



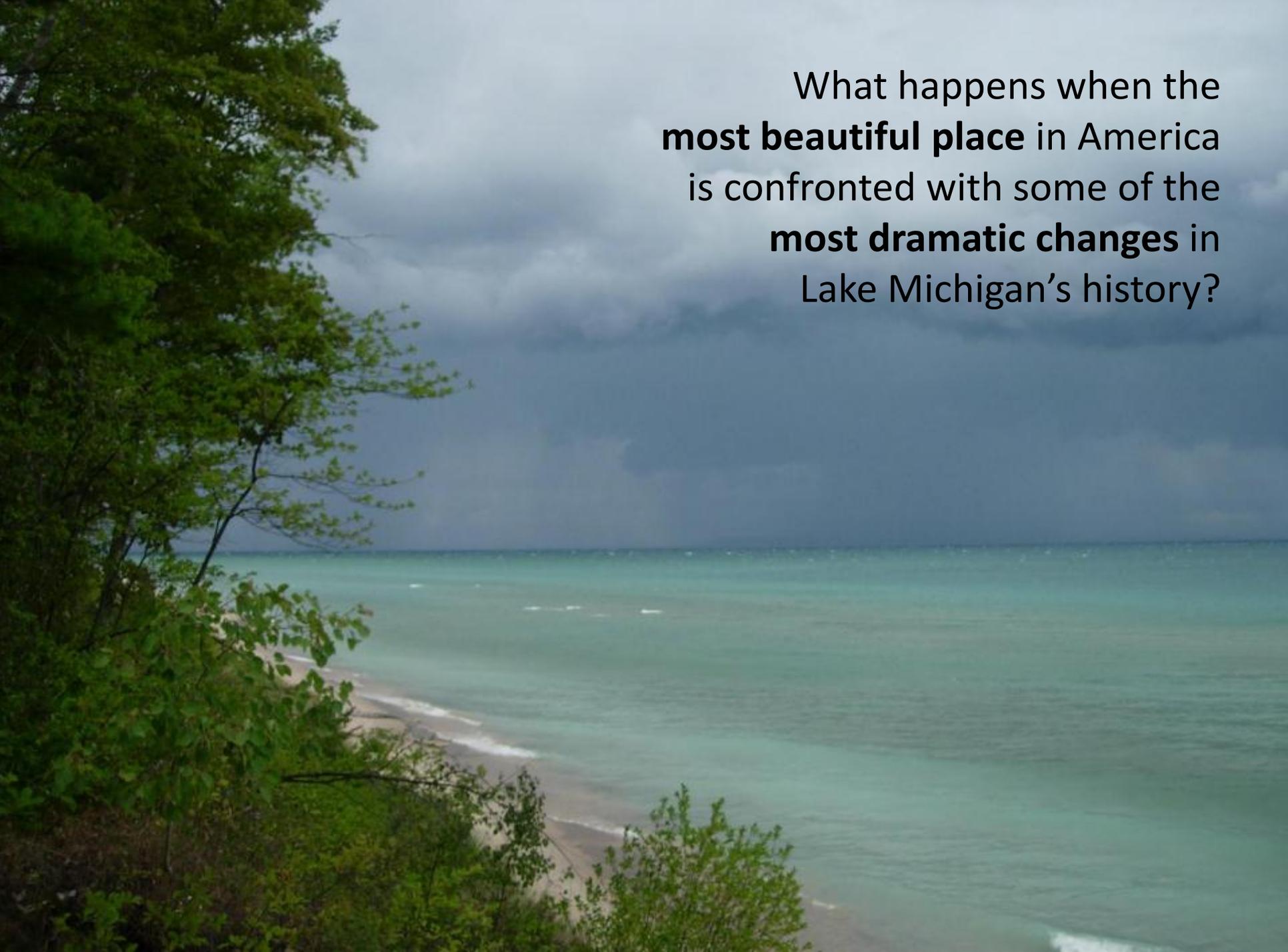
**A decade of Lake Michigan  
nearshore ecosystem change:  
*observations from Sleeping Bear Dunes***

Brenda Lafrancois, Harvey Bootsma, Emily Tyner,  
Sue Jennings, Dan Ray, Jay Glase, Chris Otto





What happens when the **most beautiful place** in America is confronted with some of the **most dramatic changes** in Lake Michigan's history?



# Overview

- Part I – A chronology of ecosystem change
- Part II – Management and scientific response
- Part III – Toward a new stewardship

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North Manitou Island, SLBE, August 2004

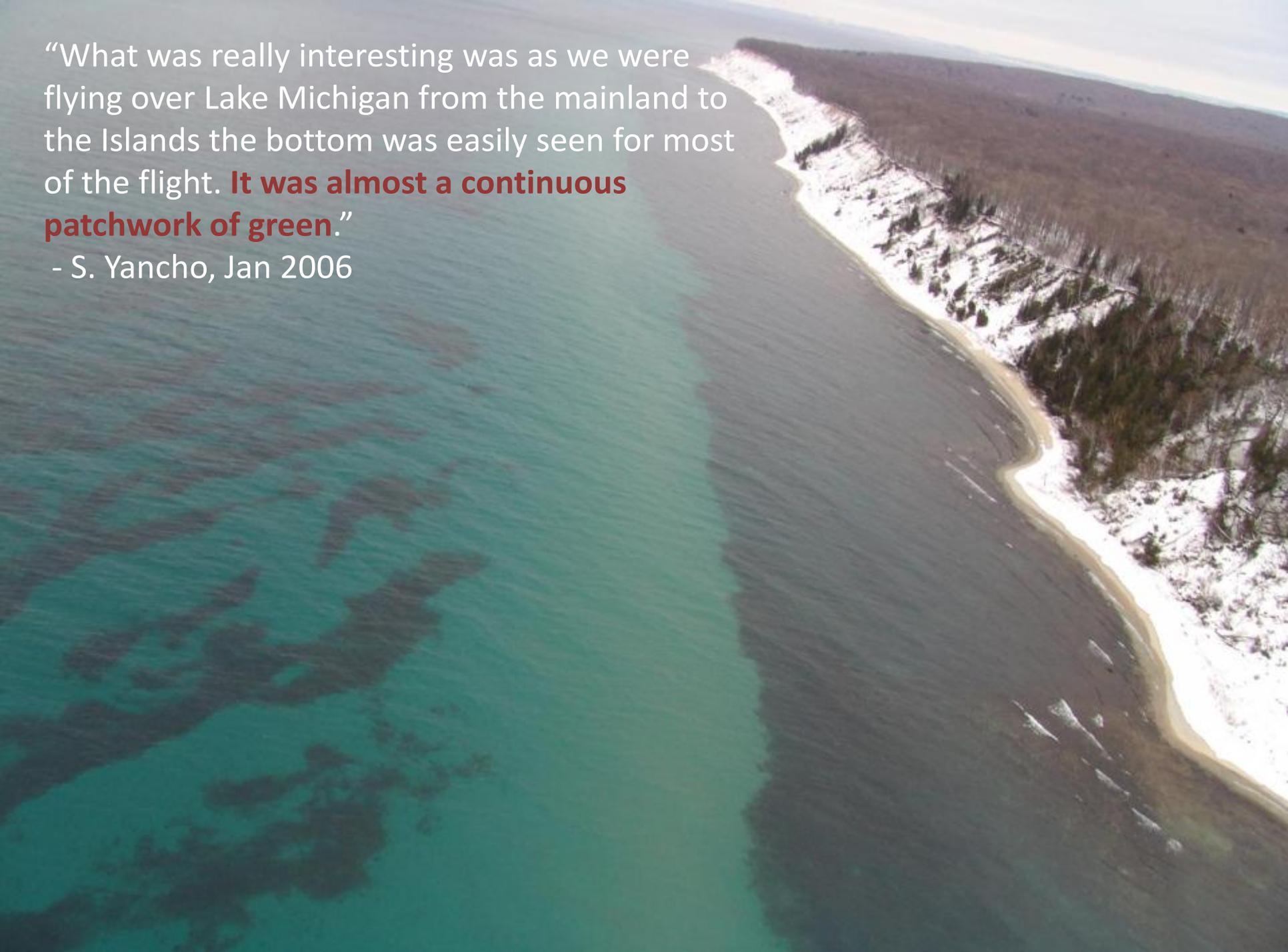
“The person who grabbed the sample said it  
**smelled just like human waste** when he gathered  
the sample from the back of the boat.”  
- S. Yancho, Aug 2005



“I had heard a bit about possible *Cladophora* problems on the Michigan side of the lake, but **I was not aware of how severe** the problem is... it appears that some parts of the Manitou Island shoreline have as much *Cladophora* as we do along the Wisconsin shoreline...”

- H. Bootsma, Jan 2006



An aerial photograph showing a shoreline. The water is a mix of light and dark green, indicating varying depths or vegetation. The land is covered in snow and sparse, dark green trees. The sky is a pale, overcast blue.

“What was really interesting was as we were flying over Lake Michigan from the mainland to the Islands the bottom was easily seen for most of the flight. **It was almost a continuous patchwork of green.**”

- S. Yancho, Jan 2006



“This is most likely the domino effect of zebra mussels.” - S. Paulic, Aug 2005





U5 H65 133HD+D CA-80 14AUG08  
D5 0158.3FF 42F 11:11:58

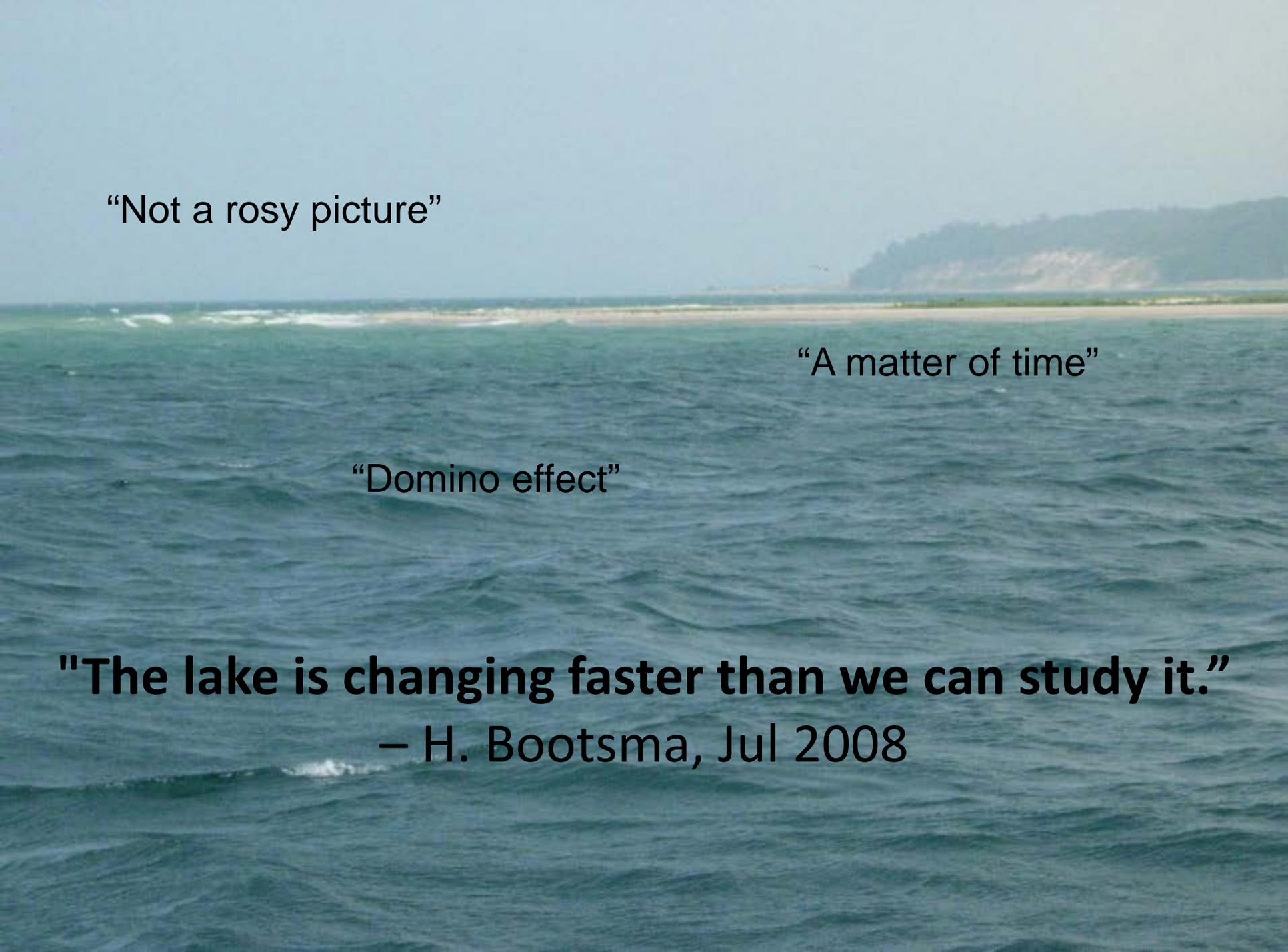


August 2006



**“It just wasn't native. Nearly everything I looked at was an invasive species in and of itself, or was facilitated by one.”**

**– B. Lafrancois**



“Not a rosy picture”

“A matter of time”

“Domino effect”

**“The lake is changing faster than we can study it.”**

– H. Bootsma, Jul 2008



Photo: A. Van Zoeren



Photo: A. Van Zoeren



“Sleeping Bear Dunes is key to Piping Plover survival, since we continue to provide habitat and protection to a third of the entire population. **While we can mitigate some threats, large scale ecosystem shifts are much more daunting, if not impossible to contend with.**” – Sue Jennings, SLBE wildlife biologist



Photo: A. Van Zoeren



## **Botulism takes fatal toll on thousands of Great Lakes birds**

**Botulism and the infamous zebra mussel are blamed for killing birds - from gulls to loons - by the thousands**

**BIRD AND FISH POISONING SPREADS IN GREAT LAKES**

Bob Allen

December 3, 2007

**TOXIN KILLS ENDANGERED BIRDS**

Bob Allen

July 23, 2007

## **Chain reaction killing loons in Great Lakes**

Experts cite Type E botulism traced to mussels

### **Are Lake Superior's loons next?**

Loons are dying in and around the Great Lakes by the thousands, and the die-offs are moving closer to Minnesota. A type of botulism is going through the food chain.

### **Lake invaders may be killing birds**

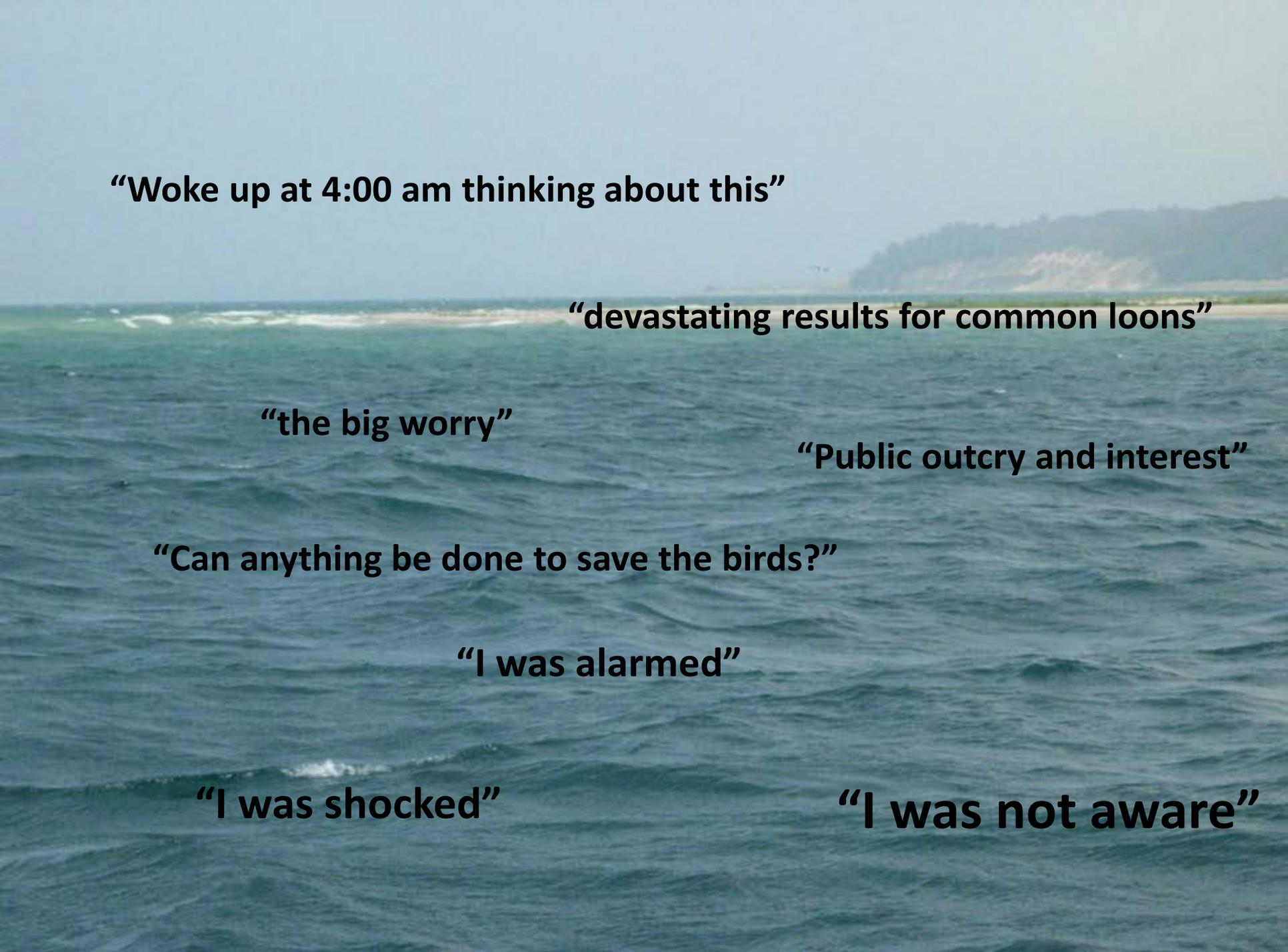
Scientists suggest invasive mussels in the Great Lakes may be responsible for the deaths of thousands of migratory birds

### **Hundreds of bird deaths sound alarm on problems in the Great Lakes**

12:36 PM, October 18, 2012 Detroit Free Press

October 18, 2012

Michigan's oldest banded loon dies from avian botulism



**“Woke up at 4:00 am thinking about this”**

**“devastating results for common loons”**

**“the big worry”**

**“Public outcry and interest”**

**“Can anything be done to save the birds?”**

**“I was alarmed”**

**“I was shocked”**

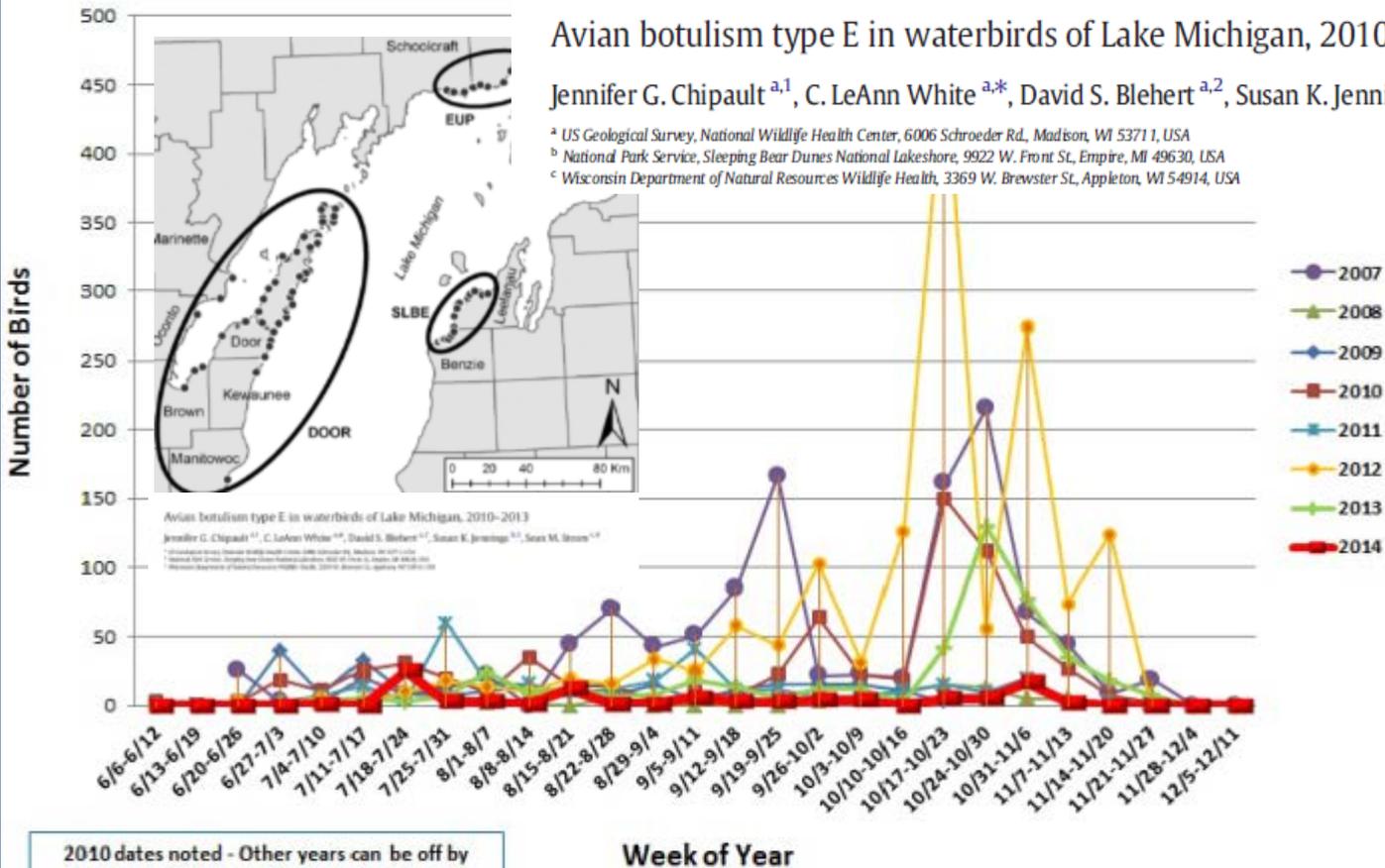
**“I was not aware”**

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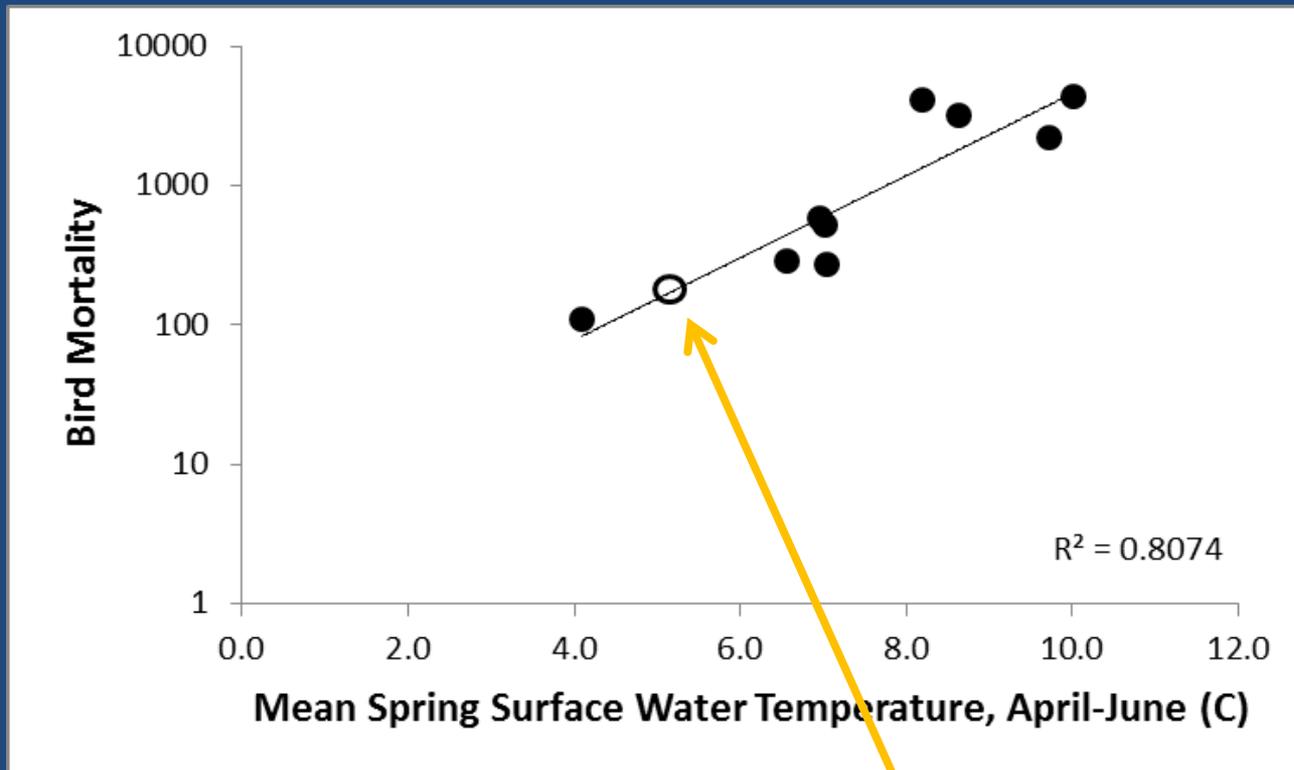
# Scientific and Management Response: Beach monitoring

**SLBE 2007-2014 - Number of Birds Found During Botulism E Events**



2010 dates noted - Other years can be off by up to two days. Data sorted by week-of-year.

# Scientific and Management Response: Beach monitoring



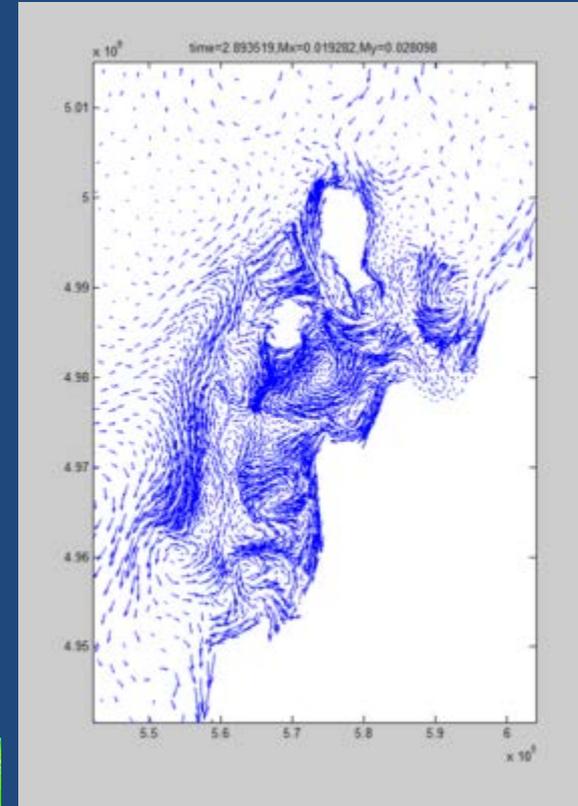
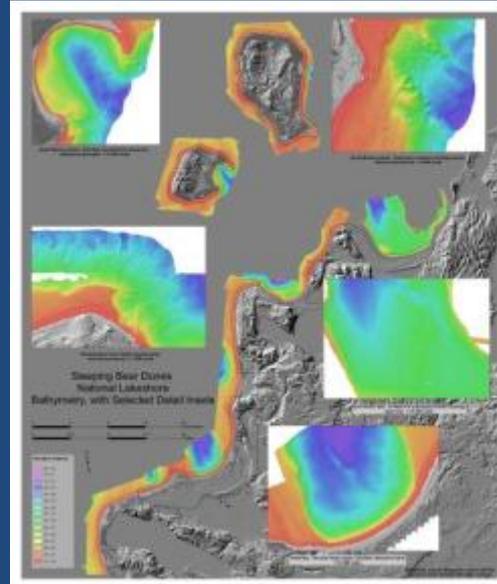
Prediction for 2014 = 57 birds  
Total to date = 110 birds

Prediction for 2015 = 182 birds  
Total to date = 296 and climbing

# Scientific and Management Response:

## Basic Research

- Benthic mapping (complete)
- Nearshore hydrodynamic modeling (in progress)
- Trophic structure



# Scientific and Management Response: Intensive Topical Research

- Nearshore histories
- Food webs and trophic pathways
- Toxin distribution
- Oxygen dynamics
- Bird gut contents

NEARSHORE BENTHIC OXYGEN DYNAMICS IN LAKE MICHIGAN

by

Emily Tyner

A Thesis Submitted in  
Partial Fulfillment of the  
Requirements for the Degree of

Master of Science  
in Freshwater Science and Technology

at

The University of Wisconsin-Milwaukee  
May 2013

STOMACH CONTENT ANALYSIS OF BOTULISM-AFFECTED BIRDS IN LAKE  
MICHIGAN

By

David Essian

THESIS

Submitted to  
Northern Michigan University  
In partial fulfillment of the requirements  
For the degree of

MASTER OF SCIENCE

Office of Graduate Education and Research

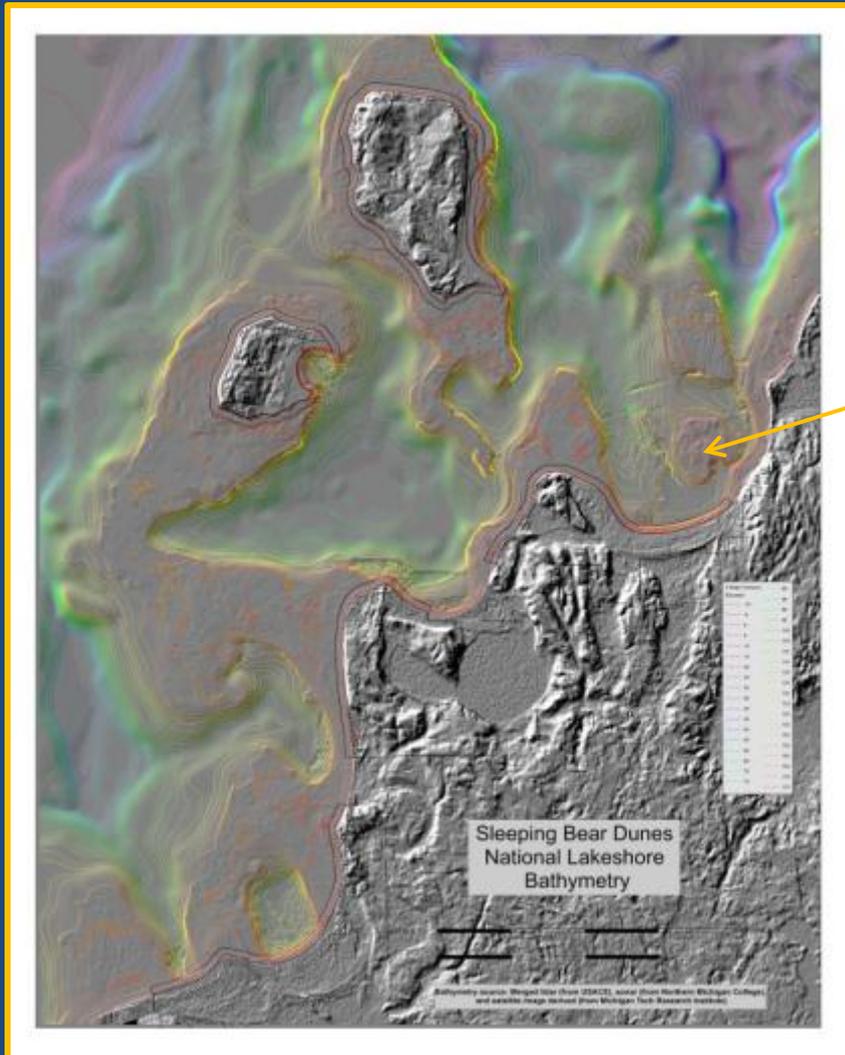
2014

Dreissenid metabolism and ecosystem-scale effects as revealed by oxygen consumption

Emily H. Tyner <sup>a</sup>, Harvey A. Bootsma <sup>a,\*</sup>, Brenda Moraska Lafrancois <sup>b</sup>

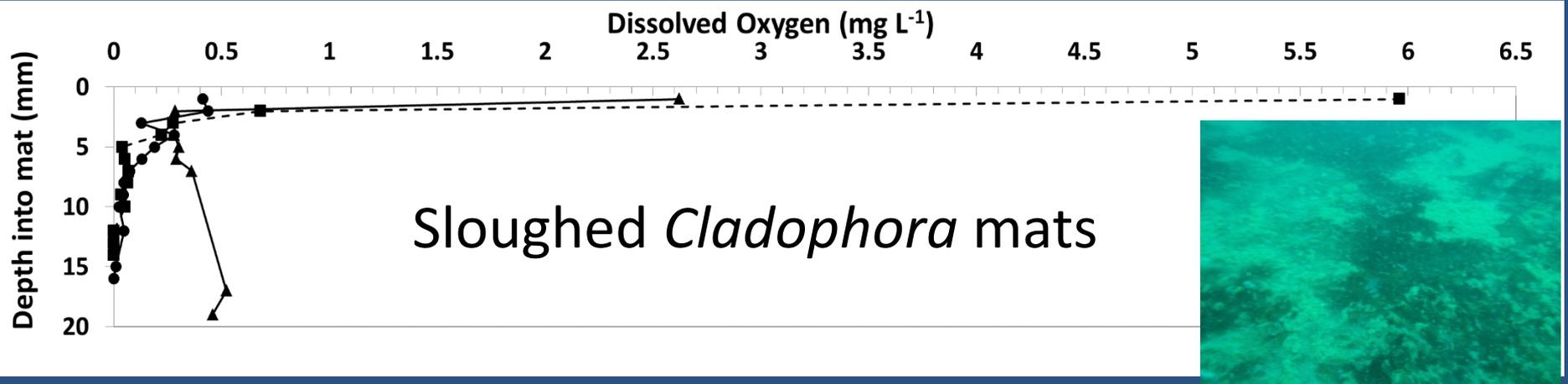


# Scientific and Management Response: Nearshore Monitoring at Good Harbor

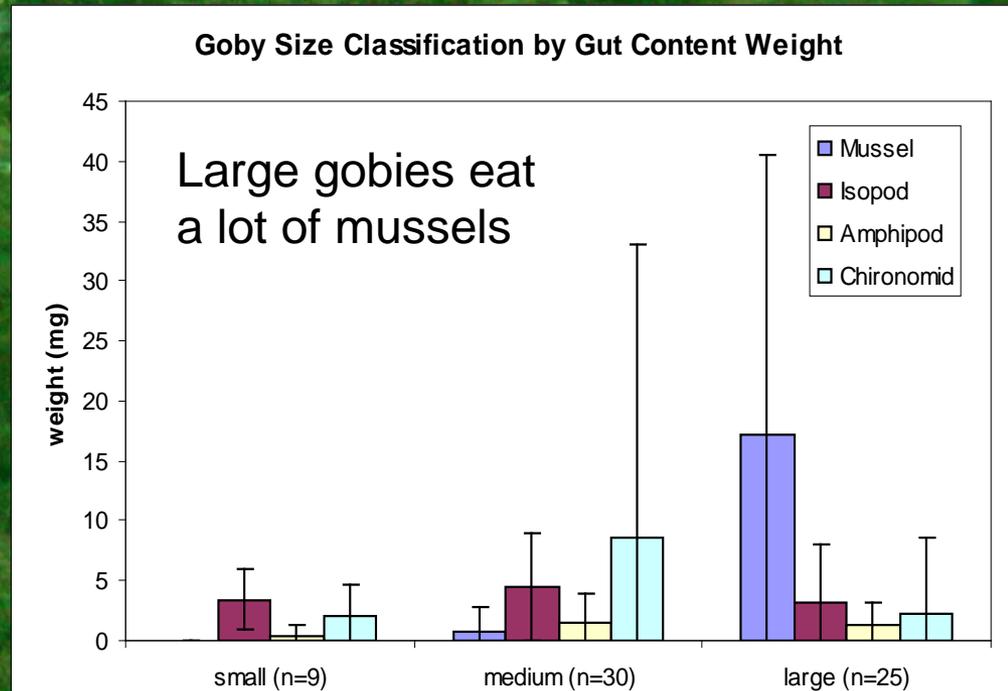


- Continuous water quality, currents, time lapse photos
- Periodic nutrients, seston, *Cladophora*, gobies, invertebrates

# Scientific and Management Response: Oxygen Dynamics

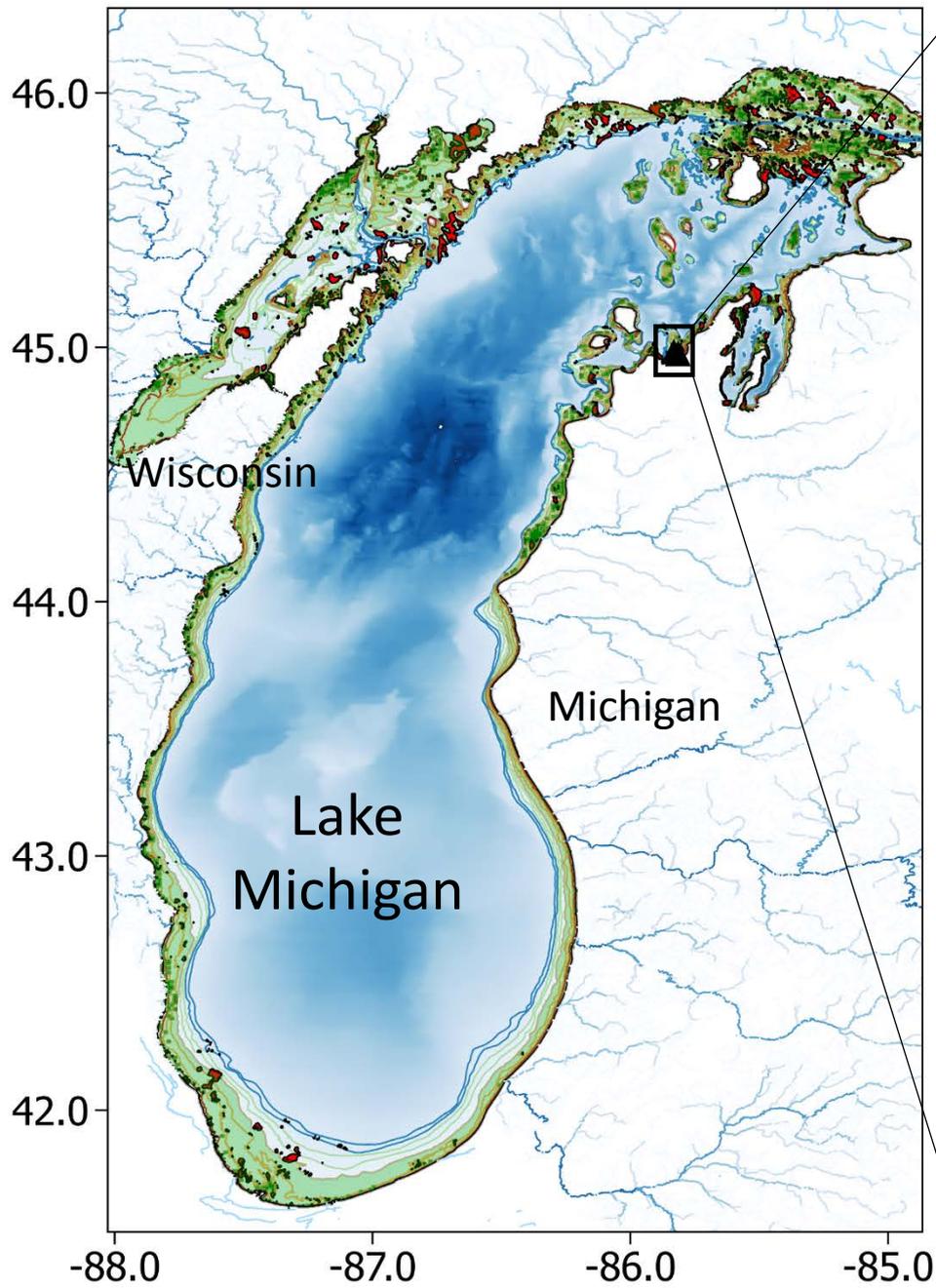


# Scientific and Management Response: Food Web Structure

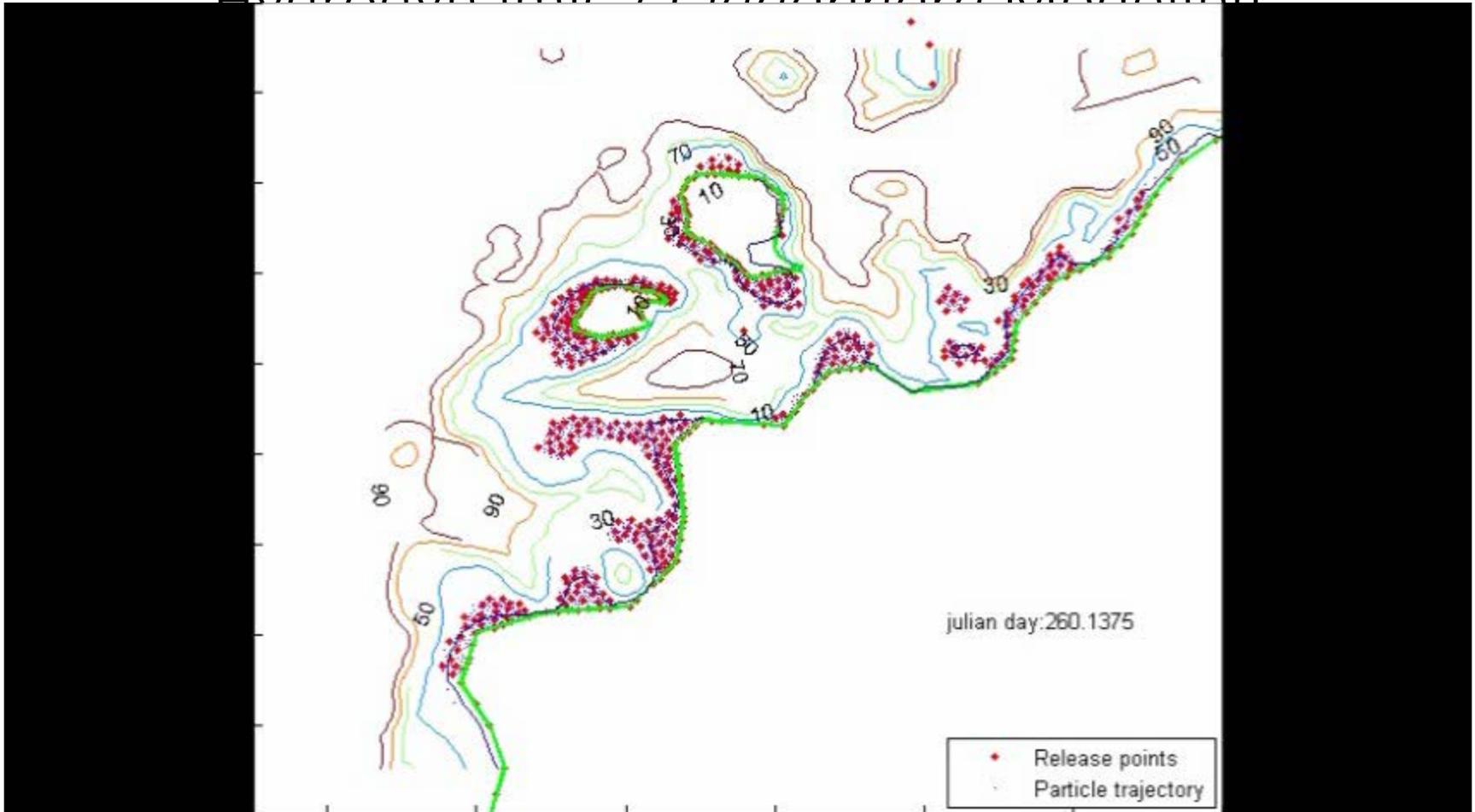


# Scientific and Management Response: Food Web Dynamics

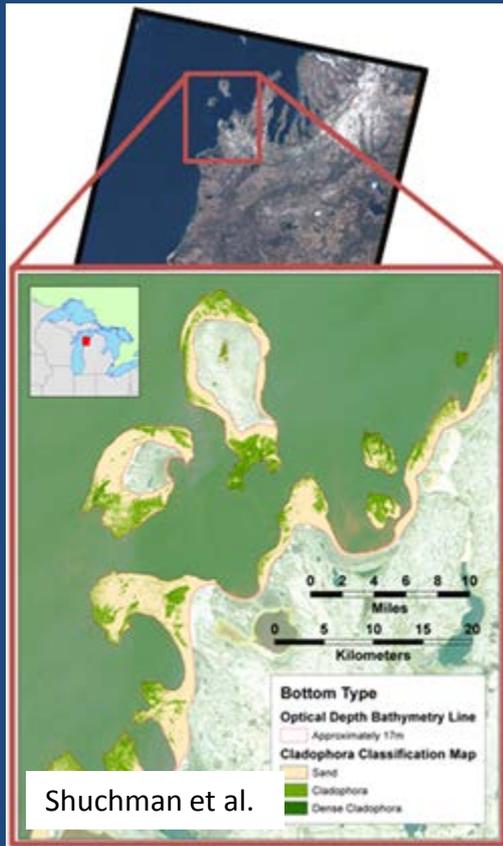




# Scientific and Management Response: Hydrodynamic / Gladenberg Modeling



# Scientific and Management Response: Research Ripples



## Association of Toxin-Producing *Clostridium botulinum* with the Macroalga *Cladophora* in the Great Lakes

Chan Lan Chun,<sup>†</sup> Urs Ochsner,<sup>†</sup> Muruleedhara N. Byappanahalli,<sup>‡</sup> Richard L. Whitman,<sup>‡</sup> William H. Tepp,<sup>§</sup> Guanyun Lin,<sup>§</sup> Eric A. Johnson,<sup>§</sup> Julie Peller,<sup>‡</sup> and Michael J. Sadowsky<sup>†,||,¶</sup>

## Prevalence of toxin-producing *Clostridium botulinum* associated with the macroalga *Cladophora* in three Great Lakes: Growth and management



Chan Lan Chun<sup>a</sup>, Chase I. Kahn<sup>a</sup>, Andrew J. Borchert<sup>a</sup>, Muruleedhara N. Byappanahalli<sup>b</sup>, Richard L. Whitman<sup>b</sup>, Julie Peller<sup>c</sup>, Christina Pier<sup>d</sup>, Guanyun Lin<sup>d</sup>, Eric A. Johnson<sup>d</sup>, Michael J. Sadowsky<sup>a,c,e</sup>

## Spatial, Temporal, and Matrix Variability of *Clostridium botulinum* Type E Toxin Gene Distribution at Great Lakes Beaches

Rasanthi U. Wljesinghe,<sup>\*</sup> Ryan J. Oster,<sup>\*\*</sup> Sheridan K. Haack,<sup>\*</sup> Lisa R. Fogarty,<sup>\*</sup> Taaja R. Tucker,<sup>§</sup> Stephen C. Riley<sup>†</sup>

U.S. Geological Survey, Michigan Water Science Center, Lansing, Michigan, USA<sup>†</sup>; CSS-Dynamac, Fairfax, Virginia, USA<sup>§</sup>; U.S. Geological Survey, Great Lakes Science Center, Ann Arbor, Michigan, USA<sup>\*</sup>

## *Cladophora*, mass transport, and the nearshore phosphorus shunt

Aaron I. Dayton<sup>a,1</sup>, Martin T. Auer<sup>a,¶</sup>, Joseph F. Atkinson<sup>b,2</sup>

## Influence of *Cladophora*–Quagga Mussel Assemblages on Nearshore Methylmercury Production in Lake Michigan

Ryan F. Lepak,<sup>†</sup> David P. Krabbenhoft,<sup>‡</sup> Jacob M. Ogorek,<sup>‡</sup> Michael T. Tate,<sup>‡</sup> Harvey A. Bootsma,<sup>§</sup> and James P. Hurley<sup>¶,†,||</sup>

## Nearshore energy subsidies support Lake Michigan fishes and invertebrates following major changes in food web structure

BENJAMIN A. TURSCHAK,<sup>1</sup> DAVID BUNNELL,<sup>2</sup> SERGIUSZ CZESNY,<sup>3</sup> TOMAS O. HOÓK,<sup>4</sup> JOHN JANSSEN,<sup>1</sup> DAVID WARNER,<sup>2</sup> AND HARVEY A. BOOTSMA<sup>1,5</sup>

# Overview

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# Toward a New Stewardship: Outreach and Interpretation



# Toward a New Stewardship: Citizen Science



- Helping NPS be responsive to changes
  - Government processes are slow; citizens rise to the challenge quickly
  - Funding is uncertain; citizens volunteer (often eagerly!) and nonprofits step in (thanks, NPCA!)

# Toward a New Stewardship: Citizen Science

- Helping NPS actively manage botulism outbreaks
  - Removing carcasses
  - Protecting wildlife from disease transmission



# Toward a New Stewardship: Citizen Science

- Collecting valuable data
  - Bird carcasses; beach and nearshore conditions
  - Integrated into broader research efforts



# Toward a New Stewardship: Citizen Science



- Sharing their knowledge, experiences, enthusiasm
  - Enriching the broader research effort
  - Connecting with local tourists, community, media



# Lessons Learned

- We need to take the long view
  - To get perspective on our current predicament
  - To forge future monitoring/management strategies
  - To avoid problem of shifting baselines
- We need local capacity and partnerships
  - Local citizens are our eyes and ears
  - NPS staff can continue to serve as a conveners
- We're excited to use Great Lakes parks as nearshore sentinels

# Acknowledgments



Citizen Scientists



Universities and Nonprofits



USGS Science Centers



Thanks, GLRI!



“We have not yet seen that level on the mainland, but it is likely a matter of time...”  
- S. Yancho, Feb 2005

North Manitou Island, SLBE, August 2004

6/24/14  
AW 10



6/10/14  
GH 10



6/3/14  
AW 10







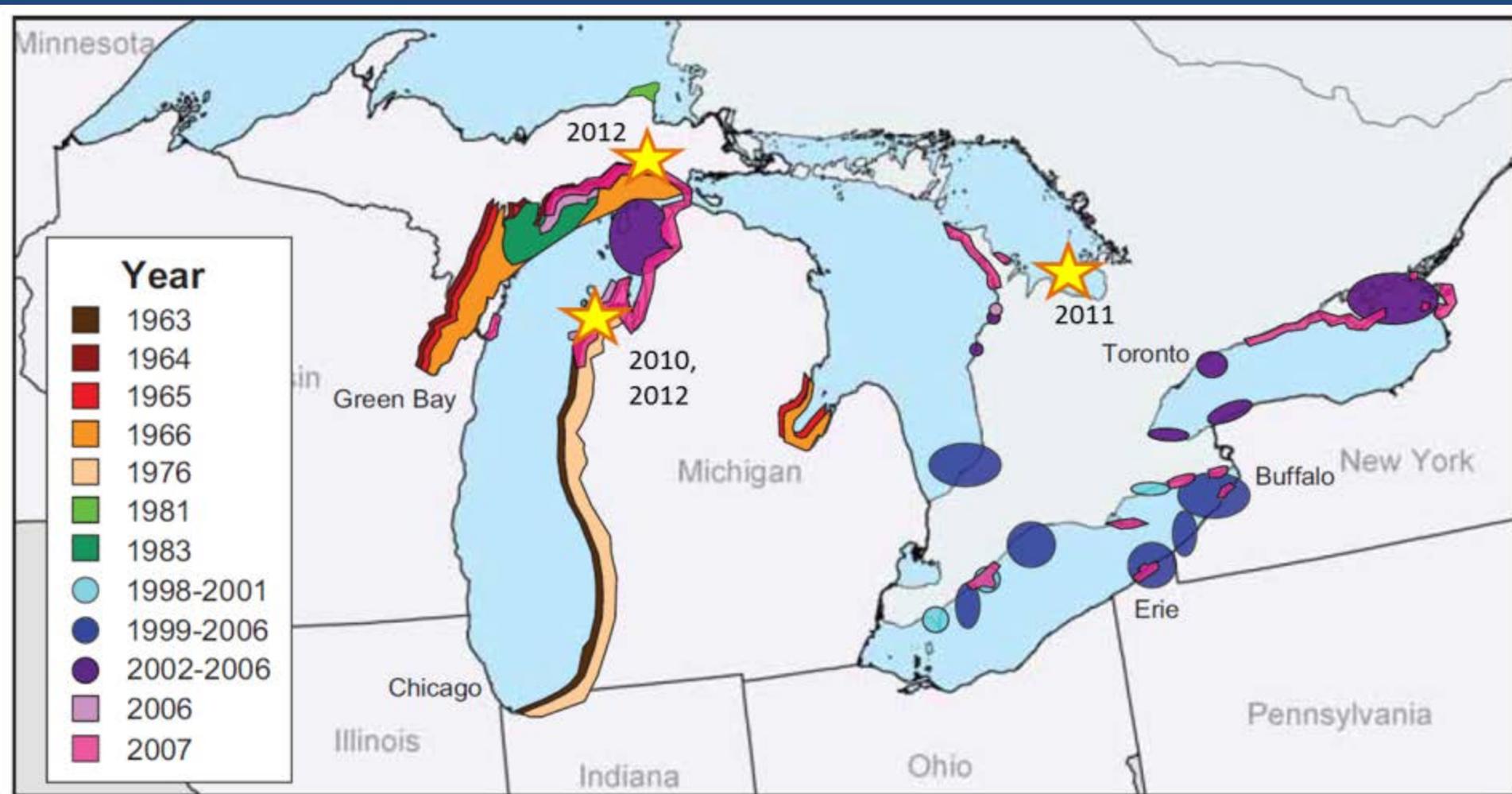


Figure 1. Historic botulism outbreaks (Zuccarino-Crowe 2009)

“We were not looking to get on the map.”  
 - K. Hyde, Oct 2006

# Scientific and Management Response

- SLBE's Good Harbor as a natural laboratory:
  - Shuchman et al. Satellite-derived **Cladophora maps**.
  - Chun et al. 2013. **Cladophora and C. botulinum**. ES&T.
  - Dayton et al. 2014. Cladophora, mass transport, **nearshore phosphorus shunt**. JGLR.
  - Turschak et al. 2014. **Nearshore energy subsidies**, fish and invertebrates. Ecology.
  - Lepak et al. 2015. Cladophora-quagga mussels and **methylmercury production**. ES&T.
  - Chun et al. 2015. **Cladophora, C. botulinum, management**. Sci Total Environ.
  - Wijesinghe et al. 2015. **C. botulinum variability**. App Environ Micro.

# Scientific and Management Response: Beach monitoring



# Scientific and Management Response: Beach monitoring

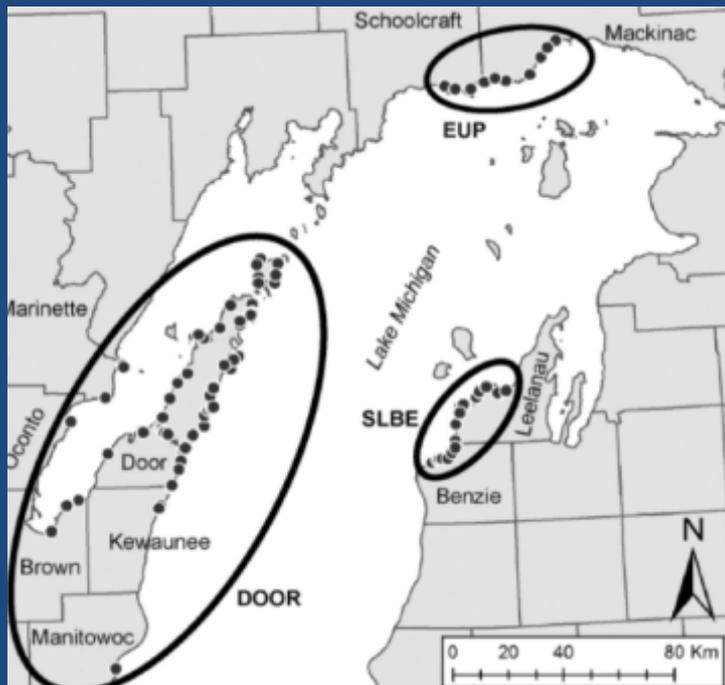
## Avian botulism type E in waterbirds of Lake Michigan, 2010–2013

Jennifer G. Chipault<sup>a,1</sup>, C. LeAnn White<sup>a,\*</sup>, David S. Blehert<sup>a,2</sup>, Susan K. Jennings<sup>b,3</sup>, Sean M. Strom<sup>c,4</sup>

<sup>a</sup> US Geological Survey, National Wildlife Health Center, 6006 Schroeder Rd., Madison, WI 53711, USA

<sup>b</sup> National Park Service, Sleeping Bear Dunes National Lakeshore, 9922 W. Front St., Empire, MI 49630, USA

<sup>c</sup> Wisconsin Department of Natural Resources Wildlife Health, 3369 W. Brewster St., Appleton, WI 54914, USA



- During 3 years, peak detection occurred in Oct; primarily migratory diving birds
- In 2011, peak detection occurred in Aug; primarily summer residents
- Variety of species affected suggests multiple routes for bird exposure to toxin

# Toward a New Stewardship: Local Partnerships

