Troubled Waters:

Exploring potential links between invasive species and type E botulism outbreaks at Sleeping Bear Dunes NL

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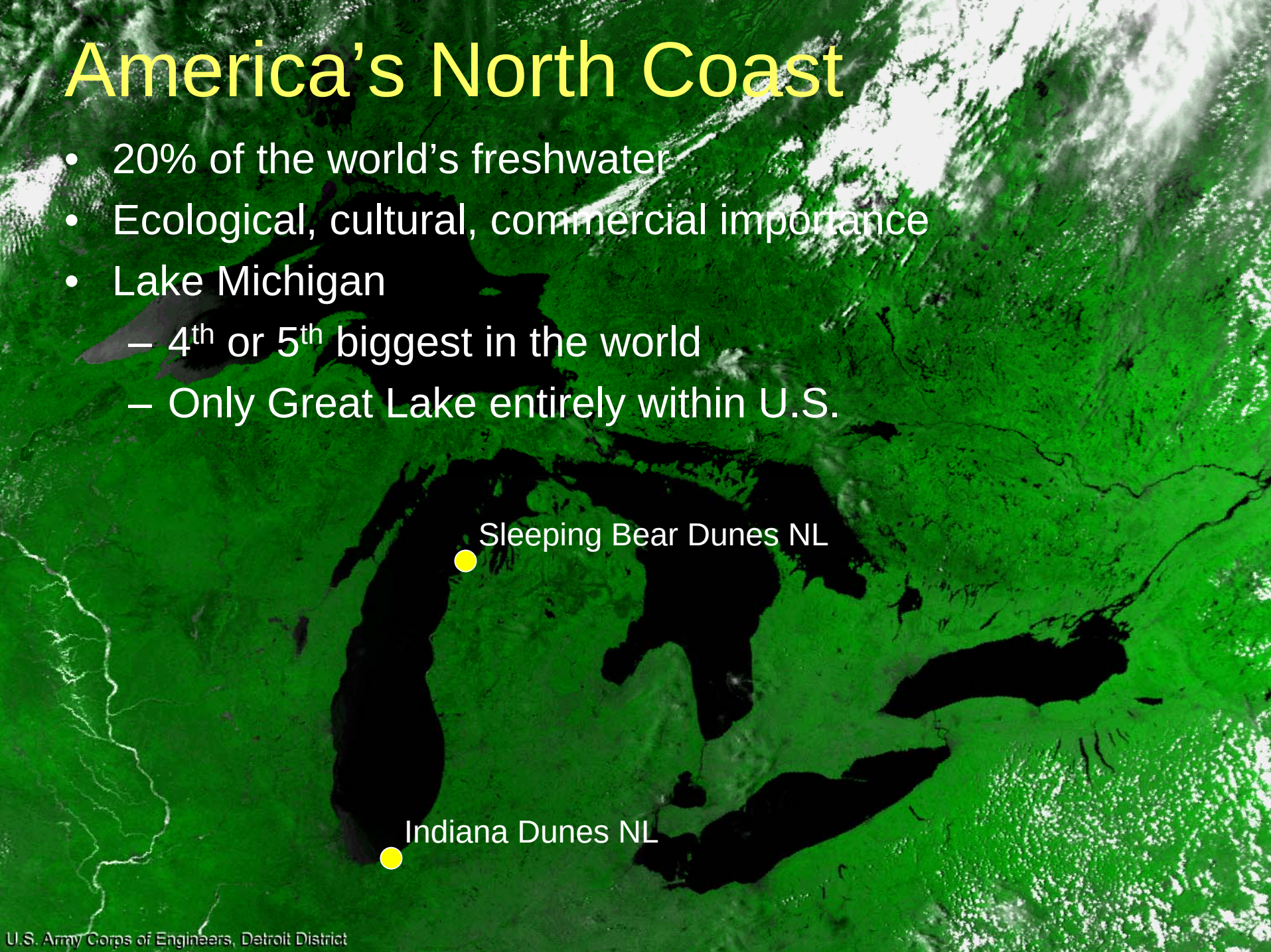
America's North Coast

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



U.S. Army Corps of Engineers, Detroit District

86°10'W
86°W
85°50'W
45°10'N
45°N
44°50'N
44°40'N
North Manitou Island
South Manitou Island
Leland
Good Harbor Bay
Lake Michigan
Sleeping Bear Bay
Glen Arbor
Glen Lake
Burdickville
Maple City
Empire
Platte Bay
Platte Lake
Crystal Lake
Frankfort
Beulah
Sleeping Bear Dunes National Lakeshore
Elev. (m)
350
171
0 3 6 12 km
0 2 4 8 mi

USGS (2007)

Die-Off 2006

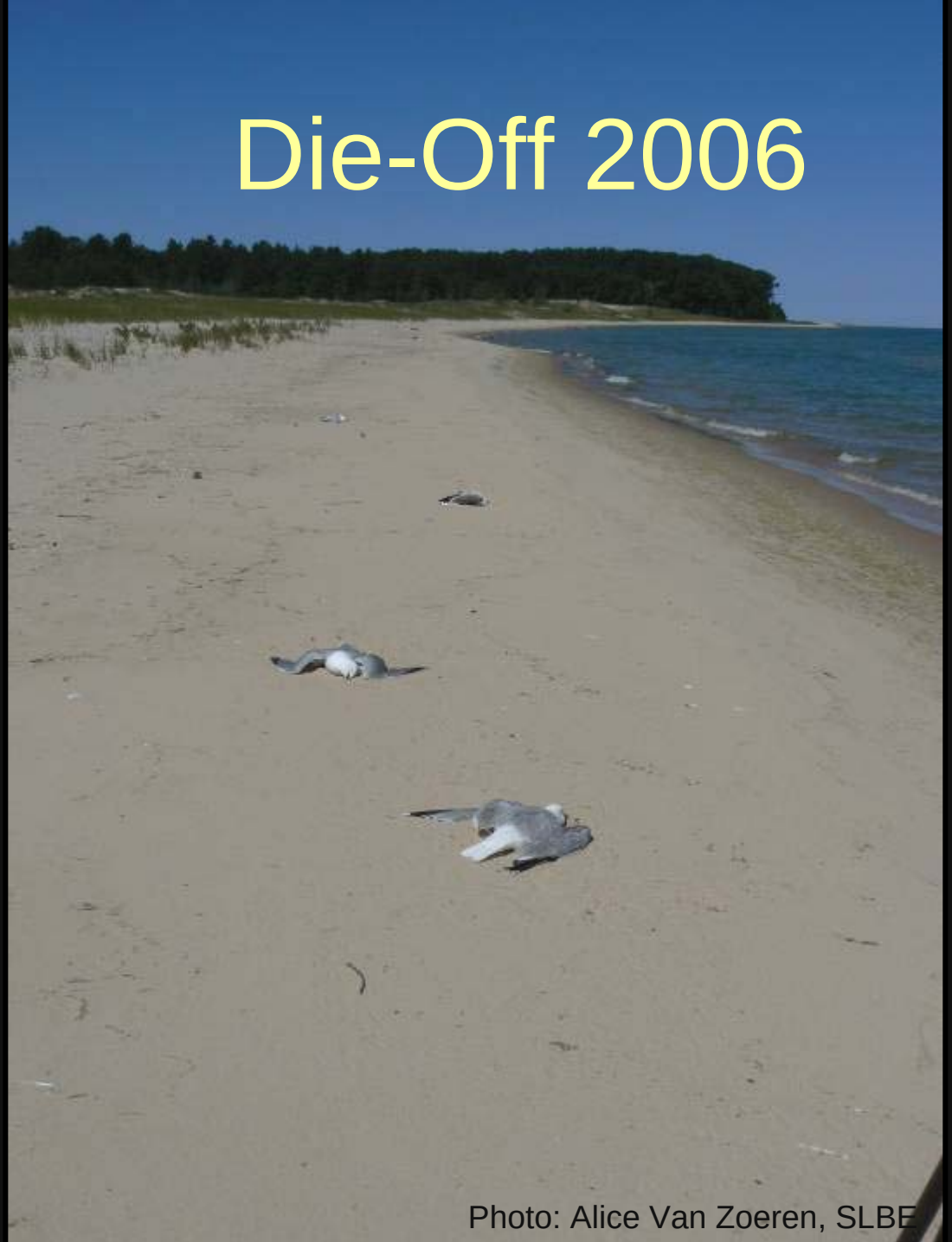


Photo: Alice Van Zoeren, SLBE

Die-off 2006

Photo: Alice Van Zoeren, 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

Type E Botulism

- 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

National Wildlife Health Center (2007)

Recent Resurgence

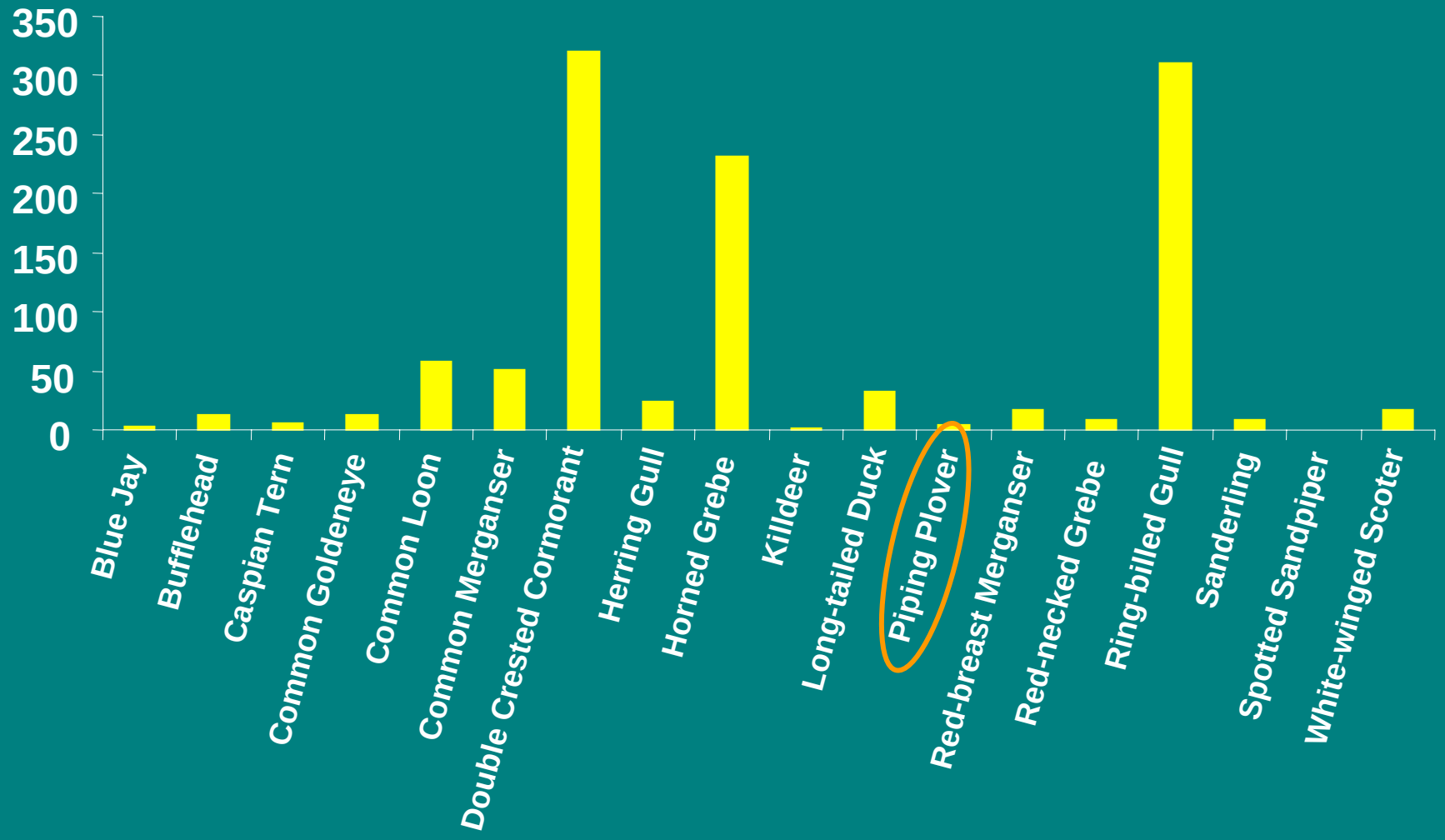
50,000+ birds since 1999

Michigan Sea Grant (2006)

2007 Die-Offs: Birds

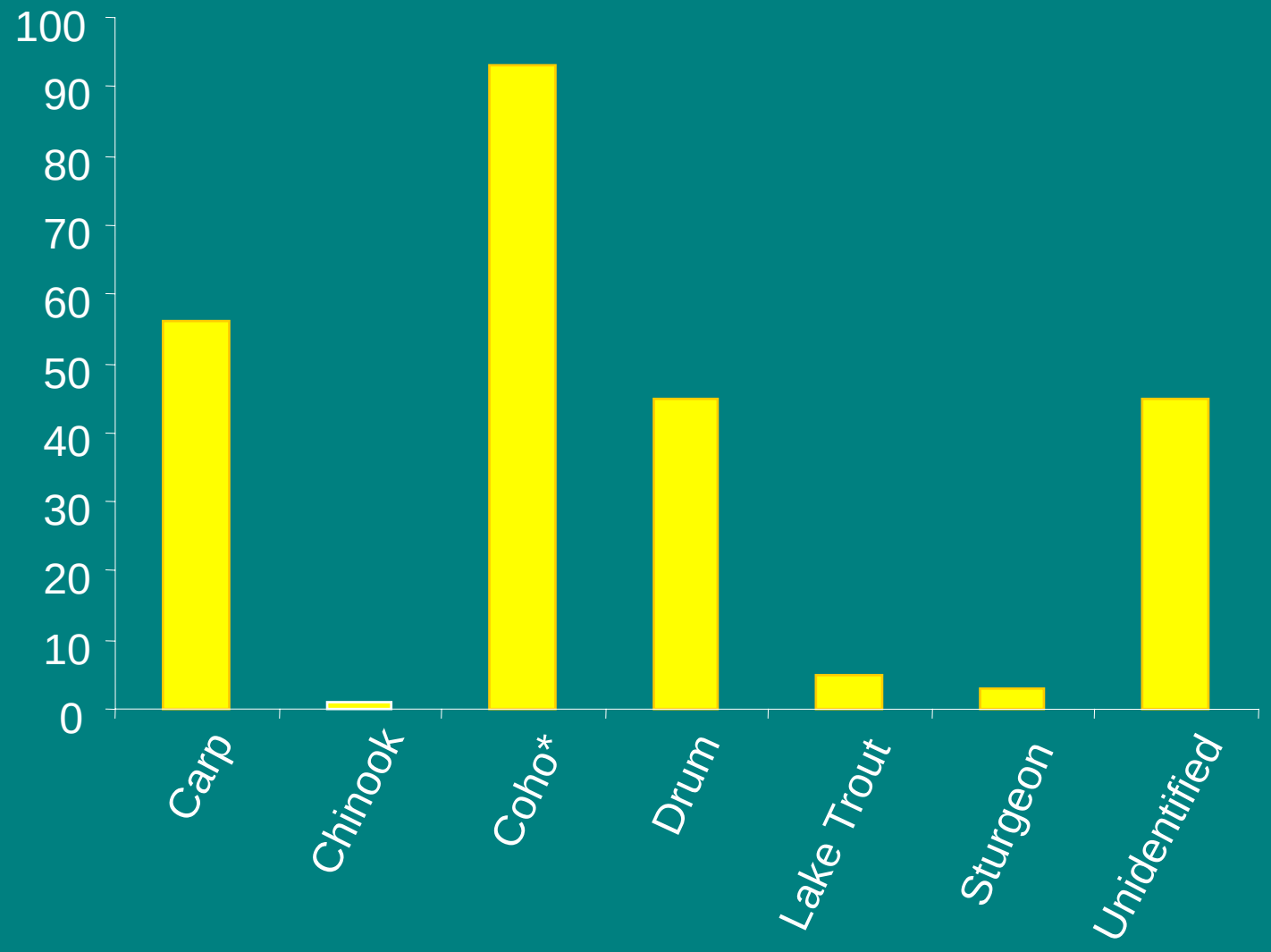
- Began earlier (late June)
- Affected a greater number of species (including T&E)
- Occurred beyond Sleeping Bear Dunes

2007 Die-Offs: Birds



Ken Hyde & Alice Van Zoeren, SLBE

2007 Die-Offs: Fish



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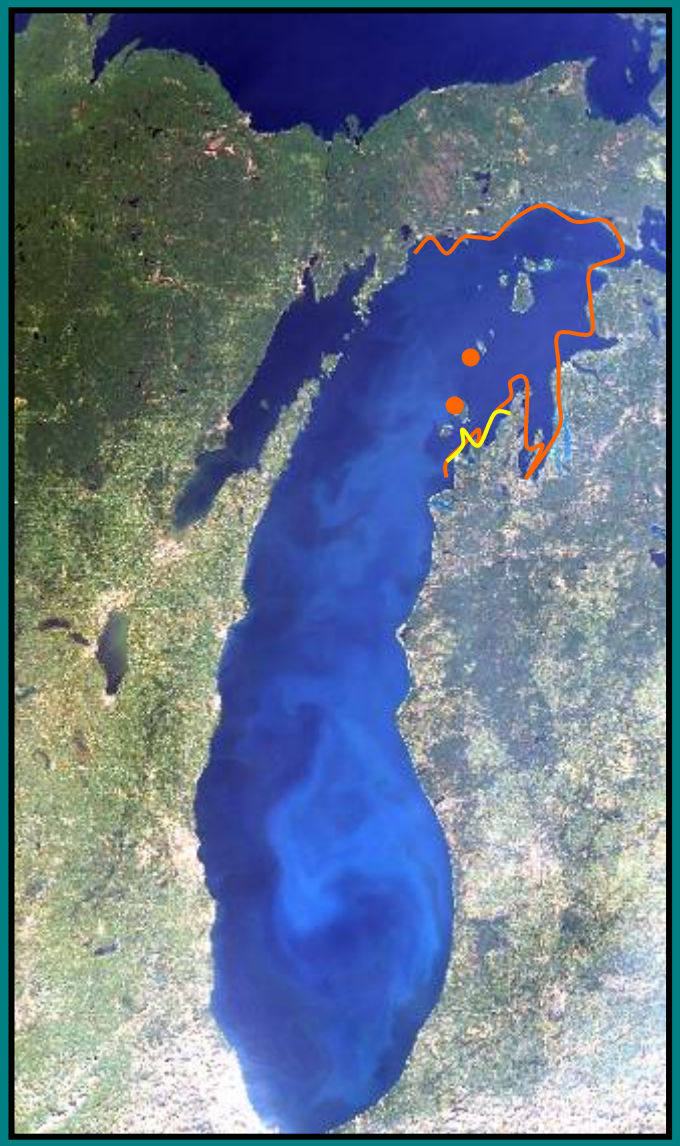
2007 Die-Offs

- At Sleeping Bear, 1,100+ birds
- Elsewhere along L. Michigan, ~ 8,000 birds (including 2,000 loons)



2007 Die-Offs

Chain reaction killing loons in Great Lakes

Experts cite Type E botulism traced to mussels

Melissa Leong, National Post, With Files From The New York Times

Published: Saturday, December 29, 2007

East Lansing, Mich. / Botulism threatens birds of the Great Lakes

Exotic species believed to bring bacteria

BY JEFF ALEXANDER
Newhouse News Service

Article Last Updated: 12/29/2007 09:18:56 PM CST

BIRD AND FISH POISONING SPREADS IN GREAT LAKES

Bob Allen
December 3, 2007

Scientists Examine Bird Deaths o Great Lakes

Matt Pitts, Producer

Updated: 11/15/2007 2:44:01 PM

TOXIN KILLS ENDANGERED BIRDS

Bob Allen
July 23, 2007

timesunion.com

FOLLOW-UP ON THE NEWS

2006 bird kill one of worst ever

First published: Sunday, October 7, 2007

Botulism suspected in bird die-off

BY SHERI McWHIRTER
smcwhirter@record-eagle.com

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 i

By Tom Meersman, Star Tribune
Last update: December 8, 2007 - 1:52 AM

TRAVERSE CITY RECORD-EAGLE
Northern Michigan's Newspaper

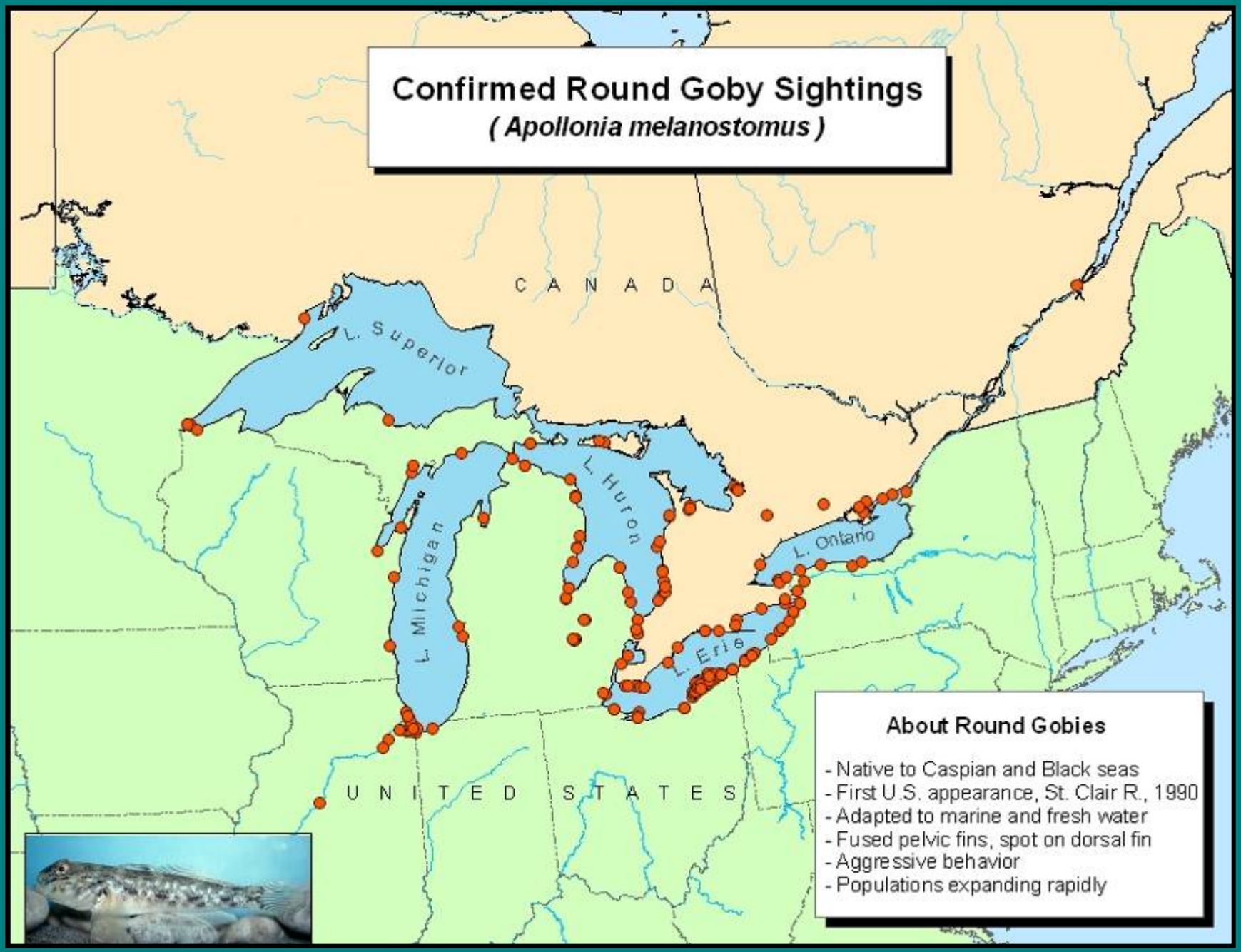
Bird die-offs return to lakeshore

By VICTOR SKINNER
vskinner@record-eagle.com

Potential Pathways

Adapted from Ruffing (2004)

Photos: Paul Murphy (SLBE, BICY)



U.S. Geological Survey (2006)

Round Gobies at Sleeping Bear

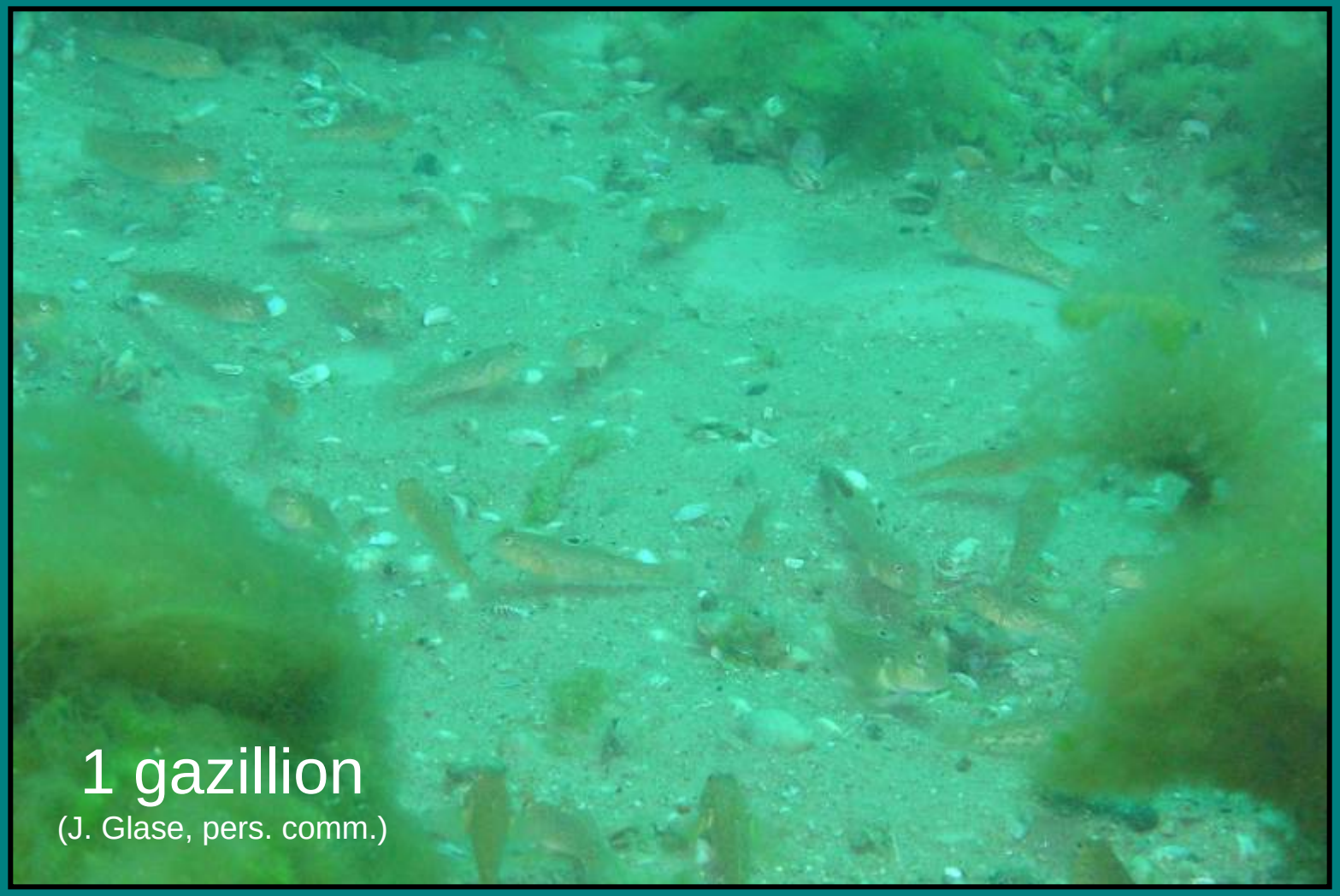


Photo: J. Sieracki (GLKN, 2006)

2007 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?

Study Sites

Rocky (2)
(Dreissenids)

Sandy (2)
(No Dreissenids)

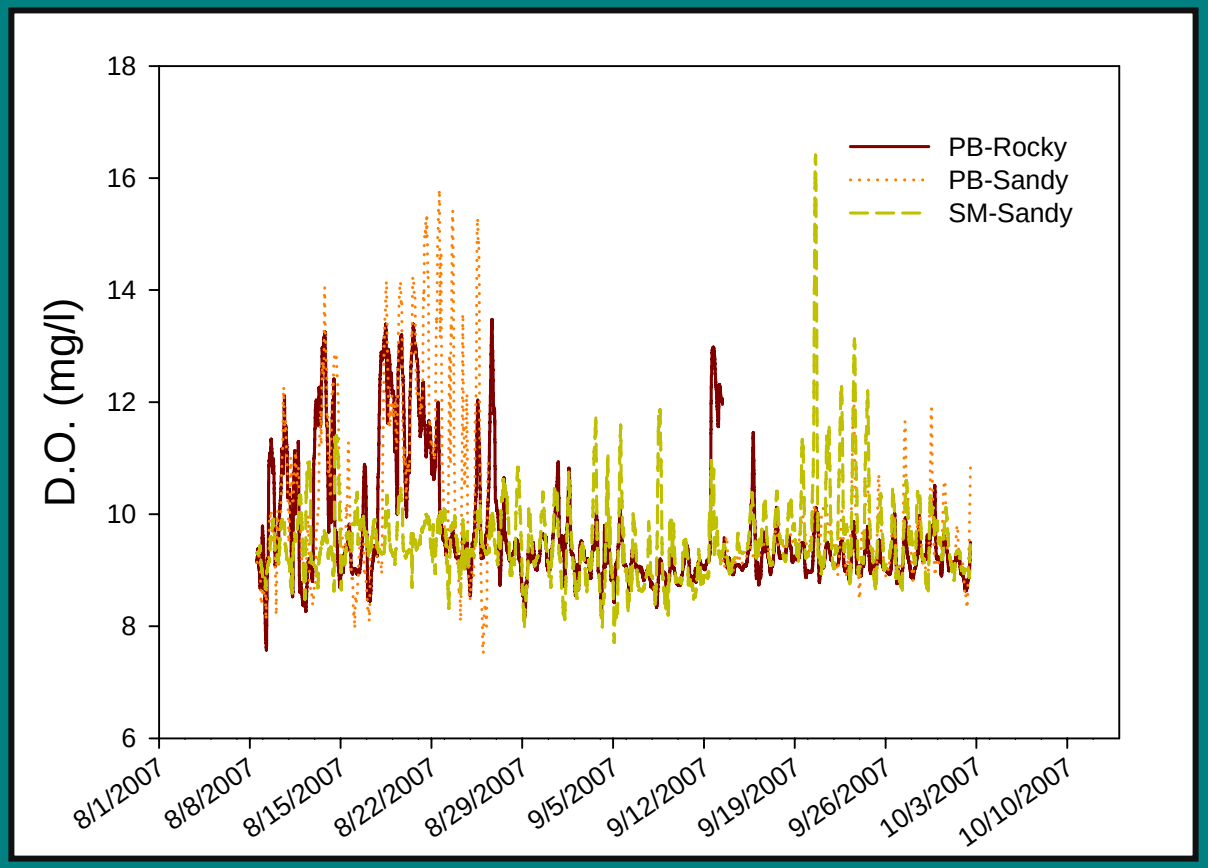
All Sites 25’

Study Sites

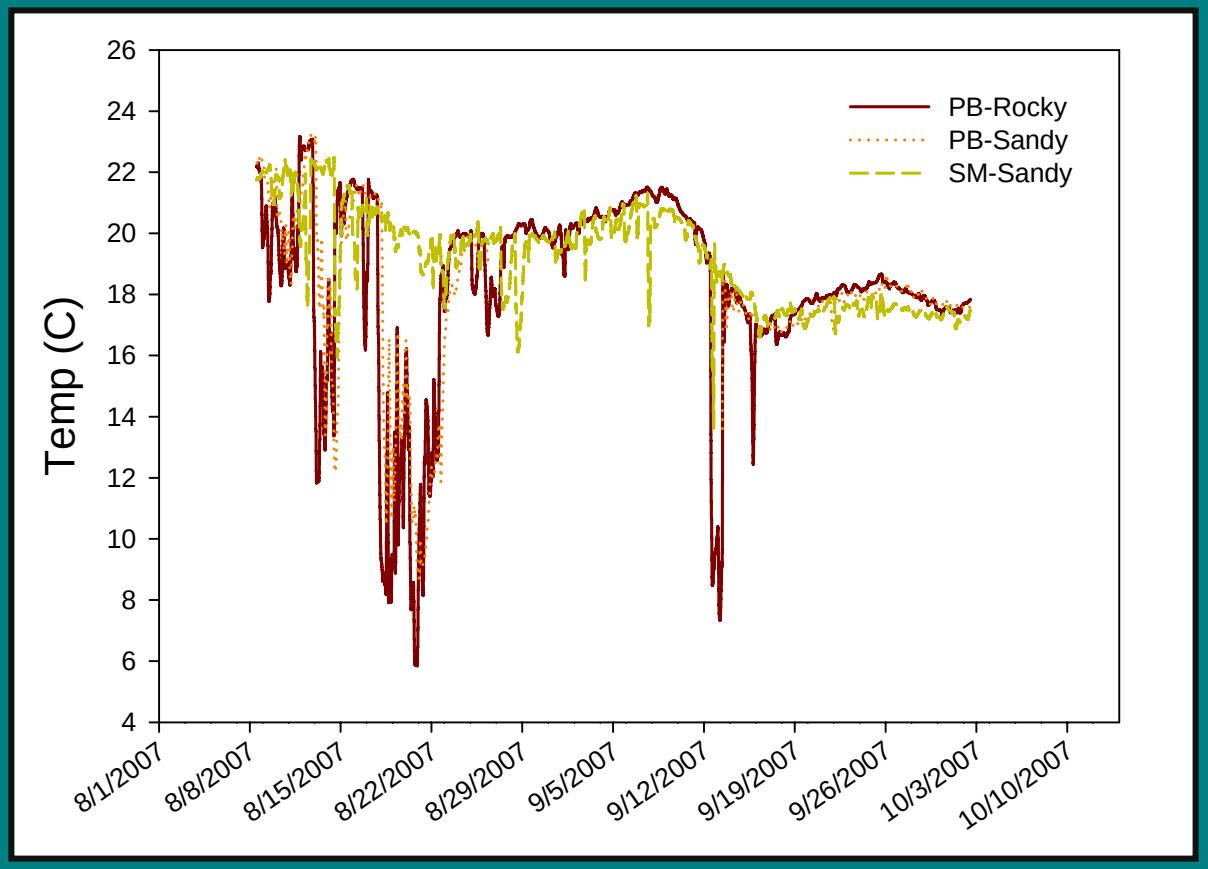
Dissolved Oxygen Studies

- Monitored 4 sites continuously, early Aug - early Oct
- Conducted spot measurements in a high-risk spot
- Conducted oxygen demand experiment

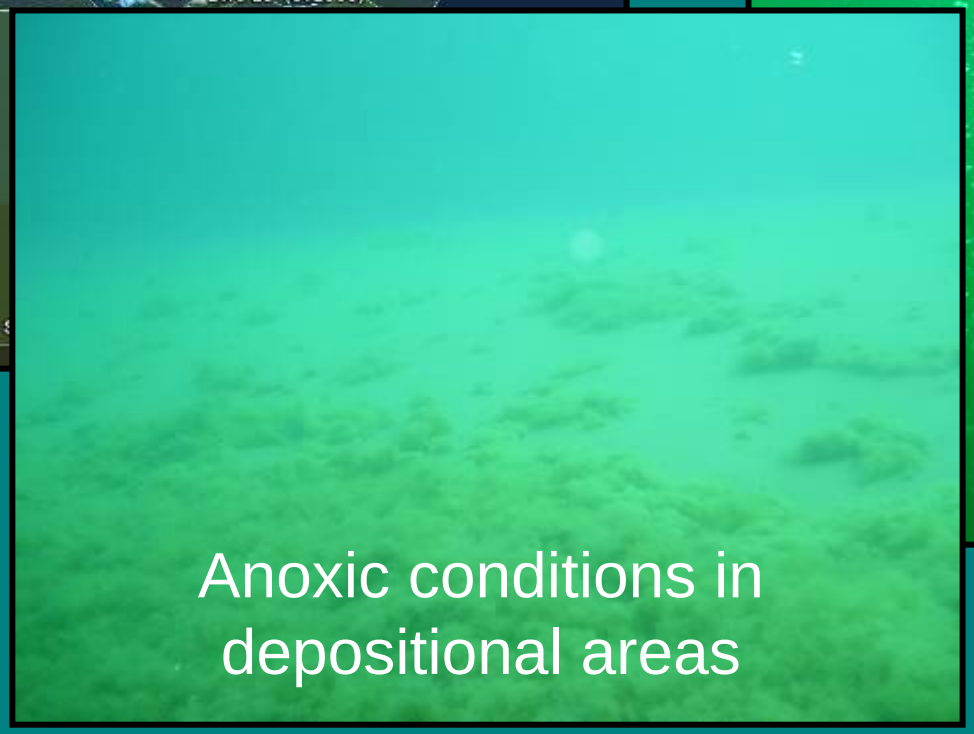
Dissolved Oxygen: Monitoring



Dissolved Oxygen: Monitoring

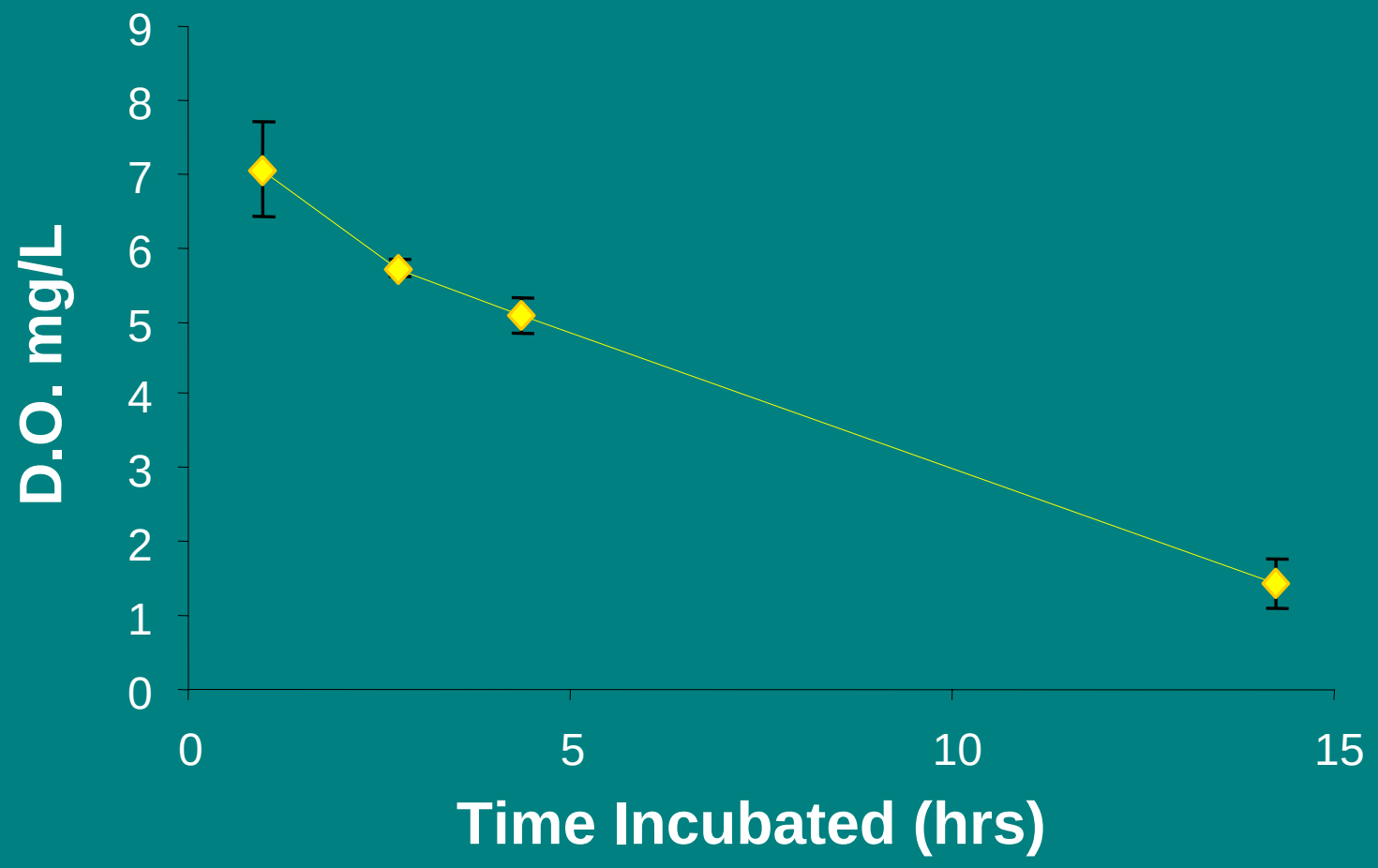


Dissolved Oxygen: Profiles



Dissolved Oxygen: Experiment

Dissolved Oxygen: Experiment



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.

Bot-E Toxin Analysis: Benthic Food Web

Toxin presence assessed using ELISA and QPCR

Bot-E Toxin Analysis: Dead Birds and Fish

Photos: Alice Van Zoeren, SLBE

Food Web Analysis: Gut Contents

- 58 birds analyzed
- Fish and bird bones, insects, crayfish, gastropods, and dreissenids distinguishable
- 19% had identifiable fish bones; 16% had clear evidence of dreissenids
- Percentages of these likely to increase as work continues

Food Web Analysis: Stable Isotopes

- Rocky sites only
- Sampled once during September
- Analysis in progress

Conclusions

Photo: A. Van Zoeren

- D.O. depletion uncommon in nearshore, except:
  - Depositional areas
  - Nighttime?
  - Microhabitats?
- 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 monitoring
- Conduct intensive studies
  - Mapping
  - Food webs
- Create image database
  - Monitoring
  - Outreach (big poster-child potential!)

Photo: T. Lafrancois

Acknowledgments

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- Bob Whaley

Photo: Alice Van Zoeren, SLBE