USGS Great Lakes Science Center Research & Examples of Remote Sensing Applications

Russell M. Strach,
Center Director

May 7, 2014

(David “Bo” Bunnell)

U.S. Department of the Interior
U.S. Geological Survey

Outline

I. **USGS-GLSC Program Overview**

II. **Controlling *Phragmites***

III. **Estimating global freshwater fish production**

IV. **Describing fish spawning habitat**

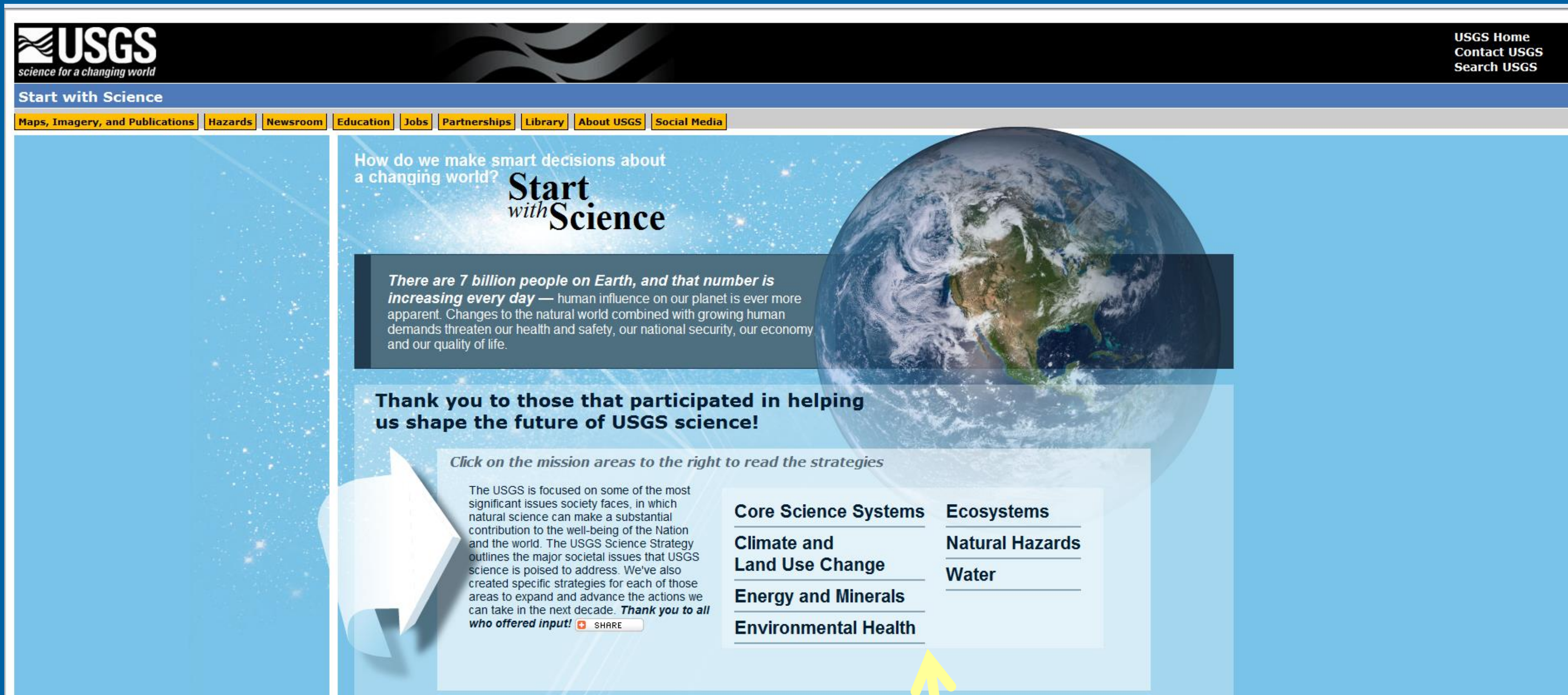
V. **Water quantity trends**

USGS

- **Regional Structure**

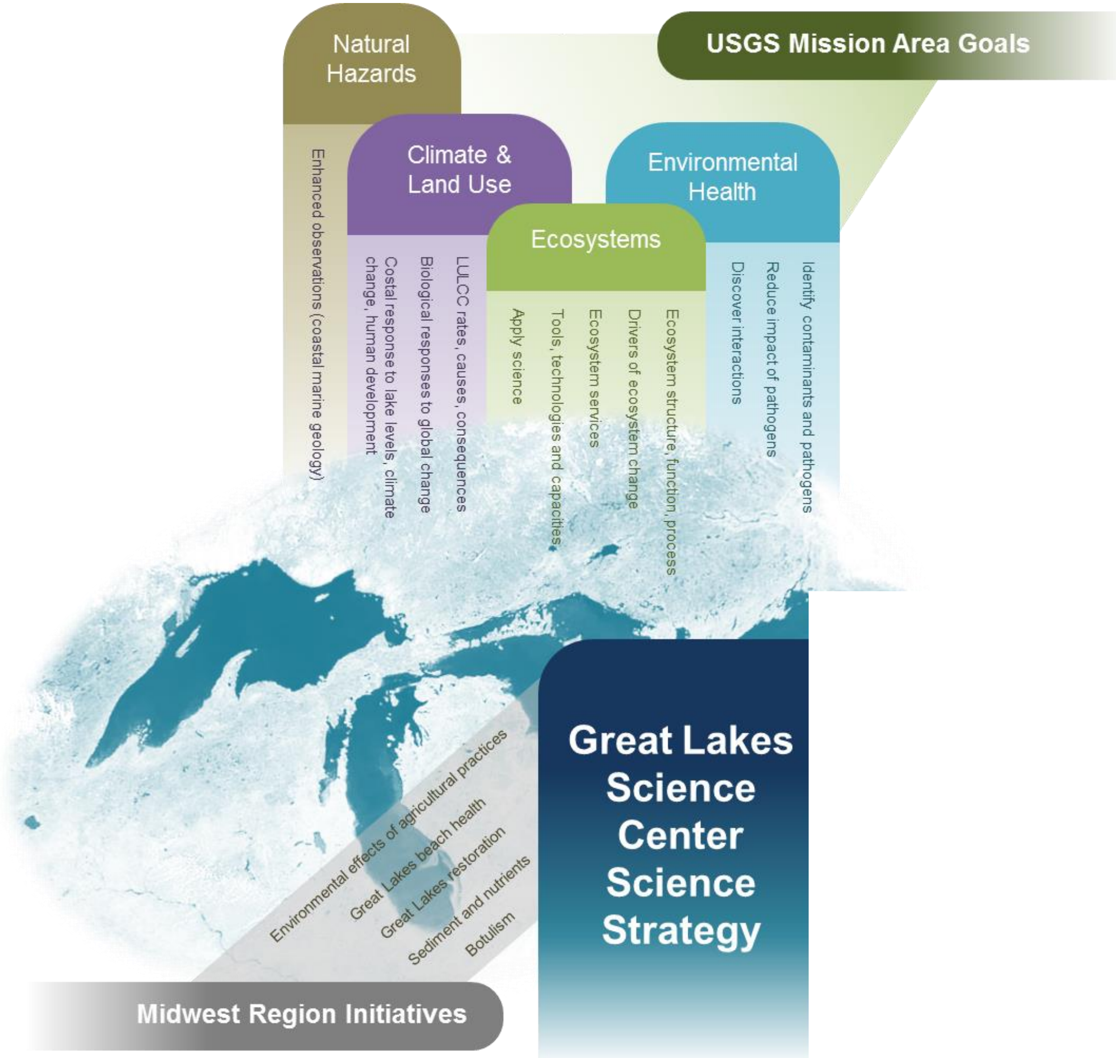
- **GLSC one of 18 centers in the Midwest region**

USGS



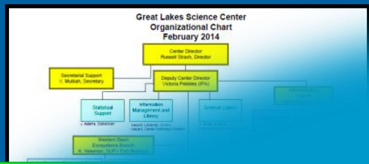
7 USGS Mission Areas

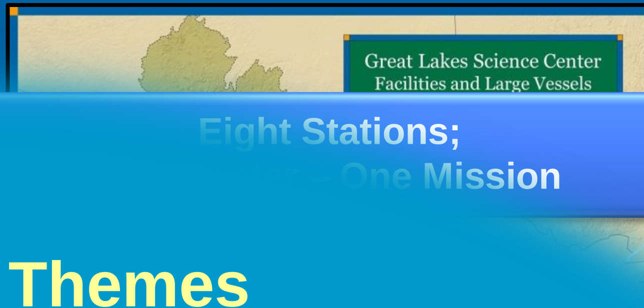
GLSC Science Organization meshes with regional and national priorities



Geographical Extent

Supervisory Structure



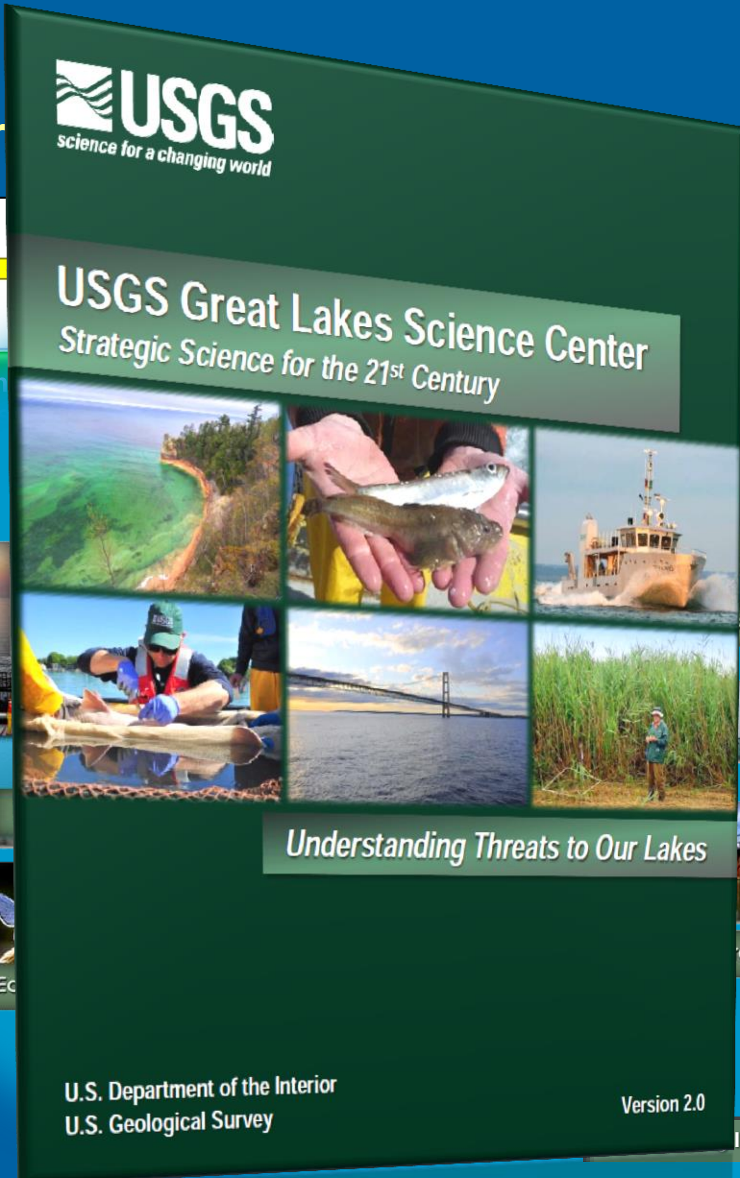


Eight Stations;
One Mission

Western

Six Science Themes

Emerging Issues



GLSC Science Strategy

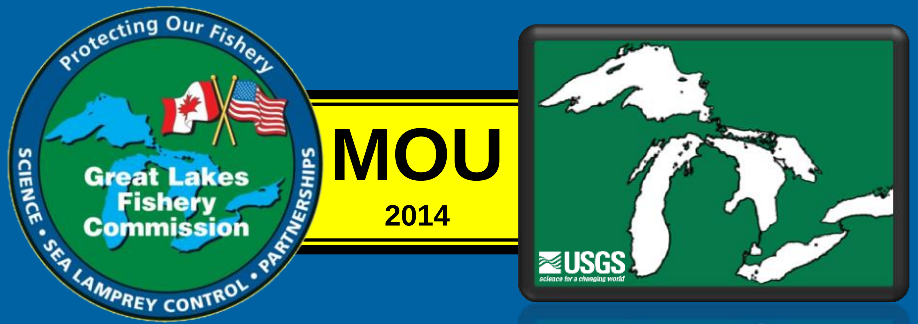
Version 2.0

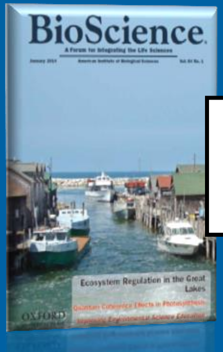
March 2014

Deepwater Ecosystems

Highlights

- New MOU cleared for signature with GLFC
- 3 new vessels since 2012
- *Bioscience* paper
- Great Lakes Acoustic Telemetry Observation System (GLATOS)
- Advanced technologies partnership w/ ICES & MBARI





Changing Ecosystem Dynamics in the Laurentian Great Lakes: Bottom-Up and Top-Down Regulation

USGS

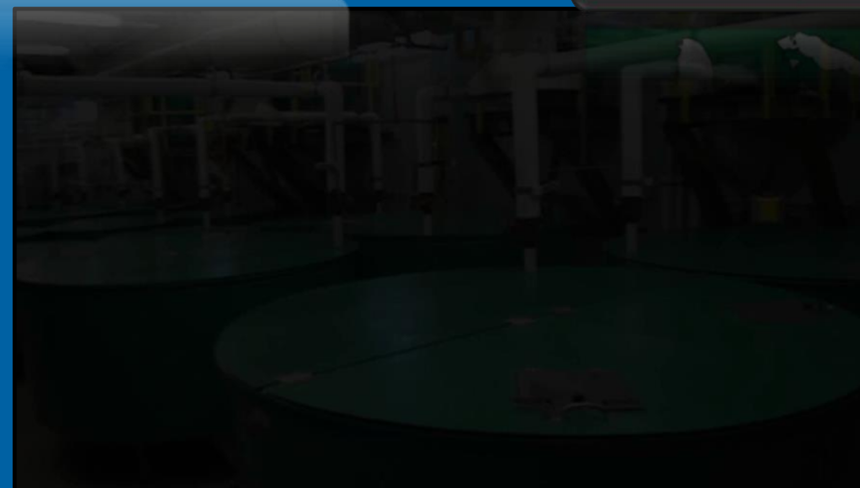
Coastal Ecosystems

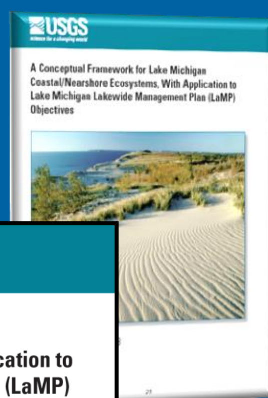
Highlights

- New MOU with GLC
- New Ann Arbor Wet Lab
- New leadership to HABs/ hypoxia science
- Coastal nearshore framework
- Rivermouth science trying to fill existing knowledge gaps

Great Lakes Commission des Grands Lacs

MOU
2014





USGS
science for a changing world

A Conceptual Framework for Lake Michigan Coastal/Nearshore Ecosystems, With Application to Lake Michigan Lakewide Management Plan (LaMP) Objectives

Great Lakes rivermouth ecosystems: Scientific synthesis and management implications

James H. Larson[a,*], Anett S. Trebitz[b], Alan D. Steinman[c], Michael J. Wiley[d], Martha Carlson Mazur[e], Victoria Pebbles[f], Heather A. Braun[f], Paul W. Seelbach[g]

USGS

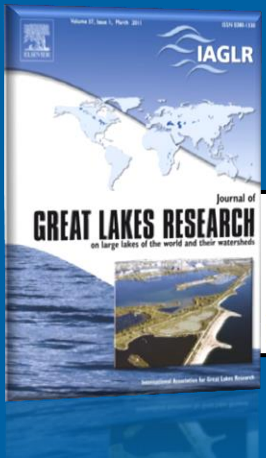
Environmental Health

Highlights

- **Beach health**
  - **predictive modeling for closures**
  - **Identifying pathways by which pathogens contaminate and pose risk**
- **Avian botulism outbreaks**
  - **Identifying the pathways**
  - **Recent study identified linkage to lake level and water temperature.**

Beach Monitoring Criteria: Reading the Fine Print

Meredith B. Nevers* and Richard L. Whitman



Links between type E botulism outbreaks, lake levels, and surface water temperatures in Lake Michigan, 1963–2008

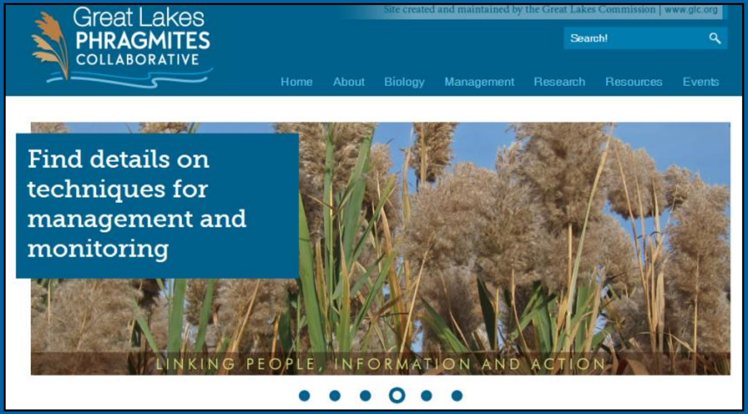
Brenda Moraska Lafrancois [a,1], Stephen C. Riley [b,*], David S. Blehert [c,2], Anne E. Ballmann [c,3]

[a] National Park Service, St. Croix Watershed Research Station, 16910 152nd St. N, Marine on St. Croix, MN 55047, USA
[b] U. S. Geological Survey, Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI 48105, USA
[c] U. S. Geological Survey, National Wildlife Health Center, 6006 Schroeder Rd., Madison, WI 53711, USA

Invasive Species

Highlights

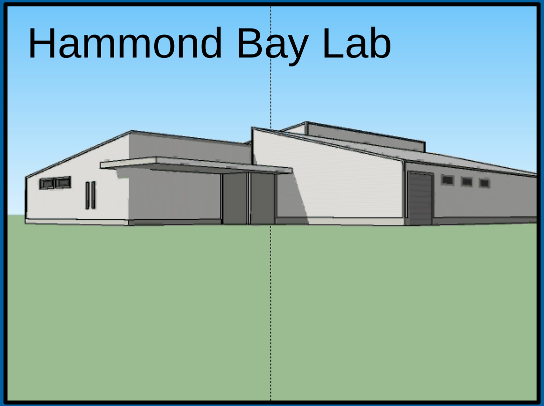
- **Sea lamprey control**
  - New Hammond Bay lab
  - Attractants
  - Expanding pheromone use
- **Alewife effects on native fishes**
- ***Phragmites* control**



Blocking and guiding adult sea lamprey with pulsed direct current from vertical electrodes

Nicholas S. Johnson*, Henry T. Thompson, Christopher Holbrook, John A. Tix

USGS, Great Lakes Science Center, Hammond Bay Biological Station, 11188 Ray Road, Millersburg, MI 49759, USA



A synthesized mating pheromone component increases adult sea lamprey (*Petromyzon marinus*) trap capture in management scenarios

Nicholas S. Johnson, Michael J. Siefkes, C. Michael Wagner, Heather Dawson, Huiyong Wang, Todd Steeves, Michael Twohey, and Weimin

USGS

Restoration Ecology

Highlights

- **Huron-Erie Corridor Initiative**
  - Adaptive management approach to restoring fish habitat
  - Constructing 3rd reef

- **Lake Ontario fish restoration**
  - Raising native bloater and cisco for stocking

- **Pollinator threats**
  - Recent *Ecological Applications* paper identified habitat and climate threats to bees on national park lands

- **Wetland Connectivity**
  - Western L. Erie Coastal Wetland Restoration Assessment

HURON-ERIE CORRIDOR INITIATIVE

Journal of Applied Ichthyology

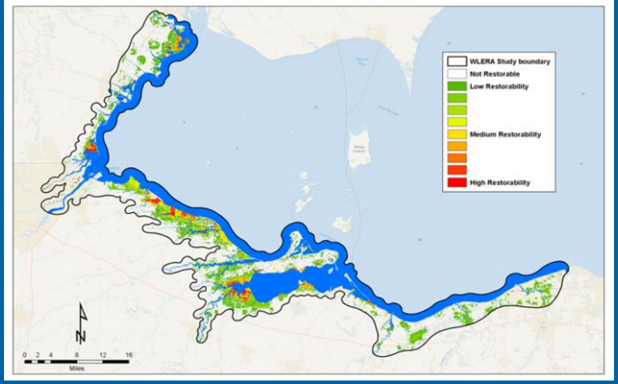
Lake sturgeon response to a spawning reef constructed in the Detroit river

By E. F. Roseman[1], B. Manny[1], J. Boase[2], M. Child[3], G. Kennedy[1], J. Craig[1], K. Soper[4] and R. Drouin[4]

Ecological APPLICATIONS

Floral and nesting resources, habitat structure, and fire influence bee distribution across an open-forest gradient

Ralph Grundel,[1,3] Robert P. Jean,[2] Krystalynn J. Frohnapple,[1] Gary A. Glowacki,[1,4] Peter E. Scott,[2] and Noel B. Pavlovic[1]



USGS

GLSC Unique Capabilities

- 8 Field Stations – basin-wide coverage
- Deepwater, nearshore, and terrestrial programs
  - Large & small vessel fleets
- Fish rearing and aquatic research labs (3)
- Genetics labs (2)
- Long-term databases (e.g., prey fish)



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Sustainable Management of Invasive *Phragmites*: Are There New Options on the Horizon?

Dr. Kurt Kowalski
USGS – Great Lakes Science Center
1451 Green Road
Ann Arbor, MI 48105
734/214-9308; kkowalski@usgs.gov

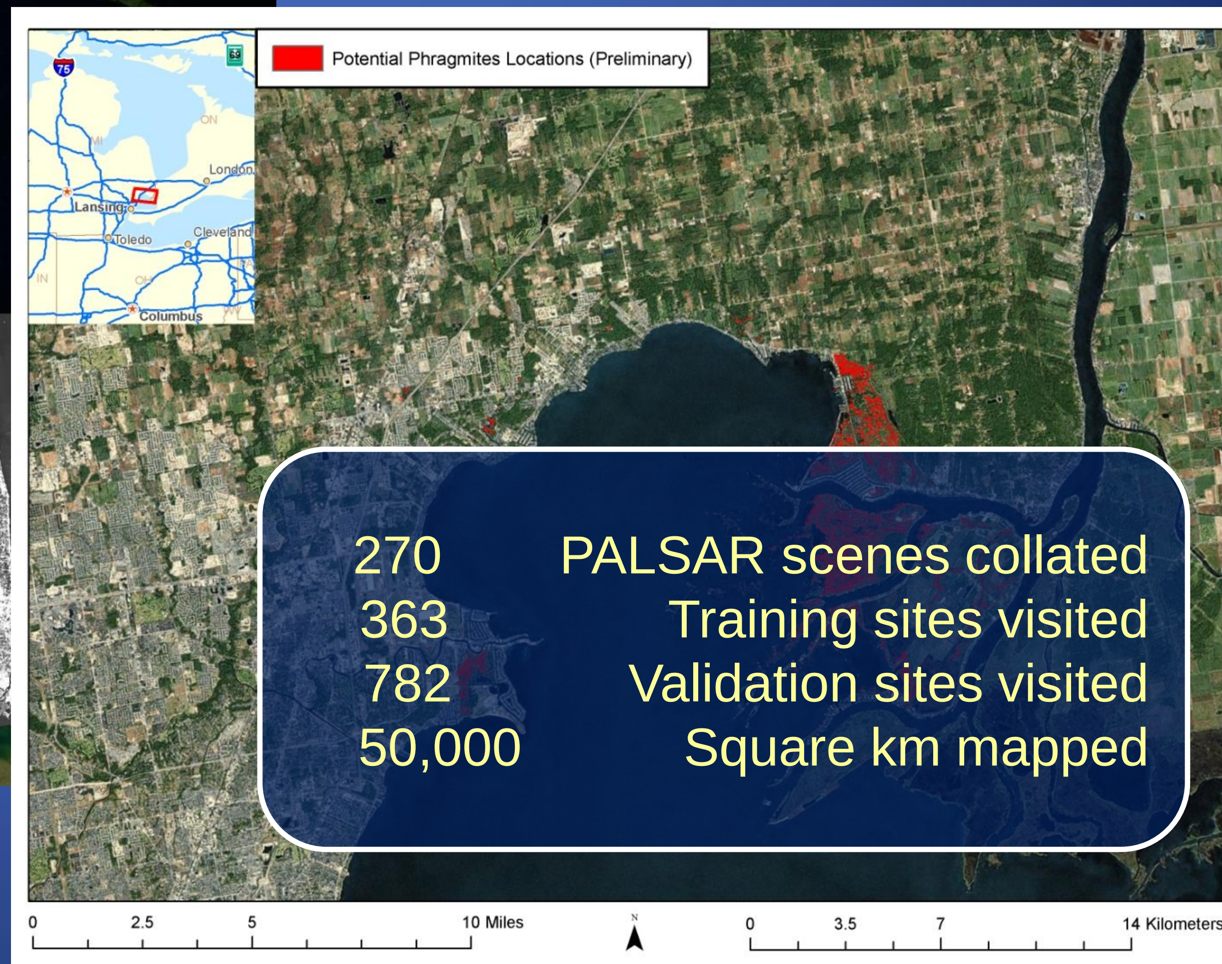
Conceptual Framework

- Where is it?
  - Map

From 2009-2010 radar …

… to *Phragmites*

Data source:
Alaska Satellite Facility



270	PALSAR scenes collated
363	Training sites visited
782	Validation sites visited
50,000	Square km mapped

Current *Phragmites* Extent (US)

Journal of Great Lakes Research Supplement 39 (2013) 65–77

Contents lists available at ScienceDirect

Journal of Great Lakes Research

journal homepage: www.elsevier.com/locate/jglr

ELSEVIER

IAGLR

Mapping invasive *Phragmites australis* in the coastal Great Lakes with ALOS PALSAR satellite imagery for decision support

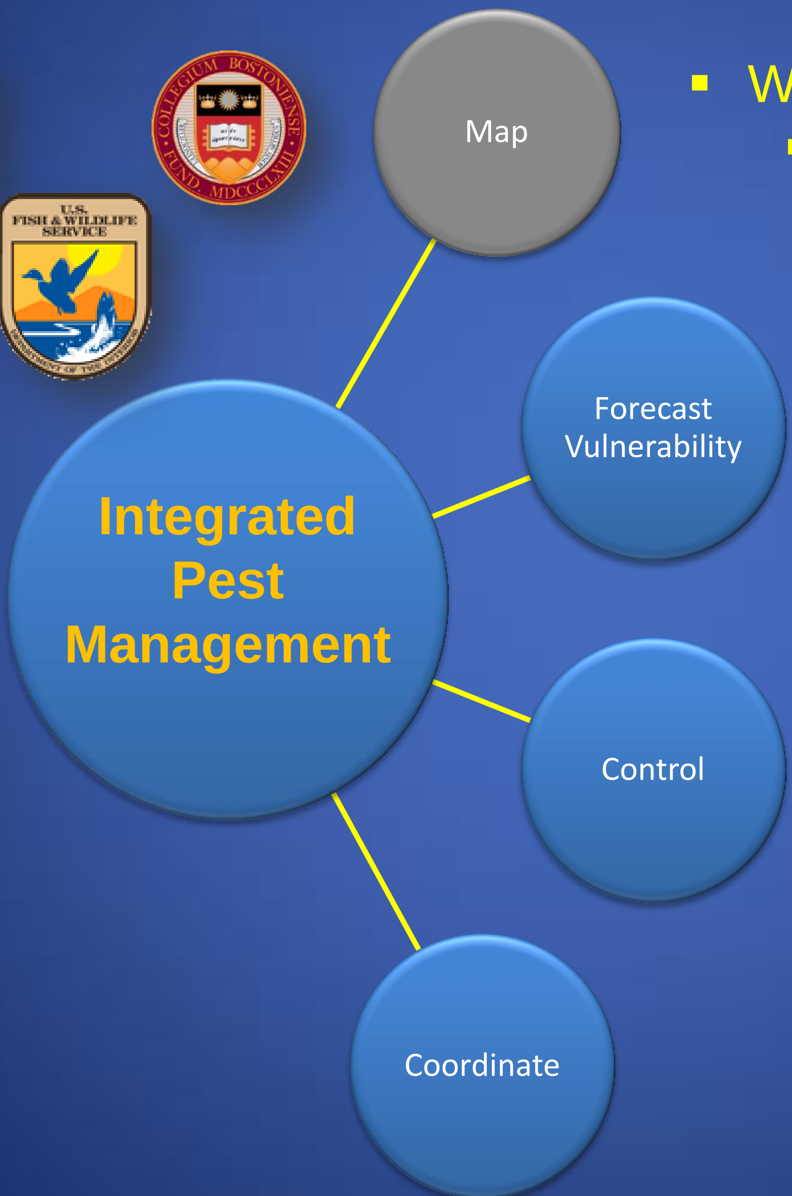
Laura L. Bourgeau-Chavez [a,*], Kurt P. Kowalski [b,1], Martha L. Carlson Mazur [c,2], Kirk A. Scarbrough [a], Richard B. Powell [a], Colin N. Brooks [a], Brian Huberty [d,3], Liza K. Jenkins [a], Elizabeth C. Banda [a], David M. Galbraith [b], Zachary M. Laubach [a], Kevin Riordan [a]

[a] Michigan Tech Research Institute, Michigan Technological University, 3600 Green Ct., Suite 100, Ann Arbor, MI 48105, USA
[b] U.S. Geological Survey, Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI 48105, USA
[c] Earth and Environmental Sciences, Boston College, Devlin 213, 140 Commonwealth Avenue, Chestnut Hill, MA 02467, USA
[d] US Fish & Wildlife Service Region 3 Ecological Services, 5600 American Blvd, West, Suite 990, Bloomington, MN 55437-1173, USA

USGS

MMU = 0.2 hectare, or 0.5 acre
overall mapping accuracy ~87%

Conceptual Framework

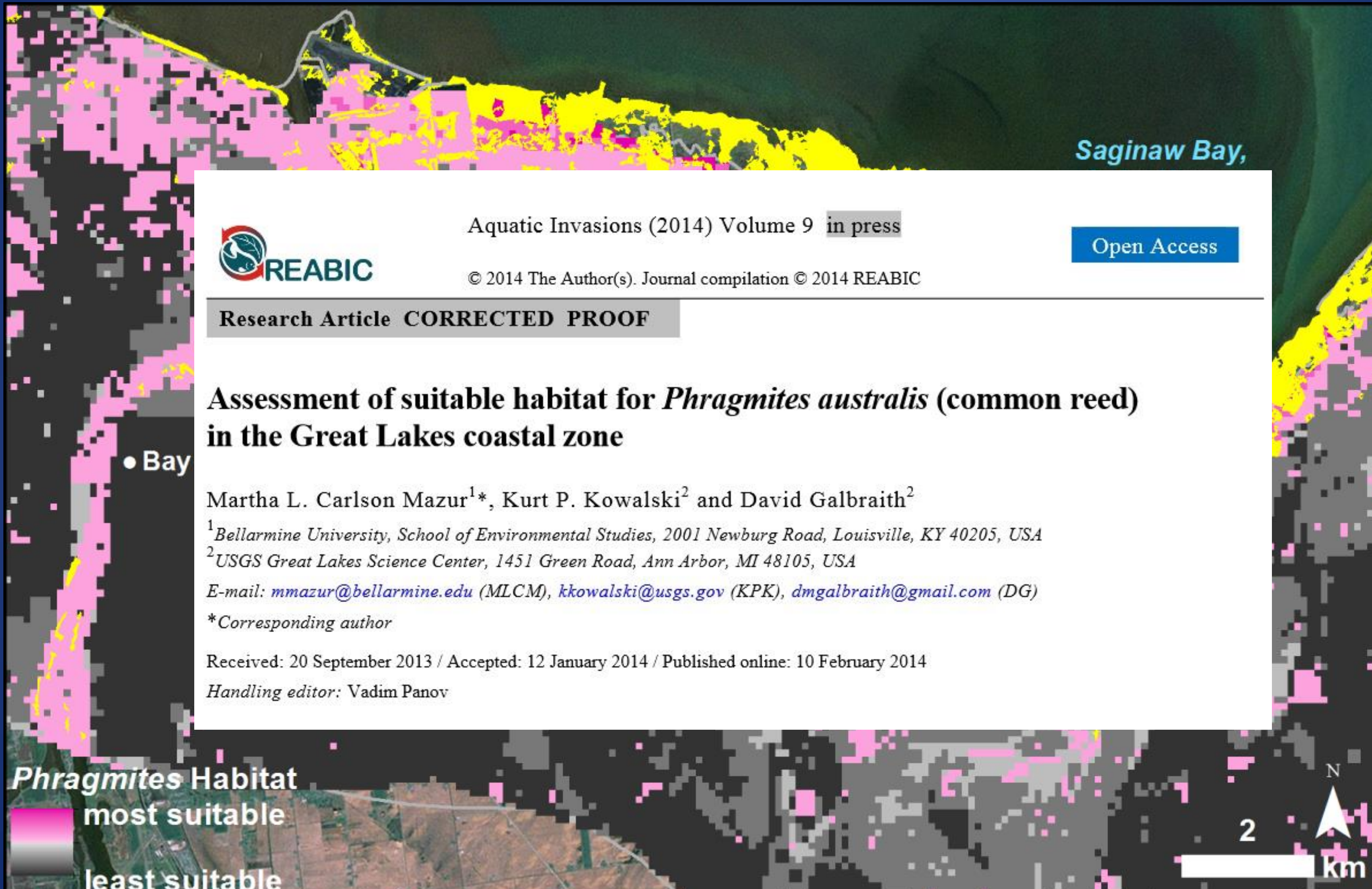


- Where is it?
  - Map
- Where could it go in coastal zone?
  - Vulnerability
  - DST

Existing *Phragmites* stands…

USGS

…and habitat suitability index



Aquatic Invasions (2014) Volume 9 in press

REABIC

Open Access

Research Article CORRECTED PROOF

Assessment of suitable habitat for *Phragmites australis* (common reed) in the Great Lakes coastal zone

Martha L. Carlson Mazur[1]*, Kurt P. Kowalski[2] and David Galbraith[2]

[1]*Bellarmine University, School of Environmental Studies, 2001 Newburg Road, Louisville, KY 40205, USA*
[2]*USGS Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI 48105, USA*

E-mail: mmazur@bellarmine.edu *(MLCM)*, kkowalski@usgs.gov *(KPK)*, dmgalbraith@gmail.com *(DG)*

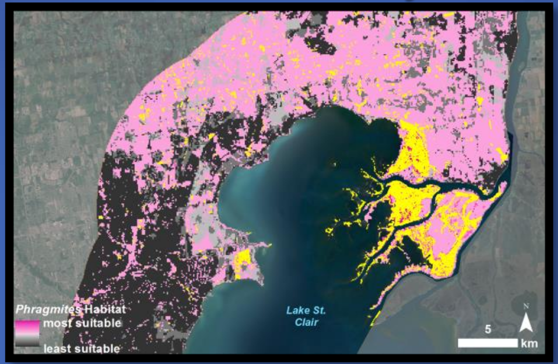
**Corresponding author*

Received: 20 September 2013 / Accepted: 12 January 2014 / Published online: 10 February 2014

Handling editor: Vadim Panov

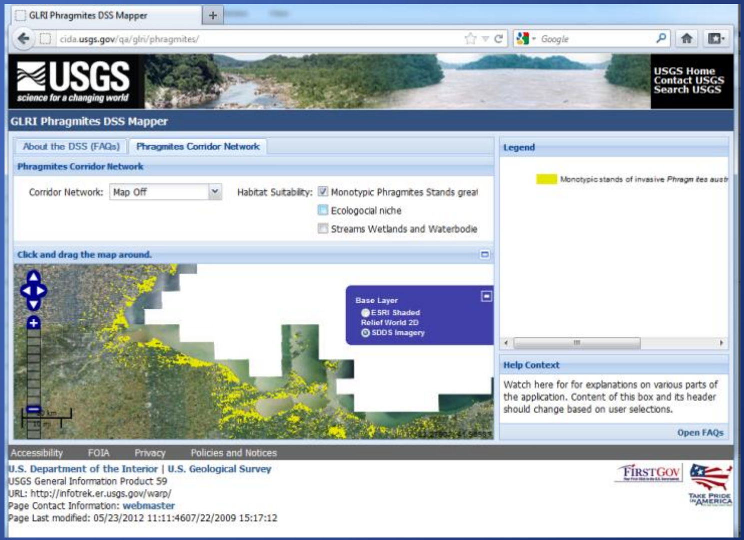
Decision Support for *Phragmites* control

Habitat Suitability Index



Phragmites Distribution

Decision Support Tool



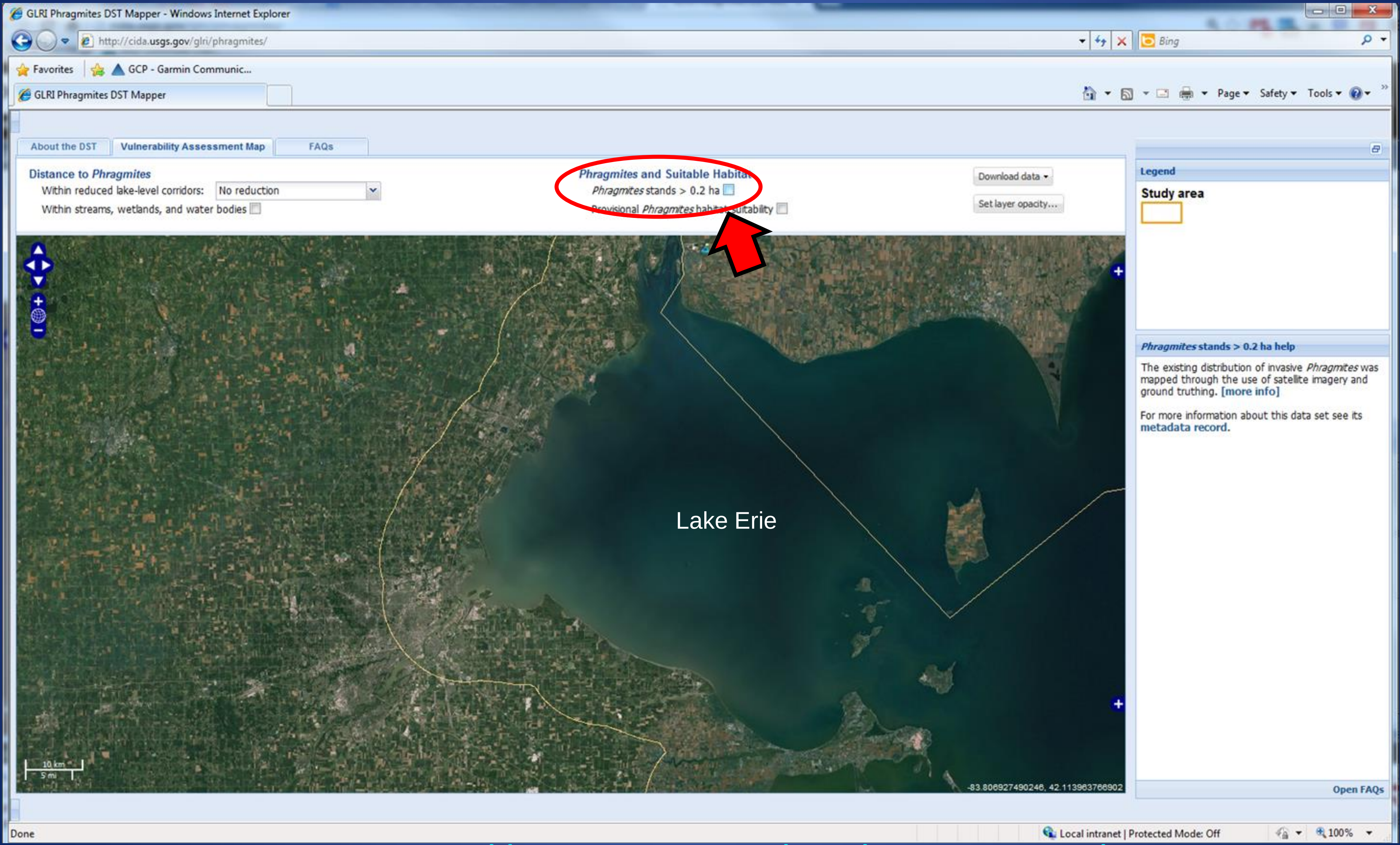
USGS

URL: http://cida.usgs.gov/glri/phragmites/

Online Decision Support Tool

URL: http://cida.usgs.gov/glri/phragmites/

Online Decision Support Tool



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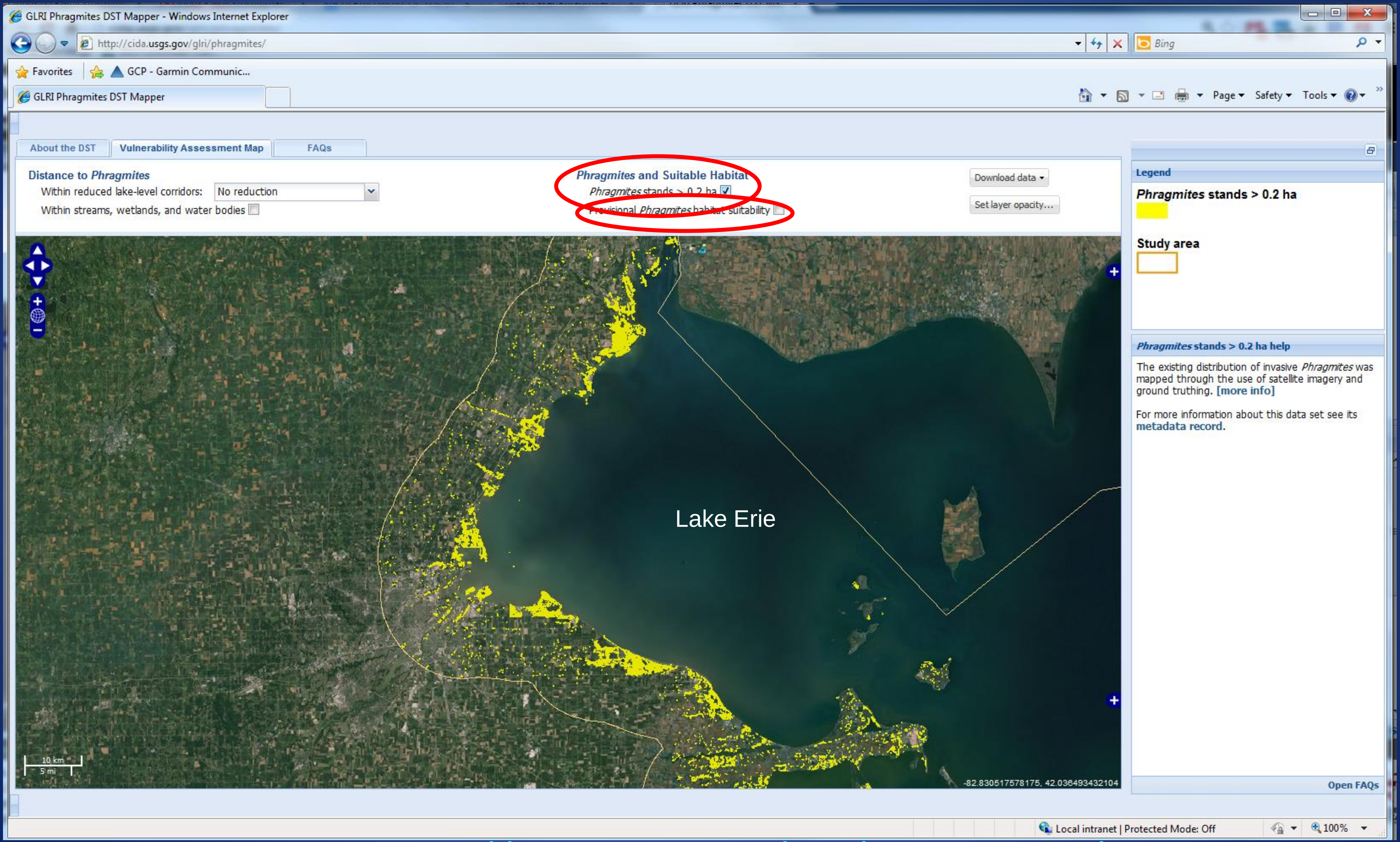
Online Decision Support Tool



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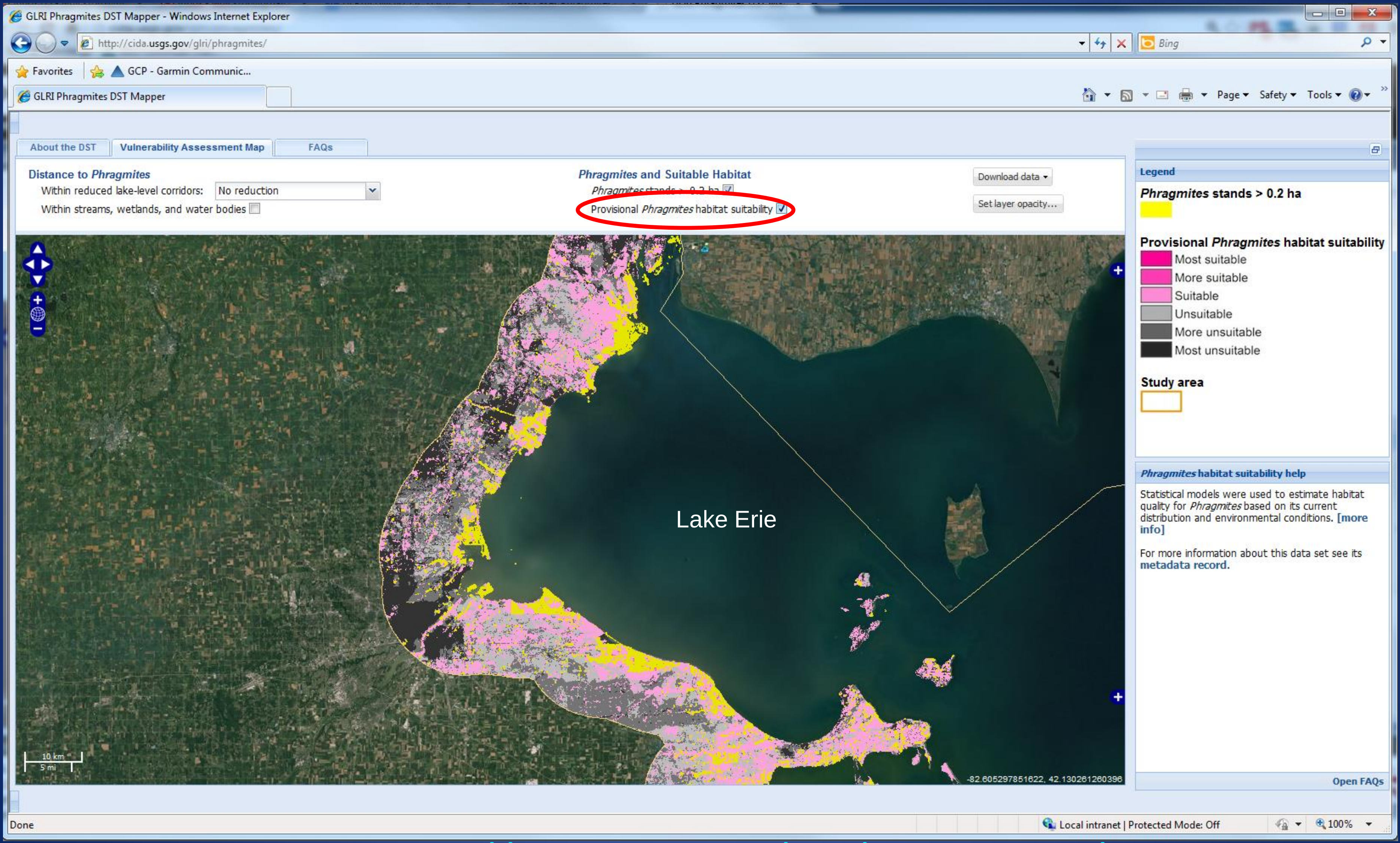
Online Decision Support Tool



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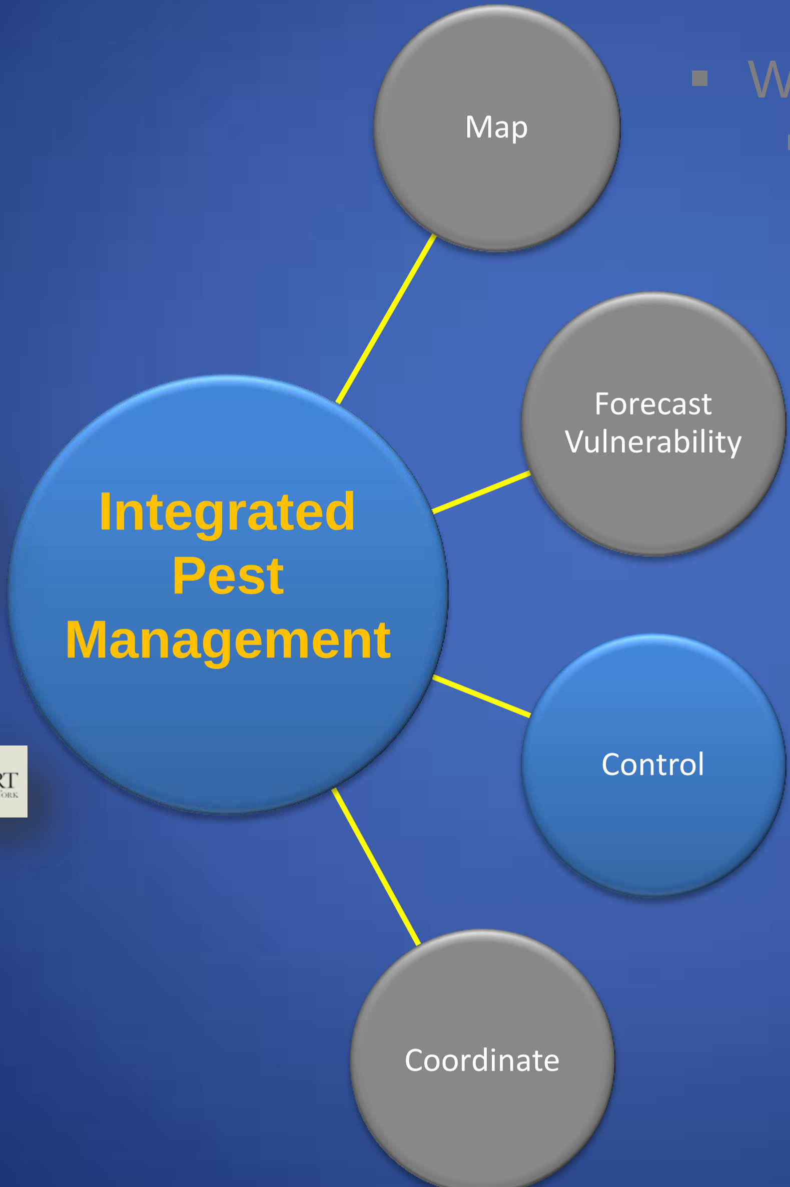
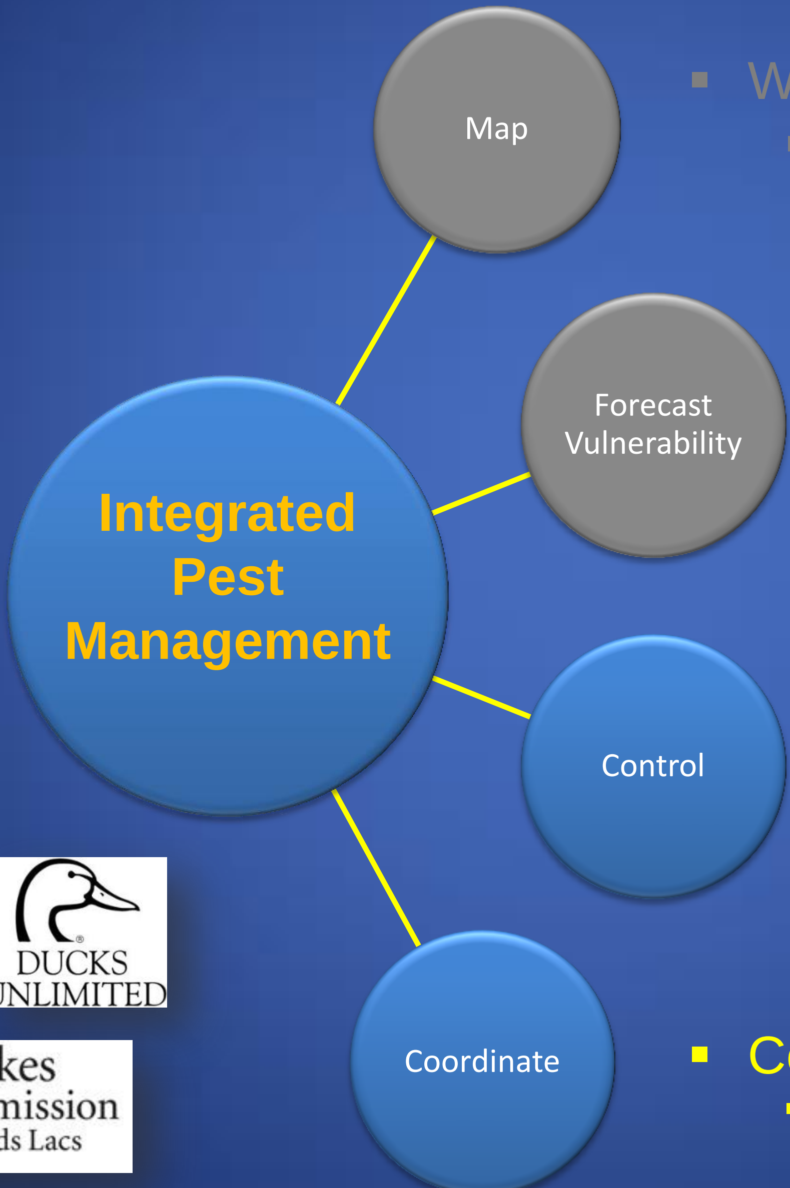
Conceptual Framework



- Where is it?
  - Map
- Where could it go in coastal zone?
  - Vulnerability
  - DST
- Innovative methods
  - Gene silencing
  - Microbial Symbiosis
  - *Biocontrol*

Conceptual Framework



- Where is it?
  - Map
- Where could it go in coastal zone?
  - Vulnerability
  - DST
- Innovative methods
  - Gene silencing
  - Microbial Symbiosis
  - *Biocontrol*
- Collective impact
  - Great Lakes *Phragmites* Collaborative

DUCKS UNLIMITED

Great Lakes Commission des Grands Lacs

Outline

I. USGS-GLSC Program Overview

II. Controlling *Phragmites*

III. **Estimating global freshwater fish production**

IV. Describing fish spawning habitat

V. Water quantity trends

USGS

Using Remote Sensing to Estimate Inland Fisheries Production at the Global Scale

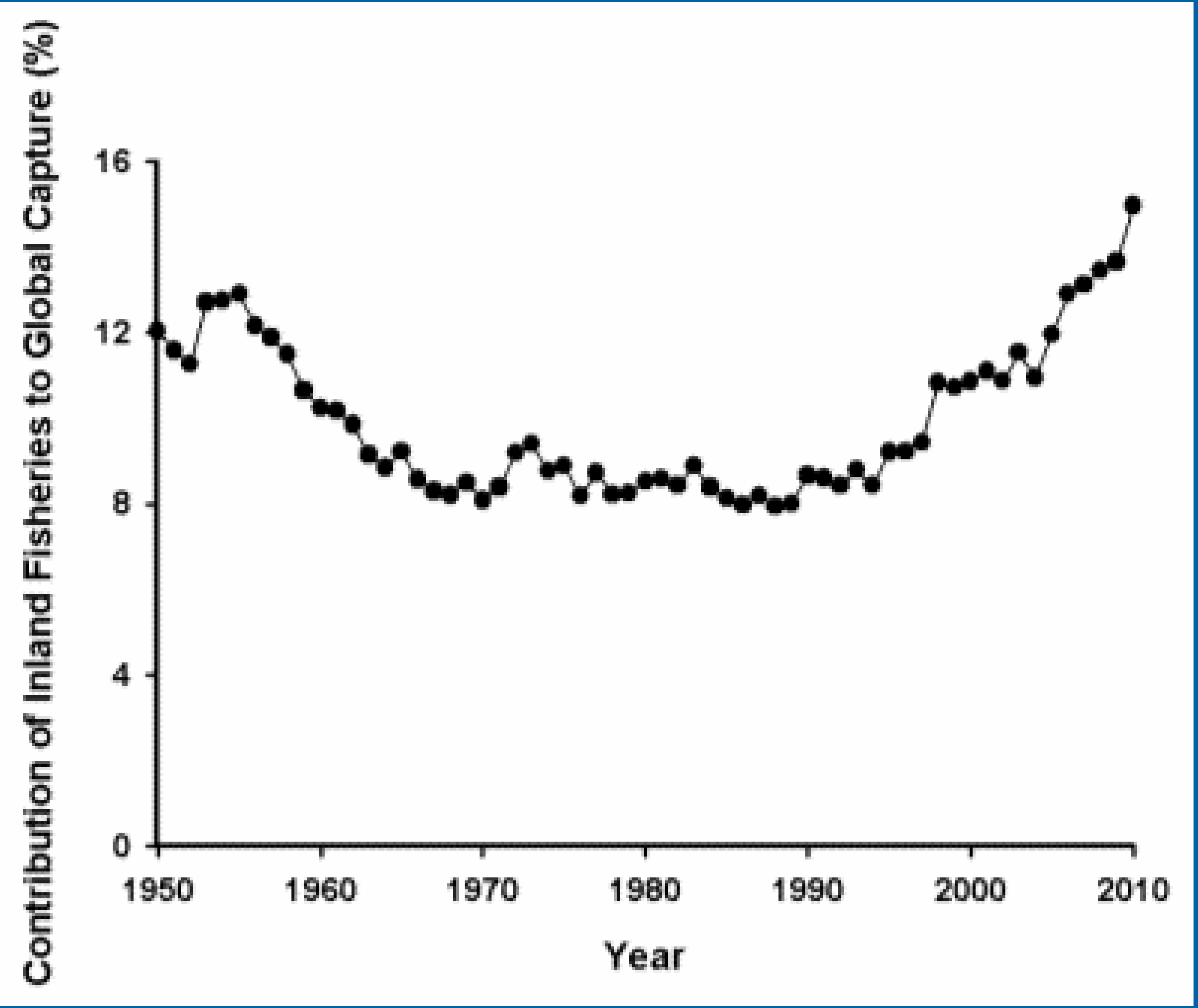
USGS
Andy Deines
Bo Bunnell
Mark Rogers
Whitney Woelmer
David Bennion
David Warner
Justin Mychek-Londer
Doug Beard

MTRI
Robert Shuchman
Mike Sayers
Zach Raymer
Amanda Grimm

USGS National Climate Change Wildlife Science Center

MichiganTech Research Institute

FAO: Inland fisheries are an increasing contributor to global capture



USGS

MichiganTech Research Institute

- **Inland capture fisheries also believed to be underestimated; diminishes their importance relative to marine harvest.**

- **Inland fisheries provide important ecosystem services (esp. in developing countries):**
  - **protein-rich food securities**
  - **employment**
  - **commerce**
  - **recreation**

USGS

MichiganTech Research Institute

<u>Goal</u>: Develop less biased estimate of global inland fisheries harvest.

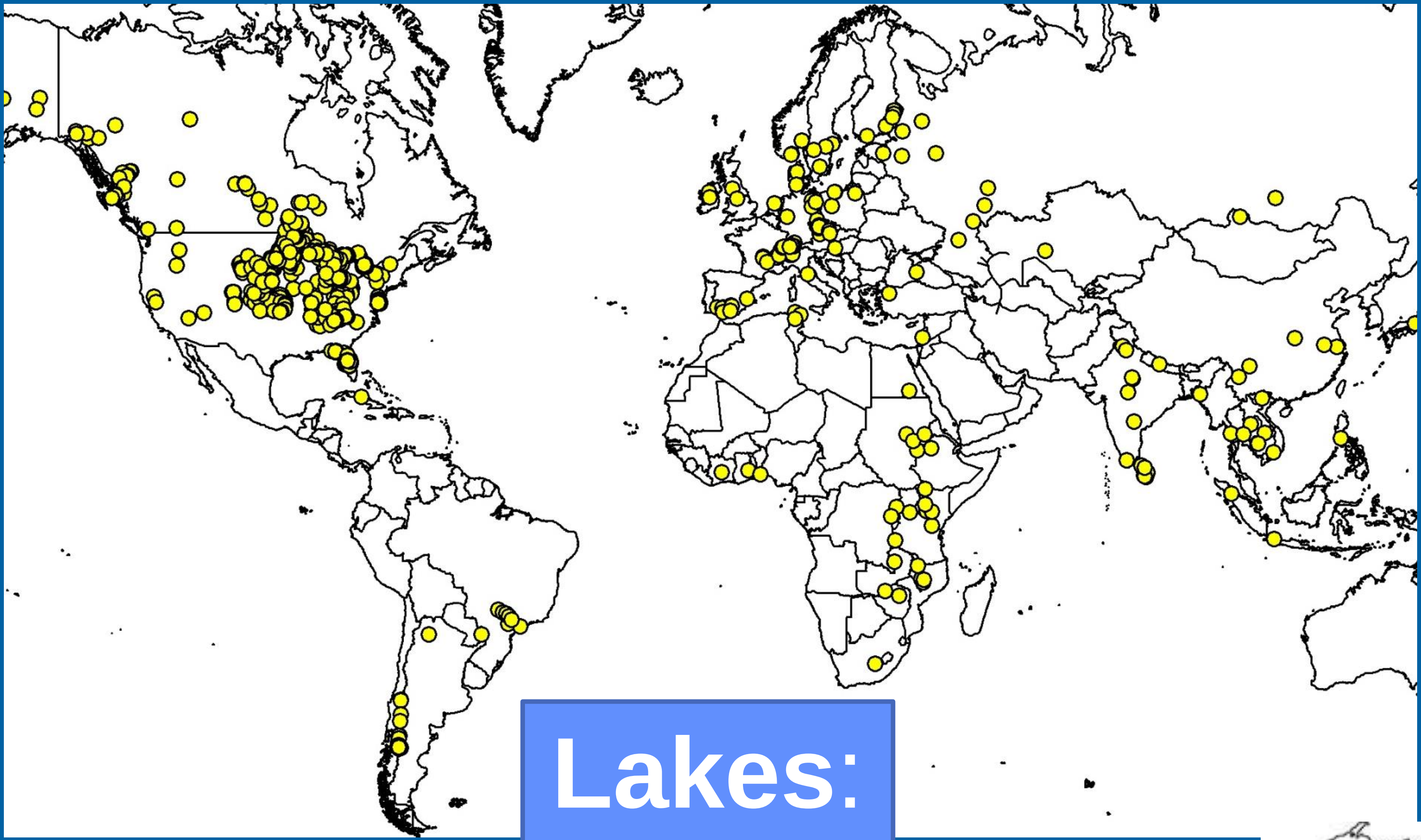
<u>Hypothesis</u>: Lake productivity and climate are strong predictors of fish harvest.

<u>Strategy</u>: 1) Build statistical "training" models relating remotely sensed data (e.g., productivity, climate, lake size) to known fish harvest. 2) Extrapolate.

Strategy #1: Training Models

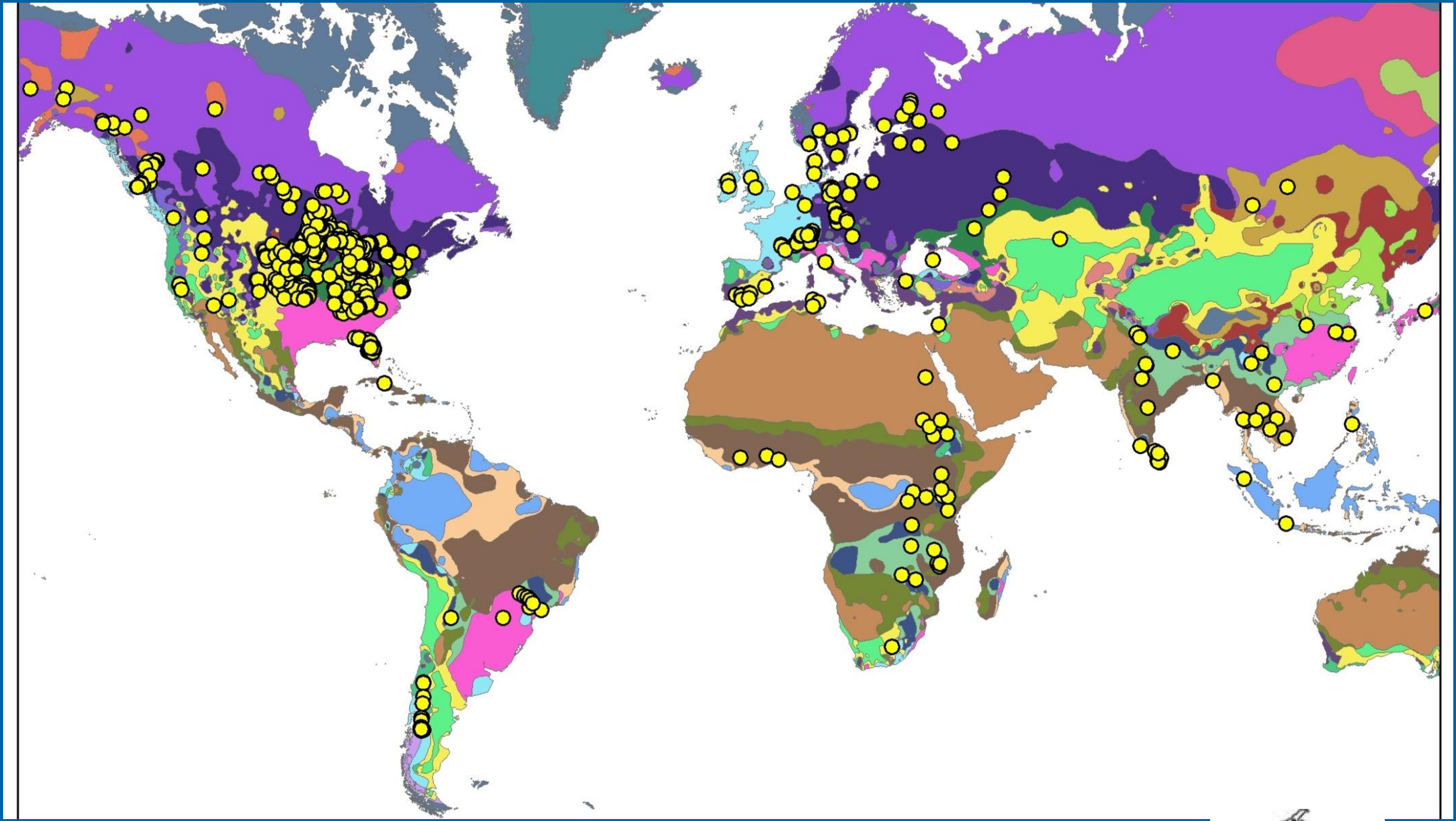
1. Scour the globe for fisheries harvest (Worldcat database) and *in situ* chlorophyll.

WorldCat Database



Lakes: 726

Köppen-Geiger Climate Ecoregions



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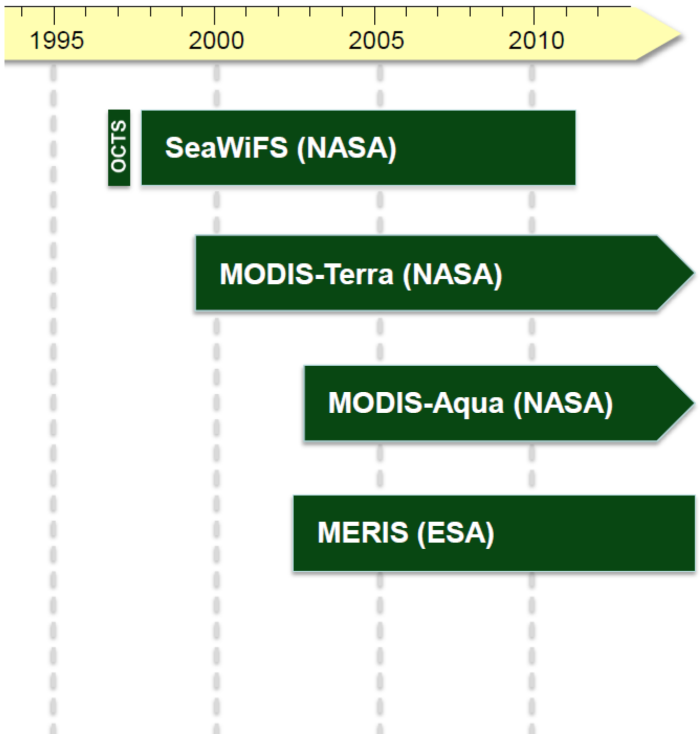
Research Institute

Strategy #1: Training Models

1. **Scour the globe for fisheries harvest (Worldcat database) and *in situ* chlorophyll.**
2. **Estimate chlorophyll from satellites where *in situ* does not exist.**

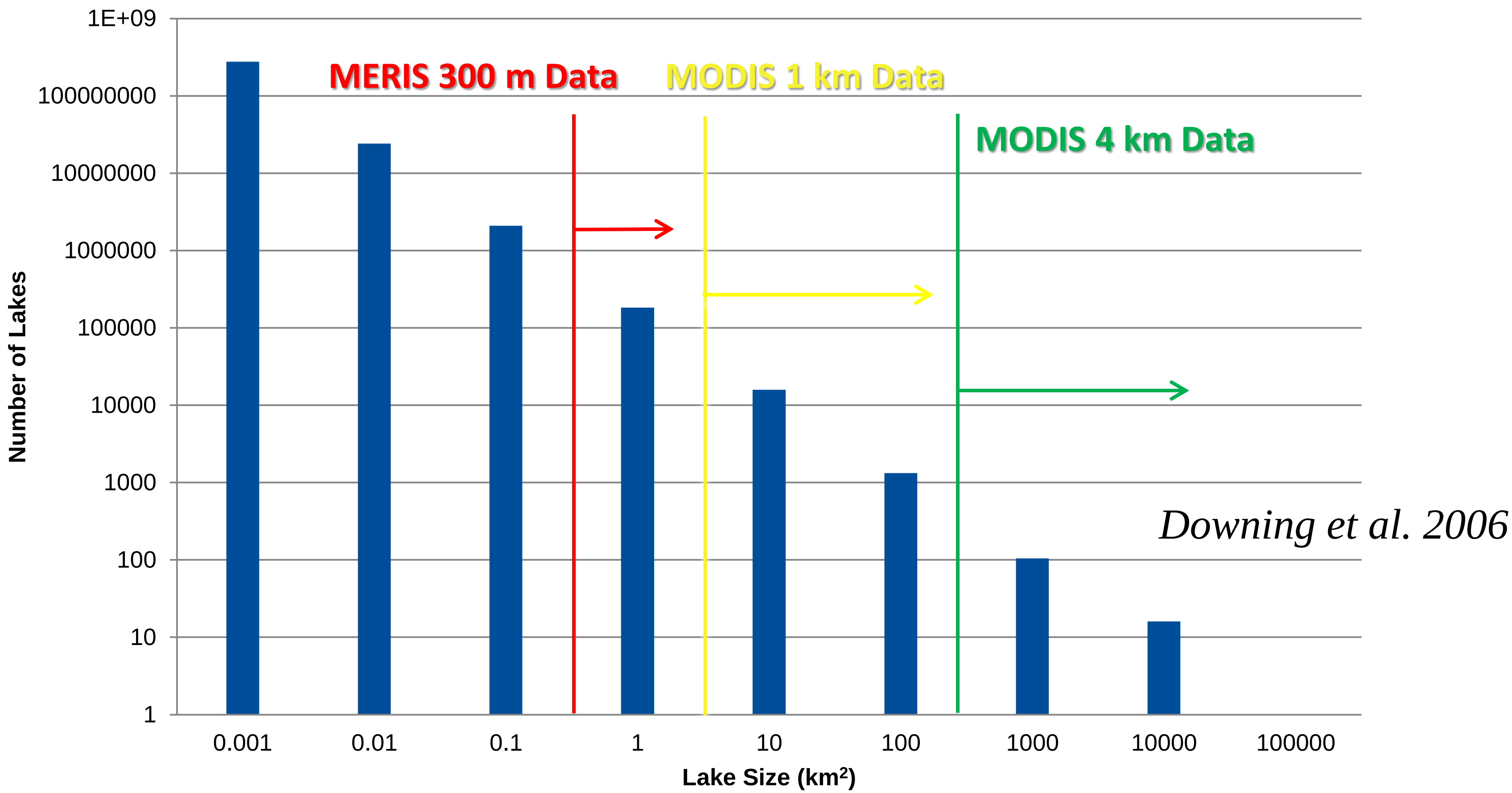
MODIS vs. MERIS

- MODIS and SeaWiFS are the US “workhorses” for water color remote sensing
  - 1 km native resolution
  - Global product 4 km resolution
- Full-resolution (300 m) MERIS data became available through NASA late last fall



- Multi-mission reprocessing has led to high consistency between SeaWIFS/MODIS/MERIS/VIIRS OC products
- NASA has found that MERIS estimates tend to be lower than MODIS in eutrophic waters, but without a robust in situ dataset, they can’t determine which is more correct

Lake Size and Satellite Sensor Resolution



From Global Lakes and Wetlands Database (GLWD):

MODIS 4 km Data: ~1000 Mappable Lakes

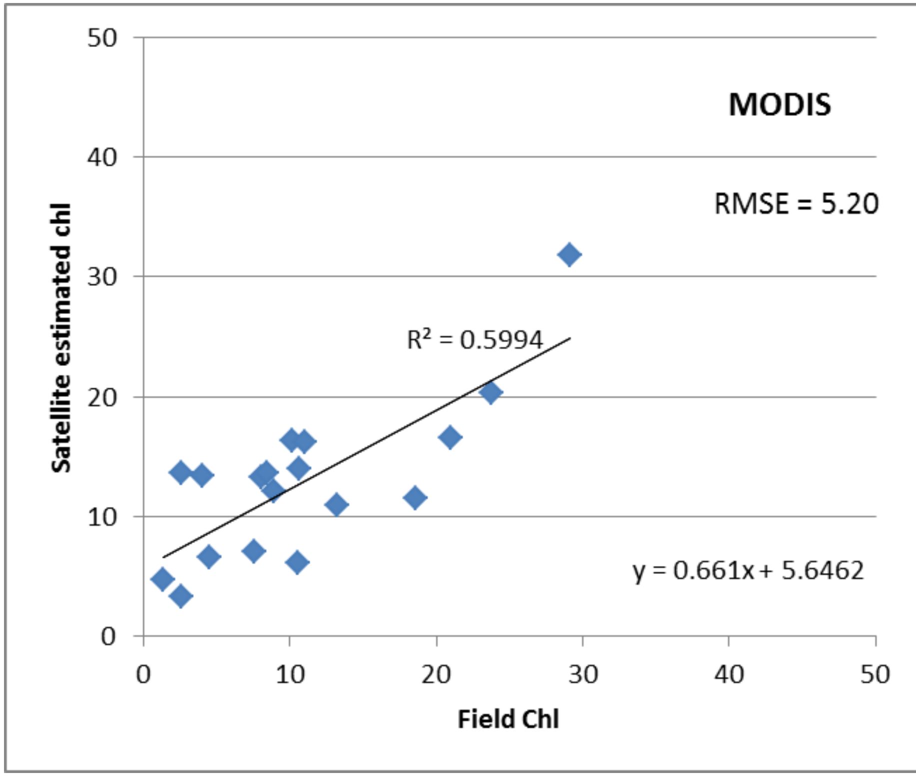
MODIS 1 km Data: ~19000 Mappable Lakes

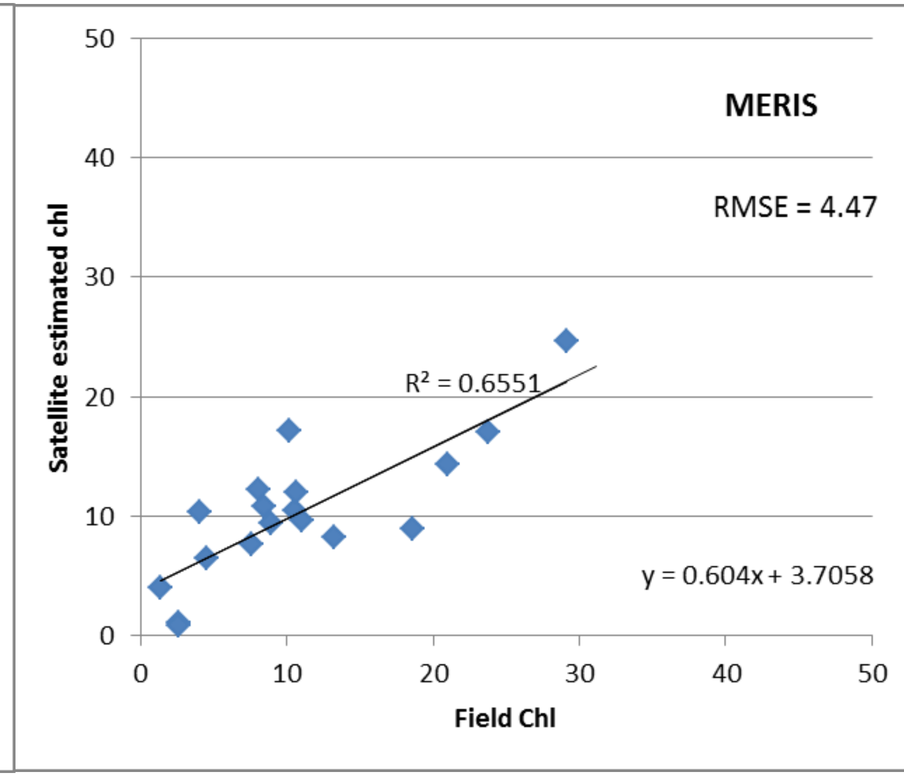
MERIS 300 m Data: ~160000 Mappable Lakes

A new estimate of the number of lakes observable from space will be produced at the end of the project!

MODIS and MERIS vs. in situ Measurements: Lower-chl Lakes

Satellite vs. in situ comparisons with date ranges <5 months





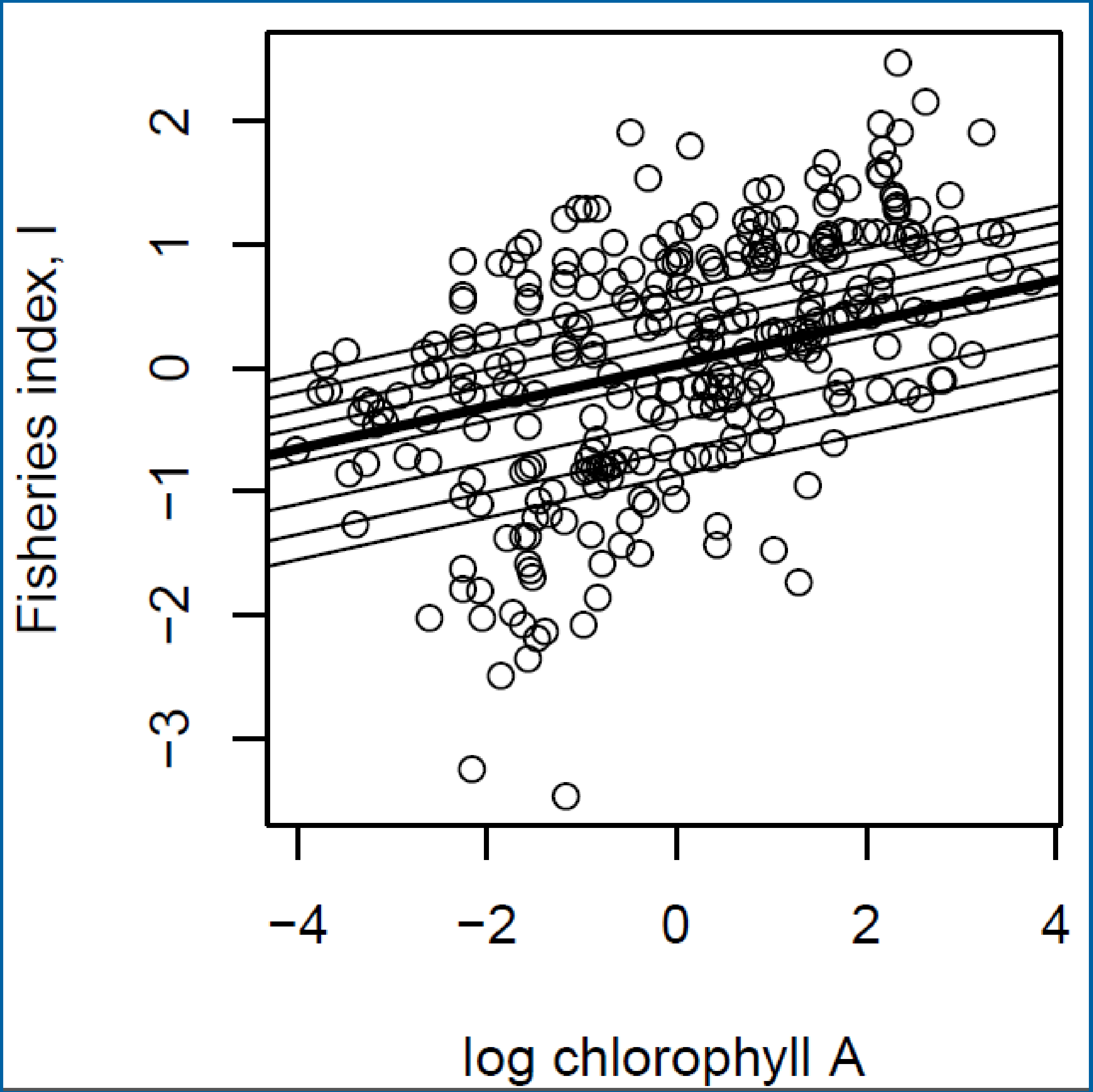
N = 18

Still a work in progress

Strategy #1: Training Models

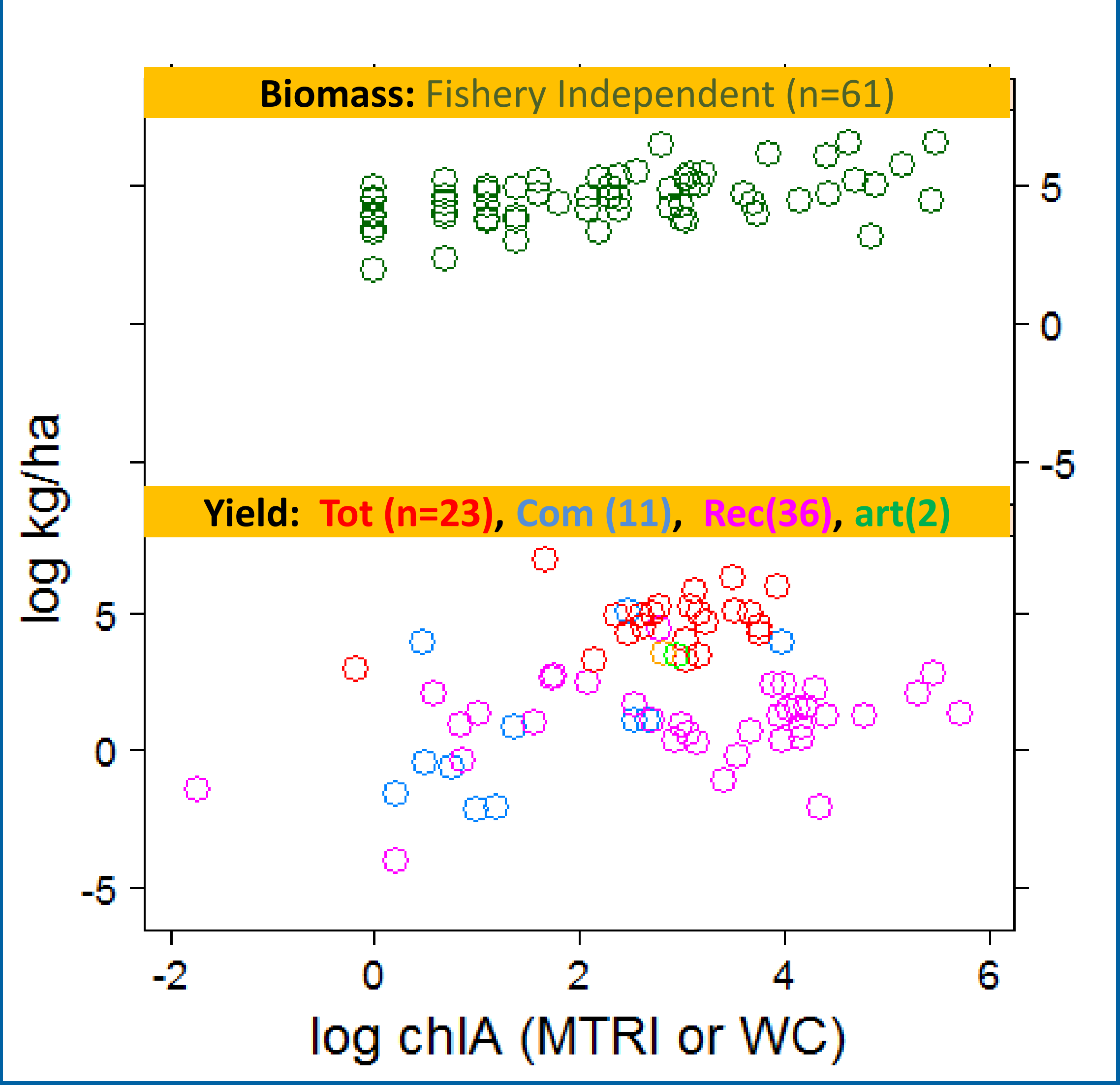
1. Scour the globe for fisheries harvest (Worldcat database) and *in situ* chlorophyll.
2. Estimate chlorophyll from satellites where *in situ* does not exist.
3. Build statistical models.

Meta-analysis: Fishery yield ~ Chlorophyll *a*



Deines et al. in review

Worldcat lakes: Fishery yield ~ Chlorophyll *a*



Strategy #1: Training Models

1. Scour the globe for fisheries harvest (Worldcat database) and *in situ* chlorophyll.
2. Estimate chlorophyll from satellites where *in situ* does not exist.
3. Build statistical models.

Strategy #2: Extrapolate

1. Determine 2011 global distribution of inland chlorophyll and lake size.

USGS

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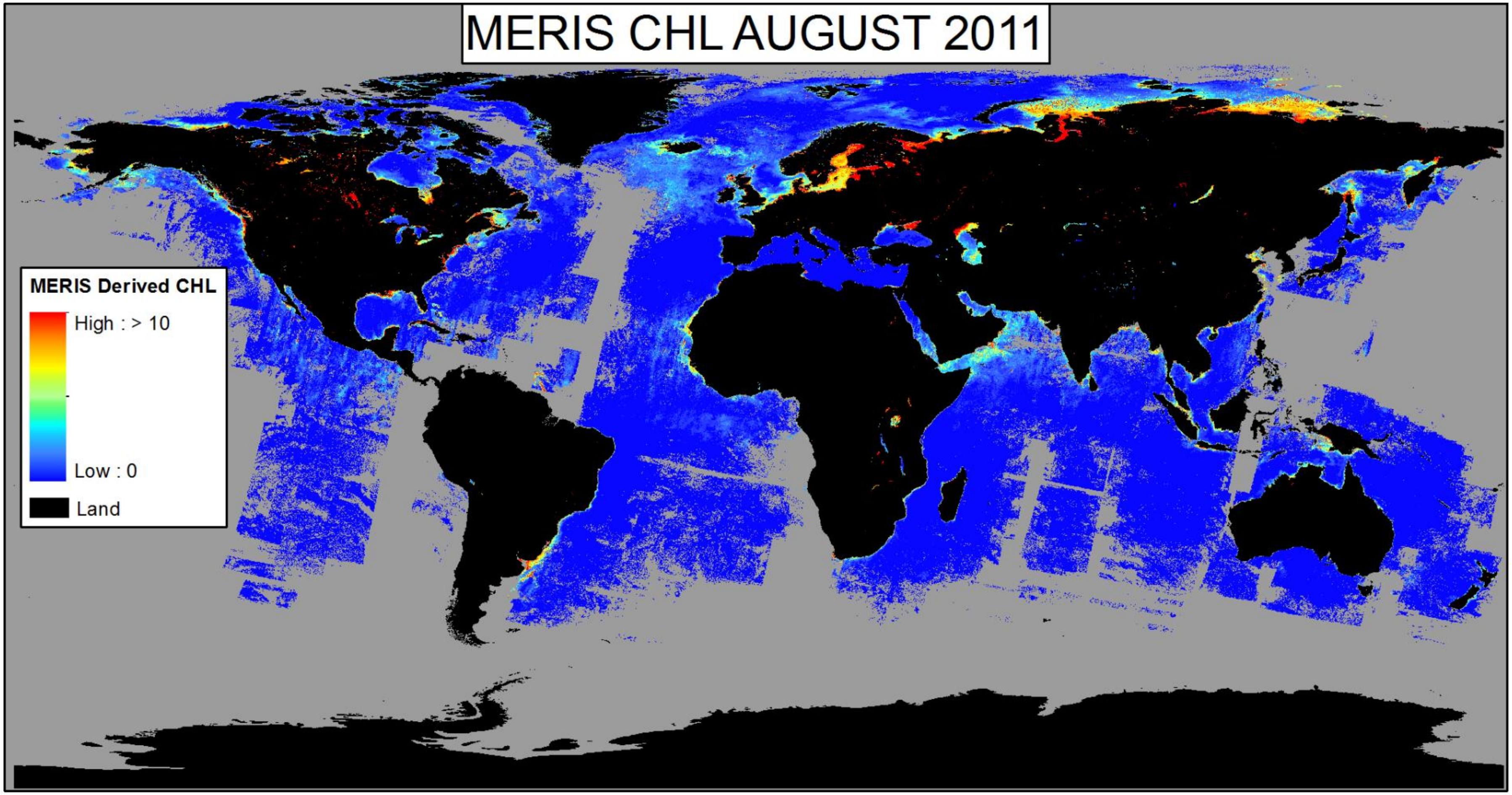
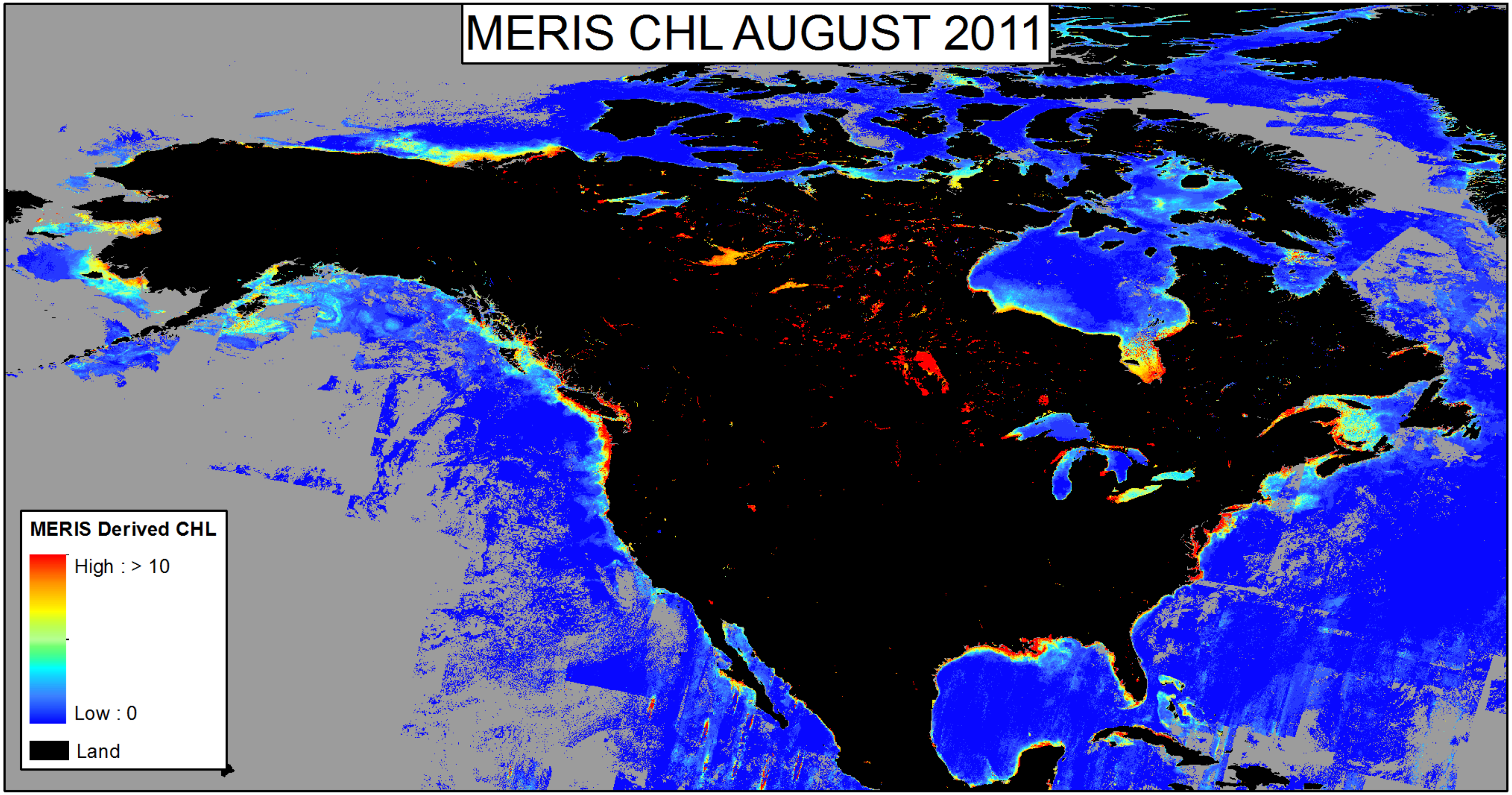
Extrapolation: world view



Extrapolation: North America



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Feasibility of Using Satellite Imaging to Remotely Identify Lake Trout Spawning Sites

Amanda Grimm, Thomas Binder, Colin Brooks, Stephen Riley, Rick Dobson and Chuck Krueger

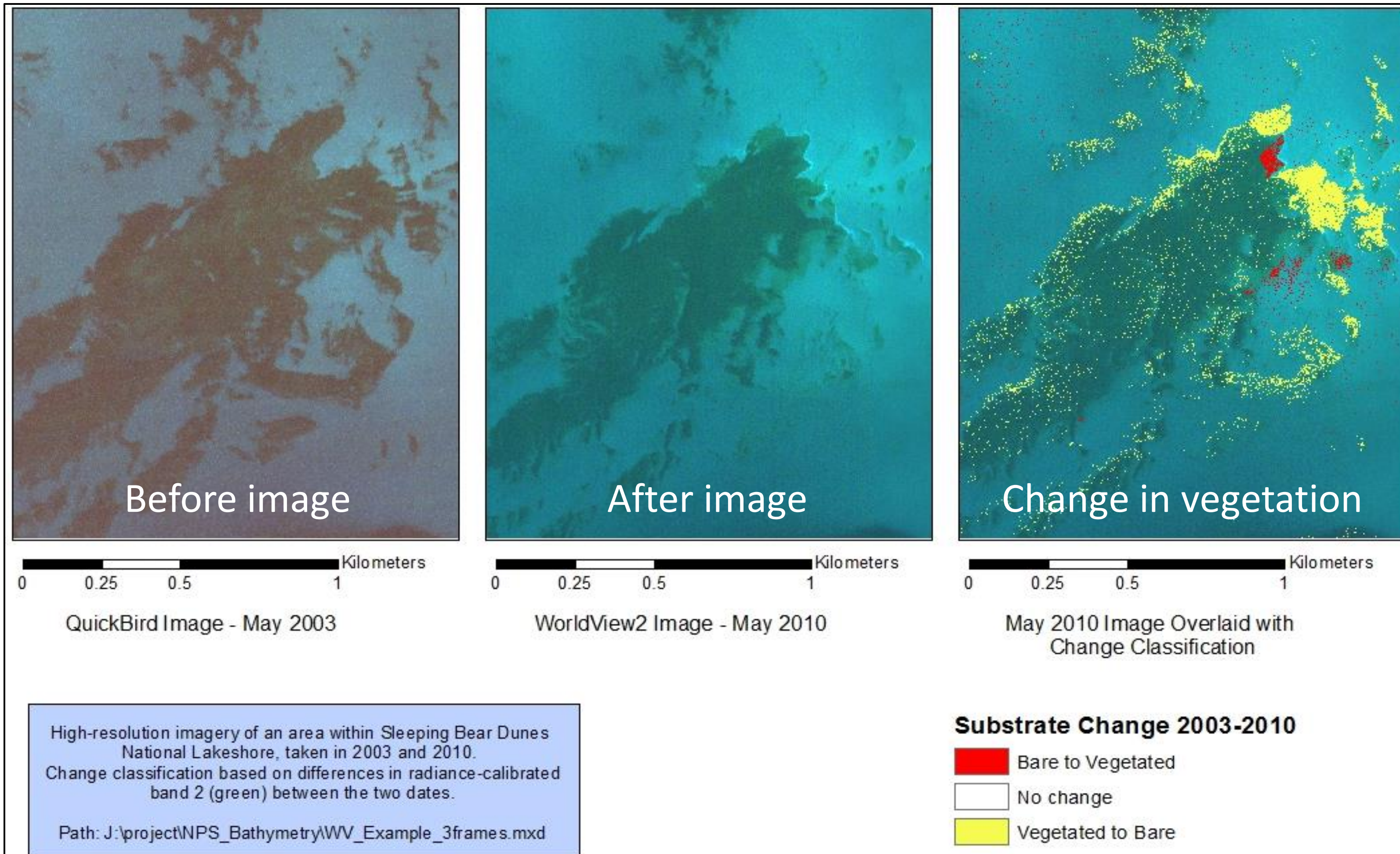
Funding: Great Lakes Fishery Trust

Photo: Ellen Marsden

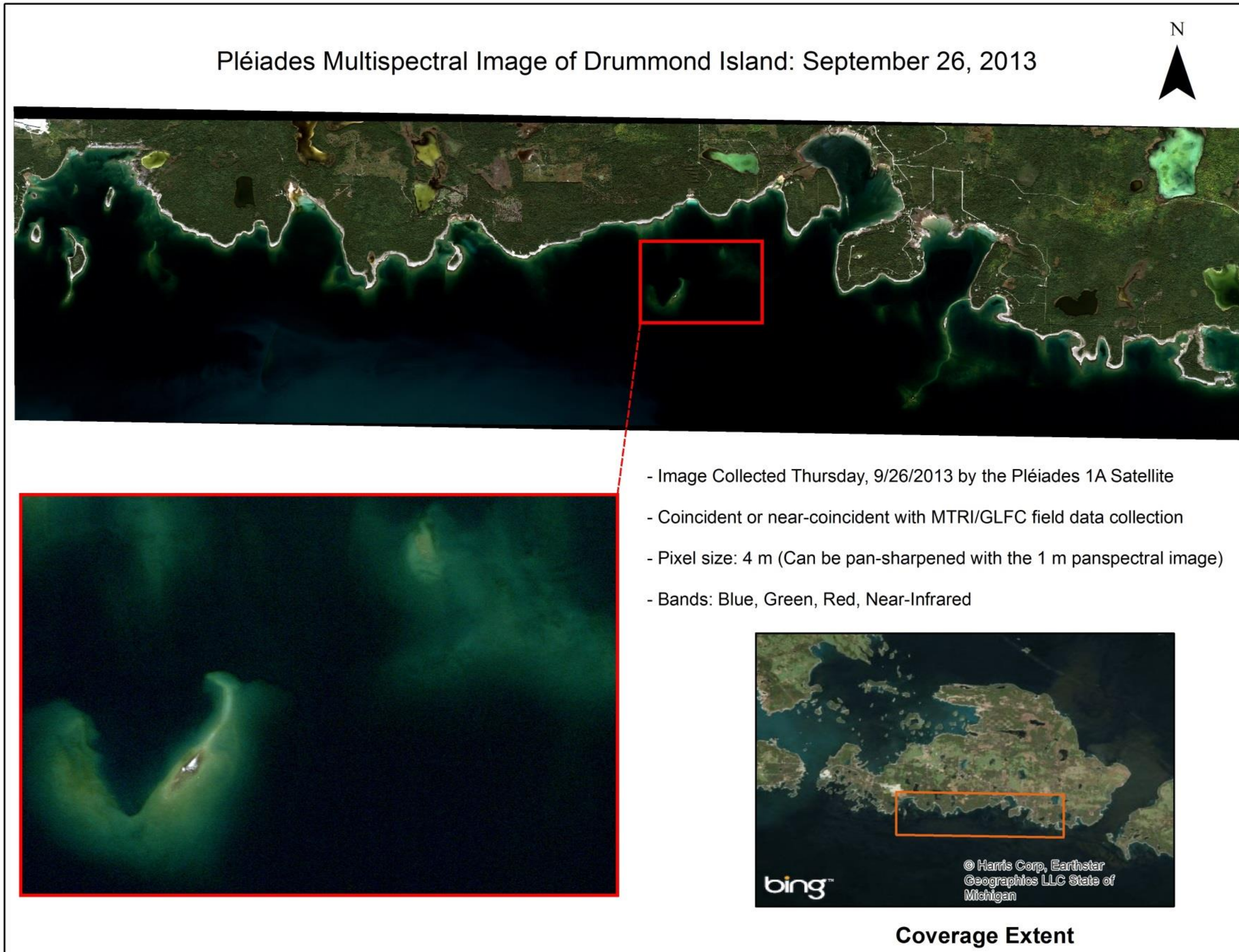
Observation: Sites at which lake trout deposit eggs are cleaner than substrate on surrounding sites (Drummond Island acoustic telemetry study)

Question: Can satellite imaging be used to identify potential lake trout spawning sites by locating 'clean' areas on reefs?

Method: Map change in substrate radiance using techniques used previously by MTRI to map changes in *Cladophora* blooms at Sleeping Bear Dunes



Pre-spawning image of spawning reefs in 2013



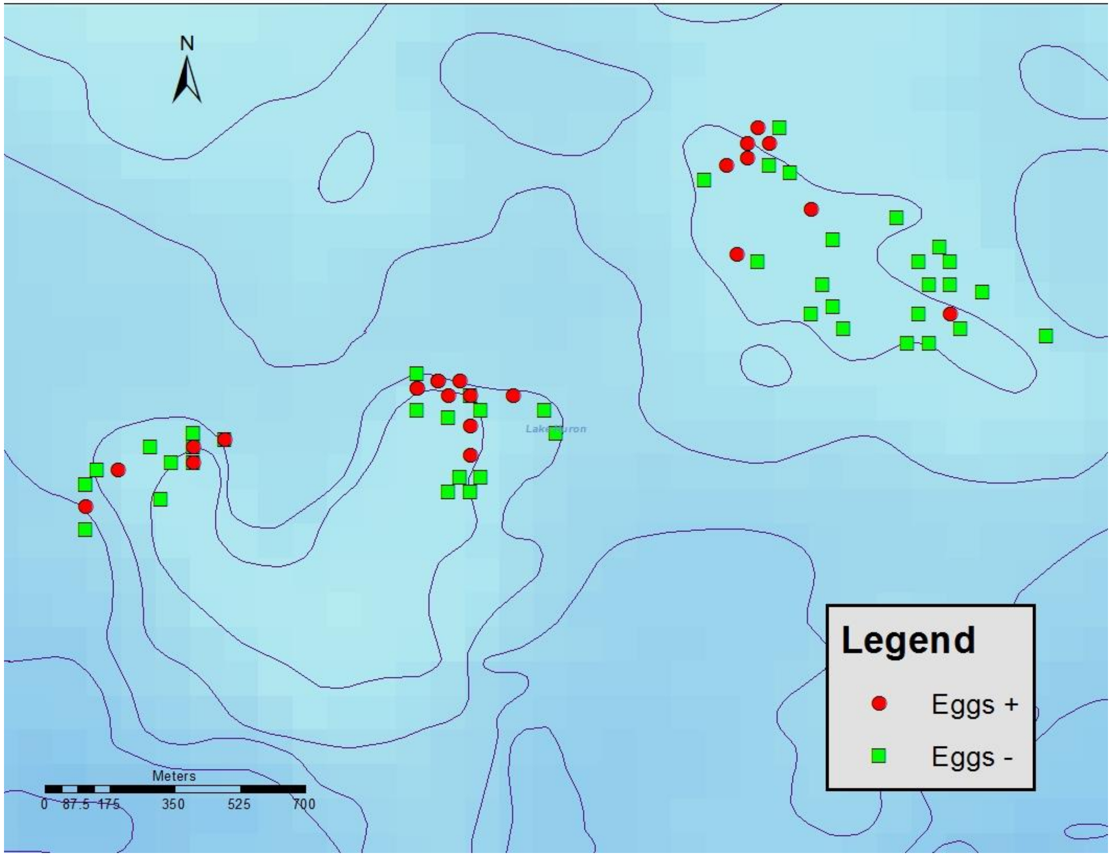
<u>Promising preliminary results</u>:

- Accurately identified differences in algal density between 0 and 60% cover using substrate radiance – above 60% cover was difficult to distinguish

- Classified 60 sites on two reefs as spawning site or non-spawning site using logistic regression: (*Spawning ~ pre-spawning radiance + change in radiance*)

↓

Correct assignment approximately <u>85%</u> of the time



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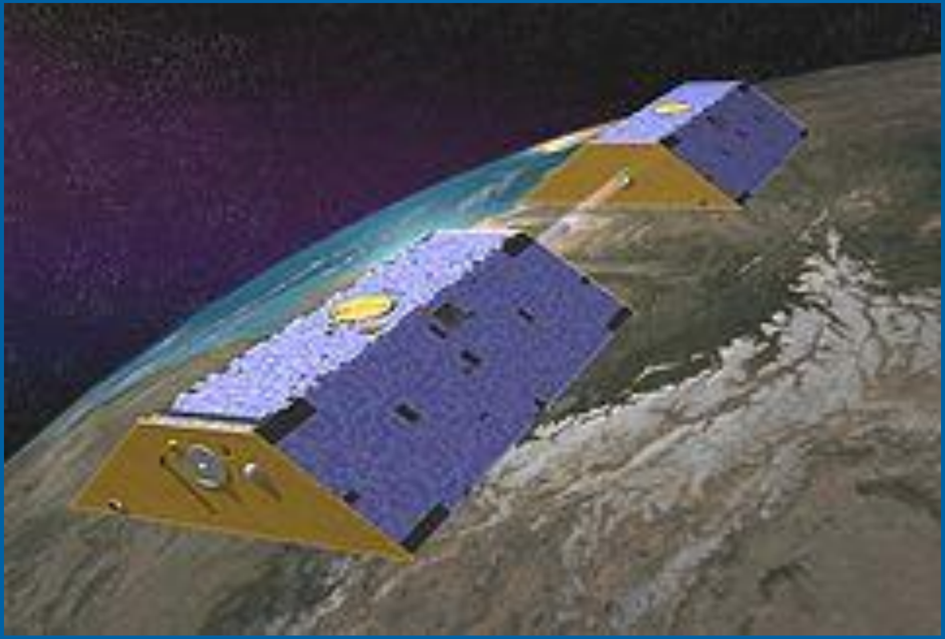
V. **Water quantity trends**

Feasibility of Using GRACE Satellites to Assess Water Quantity* in US

Chris Hoard and Howard Reeves, USGS Michigan Water Science Center
hwreeves@usgs.gov

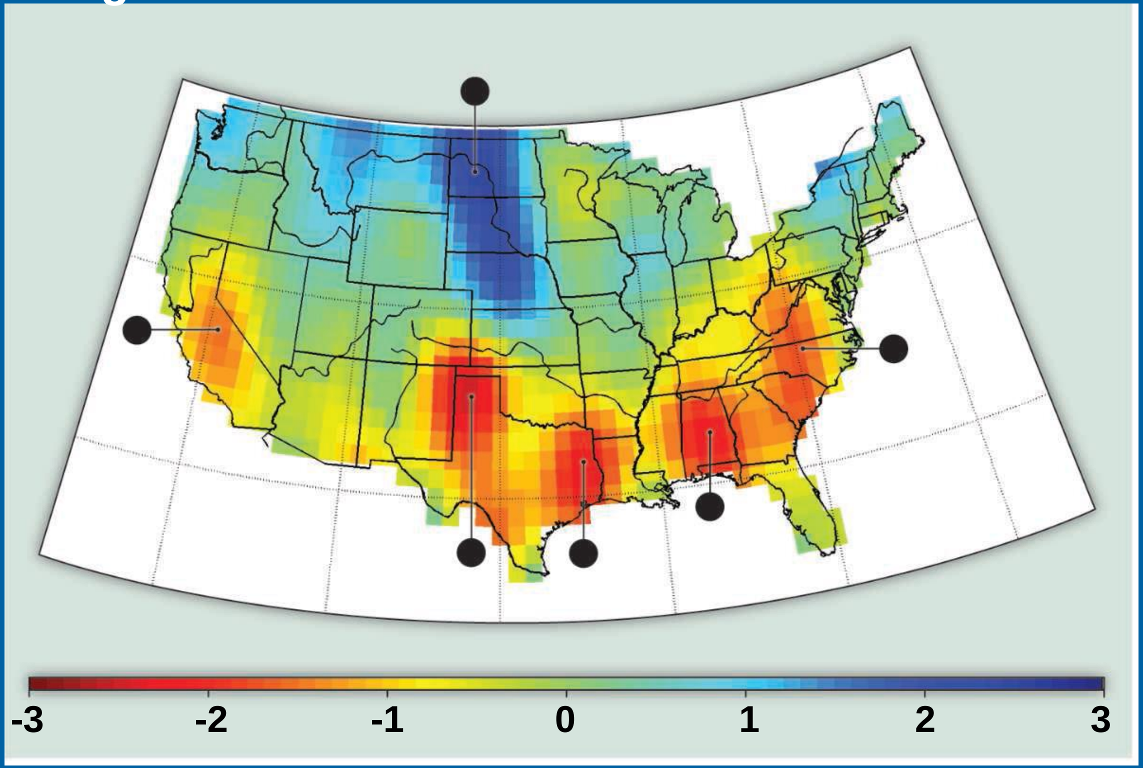


* Includes surface water, snowpack, vegetation, soil moisture, and groundwater.

USGS

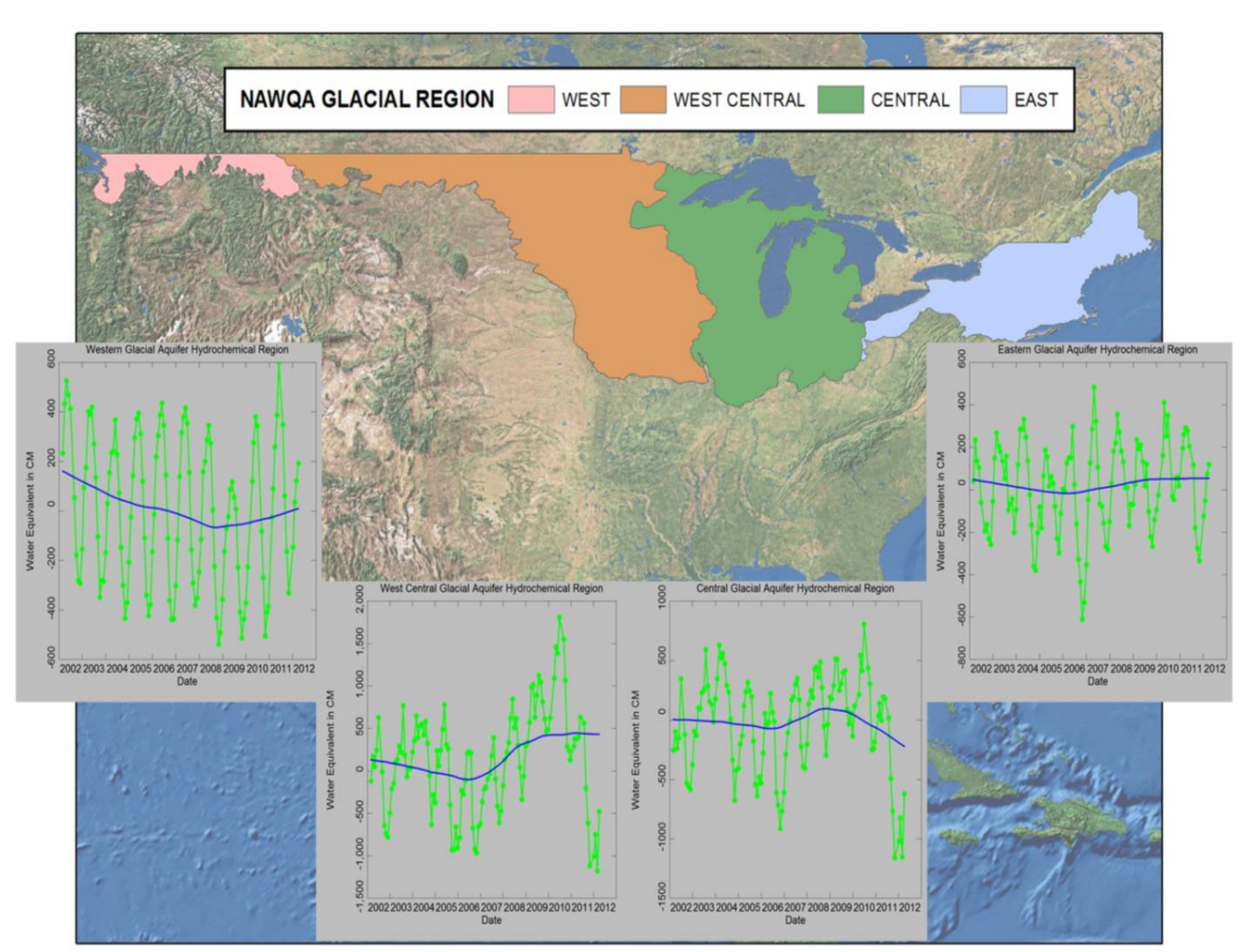
Capitalizing on recently developed methods to use GRACE satellite to estimate groundwater quantity:

Famiglietti & Rodell 2013. *Science* 340: 1300-1301.



Change (cm/year) between 2003 and 2012

Preliminary analysis for demonstration only:



Changes in terrestrial water between 2002-2012 by NAWQA glacial region, derived from GRACE data. The change in mass reported for each cell represents the difference between the mass measured in that month and the average mass for the period of Jan 2004-Dec 2009.

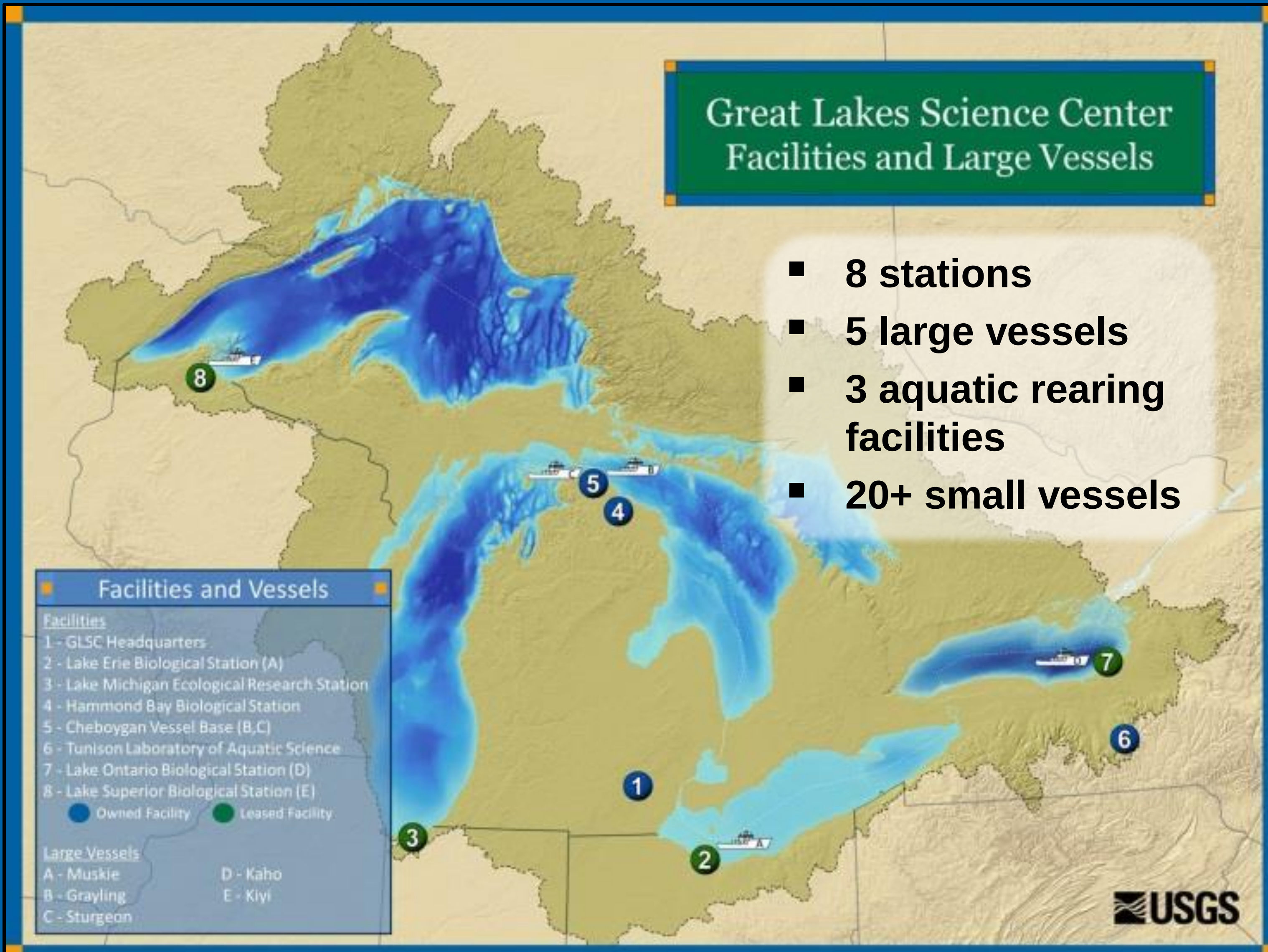
USGS

- **GRACE land-data were processed by Sean Swenson, supported by NASA MEaSUREs Program and are available at http://grace.jpl.nasa.gov**

Thank You!

USGS

GLSC: Eight Stations – One Mission



- **8 stations**
- **5 large vessels**
- **3 aquatic rearing facilities**
- **20+ small vessels**