

# **Troubled Waters:**

## **Factors Contributing to Type E Botulism Outbreaks at Sleeping Bear Dunes National Lakeshore**

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# Type E Botulism

## Large Die Off in 2006



# SLBE Die-off 2006

- Nearly 3,000 birds
  - Ring-billed Gulls
  - Herring Gulls
  - Double-crested Cormorants
  - Horned and Red-necked Grebes
  - Mergansers
  - Common Loons
  - Scoters
- Scores of fish
  - Lake trout, carp, and round gobies
- Cause of death = botulism type E



Photo: Alice Van Zoeren, SLBE



# America's North Coast

- 20% of the world's freshwater
- Ecological, cultural, commercial importance
- Lake Michigan
  - 4<sup>th</sup> or 5<sup>th</sup> biggest in the world
  - Only Great Lake entirely within U.S.

Sleeping Bear Dunes NL

Indiana Dunes NL

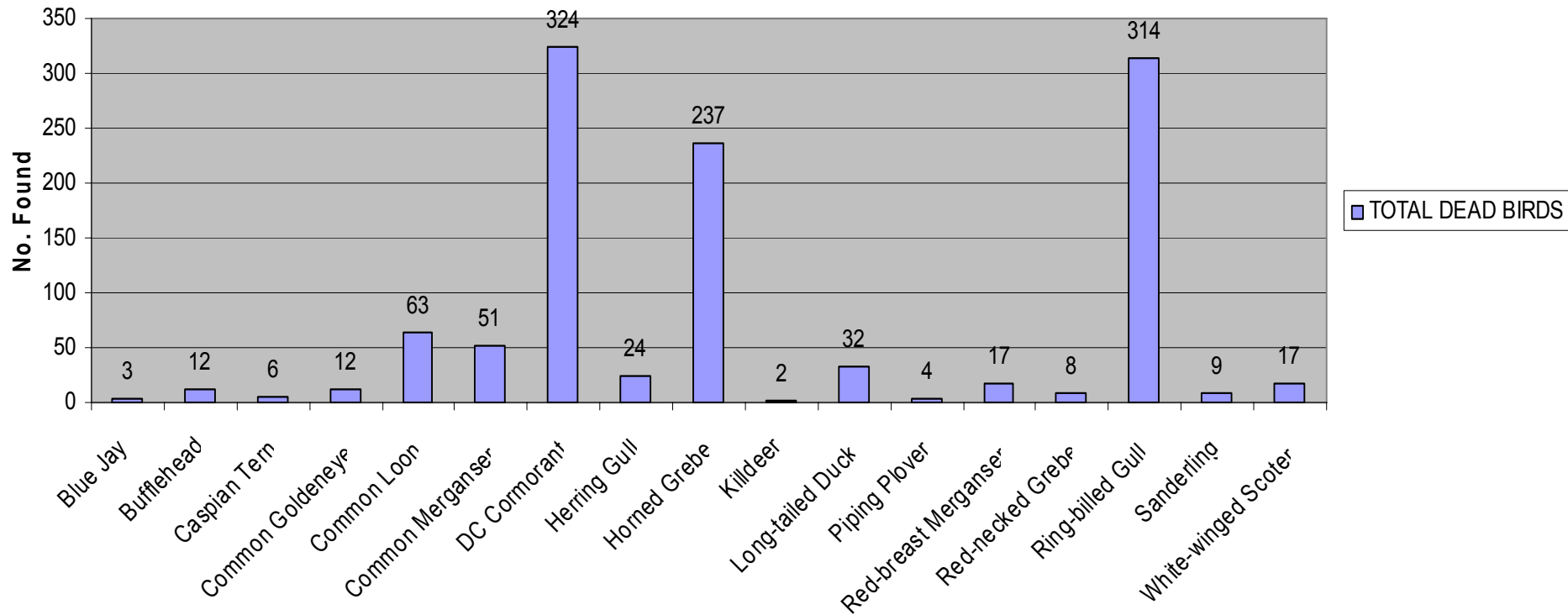


# Birds and Fish Involved



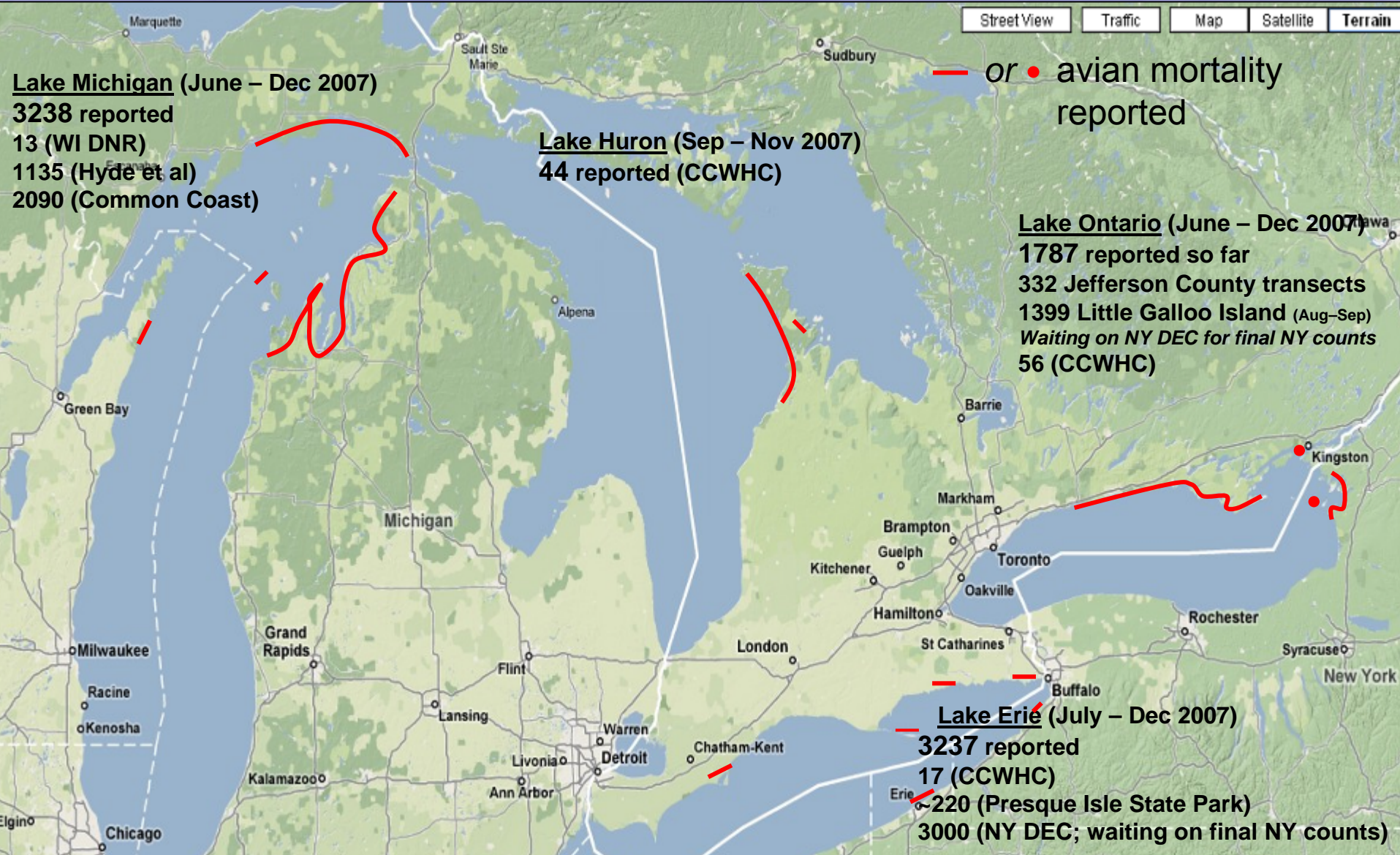
# 2007 - 17 Species of Birds, 8 Fish

Sleeping Bear Dunes - 2007 Bird Die-off Totals





# Preliminary 2007 Great Lakes Carcass Count = 8319





# Fish-eating Birds, Diving Ducks, and Shorebirds





# 2007 Piping Plovers lost - 2 Adults & 2 Chicks



# Botulism's Additional Impacts in Lake Michigan



- Human Food.....Visitor Experience.....Toxin Longevity



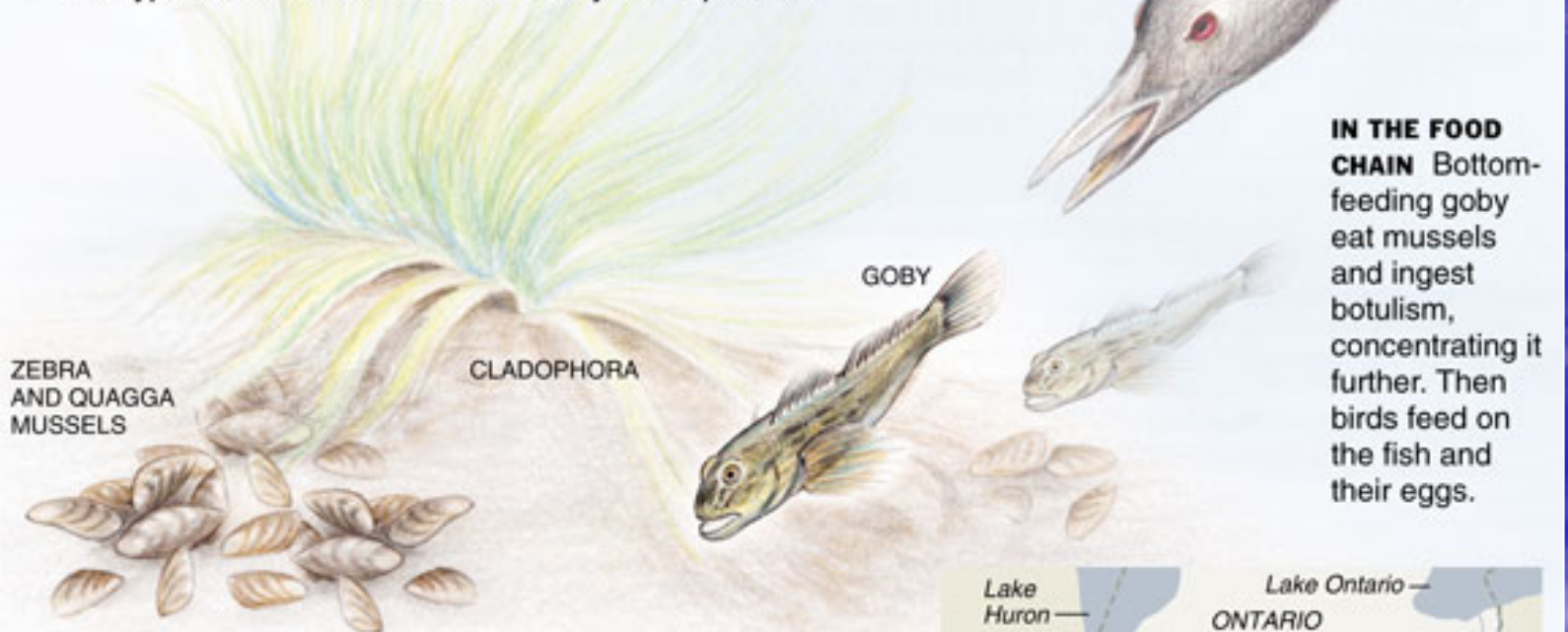
# Type E Botulism

- Toxin produced by vegetative form of *C. botulinum* under anoxic conditions
- Different than type C botulism
  - Affects mainly fish and fish-eating birds
  - Occurs mainly in Great Lakes
- Potent toxin
  - Prevents nerve transmission
  - Dizziness, disorientation, neck or wing-droop
  - Leads to death via drowning, water deprivation, electrolyte imbalance, respiratory failure, predation

# Probable role of invasive species...

## Aquatic Invaders and Stricken Birds

Large numbers of Lake Erie fish and birds are dying from type E botulism. Scientists suspect invader species from Eastern Europe — two types of mussels and a fish — may be responsible.



### A CHANGED ECOSYSTEM

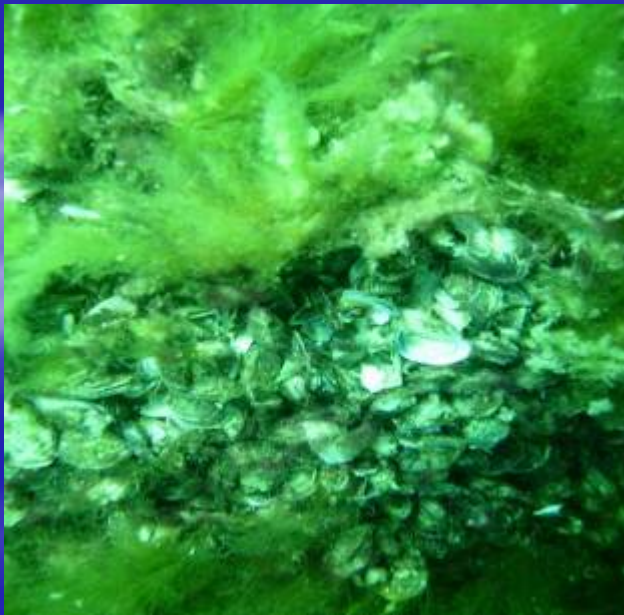
Zebra and quagga mussels filter algae from the water, making the lake clearer. Sunlight reaches the lake bed, prompting plant growth.

**BACTERIA THRIVE** Decaying plants create an oxygen-deprived environment favorable for botulism bacteria. As they filter the water, mussels may concentrate the toxin.





# Zebra and Quagga Mussels

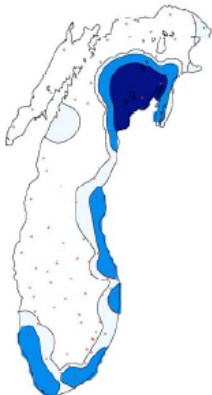


# The Quagga Invasion

Thomas F. Nalepa slides; Great Lakes Environmental Research Laboratory, NOAA

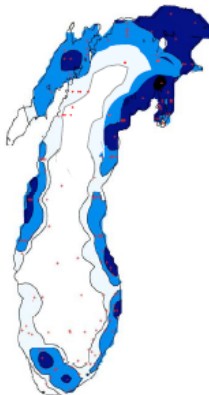
## *Dreissena polymorpha* (zebra mussel)

1994/95



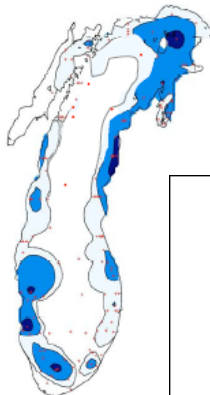
$10^1$   $10^2$   $10^3$   $10^4$   $10^5$   
Density (per m<sup>2</sup>)

2000



$10^1$   $10^2$   $10^3$   $10^4$   $10^5$   
Density (per m<sup>2</sup>)

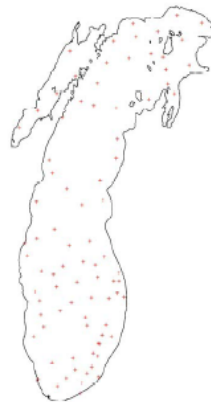
2005



$10^1$   $10^2$   $10^3$   $10^4$   
Density (per m<sup>2</sup>)

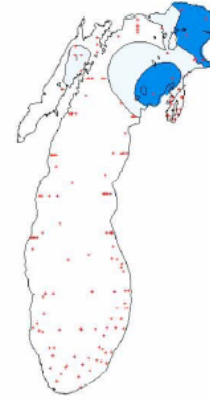
## *Dreissena rostriformis bugensis* (quagga mussel)

1994/95

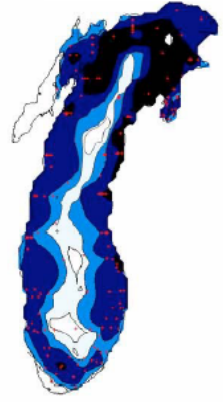


$10^1$   $10^2$   $10^3$   $10^4$   $10^5$   
Density (per m<sup>2</sup>)

2000



2005



$10^1$   $10^2$   $10^3$   $10^4$   $10^5$   
Density (per m<sup>2</sup>)



# Round Gobies eat Zebra & Quagga Mussels, Crayfish, Copepods, Macro-Invertebrates – All Type E Toxin Accumulators



**Round Goby**



# Major Round Goby Population Increase Since 2005



1 gazillion

(J. Glase, pers. comm.)

Photo: J. Sieracki (GLKN, 2006)



# Summertime - Dense Algae, Mussels and/or Gobies on the Beach



NPS Photo

# Possible Food Chain Routes

- Diving Ducks – Dive to feed on Mussels, crayfish, aquatic insects.
- Piscivorous Waterbirds – Sick Round Gobies and other Fish
- Ring-billed Gulls – Sick fish & Carrion
- Shorebirds – Macroinvertebrates in algae, dead Mussels in shells, small 'Tidbits' of Carrion, Maggots in bird & fish carcasses



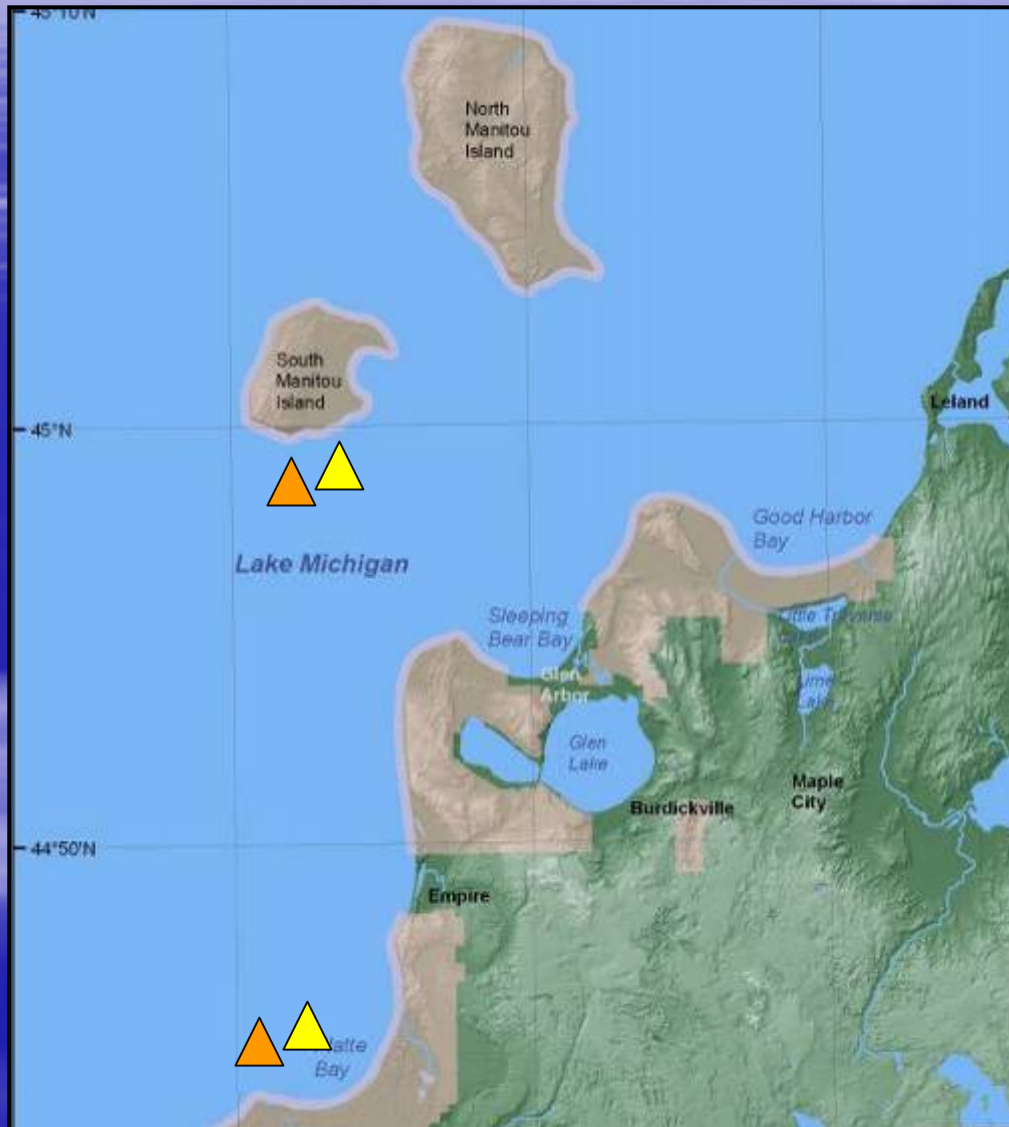


# Questions

- Are anoxic conditions present?
- Is type E toxin present in key benthic food web components?
- Is type E toxin present in dead fish and birds?
- What have affected fish and birds consumed?



# 2007 Study Sites



▲ Rocky (2)  
(Dreissenids)

▲ Sandy (2)  
(No Dreissenids)

All Sites 25' Deep

# Study Sites

**Rocky**



**Sandy**



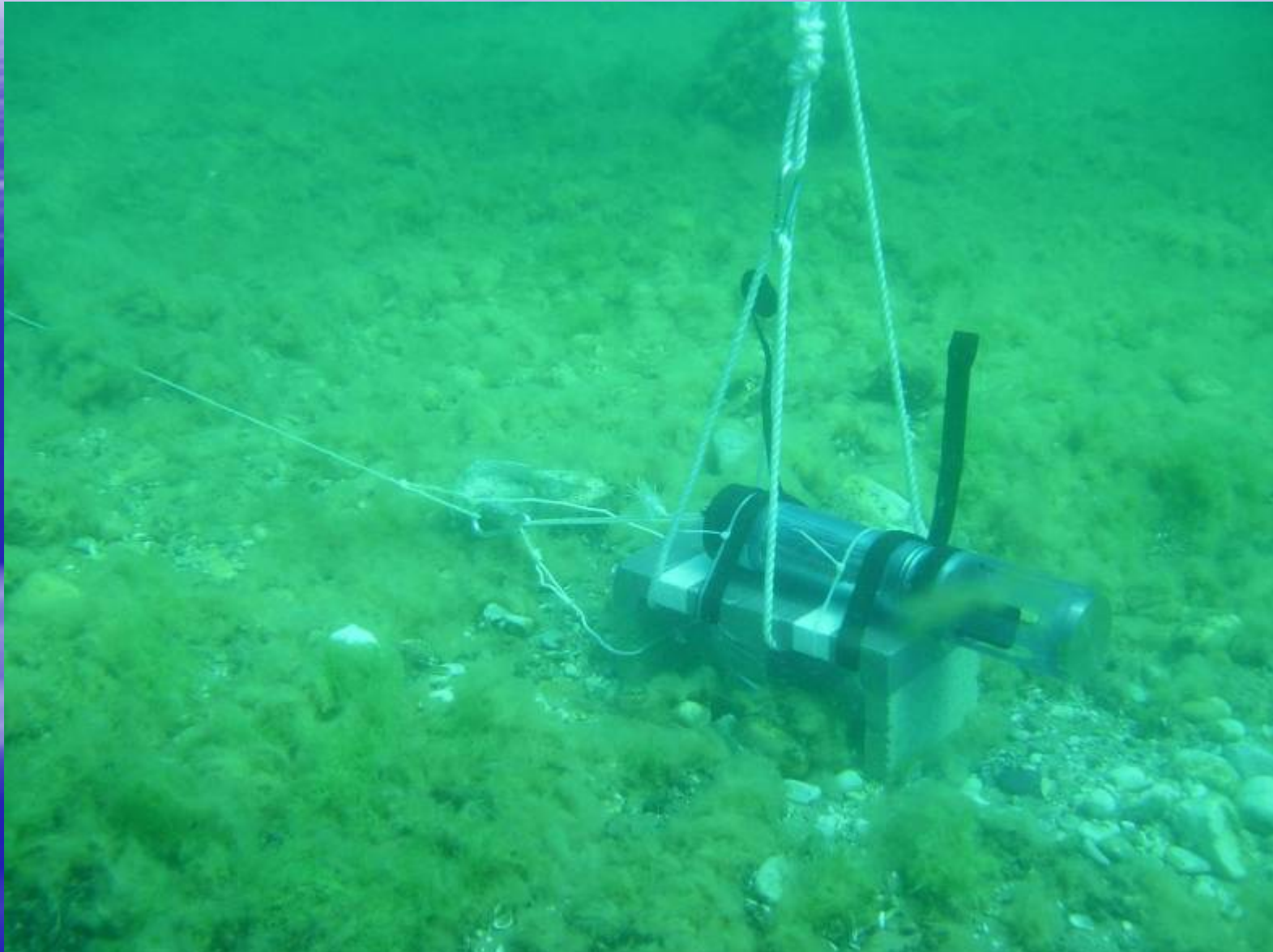


# Additional Light, Mussels, & Phosphorus Cycling in Near-Shore Areas = Dense Algae



# Amazing Water Clarity

NPS Probe at 7m depth



# Dissolved Oxygen: Summary

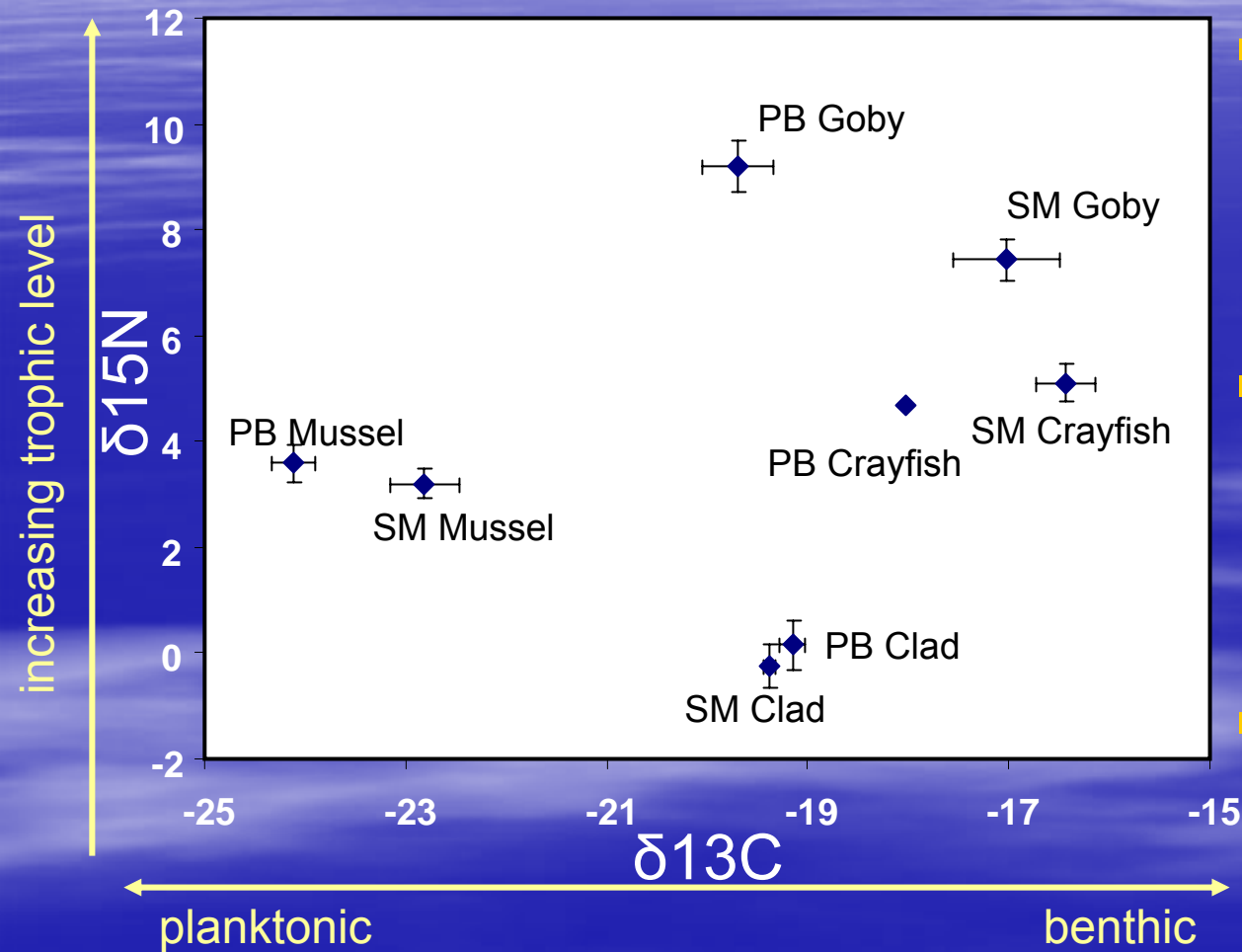
- No evidence of oxygen depletion at continuous monitoring sites; however,
- Anoxic conditions present in depositional areas, and
- Evidence of high oxygen demand from *Cladophora* in the dark.





# Trophic Linkages: Stable Isotopes

- H. Bootsma UW-Milwaukee Great Lakes WATER Institute



- Mussels consuming mainly phytoplankton
- Gobies consuming more than just mussels
- Gobies feeding differently at SM and PB sites

# Trophic Linkages: Gut Contents

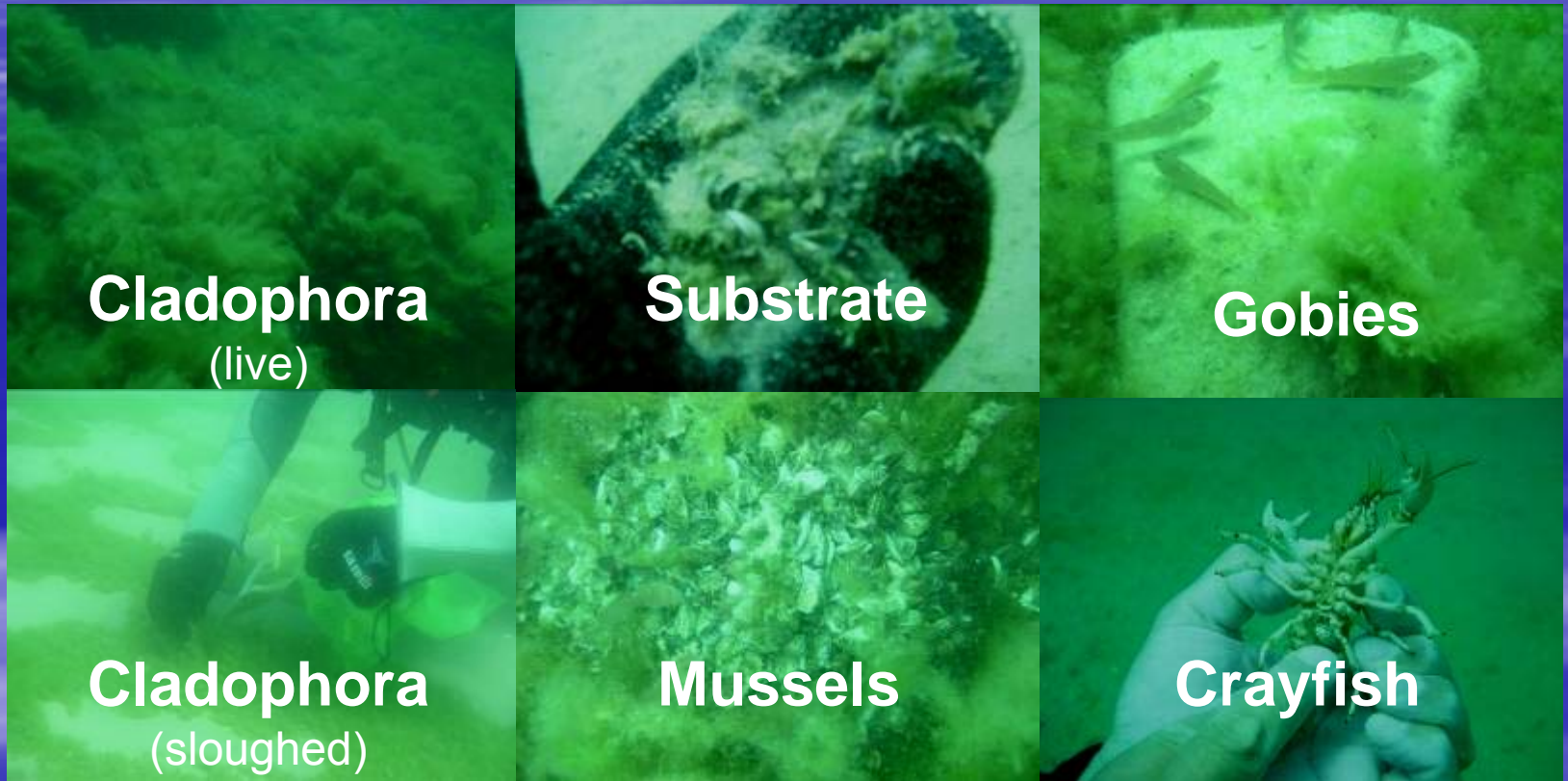
- J. Leonard, R. Holman, Northern Michigan University

- 58 birds analyzed
- Fish and bird bones, insects, crayfish, gastropods, dreissenids, etc. distinguishable
- 17% had identifiable gobies; 33% had clear evidence of dreissenids
- Horned Grebes (9), Red-necked Grebes (3), & Herring Gulls (3), did NOT have gobies in gut contents



# Bot-E Toxin Analysis:

- J. Czarnecki, US Naval Medical Research Center



Toxin presence assessed using ELISA and QPCR



# Conclusions

- D.O. depletion uncommon in nearshore, except in depositional areas
- Bot-E toxin present in dead fish and birds
- Goby and dreissenid remains present in some birds
- In general, some support for hypothesized toxin pathway

# Future Directions

- Expand D.O. monitoring
- Expand toxin detection & monitoring
- Conduct intensive studies (2009-2011)
  - Mapping
  - Food webs
- Create image database
  - Monitoring
  - Outreach



Photo: T. Lafrancois

# Acknowledgments

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