Type E Botulism in the Great Lakes
Conference Overview

Grace McLaughlin
USGS National Wildlife Health Center

*Clostridium botulinum* type E
- Spores found primarily in cold water environments (Great Lakes, Baltic Sea)
- Toxin production NOT dependent on a bacteriophage
- Primarily afflicts fish and fish-eating birds
- Causes disease in humans

**Type E botulism outbreaks in the Great Lakes**

<table>
<thead>
<tr>
<th>Year</th>
<th>Lake</th>
<th>Number</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>1963-1964</td>
<td>Michigan</td>
<td>&gt;12,000</td>
<td>Gulls, Loons</td>
</tr>
<tr>
<td>1976-1983</td>
<td>Michigan, Huron</td>
<td>&gt;1800</td>
<td>Gulls, Loons</td>
</tr>
<tr>
<td>1998-2002</td>
<td>Huron, Michigan</td>
<td>~2500</td>
<td>Mergansers, Gulls, Loons</td>
</tr>
<tr>
<td>1999-2001</td>
<td>Erie</td>
<td>&gt;25,000</td>
<td>Mergansers, Gulls, Loons</td>
</tr>
<tr>
<td>2002</td>
<td>Erie</td>
<td>&gt;25,000</td>
<td>Long-tail ducks, Gulls, Loons, Mergansers, Cormorants</td>
</tr>
</tbody>
</table>

**Locations of other type E outbreaks in birds**
- Canche Estuary, France 1996 – 5-10,000 gulls
- Salton Sea (California) - isolated cases – pelicans, cormorants
- Alaska - isolated cases
Epizootiology of Avian Botulism

Factors involved in avian botulism outbreaks
- Toxigenic bacteria
- Appropriate environmental conditions
- Proper substrate
- Availability of toxin to birds

Type E botulism cycle in Great Lakes

Research Needs
- Spatiotemporal distribution of type E spores and cells in Great Lake sediments and fish
- Sources of cells and toxin for fish and birds
- Environmental correlates
- Population effects in birds
- Non-avian mortality
**Pennsylvania Update 2002**  
*Bob Wellington and Mike Mumau*

- March, May – dead alewives, turtles  
- June – dead gobies & mudpuppies – less algae than in past years  
- July – rapid temperature drop 75˚F → 50˚F in 2 days  
- Monitored water temperature – 70°-80°F in July-September, 50°F November  
- Invertebrate mortality  
- Several invasive species  
  - Alewives, gobies  
  - Algae (*Cladophora*? If so, long ago.)  
  - Invertebrates (mussels, amphipods)  
- Blue-green algae blooms  
- ~2000 fish collected ~10 species  
  - July 10-11 = 446 (22.3% of total)  
- Fewer dead birds than 2001  
- Gulls in Summer  
- Loons in Fall  
- Invertebrates – could be substrate for significant toxin production.

**New York Update 2002**  
*Don Einhouse*

- Fish mortalities – effects on trends, abundance  
  - March-April: alewives, gizzard shad – temperature stress  
  - May-June: smelt – spawning, *Gluega*  
  - June-July: smallmouth bass – spawning? upwelling?  
  - June-August: warmwater species., upwelling  
- June 50% gobies  
- July 44% sheepshead  
  - Also thousands of mudpuppies  
- September mortality: 81% sheepshead  
  - Only 4% net (live) samples, yellow perch 40%  
  - Why don’t yellow perch and gizzard shad die?  
- Smallmouth bass survival has not changed with Botulism E  
- Forage fish composition  
- Gobies  
  - 1994 – Cleveland  
  - 1995 inconclusive numbers  
  - 1996 moving East and West in Central basin, into West  
  - 1997 into eastern basin  
  - 1999 well into NY waters, but low numbers  
  - 2000 declining in western basin, including East  
  - 2001 huge number in eastern basin  
  - 2002 declining in abundance
Sturgeon Mortality
- Rare to find on beach pre-2000
  - 5 in 1996 - upwelling
- >25 in 2001
  - Corresponded with high goby numbers
- Fewer in 2002
  - also fewer gobies in trawls

Changes in Food Web
- Shift to gobies post 1998
- Sheepshead eat mussels

Questions:
- Where is anaerobic environment?
  - In anything that dies. Pockets in substrate.
- Benthic fish species absent from kills – why?
  - Different susceptibility?
- Role of mussels?
- How to determine botulism E mortality?

NY Avian Mortality
Ken Roblee
- >3000 Gulls in June & July
  - Concurrent with mudpuppy mortality
- October-December estimated >17,000 birds
  - >12,600 long-tailed ducks
  - >2000 loons
  - >1000 mergansers

NY Pathological Investigations
Ward Stone
- 7000+ submissions for botulism in 2003
- First diagnosis of type E - 2000
- Food habits: gobies, mudpuppies
- Sheepshead, bass
  - Moribund fish
- Feeding experiments
  - Gobies – gull liver
- Toxin identified in gizzard contents
  - Gulls in summer – mudpuppies
  - Mergansers – mudpuppies, gobies
  - Shorebirds - fly larvae from carcasses
  - Long-tailed ducks – mussels, gobies
- Few puddle ducks
- Scaup undetermined cause of death
New York Mortality – bird pickup numbers

<table>
<thead>
<tr>
<th></th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>Totals</th>
</tr>
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<tbody>
<tr>
<td>Totals</td>
<td>1100</td>
<td>706</td>
<td>7202</td>
<td>9008</td>
</tr>
<tr>
<td>Long-tailed ducks</td>
<td>1</td>
<td>44</td>
<td>4877</td>
<td>4913</td>
</tr>
<tr>
<td>Gulls</td>
<td>543</td>
<td>228</td>
<td>&gt;1030</td>
<td>&gt;1800</td>
</tr>
<tr>
<td>Red-breasted Merganser</td>
<td>424</td>
<td>16</td>
<td>627</td>
<td>1067</td>
</tr>
<tr>
<td>Loons</td>
<td>106</td>
<td>303</td>
<td>434</td>
<td>843</td>
</tr>
</tbody>
</table>

Birds still being collected from 2002-2003
Estimates of dead birds much higher

Food Habits

- Gobies:
  - Loons: 56-61%
  - Horned grebe: 54%
  - Long-tailed Ducks: 60% of 169
- Mudpuppies
  - Gulls – 17-82%
  - Mergansers: 20-40%

Feeding Experiments – New York

- Feeding livers – assuming problem is botulism toxin, some negative samples used also
- Gobies, Centrarchids, fatheads susceptible
- Yellow Perch and Painted Turtles show some resistance
  - Yellow Perch impaired up to 1 week
  - Altered swimming ability
  - Change in activity patterns

Botulism Type E Genetics

- 10 different type E strains
  - Fish, sediments
- How do these compare to?
  - Other years
  - Huron
  - Michigan
  - Superior
  - Mediterranean, Baltic
  - France
  - Alaska
Canadian Update

Jeff Robinson

- Mortality distribution
- Food habits
- Loon population data
- Experimental dosing
- Loons
  - Believe Stratum 4 breeders
  - Population 19,000 to 40,000 breeding pairs
- Several Lake Erie events
  - June, July, August: gulls, terns, cormorants
  - September: gulls, cormorants
  - October: gulls
  - Late October & November: Common Loons, Long-tailed Ducks, Red-breasted Mergansers
- Lake Huron - October
  - Grebes, mergansers, Common Loons
  - Goderich and Port Elgin
- Ontario (not confirmed)

Environmental Parameters Associated with Outbreaks of Botulism in Lake Erie

Alicia Perez-Fuentetaja, Ted Lee, Mark Clapsadl

Identify environmental conditions in Lake Erie associated with presence of Clostridium botulinum type E.
Are there areas of low oxygen where the bacteria are found?
10m inshore, 20m offshore depths.
Triplicate samples
Physico-chemical parameters 0.5 m above sediment.

- Algal bloom at time of June-July outbreak
- Oxygen, Redox, pH drop in August
  - Rocke, Samuel – JWM
- Weather event in August
  - strong winds, wave action – mixing
- Sample processing in progress

Botulism: Atypical Pathogenesis in Other Species

Dr. Robert H. Whitlock, New Bolton Center, University of Pennsylvania

- Cattle
  - Grains – oat and rye silage
  - 1 Cat carcass killed 431 of 441 cows
  - Feeding in avian botulism site
• Horses
  – Ravens as vectors from carcasses
  – Wounds – castration,
    • drainage contaminated feed
  – 1979 racetrack – 30 horses died
• Diagnosis, vaccine, treatment

**Botulism in Fish**  
*Getchell, Bowser, et al.*

• Rule outs – bacteria, viruses, weather (750)
• For Botulism E – quantitative PCR
  – Process intestinal contents, liver, etc.
  – Looking for light chain E toxin gene (not toxin)
• Found in sheepshead from July 2001 dieoff
  – Kd, Lv, Sp pool; 3K genome equivalents
• 15-23K genome equivalents GIT contents
  – Only found in very few fish
• 200 – 148K in bird samples
• What about in healthy fish? No vegetative cells

**Fish Susceptibility to Botulism E**  
*Moccia et al.*

• Fish Botulism Exposure Model
  – Standardize methods
• Temporal aspects, Sensitivity
  – Trout, goby, perch, walleye, mudpuppy
• Dose-response model
• Toxin titers
  – Tissue distribution
• Methods
  – Dosages to intubate fish
  – Temporal pattern, tissue distribution
  – Calculate up-web transport
• Temporal Observations
  – Restless, agitated, inc. swimming
  – Disequilibrium, altered posture, righting response lost
  – Lethargy interspersed with swimming, lack of coordination
  – Head up/tail down posture, breaching
  – Loss of motor function except respiration
  – Respiratory failure
• Prolonged course
• Altered behavior - increased predation risk?
• Tissue distribution?
• Persistence of toxin?