Avian Botulism in Lake Erie Workshop Proceedings

Co-Sponsored by

New York Sea Grant
Pennsylvania Sea Grant

Photo credit: Eric Obert, PA Sea Grant

January 24-25, 2001
Erie, Pennsylvania

TABLE OF CONTENTS

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Introduction – Workshop Objectives

Fish and bird die-offs along the shores of Lake Erie in the summer and fall of 2000 concerned Sea Grant staff, agency representatives, researchers and citizens. In order to understand the extent of these die-offs, gather information, create a functioning network of those involved, and explore the ecological impacts, staff of Pennsylvania Sea Grant invited New York Sea Grant to work together to coordinate a binational workshop on avian botulism in Lake Erie.

On January 24-25, 2001, New York and Pennsylvania Sea Grant co-sponsored the first Lake Erie conference on avian botulism, held in Erie, Pennsylvania. This conference brought together more than sixty researchers, fishery and wildlife biologists, resource managers, and agency representatives. The goal of the workshop was to share information from the American and Canadian shores and develop a research agenda for future efforts. Organizers wanted to determine the extent of the botulism problem based on geography and environmental conditions that existed during the outbreaks. During the second day of the conference, several breakout sessions were convened to address the research agenda questions that were posed to participants. Although organizers realized that the meeting was premature from a data standpoint, they wanted to create a functioning network of scientists who collaborate on research issues and respond to future outbreaks.

According to Dr. Christopher Brand of the U.S. Geological Survey (USGS) National Wildlife Health Center, who discussed both type C and type E botulism: "While there are some similarities, there are also major differences in molecular biology, microbiology, and ecology between *Clostridium botulinum* types C and E which may explain the different epizootiological presentations of these diseases." Dr. Brand indicted that some of the major, but basic, questions regarding type E avian botulism include:

- the role of various fish species in transferring toxin to birds;
- whether fish are susceptible to type E toxin or toxin in fish is primarily formed postmortem;
- whether fish-eating birds such as loons scavenge dead fish or mistake them for live fish;
- the importance of the carcass-maggot cycle during type E outbreaks in the summer;
- human health risks from sick or dead birds during outbreaks, as well as directly from fish;
- current prevalence and distribution of *C. botulinum* type E in fish and sediments of Lake Erie (as well as other Great Lakes);
- the impact of type E botulism on loon populations;
- specific ecological conditions required for type E toxin production and transfer to birds.

It is the hope of the conference organizers that the work and collaboration that began at the workshop will be able to answer some of these important questions.

Background

Avian Botulism in Lake Erie

Avian botulism, a disease caused by *Clostridium botulinum*, has been recognized as a major cause of mortality in migratory birds since the early 1900s. Although type C botulism has caused the die-off of thousands of waterfowl (especially ducks) across the western United States, type E has been mainly restricted to fish-eating birds in the Great Lakes. Other outbreaks of type E have sporadically occurred in Alaska, Florida, and California, with periodic outbreaks occurring in Lake Michigan and Lake Huron over a twenty-year period beginning in 1964. During 1999 and 2000, a large die-off of waterfowl occurred in Lake Erie and type E botulism was isolated in these outbreaks.

The bacterium is classified into seven types (A-G) by using characteristics of the neurotoxins that are produced. The toxins produced by *C. botulinum* are among the most potent biological poisons, warranting human health and safety concerns. These neurotoxins bind to the receptors on nerve endings, impacting neuromuscular function, which results in the paralytic effect on birds. Impacted waterfowl typically show signs of weakness, dizziness, inability to fly, muscular paralysis, and respiratory impairment. Often, the inner eyelid or nictitating membrane becomes paralyzed, impairing the bird's normal vision. The necks of impaired birds may become so weak that the animal actually drowns.

Although type C and type E avian botulism outbreaks occurred in the Great Lakes in the past, there are some significant differences between the two types. Type C botulism primarily impacts dabbling ducks and bottom-feeding waterfowl, although shorebirds may also fall victim to this type of botulism. In type C botulism, the bacterium, *C. botulinum*, does not produce toxin unless it is infected by a specific "phage" or virus. This relationship with a phage is not known to exist with type E. Type E botulism typically impacts fish-eating birds like loons and grebes. Several species of gulls that are common in the Great Lakes region have been impacted by type C and type E botulism. Fish carcasses may also contain type E toxin and feeding on these carcasses or maggots from the carcasses can pass the disease onto birds. While live fish can carry spores of type E botulism, it is not known whether they can carry the toxin itself or become sick and die from the toxin. Type E toxin has been found in carcasses of several species of Great Lakes fish, including round gobies, and researchers are studying the role this invader may play, if any, in recent outbreaks of the disease in Lake Erie.

Dead Gulls - Lake Erie

Photo credit: Eric Obert, PA Sea Grant

Spores of type C and type E botulism are naturally found in anaerobic habitats such as soils and aquatic sediments, and can also be found in the intestinal tracts of live, healthy animals. The spores can remain in the ecosystem for extended periods of time, even years, and are quite resistant to temperature extremes and drying. In the absence of oxygen, with a suitable nutrient source, and under favorable temperatures and pH, spores can germinate and vegetative growth of bacterial cells can occur (Brand, *et al.* 1988).

Botulism toxin is only produced during vegetative growth, not when the bacterium is in its spore stage. Decaying animal and insect carcasses provide favorable conditions for botulism toxin production since the decay process uses up oxygen and creates anaerobic conditions (Friend, *et al.* 1996). Toxin-laden carcasses, or invertebrate scavengers such as maggots that can accumulate the toxin, constitute a major route by which wildlife ingest this powerful neurotoxin.

Type C botulism is often perpetuated through a carcass-maggot cycle. Birds that have died from type C botulism decay and become hosts for maggots. The maggots may contain the toxin and if fed upon by other birds, the cycle is continued. In many avian botulism outbreaks, healthy birds are often found in close proximity to sick and dying birds. This close proximity helps to spread the disease among the birds, often causing greater mortality.

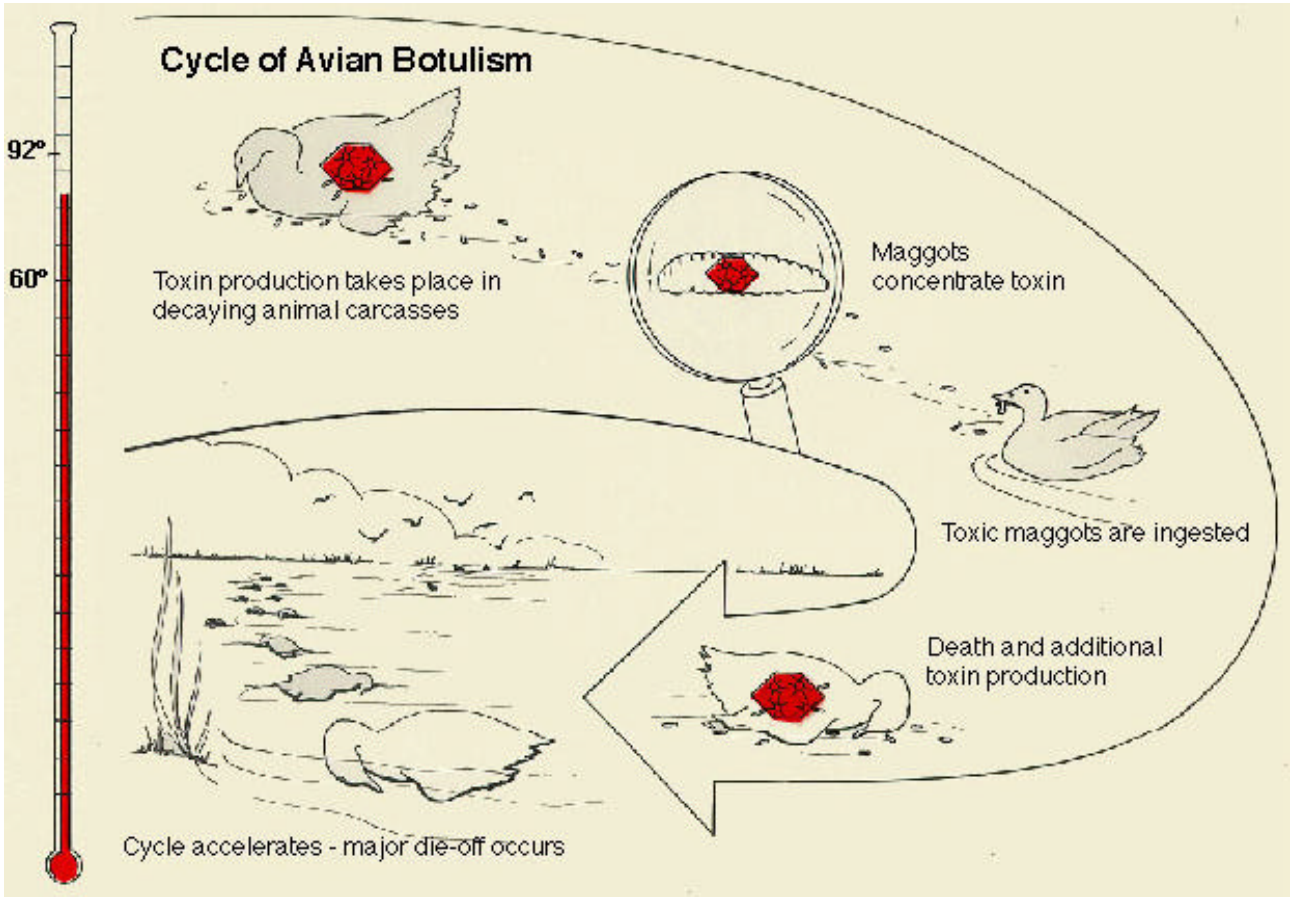


Illustration from: U.S. Geological Survey, Avian Botulism Factsheet

Human Health Considerations

Human botulism is typically caused by eating improperly canned or stored foods and normally involves type A or type B botulism toxin. There have been several fatalities during the 1960s in the Great Lakes basin attributed to type E toxin, but these were caused by eating improperly smoked or cooked fish that contained the toxin. Humans, dogs, and cats are generally considered resistant to type C avian botulism (Friend, *et al.* 1996).

The toxin found in food items will be killed by proper cooking of fish and waterfowl. When canning or smoking fish or waterfowl, methods should be used that incorporate sufficient heat to insure that any toxins will be killed off. Anglers and hunters should avoid harvesting any sick or dying fish or waterfowl, or those demonstrating unusual behavior, in areas where avian botulism has occurred. People should not handle dead birds or fish with bare hands. The use of gloves or an inverted plastic bag is recommended in order to avoid risks. If a diseased or dead bird is handled without gloves, hands should be thoroughly washed with hot soapy water or an anti-bacterial cleaner.

In case of a die-off, individuals are urged to contact local agencies responsible for fish and wildlife management to notify them of fish and bird mortalities. It is important to record the location, type of birds or fishes, and number of carcasses found. Stakeholders should follow agency recommendations in handling dead fish and wildlife. In certain areas, burying of the carcasses is allowed, in other areas incineration may be recommended. If birds are to be collected, they should be placed in heavy plastic bags to avoid the spread of botulism-containing maggots.

References:

Brand, Christopher J., Stephen M. Schmitt, Ruth M. Duncan and Thomas M. Cooley, *An Outbreak of Type E Botulism Among Common Loons (Gavia immer) in Michigan's Upper Peninsula*, Journal of Wildlife Diseases, 24(3), 1988, pp. 471-476

Friend, Milton, Louis N. Locke and James J. Kennelly, National Wildlife Health Laboratory, Madison, Wisconsin. 1996.
Avian Botulism Factsheet: http://www.nwhc.usgs.gov/facts/avian.html

State Findings

Pennsylvania

According to information presented by Dr. Mike Campbell and Dr. Larry Gauriloff from Mercyhurst College, there were a total of 311 birds collected at Presque Isle State Park in 1999, including 268 gulls of various species. Species such as ring-billed, herring, Bonaparte's, and greater black-back gulls were included in the mortality. Of that total, 12 common loons, 14 mergansers, 2 grebes, and 3 coots were found. In 2000, the number rose to 535 birds, with 374 gulls involved in the die-off. There were 44 coots, 33 common loons, and 71 mergansers counted at Presque Isle State Park.

Their research provided these spatial and temporal findings related to bird mortalities:

- Greater overall mortality in 2000 than in 1999
- Gull mortality mainly in summer to early fall
- Loon and merganser die-off mainly in late fall
- Die-offs seem to occur in episodes following changes in weather

New York

Biologists from the New York State Department of Environmental Conservation took the lead on collecting birds and developing mortality surveys based on their findings. During a two-week period in November 2000, a major die-off occurred along the New York shoreline of Lake Erie.

Lake Erie Botulism Mortality Surveys
100m Transect Survey Results
NYSDEC 11/28/00 - 11/29/00

Species	Predicted Mortality	Upper Limit 95% Confidence	Lower Limit 95% Confidence
Common Loon	583	816	351
Horned Grebe	109	193	26
Red-Breasted Merganser	2479	3097	1862
Bufflehead	91	183	0
Mallard	18	54	0
Great Black-Backed Gull	128	230	25
Herring Gull	237	352	122
Ring-Billed Gull	1714	2172	1256
Bonaparte's Gull	36	86	0
Common Crow	18	54	0
Black Duck	18	54	0
Total Birds	**5431**	**7291**	**3642**

Workshop Summary

The purpose of the Avian Botulism Workshop was to bring researchers and natural resource agency staffs together to discuss the current outbreak of type E botulism occurring in Lake Erie. The objectives were to identify what is currently known about avian botulism, and to develop a coordinated lake-wide effort to address research and outreach needs.

HISTORY

Avian botulism has been recognized as a major cause of mortality in migratory birds since the 1900s, with type C outbreaks impacting mainly ducks and bottom-feeding waterfowl. Great Lakes outbreaks in 1964 and the recent 1999-2000 outbreak on Lake Erie have been attributed to *Clostridium botulinum* type E, primarily impacting gulls and fish-eating birds such as mergansers and loons. During 1999 and 2000, an unprecedented die-off of gulls, loons, and mergansers occurred in Lake Erie, with dead birds appearing on both Canadian and U.S. beaches. Several thousand birds were affected, with gull mortality occurring mainly in the summer to early fall, and loon and merganser mortality concentrated in late fall. All major mortality episodes occurred during or following stormy weather when temperatures decreased. In addition to bird mortalities, sporadic die-offs of mudpuppies (aquatic salamanders) and multiple fish species occurred in the central and eastern basins of Lake Erie from March to late November 2000.

CURRENT KNOWLEDGE

Spores of type C and type E botulism are naturally found in anaerobic habitats such as soils and aquatic sediments, and can also be found in the intestinal tracts of live, healthy animals. The spores can remain in the ecosystem for extended periods of time, even years, and are quite resistant to temperature extremes and drying. In the absence of oxygen, with a suitable nutrient source, and under favorable temperatures and pH, spores can germinate and vegetative growth of bacterial cells can occur (Brand, *et al.* 1988). In type C botulism, the bacterium, *Clostridium botulinum*, does not produce toxin unless it is infected by a specific "phage" or virus. This relationship with a phage is not known to exist with type E. Type E botulism typically impacts fish-eating birds like loons and grebes. Fish carcasses may also contain type E toxin and feeding on these carcasses or maggots from the carcasses can pass the disease onto birds. Live fish can carry spores of type E botulism; however, it is not known whether they can carry the toxin itself or become sick and die from the toxin. Type E toxin has been found in carcasses of several species of Great Lakes fish, including round gobies.

RESEARCH PRIORITIES

Some of the major, but basic, questions regarding type E avian botulism include the specific ecological conditions required for type E toxin production.

1. What role have lower lake levels and warmer water temperatures played in the recent outbreaks?
2. Have these environmental conditions contributed to an increase in algal blooms?
3. Does the die off of algae create the anaerobic conditions necessary for botulism production, and are these conditions responsible for fish kills?
4. Are there linkages between algal toxins such as anatoxin-a or microcycstin-LR and avian botulism?

5. What is the role of various fish species in transferring toxin to birds?
6. Are fish susceptible to type E toxin or is toxin in fish primarily formed postmortem in fish carcasses.
7. Are fish-eating birds such as loons, scavenging dead fish or mistaking them for live fish?
8. What is the importance of the carcass-maggot cycle during type E summer outbreaks?
9. What is the current prevalence of *C. botulinum* type E in the fish and sediments of Lake Erie?
10. Are there human health risks associated with handling dead birds or the consumption of fish?

OUTREACH AND RESEARCH PRIORITIES

The final objective of the workshop was to address "Where do we go from here." Conference attendees listed the following suggestions as to what the next steps should be related to coordination and networking of the Great Lakes region:

1. Develop a cohesive database for fish, birds, and limnological data.
2. Develop a quick response lake-wide network in order to keep all states and provinces apprised of the latest developments in bird mortalities and fish kills.
3. Develop public outreach information by networking on a lake-wide basis. Enlist the help of Health Canada and U.S. Food and Drug Administration in developing lake-wide health advisories.
4. Standardize analysis and sampling protocols for fish pathology and disease detection.
5. Coordinate scientific research and response plans for the coming year and seek research funding from federal agencies to address research as defined in research priorities section.
6. Identify point of contact person(s) who will coordinate effort for each state and province.
7. Use the National Wildlife Health Center as a clearinghouse to track outbreaks.
8. New York and Pennsylvania Sea Grant will coordinate binational monitoring effort.
9. Enlist the help of the LaMP, charter captains, marinas, and wildlife groups in reporting fish kills, bird mortalities and the dissemination of outreach materials.

New York Presentations

Bill Culligan
Lake Erie Unit Leader
NYS Department of Environmental Conservation
Dunkirk, NY

Fish and Related Die-offs in New York Waters of Lake Erie-2000

March: Alewives - likely from temperature shock, common occurrence. Millions of fish in total.

April: Smallmouth bass, rock bass, stone cats, mudpuppies, a few carp. Unusual event for this time of year, thousands of fish total.

Late May: Mudpuppies, hundreds of individuals, unusual event, suspected upwelling.

Late June: Smallmouth bass - post spawn , rock bass, stone cats, sheepshead, mudpuppies Common to see bass at this time, other species were unusual. Thousands of fish.

Sturgeon: 8 dead fish: 2 in August, 3 in September, 2 in October, 1 in November. Typically, only one dead sturgeon per year is found. All fish had been dead for at least several days.

September: Mudpuppies far east end Canadian waters, possible upwelling?

Late November: Carp in Dunkirk area, lake trout- post spawn. Hundreds of carp, several dozen lake trout. This corresponded with a major bird die-off.

NYSDEC had tests done in late November on carp (by Dr. Paul Bowser, Cornell University), zebra mussel, and goby (Ward Stone, NYSDEC, Albany) from the Dunkirk area, all were negative for type E botulism.

An important point is that all species mentioned, except alewives, are benthic.

Russ Biss
NYS Department of Environmental Conservation
Bureau of Wildlife, Region 9

Type E Botulism - Lake Erie - 2000

The first calls regarding dead waterbirds along Lake Erie came into the Buffalo DEC Offices on November 16, 2000.

Several red-breasted mergansers and gulls were submitted to the DEC Wildlife Pathologist, Ward Stone on November 17, 2000. Ward Stone determined that type E botulism toxin was the cause of the mortality. This was the first time that we had experienced type E botulism mortality in New York State. Additional specimens were collected and submitted on November 27, 2000. On this occasion, specimens from Dunkirk Harbor were included. Removal of dead birds was conducted at several locations along the Lake Erie shoreline by DEC staff and volunteer groups, following safety precautions offered by Ward Stone.

On November 27 and 28, 2000, Wildlife Biologist Ken Roblee conducted counts of dead birds at 65 different 100-meter transects along the Lake Erie shoreline. The early estimates of waterbird mortality were as high as 8,000. Mr. Roblee's surveys placed predicted mortality in the range of 5,400 - 6,500 birds.

On December 4, 2000, a combined work group consisting of Region 9 Fish and Wildlife staff and four members of Ward Stone's pathology unit picked up over 1,100 birds from areas scattered along the Lake Erie shoreline. The sites where the pick-ups occurred were primarily public beaches and harbors with public access. The following figure indicates percent mortality on the New York Lake Erie shoreline by species observed.

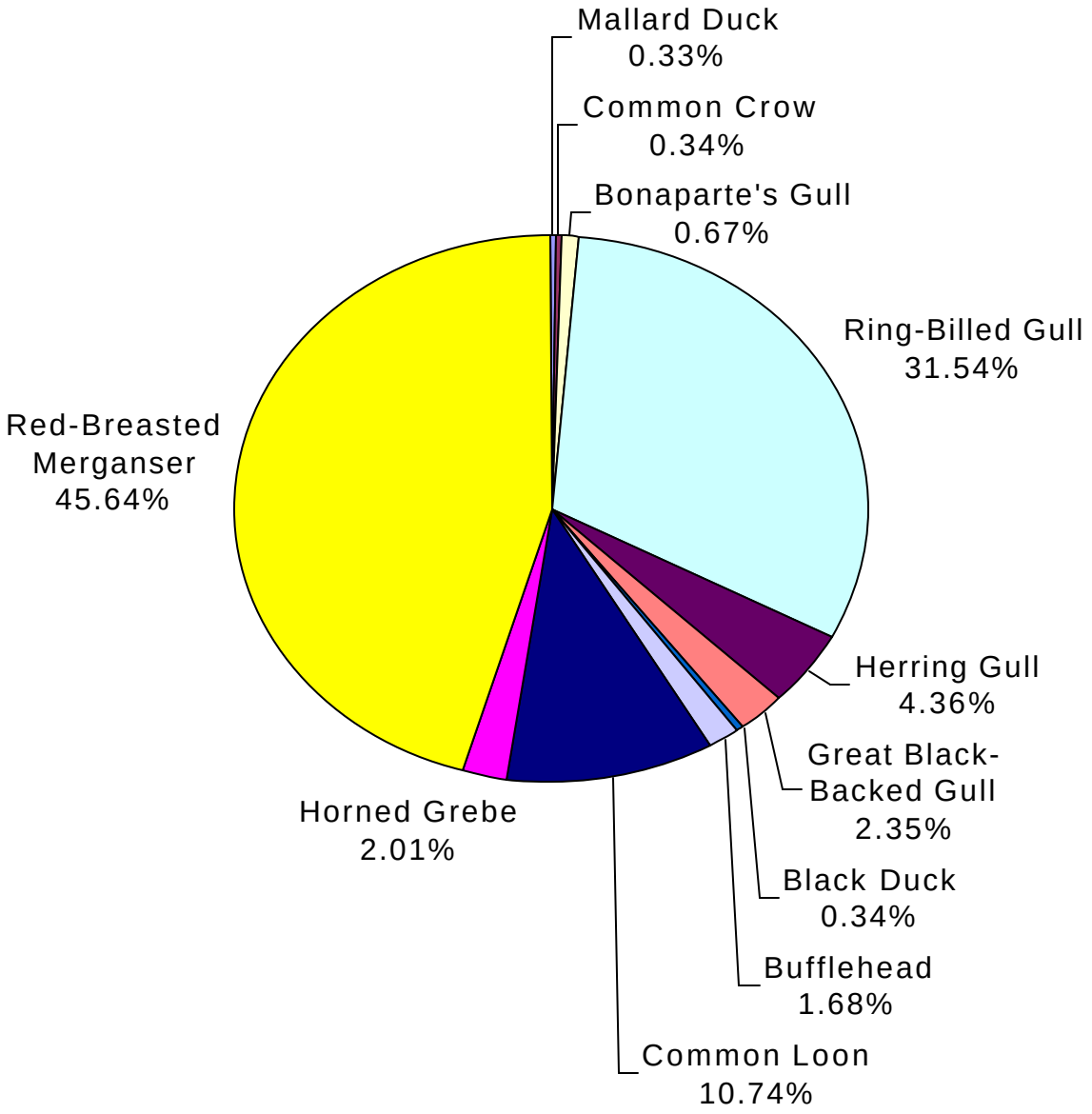
Three collection points were established for the public to drop off birds collected on private beaches and from organizations that organized beach clean-ups independent of DEC efforts. The three drop off points were the NYSDEC Lake Erie Research Station in Dunkirk, Woodlawn Beach State Park, and Evangola State Park.

Birds Collected from Lake Erie Shoreline

Information from: NYS Department of Environmental Conservation

	Dunkirk Harbor	Wendt Beach	Hamburg Town Park	Woodlawn Beach	Wanakah	Sturgeon Point	Blue Water Beach	Wide Beach	Bayview	Evangola State Park	Hoover Beach	Barcelona East and West	Clifton Heights	St. Columbans Retirement Home	Sheridan Drive Boat Launch	Beaver Island	TOTAL
Common Loon	37	39	2	12	4	2	3	1	2	1	1	0	1	1	0	0	106
Merganser Sp.	177	132	25	40	10	8	1	1	9	11	7	0	0	0	3	0	424
Ring-billed Gull	231	101	15	25	16	15	1	5	2	8	5	2	0	0	1	0	427
Herring Gull	27	24	5	7	0	0	1	0	0	2	0	2	0	0	1	1	70
G.B.B. Gull	27	5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	33
Bonaparte's Gull	6	5	0	0	1	0	0	0	0	1	0	0	0	0	0	0	13
Horned Grebe	0	6	0	2	0	1	0	1	0	1	0	0	0	0	0	0	11
Bufflehead	5	2	0	0	1	1	0	0	0	0	0	0	0	0	0	0	9
Mallard	4	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	5
Canada Goose	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
D.C. Cormorant	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Rock Dove	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Black Duck	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
C. Goldeneye	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Greater Scaup	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Oldsquaw	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
American Crow	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
American Robin	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTAL	517	319	47	89	32	27	6	9	14	25	13	4	1	1	5	1	1100

Percent Mortality On NY Lake Erie Shoreline By Species Observed
(Information Provided by NYSDEC)



Avian Botulism Problem on Pennsylvania's Lake Erie Shore

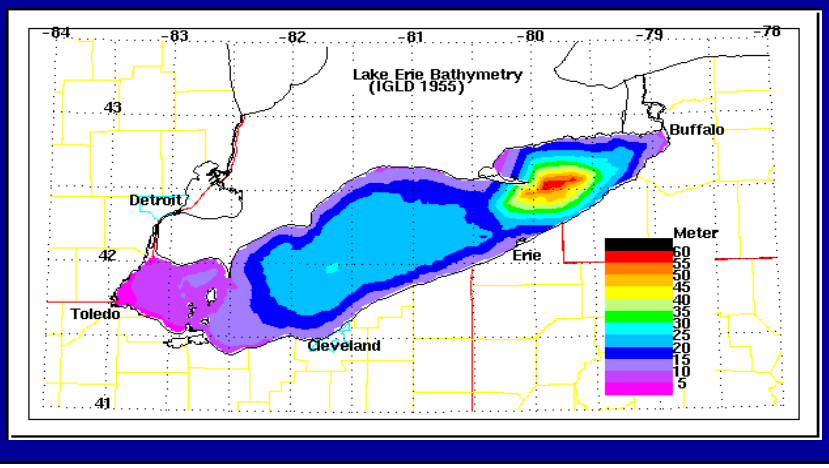
Bird Mortality Summaries for 1999-2000 and Preliminary Microbiological Analyses

Dr. Mike Campbell and Dr. Larry Gauriloff
Biology Department
Mercyhurst College

Work supported by Pennsylvania Sea Grant

Pennsylvania's Unique Position:

At the border between Lake Erie's Central and Eastern Basins



June to Early October 1999: The Mystery Begins

Erie Morning News Article by Jack Grazier, October 7

- Wildlife Rehabilitator Wendy Campbell is brought more than a dozen seagulls with symptoms of muscular weakness/paralysis.
- Pennsylvania Game Commission Officer Larry Smith reports dead gulls appearing all along PA Lake Erie Shoreline.
- Over 150 dead gulls picked up by officials at Presque Isle State Park.
- Mike McCarthy of U.S. Fish & Wildlife Service cites possible explanations for dieoff, including: avian botulism, avian cholera, and rodenticide poisoning.

The Mystery Continues

Morning News Article by Jack Grazier, October 22

- Poisoning still suspected as possible cause of gull deaths
- Specimens undergoing tests at National Wildlife Health Center (NWHC) in Madison, Wisconsin

The Mystery Begins to be Unraveled

Morning News Article by John Bartlett, November 2

- NWHC lab in Madison Confirms Type E Botulism as cause of death of gulls collected from Presque Isle.

Summary of diagnoses made by NWHC of 13 birds collected from Presque Isle in 1999

- Type E Botulism indicated as cause of death for:
  - 3 Ring-billed gulls
  - 2 Black-backed gulls
  - 3 Herring gulls
  - 2 Bonaparte's gulls
- Cause of death undetermined for:
  - 2 Ring-billed gulls
  - 1 Horned grebe

Summary of bird mortality tallied at Presque Isle State Park in 1999

Species	Number Collected
Ring-billed gull	79
Herring gull	32
Black-backed gull	16
Bonaparte's gull	6
Unidentified gulls	135
Plovers and Sandpipers	4
Coot	3
Common Loon	12
Mergansers	14
Horned Grebe	1
Pied-billed Grebe	1
Scaup Duck	2
Flicker	2
Total	**307**

Summary of bird mortality tallied at Presque Isle State Park in 2000

Species	Number Collected
Ring-billed gull	149
Herring gull	97
Black-backed gull	20
Bonaparte's gull	1
Unidentified gulls	107
Turns	1
Plovers and Sandpipers	2
Coots	44
Common Loon	33
Mergansers	71
Horned Grebe	3
Scaup Duck	2
Bufflehead	2
Hawk	1
Flicker	1
Morning Dove	1
Total	**535**

Summary of bird mortality tallied at North East PA in 2000

Gulls	23
Shorebirds	2
Loons	8
Mergansers	15

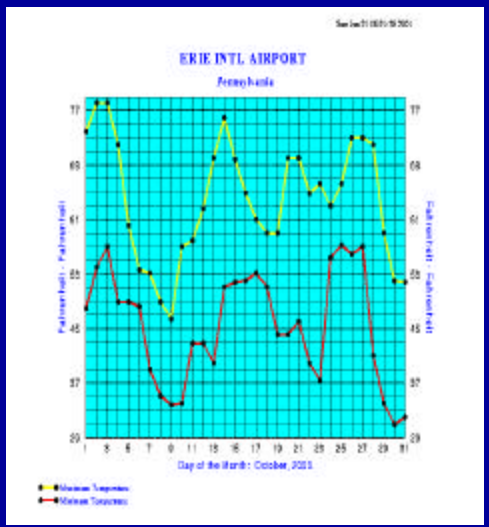
Avian botulism research initiatives supported by PA Sea Grant in 2000

- Analysis of spatial and temporal patterns in bird mortality in relation to environmental factors
- Stomach content analysis of dead birds
- Microbiological analysis
  - Beach samples
  - Nearshore bottom sediment samples
  - Animal tissue samples

Analysis of spatial and temporal patterns in bird mortality in relation to environmental factors

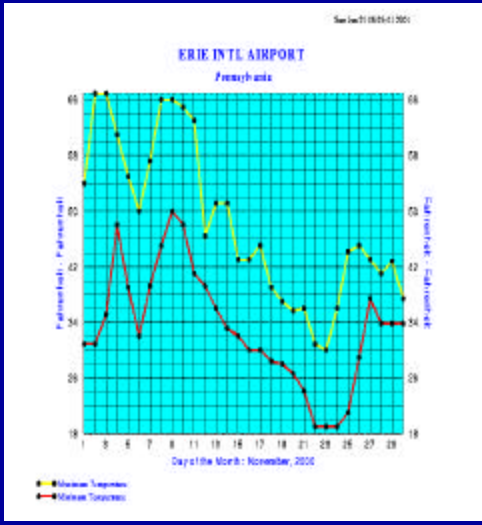
- Greater overall mortality in 2000 then 1999
- Gull mortality mainly in summer to early fall
- Loon and Merganser die-off mainly in late fall
- Die-offs seem to occur in episodes following changes in weather

Mortality Episodes in 2000



- September 13-19: Mostly gulls at Presque Isle
- October 10-11: Mostly gulls
- November 18-19: Mostly Mergansers

Mortality Episodes in 2000



- All major mortality episodes occurred during or following stormy weather when temperatures decreased.
- Eastern end of PA shoreline did not experience significant bird mortality until mid October and November

Stomach Content Analysis of Dead Birds: September-December 2000

- Birds sampled:
  - 7 Ring-billed gulls
  - 2 Herring gulls
  - 1 Black-backed gull
  - 3 Common loons
  - 3 Mergansers

Stomach contents of birds that had identifiable material in their guts

- Most contained fish bones
- One loon had a partially intact fish (a goby or bullhead catfish)
- One merganser had an 8 inch mudpuppy
- One ring-billed gull had a full gut with fish bones, spines, and scales, zebra mussel shell fragments and byssal thread clusters, and decomposing wood, leaves, and seeds.

Microbiological Analyses

- Beach samples from lake-side Presque Isle, Presque Isle Bay, and mouth of Walnut Creek
- Materials tested included sand, decaying *Cladophora*, plant debris, and zebra mussel shells
- Nearshore bottom samples from lake-side Presque Isle, Gull Point, and Presque Isle Bay

Microbiological Analyses of animal tissues

Samples of various tissues collected from dead specimens of fish and birds between Presque Isle and the PA/NY border

Microbiological Analyses

Isolates exhibiting the following characteristics are considered likely to be *Clostridium botulinum* (Type E or non-proteolytic Type B & F):

- Gram + bacilli
- Endospores oval, subterminal with appendages
- Anaerobic
- Casein hydrolysis negative
- Hydrogen sulfide production negative
- Milk coagulation positive

Final Identification (planned):

- BBL Crystal ID System Anaerobic ID Kit
- DNA macrorestriction fragment analysis by pulse-field gel electrophoresis

Tentative Microbiological results

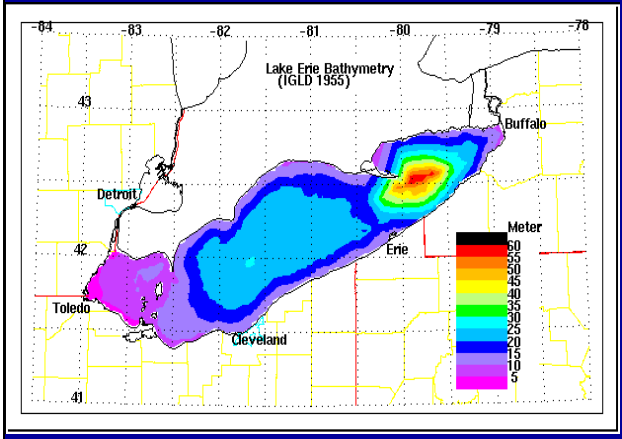
Preliminary Positive indications of Type E *C. botulinum* for:

- Beach Samples- including zebra mussel shells (6/11)
- Nearshore bottom sediment samples (7/19)
- Gulls (7/9)
- Merganser (1/1)
- Fish (3/*)
- Mudpuppy from Merganser gut (1/1)

Tentative Microbiological results:

- Possibly positive indications for *Cladophora* samples from beach and nearshore area
- Negative indications of Type E *C botulinum* for a 78 inch dead sturgeon washed ashore on September 18, 2000
- All samples taken from sturgeon were negative, including liver, gill, gut tissues, and gut contents, which included *Cladophora*

Final Thoughts



- Episodic nature of bird die-offs may be correlated with internal seiche phenomena in Lake.
- Timing and intensity of these phenomena may differ between the Central and Eastern Basins of Lake Erie.

Chuck Murray
Pennsylvania Fish and Boat Commission
Lake Erie Research Unit

Lake Erie Research Unit

Background Information

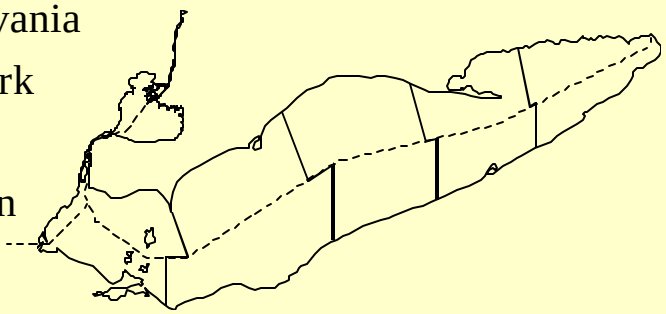
Lake Erie Research Unit

- Monitor sport and commercial fisheries
- Conduct a series of assessment surveys to estimate the populations of keystone species, including walleye, perch, lake trout and various forage fish
- Biweekly limnological evaluation of Lake Erie.
- Formulate harvest regulations for the sport and commercial fisheries

Lake Erie Committee

Lake Wide Cooperative Effort

- Pennsylvania
- New York
- Ohio
- Michigan
- Ontario



Interagency Standardized Assessment

- Trawling
- Gill netting
- Limnological profiles
  - Temperature
  - O_2
  - PO_4
  - Zooplankton
  - Phytoplankton*
  - Spring/fall benthos

Fish Kills

Avian Botulism

What Species Are Dying?

- Gizzard shad
- Carp
- Drum
- Bass
- Burbot
- Whitefish
- Perch
- Stonecats
- Gobies

When did these fish kills occur

- **Gizzard Shad**
  - **Spring** **-Lake wide**
- **Carp**
  - **Mid-June** **-Western Basin**
- **Multi-Specific**
  - **Mid-June through July** **-Presque Isle**
- **Multi-Specific**
  - **October** **-Central Basin**
- **Sturgeon**
  - **Summer-Fall** **-Eastern Basin**

Why Are Fish Dying?

1) Temperatures Intolerances

Inversions

Seiches

Storms

Why Are Fish Dying?

2) Anoxia:

Low Dissolved in PA on

9/3/1999	**2.7 ppm**
9/6/2000	**1.7ppm**

Why Are Fish Dying?

3) **Algal Blooms**

Blue Greens	***Microcystis sp*.**
Filamentous algae	***Cladophora sp*.**

Why Are Fish Dying?

4) Historically low lake water levels

Why Are Fish Dying?

5) Spawning Stress

Why Are Fish Dying?

6) Discarded by-catch

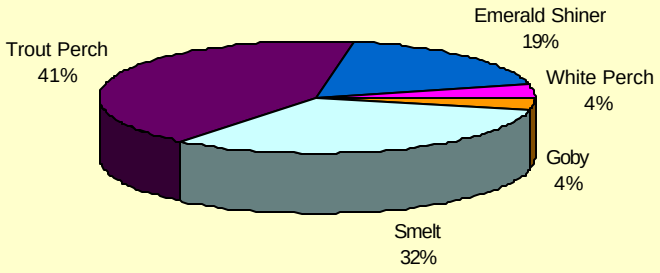
Why Are Fish Dying?

7) Exotics

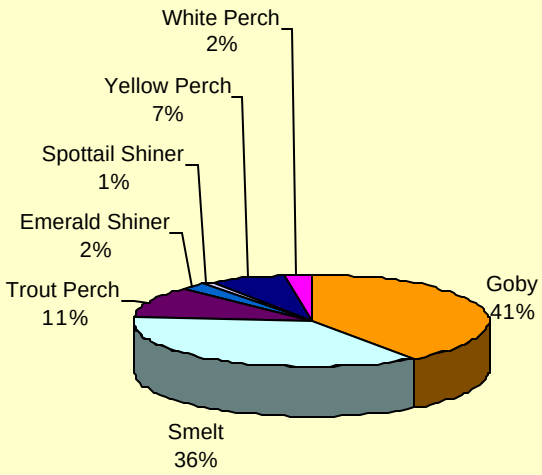
zebra mussels / pseudofeces

gobies

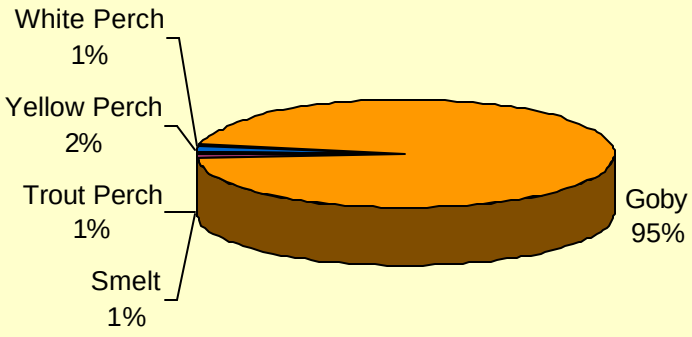
1997 Trawls



1998 Trawls



1999 Trawls

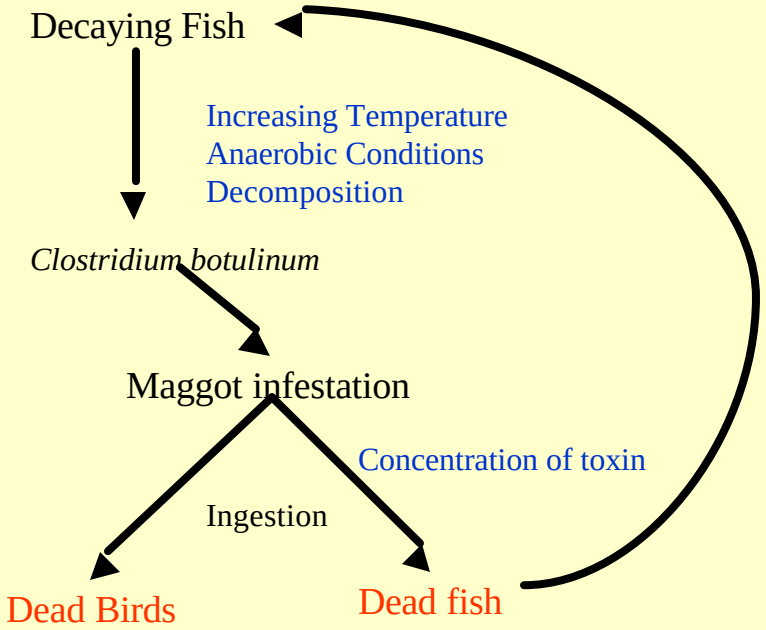


Why Are Fish Dying?

8) Old Age

Why Are Fish Dying?

9) Botulism Poisoning?



Clinical Signs of Botulism in Fish

- Disorientation
- Erratic swimming
- Complete ataxia
- Flaccid paralysis
- Death

Why Are Fish Dying

- **Temperatures Intolerances**
- **Anoxia**
- **Algal Blooms**
- **Historically low water levels**
- **Spawning stress**
- **Discarded By-catch**
- **Exotics**
- **Old age**
- **Botulism poisoning?**
- **Synergistic Effects of any or all of these factors**

Fish Kill Generalizations

"Natural" phenomena

Diffuse

No point source event

No physical trauma evident

Multi-specific

Species Generalizations

- Nearshore community
- Diet:
  - Benthos
  - Invertebrates
  - Scavengers
- Pelagic predators are showing up less frequently.

Identification of the Causal Agent

- Track the fish kills spatially/temporally
- Organize a relational database
- Establish a clearinghouse for information

Reporting Fish Kills

- Centralized database
  - Person reporting, species composition, magnitude, date, location, validation, pathological assessment, chemical profile.
- Coordinating agency (by jurisdiction)
- Interagency collaboration

Robert Wellington
Erie County Department of Health
Erie, Pennsylvania

Mr. Wellington provided the following timeline of observations made in Erie County, Pennsylvania:

1997

April 30	Eleven dead bluegills-sunfish in west part of Presque Isle Bay.
May 9	Pennsylvania Fish and Boat Commission representative reports that following a late-April severe storm he found many dead bluegills and pumpkinseeds around his nets, but live fish in the nets.
July 7	Meeting held on high lake levels threatening water supply, pump house etc.

1998

February	Warmest February and least amount of snowfall on record.
July 1	A report from Presque Isle State Park regarding large, dead channel catfish washing up on the beach for the past three weeks. (10-15/day)
August	Had complaints of taste and odor problems with our public water supply.
October	Noted more sick gulls than normal. Wendy Campbell, local rehabilitator, brought this to our attention. Not that many dead birds compared to the hundreds of live birds noted. Once the weather got colder, the issue seemed to be almost forgotten.
December	Very low water in the streams most of the fall. Very late run of steelhead, with thousands of steelhead in Elk Creek and lower Walnut Creek. Weather got very cold, with reports of trapped steelhead under the ice as water levels fell and the ice formed.

1999

March 2	Thousands of dead gizzard shad and many dead alewife at the foot of East Avenue near a thermal discharge. "Millions" of live young-of-year gizzard shad in the area, a "handful" of adults, and thousands of live emerald shiners observed.
April 5	Thousands of dead fish along the shoreline at Sixteen-Mile Creek. Estimated that 99% were dead alewife. They had been dead for quite some time. (About 7" average length) Also, thousands of dead alewives found along the beach at Twelve-Mile Creek. Some dead gizzard shad were also present. A strong odor of dead fish was noted in the area south from the shoreline. At the lakeshore at Trout Run (about 10 miles west from Erie, Pa.) there were many dead fish. It was estimated that 5% were dead gizzard shad (<6" long), 20% were dead alewives (<6" long) and 75% were dead alewives (>7" long).
April 25	Five dead adult steelhead on beach at Raccoon Creek. Dead alewives, one dead sucker, one burbot. Alewife die-off seems small compared to the east side of Erie.

April 27	Thousands, if not millions, of dead alewives in approximately a quarter mile section of beach at Sixteen Mile Creek. A few dead gizzard shad were noted. Thousands of dead alewives at Twelve-Mile Creek beach. One dead drum, and one dead gull. Thousands of dead alewives, one dead steelhead and one dead gull found at Eight-Mile Creek area.
June- July	The algal problems along our shoreline are reminiscent of the mid-1960s. Rumors of more dead birds were noted. Algae tentatively identified as *Cladophora*, washed up on shore and created strong, rotten sewage odors. Black, slimy, filamentous sludge beds merged with dead freshwater drum (sheepshead) and some rock bass. The news media printed an article about the odor and mess along the beaches.
August 16	Received a call from a resident near the mouth of Elk Creek. It was reported that there were four dead gulls, and one very sick gull. Also, dead fish were reported. Called the Pennsylvania Game Commission and the US Fish and Wildlife in State College, to report the situation. The Pennsylvania Game Commission became involved in the issue, and worked very closely with people at Presque Isle State Park. Birds were subsequently collected. Some were sent for analysis. About this time, the CDC in Fort Collins, Colorado, reportedly became involved. It should be noted at this time that the West Nile Virus was an emerging problem in New York State. There was concern by some that the die-offs might be related.
August 18	Near the mouth of Elk Creek, saw dead stonecat, channel catfish, bullhead, carp, freshwater drum, gizzard shad and two dead gulls. At Raccoon Creek beach, perhaps 300' offshore, between the two extreme concrete jetties, and from the beach area out to about 15' noted a "muddy green" algae concentrated in this area. Saw 15 dead gizzard shad, 2 rock bass, 22 freshwater drum, 3 goby, 1 catfish, 1 stonecat, and 1 walleye.
September 17	One dead gull (lots of live maggots) at Chestnut Street in the Presque Isle Bay.
September 29	Harry Leslie (PISP) reported picking up 63 dead gulls, 4 plovers, and 2 flickers.
October 18	Called to the beach #2 area to see dead fish. Observed about 50. All had been dead for quite some time - mostly alewives.

NOTE: During the summer of 1999, the City of Erie Water Authority recorded an all-time high intake temperature of 80 degrees F. The intake is about 1.25 miles out into the lake, and is about mid-depth on a crib in about 35' of water. Water Authority staff would be able to search records for the exact day(s).

2000

February	Very low water due to the previous summer's drought-like conditions. Lake Levels about the same as noted in the early 1960s.
April 27	Approximately 50 dead sunfish-bluegills in the west end of the bay.
May 10	Larry Smith, Pennsylvania Game Commission, noted that between July to December 2, 1999, they had picked up 316 dead birds.
June 27	Was called to a "Rotten Sewage" complaint, east of the city of Erie. The people complaining lived south of Pa. Rt. 5. The cause of the problem was found to be decaying algae washed up along the shoreline.
June 29	News release ran about the rotting *Cladophora* along the lakeshore.

June 30	Many large dead smallmouth bass on the beach #2 area of the Park, even though the fish were being picked up on a regular basis.
August 15	Sampling in Lake Erie sediments revealed a live burrowing mayfly nymph in about 53' of water off Eight-Mile Creek. The dissolved oxygen in the water at the bottom was 6.18 ppm. This bottom depth was above the thermocline. Temperature was 22.98 C at the bottom.
August 24	Fish were reported dead on the beach east from the Northeast Marina towards Twenty-Mile Creek. Saw over 200 dead freshwater drum, 19 smallmouth, 2 suckers, 3 carp, 2 goby, 1 walleye, 1 yellow perch, 1 bluegill, 10 stonecats, 1 catfish, 2 gizard shad, and 2 dead gulls.
September 7	Was again called to the area near Twenty-Mile Creek for a die-off of large smallmouth bass. There were about a dozen dead fish from about 16" to 20". Also one dead gull.
October	Gill nets were set to collect fish for contaminants. The nets were set east from Erie. The outside net was loaded with large (apparently healthy) smallmouth bass. The inside net had 10 large lake trout, a few bass and one carp. The lake trout were collected in about 12' to 14' of water, only about one mile east from the channel at the east end of the bay.

Canadian Presentations

Jeff Robinson
Canadian Wildlife Service
Dr. Ian Barker
University at Guelph

Findings

According to Jeff Robinson of the Canadian Wildlife Service and Dr. Ian Barker of the University at Guelph, an avian botulism outbreak occurred in 1998 and significant outbreaks occurred along the Canadian shoreline of Lake Erie during 1999 and 2000. In October and November 1999, a major die-off occurred between Rondeau Provincial Park and Point Pelee National Park that resulted in mortalities estimated at 6,000 birds. Type E toxin was confirmed in this outbreak and approximately 90 percent of the birds were mergansers. In 2000, an earlier outbreak of botulism that involved gulls and shorebirds was followed by an outbreak late in the fall that included mergansers and loons.

During his talk, Dr. Barker suggested that something is going on that is changing the lake ecosystem. He encouraged others to look for perturbations on the system, like significant weather or wind patterns that might be linked to these outbreaks.

He spoke about the bird mortalities seen on the Canadian shore, including common loons, red-breasted mergansers, grebes, and diving ducks. Dr. Barker mentioned that during one of the outbreaks, there was a dead bird found nearly every 10 meters, indicating the extent of the die-off. The issue of shoreline access complicated the bird monitoring efforts.

Noting that the sentinel species of birds are moving through the Canadian areas during October and November, Dr. Barker mentioned that botulism outbreaks during this time can be especially devastating. He pointed out that the loons impacted by the botulism outbreak are probably birds from Minnesota and the Canadian North.

Dr. Barker mentioned the fish and mudpuppy die-offs that occurred in Canadian waters of Lake Erie. Although these have not been definitively linked to the outbreak, could these die-offs be related to the situation?

Robinson provided an overview of the bird and fish die-offs that occurred over the past few years. He mentioned that in 1999 a fish die-off occurred in August, followed by a bird die-off. He also reported a die-off of sturgeon (6 fish recovered), but the fish were in an advanced stage of decomposition, so no tests were taken.

Reporting on the western basin, Robinson stated that there were no recorded botulism outbreaks in cormorant, gull, and heron colonies in that region of the lake. He also pointed out that scaup regularly feed on zebra mussels, but they had not seen many dead scaup.

Double crested cormorants have not been impacted by the botulism outbreaks on the Canadian side, since these birds have migrated out of the area by October.

Table 1: Botulism Outbreak (Ontario) 1999
Summary of Observations

Date	Location	Source	Comment
Pelee National Park, Rondeau Provinical park, Long Point, south shore of Lake Eriei (Ohio & Erie, Pennsylvania	early September to October 26	Russ Weeber	shorebirds & carp (Pelee) gulls - south shore of Lake Erie gulls and one Great Blue heron - Long Point
Grand Bend (Lake Huron)	October 24	Dave Martin	Common Loon (16) & Oldsquaw (2)
Ipperwash (Lake Huron)	October 24	Alf Rider	Common Loon (20), Red-throated Loon (1), Red-necked Grebe (3), Horned Grebe (2), Oldsquaw (2), Surf Scoter (1), Ring-billed Gull (20) and Great Black-backed Gull (1)
Rondeau Provincial Park (Lake Erie)	October 26	Michael Malone	Common Loon (1), Horned Grebe (8), Red-breasted Merganser (40+), Ring-billed Gull (1), Herring Gull (1) and Great Black-backed Gull (1)
Pinery Provincial Park	October 27	Jack Mayos	Common Loon (~280), Red-breasted Merganser (~20), grebes & gulls, 10 Sturgeon (2 to 6 feet long)
Erie Beach (Lake Erie)	October 27	Steve Charbonneau	Common Loon (1), Horned Grebe (8), Red-breasted Merganser (178), Greater Scaup (1), Bonaparte's Gull (1), Ring-billed Gull (4), Great Black-backed Gull (1)
Port Burwell, Port Bruce, Port Stanley, Rondeau Provincial Park and Wheatley (Lake Erie), Sarnia, Grant Bend (Lake Huron)	October 28	Dave Martin	Merganser - Rondeau to Wheatley Loons - Sarnia to Grand Bend sturgeon - Sarnia Ring-billed Gull (2) and Great Black-backed Gull (2) - Port Stanley
Grand Bend	October 29	Chris Earley	Common Loon (1), Red-throated Loon (1)
Pinery Provincial Park, Ipperwash	November 2	Dave Martin	Loon (~250) - Pinery Loon (~50) - Ipperwash low numbers of other unidentified species
Rondeau Provincial Park, Pelee National Park	November 3	Chuck LeBer	estimated 6000 ducks died in Pelee and Rondeau area, with 6 testing positive for Type "E" botulism; 90% were mergansers, 8% grebes, 1% loons, 1% Bonaparte's Gulls and Oldsquaw
Long Point, Turkey Point Provincial Park (Lake Erie)	November 4	Dave Martin	a few gulls at Long Point tip large numbers of dead mergansers noted off-shore (date?) Major outbreak in Pelee and Rondeau area in late August involving many gulls and shorebirds (Spotted Sandpipers and Sanderlings mostly)
Pinery Provincial Park	November 4-5	Terry Crabe	loons (148), Common Mergansers (44), Oldsquaw (26)
Pinery Provincial Park	November 10	Harold Stiver	Loons (75)
Grand Bend, Port Franks	???	Dave Martin	loons, grebes and mergansers - 30 to 40/day being seen

Geoff Carpentier. "Avian Botulism Outbreak Along the Lower Great Lakes". Ontario Birds, Vol. 18(2), August 2000. pp. 84-91.

Table 2: Summary of Reported Numbers of Birds Impacted			
Species	**Lake Huron**	**Lake Erie**	**Total**
Common Loon *(Gavia immer)*	**540**	**2**	**542**
Red-throated Loon *(G. stellata)*	**2**		**2**
loon sp.	**300**	**60**	**360**
Horned Grebe *(Podiceps auritus)*	**2**	**16**	**18**
Red-necked Grebe *(P. grisegena)*	**3**		**3**
grebe sp.		**48**	**48**
Great Blue Heron *(Ardea herodias)*		**1**	**1**
Common Merganser *(Mergus merganser)*	**44**		**44**
Red-breasted Merganser *(M. serrator)*	**20**	**218**	**238**
merganser sp.		**5400**	**5400**
Greater Scaup *(Aythya marila)*		**1**	**1**
Oldsquaw *(Clangula hymemalis)*	**38**	**30**	**68**
Surf Scoter *(Melanitta perspicillata)*	**2**		**2**
ducks sp.		**600**	**600**
Bonaparte's Gull *(Larus philadelphia)*		**31**	**31**
Ring-billed Gull (*L. delawarensis)*	**20**	**7**	**27**
Herring Gull *(L. argentatus)*		**1**	**1**
Great Black-backed Gull (*L. marinus)*	**1**	**4**	**5**
gulls		**yes**	**?**
Sanderling *(Calidris alba)*		**yes**	**?**
Spotted Sandpiper *(Actitis macularia)*		**yes**	**?**
sandpiper sp.		**yes**	**?**
Total	**972**	**6419**	**7391**

Reports of birds dying from botulism are widespread and fairly common in certain areas. Incidents involving Type E botulism are much rarer and, as mentioned, are generally confined to the Great Lakes region. Outbreaks have been recorded in Ontario in at least 1994 (Goderich - involving Herring and Ring-billed Gulls) and 1998 (Lake Huron - involving dozens of loons). In both cases, the type of botulism was not confirmed.

Dr. Tom Murphy
National Water Research Institute
Burlington, Ontario

Algal Toxins – Initiators of Avian Botulism?

Dr. Murphy spoke about work that is being done in collaboration with Dr. Kim Irvine from Buffalo State College in Buffalo, New York. Both Dr. Murphy and Dr. Irvine have worked together on avian botulism outbreaks that have occurred in lakes in the Canadian prairie regions. Their research has been funded by Ducks Unlimited.

According to Dr. Murphy, the linkages between avian botulism and algal toxins are "intriguing." Noting that algal toxins, anatoxin-a and microcycstin-LR, were present during outbreaks of avian botulism that occurred in Whitewater Lake, Manitoba, Canada, Dr. Murphy suggested that more study is needed to understand these linkages. Type C botulism was involved in these outbreaks and carcasses of birds that lasted throughout the winter appeared to perpetuate the outbreak. Birds involved in this outbreak were molting, so they were unable to fly and must alter their diet. These birds are forced to eat food that ducks capable of flying might reject.

In the Canadian research areas, wind produced hotspots of these toxic blue-green algal species. The areas of the lake that had these hotspots had ideal water conditions for algal growth. As part of this project, the water chemistry and geochemistry of the lake was thoroughly studied.

Dr. Murphy also provided information on the impact of microcystins in other areas of the world, including areas of Japan, where pearl oysters have been wiped out by these algal toxins. He noted that these toxic algal blooms seem to be increasing around the world.

Regarding Lake Erie, Murphy pointed out that the lake has both *Microcystis* and microcystins, and he posed a question concerning the role that zebra mussels may play. He also mentioned that fishes do take in microcystins and these may be toxic to fish.

Dr. Murphy indicated that the potential for interactions between the presence of microcystins and botulism is high and should be resolved by research. He also suggested that research is needed on the impacts of microcystins on fish and ducks.

Dr. Christopher J. Brand
USGS National Wildlife Health Center
Madison, Wisconsin

Type E Avian Botulism Outbreaks: Lake Erie Outbreaks in Relation to Type E and Type C Outbreaks from a National Perspective

Summary: A brief overview of the USGS National Wildlife Health Center (NWHC) was provided, including its mission, facilities, and functional capabilities. Functional capabilities, including diagnostic assistance, rapid field response and investigation of wildlife disease outbreaks, and directed research on specific wildlife disease problems and issues. Studies of avian botulism have been a significant portion of the center's activities since its establishment in 1975. While most efforts have involved type C avian botulism, the center has been involved in diagnosis and field investigation of type E outbreaks.

The history and changing geographic patterns of occurrence of avian botulism, types C and E, were discussed and presented on a map from the USGS National Atlas (www.nationalatlas.gov/wildmortfrm.html). Avian botulism outbreaks over the course of history in the U.S. and Canada have been almost exclusively due to type C, with the exception of a small number of type E outbreaks in the Great Lakes, one in Alaska, and several individual cases from other locations: near Panama City, Florida, and the Salton Sea in southern California (unpublished data from NWHC diagnostic and epizootic data bases).

Prior to the recent outbreaks of type E avian botulism on Lake Erie, type E outbreaks have been documented periodically on Lake Michigan and Lake Huron during 1964 - 1984. These outbreaks have been summarized by Brand et al. (*1983, Wilson Bulletin 95:269-275)* and Brand et al. (*1988, Journal of Wildlife Diseases 24:471-476).* The first reported occurrences of type E avian botulism in 1963 and 1964 were investigated by the Michigan Department of Natural Resources and reported by Fay et al. (*1965, Pub. 13, Great Lakes Research Division, University of Michigan).* These widespread outbreaks along Michigan's southern shore of Lake Michigan (1963) and the southern shore and Upper Peninsula shores (1964) killed over 12,000 birds total (primarily loons and gulls). Following these incidents and the occurrence of 11 cases of human type E botulism from consuming improperly prepared fish from the Great Lakes during 1960-1963, surveys for *Clostridium botulinum* type E in healthy fish (Bott, *1966, Journal of Bacteriology 91:919-924;* and in lake sediments (Bott et al., *1968, Journal of Bacteriology 95:1542-1547*; Sugiyama et al., *1970, Proc. First U.S. - Japan Conf. on toxic microorganisms: 287-291;* Graikoski et al., *1970, Proc. First U.S. - Japan Conf. on toxic microorganisms* 95:271-277*)* disclosed the widespread environmental occurrence of type E botulism bacteria in all lakes,

particularly in Lake Michigan and Lake Huron. Field investigations of three type E avian botulism outbreaks on Lake Michigan by the NWHC in collaboration with the Michigan Department of Natural Resources, Wisconsin Department of Natural Resources, and Illinois Department of Conservation during 1980-1983 provided additional observations and documentation contributing to the scant knowledge on the epizootiology of this disease, including:

- demonstration of preformed type E toxin in fish in the proventriculus and ventriculus of birds sick and dead from avian botulism;

- demonstration of type E toxin in dead fish along Lake Michigan shores in association with late fall type E outbreak (including alewife, burbot, and smelt);

- demonstration of toxins from both type C and type E in individual birds dying during outbreaks during summer months;

- absence of carcass-maggot cycle involved in late fall outbreaks.

An overview of the current state of knowledge of type C avian botulism was presented and compared and contrasted with type E. While there are some similarities, there are also major differences in molecular biology, microbiology, and ecology between *C. botulinum* types C and E which may explain the different epizootiological presentations of these diseases. Some of the major, but basic, questions regarding type E avian botulism include: the role of various fish species in transferring toxin to birds; whether fish are susceptible to type E toxin or toxin in fish is primarily formed postmortem in fish carcasses; whether fish-eating birds such as loons scavenge dead fish or mistake them for live fish; the importance of the carcass-maggot cycle during type E outbreaks in the summer; human health risks from sick or dead birds during outbreaks, as well as directly from fish; current prevalence and distribution of *C. botulinum* type E in fish and sediments of Lake Erie (as well as other Great Lakes); the impact of type E botulism on loon populations; and specific ecological conditions required for type E toxin production and transfer to birds.

Work Group Breakouts

Group 1

Disease/Human Health Research Needs:

Are fish carrying spores and/or toxin?
- During outbreaks and during non-epizootic periods.
- Need to look at sportfish vs. fish that are not harvested/consumed. (by species, location)
- Look at trophic levels related to fish - benthic, open water. Through trophic chain - spores may get into fishes.

Two different questions:
1a. During outbreaks - are fish safe to eat?
1b. During non-outbreak periods, are there concerns about eating fish?
2. During outbreaks or non-outbreaks, what is the risk of handling sick/dead fish or birds?

- Know what you are testing for.
- Know the technique will give you the information you are looking for.

NOAA GLERL - May be able to provide assistance with this research. Sampling protocols – are very complex.

Question: Do lower lake levels have something to do with outbreaks? Any connections?

What unique climatic and hydrological conditions are present before/or during outbreaks?

- What role does water clarity and resulting changes in fish movement/feeding areas play?
- What role do gobies play in outbreaks?

Need to understand the dynamics with fish in these outbreaks.

- Research being conducted (by funded PASG) on Type E spores in Lake Erie.

Public needs information on:
- Proper cooking techniques for fish.
- Proper handling of birds found during outbreaks.
- Proper carcass disposal.

Look into University/Agency facilities that exist (incinerators).

What should the next steps be?
- Need agency (Health Canada, Federal Agencies) assistance in developing coordinated advisories/information for other agencies to distribute to the public.
- Great Lakes Commission, USGS may provide funding for research on botulism.
  $\Rightarrow$ Get this on their priority list.

Group 2

Points of Synthesis:

- Need to identify vulnerable species.
- Establish means of analyzing relations between fish and bird data (a role for LaMP).
- Coordinate/facilitate sharing expertise (ex. fish identification from bones)
- Results made available to broader audience.
- Web site postings.
- Beach cleaning - How clean is natural and appropriate?

Data Issues:

- Beware of over-emphasis of potential.
- Geographical variations in need for carcass pick-up/disposal.
- Modeling capability
  ⇒ Great Lakes USGS Fisheries Res. Center
  ⇒ Canada Center for Inland Waters
- (Goby) Die-off hypothesis
  ⇒ Test via GIS model.
- Dead fish hypothesis.
- Focus on cause of fish mortality.
- Possibility of multiple causes.
- Prioritize data/methods needs for upcoming season.
- Characterize "baseline"
- Fish populations.
- Limnology.
- Cornell Lab has sampling protocols for fish. Guelph Lab does too.
- Certified aquaculture - true facilities needed to do toxin studies.
- Identify local person in each jurisdiction to be responsible to respond to fish kills.
- Funding source?
- Check federal aid sources for fisheries work. USGS, FDA, GLPF, Ann Arbor
- Need public outreach information regarding reporting ASAP. Identify investigating laboratory to establish base funding. PA and NY?

Group 3

Wildlife Bird Group Research Needs:

- Determine whether fish carry toxin.
- Determine whether sick birds carry toxin.
- Test for toxin in zebra mussels and other possible vectors.
- Test healthy birds during outbreaks.
- Test for toxins in area around dead birds.

- Consider sources of toxic substances other than botulism - algae toxins, pesticides.
- Contribution to stress by other factors.
- Look at susceptibility varying among bird species.
- Develop a model to predict potential for outbreaks using various environmental factors.
- Bottom-feeding vs. surface feeding fish as vectors?
- Look at subtle variations in feeding habits of various bird species.
- Look for "hot beds" of toxin.
- Try to determine why outbreaks come and go.
- Dovetail banding operations with bird sampling.
- Initiation of long-term studies of populations with banding program.
- Encourage people to look for bands.
- Evaluate mudpuppies when events occur involving them.
- Lake populations of turtles affected?
- Look at ratios of adults/juveniles (gulls).

Priorities:

- Blood samples from live fish and birds (toxin analysis).
- Establish fast response team to collect data.
- Regular surveys (aerial?) to locate populations of various species prior/during die-offs.
- Organize a beach survey program for upcoming season (shore-wide, standardized methodology)
- Standardize methods of doing carcass pick-ups and estimating mortalities.
- Permits!? for birds, fish, etc.
- Plans to involve volunteers in pick-ups - training.
- Identify central agent to track activities and collect data.
- Seek funding support to cover costs of survey team (some paid individuals).
- Public outreach to shoreline residents, charter boat captains, marina people.
- Include benthic organisms in the survey/sampling plans.

Human Heath Concerns:

- Disposal methods: standardized.
  ⇒ How to advise without scaring.
  ⇒ General public - report but do not touch without gloves.
- Incinerator(s) available for disposal? Can state coordinate arrangements for incineration.
- Mechanics of carcass removal need to be defined.

Appropriate Goals for Work Group?

1. Standardized public outreach information (education).
2. Specific plans for response to upcoming season.
   a. scientific - including survey effort
   b. management
3. Standardize methods of reporting mortality/episodes.
4. Identify person(s) who will coordinate reporting.
   - Clarify roles/responsibilities of involved parties - who should people call?
   - NWHC serve as clearinghouse to track overall (U.S.)
   - Sea Grant coordinate bi-national monitoring effort.
5. Publicize opportunities to share findings/results.

Group 4

Relevant Research Issues and Fisheries Questions:

- Cohesive database: fish, bird die-offs, limnological data.
- Standardized reporting of fish kills
- Quick response network - AFS, USFW, USACE, federal guidelines as templates.
- Fish pathology/disease detection improvement and development of a standardized analysis protocol (including collections, preservation tech.)
- Type E botulism - killing fish?
- Defining links in Great Lakes food webs.
- Accumulation mechanism of toxins.
- Change in D.O. regime in Lake Erie and relationship to botulism outbreak?
- Microcystis vs. botulism as causative agent.
- Incidence of spores in gobies, zebra mussels.
- Spatial, temporal patterns.
- Better define life cycle.
- Relationship between overturns and botulism outbreaks.
- Species sensitivity to botulism - bioassays.
- Cladophora link in botulism, water quality.
- Goby and zebra mussel links to botulism.
- Characterize patterns of incidence with epidemiological aspects - what are patterns of events?
- Development of field tests.

Sampling and Assessment:

- Culture techniques in lab.
- Microbiological sediment analysis.
- List of vulnerable species, guilds.
- Determining vectors.
- Baseline limnological data; D.O., temp, phytoplankton, pH, zooplankton, chl.a, conductivity, redox potential.
- Interagency training program for sampling, analysis.

Proposal Topics, Titles:

- Prevalence of botulism in sick fish in Lake Erie.
- Relationship between fish eating birds (mortalities) and botulism.
- Role of fish kills in incidence of botulism.
- Survey of C.b. spores in microflora of gastrointestinal tract in fish.
- Pattern analysis of fish mortalities and limnological trends.
- Pattern distribution of C.b. spores in fish tissues.
- Abiotic and biotic factors determining botulism outbreaks.
- Relationship between fish stressors and susceptibility to C.b. outbreaks.
- Spatial/temporal list of spores in inverts, fish and sediments.

Human Health Aspects:

- Developing mechanism for disposal of carcasses - quantify mortalities - nothing in place.
- Different mechanism for public/private properties.
- Disposal guidelines: public concerns.
  $\Rightarrow$ incineration is optimal tech.
  $\Rightarrow$ state regs in place
  $\Rightarrow$ public information bulletins
  $\Rightarrow$ reporting system

Working Group Objectives:

- Develop network of expertise
- Develop standardized reporting, sampling, collection, analysis, protocols.
- Use LaMP as forum for reporting die-offs, information dissemination.
- Pooling of data sources and interpret data.
- Develop research plan.
- Point contacts within each jurisdiction, mini-working groups as subset - setup first, then reconvene multi jurisdictional group.
- ID potential funding agencies.
- Develop list of experts in this field.
- Develop list of labs.

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January 24-25, 2001
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Avian Botulism Workshop
Evaluation Results

1.) Do you think the workshop achieved its overall goal of sharing information, developing a research agenda and providing networking opportunities?

Yes 52 No _____ Uncertain _____

Comments:

- The networking opportunities will make it much easier to contact people in other states/provinces if a die-off occurs. It might be good to have a contact in each state to notify if a die-off occurs in our state.
- Good opportunity to meet all the players. The situation is more widespread then I had thought.
- Good start to learning more about avian botulism problem.
- Excellent.
- Lots of good information.
- Eye opening and informative.
- Wide range of people with different areas of expertise was good.
- Should let speakers know you plan to publish proceedings beforehand so a document can be provided at time of workshop.
- I felt it was very informative and produced a good beginning regarding steps to answering some of the unknowns.
- Excellent, great participation and excellent, knowledgeable people for different areas.
- We have laid a lot of groundwork. Follow through will be very important.
- Well organized.
- Excellent presentations.

2.) Were the presentations, breakout sessions and summary session effective/worthwhile?

Yes 51 No _____ Uncertain 1

Comments:

- Our breakout session (wildlife) was one of the best I have attended.
- Presentations were interesting; could not attend day 2.
- Need smaller, more cohesive groups focusing on specifics.
- Should promote healthy interaction among attendees.
- Breakout sessions gave more people an opportunity to speak their views.
- Helps to learn how other states were handling the problems.

- Overlap between groups demonstrated good consensus of issues and understanding in general.
- Breakout session (wildlife/birds) got off track.
- I do not feel that it should have been broken up into groups/disciplines. I feel it would have worked better as a whole group effort.
- Came up with many valuable suggestions.

3.) Which portion(s) of the workshop did you find the most informative and interesting?

Comments:

- Presentations
- All were useful and informative!
- All
- Seeing the updates--hearing the problems, findings in each state were helpful. Chris Brand's overview was also very informative.
- Breakout groups and summary--when bird and fish people summarized their discussions.
- Would recommend that workshop discussions be integrated, not split up. Help to ensure integration of information from different disciplines at all stages of workshop.
- Dr. Brand - excellent!
- Only stayed for first day of presentations.
- The pooling of the different group in order to find the answers to the problems.
- Dr. Brand - very informative, good ideas.
- Speakers.
- Breakout sessions - statistics and anecdotal information.
- Everyone was informative.
- Brand lecture on botulism ecology.
- First day presentations - a lot of knowledge covered.
- National perspective and historical background of avian botulism. Extent of A - C throughout the country.
- All
- National perspective.
- Breakout summarized material and came up with good ideas.
- All
- Day 1 - information exchange.
- Presentations on Wednesday and Thursday morning.
- Breakout sessions and Dr. Christopher Brand.
- Presentations by Fish & Wildlife, health centers and fisheries personnel.
- Presentation by Dr. Brand.
- Dr. Brand's section - workgroups, exchanges and summaries of States/Canada of what is happening.
- Dr. Brand, NWHC, provided a good historical and regional overview. Reports from PA, NY and Canada on the recent outbreak were also valuable.
- Day 1 presentations - excellent background information on botulism cases, mechanisms of transmission, and outbreaks.

- Q&As are always helpful.
- Dr. Brand. Historical incidence of botulism in Great Lakes.
- Chuck Murray's presentation was very good. Chris Brand's presentation on Thursday was very good.
- Background, shared information and networking.
- All equally useful.
- The presentation by Dr. Brand, where outbreaks of botulism have occurred throughout North America.
- Information from Wildlife Health Center, and learning how other states and provinces reacted to outbreak.
- Formal presentations.
- All aspects - defining the fisheries links.
- Presentations by Dr. Brand - historical perspective and general overview of avian botulism.
- Maps presented by several that delineate geography of 1999-2000 Lake Erie outbreak.
- All.
- The outbreak sessions, where brainstorming was encouraged and a variety of ideas were exchanged.
- Both sessions and presentations were valuable.

4.) Was the conference well organized?

Yes 52 No _____ Uncertain _____

Comments:

- Great job!
- Excellent
- Great!
- Very well.
- Nice job Eric and Helen!
- All portions of the agenda were covered.

5.) Were the facilities/food suitable?

Yes 50 No _____ Uncertain 2

Comments:

- Very suitable.
- Need coffee.
- Coffee at break on first day would have been appreciated, particularly as sessions went a bit long.
- Very good, though session room a bit small/tight.
- First class.
- Needed more elbow room - facilities too small.
- Excellent.
- Excellent - thank you!
- Room not large enough for size of group. Excellent hotel and easily accessible.

- Room was a little warm first day and crowded.
- Excellent. Thank you!
- Need a larger conference room with better temperature control.
- Continental breakfast needed more variety with cereals, pastry, milk!
- Larger room.
- A little cramped in session room.
- Thanks for picking up the three meals.
- Room could be a little larger, but excellent food, services, accommodations.
- Excellent, extraordinary.
- Needed a little more comfortable meeting room (heat, crowding); screen for projection inadequate.
- Room too warm and crowded, I like space. Breakout sessions should have been in separate rooms, as too much noise was present in the main presentation room for two sessions.
- No decaf coffee. No coffee break except at dinner.

6.) Would you be interested in attending a follow-up workshop on this topic in the future?

Yes 48 No _____ Uncertain 4

Comments:

- Please plan another!
- I would like to thank you for inviting me to this workshop. It was very informative and gave me an opportunity to hear first hand about the problem here. Please include me in future meetings.
- I plan to continue on researching the botulism outbreak and I would like to share my finding and learn other findings.
- My state, Ohio, has not been directly affected by Type E botulism, so I doubt if I could get authorization to attend another workshop.
- Idea to go to Canada, Wisconsin or other location to see new turf.
- I would be disappointed if no follow-up workshops were arranged.
- Or would send another delegate, as appropriate.
- I think it is important to meet again.

7.) Please provide any additional suggestions or topic areas that may prove beneficial to organizers and researchers involved with this project?

- Just be sure to emphasize to all to keep the lines of communication open and to keep everyone informed. Should someone from the Great Lakes Commission - policy maker be invited and be more involved with the work?
- The Waterbird Society (formally the Colonial Waterbird Society) will be holding their Annual Conference in Niagara Falls, Ontario, 7-11 November 2001. We could have at least a presentation - perhaps a session on this topic. Ideally perhaps 3-4-5 papers/presentations. I'm one of the conference organizers and would be glad to discuss with Sea Grant officials to see what we can do.--Chip Weselob, 416-739-5846.

- Consider global perspective-are other areas (e.g. Ponto-Caspian) experiencing similar outbreaks? Focus on other large, freshwater lake ecosystems with exotic species introductions to use for comparison with situation in Lake Erie and other Great Lakes. Perhaps this is a global issue of significance?
- Funding for more work - sources.
- More Human Health representation, Water Quality.
- Environmental Parameters - how do current conditions compare with the Michigan outbreaks in the 1960s through 1980s?
- Can't think of any, you all did a very thorough job!
- Joint publication of records of "type E" events - multidisciplinary analysis very N.B. We have data in hand. Joint/collaborative research planning/proposals.
- Incorporate a network and data system which all states and agencies can exchange information.
- Explain objective and what is the expected follow-up on the discussions more fully.
- A secretary (note taker) may have been helpful. Speaker notes/handouts could help.
- Good chance to develop dialogue and share information.