowance for spatial resolution, of lake evaporation based on eddy covariance stations, LLTM, CHARM, WRF, FVCOM, FVCOM-Ice, and POM.
  Coordinate with project IPEMF 2.1 on estimates of over-lake precipitation.
  Evaluate the influence of lake heat storage and ice cover on evaporation under all of these modeling and observation systems.
  Longer term: Establish a framework for intercomparison of evaporation under all of these systems.
- Which journal papers, reports, and products (e.g., forecasts, briefs, models, etc.) will be *developed or improved* upon?
  Historical lake evaporation 1984-2014 as simulated by various models.
- FY14 progress made on the project as compared to stated milestones and goals
  This is a new project, but builds on previous branch-wide work, primarily Gronewold, Anderson, Lofgren, Blanken, Wang, Smith, Hunter, Lang, Stow, Beletsky, and Bratton, 2014: Potential impacts of extreme winter conditions on the thermal regime of Lake Michigan. J. Geophys. Res., under revision.
- What challenges were encountered during the past year and what is the plan to reduce or eliminate them this year?
  Retrospective model runs of CHARM, WRF, FVCOM, and POM do not currently exist.

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Observation Systems and Advanced Technology

OSAT 1.1 Satellite and Airborne Research and Product Development
(George Leshkevich)

Key Internal Personnel: Jia Wang, Drew Gronewold, Steve Ruberg
Key External Partners: Ayumi Manome; Robert Shuchman, MTRI; Son V. Nghiem, NASA/JPL; William Pichel, NOAA/NESDIS; Dorothy Hall, NASA; Andy Maillet, Canadian &, U.S. Coast Guard; Joe Ortiz, Kent State University, John Lekki, NASA GRC

Executive Summary

This project is composed of several continuing projects including SAR ice type classification, color producing agent (CPA) algorithm development, hyperspectral HAB detection algorithm development, and two new projects including evaluation of SMAP soil moisture data for the Great Lakes basin (collaborating with NASA/JPL) and satellite ice surface temperature (collaborating with NASA/GSFC). These projects are in various stages of development from mature to just starting. The main goal for each of the sub-projects is to develop or improve satellite (or airborne) algorithms for the detection and retrieval of several Great Lakes water quality parameters such as chlorophyll, DOC, suspended minerals, primary production, ice types, and harmful algal blooms (HABs) with expectation that the retrieved products can be produced operationally and made available to the user community via the Great Lakes CoastWatch node and other distribution sites. Users would include NOAA NESDIS, National Ice Center, U.S. Coast Guard, commercial shippers, Great Lakes managers (ex. water intake managers), physical and biological modelers and researchers, and the public including recreational and educational purposes.

Budget Summary	
Item	***Total ($)***
Equipment	
Supplies	$5,000
Field Travel *(field work)*	$2,000
Science Conference Travel *(conferences e.g. AMS, IAGLR, AGU)* *$2,500 request included in standard allotment*	
Science Meeting Travel *(e.g. working groups, PI meetings)*	$3,000
Admin Travel *(e.g. Advisory Board meetings)*	$3,000
***Please note here any International travel and the location ($ amount is included in one of the above categories)*	--
Contracts/CILER	
Other (specify)	
Total Amount	$13,000
Staffing and Ship Time	
Federal Staff	0.50 FTE
Contract and CILER Staff	0.00 FTE
Total Staff	**0.50 FTE**
Total Ship Time Days	**4**

Project Details

Personnel Requirements

George Leshkevich (50% of time)

Significant Collaborating Partners** (external) Robert Shuchman, MTRI; Son V. Nghiem, NASA/JPL; William Pichel, NOAA/NESDIS; Dorothy Hall, NASA; Andy Maillet, Canadian Coast Guard, U.S. Coast Guard; Joe Ortiz, Kent State University, John Lekki, NASA GRC

Describe what work is intended to be done

a) **Ground Penetrating Radar (GPR) Ice Thickness.**
(Leshkevich, Canadian Coast Guard)
Ice thickness measurements are needed not only by the U.S. and Canadian Coast Guards for use in operational ice breaking activities and resource deployment but also by modelers working on ice growth and motion models. Deploy the GPR on Canadian and/or U.S. Coast Guard ice breaking vessels, evaluate the GPR shipborne operation and determine accuracy over various ice types. This project is dependent on Canadian GPR and Coast Guard personnel availability. An article has been published in a trade journal describing the airborne (helicopter) field experiment and data processing.

b) **Airborne Hyperspectral Imagery.**
(Leshkevich, NASA GRC, MTRI, Kent State University)
This project is a continuation of the Lake Erie Harmful Algal Bloom (HAB) project started with NASA GRC. During this past summer (2014), NASA GRC and NRL have used airborne hyperspectral sensors to make measurements in the western basin of Lake Erie concurrent with HICO (space station) hyperspectral data collection. Use previously collected airborne hyperspectral data and concurrent in situ data collected in western Lake Erie to develop/modify an algorithm to detect phycocyanin (an indicator of early HAB development) using hyperspectral data. Test the algorithm on subsequent satellite hyperspectral (HICO) data and/or airborne hyperspectral data and modify algorithm as needed. When fully developed, the algorithm can be tested using an unmanned (UAV) aircraft to demonstrate UAV capability for HAB monitoring.

c) **CPA Algorithm for Chlorophyll, DOC, and Suspended Sediments - MODIS CPA Transition.**
(Leshkevich, MTRI)
Continue process to transfer Color Producing Agent (CPA) algorithm to NESDIS for evaluation for operational production as well as continuation of testing with NPP satellite data and simulated Sentinel-3 data.

d) **CPA Algorithm for Chlorophyll, DOC, and Suspended Sediments - CPA hydro-optical model development.**
(Leshkevich, MTRI, Ruberg)
Continue CPA hydro-optical model development, optical spectral measurements of IOP's and AOP's (water leaving radiance, remote sensing reflectance, down-welling irradiance, CPA absorption and backscatter, etc.) using Satlantic, AC-S and BB9 instrumentation concurrent with collection of water samples for chlorophyll, CDOM, DOC, and suspended mineral are planned to be made in:
Western Lake Erie: weekly combined with regular sampling - April to October
Saginaw Bay: every other week: May to October
Lake Michigan: monthly combined with CSMI - March to November

Lake Superior: August, 4 ship days

Ship time and personnel are already allocated in other OSAT projects.

e) Satellite SAR Ice Type Classification and Mapping – SAR.
(Leshkevich, JPL, NESDIS)
Continue work with NESDIS to transfer the Synthetic Aperture Radar (SAR) ice type classification technology (algorithm) for operational use. Using NESDIS calibration and processing, the ice type classification algorithm was used to classify ice types in Radarsat-2 scenes for a demonstration carried out on the USCGC Mackinaw on Lake Superior during March-April 2014. Results of different calibration offset options will be compared to "ground truth" and evaluated. Testing of the algorithm with the newly launched Sentinel-1 C-band SAR satellite data (if available this winter) will be done. Products include maps of Great Lakes ice types of use to the National Ice Center (NIC) and U.S. Coast Guard. A journal article on the ice classification algorithm has been published.

f) MODIS - Thermal Signatures of Great Lakes Ice.
(Leshkevich, NASA Goddard, Jia Wang, Ayumi Manome, Coast Guard)
This project is a continuation of work started earlier to measure the spectral signature of Great Lakes ice types in the visible and thermal infra-red for the purpose of ice type classification. Collection of surface temperature of different ice types is planned on Lake Erie or Lake Superior using small (button) thermistors placed on the ice surface. The data will be used to validate a MODIS ice surface temperature algorithm, data from which can be used in ice growth models.

g) Satellite Soil Moisture Retrieval
(Leshkevich, JPL, Gronewold)
This project focuses on evaluation of the retrieval of soil moisture in the Great Lakes basin from satellite radar (scatterometer and/or SAR) measurements. Soil moisture is an important hydrological parameter and is useful for runoff modeling as well as flood / drought forecasting among other uses. The Soil Moisture Active Passive (SMAP) satellite is scheduled for launch in January 2015 from which maps of soil moisture can be derived for the Great Lakes basin. If found useful, soil moisture can be developed into a standard product and incorporated in basin runoff models.

Global Lakes Temperature Collaboration (GLTC)
Continue collaboration with the Global Lakes Temperature Collaboration (GLTC) to assess and document long term changes in global lake temperatures. Participants from around the world contributing data and analysis. One journal article submitted and another to be submitted soon.

Associate Editor for Journal of Great Lakes Research
Continue associate editor duties and handling of manuscripts for the journal.

<u>Budget Explanation</u>
Budget covers Supplies and Travel (Field, Conference, Science Meeting, Admin) to be expected for the different projects such as meetings at NESDIS (College Park, MD) and field work. Ship time can be leveraged from Coast Guard or other OSAT projects and needed equipment (ex. thermistors) supplied by collaborating agencies. The project should not increase the current GLERL security level.

Integration

This project is linked to but not dependent on the Great Lakes CoastWatch Operations project as satellite and airborne derived products can be made available to the user community via the Great Lakes CoastWatch website and also to OSAT HAB monitoring project.

Progress & Project Improvement (if project is continuing / on-going)

What are the expected short-term (FY15) and longer term (2-5 years) outcomes and milestones?

- Continue transfer and testing of SAR ice type classification algorithm to NESDIS (including testing with Sentinel-1 data if available this winter)
- Continue transfer of CPA algorithm to NESDIS for evaluation for operational use
- Continue development of hyperspectral HAB detection algorithm
- Collect ice surface temperature measurements

Which journal papers, reports, and products (e.g., forecasts, briefs, models, etc.) will be *developed or improved* upon?

- Leshkevich, G. and S.V. Nghiem. Great Lakes Ice Classification Using Satellite C-band SAR Multi-Polarization Data. *Journal of Great Lakes Research,* Supplement 1 on Remote Sensing, Volume 39 (2013).
- Shuchman, R.A., Leshkevich, G., Sayers, M., Johengen, T., Brooks, C., and Pozdnyakov, D. Generation of an Operational Algorithm to Retrieve Chlorophyll, Dissolved Organic Carbon, and Suspended Minerals from Great Lakes Satellite Data, , *Journal of Great Lakes Research,* Supplement 1 on Remote Sensing, Volume 39 (2013).
- Shuchman, R.A., Sayers, M., Fahnenstiel, G., Leshkevich, G. Satellite Derived Primary Productivity Estimates for Lake Michigan, *Journal of Great Lakes Research,* Supplement 1 on Remote Sensing, Volume 39 (2013).

New (or submitted) journal papers planned include: GLTC Data paper, GLTC Trends Paper, scatterometer ice paper, upwelling paper, CoastWatch update, ice temperature, CPA time series?

FY14 progress made on the project as compared to stated milestones and goals

- SAR ice type classification algorithm transferred to NESDIS for operational use (milestone) and short demonstration completed on Lake Superior aboard USCGC Mackinaw in March-April
- Continued development of CPA algorithm and initiated transfer to NESDIS for evaluation for operational use
- What challenges were encountered during the past year and what is the plan to reduce or eliminate them this year? Many of the projects are weather, personnel, and equipment dependent.

Relevance to NOAA & Public

- What science question are we answering? Several based on the hypothesis that satellite sensors can be used to retrieve measurements of Great Lakes water quality parameters including chlorophyll, DOC, suspended minerals, HAB's, ice type/temperature
- What is the societal relevance? Improved water quality, cost savings, economy, recreation, education
- Under what NOAA and DOC goals does the work fit?
  DOC FY2014-2018 Strategic Plan
  3 – Environment

Ensure communities and businesses have the necessary information, products, and services to prepare for and prosper in a changing environment
3.1. Advance the understanding and prediction of changes in the environment through world class science and observations (NIST, NOAA)

NOAA 5-year research and development plan 2013-2017
C. Healthy Oceans: Marine fisheries, habitat, and biodiversity are sustained within healthy and productive ecosystems
F. Accurate and Reliable Data from Sustained and Integrated Earth Observing Systems

What part of GLERL's mission or which Strategic Plan milestone does this support?

- Observing Systems and Advanced Technology
- The Observing Systems and Advanced Technology (OSAT) branch develops, tests, evaluates, and implements new remote sensing products, observation platforms, and instrumentation to continuously improve GLERL's and NOAA's observational capabilities.
- Develop satellite remote sensing products supporting scientific understanding of primary productivity and ice formation

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OSAT 1.3 Underwater Remote Sensing
(Ruberg)

Internal partners: Braymer, Beadle, Constant, Baldridge
External partners: Russ Miller (CILER), Russ Green (TBNMS), Biddanda (GVSU)

Executive Summary

Acoustic sensing systems are deployed on buoys, autonomous vehicles, remotely operated vehicles, and research vessels. Remote sensing devices can be either active or passive: active by emitting a signal and then measuring information about the returning signal, or passive by listening for physical and biological sounds. Technology includes sensors such as passive acoustics (underwater microphone) and side-scan and multibeam sonar. Preliminary work on sound and chemical seascapes will be initiated (workshop at GLERL) with soundscape equipment lab tested or deployed potentially at Muskegon; work will continue on the use of acoustic imaging technology for mussel areal coverage estimation on Lake Michigan, and work will continue on Lake Huron submerged sinkhole systems.

Budget Summary	
Item	***Total ($)***
Equipment	$9,000
Supplies	
Field Travel *(field work)*	$2,000
Science Conference Travel *(conferences e.g. AMS, IAGLR, AGU)*	
Science Meeting Travel *(e.g. working groups, PI meetings)*	$2,500
Admin Travel *(e.g. Advisory Board meetings)*	
*** International travel*	--
Contracts/CILER	
Other (specify)	
Total Amount	$13,500
Staffing and Ship Time	
Federal Staff	0.2 FTE
Contract and CILER Staff	0.1 FTE
Total Staff	**0.3 FTE**
Total Ship Time Days	**15**

Project Details

Personnel Requirements

Project management and field work for Lake Huron and Lake Michigan work (Ruberg 5%). Benthic Mapping consultation, Baldridge. Doran Mason is leading the sound and chemical seascape research (10%). Constant (5%), Beadle (5%), Miller (5%) will work on Sinkhole and Benthic Mapping projects with Braymer.

Work Description:

Benthic mapping and assessment. Sidescan sonar data will be collected on Lake Michigan along transects at Muskegon, Grand Haven and Ludington to determine mussel spatial distribution and determine change over time. Imagery was collected in 2012 and 2014 at Muskegon using a Klein 3000 sidescan sonar. The 2012 and 2014 imagery was processed using GEOCODER software creating a benthic map representing mussel density variability. The GEOCODER intensity map is currently being correlated with LTER transect mussels samples. Data will be collected on R/V Storm over 3 days on Lake Michigan at Grand Haven, Muskegon and Ludington by Beau Braymer and Kyle Beadle. GEOCODER intensity maps will be created by Kyle. Ground truth using AUV at all transects will be done by Miller and Ruberg. Ponars will be collected over 2 days from 23' vessel at selected locations to provide additional ground-truth.

Lake Huron Sinkhole Mapping and Survey. We will collect flow data at Middle Island vents and use sidescan and multi-beam sonar to improve our understanding of karst features and pockmarks in water depths of 100 meters and greater. One additional karst feature was discovered in 2013 in northern Lake Huron to be actively venting highly conductive groundwater at a depth of 117m. Ambient lake water is approximately 150 uS/cm where water in the sinkhole was found to be as high as 2,792 uS/cm. In 2015, a remotely operated vehicle with a CTD attached will be used to investigate pockmarks and additional sinkholes. Ponars will be collected at pockmark locations. The recently discovered active sinkhole will be mapped using ROV and CTD with geo-referencing acoustic system. This preliminary data will be collected in preparation for proposal submissions to Ocean Exploration. Previous work on this topic was funded by Ocean Exploration (~$600K) and NSF (~100K) resulting in eleven peer-reviewed publications and numerous presentations as well as production of extensive outreach and education material. All work in 2015 will be done over 4 days from the R/V Storm.

Sound and Chemical Seascape Workshop. Initiate a sound and chemical seascape workshop at GLERL and publish workshop results in a peer-reviewed journal. Visit the Bio-Optical Oceanography Laboratory at the University of Puerto Rico to discuss a demo project using ReCON technology on nearby reef systems. Publication of workshop results will not happen until late 2015 (early FY16).

Mill Debris Assessment. In collaboration with NOAA Restoration (Terry Heatlie) efforts, this project will support the Michigan Department of Environmental Quality in coordination with USEPA, the Great Lakes Commission, West Michigan Shoreline Regional Development Commission and the Muskegon Lake Watershed Partnership. The work includes investigation into the locations of excessive mill debris and preparation of design plans to ultimately remove the mill debris material from two Mill debris sites, located along the south and northwest shorelines of Muskegon Lake. The sites are comprised of approximately 12-20 acres. The investigation will be completed through a partnership with the Great Lakes Commission. Sidescan and drop camera work will be done from a small boat (6 days) on weather days as crew is available.

Budget Explanation

- No funds for non-federal staff requested in this proposal.
- Soundscape monitoring equipment (~ $9,000). Sidescan sonar data collection can be improved by using a trolling control ($7,000). Field travel costs for Ruberg and Constant are estimated at $1,000; field travel costs for Russ Miller for AUV and Sinkhole ROV work are estimated at $1,000. Travel costs for visit to the University of Puerto Rico for ReCON and soundscape meeting ($2,500).
- No increase to GLERL security level as a result of this project.

Integration

Work on Lake Michigan is linked to the GLERL LTER and CSMI projects. Work on sinkholes will be integrated with ongoing collaborative research with GVSU funded by NSF. TBNMS outreach and education. Data collected will be used to pursue additional funding through NOAA/OAR Ocean Exploration and NSF.

Progress & Project Improvement (if project is continuing / on-going)

- Expect mussel areal observations to allow an understanding of mussel areal extent change over time; the 2-5 year plan is to determine mussel density with depth and extend observations to additional transects along the east shore of L Michigan. The long-term goal for sinkhole work is to determine if sinkhole groundwater flows make a significant contribution to lake levels. Other long-term studies will look at sinkhole systems with hypoxic/anoxic conditions as representing the early earth (photic zone) or extreme life forms (aphotic zone).
- Journal articles targeted for Marine Technology Society Journal, Ecosystems, etc.
- Vessel time scheduled in 2014 for the sinkhole work was not used due to PI scheduling issues.

Relevance to NOAA & Public

Science and Engineering Questions: Do the physical and chemical characteristics (temperature, specific conductivity) of submerged sinkhole systems differ across geological strata/depth? Can accurate areal estimates of mussel coverage be obtained using acoustic imaging techniques? Can an effective soundscape recording techniques be deployed using ReCON technology? Can sound and chemical seascapes be used to determine the health of ecosystems? Can sound and chemical seascapes be used to determine biomass of zooplankton and fish in the Great Lakes and coastal areas?

Societal Relevance: Improved measurement techniques. Advance understanding of mussel decline or advancement into shallow or deeper waters. Improved understanding of food webs leading to better coastal information about the availability of biomass supporting fisheries.

DOC Goals:

- **Innovation**. Fostering a more innovative U.S. economy—one that is better at inventing, improving, and commercializing products and technologies that lead to higher productivity and competitiveness.
- **Data**. Improve government, business, and community decisions and knowledge by transforming Department data capabilities and supporting a data-enabled economy.
- **Environment**. Ensuring communities and businesses have the necessary information, products, and services to prepare for and prosper in a changing environment.
- **Operational Excellence**. Delivering better services, solutions, and outcomes that benefit the American people.

NOAA Goals: Weather ready nation, healthy oceans, and resilient coastal communities.

GLERL Strategic Plan milestones. Integrate new technologies into field sampling design; improve accuracy and reliability of water level forecasts.

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OSAT 2.1 Vessel Observations Improvements and Outreach
(Ruberg)

Constant
Internal partners: Vessel operators and users.
External partners: TBNMS, UM, MTU

Executive Summary
OSAT's mission for vessel operations is to provide support for field research and technology development. To advance observational capacity in Great Lakes research, OSAT personnel develop scientific instrumentation and gear that ensures the smooth operation of our scientific fleet of vessels. Vital to this effort is OSAT's work in improving navigation, field communications, and data collection and storage on-board our vessels. The Green Ship Initiative, also conducted under OSAT's vessel operations, develops advanced technology to convert research vessels from petroleum-based fuels and lubricants to renewable and environmentally-friendly products that reduce fossil fuel emissions. Projects this year will focus on the Alliance for Coastal Technologies Dissolved Oxygen Sensor Performance Verification, acoustic survey system upgrades and vessel support for the UM

Budget Summary	
Item	***Total ($)***
Equipment	$5,000
Supplies	$ 1,000
Field Travel *(field work)*	$ 500
Science Conference Travel *(conferences e.g. AMS, IAGLR, AGU)*	
Science Meeting Travel *(e.g. working groups, PI meetings)*	
Admin Travel *(e.g. Advisory Board meetings)*	
*** International travel*	--
Contracts/CILER	
Other (specify)	
Total Amount	$6,500
Staffing and Ship Time	
Federal Staff	0.15 FTE
Contract and CILER Staff	0 FTE
Total Staff	**0.15 FTE**
Total Ship Time Days	**21**

Project Details
Personnel Requirements
Overall project lead is Constant (10%) for CTD Upgrades on Laurentian and display and met station installation on Storm; Ruberg (5%) will be one of four members of the ACT Technical Advisory Committee during DO Testing at Muskegon.

Work Description:
ACT DO Sensor Tests, R/V Laurentian. The Laurentian CTD bottle firing mechanism will require maintenance. An Alliance for Coastal Technologies Dissolved Oxygen Sensor Test project will be held at the Lake Michigan Field Station. ACT will share the cost for the upgrade. Requested vessel days at Muskegon will be approximately 4 days.

Acoustic Survey, R/V Storm. The sidescan and multibeam sonars are used by GLERL for benthic classification and by TBNMS for archeological survey. The acoustic survey system will require display upgrades and met sensor system installation.

Vessel Outreach and Education
Class 1. Great Lakes Ecology Class. Date of ship time use June. Ship arrives in Cheboygan where the vessel operates for approximately 10 days.
Class 2. UM Biological Station short class on Great Lakes Oceanography. Dates of ship time use August, Ship to arrives in Cheboygan where it operates for approximately 6 days.

Budget Explanation
- No non-federal staffing requested for this project.
- CTD Rosette maintenance, $3,000. Met system and display costs for the survey vessel is estimated at $2,000. Field travel for Ruberg and Constant is estimated at $500.
- No increase to GLERL security level as a result of this project.

Integration
CTD upgrades are linked to the ACT DO Sensor Performance Verification at the Lake Michigan Field Station.

Progress & Project Improvement (if project is continuing / on-going)

Relevance to NOAA & Public
Engineering and Science Questions: An improved understanding of the performance of various DO sensors will be documented in an ACT report.

DOC Goals:
- **Innovation**. Fostering a more innovative U.S. economy—one that is better at inventing, improving, and commercializing products and technologies that lead to higher productivity and competitiveness.
- **Data**. Improve government, business, and community decisions and knowledge by transforming Department data capabilities and supporting a data-enabled economy.
- **Environment**. Ensuring communities and businesses have the necessary information, products, and services to prepare for and prosper in a changing environment.
- **Operational Excellence**. Delivering better services, solutions, and outcomes that benefit the American people.

NOAA Goals: Weather ready nation, healthy oceans, and resilient coastal communities.

GLERL Strategic Plan milestones: Improve year-round, under-ice ecological observing system capabilities; integrate new technologies into field sampling design.

OSAT 3.1 Real-time Coastal Observations Network (ReCON)
(Ruberg)

Internal partners: GLERL - Muzzi, Constant, Donahue, Yagiela, Mason, Gronewold, Rutherford, Vanderploeg, Anderson
NOAA – NOS- Martinez
CILER / UM -Johengen Beadle, Miller
External partners: Jim Hendee (AOML), Peter Blanken (U Colorado), Chris Spence (Env Canada), John Lenters (Limnotech), Branko Kerkez (UM), Russ Green/Ellen Brody (TBNMS)

Executive Summary

Successful ecosystem forecasting and forecast validation depend on the availability of data describing the present state of coastal waters at a variety of time and space scales. This in-situ observing systems project intends to build a programmatic and engineering research and development base to establish coastal environmental observation networks that complement GLERL's ecosystem forecasting research goals. On-water observation networks will include the deployment of autonomous underwater vehicles, fiber optic cabled and high-bandwidth wireless systems. In addition to advancing NOAA's scientific real-time data acquisition capability, the project is making relevant data accessible to regional managers, the public and educational institutions through a web-based data interface accessible using current internet technology. Observation systems will be deployed at multiple sites for the purposes of continued engineering development, scientific data collection, and pre-operational decision support in Lakes Huron and Michigan. Lake Michigan deployments will support CSMI activities and Lake Huron work will involve development of cabled systems and continued development of a high-band-width point to point link from Thunder Bay Island.

Budget Summary	
Item	***Total ($)***
Equipment	$6,000
Supplies	$ 5,000
Field Travel *(field work)*	$ 1,000
Science Conference Travel *(conferences e.g. AMS, IAGLR, AGU)*	
Science Meeting Travel *(e.g. working groups, PI meetings)*	
Admin Travel *(e.g. Advisory Board meetings)*	
***International travel*	--
Contracts/CILER	
Other (specify)	
Total Amount	$12,000
Staffing and Ship Time	
Federal Staff	0.55 FTE
Contract and CILER Staff	0.10 FTE
Total Staff	**0.65 FTE**
Total Ship Time Days	**14**

Project Details

Personnel Requirements

Overall project lead is Ruberg (10%); Doran Mason is co-leading the ecological observing system research (10%). Ron Muzzi is lead engineer contributing technical leadership, design and programming (25%). Steve Constant leads the field and lab technical activities (10%). Kyle Beadle will be assisting with buoy and mooring prep and additional programming associated with buoy instrumentation at Muskegon (10%).

Work Description:

The Lake Michigan work will take place along the Muskegon LTER transect in conjunction with GLRI and CSMI funded components. The primary focus at Muskegon is to deploy the BioSonics fisheries acoustics system at the M45 stations. This real-time ecological observing system will provide data about fish behavior along with physical measurements (temperatures, currents) and biological imagery of 45m benthos. Buoy prep work will be done in MIL, buoy deployments can be done in 1 day in March 2015, buoy retrievals will be done in 1 day in November 2015. Two additional vessel days are planned for buoy maintenance and repair. All work is daytime. Buoy deployments/retrievals work best from 5501; weather and transit days not factored in. Deployment of buoys (loads up to $1500lbs) must be done with careful concern for crew safety requiring proper safety precautions and very calm seas – crew competence is high after 10 years of experience in deploying ReCON and UM design buoys. Data will be displayed and stored using PC Real-time and standard ReCON web display.

The Lake Huron work will take place on Spectacle Reef and Thunder Bay Island (TBI). The Lake Huron work includes deploying a cabled system at TBI and adding ice observations capability to Spectacle Reef. TBI cable deployment will be done from the Storm (too shallow for Laurentian) over 2 days in September 2015. Vessel crew has experience in laying cable however this work will require advanced planning to execute successfully and safely – cable length is short (~1800 ft.) so handling is not unwieldy. TBI work will require a 25' Whaler or other vessel (3 Days) with shallow draft needed for access. All work is daytime; weather days not included. Data will be displayed and stored using PC Real-time and standard ReCON web display.

GLOS external funding ($22,000) will support AUV deployments at Muskegon (2 ship days) to ground-truth quagga mussel observations; deployment and retrieval of UofM GLOS buoy at Ludington and ReCON buoy at Alpena (4 ship days). This external funding also provides supply and travel funds to support transfer of GLERL buoy data to NDBC, GLOS meeting attendance and conference attendance.

Budget Explanation

- No non-federal staffing requested for this project.
- Field travel for work at TBI and Spectacle Reef are estimated at $1,000. Observing system cable and supply costs for projects are estimated at $6,000 – supplies for the system are estimated at $5,000.
- No increase to GLERL security level as a result of this project.

Integration

Work on Lake Michigan is linked to the GLERL LTER and CSMI projects. Work on Spec Reef is linked to GLERL evaporation observations and OSAT year-round, under ice observation capabilities.

Progress & Project Improvement (if project is continuing / on-going)

- Initial deployment of ecological observing system technology in 2015 leading to (2-5 years) a year-round, under ice capability at Stannard Rock (L Superior) and Spectacle Reef.

- Journal articles targeted for Marine Technology Society Journal, Ecosystems, etc.
- Ecological observing system deployed at Muskegon in FY14 with limited success. Challenges were low tech and stemmed from an initial lightning strike; the new elastic moorings will help eliminate problems encountered.

Relevance to NOAA & Public

Engineering and Science Questions: Can a cost-effective real-time ecological observation system be deployed and operated at Muskegon, MI? Can real-time acoustic and video observations along with standard physical, biological and chemical measurements improve our understanding of benthic and pelagic ecosystems? Can we operate and maintain a system of evaporation stations and extend this capability to year-round, under ice observations?

Societal Relevance: Improved understanding of food webs leading to better coastal information about the availability of biomass supporting fisheries. Improved understanding of atmospheric and in-lake measurements needed to estimate Great Lakes water levels. Increased physical observations used for coastal information by Coast Guard, TBNMS researchers, commercial shipping, and the public.

DOC Goals:

- **Innovation**. Fostering a more innovative U.S. economy—one that is better at inventing, improving, and commercializing products and technologies that lead to higher productivity and competitiveness.
- **Data**. Improve government, business, and community decisions and knowledge by transforming Department data capabilities and supporting a data-enabled economy.
- **Environment**. Ensuring communities and businesses have the necessary information, products, and services to prepare for and prosper in a changing environment.
- **Operational Excellence**. Delivering better services, solutions, and outcomes that benefit the American people.

NOAA Goals: Weather ready nation, healthy oceans, and resilient coastal communities.

GLERL Strategic Plan milestones: Improve year-round, under-ice ecological observing system capabilities; integrate new technologies into field sampling design; improve accuracy and reliability of water level forecasts.

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External Science Project Planning

Ecosystem Dynamics

ECODYN EX 1 Invasive Species - GLRI/CSCOR: Forecasting bioeconomic impacts of invasive species on Great Lakes food webs and fisheries.
(Ed Rutherford)

GLERL: E. Rutherford (PI), D. Mason (co-PI). T. Hunter (modeler)
Internal Collaborators: H. Zhang and Dmitry Beletsky (CILER)
Collaborating Partners: Lori Ivan (Michigan State Univ.), Sara Adlerstein, Yu-Chun Kao, Catherine Riseng and Lacey Mason (Univ. Michigan), David Lodge (Univ. Notre Dame), Marion Wittmann (Univ. Notre Dame); Tim Johnson (Ontario Ministry Natural Resources); David Finnoff (Univ. Wyoming); Matthew Barnes (Texas Tech Univ.), Lindsay Chadderton (The Nature Conservancy); Jonathan Bossenbroek (Univ. Toledo)

Executive Summary

Invasive species are one of five key NOAA-identified stressors of native biodiversity and ecosystem function in the Laurentian Great Lakes where at least 184 nonindigenous species are established. It is therefore critical to forecast species invasions and their costs, and to predict the effectiveness and costs of potential management responses to these invasions. GLERL scientists will collaborate with CILER scientists and external university researchers to model natural dispersal of invasive species larvae in four of five Great Lakes; develop databases and eco-regional habitat classifications for environmental niche modeling; and apply food web models to predict impacts of invasive species on Great Lakes food webs and fisheries. Findings will be published in peer reviewed manuscripts, and GIS databases will be available through University of Michigan's Great Lakes Aquatic Habitat Framework (GLAHF) project.

Budget Summary	
Item	***Total ($)***
Equipment:	
Supplies:	
Field Travel:	
Science Conference Travel: *IAGLR*	$ 1,000
Science Meeting Travel: *June 2015 project meeting*	$ 1,000
Admin Travel: *Advisory board travel to Discovery Channel HQ, Silver Spring*	
***Please note here any International travel and the location ($ amount is included in one of the above categories)*	--
Contracts/CILER:	$ 98,214
Other (specify): *GLERL IT*	$ 2,500
Total Amount	$102,714

Staffing and Ship Time	
Federal Staff	0.90 FTE
Contract and CILER Staff	0.85 FTE
Total Staff	**1.75 FTE**
Total Ship Time Days	**0**

Project Details

Personnel Requirements

Rutherford (0.4 FTE) - Lead PI; Mason (0.2 FTE) - Supporting PI; Hunter (0.3 FTE) - IBM Modeling.

Funded Collaborators: Zhang (CILER) –0.4 FTE, food web modeling; Beletsky (CILER) – 0.09FTE, hydrodynamics and fish larvae dispersal modeling; Adlerstein (CILER) – 0.16 FTE food web modeling; Research Technician 0.2 FTE, food web modeling;

Non-Funded Collaborating Partners: Lori Ivan (Michigan State Univ.) IBM modeling; Catherine Riseng and Lacey Mason (Univ. Michigan) Great Lakes habitat databases; David Lodge (Univ. Notre Dame) and Marion Wittmann (Univ. Notre Dame) – co-PIs; Tim Johnson (Ontario Ministry Natural Resources) co-PI; David Finnoff (Univ. Wyoming) co-PI; Matthew Barnes (Texas Tech Univ.) co-PI; Lindsay Chadderton (The Nature Conservancy) co-PI; Jonathan Bossenbroek (Univ. Toledo) co-PI.

Work:

Modeling will focus on Lake Erie, Huron, Michigan, and Ontario.

a. Food web models and larval dispersal models will be developed for each lake. Models will forecast potential impacts of new invasive species on food webs. For Lake Michigan and Lake Erie, model results will be linked to an economic model to estimate bioeconomic impacts. Current-mediated dispersal models will predict natural dispersal of invasive larvae in four Great Lakes. Habitat layers developed to support environmental niche modeling of potential invasive habitat will be made available on GLAHF website. An ecological habitat classification of the Great Lakes will be completed.
b. Work will take place from Oct. 2014 – Sept. 2015.
c. Day)
d. Continuous
e. Methods: Food web modeling: we will use Ecopath with Ecosim, the Atlantis Ecosystem model, and Individual based bioenergetics models to compare impacts of Asian carp in Lake Erie, Lake Michigan and Lake Huron. In Lake Ontario, and for other invasive species in Lake Erie and Michigan, we will use the Ecopath with Ecosim models. The Princeton Ocean Model (POM) will be used to forecast natural dispersal of invasive larvae from rivers, ports and ship ballast locations.
f. Key resources:
    - IT resources required (computers)
    - Editorial, media, graphics, web services, public relations support required: we require assistance with graphics to prepare manuscripts for Journal publications

Budget Explanation

- Staffing: self-explanatory based on entries above.

- Resources needed: none required.
- GLERL security low

Integration

Project results will be integrated with is directly linked to GLRI supported Asian carp committee, and ACOE.

Progress & Project Improvement

- Expected short-term (FY15) outcomes: finish modeling Asian carp impacts on the food webs in 4 Great Lakes; model impacts of ruffe, killer shrimp, golden mussel and snakehead on food webs in Lake Erie and Michigan. Write up results.
- Expected long-term outcome (2-5 years): publication of results and use of models to investigate impacts of other invasives (Dreissena), climate change and land use on Great Lakes food webs.
- FY14 progress: We completed simulations of Asian carp impacts in Lake Erie, Lake Huron and Muskegon Lake. We configured a food web model for Lake Michigan. We ran simulations of ruffe, killer shrimp and golden mussel impacts on the Lake Erie food web.

Relevance to NOAA & Public

What science question are we answering?

What is the potential impact of invasive species on Great Lakes food webs? And, what are uncertainties associated with our model projections?

Societal relevance:

Invasive Species cause great damage to the GL and at least $200 million annually to the whole US.

Relevant NOAA and DOC goals: This project meets goals and objectives of DOC and NOAA strategic plans.

DOC FY2014-2018 Strategic Plan: Environment: 3.1. Advance the understanding and prediction of changes in the environment through world class science and observations 3.4: Foster healthy and sustainable marine resources, habitats, and ecosystems through improved management and partnerships.

NOAA 5-year research and development plan 2013-2017: under the “Healthy Oceans Goal”, this project meets the objective that fisheries, habitat, and biodiversity are sustained within healthy and productive ecosystems.

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ECODYN EX 2 Expanding Environmental Intelligence Assets in Western Lake Erie
(Timothy Davis)

Steve Ruberg (GLERL), Duane Gossiaux (GLERL), Tom Johengen (CILER), Joe Smith (CILER), Alicia Ritzenthaler (CILER), Greg Doucette (NOAA/NOS-Marine Biotoxins)

Executive Summary

In response to the Toledo drinking water emergency of August 2-4, 2014, USEPA requested input from state and federal agencies on areas where strategic investments may lower the risk of future impacts of harmful algal blooms (HABs) on western Lake Erie (WLE) communities. The National Oceanic and Atmospheric Administration's (NOAA) Great Lakes Environmental Research Laboratory (GLERL), and the affiliated Cooperative Institute for Limnology and Ecosystems Research (CILER) have maintained observing systems and sampling programs in WLE for several years, and have received support from the Great Lakes Restoration Initiative to expand these capabilities since 2010. To expand these efforts, NOAA-GLERL will be responsible for three integrated projects that will increase our capacity to monitor and forecast bloom events: 1) deploy instrumentation capable of detecting harmful algal bloom (HAB) toxicity in near real-time, 2) use airborne sensors to track areal extent, and 3) deploy *in situ* sensors on autonomous vehicles to detect bloom initiation. The first part of the project will be the acquisition of and microcystin assay development for the Environmental Sample Processor (ESP). These data will help inform operators of drinking water utilities in western lake Erie of changing HAB conditions in the lake that are likely to impact the quality of their raw water.

Budget Summary	
Item	***Total ($)***
Equipment	$675,000K
Supplies	$ 40,000K
Field Travel *(field work)*	
Science Conference Travel *(conferences e.g. AMS, IAGLR, AGU)*	
Science Meeting Travel *(e.g. working groups, PI meetings)*	
Admin Travel *(e.g. Advisory Board meetings)*	$ 5,000
*** International travel*	--
Contracts/CILER	$180,000
Other (specify)	
Total Amount	$900,000
Staffing and Ship Time	
Federal Staff	0.40 FTE
Contract and CILER Staff	1.30 FTE
Total Staff	**1.70 FTE**
Total Ship Time Days	**15**

Project Details

Personnel Requirements

Federal: Timothy Davis 0.2 FTE, Duane Gossiaux 0.1 FTE, Steve Ruberg 0.1 FTE
CILER: Tom Johengen 0.1 FTE, Joe Smith 0.1 FTE, Alicia Ritzenthaler 1 FTE
External: Greg Doucette 0.1 FTE

Describe what work is intended to be done

NOAA-GLERL will be responsible for three integrated projects that will increase our capacity to monitor and forecast bloom events: 1) deploy instrumentation capable of detecting harmful algal bloom (HAB) toxicity in near real-time, 2) use airborne sensors to track areal extent, and 3) deploy *in situ* sensors on autonomous vehicles to detect bloom initiation. The first part of the project will be the acquisition of and microcystin assay development for the Environmental Sample Processor (ESP). A research technician position (RT) with the Cooperative Institute for Limnology and Ecosystems Research (CILER) will be responsible for the bulk of the laboratory and fieldwork associated with the preparation and deployment of the ESP. The RT, with guidance from Dr. Tim Davis NOAA-GLERL) and Dr. Greg Doucette (NOAA-CCEHBR), will develop the microcystin ELISA assay. This process will take 2-3 months to ensure we have a robust method that yields microcystin data similar to the Abraxis ELISA kits, which is currently our 'gold standard' for monitoring Lake Erie. The process of developing the ESP-based ELISA assay will require reciprocal trips for Dr. Davis and the RT to travel to Dr. Doucette's laboratory and vice versa. Drs. Davis and Doucette will communicate with MBARI to schedule a senior researcher, research technician and IT specialist to travel to GLERL and assist Dr. Davis and the RT prepare the ESP for the initial deployment and to ensure that the real-time communications between the ESP and GLERL are functioning properly. We anticipate the initial deployment will occur in June or early July at the Toledo water intake structure. The ESP will be monitored and maintained until it is extracted permanently after the bloom dissipates. The MC data collected will be uploaded to GLERL's water quality webpage on a near real-time basis.

In order to augment satellite remote sensing monitoring and detection, two hyperspectral radiometer flights will be conducted each week for 3 months after bloom initiation. Flights will initially be focused on detection of *Microcystis* at water intakes but will be expanded to include tracking as the bloom increases in areal extent. Transects across the bloom edges will be used to improve particle model tracking results during cloudy periods when satellite observations are ineffective. Autonomous vehicles will be deployed to provide early indication of bloom formation and provide confirmation of radiometer flight observations using phycocyanin and chlorophyll sensors and imagery.

Milestones:

Milestones and Deliverables	FY14 Q3	FY14 Q4	FY15 Q1	FY15 Q2	FY15 Q3	FY15 Q4	FY16 Q1	FY16 Q2
Hire a CILER research technician			X					
Acquisition of the ESP				X				
Develop the microcystin ELISA assay				X	X			
Deploy the ESP in Lake Erie					X	X	X	
Upload toxin data for GLERL water quality webpage					X	X	X	
Report findings of the ESP							X	
Develop the ESP-based qPCR assay							X	X
Purchase radiometer and equipment					X			
Radiometer flyovers of western Lake Erie					X	X	X	
Complete analysis of radiometer data							X	
Deploy wave glider					X	X	X	

MOPs – An estimate-in quantifiable terms- of how this project will directly help to achieve a Measure of Progress (MOP) for any Focus Area in the Great Lakes Action Plan:

Work will be used by AOC managers, water intake managers, and beach managers, and will contribute to the following Measures:

Focus Area 3 Measures:
3. Extent (sq. miles) of Great Lakes Harmful Algal Blooms. In 2015, the additional data generated by the aforementioned instruments along with the currently deployed SOAR instrumentation will be used by restoration managers to estimate reductions in HAB extent, by drinking water managers to protect water intakes against potential toxin (microcystin) contamination, and by beach managers to issue HAB warnings.
Principal Actions to Achieve Progress
Improve Public Health Protection at Beaches and Generate Critical Information for Protecting Nearshore Health. The added monitoring tools will improve our ability to detect and track HABs and so improve our ability to provide necessary, timely information to beach and drinking water managers.

Focus Area 5 Measures:
1. *Improvement in the overall aquatic ecosystem health of the Great Lakes using the Great Lakes 40 point scale.* Satellite remote sensing and observing system components currently deployed and in development are and will continue to contribute to ecosystem assessment and evaluation for western Lake Erie through decision tool development efforts.

Collaborative Arrangements: NOAA-GLERL will arrange the contract with the Monterey Bay Aquarium Research Institute (MBARI) who will arrange to send a senior researcher, a research technician and IT specialist to GLERL before and during the initial deployment.

How will the work be accomplished?

- What are key processes necessary to accomplish the work?
  Please see EPA scope of work for these details
- What are key resources necessary to accomplish the work?
  - Vessels – 41' Huron Explorer for Lake Erie (Work days 10; Weather day allowance 5 = 15 total days). We will also need a captain for these days.
  - Laboratory Space: This instrument will require dedicated storage and work space. With the FIBs program winding down the fieldwork component it would be ideal to use some of that laboratory space to house this machine and be able to conduct the bench top analyses needed to QA/QC the methods we will be developing. We will also need space in High Bay for testing of the pressure housing before and after deployments.
  - IT resources required (new computers, high performance computing time, data storage, specialized computer hardware or software)
    The ESP will need the capacity to talk with the GLERL server to directly upload data to our database. We will also need the ability to communicate back to the instrument if settings need to be changed or sampling times need to be adjusted. The instrument runs off a Linux platform so this is the major communications hurdle we will need to overcome in order for this effort to be successful.
  - Editorial, media, graphics, web services, public relations support required
    As my statement above indicates we will need to configure the HABs portion of the website to account for the incoming data being sent from the ESP.
- Identify health and safety issues associated with performing the work (extreme weather, pathogens, rigging, etc.)

Deploying this instrument may entail working in less-than ideal conditions but all of the safety regulations for the boat and crew on Lake Erie are discussed with the scientists and the captain makes the final call. The instrument is large and heavy therefore proper safety gear will need to be donned when deploying the unit.

- How will samples and data be generated and managed?

The ESP samples and analyzes the samples remotely. Alicia will manage the data as her primary focus will be the instrument deployment and operation.

Budget Explanation

1) ESP: capital equipment, $400K; CILER technical staff, $100K; instrument set-up support, $50K
2) hyperspectral radiometer equipment and flights and wave glider rental, $275K
3) Ship time, vessel crew, supplies, travel: $75K

Integration

This work integrates with the GLRI-funded *Microcystis* Ecology and SOAR projects as well as the modeling efforts as it provides the ground-truth data for these efforts.

ECODYN EX 3 NOAA Support CSMI of Lake Michigan 2015
(Hank Vanderploeg)

Federal: H. Vanderploeg, J. Liebig, J. Cavaletto, E. Rutherford, D. Mason, N. Morehead (0.17 FTE each), S. Pothoven (0.04 FTE)
CILER: Burton, Nalepa, Rowe, Mabrey K, TBN Tech

Executive Summary
Funding amount: Subproject A, $100,000; Subproject B, $149,426; Total = $249,426

Subproject A. Lake Michigan 2015 Benthic Survey (Nalepa [CILER], Vanderploeg, lab tech [CILER], and postdoc [CILER]; total cost salaries $100,000 as grants to CILER) GLERL has documented trends in dreissenid populations and the keystone amphipod *Diporeia* in the main basin of Lake Michigan every 5 years since 1994/1995. Samples have been collected in triplicate at 130 sites in 1994/1995, 2000, 2005, and 2010. In addition, GLERL has collected samples for these two taxa at a subset on 40 sites in the southern basin every year since 1998. Further, the total benthic community (all taxonomic groups) have been sampled/analyzed at these southern basin sites for two consecutive years every five years since 1980-81 (i.e., 1980-81. 1986-87, 1992-93, 1998-99, 2004-05, and 2010-2011). This is the longest data set of benthic populations in the Great Lakes that have been consistently collected at the same sites using the same methods. To maintain consistency in both the whole lake data set and the data set in the southern basin, in 2015 GLERL in cooperation with EPA, USGS and academic partners will collect samples at the same 130 sites that were sampled in previous years (1994/1995, 2000, 2005, and 2010) and process in whole the benthic collections in the southern basin and do analysis of mussels and Diporeia in all collections from all sites

In addition to densities, a key component of assessing trends in dreissenid populations is accurate estimates of biomass. To estimate biomass, GLERL has developed length-weight regressions and determines size-frequencies of populations during the whole-lake surveys and will do it again in 2015. In addition to documenting temporal trends in biomass, GLERL will use statistical tools to take into account the natural variance of biomass with depth to create better estimates of spatial distributions and total abundance. We have used these new tools to reexamine spatial patterns of biomass in 2000, 2005, and 2010. We will again apply these statistical tools to biomass estimates in 2015: one method based on organizing stations into transects and fitting depth-dependent models, and a second method based on universal Kriging. These methods will allow us to infer whether there are significant trends in biomass over time, not only at specific stations, but lakewide and within sub-regions of the lake. Again, as with density estimates, it is critical that biomass is determined exactly the same way as in previous years.

Subproject B. Temporal and spatial coupling of nutrients and food web—microbes to fish (Vanderploeg, Rutherford, Pothoven, Cavaletto, Liebig, and Mason (GLERL); Carrick [CMU], and CILER tech). Total cost = $149,426 (Grants: $104,825 [CILER/CMU]; ship support: $44,600).

In support of EPA/USGS efforts to sample food web components at multiple transects around the periphery of the Lake during two seasons, we propose to conduct more intensive temporal (including diel sampling) and fine-scale spatial sampling across seasons— nearly monthly—in the Muskegon/Grand River Region of Lake Michigan so we can project EPA/USGS results across time for greater generalization of results and development of spatially explicit ecosystem models incorporating nutrient movement from inshore to offshore, and impacts of dreissenids and other stressors. In addition we will set aside ship-time for responsive sampling of events such as rain or flooding events. Moreover, we will

incorporate the microbial food web (MFW) as part of our study to fully describe connections of the food web. The MFW has been largely ignored by GLERL, EPA, and USGS and has increased in importance to food web function as dreissenids have radically altered food web structure. Our approach will be similar to Year of Lake Michigan 2010 and Lake Huron 2012, where we have been examining detailed diel spatial coupling seasonally (April, July, and September) of the food web using a variety of advanced tools including plankton survey system that we tow-yow behind our vessel simultaneously with fisheries acoustics (in moon pool shipboard). These studies have revealed extreme spatial organization of the lower food web, with larval fishes and zooplankton inhabiting narrow vertical layers between the metalimnion and hypolimnion, and this pattern can vary radically from nearshore to offshore and across season.

We have no knowledge of spatial coupling during the time of early stratification, which is critical for deep chlorophyll layer formation as well as zooplankton and larval fish production. Therefore we will examine spatial coupling of the food web at this time (May and June) to augment our standard seasonal sampling (April, July, September) seasons to understand nutrient flow from inshore to offshore in the Muskegon and Grand River, the largest source of nutrient loading directly into Lake Michigan. We will also be deploying for the first time anywhere on the Great Lakes a MOCNESS with laser strobe unit, which will allow us to define accurately the vertical distribution of visual macro-zooplankton and micro-nekton such as larval fishes, *Bythotrephes*, and probably *Mysis*. These data with the biomass distribution of dreissenids are necessary for understanding and forecasting production of the food web.

Limited seasonal studies in 2013 indicated that ~ 80% of primary production is now in the picophytoplankton (< 2 µm), which is not available to most mesozooplankton; in contrast in earlier years it constituted ~ 20-30%. However, there is evidence that ciliates, a preferred prey of copepods, are still abundant. Therefore we will evaluate the sustainability of the pelagic food web in Lake Michigan, with particular emphasis on measuring the link between the MFW and crustacean zooplankton that directly feed fish and the role of mussels in affecting that link. We predict the MFW is resilient to the quagga mussel-induced ecosystem changes, due to the fast growth rates and ecological plasticity of its major components, so that it may act to stabilize the pelagic system towards a new steady state. Several outcomes will result from this work. First, we will assess the relative importance of the MFW in Lake Michigan by comparing our data collected with measurements made pre-dreissenid in 1980-90 and 1998-2000. Second, we will help revise water quality models under development at GLERL by incorporating the MFW into it. Last, we will augment GLERL monitoring of plankton assemblages in 2015 Year of Lake Michigan to fully describe the pelagic system.

*Field Sampling***-** Sampling will be conducted at three stations in Lake Michigan (nearshore M15, mid-depth M45, and offshore M110) in monthly (March-October) in 2015 will be used to estimate the standing stock of plankton at each site, while intensive experiments will be carried in spring (April) and summer (July or August) and possibly fall (October/November) to evaluate rates of carbon flux through the MFW to higher trophic levels.

Budget Summary	
Item	***Total ($)***
Equipment	
Supplies	
Field Travel *(field work)*	
Science Conference Travel *(conferences e.g. AMS, IAGLR, AGU)*	
Science Meeting Travel *(e.g. working groups, PI meetings)*	
Admin Travel *(e.g. Advisory Board meetings)*	
***International travel*	--
Contracts/CILER	$204,825
Other – Vessel Time)	$ 44,600
Total Amount	$249,425
Staffing and Ship Time	
Federal Staff	1.06 FTE
Contract and CILER Staff	0 FTE
Total Staff	**1.06 FTE**
Total Ship Time Day s	**16 Laurentian**

Project Details
Authority for Work: Coast and Geodetic Survey Act, 33 U.S.C. 883d
Funding amount: Subproject A, $100,000; Subproject B, $149,426; Total = $249,426

Personnel Requirements
Federal:
Vanderploeg 0.17 FTE, Liebig 0.17 FTE, Cavaletto 0.17 FTE, Rutherford 0.17 FTE, Mason 0.17 FTE, Pothoven 0.04 FTE, Morehead 0.17 FTE

CILER:
A. Burton, T. Nalepa, M. Rowe, K. Mabrey, TBN Tech

Describe what work is intended to be done
The work consists of two subprojects that examine spatial distributions and interaction of benthic and pelagic components of the food web to better understand the movement of nutrients from inshore to offshore and spatial coupling of the food web that has been disrupted by dreissenid mussels.

Subproject A. Lake Michigan 2015 Benthic Survey (Nalepa [CILER], Vanderploeg, lab tech [CILER], and postdoc [CILER]; total cost salaries $100,000 as grants to CILER) GLERL has documented trends in dreissenid populations and the keystone amphipod *Diporeia* in the main basin of Lake Michigan every 5 years since 1994/1995. Samples have been collected in triplicate at 130 sites in 1994/1995, 2000, 2005, and 2010. In addition, GLERL has collected samples for these two taxa at a subset on 40 sites in the

southern basin every year since 1998. Further, the total benthic community (all taxonomic groups) have been sampled/analyzed at these southern basin sites for two consecutive years every five years since 1980-81 (i.e., 1980-81. 1986-87, 1992-93, 1998-99, 2004-05, and 2010-2011). This is the longest data set of benthic populations in the Great Lakes that have been consistently collected at the same sites using the same methods. To maintain consistency in both the whole lake data set and the data set in the southern basin, in 2015 GLERL in cooperation with EPA, USGS and academic partners will collect samples at the same 130 sites that were sampled in previous years (1994/1995, 2000, 2005, and 2010) and process in whole the benthic collections in the southern basin and do analysis of mussels and Diporeia in all collections from all sites

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Milestones:

- Whole lake benthic survey will be conducted in 2015
- Sample analysis and data analysis will start immediately and continue through 2016
- Data report and papers will be written during 2016

Measures of Progress:

We will provide lake-wide abundance estimates of the most important invasive species in Lake Michigan and compare it with past abundance to describe population trends necessary for adaptive management of the Great Lakes.

By providing a framework for understanding the effects of nearshore to offshore lower trophic measures and inter-basin trophic measures this work supports focus areas 2, 4, and 5 Great Lakes Action Plan.

Focus Area 2: Invasive Species

Goal 5: An effective, efficient and environmentally sound program of integrated pest management for invasive species is developed and implemented, including program function of containment, eradication, control and mitigation.

Measure 3. Will provide models to determine effectiveness of control plans.

Focus Area 4: Habitat and Wildlife Protection and Restoration.

Goal 1: Protection and restoration of Great Lakes aquatic and terrestrial habitats, including physical, chemical, and biological processes and ecosystem functions, maintain or improve the conditions of native fish and wildlife.

Goal 3: Sound decision making is facilitated by accessible, site specific and landscape-scale baseline status and trend information about fish and wildlife resources and their habitats.

Measure 4. Will provide information for recovery action plans.

Focus Area 5: Accountability, Education, Monitoring, Evaluation, Communication, and Partnerships:

Goal 1. A cooperative monitoring and observing system provides a comprehensive assessment of the Great lakes ecosystem. To help meet:

Objective 10: provide timely data and information to decision makers.

Collaborative arrangements
This project is collaboration between GLERL, EPA, USGS, and academic partners as part of the Coordinated Science and Monitoring Program to describe the status of Lake Michigan and understand its capacity to deliver important ecological services.

Subproject B. Temporal and spatial coupling of nutrients and food web—microbes to fish (Vanderploeg, Rutherford, Pothoven, Cavaletto, Liebig, and Mason (GLERL); Carrick [CMU], and CILER tech). Total cost = $149,426 (Grants: $104,825 [CILER/CMU]; ship support: $44,600).

In support of EPA/USGS efforts to sample food web components at multiple transects around the periphery of the Lake during two seasons, we propose to conduct more intensive temporal (including diel sampling) and fine-scale spatial sampling across seasons— nearly monthly—in the Muskegon/Grand River Region of Lake Michigan so we can project EPA/USGS results across time for greater generalization of results and development of spatially explicit ecosystem models incorporating nutrient movement from inshore to offshore, and impacts of dreissenids and other stressors. In addition we will set aside ship-time for responsive sampling of events such as rain or flooding events. Moreover, we will incorporate the microbial food web (MFW) as part of our study to fully describe connections of the food web. The MFW has been largely ignored by GLERL, EPA, and USGS and has increased in importance to food web function as dreissenids have radically altered food web structure. Our approach will be similar to Year of Lake Michigan 2010 and Lake Huron 2012, where we have been examining detailed diel spatial coupling seasonally (April, July, and September) of the food web using a variety of advanced tools including plankton survey system that we tow-yow behind our vessel simultaneously with fisheries acoustics (in moon pool shipboard). These studies have revealed extreme spatial organization of the lower food web, with larval fishes and zooplankton inhabiting narrow vertical layers between the metalimnion and hypolimnion, and this pattern can vary radically from nearshore to offshore and across season.

We have no knowledge of spatial coupling during the time of early stratification, which is critical for deep chlorophyll layer formation as well as zooplankton and larval fish production. Therefore we will examine spatial coupling of the food web at this time (May and June) to augment our standard seasonal sampling (April, July, September) seasons to understand nutrient flow from inshore to offshore in the

Muskegon and Grand River, the largest source of nutrient loading directly into Lake Michigan. We will also be deploying for the first time anywhere on the Great Lakes a MOCNESS with laser strobe unit, which will allow us to define accurately the vertical distribution of visual macro-zooplankton and micro-nekton such as larval fishes, *Bythotrephes*, and probably *Mysis*. These data with the biomass distribution of dreissenids are necessary for understanding and forecasting production of the food web.

Limited seasonal studies in 2013 indicated that ~ 80% of primary production is now in the picophytoplankton (< 2 µm), which is not available to most mesozooplankton; in contrast in earlier years it constituted ~ 20-30%. However, there is evidence that ciliates, a preferred prey of copepods, are still abundant. Therefore we will evaluate the sustainability of the pelagic food web in Lake Michigan, with particular emphasis on measuring the link between the MFW and crustacean zooplankton that directly feed fish and the role of mussels in affecting that link. We predict the MFW is resilient to the quagga mussel-induced ecosystem changes, due to the fast growth rates and ecological plasticity of its major components, so that it may act to stabilize the pelagic system towards a new steady state. Several outcomes will result from this work. First, we will assess the relative importance of the MFW in Lake Michigan by comparing our data collected with measurements made pre-dreissenid in 1980-90 and 1998-2000. Second, we will help revise water quality models under development at GLERL by incorporating the MFW into it. Last, we will augment GLERL monitoring of plankton assemblages in 2015 Year of Lake Michigan to fully describe the pelagic system.

*Field Sampling***-** Sampling will be conducted at three stations in Lake Michigan (nearshore M15, mid-depth M45, and offshore M110) in monthly (March-October) in 2015 will be used to estimate the standing stock of plankton at each site, while intensive experiments will be carried in spring (April) and summer (July or August) and possibly fall (October/November) to evaluate rates of carbon flux through the MFW to higher trophic levels.

Experiments

Experiments will be carried at all three stations on two or three dates (April, August, and possibly October) and three depths (epi, meta, and hypolimnion); we will collect water and animals to determine the rates of picoplankton growth and loss, microzooplankton growth and grazing. In another project we will examine mussel grazing on the MFW using standard protocols, and should other funding opportunities arise, we will also examine mesozooplankton grazing on the MFW in companion experiments; if not, we will rely on previous literature studies. Size fractionated primary production and chlorophyll a concentrations will be measured. Rates of primary production will be measured in duplicate bottle using a clean 14-carbon technique (Fitzwater et al. 1982) that will be post fractionated to determine size specific production rates (Fahnenstiel and Carrick 1992).

METHODS DETAILS:

Pico, Nano, and Micro-plankton Biomass: Both pico- and nanoplankton (heterotrophic and phototrophic cells 0.2 to 2 µm in size) will be enumerated using epifluorescence analysis. Larger phytoplankton cells by FlowCAM, microzooplankton by Utermöhl method using differential interference contrast microscopy (DIC). Rotifers and colonial protists will be settled from 1-L samples.

Picoplankton Growth and Grazing Mortality: Simultaneous rate measurements of picoplankton (bacteria and cyanobacteria) growth and loss rates will be measured using 2-point bottle enclosure experiments, using the prokaryotic inhibitor, ampicillin to arrest cytokinesis.

Phytoplankton Growth and Grazing Mortality: Phytoplankton growth and grazing loss rates from microzooplankton will be determined using a modified dilution assay.

Milestones:

- Field sampling and experiments will be carried out in 2015
- Sample and data analysis will begin and continue through 2016
- Presentations will be made during 2016 and 2016
- Papers will be written during 2016

Measures of Progress:

In support of EPA/USGS, our project will provide detailed seasonal information and spatio-temporal connections of the entire food web and movement of nutrient through it in the Muskegon/Grand River region of Lake Michigan so we can project EPA/USGS results across time for greater generalization of results and development of spatially explicit ecosystem models incorporating nutrient movement from inshore to offshore, and impacts of dreissenids and other stressors. Describing the current state of lower food web is paramount to facilitate our understanding, management, and restoration of the Lake Michigan ecosystem. In particular our study of the MFW is addressing a major research gap because we believe the MFW is exerting a stabilizing influence on the pelagic food web.

By providing a framework for understanding the effects of nearshore to offshore lower trophic measures and inter-basin trophic measures this work supports focus areas 2, 4, and 5 Great Lakes Action Plan.

Focus Area 2: Invasive Species

Goal 5: An effective, efficient and environmentally sound program of integrated pest management for invasive species is developed and implemented, including program function of containment, eradication, control and mitigation.

Measure 3. Will provide models to determine effectiveness of control plans.

Focus Area 4: Habitat and Wildlife Protection and Restoration.

Goal 1: Protection and restoration of Great Lakes aquatic and terrestrial habitats, including physical, chemical, and biological processes and ecosystem functions, maintain or improve the conditions of native fish and wildlife.

Goal 3: Sound decision making is facilitated by accessible, site specific and landscape-scale baseline status and trend information about fish and wildlife resources and their habitats.

Measure 4. Will provide information for recovery action plans.

Focus Area 5: Accountability, Education, Monitoring, Evaluation, Communication, and Partnerships:

Goal 1. A cooperative monitoring and observing system provides a comprehensive assessment of the Great lakes ecosystem. To help meet:

Objective 10: provide timely data and information to decision makers.

Collaborative arrangements:
This project is collaboration between EPA, USGS, GLERL and academic partners as part of the Coordinated Science and Monitoring Program to describe the status of Lake Michigan and understand its capacity to deliver important ecological services.

Integrated Physical and Ecological Modeling and Forecasting

IPEMF EX 1 Climate Change Activities - GLRI/EPA
(Brent Lofgren)

Executive Summary
Authority: Coastal Zone Management Act (CZMA, 16 U.S.C. 1456c); Economy Act
Total Funding: $1,163,753 Year 5: $375,982

Project Title: Community outreach and technical assistance for assessing climate change risks and vulnerabilities within the Great Lakes region

Federal:
Brent Lofgren 0.16 FTE, Jia Wang 0.10 FTE

NOAA's GLERL will work to link models for riverine chemical loads, lake dynamics and seasonal stratification characteristics, and mixing of toxics and nutrients with regional atmospheric model outputs to inform models of Great Lakes water quality in the context of climate change. The question of Great Lakes water quality will be addressed through utilizing the Process-based Adaptive Watershed Simulator (PAWS) and GLERL's existing model on lake dynamics, coupled with a nutrient phytoplankton-zooplankton-detritus model. Outputs from this combination of models include simulations of river flow with chemical loading based on energetically consistent land surface and atmospheric models, models of chemical transport within lakes including tributary loading inputs, and simulations of lower trophic level processes. This model combination will help to inform projection of available water quantities and nutrient loading, both subjects of interest to many existing GLRI projects. Results will be disseminated through the Great Lakes Water Level Dashboard and NOAA CSC's "Supporting Great Lakes Communities Adapting to Climate Change" project. Results will also be shared with Lake Superior LAMP developers.

Budget Summary	
Item	***Total ($)***
Equipment	$ 3,000
Supplies	$ 39,534
Field Travel *(field work)*	
Science Conference Travel *(conferences e.g. AMS, IAGLR, AGU)*	
Science Meeting Travel *(e.g. working groups, PI meetings)*	$ 12,000
Admin Travel *(e.g. Advisory Board meetings)*	
*** International travel*	--
Contracts/CILER	$321,448
Other (specify)	
Total Amount	$375,982

Staffing and Ship Time	
Federal Staff	0.26 FTE
Contract and CILER Staff	1.0 FTE
Total Staff	**1.26 FTE**
Total Ship Time Days	**0**

IPEMF EX 2 Decision Support Tools for Nearshore Water Quality Prediction - GLRI/EPA
(Anderson and Davis)

Executive Summary
Funding Amount: $836,494
Authority: P.L. 111-88, the Interior, Environment and Related Agencies Appropriations Act, 2010

Subproject - FIB (Anderson)
Current water quality monitoring in the nearshore zone involves a lag time between sample collection and water quality reporting. This may permit swimming at coastal beaches when bacterial levels could pose health threats or unregulated toxic algal blooms occur. Predictive decision support tools enable environmental and public health officials to notify the public of expected water quality one to two days in advance thereby preventing beach closures when conditions are safe and avoiding negative local economic impacts. The purpose of this work is to develop and implement decision support tools to provide nearshore water quality information up to two days in advance and for forecasting the trajectory and fate of harmful algal blooms in the Great Lakes.

Subproject – HABs (Davis)
In FY14 we will continue development and implementation of our statistical seasonal HAB forecast and our mechanistic HAB decision support systems to incorporate (1) watershed loading at rivermouths (e.g. phosphorus loading) into Lake Erie, (2) 3D hydrodynamics, (3) 3D particle transport to further transition our Lake Erie HAB Forecast Bulletin into an operational tool and provide information to management agencies on the effects of watershed loading on the growth and persistence of Microcystis blooms. We will also conduct field sampling in an event response manner and collect samples during the algal bloom season when blooms are present and in locations where blooms are found. FY14 beach water quality forecasting areas include continued operation at existing Virtual Beach sites (Metropolitan Beach, Lake St. Clair) and continued intensive monitoring and mechanistic support tool programs in Metropolitan and Memorial Beaches, Lake St. Clair. Working closely with USGS, beach managers, and homeowners, we plan to monitor E. coli and other environmental factors in the Clinton River system and Lake St. Clair to evaluate the capability for operational beach water quality forecasting. We will use mechanistic and statistical approaches to evaluate variability of pathogens in the system and skill of operational support tools.

Milestones and Deliverables	FY14 Q3	FY14 Q4	FY15 Q1	FY15 Q2	FY15 Q3	FY15 Q4	FY16 Q1	FY16 Q2
Link watershed-hydrodynamic- bacteria model in Lake St. Clair	X							
Field sampling for western L. Erie harmful algal blooms		X	X			X	X	
Deploy moored data buoy in Lake Erie	X							
Expand decision support tool for Lake St. Clair to include particle model for bacteria loading	X	X	X					
Bacterial sample analysis from Lake St. Clair	X	X	X	X	X	X		
Bacterial field sampling in Lake St. Clair	X	X	X	X	X	X		
Stakeholder communications products (e.g. fact sheets, website and workshop(s)) to continue partnerships/ end user outreach		X	X	X	X	X	X	
Develop test bed for beach water quality forecasts for Metro Beach		X						

Milestones and Deliverables	FY14 Q3	FY14 Q4	FY15 Q1	FY15 Q2	FY15 Q3	FY15 Q4	FY16 Q1	FY16 Q2
Evaluate Strengths and Weakness of Forecast Decision Support Tools (NOAA)				X				
Deploy a moored data buoy in Lake St. Clair to collect high frequency environmental data for decision support tool development	X			X				
Deploy an automated bacterial sampler in Clinton River watershed for decision support tool development	X							

Great Lakes Action Plan Measure of Progress:

Measure
1. Five year average annual loadings of soluble reactive phosphorus from tributaries draining targeted watersheds.
2. Percentage of beaches meeting bacteria standards 95% or more of beach days.
3. Extent (sq. miles) of Great Lakes Harmful Algal Blooms.
4. Annual number of days U.S. Great Lakes beaches are closed or posted due to nuisance algae.

Budget Summary	
Item	***Total ($)***
Equipment	$ 5,000
Supplies-chemicals, nets, labware, bottles, nets	$ 82,707
Field Travel *(field work)*	$ 8,000
Science Conference Travel *(conferences e.g. AMS, IAGLR, AGU)*	
Science Meeting Travel *(e.g. working groups, PI meetings)*	$ 8,000
Admin Travel *(e.g. Advisory Board meetings)*	$ 4,000
*** International travel -*	
Contracts/CILER	$577,989
Other – Vessel Time	$ 22,400
Other – GLERL Labor Offset	$122,232
Total Amount	$830,328
Staffing and Ship Time	
Federal Staff	1.25 FTE
Contract Staff	1.85 FTE
Total Staff	**3.10 FTE**
Total Ship Time Days	**100** **52 small boat (FIB-28 /HAB -24)** **48 Storm or 41' (HAB)**

Project Details

Decision Support Tools for Nearshore Water Quality Prediction - GLRI/EPA –FIBs

Personnel Requirements

GLERL: Anderson (0.20 FTE); Clites (0.10); Davis (0.10) Gossiaux (0.10), Constant (0.10), Gronewold (0.05); Lang (0.05) Ruberg (0.05), Vanderploeg (0.05)

Budget Summary	
Item	***Total ($)***
Equipment	$ 5,000
Supplies-chemicals, nets, labware, bottles, nets	$ 82,707
Field Travel *(field work)*	$ 8,000
Science Conference Travel *(conferences e.g. AMS, IAGLR, AGU)*	
Science Meeting Travel *(e.g. working groups, PI meetings)*	$ 8,000
Admin Travel *(e.g. Advisory Board meetings)*	$ 3,000
*** International travel -*	
Contracts/CILER	$577,989
Other – Vessel Time	$ 22,400
Other – GLERL Labor Offset	$122,232
Total Amount	$830,328
Staffing and Ship Time	
Federal Staff	0.80 FTE
Contract Staff	0.00 FTE
Total Staff	**0.80 FTE**
Total Ship Time Days	**28 small boat**

Decision Support Tools for Nearshore Water Quality Prediction - GLRI/EPA –HABs

(Note: Also referred to as GLRI Microcystis Ecology (Expanded))

Personnel Requirements

GLERL: Davis (0.2 FTE); Gossiaux (0.1); Vanderploeg (0.05); Constant (0.1)

CILER**:** Johengen (0.1); J. Smith (0.5); Burtner (0.45); Palladino (0.3); Joseph Joshi (0.5)

Describe what work is intended to be done

The focus of this project will be on understanding changes in HAB dynamics, bloom toxicity, and intensity under various environmental parameters including nutrient loading and speciation, light, temperature, reactive oxygen species as well as the interaction of these potential drivers of HAB formation and toxicity. In order to effectively gauge the success of these efforts and connect land-use to water quality, annual monitoring of HAB density, frequency, and toxicity as well as in-lake nutrient concentrations is critically needed. Furthermore, expanding our sampling efforts is essential as each system that suffers the effects of poor water quality and HAB formation may respond differently to the same remediation strategy. As such, we cannot extrapolate the same outcome from one system to another. The scope of our proposed work

will include ecological forecasting, nearshore transport of nutrients and harmful algal blooms, with the ultimate goal of developing predictive tools to assist managers and public health officials in their decision-making.

How will the work be accomplished?

- What are key processes necessary to accomplish the work?
  Please see 2014 GLRI statement of work for these details
- What are key resources necessary to accomplish the work?
  - Vessels – 41' Huron Explorer for Lake Erie (Work days 24; Weather day allowance 24 = 48 total days). 26' small boat for Saginaw Bay (Work days 12; Weather day allowance 12 = 24 total days). We will also need captains for these dates as well.
  - IT resources required (new computers, high performance computing time, data storage, specialized computer hardware or software)

  Please see 2014 GLRI statement of work for these details
  - Editorial, media, graphics, web services, public relations support required

  Please see 2014 GLRI statement of work for these details
- Identify health and safety issues associated with performing the work (extreme weather, pathogens, rigging, etc.)

Please see 2014 GLRI statement of work for these details

- How will samples and data be generated and managed?

Please see 2014 GLRI statement of work for these details

Budget Explanation

Budget Summary - HABs	
Item	***Total ($)***
Admin Travel *(e.g. Advisory Board meetings)*	$1,000
Total Amount	$1,000
Staffing and Ship Time	
Federal Staff	FTE 0.45
Contract and CILER Staff	FTE 1.85
Total Staff	**FTE 2.3**
Total Ship Time Days	**72 (24 small boat; 48 Storm or 41')**

Integration

This work integrates with the GLRI-funded SOAR project and the modeling efforts as it provides the ground-truth data for these efforts.

IPEMF EX 3 Sea Ice - NASA/UNIV OF WISCONSIN
(Jia Wang)

Executive Summary

NOAA (Wang) and UMich (Hu) budget will support a synthesis study using our ice-ocean-ecosystem model and in situ and satellite measurements for the period of 2009-2013. Wang and Hu will refine and run the model, and investigate the impacts of the ecosystem behavior during both positive and negative phases (years) of the Arctic Dipole Anomaly (DA). Record low Arctic summer sea ice in 2012 is a test bed to study the response of ecosystem to the extreme +DA event. We will choose an –DA year (2009) to investigate an opposite scenario. We also investigate, using our model, the nutrient transport from the Bering Sea to the Chukchi Sea during these +DA and –DA years and differentiate the responses to +DA and –DA forcing using data from our NASA-project PIs and NOAA RUSALCA data. Wang and Hu will work with this team on a synthesis study and submit a manuscript to a refereed journal.

Budget

Two months of salary for Haoguo Hu to further run/ process model output and measurements for publication (include fringe benefits and 26% overhead)	$26,000
Travel expenses for a scientific meeting and a PI meeting (Wang and Hu)	$ 4,000
Total:	**$30,000**

Annual Report:

Work accomplished during June 2010-May 2013:

1) Established an ice-ocean-ecosystem model in the Bering-Chukchi-Beaufort seas and ran the model for the field study years 2007-2013, and validated the model using both satellite and in situ measurements.
2) Published a paper in JGR-Oceans for the 2007-2008 period.
3) We are working on another paper on the field survey years (2009-2011) using both NASA satellite data and our field measurements conducted by our PIs on this project.
4) Processed and analyzed the field measurement data provided not only by our NASA-project PIs, but also by Wang's NOAA-project PIs, and analyzed the satellite-measured chlorophyll concentration
5) Refined the ecosystem model by adding tides and investigate nutrient transport into the Chukchi Sea from the Bering Sea.

Publications supported in part by NASA project:

Wang, J., X. Bai, D. Wang, D.R. Wang, H. Hu, and X. Yang, 2012. Impacts of the Siberian High and Arctic Oscillation on the East Asia winter monsoon: Driving downwelling in the western Bering Sea. *Aquatic Ecosystems Health and Management, 15, 20-30.*

Wang, J., H. Hu, J. Goes, J. Miksis-Olds, C. Mouw, E. D'Sa, H. Gomes, D.R. Wang, K. Mizobata, S. Saitoh[9], and L. Luo, 2012. Modeling seasonal variations of sea ice and Plankton in the Bering and Chukchi Seas during 2007-2008. *J. Geophys. Res., 118, doi:10.1029/2012JC008322*

Deal, C.J. N. Steiner, J. Christian, J. Clement Kinney, K. Denman, S. Elliott, G. Gibson, M. Jin, D. Lavoie, S. Lee, W. Lee, W. Maslowski, **J. Wang**, and E. Watanabe, 2013, Progress and Challenges in Biogeochemical Modeling of the Pacific Arctic Region. In: The Pacific Arctic Region: Ecosystem Status and Trends in a Rapidly Changing Environment, Co-Editors Grebmeier, J.M. and W. Maslowski, Springer Publishing, (in press)

Wang, J., H. Eicken, Y. Yu, X. Bai, J. Zhang, H. Hu, D.-R. Wang, M. Ikeda, K. Mizobata, and J. Overland, 2013. Abrupt Arctic Changes and Emerging Ice-Ocean Processes in the Pacific Arctic Region and Bering Sea, In: The Pacific Arctic Region: Ecosystem Status and Trends in a Rapidly Changing Environment, Co-Editors Grebmeier, J.M. and W. Maslowski, Springer Publishing (in press)

IPEMF EX 4 Ice -Ocean-Ecosystem Modeling in the Arctic NOAA/CPO
(Jia Wang)

Co-PIs: Haoguo Hu, Xuezhi Bai, and Ayumi Fujisaki-Manome, Cooperative Institute for Limnology and Ecosystems Research (CILER), University of Michigan, Ann Arbor, MI

Executive Summary

Modeling sea ice-ocean-ecosystem responses to climate changes in the Arctic Ocean and East Siberian Sea using CIOM/PhEcoM with data assimilation from RUSALCA measurements

Focus Area: Arctic Research Program for 2015-2020: Pacific Arctic Observations and Modeling of the Causes and Consequences of Sea Ice Loss—Develop model-based data assimilation capabilities to improve model that addresses Pacific Arctic sea ice loss on the Pacific Arctic Ocean and its ecosystem

This proposed study is to implement the GLERL Coupled Ice-Ocean Model (CIOM) to the entire Arctic Ocean with variable Cartesian grids ranging from 4 km in the East Siberian Sea to 12 km elsewhere in the Arctic Ocean. The Arctic-CIOM will be run from 2000-2020 to investigate the mechanisms of why and how summer sea ice melts at the fastest rate in the Pacific Arctic (hot spot). We propose to implement the (3DVar) data assimilation approach based on PROFS to cover the East Siberian Sea (ESS) and Chukchi Sea. That will allow assimilations of existing and on-going hydrographic data and moorings from the Bering Strait onward. Importantly, PROFS' Lagrangian assimilation scheme will also assimilate the Argo data and IABP (International Arctic Buoy Program ice drifter data. Particularly the developed PROFS approach will allow CIOM to assimilate hydrographic data measured during the period (2015-2020) when the RUSALCA's moorings will be deployed. Then, a series of sensitivity simulations with CIOM combined with PROFS will be conducted to examine both positive and negative phases of AO (Arctic Oscillation) and DA (Dipole Anomaly) to identify the mechanisms responsible for accelerating loss of summer sea ice including landfast ice (hypotheses 1 and 2). In particular, the DA's impact on water temperature structure including mixing between the Pacific Water and Atlantic Water, and sea ice retreat including landfast ice in the ESS. In return, the modeling results will be discussed with those PIs with RUSALCA field observation projects and an optimal sampling strategy will be designed for a better coverage.

A 3-D, 9-compartment, Physical-Ecosystem Model (PhEcoM), coupled to CIOM, will be used to study the ice-ocean-ecosystem dynamics in the same region. The data from RUSALCA nutrient and plankton moorings will be used for conducting independent data analysis to also validate this model, and for assimilation by PROFS. This model runs from 2000-2020 will be used to test our proposed hypotheses 3 (there are three possible types of blooms and impacts of tidal and wave mixing on plankton blooms) and 4 (DA promotes plankton blooms in the Pacific Arctic).

Budget Summary	
Item	***Total ($)***
Equipment	-
Supplies	-
Field Travel *(field work)*	
Science Conference Travel *(conferences e.g. AMS, IAGLR, AGU)*	
Science Meeting Travel *(e.g. working groups, PI meetings)*	-
Admin Travel *(e.g. Advisory Board meetings)*	$10,000
*** International travel*	--
Contracts/CILER	$140,000
Other (specify)	
Total Amount	$150,000
Staffing and Ship Time	
Federal Staff	0.0 FTE
Contract and CILER Staff	0.0 FTE
Total Staff	**0.0 FTE**
Total Ship Time Days	**0**

IPEMF EX 5 Great Lakes Runoff Intercomparison Project (GRIP) – Phase II, Lake Ontario - IJC
(Drew Gronewold)

Great Lakes Environmental Research Laboratory and NOAA-NWS River Forecasting Centers (in partnership with Environment Canada)

Executive Summary

This statement of work (SOW) outlines services to be provided by the National Oceanic and Atmospheric Administration (NOAA), through its Great Lakes Environmental Research Laboratory (GLERL) and National Weather Service (NWS) River Forecasting Centers (RFCs), in support of the second phase of the international Great Lakes Runoff Intercomparison Project (GRIP). This second project phase (GRIP-O) will leverage previous federal agency investments made in FY2013 during the first phase of GRIP (GRIP-M), which focused on Lake Michigan, in order to assess and compare different experimental and operational models for forecasting runoff into Lake Ontario. Importantly, this project will also leverage a strong partnership between regional international federal agencies, with Environment Canada and NOAA-GLERL serving as lead agencies.

We therefore propose that funding for United States agency engagement in this project be routed through NOAA-GLERL to support time and travel expenses for NOAA regional staff, including modelers from NOAA-GLERL and regional NOAA RFCs. These two groups are responsible for continued maintenance and application of the large basin runoff model (LBRM) and the NWS rainfall-runoff model, both of which were employed in the GRIP-M study, and both of which will be applied in GRIP-O. A significant portion of the effort involved in GRIP-O, however, will be propagating recent investments in newly-harmonized regional geospatial frameworks into these existing modeling frameworks to facilitate model comparison and, if the results of our study suggest it would be beneficial to do so, into ensemble forecasting.

We anticipate traveling to two meetings over the course of the project. Initially, we intend to host a project kick-off meeting in Ann Arbor, Michigan, with representatives from EC, USACE, NOAA regional RFCs, and USGS. We then, near the mid-point of the project (May 2014) plan to hold a second meeting in Canada. The following table summarizes the services NOAA anticipates providing under this SOW and the associated cost of each:

Budget includes: GIS/modeling post-doctorate fellow (at least 2 months), Modeling/programming support staff (at least 4 months);Travel for regional NOAA staff (5) to Ann Arbor, MI ; Travel for regional NOAA staff (2) to Canada

Budget Summary	
Item	***Total ($)***
Science Meeting Travel *(e.g. working groups, PI meetings)*	$ 6,000
*** International travel to Canada*	--
Contracts/CILER	$40,000
Other (specify)	
Total Amount	$46,000

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IPEMF EX 6 Incorporating climate expertise in seasonal water level forecasts - UCAR / ASACE
(Drew Gronewold)

Executive Summary
Post-doc research on incorporating teleconnections in water level forecasts.

JOINT STATEMENT OF INTENT

Postdocs Applying Climate Expertise Fellowship (PACE) Program

NOAA, Great Lakes Environmental Research Laboratory (Climate-Science institution) and United States Army Corps of Engineers, Detroit District (Decision-Making institution)

Description of Partners

The proposed project leverages an existing research-to-operations collaboration between scientists and engineers at the National Oceanic and Atmospheric Administration Great Lakes Environmental Research Laboratory (NOAA-GLERL) and the Detroit District of the United States Army Corps of Engineers (USACE). These agencies, along with the University of Michigan (UM) and other regional academic institutions, develop and assess regional climate information and propagate that information into water budget projections that guide critical water level regulation, hydropower capacity planning, and commercial shipping (among other) decisions on the North American Great Lakes; the largest collection of fresh surface water on Earth (Gronewold et al., 2013). NOAA-GLERL (the official Climate-Science, or CS institution for this project) and UM, both located in Ann Arbor, Michigan, conduct climate science and climate prediction research with a network of partners that includes the UM-based Great Lakes Integrated Sciences and Assessments (GLISA) Center and the Cooperative Institute for Limnology and Ecosystems Research (CILER). Specifically, NOAA-GLERL leads innovative research projects focused not only on understanding relationships between regional climate change, hydrologic response, and water resources management, but on applying that understanding to advance the state-of-the-art in regional decision-support tools (Gronewold et al., 2011; Gronewold and Fortin, 2012; Lofgren et al., 2013). The Detroit District of the USACE, the official Decision Making (DM) partner for this project, employs climate research (from NOAA, UM, and other regional partners) in operational forecasts of Great Lakes regional water budgets and water levels in order to implement plans for dredging operations, adjusting outflows (both Lakes Superior and Ontario are regulated), and distributing official water level information used by other regional decision makers. USACE's management actions are strongly influenced by changes in climate conditions across seasonal, interannual, and decadal time scales (Quinn and Sellinger, 2006; Gronewold and Stow, 2014) and, perhaps more importantly, on the extent to which climate projections and historical climate data appropriately differentiate associated sources of variability and uncertainty.

Description of Problems and Decisions

In January 2013, water levels on Lakes Michigan and Huron dropped to their lowest levels in recorded history exacerbating management problems ranging from increased dredging requirements (to restore navigability of shipping channels) to reduced capacity of hydropower facilities. The current low water

level conditions on these two lakes and on Lake Superior (which hit a record low in 2007) are a consequence of both long-term (Austin and 1 of 3 Colman, 2007) and relatively abrupt (Assel, 1998) changes in the regional climate, and have catalyzed demands for improving Great Lakes regional climate projections and propagating those improvements into operational water level forecasts and forecast-based decisions

Unlike most other large freshwater systems on Earth, the water budget of the North American Great Lakes is strongly influenced by the difference between over-lake evaporation and over-lake precipitation (both of which, due to the massive surface area of the lakes themselves, are of the same order of magnitude with one another and with terrestrial runoff). While recent advances have been made in improving data and projections of Great Lakes over-lake fluxes, they continue to represent a considerable source of variability in short- and long-term projections and uncertainty in water resource management planning. To address these gaps in regional climate research and climate-based decision making, we intend to initiate and support a research partnership with a PACE postdoctoral fellow in order to develop new and improved projections of the Great Lakes regional water budget and, perhaps more importantly, to incorporate those improvements into routine decision-making protocols.

Mentoring Roles and Responsibilities

The primary mentors for this project are Dr. Andrew Gronewold and Mr. Keith Kompoltowicz.. We anticipate that the selected postdoctoral fellow will also collaborate with Drs. Brent Lofgren and Jia Wang (both climatologists at NOAA-GLERL) as well as 2 of 3 Dr. James Lewis and Mr. John Allis (both of USACE, Detroit District).

Matching Funds

The USACE has allocated one full year of funding for the proposed postdoctoral fellowship (roughly $80k), and both NOAA-GLERL and the USACE Detroit District agree to provide computing facilities, administrative support, and office space for the selected fellow. In particular, we anticipate the selected fellow will be based at NOAA-GLERL three to four days per week, and at the USACE offices in Detroit for one to two days per week. For additional information on matching funds, please contact either Ms. Rita Williams (rita.williams@noaa.gov) or Dr. James Lewis (James.W.Lewis@usace.army.mil).

Budget Summary	
Item	***Total ($)***
Contracts/CILER *Post-Doctoral work from June FY14 to Early FY16*	$200,000
Total Amount	$200,000

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IPEMF EX 7 Assessing long-term climate projections and impacts on water levels USACE
(Drew Gronewold)

Executive Summary
(Note: Also referred to as NOAA GLERL MIPR – Great Lakes Coastal Climate Change Guidance)
Background
The US Army Corps of Engineers recently completed guidance for a qualitative process for incorporating climate change impacts into project planning and design considerations. The Corps is now working to create guidance for a quantitative approach for addressing climate change impacts in the planning and design process. A quantitative approach has been developed for coastal impacts to projects along the ocean coasts; however similar guidance has not yet been developed for coastal Great Lakes projects. The end result of this project will be to develop similar guidance specifically for coastal Great Lakes projects. While science suggests a rise in sea level, the climate change impacts on the Great Lakes are less understood. During the development of this guidance it will be important to not only consider the range of the projected conditions but also consider the projected frequency and duration. For example, although climate researchers may project both above and below average water levels in the future, engineers will need to consider impacts to their projects of more frequent extreme high and low levels. In addition to water levels, other hydro meteorological variables shall be considered to include water temperature, ice cover, and storm frequency.

Scope
The Corps requests the support of NOAA's Great Lakes Environmental Laboratory (GLERL) to develop estimates for hydro climatic variables based on forecasted climate change scenarios. GLERL will develop the expected range of climate projections for the 50yr, 100yr, and 150yr planning horizons for the Great Lakes region. GLERL will then provide the Corps with the projected range of hydro climatic variables resulting from those climate projections. At a minimum these variables will include:

- Lake wide average water levels
- Water temperature
- Ice cover

Deliverables
GLERL shall provide electronic copies of hydro climate data sets developed along with a final report summarizing the methodology of how the data was developed.

Schedule
GLERL staff shall attend regular team meetings starting in September 2014. Data sets shall be finalized by 1 – January 2015, with the final report due 1-June 2015.

Budget Summary	
Item	***Total ($)***
Contracts/CILER	$17,500
Other (Salary Offset)	$ 7,500
Total Amount	$25,000

IPEMF EX 8 Great Lakes evaporation monitoring - NOAA Coastal Storms Program UCAR / ASACE
(Drew Gronewold)

Executive Summary
(Note: Also referred to as: Over-water meteorological and hydrological measurements to improve operational forecasts of evaporation, water temperature, and water levels)

Overview and Activities
Over-lake meteorological and hydrological phenomena across the Great Lakes have a profound, but often overlooked, impact on both off-shore and near-shore human and ecosystem health. Unfortunately, there is currently limited long-term, operational, year-round monitoring infrastructure dedicated to understanding off-shore processes such as over-lake evaporation, wind and wave propagation, and changes in lake heat content, all of which vary dramatically in the Great Lakes over time scales ranging from hours and days to seasons and decades (Gronewold & Stow, 2014). One of the only readily-available set of long-term off-shore measurements on the Great Lakes, for example, is provided by NDBC buoys, however there are only 2 or 3 of these per lake, and each is only deployed between May and November each year. Consequently, these buoys (and other experimental buoys throughout the Great lakes) do not capture critical measurements during the late fall, early winter, and mid-winter months; a period over which the lakes experience dramatic changes in evaporation rates, ice cover, snow accumulation (and distribution), and temperature (Spence C. , Blanken, Lenters, & Hedstrom, 2013). Furthermore, the NDBC operational buoys (along with other experimental buoys) are equipped with relatively conventional sensors that do not reflect the state-of-the art in off-shore monitoring technology, nor do they provide the full suite of measurements that can be leveraged in NOAA's state-of-the art operational forecasting models. Year-round operational off-shore monitoring platforms with updated instrumentation are therefore needed to address gaps not only in understanding of Great Lakes physical processes, but in NOAA's regional operational hydrological, climatological, and ecosystem forecasting portfolios as well.

Our project will fill these gaps through a two-phased approach. First, we will deploy, and manage data from, novel vessel- and buoy-based sensors that leverage recent investments in similar technology to improve understanding of over-water meteorology, evaporation, and water temperature in the Great Lakes (Laird & Kristovich, 2002; Fairall, Bradley, Hare, Grachev, & Edson, 2003). The deployment of vessel-based sensors, for example, will leverage a recently-initiated collaboration between NOAA-GLERL, NOAA-ESRL, and UC- Boulder (through CIRES) that brings NOAA's state-of-the-art arctic research technology, for the first time ever, to the Great Lakes. Testing of vessel-based sensors dedicated for the Great Lakes (see Figure 1) has already been initiated through in-kind contributions from

NOAA-ESRL and UC-Boulder (CIRES). The first phase of our project therefore represents not only a transfer of technology across geographical regions, but across the various line offices and academic partners of NOAA as well.

In addition to the vessel-based sensors, we will also add sensors to existing NOAA-GLERL buoys to create a fully integrated instrument cluster, capable of providing direct over-lake fluxes and energy balance estimates. This effort leverages a small amount of funding recently provided by the University of Michigan, as well as ongoing long-term research by NOAA-GLERL through the RECON program.

In conjunction with the field campaign, the second phase of our project will be dedicated to data analysis, system validation, and model assimilation. The data collected through this project, coupled with the project team's connections to existing regional dissemination platforms (such as GLOS, NOAA's Great Lakes CoastWatch program, and others) will allow both the general public and regional agencies to view, understand, and utilize data this new suite of unprecedented over-lake data and products.

Budget Summary	
Item	***Total ($)***
Contracts/CILER	$140,000
Total Amount	$140,000

Any documented support for the demand/need of the project by partners and constituents and how it will fill an identified gap in local and regional capacity: The North American Great Lakes constitute the largest surface of fresh water on the planet. With a drainage basin of nearly 800,000 square kilometers, no other large basin has a comparable land-to-water surface area ratio (Gronewold, et al., 2013). Recent record-setting changes in lake water levels and ice cover (Clites, et al., 2014) have significantly (and, at times, adversely) impacted recreational and shipping activities, and underscore an urgent need to improve understanding of the Great Lakes water budget, heat content, and water temperatures, particularly as climate conditions change unexpectedly and over different time scales. It is well understood that components of the water budget (i.e. over-lake evaporation, over-lake precipitation, and runoff) translate directly into changes in water levels (Angel & Kunkel, 2010) and ecosystem health (Wilcox, et al., 2002), while directly impacting commercial (Millerd, 2005) and industrial sectors (Hartmann, 1990). It is imperative, then, that NOAA's regional research and operational activities focus on explicitly understanding and quantifying changes over the vast surfaces of the lakes, and how those changes propagate into regional near-shore changes in lake water levels, surface water temperatures, ice cover, and other climate variables (Austin & Colman, 2007).

Figure 1 - Testing of new equipment during summer 2014 at Boulder Atmospheric Observatory. P-3 in background is providing data verification. If this proposal is successful, funding would be used to transfer this technology (currently employed by NOAA in arctic research missions) to Great Lakes in fall 2015

Present data sources do not offer enough information to address this scientific knowledge gap, and it has been demonstrated that conventional methods to estimate over-water conditions are not sufficient to accurately understand and predict these processes as certain regions of the lakes

are extremely sensitive to perturbations in over-water conditions. Our understanding of Great Lakes evaporation dynamics and meteorological conditions over the past 60 years, for example, is based almost entirely on extrapolating data from near-shore land-based meteorological stations.

Monitoring the Great Lakes water budget and forecasting hydrodynamic conditions are explicit NOAA missions in the region, but we currently do not have adequate infrastructure for addressing over-lake conditions. There have been persistent calls to urgently improve measurements of over-lake evaporation (Gronewold and Stow 2014). To that end, a cross- sector, international group has recently formed the Great Lakes Evaporation Network (GLEN). This group is actively working to develop novel measurement technologies, but resources are still needed to facilitate the transition of these technologies to long-term deployments.

The following is a summary of recent synthesis reports (in additional to those listed at the end of this proposal) and planning documents that each underscore a clear need for continued investments in off-shore Great Lakes monitoring to improve understanding of over-lake meteorological and climatological processes:

- **IJC International Upper Great Lakes Study (Lake Superior Regulation)** - see final recommendations related to hydroclimate processes and adaptive management
- GLISA report "Great Lakes Evaporation: Implications for water levels"
- **Great Lakes Evaporation Network (GLEN) Business Case** – prepared by the GLEN steering committee for consideration among the US and Canadian federal governments
- Congressional mandates of NOAA's Great Lakes Research Activities

Where in the region will this project apply? Is it possible to expand these activities more broadly or in other regions where CSP is working/has worked? Explain: This project is applicable throughout the entire Great lakes region, and can be aligned with most existing or future planned CSP projects. In FY15, the proposed vessel-based measurements will likely transit Lakes Superior and Michigan, while the buoy-based sensors will be deployed on Lakes Michigan, Huron, and Erie.

Description of projected activities and milestones by quarter in FY15:

FY15, Q1-Q2: We will purchase new energy balance instruments (see figure 2), leveraging the existing network of NOAA-GLERL RECON buoys and the energy balance instrumentation purchased in FY14 through funding from the University of Michigan. Each buoy will be equipped with a radiometer, a thermistor chain for measuring lake temperature at various depths, air temperature meter, a thermocouple for surface temperature, an anemometer, and a hygrometer. GLERL RECON buoys measure air temperature, surface temperature, lake temperature, and wind speed. Therefore, the only additional measurements necessary will be net radiation and relative humidity. We have already selected and validated two candidate sensors: The Huxleflux net radiometer and the Vaisala Relative humidity probe. The cost of retrofitting each buoy is approximately $10,000.

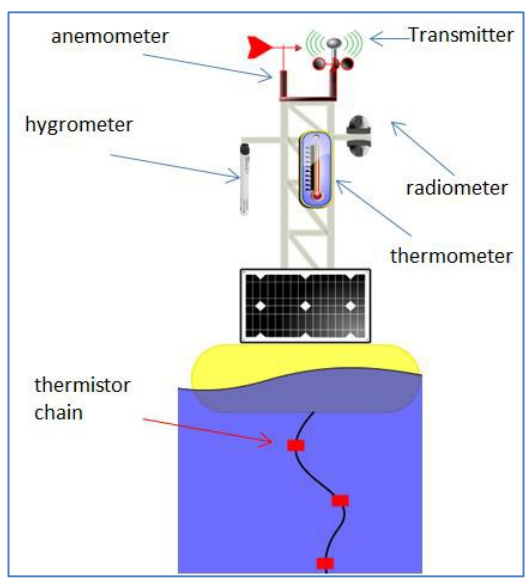

Figure 2 - Schematic representation of buoy-based instrumentation, similar to what was tested on Lake Erie in summer and fall 2014

FY15, Q3: We will deploy the buoy- and vessel- mounted sensors.**FY15, Q4 and FY16, Q1-Q2:** We will initiate the second phase of the project, in which we focus on aggregating the data from the prototype buoys and vessels and integrate the measurements into formal data distribution products. One particular example of activities during this phase is the development of new evaporation estimates through a real-time solution of the air-lake energy balance.

FY16, Q3-Q4: Continue deployments through summer 2016. Location dependent on knowledge gained in FY15 and coordination with existing CSP and NOAA efforts. GLERL will provide initial support for deployment and maintenance, as well as in initial out years, with the plan to transfer components to an operational outlet (e.g. NDBC). In addition, data from the buoy and vessel-based sensors will be incorporated into current operational models (such as the Great Lakes operational forecasting system and the Advanced Hydrologic Prediction System).

Target Audience and Partnerships

Potential Users and Audience: *Who is the intended user of the project (internal and/or external) and what additional audiences (if any) may be interested in the project?* Users include CO-OPS, NWS, GLERL, OCS, USACE, and academic scientists involved in forecasting hydrologic and hydrodynamic conditions in the Great Lakes. This includes parties involved in fundamental research (e.g. academia), applied research (e.g. GLERL), and operations (e.g. CO-OPS, NWS, USACE).

Benefit to Users: As described above, the proposed data will be pivotal to informing a broad spectrum of stakeholders. Specifically, the data will have significant benefits to NOAA operational modeling (CO-OPS, OCS, GLERL), and regional scientists who presently have very limited data on over-lake evaporation and meteorological conditions. Continued analysis of this data will improve our understanding of the Great Lakes hydrologic and hydrodynamic processes, thus enabling the future sustainable use of regional water resources and providing ecological forecasts for the Great Lakes.

Other partners that will coordinate and/or have a role in the project: This project is a direct collaboration between multiple branches of NOAA (including NOAA-ESRL, NDBC), multiple cooperative institutes (CILER at University of Michigan, and CIRES and UC- Boulder), GLOS, LimnoTech, Inc., Northern Michigan University, and the University of Toledo.

Integration/coordination with other CSP projects or other NOAA programs: The data and forecast dissemination phases of this project will be integrated with similar activities within IOOS/GLOS, NOS, and NDBC. We plan to continue aligning our work with existing and future CSP projects.

How will the project team work with intergovernmental or regional governance/collaboration groups in the region? Direct interaction with governmental and international groups is already underway as part of our work with the Great Lakes Evaporation Network (GLEN), which includes representatives from federal agencies, academia, and the private sector on both sides of the international border. The data and forecasting products resulting from this project will also be shared directly with the broader public.

Resources and Timeline

Anticipated FY Allocation	FY15	FY16	Out years
Sensor deployment	$55k	$25k	Transfer to operations
Data management, analysis, application	$80k	$80k	Transfer to operations
Travel	$10k	$5k	
TOTAL CSP FUNDING REQUESTED	**$145k**	**$110k**	
Summary of leveraged resources			
- *NOAA-ESRL staff time*	*$70k*	*$70k*	
- *NOAA-ESRL ship time*	*$200k*	*$200k*	
- *NOAA-GLERL staff time*	*$50k*	*$50k*	
- *Lighthouse-based measurements*	*$400k*	*$400k*	
- *Commercial vessel time*	-	-	*[No basis for cost of this in-kind*
- *UCAR post-doc*	*$100k*	*$100k*	
- *Vessel-based flux system*	*$120k*	*$120k*	
- *Environment Canada flux buoy*	*$100k*	*$100k*	
- *Existing operational models*	-	-	*[No basis for cost of this in-kind*
TOTAL FUNDING LEVERAGED	***>$1,000k***	***>$1,000k***	

What is the project completion date? We will complete the deployment of the proposed sensors by mid-summer 2015 (and 2016 with proposed funds). Data analysis will occur following the 2015 deployment and continue into FY16 (completion by Q3).

Will this project require Operations and Maintenance after the project has finished? If so, please discuss plans for transitioning O&M in the out years. The buoys are currently maintained and deployed by NOAA-GLERL as part of its base operations. The additional sensors will not create any additional maintenance work since they are entirely analog and integrate readily into NOAA-GLERL's existing platform. GLERL will provide out-year O&M as needed as part of this routine buoy deployment, with the effort to transfer necessary observation platforms for operational modeling to a proper operational outlet (e.g. NDBC, etc.).

Would this project leverage other NOAA and/or non-NOAA resources? Please describe and if possible give estimated monetary amounts. Yes: this project would leverage decades of research invested in existing water temperature forecasting models (including both the Advanced Hydrologic Prediction System and the Great Lakes Coastal Forecasting System). Both models could be significantly improved through more robust measurement-based calibration and verification, as well as comparison with newer models. Furthermore, the project will leverage existing instrumentation already deployed on the lakes. This project also leverages investments in NOAA's arctic research program, run through NOAA-ESRL, by transferring its vessel-based technologies and modeling platforms to the Great Lakes.

What is the scalability of this project? (e.g., what could you do at Pres Bud level, vs lower levels of funding): The project consists of instrument deployment and data analysis phases. Priority has been set on the purchase and deployment of instruments and therefore the project can be scaled to the deployment phase only and ensure the necessary measurements are carried out.

Is this project timeline sensitive or can it be funded in alternative budget cycles (FY 15 - 16)? Briefly Explain. Given the timing of other Great Lakes Coastal Storms Program work (particularly that led by Dr. van der Westhuysen) and the ongoing development of the Great Lakes Operational Forecasting System scheduled to be complete by FY17 (with OAR/GLERL, NOS/OCS, NOS/CO-OPS), it would be extremely beneficial and timely to implement our proposed project in FY15 such that instrument deployment can benefit these programs. Furthermore, in order to fully leverage ongoing activities related to monitoring Great Lakes evaporation (such as the testing of new vessel-based equipment, as shown in Figure 1), it would be ideal if this project were funded in the current funding cycle.

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IPEMF EX 9 A high-resolution wave and circulation model guidance system for the Great Lakes region - Coastal Storms NOAA
(Eric Anderson)

Project Manager: Andre van der Westhuysen NWS/NCEP/EMC/MMAB
Team members: Eric Anderson, Ayumi Fujisaki (NOAA/OAR/GLERL), Greg Mann (NOAA/NWS/WFO Detroit), John Kely, Edward Myers (NOAA/NOS/CSDL/MMAP), Henrique Alves (NOAA/NWS/NCEP).

Executive Summary
Focus Area 2: Observations, Modeling and Forecasting

Project Description
Background
The geographic uniqueness of the Great Lakes present myriad challenges to operational atmospheric and hydrodynamic forecasts. The intra-continental location of the Great Lakes at mid-latitudes subjects the region to nearly all varieties of meteorological forcing, from mid-latitude cyclones to arctic air mas intrusions to organized intense convective systems. Furthermore, the Great Lakes physical size and proximity to one another forces significant regional modification of atmospheric conditions and the resultant climate. Many times, the regionally-driven atmospheric responses are high amplitude and induce significant hydrodynamic events in the form of extreme wave formation and detrimental water level displacements, posing threats to safe navigation or coastal flooding and inundation. Furthermore, the large bodies of water possess complex shoreline and bathymetric structure facilitating a non-uniform response to imposed atmospheric forcing. This non- uniformity complicates the ability of operational forecasters to perform a comprehensive vulnerability assessment, which is required for effective hazard communication.

At present, wave model guidance is provided to the Great Lakes region by the NWS WAVEWATCH II (WW3) model that is run by NCEP Central Operations (NCO), using NWS North American Mesoscale (NAM) Model or NWS National Digital Forecast Database (NDFD) forecaster-prepared wind fields as input. These forecast wind fields are based on the combinations of model solutions from various national centers. Most of these are run at grid spacing greater than 12 km, with the exception of the new 4 km NAM model. The WW3 model, in turn, is run on a regular grid at a resolution of approximately 4 km.

Water level and three-dimensional water currents and water temperature forecast guidance for the Great Lakes is provided four times a day out of 30 hours by the NOS Great Lakes2 Operational Forecast System (GLOFS). GLOFS is managed by NOS's Center for Operational Oceanographic Products and Services (CO-OPS) and Coastal Survey Development Lab (CSDL), is run by NCEP/NCO, and is monitored by NCEP/NCO and NOS/CO-OPS. GLOFS nowcast cycle uses surface analyses of overland and overwater observations of meteorological variables, and its forecast cycles use surface wind and air temperature forecasts from NDFD or forecast guidance from the NAM model. GLOFS uses the Princeton Ocean Model as its core ocean model and is run on regular grids at a resolution of 5 km for Erie, Michigan, Ontario, and Huron and 10 km for Superior with 20 vertical layers. GLOFS does not presently incorporate heat flux forecasts in its forecast cycle and also does not include the effects of ice. In the longer term, GLERL is applying and testing FVCOM, an unstructured grid hydrodynamic forecast modeling system, to the Great Lakes. NOS, in collaboration with GLERL, plans to upgrade GLOFS to use FVCOM and implement it into operations on the NOAA WCOS in FY15. NOS has gained significant experience with FVCOM during NOS/CSDL application of FVCOM in its Northern Gulf of Mexico Operational Forecast System.

Problem statement

Experience has afforded insight to key problem areas across the basin. Many of these challenges are related to the complicated atmospheric conditions of the coastal zone in conjunction with the irregular physical characteristics of the shoreline and bathymetry. Of particular interest are phenomena in the shallow regions of the open waters (e.g., western Lake Erie, west arms of Lake Superior, Lake St. Clair basin) and in the transition zones in and near larger bays (e.g., Saginaw Bay, Green Bay, Grand Traverse Bay). These areas are also strategic to regional commerce: including commercial shipping routes and ports; and many are popular recreational destinations. Furthermore, the Great Lakes region currently has no model guidance capacity regarding the combined wind and wave-induced coastal surge events, including meteotsunamis/seiches. This is an important omission, since waves can significantly impact surge levels, and conversely currents can steepen waves, causing dangerous nearshore conditions

Project aim

The overall aim of this 3-year project is to address the challenges described above by developing a combined circulation, ice and wave model, run on an unstructured grid. For evaluation purposes, it will be forced by a high-resolution atmospheric model. Unstructured grid models provide a means to efficiently resolve wave and circulation processes over varying spatial scales. Using this approach, the high-risk coastal areas discussed above can be seamlessly incorporated into the model setup for the deeper water areas. This work represents the next generation in operational wave and circulation modeling in the Great Lakes, and will extend the NWS and NOS's present forecast capability to high-risk, flood-prone areas in the nearshore.

FY15 Activities

The goal of this proposed second project year is to couple the unstructured grid WAVEWATCH II model developed at NCEP with the FVCOM-based unstructured grid circulation model developed at GLERL, investigate the impact of using various physics parameterizations, and evaluate its performance for potential operational implementation at NCEP. As part of these evaluation activities, the feasibility of simulating meteotsunami/seiche events with the developed system will also be assessed.

Any documented support (i.e. need assessments, meting minutes, regulatory requirements, etc.) for the demand/need of the project by partners and constituents and how it will fil an identified gap in local and regional capacity. The need for improved guidance from NOAA related to beach hazards and water safety was outlined in a resolution signed by the Council of Great Lakes Governors on June 1, 2013 (htp:/www.cglg.org/media/1450/beach-hazards-and-water-safety-resolution-6-1- 13.pdf). In this resolution, the Governors of the Great Lakes States and the Premiers of Ontario and Quebec called for "enhanced research and better near-shore wave models through the National Oceanic and Atmospheric Administration (NOAA) and Sea Grant to better understand conditions that are conducive to dangerous currents, and how and when they appear." Furthermore, they "encourage improved dangerous current forecasting by the NOAA National Weather Service." This project directly supports these requests by developing improved atmospheric, wave, and circulation models through improvements in model spatial resolution and coupling. Through these improvements, we hope to increase model accuracy and provide forecast guidance at finer scales (e.g. local) near identified high-risk areas.

Where in the region will this project apply? Is it possible to expand these activities more broadly or in other regions where CSP is working/has worked? Explain. The application area of this project is the entire Great Lakes region. However, in future such a system could be applied to other regions where NOAA currently has operational wave and/or water quality models. This includes al NOS OFS systems in the major U.S. estuaries, such as in the Mid-Atlantic.

Provide a short description of projected activities and milestones by quarter in FY15:

FYQ1: The WAVEWATCH II (WW3) wave modeling component will be integrated into the FVCOM-based circulation modeling system for the Great Lakes currently being developed at GLERL. In this first quarter, the coupling will be implemented one-way, such that the WW3 wave model uses current and water level fields from the stand-alone FVCOM circulation model. For evaluation purposes, both models are to be forced by predictions from a high-resolution Weather Research and Forecasting (WRF) model. In this way, the effects of modeled storm surges on nearshore wave model results, and the effect of currents in narrow passages on waves (e.g. Straits of Mackinac) can be investigated.

FY15Q2: Continue the integration of the above-mentioned components by developing a two-way coupling of the wave and circulation models (full information exchange between wave and circulation models). This will allow inclusion of processes such as wind- and wave-induced setup to the coastal surge levels, and the influence of currents on the nearshore wave field.

FY15Q3: Once all the relevant wave and circulation processes are included and properly resolved, the parameterization of these processes will need to be validated. Regarding the wave model, this includes processes such as bottom friction, depth-induced breaking and nonlinear three-wave interactions. Parameterizations in the lake circulation model include the surface wind stress, bottom stress and wave stress representations. These processes will be evaluated on the basis of lake observations at present observing sites and also at the high-risk coastal areas. In addition, high-resolution test cases featuring meteotsunami/seiche events will be considered, to evaluate the model skill in representing these.

FY15Q4: Evaluate the results of the model validation conducted above and select a final set of model meshes and physics parameterizations for each of the Lakes. Test/Evaluate the coupled lake wave-circulation system at NOS/CSDL prior to any transfer of the system to NOS/CO-OPS and NCEP/EMC for operational testing on WCOS. NOTE: The actual operational implementation will not be part of the project activities. System implementation is contingent on NOS/CSDL and CO-OPS management agreeing to include it in the 5-yr NOS coastal modeling implementation plan.

Target Audience and Partnerships
Potential Users and Audience: Who is the intended user of the project (internal and/or external) and what additional audiences (if any) may be interested in the project? NWS forecasters in the Great Lakes region; Federal and State Emergency Managers; Recreational groups (e.g. pleasure boating, beachgoers); Marine and coastal industry (e.g. shipping; power stations); NOS HAB forecast operations, Downstream modeling groups (e.g. rip currents).

Benefit to Users: The proposed high-resolution coupled modeling system will extend current NOAA guidance towards the coast, providing wave, surge, circulation and water quality forecast guidance to high-risk coastal regions.

Other partners that will coordinate and/or have a role in the project: David Schwab (University of Michigan); Chin Wu (University of Wisconsin); Meng Xia (University of Maryland).

Integration/coordination with other CSP projects or other NOAA programs: Coordination with NOAA/NOS's Operational Forecast System (OFS) development activities, and NCEP/EMC's Great Lakes wave modeling activities. Coordination with Ohio State University Sea Grant recipient Chin Wu regarding rip current guidance.

How will the project team work with intergovernmental or regional governance/collaboration groups in the region?

Direct interaction with other federal partners, state government, and academic partners occurs through several channels such as the Council of Governments, Council of Great Lakes Governors, State of the Lakes conference, Great Lakes Beach Association, and International Joint Commission Lakewide Management Annex. In addition, as part of ongoing NOAA/NOS OFS development, meetings will be held with key stakeholders and decision makers to aid in defining necessary grid resolution for each lake. Finally, operational implementations that result from this project (e.g. GLOFS, WWII), will provide model output to the broader public.

Resources and Timeline

Anticipated FY Allocation	FY15	FY16	Out years
Total Costs	$350k	$320k	O&M (in kind, from base)
Travel	$7.5k	$7.5k	
Leveraged Resources	NOAA's R&D High Performance Computer Systems (Zeus)	NOAA's R&D High Performance Computer Systems (Zeus)	NOAA's Operational High Performance Computer Systems (WCOSS)

What is the project completion date? FY16Q4, with subsequent implementation dependent on the scheduling and priorities of NOS's 5-yr coastal modeling implementation plan.

Will this project require Operations and Maintenance after the project has finished? If so, please discuss plans for transitioning O&M in the out years. Yes. It is intended that he developed system will be transitioned to NCEP/EMC-NOS/CO- OPS for operations, and hence will form part of the O&M that is already in place for maintaining such systems.

Would this project leverage other NOAA and/or non-NOAA resources? Please describe and if possible give estimated monetary amounts. This work will leverage NOAA's High-Performance Computer Systems, both during the research and development phase (Zeus computer) and the operational phase (WCOS).

What is the scalability of this project? (e.g., what could you do at Pres Bud level, vs lower levels of funding) At lower budget levels, the project could be carried out without the meteo-tsunami component ($50k). At lower levels that this, the modeling system could conceivably be developed for a subset of the Great Lakes only. However, this would severely deteriorate the utility of the intended next-generation forecast guidance.

Is this project timeline sensitive or can it be funded in alternative budget cycles (FY 15 - 16)? Briefly Explain.
Project is timeline sensitive because it is aligned with current operational development work at GLERL (FVCOM system) and NCEP (unstructured WW3)

Observations Systems and Advanced Technology

OSAT EX 1 Great Lakes CoastWatch Operations - NOAA/NESDIS
(George Leshkevich-Lead GLERL PI)

Key External Partners: National CoastWatch Program (NOAA/NESDIS; Songzhi Liu (CILER)

Executive Summary

CoastWatch is a nationwide National Oceanic and Atmospheric Administration (NOAA) program within which the Great Lakes Environmental Research Laboratory (GLERL) functions as the Great Lakes regional node. In this capacity, GLERL obtains, produces, and delivers environmental data and products for near real-time observation of the Great Lakes to support environmental science, ecosystem forecasting, decision making, and supporting research. This is achieved by providing Internet access to near real-time and retrospective satellite observations, derived products, modeled, and in-situ Great Lakes data. The goals and objectives of the CoastWatch Great Lakes Program directly support NOAA's statutory responsibilities in estuarine and marine science living marine resource protection, and ecosystem monitoring and management. Clients include Federal, state, and local agencies, academic institutions, and the public. Data includes a suite of enhanced digital images including satellite-derived surface water temperature (SST), visible and near-infrared reflectance, brightness temperatures, cloud masks, satellite/solar zenith angle data and graphics from the NOAA/AVHRR (Advanced Very High Resolution Radiometer), MetOp A and B, and (soon) NPP VIIRS (National Polar-orbiting Partnership (Suomi) Visible Infrared Imaging Radiometer Suite) series of satellites in HDF format. Products created include a daily, cloud-free composite SST image with NIC ice concentration overlay during winter months (.png, .ascii, KML formats), cloud-masked and land-masked SST images in Geotif format, and 512 x 512 subsets by lake in .png format. In addition, GOES (Geostationary Operational Environmental Satellites) visible, near infrared, water vapor, and SST images of the Great Lakes, MODIS true color 250m resolution imagery of each Great Lake (and synoptic scene), GLCFS modeled products, and in situ data, including marine and meteorological observations, buoy observations, water level gauge measurements from NOAA's National Ocean Service, are routinely acquired or produced, stored, and made available to Great Lakes CoastWatch data users.

Budget Summary	
Item	***Total ($)***
Equipment	
Supplies	
Field Travel *(field work)*	
Science Conference Travel *(conferences e.g. AMS, IAGLR, AGU)*	
Science Meeting Travel *(e.g. working groups, PI meetings)*	$ 2,500
Admin Travel *(e.g. Advisory Board meetings)*	
***Please note here any International travel and the location ($ amount is included in one of the above categories)*	--
Contracts/CILER	$109,550
Other (Communications)	$ 5,000
Total Amount	$117,050

Staffing and Ship Time	
Federal Staff	0.5 FTE
Contract and CILER Staff	1.0 FTE
Total Staff	**1.5 FTE**
Total Ship Time Days	**N/A**

Project Details

Personnel Requirements

George Leshkevich, 50% of time, Songzhi Liu, 100% of time

Describe what work is intended to be done

CoastWatch Great Lakes Node - FY 2014-15 Plans covers all Great Lakes, day and night data utilizing new server and storage capacity and made available via Great Lakes CoastWatch website

Maintain and improve web site for data/product availability and distribution:

- Implement NPP VIIRS SST data on website
- Convert HDF files to netCDF and populate disks
- Install and implement THREDDS software with LAS or ERDAP front end
- improve/expand GIS utility via implementation of Great Lakes GIS database from University of Michigan.
- complete implementation of Google Earth file structure for additional access/distribution of Great Lakes CoastWatch data and products. (ex. GLSEA with hi-res SAR wind overlay).

Expand Product Suite:

- add products as they become available (ex.VIIRS SST):
- improve AVHRR turbidity product
- chlorophyll, CDOM, and suspended mineral (SM) from MODIS data (working with OCPOP)
- SAR and scatterometer ice products (not funded by CoastWatch)
- scatterometer wind product
- primary productivity
- Harmful Algal Bloom (HAB) product
- NESDIS high resolution SAR winds
- night time only SST composite chart
- Great Lakes upwellings
- soil moisture in Great Lakes basin (not funded by CoastWatch)

Other activities:

- participate in other activities as appropriate.
- present CoastWatch Great Lakes Program updates at conferences such as the ASPRS/EGLR Special Technical meeting, IAGLR, ISPRS, and/or State-of-the-Lake Conferences.
- continue collaboration with Michigan Sea Grant for contoured SST product.
- continue transfer of ice type classification algorithm to NESDIS (Bill Pichell)
- continue to work with OCPOP for transfer of CPA algorithm

Budget Explanation

The Great Lakes CoastWatch node at GLERL is funded by NOAA/NESDIS as part of the NOAA CoastWatch program. Funds support a CoastWatch operations assistant, supplies and equipment as needed, travel and communications (portion of Internet costs). The project is not expected to increase the current GLERL security level.

Integration

This project is linked to but not dependent on the Satellite and Airborne Research and Product Development project as products developed in that project can be made available to the user community via the Great Lakes CoastWatch website.

Progress & Project Improvement (if project is continuing / on-going)

- What are the expected short-term (FY15) and longer term (2-5 years) outcomes and milestones? A major short-term goal is to complete the THREDDS server implementation with the LAS or ERDAP front end. Longer term goals include incorporating new products as they become available such as ice type product, CPA product, and upwelling product.
- Which journal papers, reports, and products (e.g., forecasts, briefs, models, etc.) will be *developed or improved* upon? An article updating the Great Lakes CoastWatch Program is planned.
- FY14 progress made on the project as compared to stated milestones and goals. The FY14 milestone of implementing the THREDDS server (without LAS or ERDAP front end) was met
- What challenges were encountered during the past year and what is the plan to reduce or eliminate them this year? Network and server reconfiguration causing several days of website outage.

Relevance to NOAA & Public

- What science question are we answering? Questions on Great Lakes surface water temperatures, ice cover, turbidity, HAB's, etc. from modelers, researchers, media, and public
- What is the societal relevance? Economy (charter and sports fishing, commercial shipping), Safety (safe navigation, drinking water), recreation (swimming, fishing), education (students, public), research (data used in modeling and forecasting (ex.) NCEP models)
- Under what NOAA and DOC goals does the work fit?
  DOC FY2014-2018 Strategic Plan
  4 Data - Improve government, business, and community decisions and knowledge by transforming Department data capabilities and supporting a data-enabled economy

  4.1. Transform the Department's data capacity to enhance the value, accessibility and usability of Commerce data for government, business and the public (ESA, NIST, NOAA, NTIS)

  4.2. Improve data-based services, decision-making, and data sharing within the Department and with other parts of the federal government (BIS, ESA, ITA)

  4.3. Collaborate with the business community to provide more timely, accurate, and relevant data products and services for customers (ESA, NOAA)

NOAA 5-year research and development plan 2013-2017
F. Accurate and Reliable Data from Sustained and Integrated Earth Observing Systems

What part of GLERL's mission or which Strategic Plan milestone does this support?

- Observing Systems and Advanced Technology
- The Observing Systems and Advanced Technology (OSAT) branch develops, tests,
- evaluates, and implements new remote sensing products, observation platforms, and
- instrumentation to continuously improve GLERL's and NOAA's observational capabilities.
- Develop satellite remote sensing products supporting scientific understanding of
- primary productivity and ice formation

OSAT EX 2 GLOS – NOS/IOOS.
(Ruberg, Johengen)
Deployment and retrieval of UofM GLOS buoy at Ludington and GLERL buoy at Alpena. We will receive IOOS funding ($30,000) for buoy deployments and data transfer to GLOS.
Ship time 6 Days

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OSAT EX 3 Synthesis Observations and Response (SOAR)
Ruberg

Internal partners. Muzzi, Constant, Beadle, Miller, Donahue, Yagiela, Mason, Joseph-Joshi, Vanderploeg, Anderson, Davis, Stow, Churnside, Leshkevich
External partners. Johengen, Obenour, VanderWoude

Executive Summary

The SOAR project provides environmental intelligence on coastal conditions to regional managers on Lakes Michigan, Huron and Erie. The implementation of the project includes the deployment and support of on-water and remote sensing platforms where observations from these systems are used to create database products to evaluate restoration effectiveness, provide ecosystem assessment, report on restoration progress, and aid in decision support for regional managers. The project will provide an up-to-date (including real-time data) web presence to support accountability, management and restoration activities.

The project will monitor and report on hypoxic conditions, algal blooms, and nutrients in AOCs and areas impacted by AOCs using real-time sensor networks and satellite remote sensing. The project will develop adaptive management support products including improvements to satellite imaging tools to assess harmful algal blooms (HABs) extent and fate on a daily, weekly and seasonal basis, advancements in biologically and physically coupled particle trajectory forecasts, measurement of *in situ* concentrations of algal toxins using ELISA and quantitative PCR, and assessment of ecosystem condition based on high resolution time series moorings for observations of physical, chemical and biological parameters, and deployment of hypoxia monitoring buoys. Many of these observations will be used to make improvements to the HABs Bulletin and seasonal forecast used by regional managers such as water intake and beach managers. This work will focus on determining algal toxin concentrations in important human and food-web components and on continuously monitoring ecosystem parameters such as chlorophyll, phycocyanin, phycoerythrin, nutrients, turbidity, conductivity, temperature, currents, waves, and dissolved oxygen. The project will improve our understanding of open-lake and near-shore phosphorous related to river contributions, the relationship between blue-green algae growth and phosphorus, assist in the ability to determine phosphorus movement in the lake and its advection and re-suspension, and determine targets at which SRP/DP trigger harmful algal blooms.

Budget Summary	
Item	***Total ($)***
Equipment	$ 275,700
Supplies	$ 50,000
Field Travel *(field work)*	$ 5,000
Science Conference Travel *(conferences e.g. AMS, IAGLR, AGU)*	$ 3,000
Science Meeting Travel *(e.g. working groups, PI meetings)*	$ 2,000
Admin Travel *(e.g. Advisory Board meetings)*	$ 300
***Please note here any International travel and the location ($ amount is included in one of the above categories)*	--
Contracts/CILER	$ 475,000
Other (specify) NOAA/ESRL (Churnside)	$ 140,000
Total Amount	$ 951,000
Staffing and Ship Time	
Federal Staff	1.30 FTE
Contract and CILER Staff	0.90 FTE
Total Staff	**2.20 FTE**
Total Ship Time Days	**35**

Project Details

Personnel Requirements

Overall project lead is Ruberg (60%); Johengen is CILER co-lead (10%); Constant (70%), Kyle Beadle (80%)

Work Description:

Saginaw Bay, western Lake Erie, and Muskegon (Johengen, Davis, Ruberg):

- Collect ground truth samples to help compare and refine various remote sensed determinations of sediment plumes and nuisance algal blooms using discrete measurements of chlorophyll, total suspended matter, and CDOM.
- Conduct profiles to measure inherent optical properties using the Wetlabs acs and bb9 absorption and backscatter instruments, to aid in continued algorithm refinement of remote sensing estimations of color producing agents (chlorophyll, total suspended matter, and CDOM).
- Conduct 3-4 detailed 3-dimensional surveys with our existing Autonomous Underwater Vehicles to map spatial distributions of the Maumee River plume and harmful algal blooms.
- Deploy real-time buoys providing observations of phosphorous re-suspension events, episodic hypoxia events, and observations of relevant water quality parameters (temperature, conductivity, chlorophyll, phycocyanin, turbidity, and CDOM).
- Deploy the Environmental Sample Processor (ESP) on western Lake Erie (Stone Lab) to obtain real-time measurements of *in situ* concentrations of microcystins (cyanotoxin) and abundances of potentially-toxic cyanobacteria using ELISA and quantitative PCR, respectively.

- Deploy real-time buoys at Muskegon MI for long-term monitoring and assessment of the changing Lake Michigan ecosystem. These systems will provide observations of temperature, conductivity, chlorophyll, turbidity,

Central Lake Erie observations (Ruberg). The central basin of Lake Erie is the second largest hypoxic zone in the United States creating drinking water concerns for approximately two million citizens. A real-time buoy will be deployed north of Cleveland in 21m of water to detect the onset of hypoxia, internal waves, and upwelling events. In-situ observations will be analyzed in conjunction with meteorological observations to understand and provide warnings of physical processes that transport hypoxic water into water intakes.

Remote Sensing (VanderWoude, Leshkevich, Ruberg). Western Lake Erie, Saginaw Bay and Green Bay are the most optically complex waters in the Great Lakes requiring continued work on satellite remote sensing retrieval algorithms capable of estimating color producing agents (CPA) and HABs in these areas. The use of combined retrieval algorithms for ecologically distinct regions, or 'lakescapes' will improve assessment accuracy and permit comparative trend analysis of blooms and frequency of blooms within the lakescapes to enhance the seasonal HABs forecast. A bioregional analysis will be used to distinguish spectrally different water masses within the western basin of Lake Erie on top of the lakewide comparisons.

Aerial remote sensing (Churnside, Ruberg, Leshkevich). This project will use the NOAA Lidar and ocean color radiometers on a small aircraft to capture small-scale variability and vertical distribution of algae. Data will be collected over western & central Lake Erie, Saginaw Bay, and Green Bay in July and again in August of 2016. Data will be analyzed to 1) compare airborne, satellite, and *in situ* measurements to improve the quality of satellite remote sensing products relevant to harmful algal bloom monitoring, and 2) evaluate the cost-effectiveness of an airborne component of the annual monitoring program.

HABs forecasting (Stow, Obenour, Ruberg, Davis). The **seasonal HAB forecast** will be expanded to include additional data products that improve forecast accuracy, such as new bloom estimates derived from improved satellite remote sensing, sensitive molecular HAB detection techniques, biophysical factors derived from the observing network and remote sensing work (wind stress, wind direction, temperature, summer nutrient loads, etc.), and improved climate-based forecasts of river phosphorus loads. A plan will be developed for refining bloom predictions over the summer, as additional forecasting inputs become available (e.g., spring nutrient load will be available before August wind speed) for publication by NOAA. Model scope will be expanded to address bloom timing, in addition to bloom size.

Daily and weekly HABs assessment and evaluation will reported through the **HABs Bulletin** (Anderson, Davis, Ruberg). Work will continue on making improvements to the daily and weekly HABs information by incorporating improved particle trajectory models reporting on a daily basis when remotely sensed initial conditions can be obtained, incorporating biophysical information related to wind stress, and adding real-time toxicity information.

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Infrastructure Project Planning

Executive Management Initiatives

HABHRCA-Great Lakes Knauss Fellow
(Timothy Davis)

Executive Summary
NOAA has a primary responsibility for implementing the recently authorized Harmful Algal Bloom and Hypoxia Research and Control Act (HABHRCA). NOAA-GLERL has been charged with completing the Great Lakes section of the HABHRCA reporting requirements to Congress and the President. The Knauss Fellow will be responsible for leading the coordination, writing, editing, and formatting of the Great Lakes HABHRCA reporting requirements due June 30, 2015 and December 30, 2015. This position will closely collaborate with another Fellow, who will be leading NOAA's overall HABHRCA reporting effort. The Fellow will also work closely with Great Lakes HAB and hypoxia scientists from GLERL and the University of Michigan/Cooperative Institute for Limnology and Ecosystems Research. The Fellow will compose an important document that will synthesize the current Great Lakes HAB and hypoxia research efforts, discuss knowledge gaps, and develop future research plans in these areas for federal leadership and relevant stakeholders.
(Note: Director's Office is funding 50% and 50% funding is included in GLRI X .)

Budget Summary	
Item	***Total ($)***
Equipment	
Supplies	
Field Travel *(field work)*	
Science Conference Travel *(conferences e.g. AMS, IAGLR, AGU)*	
Science Meeting Travel *(e.g. working groups, PI meetings)*	
Admin Travel *(e.g. Advisory Board meetings)*	$ 8,000
*** International travel*	--
Contracts/CILER -NOAA-Sea Grant Knauss Fellowship stipend	$60,000
Other (specify)	
Total Amount *(note: funded from management and GLRI accounts)*	$68,000
Staffing and Ship Time	
Federal Staff	1.3 FTE
Contract and CILER Staff	0.2 FTE
Total Staff	**1.5 FTE**
Total Ship Time Days	**n/a**

Project Details

Personnel Requirements

GLERL: Timothy Davis 0.1 FTE, Steve Ruberg 0.1 FTE, Eric Anderson 0.1 FTE, Knauss Fellow 1 FTE
CILER: Tom Johengen 0.1 FTE, Sonia Joseph Joshi 0.1 FTE,
External: Alan Lewitus (NCCOS) 0.1 FTE, NCCOS Knauss Fellow 1 FTE

Describe what work is intended to be done

This proposal is not a typical research proposal so many of the aspects requested in the outline for this section do not apply. The Knauss Fellow will be the lead writer for the Great Lakes portion of the reports to Congress and the President that are mandated in the 2014 HABHRCA legislation. Within the legislation, NOAA is required to lead an interagency working group (IWG) which includes representatives from several federal agencies including, but not limited, to EPA, CDC, Oceanographer of the Navy, NSF, USDA, USGS, USACE . This task is primarily being shouldered by NCCOS (Mary Erickson). The legislation specifically requires the IWG to submit five reports and they are as follows:

- ***Comprehensive HAB and Hypoxia Research Plan and Action Strategy*** **(Due: June 30, 2015)**
- Report on Implementation of the HABs and Hypoxia Action Strategy
- **Great Lakes Hypoxia and HAB integrated assessment (Due: December 30, 2015)**
- **Great Lakes HABs and Hypoxia Plan (Due: June 30, 2016)**
- Progress Report on Northern Gulf of Mexico Hypoxia

GLERL is leading the Great Lakes Subgroup of the IWG which includes representatives from EPA, NIH/NIEHS and NOAA. The two bullets that have been bolded and underlined are the aspects of the reporting requirements that GLERL has been charged with composing and will be responsible for their content and timely submission. The due date for the submission of these documents is extremely aggressive (see above) and therefore will take a **full-time effort** to complete. This cannot be completely placed on GLERL PIs as it would significantly hinder our ability to lead quality research programs, **therefore, being able to support a Knauss Fellow is critical for NOAA to meet the reporting requirements of the legislation.** GLERL has already submitted a position description that was approved by NOAA-SeaGrant and in that process GLERL had to confirm our ability to fund the potential position if we were successful in the interview process. In addition, NCCOS recognizes the significance of the effort these reports will require and is also interviewing a Knauss Fellow to oversee the NCCOS effort on preparing these reports. The bullet that has been bolded and italicized is a report that the GLERL Fellow will be working closely with the NCCOS Fellow to complete.

The GLERL Fellow will work on the Great Lakes reports with me, Eric Anderson and Steve Ruberg who are GLERL's representatives to the IWG. The Fellow will also work closely with Great Lakes HAB and hypoxia scientists from the University of Michigan/Cooperative Institute for Limnology and Ecosystems Research. Additional responsibilities would be for the Fellow to engage appropriate regional stakeholder groups who will have important insights and opinions on the reports being drafted. **Leading this effort puts GLERL in a strategic position to highlight the work we are doing in the boarder context of Great Lakes HAB research. It also allows us to decide the knowledge gaps that need to be filled and to develop preliminary budgets for accomplishing the goals that will be highlighted in the reports.**

Due to the fellowship requirements the Fellow is required to spend a majority of their time in Washington D.C. NCCOS has agreed to host the GLERL fellow and this is advantageous, as it will allow ample time to coordinate with the NCCOS Fellow to accomplish the assigned tasks. The GLERL Fellow will travel to Ann Arbor for 3-5 days per month, which will give them the opportunity to work directly with GLERL scientists as well as meet with relevant stakeholders as appropriate. The fellow would need to have access to an office, computer and a GLERL email address. Overall, **to ensure that GLERL can**

deliver the assigned mandatory reports, it is essential to hire a Knauss Fellow. Leading these efforts puts GLERL in the spotlight during a time when federal leadership seems to have great interest in HABs and hypoxia research. As such, it is imperative that we have the necessary resources to complete the assigned tasks.

Budget Explanation

The budget for this project is fairly straightforward. NOAA-SeaGrant requests host offices support the fellow at a standard stipend of $60K. This includes $3.5K overhead. We request an additional 8K in travel support for the fellow to travel between Washington D.C. where they are required to spend a majority of their time and GLERL where they will visit between 3-5 days per month. The specific Fellow we have in mind has a residence in Ann Arbor and will have a residence in Washington DC. The $8K in travel will support 12 round trip airfares from DC to Detroit (average $575 per flight = $6.9K) and $1,100 for travel between the Fellow's residences and the airport (average $92 x 12 = 1.1K).
NOTE: $34,000 will be covered from the Director's Office budget and GLRI project

Integration

GLERL IWG representatives include a PI from each of GLERL's research branches, ECO DYN (Davis), OSAT (Ruberg), IPEMF (Anderson). Therefore, this project will incorporate all aspects of GLERL's HAB program (modeling, forecasting, ecology and physiology). The reports that will be composed will encompass current research such as GLERL/CILER GLRI research, proposed MERHAB research as well as dictate many of the future HAB projects at GLERL.

Progress & Project Improvement (if project is continuing / on-going)

This is a new proposal and the progress of the Fellow will be monitored by GLERL/NCCOS IWG leads.

Relevance to NOAA & Public

First and foremost, the 2014 HABHRCA bill makes a number of amendments to the previous HABHRCA legislation that would promote and coordinate a national research strategy for improving the understanding and prevention of marine and freshwater harmful algal blooms (HABs) and hypoxia events. It specifically, and for the first time, states the Great Lakes as a focus are for HAB and hypoxia research. It also:

1. Requires the Under Secretary of Commerce for Oceans and Atmosphere, acting through the IWG, to enhance the existing national harmful algal bloom and hypoxia program and develop and submit to Congress a comprehensive research plan and action strategy to address marine and freshwater harmful algal blooms and hypoxia.
2. Sustains NOAA's primary responsibility to administer the Program and establishes the Under Secretary's duties.
3. Requires the IWG to submit to Congress and the President an integrated assessment that examines the causes, consequences, and approaches to reduce hypoxia and harmful algal blooms in the Great Lakes and develop and submit to Congress a plan for reducing, mitigating, and controlling such hypoxia and blooms

This work aligns with multiple goals and objectives of NOAA's Strategic Plan including 'Healthy Oceans' and 'Climate Adaptation and Mitigation'. The objective within Healthy Oceans to improve the understanding of ecosystems to inform resource management decisions is directly related to the wide-ranging water quality assessments being made under the proposed work. Within the Climate Adaptation and Mitigation goal the current project most closely aligns to the objective of improving the scientific understanding of the changing climate system and its impacts.

Furthermore, the proposed work strongly supports NOAA's long-term goals and objectives of:

- Resilient Ecosystems, Communities, and Economies
  - *Improved coastal water quality supporting human health and coastal ecosystem services*
- Weather-Ready Nation
  - *Healthy people and communities due to improved air and water quality services*.
  - *Improved understanding of ecosystems to inform resource management decisions*

The proposed project closely aligns with the Great Lakes Water Quality Agreement Annex 4 and the Lake Erie LaMP reports. Both documents contain specific language pertaining to reducing HAB events in the Great Lakes and specifically in Lake Erie (Lake Erie LaMP) through nutrient remediation. This effort also supports GLERL's Strategic Plan for long-term ecosystem research focused on eutrophication and climate change, with a near-term emphasis on HABs.

Ann Arbor Administration, Facilities and Operations

Ann Arbor Administration
Discretionary funds for supplies and services $20,000

Administrative Office Initiatives – Ann Arbor Facilities and Operations
(Salyers)

Key Internal Personnel: Sandra Salyers, Dennis Henman, Eugenia Lashbrook, Michael Ryan, Rita Williams
Key External Partners: Barbara Gerych and Timothy Powell (Contractors)

Executive Summary
This project reflect infrastructure cost for GLERL main building South State Road in Ann Arbor, which house over 50 federal and non-federal staff. As well as GLERL's Lake Michigan Field Station (LMFS) located in Muskegon, Michigan where our research vessel fleet is housed and 11 federal and non-federal is staffed.

Budget Summary	
Item	***Total ($)***
Equipment	
Supplies	
Services	$ 1,800
Field Travel *(field work)*	
Conference Travel *(conferences e.g. FEW,EEO)*	
Admin Travel *(e.g. Advisory Board meetings, Training)*	
Lease / Taxes / Utilities	$1,647,409
Calibrations, Repairs & Maintenance	$ 500
Vehicles	$ 80,500
Vessel Operation	
Fuel	
MET Stations	
Contracts/CILER	
Total Amount	$1,730,209

Budget Details

Budget Details	
Item	***Total ($)***
Services	
Building Security Monitoring	$ 600
Recycling	$ 1,200
Services Subtotal	**$ 1,800**
Vehicles	
Vehicles	$ 75,000
Vehicle Insurance - Canada	$ 2,500
GSA Vehicle Accidents	$ 3,000
Vehicles Subtotal	**$ 80,500**
Lease / Taxes / Utilities	
Lease	$1,580,909
Property Taxes	$ 50,000
Copiers	$ 4,500
GSA phones	$ 12,000
Lease / Taxes / Utilities Subtotal	**$1,647,409**
Calibrations, Repairs & Maintenance	
Phone system maintenance	**$ 500**
Total Amount	**$1,730,209**

Ann Arbor Facility Projects
(Ryan)

Building Security Upgrades
Project Details
In August, 2014 GLERL had it annual security inspection by an OAR/HQ representation and from that inspection the following items are recommendations to upgrade GLERL security.

- *Front entry barriers* *$ 3,000*
- *Parking lot signage* *$ 1,000*
- *Upgrade facility security system* *$30,000*

Also due to several power outages over the last few years, the need for backup generator to power lab refrigeration units and computer server is needed.

- *Backup generator for labs and computer room* *$57,000*

On-Going Furniture Replacement
Project Details
Continuing project to replace old worn out furniture with new furniture that has a consistent design throughout the building.

- *Furniture* *$34,000*

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Safety and Environmental Compliance Annual Operating Budget
(Kim Kulpanowski)

Executive Summary

GLERL's Safety, Environmental Compliance, and Quality Management Office is a service department of one with a reliance on all to incorporate safety, environmental compliance, and quality improvement efforts into their daily routines. Customers include: the Director, GLERL; Deputy Director, GLERL; all GLERL occupants (staff, visitors, contractors, CILER, other NOAA agencies, Post docs, visiting scientists, volunteers, cleaning staff); OAR, NOAA, NRC, MDEQ, OSHA, and EPA. The services out of this office cover the gamete of safety and environmental compliance activities including new occupant orientations, training, regulatory required written program development and maintenance, hazardous waste management, MSDS management, safety inspections, corrective actions and reports, injury reporting and investigation/follow-up, and worker's compensation assistance to supervisors/staff. In addition to daily programmatic activities, this office stands ready to participate in PI called/lead project planning meetings to provide assistance with safety, environmental compliance, risk assessments, JHA creation, SOP promotion, data management plans, QAPPs, training, PPE selection/purchase, NEPA consideration, etc.

With the formalization of facility management roles in Ann Arbor and at the LMFS, facility safety equipment inspections have been transitioned to the facility managers providing some greatly appreciated assistance. Additional facility manager interactions take place to address items such as lab ventilation systems and processing of new and departing occupants. Other cross cutting activities include engagement with the security personnel at GLERL to conduct/report annual evacuation and shelter in place drills and to review and update the Occupant Emergency Plan.

In addition to safety and environmental compliance activities, this office has taken the lead on Quality Management efforts at the lab. In that capacity, this office has coordinated the development and review of Quality Assurance Project Plans (QAPPs) and promoted the Information Quality Act (IQA) through the development and implementation of in-house IQA compliance tools and procedures and response to NOAA IQA data calls. To advance this effort, training in EPA quality approaches in addition to participation in the U.S. DOC Baldrige Performance Excellence regional conference and other learning opportunities have been embraced. The Safety, Environmental Compliance, and Quality Management Office establishes strategic objectives and milestones to promote quality, safety, and environmental compliance inclusion in GLERL project planning, execution, and review efforts. This office also promotes the NOAA data management directives and routinely participates in the NOAA Environmental Data Management workshops, presenting at the last one, with an emphasis on DMP development/review in support of GLERL's research projects.

The manager of the Safety, Environmental Compliance, and Quality Office chairs the GLERL Safety Committee. This committee has routinely been acknowledged and held up as an example, routinely meeting and taking actions to advance the program. The committee has also been unique in the communication of annual goals and report outs on progress towards meeting those goals.

On occasion, consultant assistance has been needed and this office is very involved in the contracting process and oversight of the contractor activities in those cases.

Budget Summary	
Item	***Total ($)***
Equipment	
Supplies	$ 9,000
Services (NRC decommissioning/license termination effort)	$ 53,000
Field Travel *(field work)*	$ 1,600
Conference Travel *(conferences e.g. FEW,EEO)*	$ 5,000
Admin Travel *(e.g. Advisory Board meetings, Training)*	
Lease / Taxes / Utilities	
Calibrations, Repairs & Maintenance	
Vehicles	
Vessel Operation	
Fuel	
MET Stations	
Contracts/CILER	
Other	
Total Amount	$68,600
Staffing and Ship Time	
Federal Staff	1.0 FTE
Contract and CILER Staff	0
Total Staff	**1.0 FTE**
Total Ship Time Days	

Project Details

Personnel Requirements

Kim Kulpanowski (100%), Duane Gossiaux (1%) for Radiation safety effort only, Future Hire? (50%) –

Work intended to be done

a. Location: Work will take place at GLERL and the LMFS.
b. Hours: Work will usually take place during the regular workweek and regular working hours. Given the commute to the LMFS can be up to 6 hours round trip, day trips are typically a 12 hour day. Comp time has been requested on occasion due to work load and looming deadlines.
c. Methods: Some work is accomplished through informal meetings with PI's and/or ship crew and discussions among other personnel that overlap with safety activities. Email notices are issued to supervisors for monthly inspections; reports are issued to supervisors for corrective action tracking and reporting; new occupant forms are used to schedule new occupant training; forms are available on the safety page to request hazardous waste characterizations, personal protective equipment purchases, assist in development of JHAs, PPE certifications, LOTO procedures; safety reminders/lessons learned are issued in email notices, safety newsletter

articles, All Hands presentations; Training sessions are coordinated to ensure maximum availability of staff; meetings are called for formal topic discussions.

d. Key resources include:
   - Boat ops group – responsible for vessel operations safety
   - MIL – fork lift training/operation and machine shop training/oversight
   - IT – standard support of desktop computers and printers. IT support is needed to advance data management efforts, project planning tool development and use, and quality management efforts, e.g. establishment of SOP library
   - Web services support – Web page support is needed for the safety page and to advance data management efforts and project planning tool development and use.
   - Information Services: Occasional use for development of posters, floor plans, coordination of efforts/products in overlapping areas of Information Quality Act etc.
   - Safety Committee- provides occupant representation, sounding board for safety officer, and assistance with committee initiatives
   - Facility managers-to conduct facility safety equipment inspections
   - Director's office for leadership support
   - PIs for oversight of on the job training and implementation of their program responsibilities
   - Admin support for coordination of in and out processing of occupants
   - Lab team coordinators for training on safe use of lab equipment
   - Supervisors for inspections, corrective actions, project planning
   - Staff for support of program during day to day activities

e. Health and safety issues:
   - The safety issues involving the use of chemicals, radioactive materials, overhead crane, forklift, research vessels etc. are extensive but are addressed through training, certification, regular inspections, personal protective equipment, MSDS (Material Safety Data Sheets), JHA's (Job Hazard Analyses), SOP's (Standard Operating Procedures), and engineering controls.

<u>Budget Explanation</u>

- Staffing: There is a desire to improve the program in many ways, but a staff of one usually operates in the urgent and important time management box, with little time for improvement opportunities afforded in the important, but not urgent time management box.
- Decommissioning effort: A consultant assistance effort, including disposal of remaining rad inventory, final status survey, all paperwork and reports due for submission to U.S. NRC to release the LMFS and Laurentian for general use and for license termination.

<u>Integration</u>

Many of the GLERL internal and external projects are dependent upon the services that Safety provides.

<u>Progress & Project Improvement (project is on-going)</u>

<u>Progress & Project Improvement (if project is continuing / on-going)</u>

Include:

- What are the expected short-term (FY15) and longer term (2-5 years) outcomes and milestones?

  FY15 short term outcome: If status quo, the expected short term outcome is that the program will continue in a maintenance mode, with every effort made to meet regulatory compliance

requirements for training, program reviews, reporting, etc. The addition of the NRC license termination effort will strain time budgets for other activities.

FY15 milestones:

- Completion of three month detail to NOAA Program Planning and Integration, 11/30/14
- GLERL Project Reviews Dec 2014
- NRC license termination
  - Procurement SOW Dec 2014
  - Rad waste prep/shipment Dec 2014
  - Final Status Survey Jan 2015
  - FSS report, review and submission to NRC Jan. 30, 2015
  - Responding to NRC and final termination, July 2015
- Annual written program reviews/updates Dec. 30, 2014 and other various dates
- Web page maintenance i.e. updates in conjunction with written program reviews
- Annual refresher training, NOAA 12/30/14, others various dates
- Safety Committee membership refresh (1/30/2015) and four calendar-year meetings.
- GLERL Project Planning Meetings at PI's invitation per GLERL policy
- OSHA 300 summary log created/posted Feb 1, 2015
- Monthly inspections
- Quarterly inspection reports
- ~Quarterly trips to LMFS
- Completion of LMFS consultant respirator program evaluation effort 3/30/15
- GLERL EPA GLRI QAPP support for review/approval of 4 QAPPs April 1, 2015
- Biosafety program update and waste disposal, 5/30/15
- New occupant orientations, ~26 per year, upon arrival or shortly thereafter
- MDEQ radioactive waste report timely completed submitted ~June 2015
- Professional development/certification points for CIH at ABIH conf 6/15/15
- NOAA Data Management Workshop participation TBD, Fall 15.
- Annual evacuation and shelter in place drills, 9/30/15
- Participation on OAR NEPA working group, 3 times per year

- Which reports, processes and products will be *developed or improved* upon?

New Initiative: Review of NOAA OER cruise plan tool obtained from NOAA EDM workshop contact for use at GLERL to enhance safety and env compliance, planning, and data management efforts, to be done in coordination with OSAT personnel and IT.

- FY14 progress made on the project as compared to stated milestones and goals.

The safety committee completed its goals based on a customer needs survey: Lab coat laundry service changed, request for hall spill clean up supplies submitted to facilities, concern re equipment overboard on ships addressed through JHA review/highlight and GAR campaign to advance risk assessment approach.

The ultimate goal of a safe work place was supported by a 0 injury statistic for FY14. The following was proposed for FY14, but it is not clear to me if it was ever incorporated into the GLERL Strategic Plan. I have added a status line based on my knowledge.

- *Develop, communicate, and promote a Safety, Environmental Compliance, and Quality Policy statement(s) (STATUS: developed and submitted for management consideration)

- *Establish an Injury and Illness Prevention Plan to formally address the Goal of zero Occupational Safety and Health Administration-recordable injuries/illnesses and annual injury rate reductions through the following efforts: (STATUS: Plan was developed and submitted for management consideration)
    - *Accountability for corrective actions
    - * Accountability for timely incident reporting and investigations
    - *Monthly safety inspections of boat ops at LMFS (STATUS: now in place)
    - *Advancement of the supervisor safety observation effort
    - *Continued safety awareness communications through email, newsletter, etc.
    - *Completion of training needs/requirements in concert, not competition, with field program demands (STATUS: completed pre-field training effort '14)
    - *Planning/scheduling activities to build in time to address safety (and environmental compliance and quality) aspects of the project
    - *SOP and JHA development and/or other safety responsibilities described and evaluated in performance plans/reviews
- *Submission of required planning documentation in keeping with project approval process timeline (STATUS: not done)
- *Finalization and implementation of the SPCC Plan at the LMFS (STATUS: Done, signed at LMFS)

- What challenges were encountered during the past year and what is the plan to reduce or eliminate them this year?

    - Resources and support for an integrated safety, health env compliance and quality approach to the way GLERL does business. A draft Quality Management Plan and a draft Injury illness and Prevention Plan have been proposed to advance this concept.
    - Building a culture that finds opportunities for improvement through a lessons learned, PDCA quality approach
    - Change management that considers safety, env. Compliance, quality to address the deviations from plan, procedures, policies.
    - Due to understaffing and temporary supervisor roles, many initiatives have not advanced.
    - The DOT/IATA hazardous material shipping needs. Expertise may be more appropriately housed in the admin office where packages are shipped from and/or use of contractor support for this activity may need to be budgeted for.

- Long-term outcomes and milestones (2-5 years out) depend on the culture at the lab and research direction. Professional outcome desires include: a resident safety and environmental compliance professional at the LMFS to advance the programs there; involvement in the DOC/NOAA Organizational Excellence goal to advance a culture of quality and continual improvement beyond compliance at the GLERL, OAR, and, NOAA levels; involvement in data management advances at GLERL through participation with the NOAA environmental data management community, GLERL staff, etc. resulting in the use of data management plans and supporting infrastructure; a refresh of training programs using new formats and tools to take advantage of new technology training approaches resulting in enhanced content presentation and audience engagement; a highly regarded and useful safety and env compliance web page.

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Information Services Operations
(Margaret Lansing)

Executive Summary

The Information Services Branch (ISB) oversees GLERLs customer service strategy for internal and external customers, stakeholders, and the public. ISB serves as the two way information conduit for GLERL. ISB strategically promotes GLERL's science, products and services. ISB strategically engages with partners to facilitate our internal understanding of external end user needs for GLERL products. ISB engages with stakeholders and customers across local, regional and international levels. Science is translated and messaging is targeted to meet needs of each audience. ISB oversees GLERL's publications, library services, media relations, Congressional affairs, web site content, social media campaign, library affairs and outreach and education program.

Budget Summary	
Item	***Total ($)***
Equipment (computer)	$ 600
Supplies	$14,250
Services	
Field Travel *(Outreach Events w/ registration fees)*	$ 3,200
Conference Travel *(Great Lakes regional conferences e.g. Healing our Waters, Great Lakes Commission biannual, Sea Grant)*	$ 1,500
Admin Travel *(e.g. Congressional visits, Silver Spring HQ meetings, LMFS meetings - Lansing)*	$ 1,250
Lease / Taxes / Utilities	
Calibrations, Repairs & Maintenance	
Vehicles	
Vessel Operation	
Fuel	
MET Stations	
Contracts/CILER Summer Fellow – Science Communications	
Other (specify)	
Total Amount	$20,800
Staffing and Ship Time	
Federal Staff	2.0 FTE
Contract and CILER Staff	1.0 FTE
Total Staff	**3.0 FTE**
Total Ship Time Days	

Project Details

Personnel Requirements

ISB personnel

- Cathy Darnell – Editor
- Kathe Glassner-Shwayder – Communications Specialist

Future ISB Hires

- 1 FTE Editor to include 25% librarian responsibilities
- 1 FTE science writer to include 10% volunteer coordinator, 10% outreach, 10% education

Future non-ISB hires key to ISB program

- 25% web master (IPEMF programmer)
- 25% AV / Communications Technology specialist (IT)

Internal Partners – Web site

Joeseph Smith – basic compliance and maintenance programming until web programmer hired
Anne Clites, Greg Lang, Tim Hunter, Brad Sagowitz GLERL web committee

Internal / External Partners – Great Lakes Seminar Series Committee

Tom Johengen, Larissa Sano, Margaret Lansing, Doran Mason, Brad Sagowitz

Internal / External Partners – In House Communications Team

Representatives from CILER (Larissa Sano, Autumn Poisson, Sonia Joseph-Joshi), Great Lakes Sea Grant Network (Rochelle Sturtevant), NOAA Great Lakes Regional Collaboration Team (Jennifer Day, Katy Hintzen, Felix Martinez) NOAA Office of Habitat Conservation (Terry Heatlie), and NOAA National Marine Sanctuaries (Ellen Brody).

NOAA / OAR Communications & External Affairs Partners

National Communications team - Representatives from all OAR Laboratories – listing below key partners for GLERL
Barry Reichenbaugh – **OAR Communications Lead**
Bonnie Myers - **"Hot Items", NOAA HQ web stories**
Rochelle Plutchak - **Social Media**
Mike Walker - **POC for OAR leadership & OAR Hub** hub.oar.noaa.gov **= internal NOAA reporting of products, events and services**
Matthew Lee – **POC for internal significant publications reporting**
Monica Allen – **OAR POC media affairs**
John Ewald – **NOAA HQ POC media affairs**

NOAA / OAR Congressional Affairs

NOAA Formulation and Congressional Analysis Division (FCAD)
Jamie Krauk **OAR FCAD Lead**
Emily Gamelin **– POC for all GLERL Congressional Communications**
NOAA Office of Legislative and Intergovernmental Affairs –
Mackenzie Tepel, POC Congressional Affairs (go through Emily Gamelin to Mackenzie)

NOAA Library Services

Steve Quillen – NOAA Central Library
Dee Hopkins – WT Cox journal subscription vendor

Stanley Elswick – NOAA Library Catalog
Joan Segal – NOAA Library Committee chair

Describe what work is intended to be done in FY15

Publications
Cathy Darnell – year round, on-going in house effort: editing of journal articles, creation of research graphics, and creation of scientific posters.

ISB Lead for Internal Event Hosting / VIP visits
Currently on the calendar:

- 12/3 NERR & partners visit
- 1/26/1/28 NOAA Chief Scientist Rick Spinrad, Steve Fine OAR Administrator late Jan visit
- 2/4 Saint Clair Detroit River System Conference

ISB Representing GLERL at Regional Conferences
Currently targeted:

- Great Lakes Commission / Healing our Waters Conference annual regional meeting (Booth, attend panels) mid – late September & location?
- Great Lakes Sea Grant Network regional meeting – September? Burlington, VT

Library Services
Details in separate project proposal template submitted separately.

Media Relations
Margaret Lansing – intermittent targets of opportunity, media teleconferences (1-2 / year), press releases (0-2 / year), Great Lakes Information Network (GLIN) announcements (4-10 / year), channeling media inquiries average 1 / day,

Congressional affairs
Margaret Lansing, John Bratton, Debbie Lee – Great Lakes Week – Great Lakes Commission Meeting, Hill Visits, Washington DC - February 23 – February 27, regional office visits (1-2 per year) regional events (1-2 per year),

Internal (NOAA/GLERL) Communications
Kathe Glassner-Shwayder - GLERL newsletter (monthly), Brown Bag Series (informal ~monthly, "Hot Item" weekly, web stories (3x year)

Web Site
- Create beta testing area with virtual machine
- Web Committee – create new "mobile compliant" template for most GLERL web site pages, implement 3rd quarter

Social Media campaign
Kathe Glassner Shwayder – Facebook - daily posts
Margaret Lansing – Twitter – daily posts
Cathy Darnell – Flickr image gallery – monthly additions of images; YouTube- addition of video clips as they become available

Outreach and Education program
Great Lakes seminar series ~6x year – requires IT support & equipment support delineated in detail in separate project submission
Laboratory Tours ~ quarterly
Community Events ~ 2x monthly, supply outreach materials to PI

NOAA Booth Events:

- Resources: ink, paper, stickers, charts, GLERL vehicle, travel funds,
- National Ocean Science Bowl – Great Lakes Region – February 1 or 8 (compensatory time for GLERL staff – Saturday event)
- Embracing Our Earth Festival 3/21 Bad Axe, MI (Lansing, Donahue – captured by Vessel Operation Budget)
- Blessing of the Boats 5/25 Muskegon, MI (Donahue, Lansing)
- International Association for Great Lakes Research Conference, 5/25-5/29 Burlington VT. (Booth staffing likely covered by In House Communications Team, supplies by ISB)
- Ann Arbor Green Fair 6/13 Ann Arbor, MI (Lansing, summer fellows)
- NE Michigan Outreach Tour 6/24 – 6/26 Congressional District Office Visit 6/24, TBNMS Sanctuary 6/25 Engineering Day, Soo Locks, Sault Ste Marie, MI 6/26 (Lansing, Clites, Darnell)
- Huron River Day 7/12 Gallup Park, Ann Arbor
- US Coast Guard Festival, Grand Haven, MI 7/24 -7/29 (ISB team dates: 7/27 - 7/30 Lansing, Glassner-Shwayder, summer fellow, +1) Vessel requirements, vessel crew captured by Vessel Operations budget
- Great Lakes Commission Healing Our Waters Conference September? Location? tbd (Booth staffing likely covered by In House Communications Team, supplies by ISB, Lansing, travel, registration fee)

<u>Budget Explanation</u>

- **The Admin travel request and Conference Travel request specified above and totally $4K is travel that has historically been covered by Director's account and /or Program Development account, these travel costs are in addition to travel funds requested in the P16 budget request submitted to Sandra. The travel request in that budget is captured above in the Field travel category and is the same dollar total as submitted in P16.
- The proposed hiring actions in this project description would increase the total ISB FTE count by one FTE as of 2016. The Editor hire would replace Darnell (retiring 11/2015). The Science Writer would be a new expense. If we are not able to hire a Federal employee to take over editing we will need to contract that work in 2016. A ball park figure for contract editing at $500 / publication for 50 publications is $25,000.
- Additional staff requests
  25% IPEMF programmer hire to handle the GLERL web site programming and compliance responsibilities.
  25% IT support staff hire to cover A/V & Communications technology

<u>Integration</u>
This project is in addition to the Library Services (current project) and in addition to the Conference Room Infrastructure (new project).

Outreach events which involve GLERL research vessels are linked to the Vessel Operations Budget (Blessing of the Boats, and US Coast Guard Festival). The Vessel Operations Budget captures vessel needs, dollars, staffing, the ISB portion is for ISB staffing, travel, and supplies.

50% FTE staffing requests are integrated with new hires "in the pipeline" for IPEMF (25% web programmer) and IT Branch (25% AV / communications technology support)

Progress & Project Improvement (if project is continuing / on-going)
The ISB Branch is in a transition year with the anticipated retirement of Cathy Darnell in November of 2015. Staffing up as indicated above (if possible) is the highest priority. Lansing and Darnell are working to capture procedures and best practices for all aspects of Darnell's work plan in case the hiring is not possible in the FY 2015 time frame.

What are the expected short-term (FY15) outcomes and milestones?

Execute work plan as delineated above

Longer term (2-5 years) outcomes and milestones?

When a science writer and web master is hired, the goal is a complete overhaul of web site content and the creation of a searchable publications data base

Which reports, processes and products will be developed or improved upon?

Complete annual report for FY2014

What challenges were encountered during the past year and what is the plan to reduce or eliminate them this year?

Short staffing is our on-going challenge; we have hiring actions prioritized to build up the ISB team.

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Information Services - Library
(Margaret Lansing)

Key internal personnel: Margaret B. Lansing - Acting Librarian, Cathy Darnell, future GLERL hire

Executive Summary

The GLERL library provides information and research supports to staff and the public. The library is networked with the NOAA Central Library, located in Silver Spring, Maryland, and it's libraries at field offices located across the nation. Disciplines covered at the GLERL branch reflect an emphasis on fresh water studies particularly in the Great Lakes Basin. The Acting Librarian manages library resources including collection maintenance, development, and the execution on the annual library subscription process.

Budget Summary	
Item	***Total ($)***
Equipment:	
Supplies: books, maps, charts	$ 1,800
Services: WT Cox Journal subscriptions, inter-library loans	$82,077
Field Travel (field work)	
Conference Travel *(conferences e.g. FEW,EEO)*	
Admin Travel *(e.g. Advisory Board meetings, Training)*	
Lease / Taxes / Utilities	
Calibrations, Repairs & Maintenance	
Vehicles	
Vessel Operation	
Fuel	
MET Stations	
Contracts/CILER	
Other (specify) - Cox Credit	-$3,789
Total Amount	$80,088
Staffing and Ship Time	
Federal Staff	0.15 FTE
Contract	0.05 FTE
Total Staff	**0.20 FTE**
Total Ship Time Days	

Project Details

Personnel Requirements

GLERL: Margaret Lansing 10%, Cathy Darnell 5%

Contract: Kathe Glassner-Shwayder 5% w/ transition if personnel hired this year to GLERL FTE - 25% of Editor position

Describe what work is intended to be done

Margaret Lansing – Acting Librarian executes annual subscription process in conjunction with NOAA Central Library and GLERL Administrative Services Branch. The librarian serves as the point of contact and institutional knowledge base for all aspects of library journal subscriptions. NOAA retains WT Cox as its primary journal vendor – they are a service provider that manages the NOAA library subscriptions from multiple publishers (American Meteorological Society, Springer, Wiley, and Elsevier. The GLERL librarian serves as the point of contact for these multiple vendors. The librarian handles special requests: inter-library loans, pdf's of articles journal articles we do not subscribe to

Cathy Darnell manages the physical collection; purchasing of books re-shelving of books, tracking and labeling of new hard copy journal issues. This year we will train Kathe Glassner-Shwayder to take this over in anticipation of Cathy Darnell's retirement November, 2016 (until we can staff the GLERL library with a future hire). In FY15 we will complete the re-shelving project in the library that was initiated in FY14.

Gaps: Need to hire staff, targeting Librarian duties to be covered part-time (~25%), this staff will be filled by the future GLERL Federal FTE hire (Editor position on GLERL hiring short list). The selectee for this position will need to be sent to NOAA Central Library to train on NOAA Connexion software. GLERL Library services program is in a holding pattern since former librarian left the federal service in March, 2013.

Integration

The dollars requested by this project description match the ISB spreadsheet already submitted to Admin Services earlier this fall. This document provides information about staff needs and plans.

Progress & Project Improvement (if project is continuing / on-going)

FY 15

- Successfully execute journal subscription process
- Complete shelf-shift and shelf labeling project initiated in FY14
- Cathy Darnell to train Kathe Glassner-Shwayder (or new hire) on current duties.

2-5 years

- Hire and train GLERL Editor to take over librarian duties (25% of time, one Critical Element in CD-430).
- New hire to become familiar with and receive training on all NOAA online library resources
- Serve as GLERL and public resource with regard to the NOAA Network Catalog (NOAALINC, WorldCat)
- Enter back log of new journals and books into system
- Cross check shelf collection with NOAA Central Library catalog
- Represent GLERL on NOAA Library committees; keep abreast of efforts to fund NOAA Institutional Repository

IT Operations - GLERL FY15 HPC, storage, and backup projects
(Brad Sagowitz)

Key Internal Personnel and External Partners: Jeff Lefevre (GLERL), Ben Burns (Contractor)

Executive Summary

GLERL has in the past utilized Direct Attached Storage (DAS) and Network File Shares (NFS) for its storage architecture which fragments space availability and creates complicated administrator maintenance. Currently, the lab is running out of drive space and the DAS units in use are aged and prime for replacement. The SAN should include enough storage to cover the amount currently in place plus at least 50% growth. GLERL also needs to start archiving and moving key backups offsite as part of the disaster recovery plan and in accordance to the 2014 security audit findings. Finally, GLERL's High Performance Computing (HPC) resources are aging and not currently configured correctly which is leading to less than ideal modelling runs in both time to complete and flexibility. HPCA SAN of approximately 200TB – 300TB should be purchased and implemented as soon as possible to ensure continued project support. A Tape robot capable of growth should also be purchased to facilitate offsite backups as well as long term project data archive.

Budget Summary	
Item	***Total ($)***
Equipment	$103,300
Supplies	$ 25,500
Services	$ 48,000
Field Travel	
Conference Travel	
Admin Travel	$ 7,500
Lease / Taxes / Utilities	
Calibrations, Repairs & Maintenance	$ 52,900
Vehicles	
Vessel Operation	
Fuel	
MET Stations	$ 7,800
Contracts/CILER	
Other (specify)	
Total Amount	$245,000
Staffing and Ship Time	
Federal Staff	2.0 FTE
Contract and CILER Staff	2.0 FTE
Total Staff	**4.0 FTE**
Total Ship Time Days	

Project Details

Personnel Requirements

Brad Sagowitz, Jeff Lefevre, and Ben Burns.

Describe what work is intended to be done

Where the work will take place

All work for this project will take place in the GLERL server room.

When the work will take place

f. SAN implementation – 1st Quarter FY15
g. Tape Robot – 2nd Quarter FY15
h. HPC Cluster – 1st Quarter FY15

How will the work be accomplished?

- What are key processes necessary to accomplish the work?
    a. SAN
        i. Procurement of the equipment
            1. Synology Enterprise NAS with 500TB of configured storage
            2. 10GB network card for NAS
            3. 10GB network module for HP switch
        ii. Installation of equipment
            1. 14U of rack space in server room
        iii. Migrate current data from old equipment to new
        iv. Point data connections to new equipment
            1. NFS mounts and CIFS mounts
        v. Ensure stability
            1. Period of 45 days
        vi. Decommission/repurpose old equipment
    b. Tape Robot
        i. Procurement of the equipment
            1. Qualstar RLS-8350 with 2 LTO-6 drives and 50 tape slot capacity
        ii. Installation of equipment
            1. 4U of rack space in the server room
        iii. Configure current backup server to control robot
            1. Utilize current Backup Exec software license
        iv. Migrate backup jobs to point to robot
    c. HPC
        i. Procure
            1. Supermicro Head Node
            2. 2 Supermicro Compute Nodes (64 cores and 128GB of memory)
        ii. Install
            1. 3U of rack space in the server room
        iii. Configure
            1. Utilize current Infiniband switch for node interconnect.
        iv. Use
            1. Speed!
            2. Profit!

Budget Explanation

- IT contract staff and federal staff for the installation and migration of data and equipment.

- GLERL to purchase $103,000 in Equipment including:
    - SAN – Minimum of 200TB which will allow for growth
    - Tap Robot – with minimum of 2 drives and 50 tapes
    - HPC Cluster – with a minimum of 48 cores and 256GB of memory plus a head node

- Brief explanation if the project will increase the current GLERL security level which is now considered "low"

Integration

This project is independent of other projects. Monies have already been requested for this project in the IT budget spreadsheet submitted to Admin Services for FY15.

Progress & Project Improvement (if project is continuing / on-going)

The following benefits will be realized by each system.

- SAN
    - Consolidate lab storage in the server room which will:
        - Free up space in the server room racks
        - Reduce cooling and power requirements
        - Provide a single pane interface for management
        - Eliminate the needs for multiple servers to serve lab storage
    - Ease of expansion (FY16 and beyond)
- Tape Robot
    - Satisfy 2014 POA&M - provide off site backups
    - Provide a media appropriate long term archive
    - Expandable to 1.2PB of backup storage (might need in FY17 or beyond)
- HPC
    - Facilitates an upgrade path from Tiger and Panther which are aged and out of warranty
    - Will be configured properly which current SGI's do not take advantage of the 40GB Infiniband switch meaning models should complete in less time.
    - Provide separation of "quasi-operational" models and research models
    - FY16 add another node or two and deprecate the use of Tiger and or Panther
    - FY17 expand the cluster further

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Lab Team Operations
(Dave Fanslow)

Executive Summary

The Lab Team is responsible for maintaining the general use lab equipment and supplies in all the Wet Labs. This includes but is not limited to the calibration, maintenance, and repair of microscopes, balances, drying ovens, muffle furnaces, centrifuges, refrigerators, freezers and incubators. Ongoing expenses include the gas cylinder rentals and DI water system lease and maintenance. Last year we voluntarily gave back most of our new equipment budget to support the HABS lab. This year replacement several new refrigerator/freezer units and major preventative maintenance on our fleet of Percival incubators can no longer be deferred. Upgrades to obsolete microscopy imaging systems for the Muskegon Lab users are also sorely needed.

Budget Summary	
Item	***Total ($)***
Equipment	$ 6,000
Supplies	$ 5,000
Services	$ 1,500
Field Travel (field work)	
Conference Travel (conferences e.g. FEW,EEO)	
Admin Travel (e.g. Advisory Board meetings, Training)	
Lease / Taxes / Utilities	
Calibrations, Repairs & Maintenance	$ 6,400
Vehicles	
Vessel Operation	
Fuel	
MET Stations	
Contracts/CILER	
Other (specify)	
Total Amount	$18,900
Staffing and Ship Time	
Federal Staff	n/a
Contract and CILER Staff	n/a
Total Staff	
Total Ship Time Days	

Budget Explanation

Equipment Replacement $6K; Consumable Supplies $3K; Maintenance of Incubators $1.35K; Gas Cylinder Rental $1.5K; Distilled Water System $2K; Maintenance of Lab Instrumentation $3.5K; Balances and Microscope annual calibration and certification $1.5K

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Marine Instrumentation Laboratory (MIL) Annual Operating Budget
(Ron Muzzi)

Steve Constant (GLERL), Future Hire (GLERL)

Executive Summary

GLERL's Marine Instrumentation Lab develops, maintains, deploys, and services instrumentation packages, moorings, buoys, and towed & autonomous underwater vehicles for high quality oceanographic, biological, chemical, and water resources data collection in support of GLERL's research projects. In consultation with GLERL PI's and their specific project requirements, MIL will provide support in the area of scientific consultation, data collection strategies, instrumentation design including mechanical, electrical, and software design and fabrication, construction of buoys, moorings, towed vehicles, autonomous vehicles, as well as land-based towers and light-house/channel marker mounted instrumentation, the necessary field support to deploy, service, and retrieve the instrumentation, and data processing, quality-control, analysis, and web presentation of collected data and products.

As an area of MIL expertise, MIL also is tasked with the maintenance and calibration of GLERL's field deployed oceanographic instrumentation. According to an ongoing maintenance and calibration schedule, MIL also oversees the contracting out of both manufacturer repairs and NIST certified calibrations as needed.

MIL also maintains and develops the Real-Time Meteorological Observation Network (RTMON) stations at exposed coastal sites and fixed navigational structures around areas of interest in the Great Lakes. This provides water-based meteorological observations, which are not obtainable otherwise, for input into GLERL ecosystem models, such as wave and circulation modeling by the Great Lakes Coastal Forecasting System. In addition, the data is provided in real-time to NWS forecasters, NDBC, GLOS, and the Coast Guard, and to the coastal user community through the GLERL web page. The sites are also used as a platform for advancing technologies, such as webcams used for ground truthing for satellite remote sensing of lake ice and eddy covariance sensors used for over lake evaporation measurements.

Budget Summary	
Item	***Total ($K)***
Equipment	
Supplies	$ 10,000
Services	
Field Travel *(field work)*	$ 1,000
Conference Travel *(conferences e.g. FEW,EEO)*	
Admin Travel *(e.g. Advisory Board meetings, Training)*	
Lease / Taxes / Utilities	
Calibrations, Repairs & Maintenance	$ 26,000
Vehicles	
Vessel Operation	
Fuel	
MET Stations	$ 12,000
Contracts/CILER	
Other (specify)	
Total Amount	$ 49,000
Staffing and Ship Time	
Federal Staff *(2) Total for MIL infrastructure, not scientific projects*	0.6 FTE
Contract and CILER Staff	
Total Staff	**0.6 FTE**
Total Ship Time Days	

Project Details

Personnel Requirements

Ron Muzzi (10%), Steve Constant (10%), Future Hire (10%) – *Note: These are requirements to maintain the MIL infrastructure & RTMON stations, though it is often difficult to precisely draw the line of distinction between working on the various scientific projects and working on the MIL infrastructure since each is integral to the other.*

Work intended to be done

f. Location: Work will take place at GLERL as well as field work throughout the Great Lakes.
g. Hours: Work will usually take place during the regular workweek and regular working hours, except when field conditions and good prudential judgment requires working overtime.
h. Methods: Work will be accomplished through informal meetings with PI's and/or ship crew and discussions among MIL personnel; research and discussion among peers, manufacturers, and other oceanographic service providers; making and drawing up plans and procedures on paper, computer, and with CAD software; writing, debugging, and testing software; electrical and mechanical fabrication with solder tools, hand tools and light duty machine shop; field trips and

boat trips to various stations to deploy and recover buoys, moorings, and other data collection devices and install and service MET stations and radio equipment on towers, light houses, and channel markers, etc.

i. Key resources include:
   - Vessels – season long use of the 2306 small boat.
   - MIL – electronics fabrication area, machine shop, high bay area, and ware-yard.
   - IT – standard support of desktop computers and printers.
   - Editorial, media, graphics, web services, public relations support – web page support is needed for the RTMON & RECON pages

j. Health and safety issues:
   - MIL – The safety issues involving the use of the machine shop, overhead crane, forklift, etc. are extensive but have been fully addressed by the safety officer and satisfied by training, certification, regular inspections, personal protective gear, MSDS (Material Safety Data Sheets), JHA's (Job Hazard Analyses), SOP's (Standard Operating Procedures), engineered protective devices, and other measures.
   - Field activities – The field activities, including small boat use and tower climbing, have been satisfied in the same way.

<u>Budget Explanation</u>

- Staffing: Due to retirements in which those positions have not been refilled, current MIL staffing consists of two federal employees: one engineer and one technician. *(Compare this to previous years when MIL staffing consisted of a supervisor, three engineers, three technicians, and a summer student for a total of eight people!)*
- Staffing: MIL is in the process of hiring a federal employee to work as an engineer/technician.
- Other budgetary considerations include use and maintenance of items such as the MIL pickup truck and the 2306 boat. Field work occasionally requires comp time. The maintenance of the forklift truck is already included in the MIL budget, but is no longer a major expense since the purchase of the new forklift.

<u>Integration</u>

Many of the GLERL internal and external projects are dependent upon the resources and capabilities that MIL provides.

<u>Progress & Project Improvement (project is on-going)</u>

- MIL short-term milestones (FY15): MIL expects to successfully support scientific projects as requested by the PI's and approved. The milestones would be the accomplishment of MIL's role in each particular project.
- MIL long-term goals (2-5 years): MIL expects to improve project data collection techniques by using its expertise in consultation with PI's. MIL also expects to provide incremental improvements in its own infrastructure consisting of the electronics shop, machine shop, high bay area, and ware-yard.
- MIL in FY14, successfully fulfilled the requests of each scientific project. For infrastructure improvement, MIL developed a wireless meter wheel for small boat use and upgraded the high bay area with new workbenches and electrical wiring.
- For MIL problems in FY14, one was the excessive clutter in the high bay area. This was resolved by a good house-cleaning and a re-organizing the lay-out of the area including the purchase of additional workbenches and the installation of electrical outlets on the workbenches. For FY15,

I plan a similar upgrade to MIL by cleaning up my own office and workbench (Ron). ;-) A more significant problem, however, has been lack of personnel, which is being resolved by one new hire, hopefully to be filled in FY15.

- RTMON short-term milestones (FY15):
    - Successfully prototype a quality, high definition, PTZ (pan/tilt/zoom capable) webcam on an RTMON station that is powered by a solar panel.
    - Move the RTMON data collection system from a Windows-based to a Linux-based computer platform.
    - Upgrade the GLERL station so that in addition to operating as a prototype development platform, it will also provide local, accurate weather information that can be highlighted on a web page.
    - Add data from Spectacle Reef Light and White Shoal Light to the RTMON network.
- RTMON long-term goals (2-5 years): Upgrade webcams on all RTMON stations, providing multiple views per station. Add additional stations, including Eddy Covariance stations, as needed according to particular scientific project needs.
- RTMON in FY14, repaired multiple stations replacing anemometers, barometers, and temperature sensors. Added a prototype webcam to the Thunder Bay Island station.
- For RTMON problems in FY14, the main concern has been the calibration of anemometers. This had been done in house for years, but in reviewing the process we have found that it does not result in an NIST-certified calibration. So for FY15 we are planning on sending these sensors back to manufacturer in order to obtain NIST-certified calibrations.

Lake Michigan Field Station Administration, Facilities and Operations

Vessel Operations
(Dennis Donahue)

Executive Summary
The Vessel Operations Branch maintains and operates GLERL's research vessels. Its primary function is the support of scientific fieldwork throughout the Great Lakes as defined by GLERL researchers, collaborators and partner institutions. As a support group within GLERL, the Vessel Operations Branch subscribes to the vision, mission and overarching goals defined by the laboratory's strategic plan with specific goals for best management and strategic capabilities.

Operational details are directly influenced by science direction and annual field support requirements. The branch also acts independently on technical issues, externally funded projects and in areas that advance GLERL's objectives, partnerships or NOAA's interests in the region.

Budget Summary	
Item	***Total ($)***
Equipment (Projects)	$ 47,000
Supplies (Operations)	$ 27,998
Services (Compliance)	$ 18,984
Field Travel *(field work)*	$ 25,000
Conference Travel *(conferences e.g. FEW,EEO)*	
Admin Travel *(e.g. Advisory Board meetings, Training)*	$ 10,000
Lease / Taxes / Utilities	
Calibrations, Repairs & Maintenance	$ 45,000
Vehicles	
Vessel Operation (Hotel – Laurentian 24 hr.)	$ 6,200
Fuel	$138,671
MET Stations	
Contracts/CILER	$265,550
Other (specify)	
Total Amount Requested	$584,403
Approval Amount Deferred	($ 59,400)
Total Amount Approved	**$525,003**
Staffing and Ship Time	
Federal Staff	4.00 FTE
Contract and CILER Staff	3.25 FTE
Total Staff	**7.25 FTE**
Estimated Total Ship Time Days	**546**

Project Details

Personnel Requirements

Key project personnel

Dennis Donahue – VOC, Andrew Yagiela, Tom Joyce, Jack Workman, Beau Braymer, Steve Bawks, Dan Burlingame, Bob Harvey

Summary

Branch efforts are divided between the functional aspects of conducting fieldwork and the management of assets. For this reason, this operations plan is divided into sections on Functional Goals and Asset Management. Both plans must develop in parallel for the branch and laboratory to succeed.

1. Facilitate scientific field requirements
    a. Development and efficient execution of annual cruise schedules, vessel manning plans, equipment inventories and field station resources.
    b. Participate in science initiatives planning and proposal development as a technical resource and to acquire advance notice of future field needs.
    c. Inventory and maintain vessel based instrumentation and gear
2. Security, Safety and Regulatory Compliance
    a. Assure personnel safety through compliance measures, resource maintenance, risk management and personnel training.
    b. Develop best management practices that meet or exceed all regulatory requirements.
    c. Maintain and execute vessel and facility security plans
3. Asset management
    a. Facility and vessel acquisition, maintenance and regulatory compliance.
    b. Develop acquisition and modernization plans for GLERL field resources that anticipate future scientific needs.
    c. Acquire equipment, skills and resources to support efficient, cost effective equipment repair and fabrication.
4. Provide new field science tools and resources
    a. Develop staff resources and skills that enhance field projects
    b. Acquire equipment and design systems that add scientific capabilities
    c. Develop shore facilities to expand lab resources
5. Marine technology initiatives
    a. Develop best management practices and innovations for research vessels
    b. Provide technical leadership and expert information
    c. Advance marine technologies that support NOAA's greater mission
6. Expand customer base
    a. Facilitate the One NOAA initiative through support of Agency interests in the region
    b. Enhance existing partnerships with NOS and Universities
    c. Secure externally funded projects that compliment GLERL interests, acquire new technologies and support operating budgets.

Budget Explanation

FY15 budget details are based upon known requirements and estimates generated from past experience. Table 1 offers a summary of FY15 requests in comparison to FY14 actual with an explanation of changes.

Table 1. Comparison FY14 Actual / FY15 Projected Costs - Detailed by Control Categories

Budget Category	FY14 Actual	FY15 Request	Change	Summary Notation
Hotel (Laurentian 24hr)	$1,979	$6,200	$4,221	Estimates impact of CSMI 24 hr. cruises
Compliance	$10,820	$18,984	$8,164	Increase due to renewal of life rafts
Operations	$23,332	$27,998	$4,666	Increase due to projected mix of platform use
Fed Travel	$33,814	$35,000	$1,186	Rounded historical value
Projects	$50,151	$47,000	($3,151)	FY 14 included some high cost projects. See Table 3. for proposed FY15 projects
R&M	$52,007	$45,000	($7,007)	FY 14 incurred higher than average engine repairs (R5002). FY 15 scheduled R&M is detailed in Table 4.
Fuel	$118,617	$138,671	$20,054	When adjusted for U/M fuel purchase, fuel estimate is level.
Contractors	$235,000	$265,550	$30,550	Reflects estimated cost increase due to change to IDIQ See Table 2 detail
Total	**$525,720**	**$584,403**	**$58683**	

The largest portion of P34 budget has historically been contract labor and the pending change to an IDIQ creates some uncertainty. FY15 contract labor costs are estimated in Table 2.

Table 2. FY 15 Contract Labor Detail

Position	Regular hours	Premium Hours	Travel
Licensed Captain I	2000	200	$3200
Licensed Captain I	1100	100	$1800
Licensed Mate I	2000	200	$3200
Deckhand III	1100	100	$1800
Total Estimated cost	**$265,550**		

Costs associated with planned vessel improvement projects are presented in Table 3. These can be prioritized to match available funds if required.

Table 3. FY15 Vessel Project Detail

Vessel	Capital Projects	Driver	Cost purchased materials/ service
8001	Navigation software	Efficiency	500
	New intercom / closed circuit cameras	Safety	2,500
5501	Navigation software	Efficiency/Quality	500
	Dog house door	Safety/Compliance	4100
	New crane brake	Safety/Compliance	600
	Add Lazarette power vent	Efficiency	160
	Add reserve 24V battery system	Safety	400
	Resolve Stbd engine smoke	Safety/Compliance	4,200
5002	Trawl valve – speed control	Science	6,000
	Navigation software	Efficiency/Quality	500
	Add 12V power supply	Safety/Science	360
	Anemometer	Science	250
	Replace inner cooler/ fuel coolers	Efficiency	3300
	Fab transom payout wheel w/T-count	Science	250
	Add transom wedges	Efficiency	200
	Cutlass run out	Safety	1400
	Add power vent to fwd storage	Safety	150
4105	Replace Engine Mounts	Safety/Compliance	2,000
	New chart plotter	Efficiency/Quality	800
	Anemometer	Science	250
	Replace anchor windlass – hydraulic	Safety/Compliance	900
2604	Replace seats – shock absorbing	Safety	600
2601	Complete engine install		2300
	New navigation package	Safety/Compliance	1500
	Fitout, carriage requirements	Safety/Compliance	1650
	Hydraulic PTO	Science	2750
23XX	Fitout, carriage requirements	Safety/Compliance	1650
	Replace seats – shock absorbing	Safety	600
	Acquire davit &install	Science	300
	Acquire surplus genset &install	Science	1,000
2506	Add Side Scan echo sounder	Science	620
Shop / OPS	TIG Welder	Efficiency	2,600
	Belt / Disc sander	Efficiency / Safety	700
FY 15 Science	Contingency for science requirements	Science	1,500
		Total	**$47,000**

R&M costs ($45,000) that have been identified are included in the attachment but the majority is held as a contingency for unforeseen repairs based upon a five year rolling average.

Integration

The Vessel Operations Plan is fully integrated with all field based projects by GLERL and its partners.

Progress & Project Improvement (if project is continuing / on-going)

Goals Include:

- Zero lost time accidents for all embarked personnel
- Zero lost time due to mechanical failures
- Total group productivity to exceed 70%
- Meet all customer requirements as defined during the planning process

Challenges include

- Improve science field planning and execution
- Resolve personnel allocations, guidance for premium time and work days
- Offsite travel and project assignments
- Improve cost recovery from external projects and partners
- Improve decision making process for mid-season requests
- Establish a long term capital plan that includes platform renewal and growth

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Lake Michigan Field Station Facility Operations

Budget Summary	
Item	***Total ($)***
Equipment	
Supplies	$ 5,000
Services	$25,900
Field Travel *(field work)*	
Conference Travel *(conferences e.g. FEW,EEO)*	
Admin Travel *(e.g. Advisory Board meetings, Training)*	
Lease / Taxes / Utilities	$30,700
Calibrations, Repairs & Maintenance	$ 900
Vehicles	
Vessel Operation	
Fuel	
MET Stations	
Contracts/CILER	
Total Amount	$62,500

LMFS - Facilities Budget Details

	Budget FY12	Spent FY12	Budget FY13	Spent FY13	Budget FY14	Spent FY14	Budget FY15	Spent FY15
N8R3SS1P32 - UTILITIES/MUSKEGON								
Office Supplies	$3,500	$207	$3,500	$2,548	$3,000	$246	$3,000	$0
General Supplies	$1,500	$2,799	$2,500	$1,866	$2,000	$1,307	$2,000	$0
UPS	$900	$952	$950	$292	$950	$225	$500	$0
Janitorial Service	$12,500	$23,022	$14,500	$6,710	$14,500	$13,738	$10,000	$0
Snow Removal	$9,000	$8,450	$9,000	$8,140	$8,500	$4,420	$12,000	$0
Pest Control	$700.00	$294.00	$1,400.00	$450	$1,150	$407	$1,200	$0
Copier	$1,500.00	$1,987.00	$2,000.00	$2,051	$2,100	$2,089	$2,200	$0
Fire Systems - maint/inspections	$900	$775	$900	$608	$900	$448	$900	$0
Safety Items	Note	Note						
Consumers Energy	$16,000.00	$12,822.00	$16,000.00	$11,471	$14,000	$13,733	$14,500	$0
DTE Gas	$8,000	$5,766	$8,000	$6,393	$7,000	$7,055	$8,000	$0
Water/Sewer	$450	$494	$500	$549	$600	$1,522	$700	$0
Waste	$2,150	$2,131	$2,400	$2,758	$3,000	$3,364	$3,500	$0
Phone	$8,000	$6,968	A	$3,684	$4,000	$3,463	$4,000	$0
End of FY Funds Returned	Prior YR	Prior YR	Prior YR	$22,000	Prior YR	$2,000	Prior YR	$0
Totals	**$65,100**	**$66,667**	**$61,650**	**$69,520**	**$61,700**	**$54,016**	**$62,500**	**$0**

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Lake Michigan Field Station Facility Projects

Budget Summary	
Item	***Total ($)***
Equipment	
Supplies	
Services	
Field Travel *(field work)*	
Conference Travel *(conferences e.g. FEW,EEO)*	
Admin Travel *(e.g. Advisory Board meetings, Training)*	
Lease / Taxes / Utilities	
Calibrations, Repairs & Maintenance	$41,800
Vehicles	
Vessel Operation	
Fuel	
MET Stations	
Contracts/CILER	
Total Amount	$41,800

LMFS – Building Project Details

	Budget FY12	Spent FY12	Budget FY13	Spent FY13	Budget FY14	Spent FY14	Budget FY15	Spent FY15
N8R3SS1P36 - FACILITIES/MUSKEGON								
Facility Repairs	$6,500	$5,501	$8,000	$6,471	$8,000	$13,821	$14,000	$1,507
Bldg 2 Construction	$25,000	$23,759	$10,000	$3,101	$0	$0	$0	$0
Storage Bldg 2	$2,000	$1,982	$2,000	$1,127	$200	$162	$0	N/A
Painting	$6,000	$5,875	$5,000	$0	$16,000	$1,900	$14,000	$0
Office Furniture	$4,500	$4,500	$22,000	$18,499		$0		$0
Bldg 3	Tabled	Tabled	$5,000	$0	$12,000	$1,757	TBD	TBD
Roof Repairs (est.,)	$5,000	$5,000	$5,000	$0	$2,500	$300	$2,500	$0
Miscellaneous					$11,300		$11,300	$0
End of FY Funds Returned	Prior YR	Prior YR	Prior YR	$25,500	Prior YR	$30,000	Prior YR	TBD
Total	**$49,000**	**$46,617**	**$57,000**	**$54,699**	**$50,000**	**$47,940**	**$41,800**	**$1,507**
Grand Total	**$114,100**	**$113,284**	**$118,650**	**$124,219**	**$111,700**	**$101,955**	**$104,300**	**$1,507**

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Lake Michigan Field Station Lab Operations
(Steve Pothoven)

Budget Summary	
Item	***Total ($K)***
Equipment	$ 4,000
Supplies	$ 7,000
Services	$ 300
Field Travel *(field work)*	
Conference Travel *(conferences e.g. FEW,EEO)*	
Admin Travel *(e.g. Advisory Board meetings, Training)*	
Lease / Taxes / Utilities	
Calibrations, Repairs & Maintenance	$ 5,000
Vehicles	
Vessel Operation	
Fuel	
MET Stations	
Contracts/CILER	$75,000
Other (specify)	
Total Amount	$91,3000

<u>Budget Explanation</u>
Supplies:

- Lab supplies for general field use and lab maintenance and to replace supplies used by non LMFS researchers, parts, DI water filters, forceps, niskin bottle repair lab chemicals, oxygen, benchtop fluorometers, chl standards, etc.
- Disposal of used chemicals

Maintenance of equipment: Routine service / calibrations on calorimeter, fluorometer, scopes, CTD and balance

Equipment:

- Replace calorimeter vessels if they fail inspection
- Replace aging image analysis software that is no longer supported
- Chemical storage cabinets

Personnel: Lab tech contract support