Type E Botulism in the Great Lakes:

A Widespread Concern

-Alicia Pérez-Fuentetaja

Sites of botulism type E outbreaks 1961-2006

Rocke and Bollinger 2007

www.glrc.us

Great Lakes: Affected organisms

- Birds; typically two major events:
  - mid-to-late summer:
    - terns, gulls and cormorants.
  - during Fall migration:
    - sandpipers and sanderlings.
    - fish-eating birds such as loons, mergansers and grebes.
    - mussel-eating ducks such as long-tailed ducks, scoters and scaup.
- Fish:
  - freshwater drum, smallmouth bass, round gobies, lake sturgeon.
- Other:
  - Mudpuppies (aquatic salamanders)

Bird mortality estimates (USGS)

Year	Lake	Number	Primary species
1963-1964	Michigan	>12,000	Gulls, Loons
1976-1983	Michigan, Huron	>1,800	Gulls, Loons
1998-2002	Michigan, Huron	~2,500	Mergansers, Gulls, Loons
1999-2001	Erie	>25,000	Mergansers, Gulls, Loons
2002	Erie	>25,000	Long-tail ducks, Gulls Loons, Mergansers, Cormorants
2004	Ontario	>2,000	Long-tail ducks, Gulls Loons, Cormorants

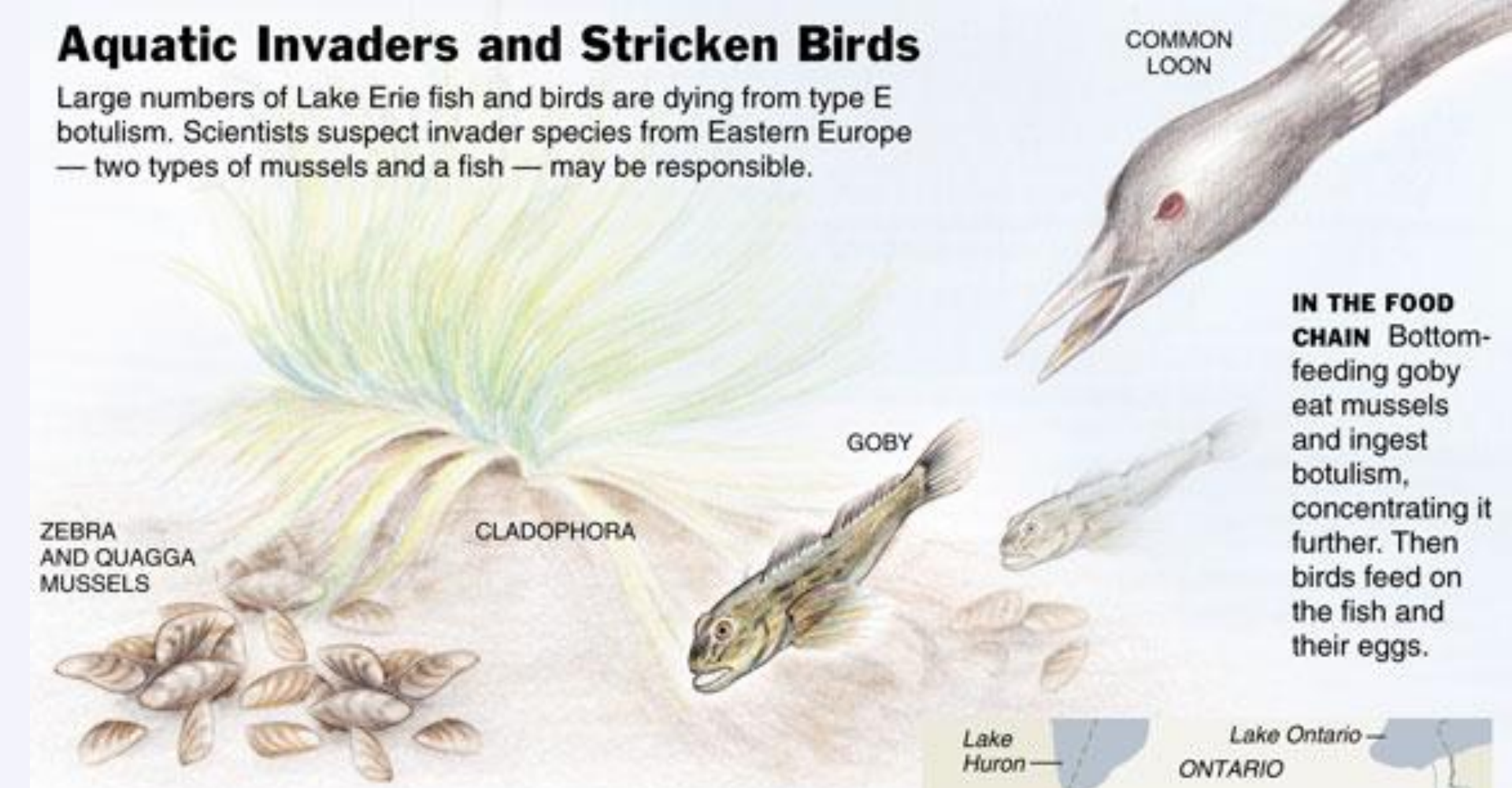
What is type E botulism?

- Neuroparalytic disease.
- Caused by a toxin produced by *Clostridium botulinum* type E.
- Botulism is transmitted through diet.
- *C. botulinum* is an environmental microbe found in soils and sediments that requires:
  - anaerobic conditions
  - warm temperatures
  - protein-rich substrates.

NYSDEC Dunkirk Fisheries Unit

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.



IN THE FOOD CHAIN Bottom-feeding goby eat mussels and ingest botulism, concentrating it further. Then birds feed on the fish and their eggs.

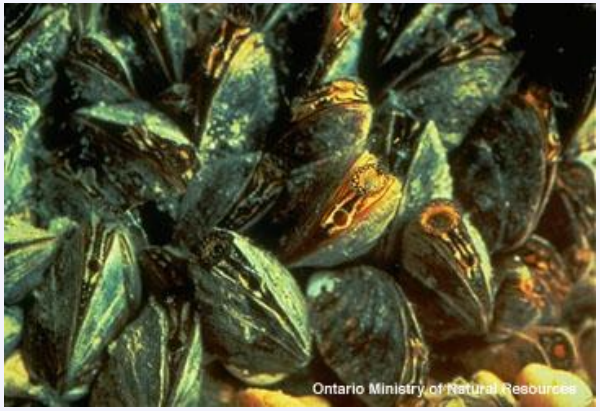
A CHANGED ECOSYSTEM Zebra and quagga mussels filter algae from the water, making the lake clearer. Sunlight reaches the lake bed, prompting plant growth.

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

Dreissenid modification of the benthic environment

Dreissenid druses and sediment beds provide habitat for *C. botulinum*:

- Feces and pseudofeces.
- Anaerobic environment:
  - Decomposition (dead mussels, pseudofeces…)
  - Sediment sheltering (shells from mussels)



http://www.iisgcp.org/EXOTICSP/zebra_mussel.htm
http://www.zin.ru/projects/invasions/gaas/drepol_i.htm

Extreme high ice cover* and type E botulism

*Assel, Cronk, Norton 2003 *Climatic Change* 57:185-204

	Michigan	Huron	Erie
1963	H: type E	H: type E	-
1977	H	-	-
1979	H	H	-
1994	H	H	-
1996	-	H	-

Alben et al.

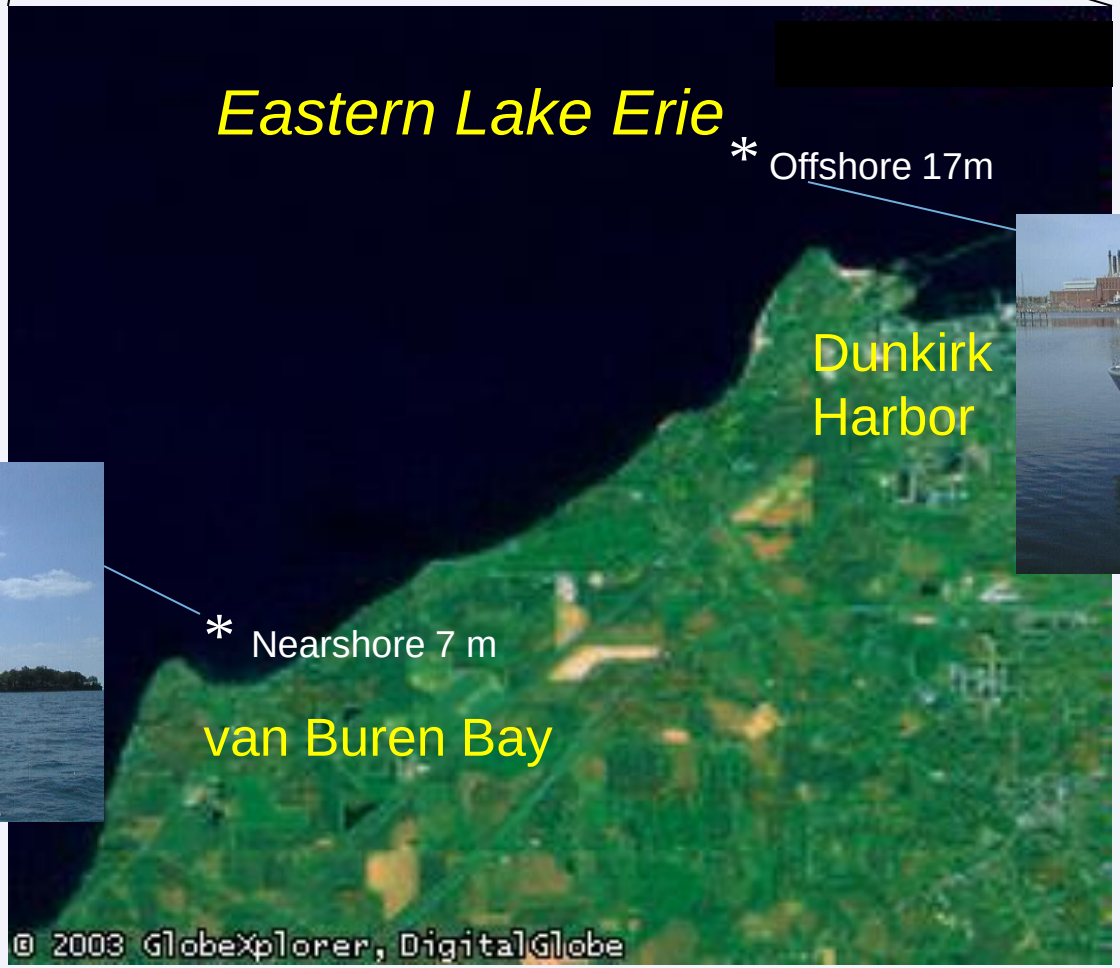
Extreme low ice cover* and type E botulism

*Assel, Cronk, Norton 2003 *Climatic Change* 57:185-204

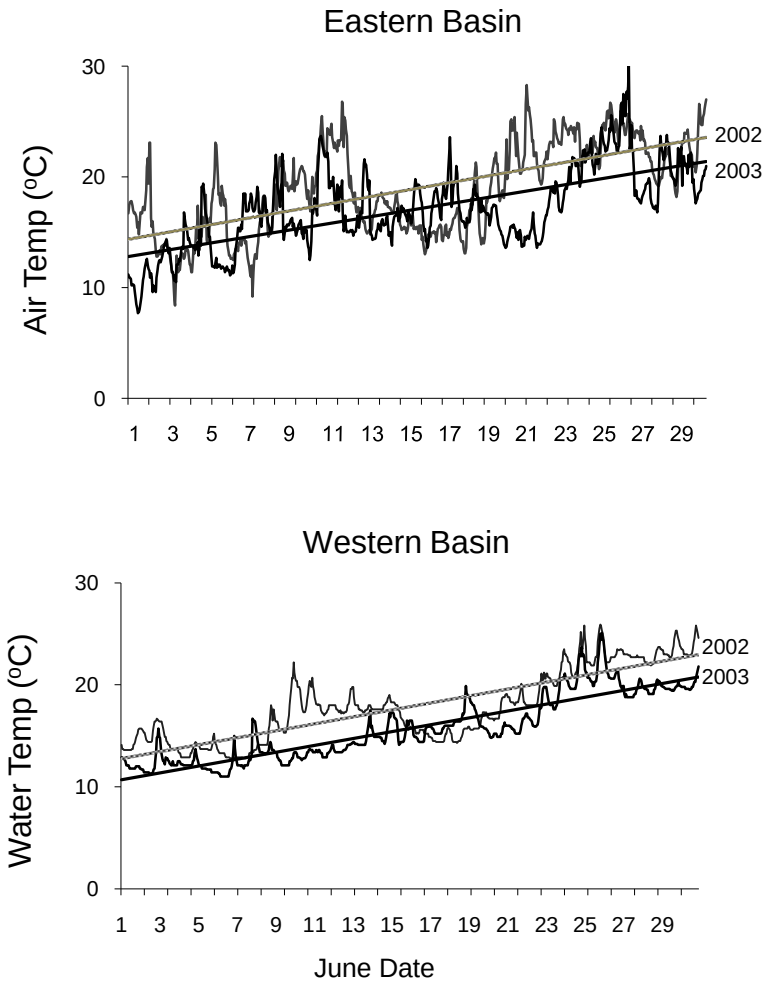
	Michigan	Huron	Erie
1964	L: type E	L: type E	-
1966	L	L	-
1983	L: type E	L: type E	L
1991	-	-	L
1998	L	L: type E	L: type E
1999	L	L: type E	L: type E
2000	-	- : type E	- : type E
2001	-	- : type E	- : type E
2002	-	- : type E	- : type E

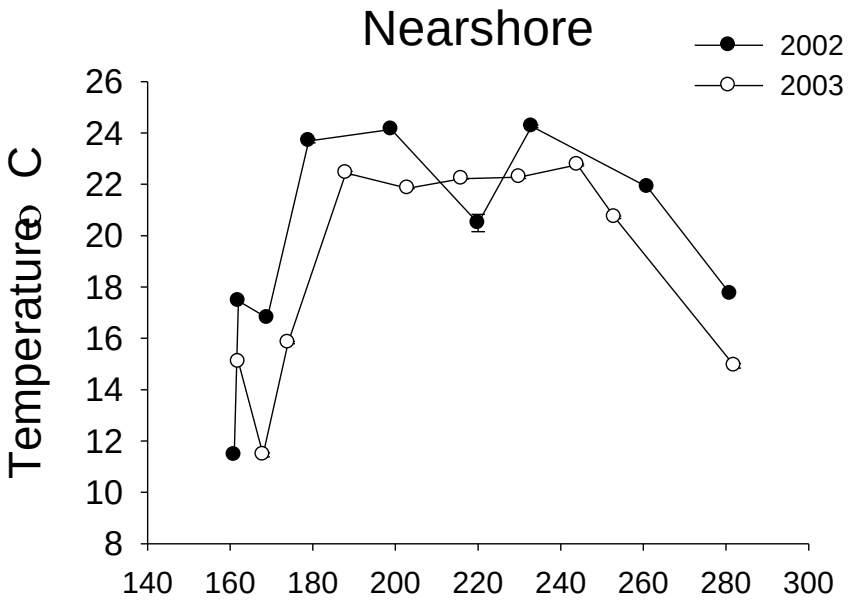
Alben et al.

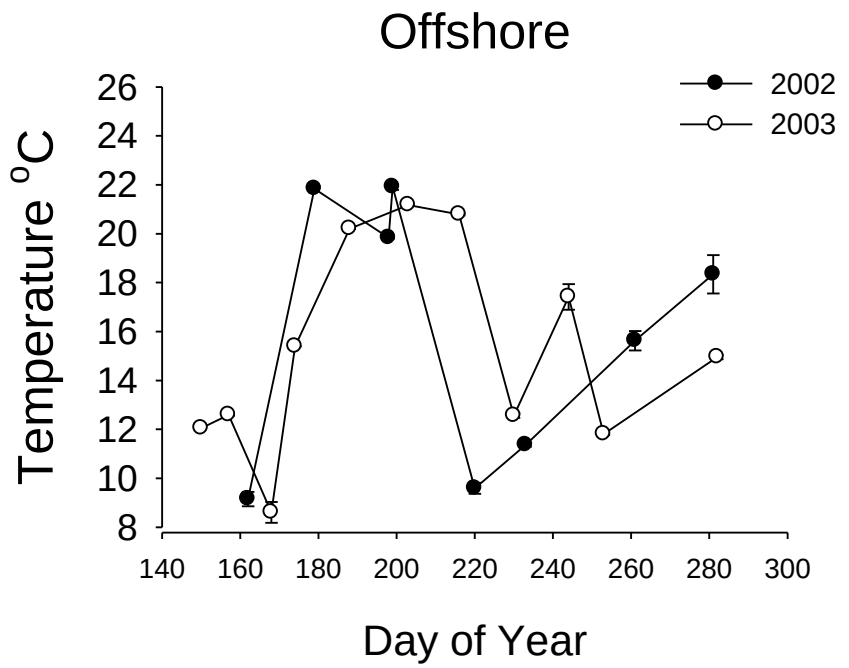
Lake Erie Stations



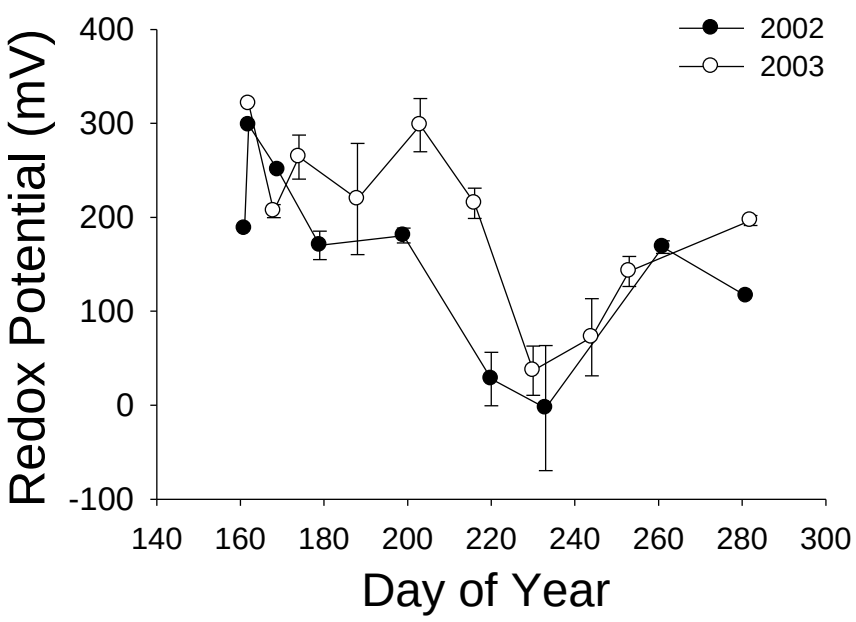
The importance of weather and climate

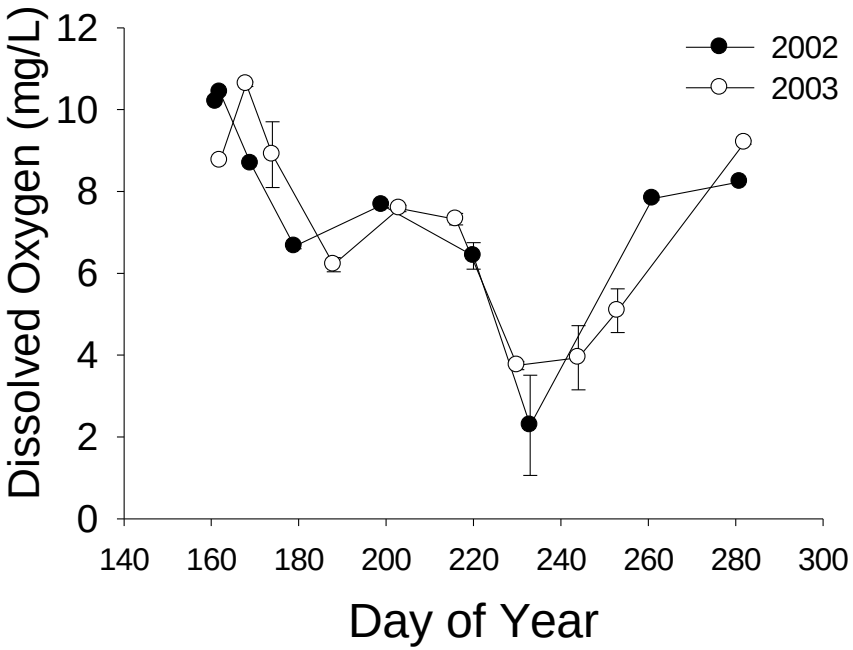



Nearshore
2002
2003
Temperature °C
26
24
22
20
18
16
14
12
10
8
140
160
180
200
220
240
260
280
300


Offshore
2002
2003
Temperature °C
26
24
22
20
18
16
14
12
10
8
140
160
180
200
220
240
260
280
300
Day of Year

Nearshore


Redox Potential (mV)
400
300
200
100
0
-100
140
160
180
200
220
240
260
280
300
Day of Year
2002
2003

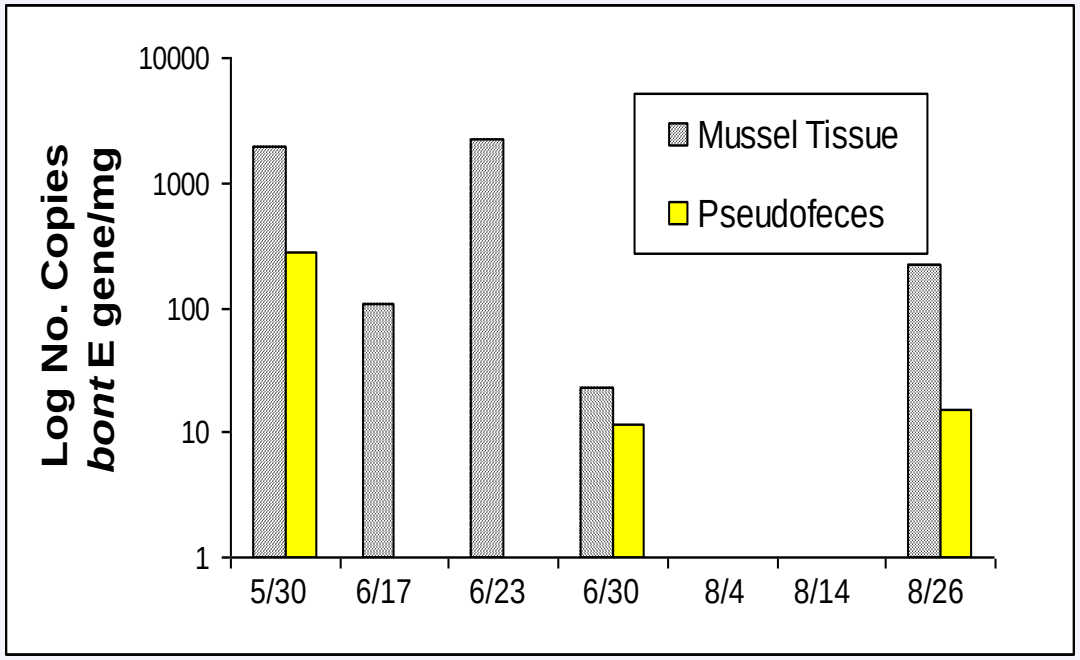

Dissolved Oxygen (mg/L)
12
10
8
6
4
2
0
140
160
180
200
220
240
260
280
300
Day of Year
2002
2003

Type E gene Positive Sediment Data

Date	Site	#DNA copies/mg
6/11/2002	Offshore	456 (outbreak)
6/28/2002	Nearshore	27.6 – 282
8/8/2002	Nearshore	215
8/21/2002	Nearshore	5,520 (outbreak)
9/18/2002	Nearshore	16.8 (dreissenid druses)
5/30/2003	Offshore	275 (dreissenid druses)
6/23/2003	Offshore	2.4
6/30/2003	Offshore	11.4 (dreissenid druses)
8/18/2003	Offshore	6.6
8/26/2003	Offshore	2.4
8/26/2003	Offshore	15 (dreissenid druses)

Number samples collected:
2002: 45 sediment, 9 feces/pseudo.; 2003: 29 sediment, 7 feces/pseudo.

Positive samples from Offshore stations 2003

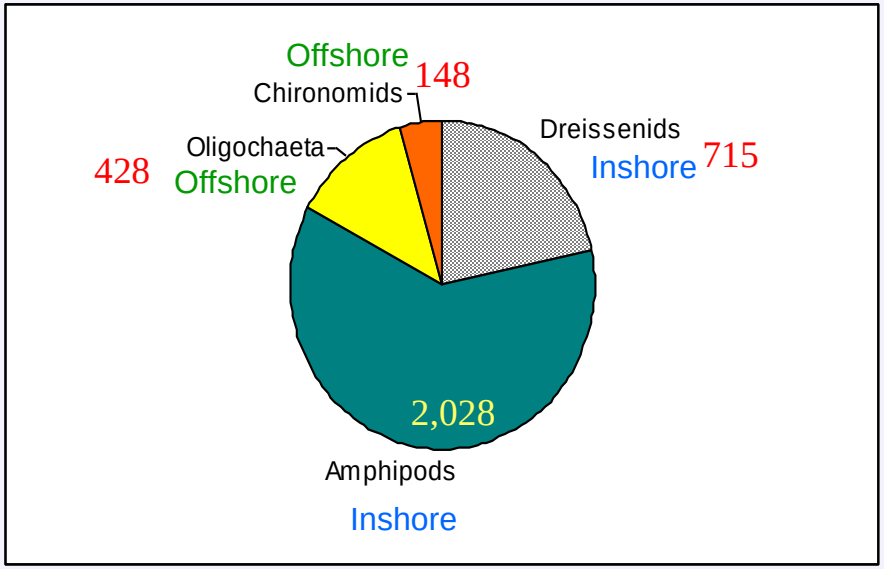


Percentage of dreissenid samples carrying spores (Type E toxin gene)

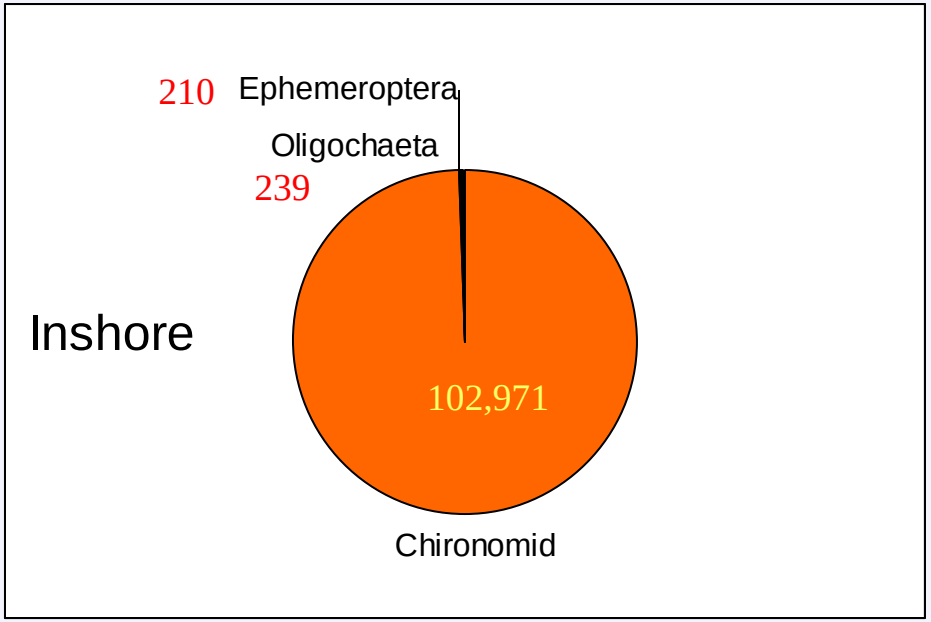
Mussel tissue	22%
Pseudofeces/feces	43%
Sediment	10%

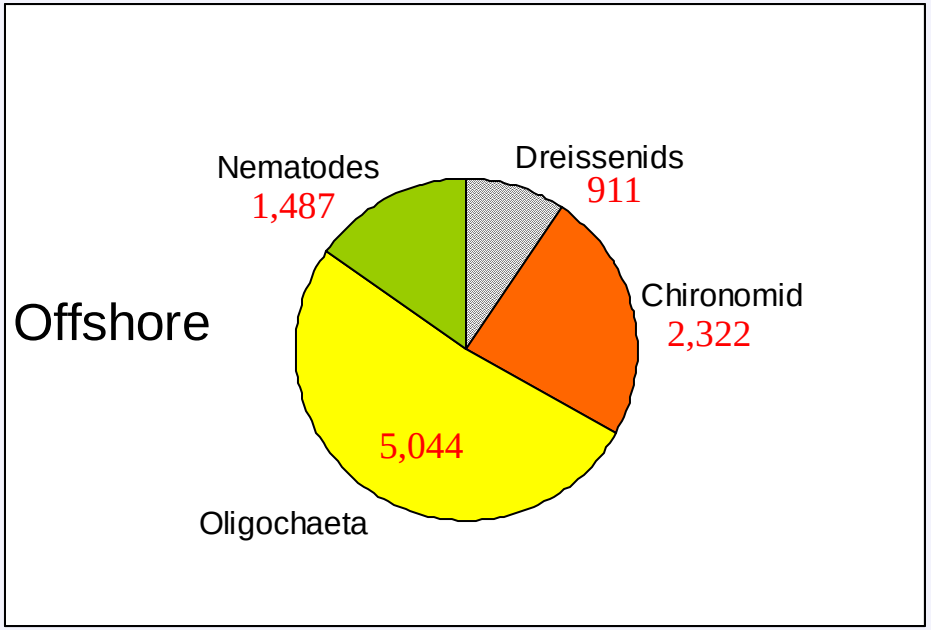
Average number copies/mg of the Type E toxin gene

Sept. 18, 2002

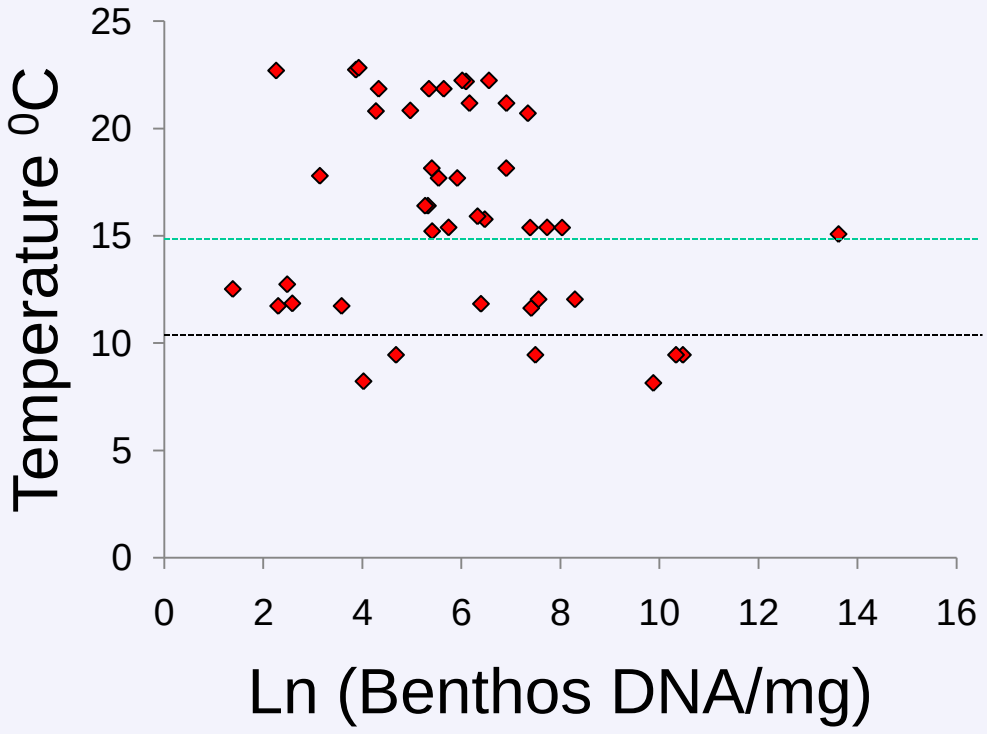


2003





Positive Benthic Invertebrate Samples by Temperature

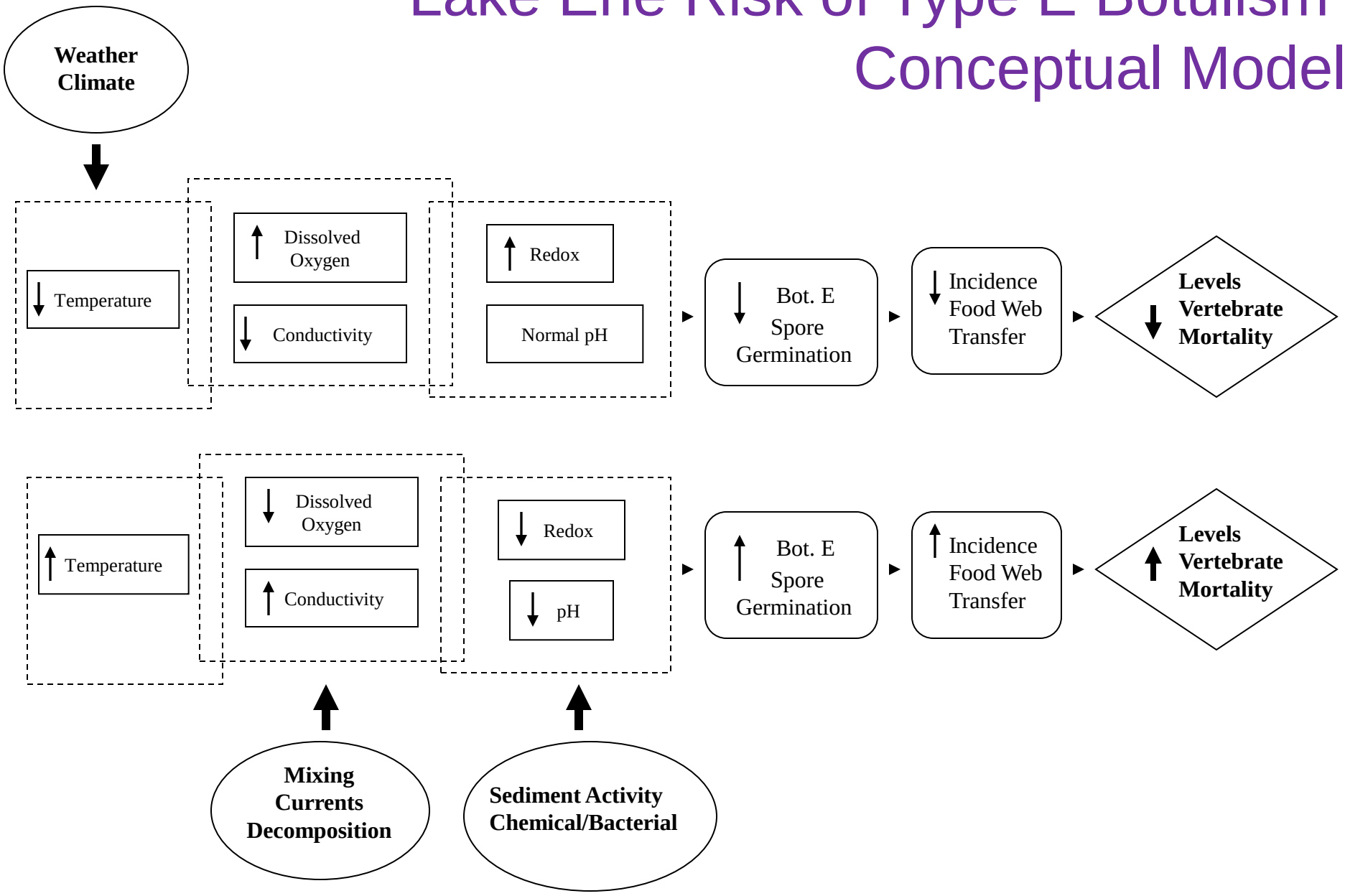


take home messages

- Near sediment conditions that increase possibility of an outbreak:
  - Temperature near 19–20^{o}C or higher
  - Anaerobic conditions
  - Low or negative redox potential
  - Adequate bacterial substrate

- Benthic organisms carry *C. botulinum* type E spores both during an outbreak year and a low incidence year.
  - on body surface and/or
  - in intestinal tracts.

Lake Erie Risk of Type E Botulism Conceptual Model



Challenges and Future Directions

- The elusive detection of *C. botulinum* type E vegetative cells or toxin in environmental samples.

- Collaboration with the New York State Museum:
  - development of a promising assay that can detect minute amounts (0.009 pg/ml of sample) of *C. botulinum* type E toxin from Lake Erie samples (1000 fold more sensitive than the expensive mouse bioassay).

Acknowledgements

Collaborators: Mark Clapsadl[1], Theodore Lee[2], Rodman Getchell[3], Paul Bowser[3], Katherine Alben[4], William Culligan[5] & Donald Einhouse[5]

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