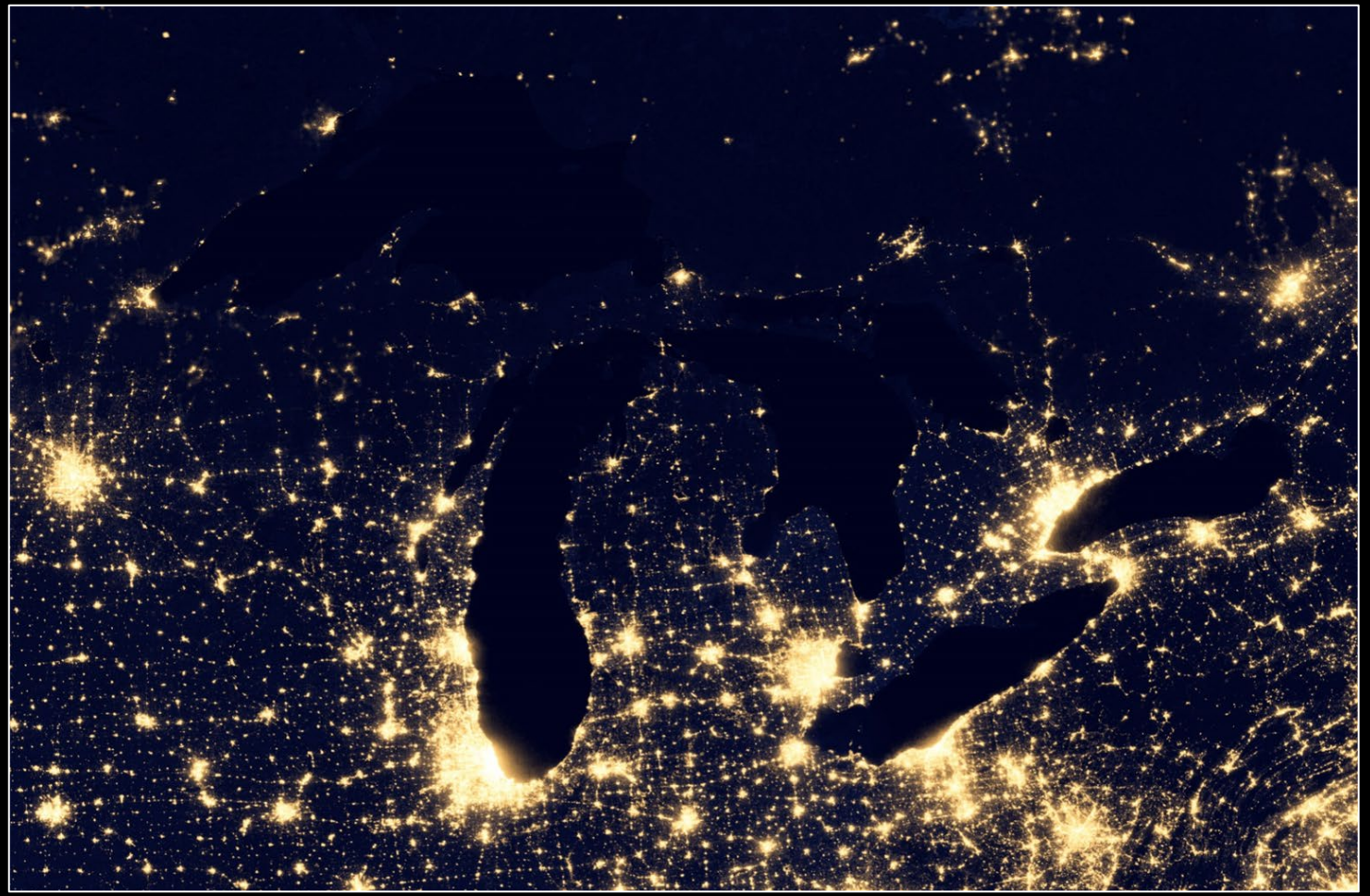
Great Lakes Science: Status and Future

Robert W. Sterner

University of Minnesota Duluth

stern007@d.umn.edu

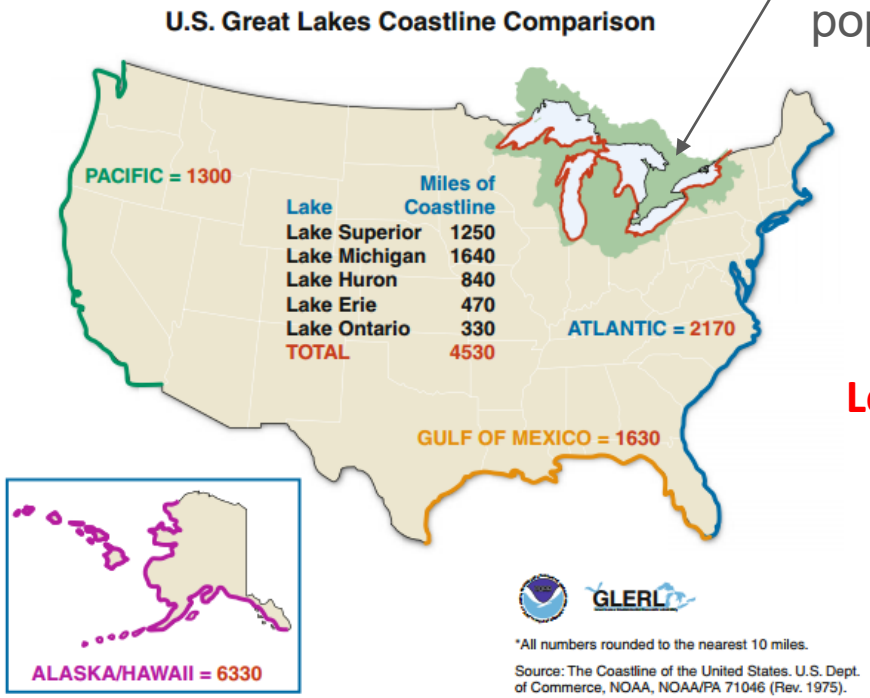
Urban Seas and Coastal Oceans Research Priorities



The Fresh Coast

10% of US and Canada population

$6 trillion GDP*
51 million jobs at
$1.3 trillion employment



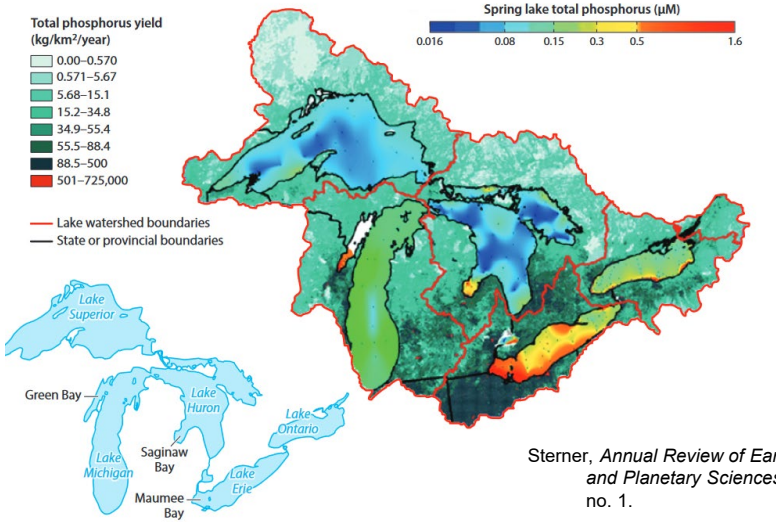
LGL contain ~20% of Earth's liquid surficial fresh water - largest freshwater system on Earth

Lengths depend on scale, but here
∑ marine lower US = 5100
∑ GL = 4530

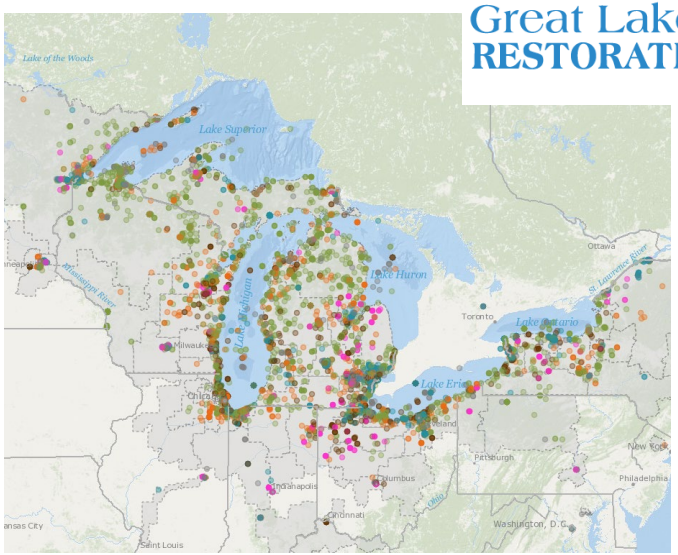
Gronewold et al. 2013

*3rd largest in world, after US and China

The Great Lakes are a **scientific test bed**, with wide ranges in conditions in a single connected and bounded system. Key areas of strength relevant to urban seas and coastal priorities include



Sterner, *Annual Review of Earth and Planetary Sciences* 49, no. 1.



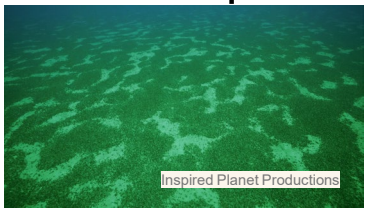
Great Lakes RESTORATION

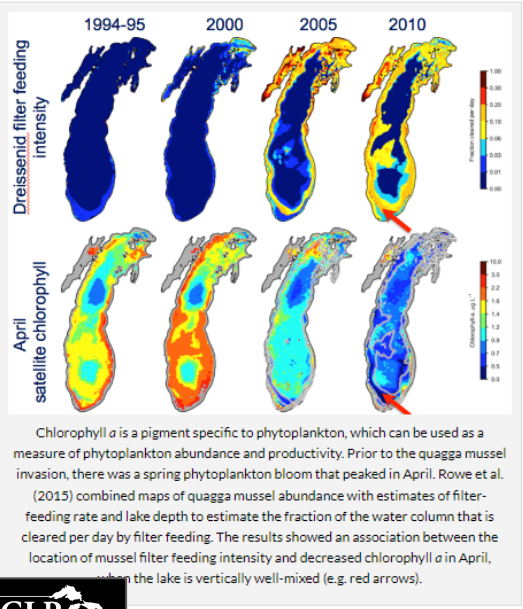
Strongly developed land to water perspectives

Highly developed restoration practices

LGL further offer systems with rapid time scales of change

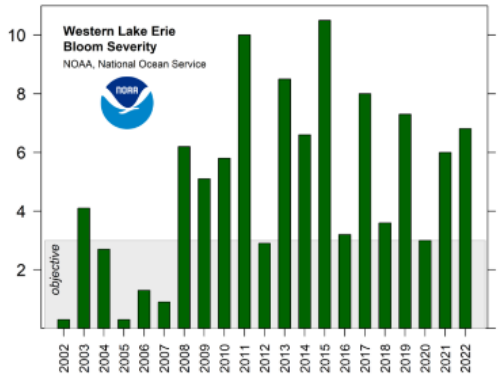
Invasive species





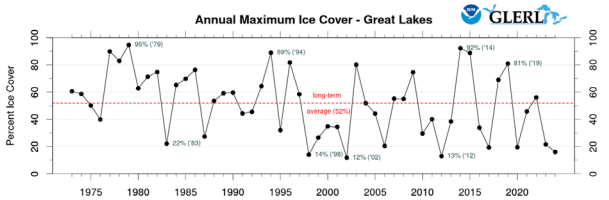
Chlorophyll *a* is a pigment specific to phytoplankton, which can be used as a measure of phytoplankton abundance and productivity. Prior to the quagga mussel invasion, there was a spring phytoplankton bloom that peaked in April. Rowe et al. (2015) combined maps of quagga mussel abundance with estimates of filter-feeding rate and lake depth to estimate the fraction of the water column that is cleared per day by filter feeding. The results showed an association between the location of mussel filter feeding intensity and decreased chlorophyll *a* in April, when the lake is vertically well-mixed (e.g. red arrows).

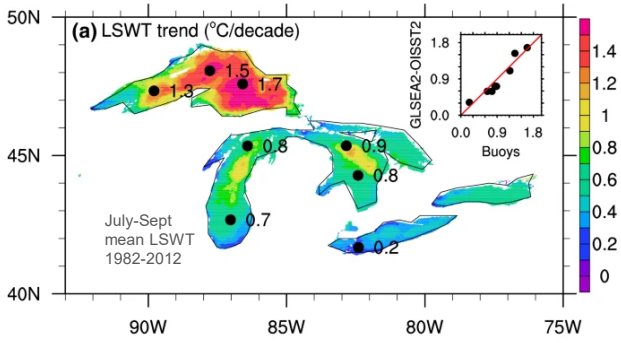
Algal blooms



Bloom severity index (SI) for 2002-2022. The SI is based on the amount of biomass over the peak 30-days. The 2022 bloom had a severity of 6.8.

Climate Warming

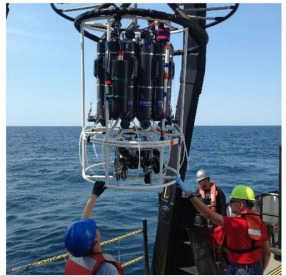


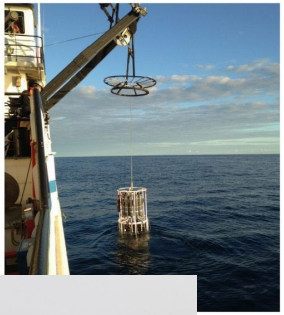


Zhong, Yafang, Michael Notaro, and Stephen J. Vavrus. "Spatially Variable Warming of the Laurentian Great Lakes: An Interaction of Bathymetry and Climate." *Climate Dynamics* 52, no. 9 (May 1, 2019): 5833–48.

CIGLR

Great Lakes science requires oceanographic tools





Current GL Science Shortcomings

Need for time series studies
Aging, outdated ships
Ice-capabilities
Workforce (development → employment)
Academic scientist participation

Primarily Mission-driven, federal employees

USGS science for a changing world

NOAA National Oceanic and Atmospheric Administration U.S. Department of Commerce

EPA United States Environmental Protection Agency

Great Lakes Fishery Commission — Protecting Our Fishery

USDA

U.S. Fish & Wildlife Service

Fundamental, mainly University-based

NSF U.S. National Science Foundation

NSF OCE awards search
Orig award date
1/1/2018-12/31/2023

$ to date

“Great Lakes” “Lake Superior”
“Lake Huron” “Lake Michigan”
“Lake Erie” “Lake Ontario”

$14 million,
30 projects,
incl. ship time
(0.67% of
OCE total)

Great Lakes science planning - we are in a new era

Examples:

great lakes observing system

Common Strategy for Smart Great Lakes

Understanding and managing the re-eutrophication of Lake Erie: Knowledge gaps and research priorities

Mohamed N. Mohamed[1,10], Christopher Wellen[2,11], Chris T. Parsons[3,12], William D. Taylor[4,13], George Arhonditsis[5,14], Krista M. Chomicki[6,15], Duncan Boyd[7,16], Paul Weidman[8,17], Scott O. C. Mundle[8,18], Philippe Van Cappellen[3,19], Andrew N. Sharpley[9,20], and Douglas G. Haffner[8,21]

Freshwater Science 38, no. 4 (December 1, 2019): 675–91.

LIMNOLOGY and OCEANOGRAPHY

ASLO

Limnol. Oceanogr. 62, 2017, 2510–2523

doi: 10.1002/lno.10585

Grand challenges for research in the Laurentian Great Lakes

Robert W. Sterner,[1]* Peggy Ostrom,[2] Nathaniel E. Ostrom,[2] J. Val Klump,[3] Alan D. Steinman,[4] Erin A. Dreelin,[5] M. Jake Vander Zanden,[6] Aaron T. Fisk[7]

[1]Large Lakes Observatory, University of Minnesota Duluth, Duluth, Minnesota
[2]Department of Integrative Biology, Michigan State University, East Lansing, Michigan
[3]School of Freshwater Sciences, University of Wisconsin Milwaukee, Milwaukee, Wisconsin
[4]Annis Water Resources Institute, Grand Valley State University, Muskegon, Michigan
[5]Department of Fisheries and Wildlife, Michigan State University, East Lansing, Michigan
[6]Center for Limnology and Department of Zoology, University of Wisconsin-Madison, Madison, Wisconsin
[7]Great Lakes Institute for Environmental Research, University of Windsor, Windsor, Ontario, Canada

AGU100 ADVANCING EARTH AND SPACE SCIENCE

Earth's Future

COMMENTARY

10.1029/2018EF000870

The Need for an Integrated Land-Lake-Atmosphere Modeling System, Exemplified by North America's Great Lakes Region

A. Sharma[1,2], A. F. Hamlet[2], H. J. S. Fernando[2], C. E. Catlett[3,4], D. E. Horton[5], V. R. Kotamarthi[6], D. A. R. Kristovich[7], A. I. Packman[8], J. L. Tank[9], and D. J. Wuebbles[10]

Key Points:

- Land-lake-atmosphere interactions impact human and natural systems in regions such as the North American

International Joint Commission

The IJC “resolves disputes between the United States of America and Canada under the 1909 Boundary Waters Treaty and pursues the common good of both countries as an independent and objective advisor to the two governments. Six commissioners appointed by the highest levels of government.

The Great Lakes Science Advisory Board provides advice on research to the IJC.

IJC Science Planning

Science Strategy calls dor:

- **Basic Process Research**
- **Monitoring and Time Series**
- **Models and Forecasts**
- **Human Capital**
- **Inclusion**

Next step:

Develop a Generational Science Plan, based on a collaborative and with timeline of 1.5 y

But the Great Lakes are invisible in some key places

How open is the door to funding?

About the Division of Ocean Sciences (OCE)

The Division of Ocean Sciences supports research, infrastructure, and education to advance understanding of all aspects of the global oceans and ocean basins, including their interactions with people and the integrated Earth system. These activities provide knowledge critical to addressing many of our nation's most pressing challenges involving earth processes. OCE supports and promotes collaboration and facilitates development of a diverse scientific and educational community, including international efforts. The Division works with the U.S. ocean sciences academic community to direct funding towards advancing the frontiers of knowledge, developing the next generation of researchers, and enhancing the public's understanding of ocean sciences. The Division represents this community in the Federal context, coordinates with other Federal agencies and with international partners on research funding and infrastructure management, and participates in development of policy through national and international forums and programs.

2025-2035 Decadal Survey of Ocean Sciences for the National Science Foundation

SHARE

My recommendations to NASEM Committee

- Familiarize yourself with existing GL science planning documents - Reach out to IJC and coordinate
- Incorporate that existing science planning about the GL into your report and refer to it - where are recommendations the same? different?
- Help to increase the visibility of the Great Lakes within the oceanographic community