Type E Botulism Outbreaks: A Manual for Beach Managers and the Public

NPS Photo - Alice Van Zoeren

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U.S. Environmental Protection Agency
Great Lakes National Program Office (GLNPO)

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Great Lakes Sea Grant Network
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U.S. Department of Health & Human Services
- U.S. Food and Drug Administration

U.S. Geological Survey
- National Wildlife Health Center

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Contact List

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U.S. Fish and Wildlife Service (FWS)	Liaison to U.S. EPA GLNPO	(312) 886-1474	mcgovern.amy@epa.gov	--
U.S. FWS	Piping Plover Coordinator for Great Lakes	(517) 351-6320	vincent_cavalieri@fws.gov	www.fws.gov/midwest/endangered/pipingplover/pipingpl.html
U.S. Geological Survey's National Wildlife Health Center	Wildlife Disease Specialist	(608) 270-2491	clwhite@usgs.gov	www.nwhc.usgs.gov www.nwhc.usgs.gov/AMBLE

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Illinois-Indiana Sea Grant	Liaison to U.S. EPA GLNPO	(312) 886-6224	tepas.kristin@epa.gov	*www.iiseagrant.org*
Indiana Department of Environmental Management	Environmental Manager	(219) 757-0277	dbarnett@idem.in.gov	*www.in.gov/idem/*
Michigan Department of Natural Resources	Wildlife Disease Laboratory	(517) 336-5034	CooleyT2@michigan.gov	*www.michigandnr.com/diseasedwildlifereporting/disease_obsreport.asp*
Michigan Sea Grant	Extension Educator	(231) 922-4628	breeder@msu.edu	*www.miseagrant.umich.edu/explore/coastal-habitat/avian-botulism.html*
Minnesota Sea Grant	Aquatic Invasive Species Coordinator	(218) 726-8712	djensen1@umn.edu	*www.seagrant.umn.edu*
New York Department of Environmental Conservation	Fish and Wildlife Director	(518) 402-8924	fwfish@gw.dec.state.ny.us	*www.dec.ny.gov/animals/28433.html*
New York Sea Grant	Senior Extension Specialist	(716) 645-3610	hmd4@cornell.edu	*www.seagrant.sunysb.edu/articles/t/bringing-science-to-the-shore-since-1971*
Ohio Department of Natural Resources (ODNR)	Wildlife Program Administrator	(614) 265-6329	Carolyn.caldwell@dnr.state.oh.us	*www.dnr.state.oh.us*
	Wildlife Biologist	(419) 898-0960	dave.sherman@dnr.state.oh.us	*www.dnr.state.oh.us*
Ohio Sea Grant	Extension Specialist	(440) 350-2582	lichtkoppler.1@osu.edu	*ohioseagrant.osu.edu/outreach/extension*
Ontario Ministry of Natural Resources	Wildlife Policy Advisor	(705) 755-1573	john.dungavell@ontario.ca	*www.mnr.gov.on.ca/en*
Canadian Cooperative Wildlife Health Centre, Ontario	Botulism Reporting Hotline	(866) 673-4781	ccwhc@uoguelph.ca	*www.ccwhc.ca/*
Bird Studies Canada, Ontario	Program Manager	(888) 448-2473	--	*www.bsc-eoc.org/about/index.jsp?lang=EN&targetpg=contact*
Pennsylvania Department of Conservation and Natural Resources	Conservation and Resource Helpline	(800) 326-7734	--	*fishandboat.com/images/pages/qa/fishing/avian_botulism.htm*
Pennsylvania Sea Grant	Associate Director	(814) 217-9018	eco1@psu.edu	*seagrant.psu.edu/extension/ab.htm*
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Northern Lake Michigan Botulism Network – County Contacts				
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Antrim County		(231) 676-0566	whitepine@torch.lake.com	--
Alpena, Charlevoix, Cheboygan, Emmett, and Presque Isle Counties		(231) 347-1181 x 109	kevin@watershedcouncil.org	--
Delta, Mackinac, Menominee, and Schoolcraft Counties		(906) 487-9060	commoncoast@gmail.com	--
Grand Traverse County		(231) 935-1514	baykeeper@gtbay.org	*www.gtbay.org/our-programs/beach-rangers*
Leelanau-Sleeping Bear Dunes National Lakeshore		(231) 326-5134	Sue_Jennings@nps.gov	--
Pennsylvania Bird Carcass Incineration Program	Presque Isle State Park Manager	(814) 833-7424	hleslie@state.pa.us	--

Introduction

The Great Lakes basin has undergone a resurgence of Type E botulism (often referred to as avian botulism) in recent years, characterized by dead birds and fish along the shores of the Great Lakes. The number of deaths and areas affected appear to be increasing to levels that induce concern about the ecological health of the Great Lakes nearshore waters.

The *Type E Botulism Outbreaks: A Manual for Beach Managers and the Public* (manual) has been prepared by the Great Lakes Regional Collaboration (GLRC): Great Lakes Type E botulism Coordination and Response Initiative, to generate awareness and provide information regarding Type E botulism and how to control its spread throughout the region.

This manual is intended to provide both beach managers and the general public with guidance on Type E botulism and to provide sources of additional information. While several different strains of bacteria cause botulism, the type E strain is responsible for most of the botulism outbreaks currently affecting fish and birds in the Great Lakes, and is therefore the focus of this manual. However, some of the information contained herein does relate to the type C strain as well (also referred to as avian botulism). The content in this manual is from several federal, state, and other resources.

The following topics regarding Type E botulism are included as part of this manual:

- Background: biology, occurrence, and transmission throughout the Great Lakes region,
- Outbreak prevention,
- Human and pet health protection, and
- Frequently Asked Questions (FAQ).

The Great Lakes Botulism Coordination Network (BotNet) is a Great Lakes basinwide workgroup established to apprise its members of botulism-related breaking news, research developments, coordinated management efforts, requests for proposal announcements, and new publications. For more information, or if you wish to join BotNet, please contact: Laura Evans, U.S. EPA GLNPO, phone: 312-886-0851, e-mail: evans.laura@epa.gov OR visit *www.glrc.us/initiatives/botulism/index.html.*

Background

Botulism is a disease caused by several different strains of the bacterium *Clostridium botulinum*, which produces a toxin that acts on the neuromuscular system of animals and humans. The disease is characterized by paralysis leading to progressive muscle weakness and eventually respiratory arrest if left untreated. Several distinct strains have been identified and types C and E, in particular, are known to affect birds and fish.

The type E strain is responsible for most of the botulism outbreaks currently affecting fish and large numbers of birds in the Great Lakes. However, the type C strain has been linked to mortalities within marshes and wetlands. Dormant spores of this bacterium are native to the region and are naturally abundant in soils and sediments, but are not always in the vegetative state capable of producing the botulism toxin. These spores are not only found in the sediments of the Great Lakes, but can also be found in the intestinal tracts of live, healthy animals. The spores are resistant to extreme temperatures and desiccation, and are therefore capable of remaining in the ecosystem for long periods of time (Domske 2003).

The botulism toxin is produced only when spores germinate and the bacterium enters the vegetative growth stage. This change occurs in oxygen-deprived environments containing a suitable nutrient source (such as in areas with decaying plant material), and favorable temperatures and pH levels (Brand et al. 1988). Once these factors lead to production of the toxin, it can enter the food chain.

Animals, especially fish-eating birds, can contract botulism when they prey on other animals that harbor the toxin (CCWHC 2007). Effects of toxin poisoning include paralysis, which often leads to death. Death can also result from water deprivation, electrolyte imbalance, respiratory failure, or predation. Removal of dead birds (potential vectors) is important in dealing with a botulism outbreak.

Opportunity for rehabilitation of sick birds is limited due to the large geographic areas involved, but it may be possible when (1) the birds do not ingest an acute dose of the toxin and (2) electrolytes are administered immediately; however, even under these circumstances, rehabilitation is frequently unsuccessful (USGS-NWHC 2006).

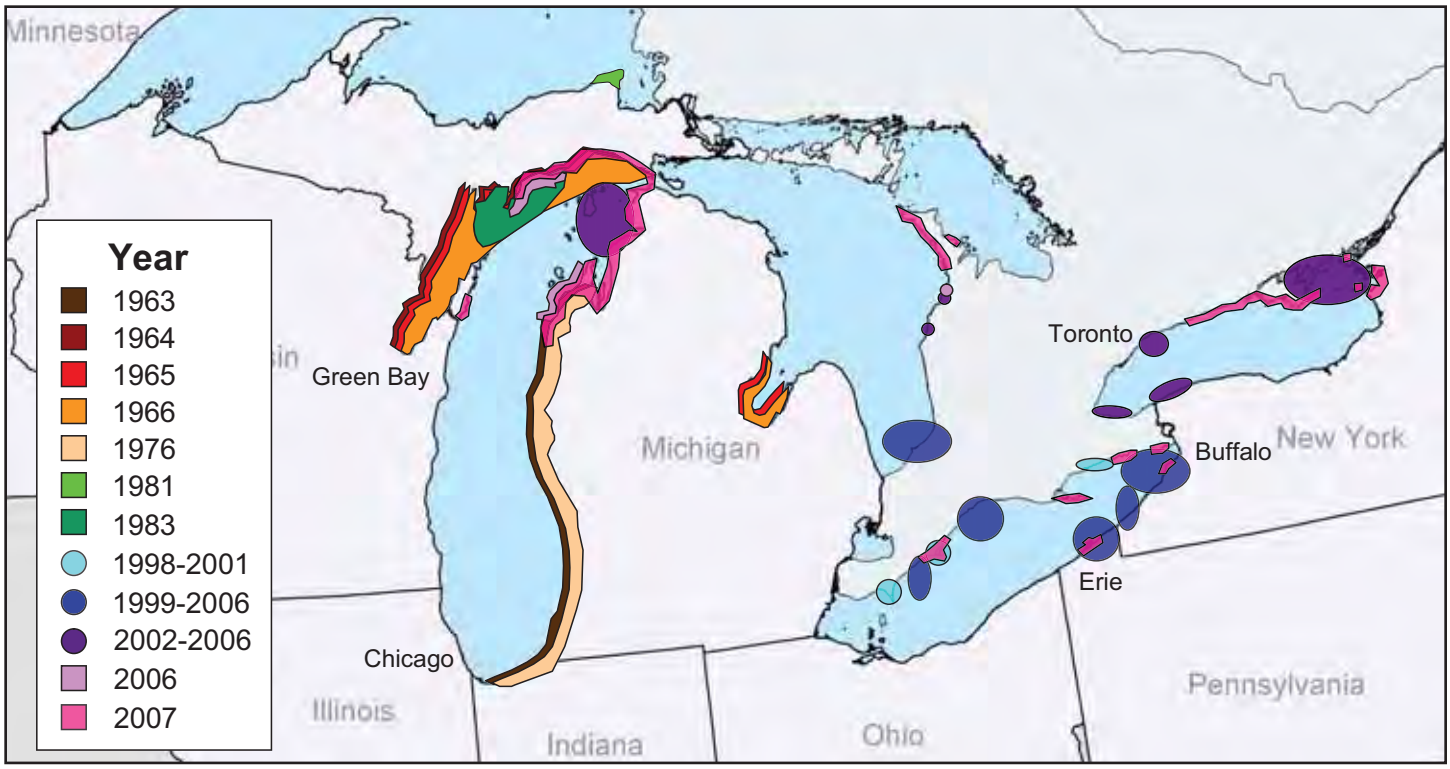


Figure 1. Historic botulism outbreaks (Zuccarino-Crowe 2009)

Occurrence of Type E Botulism

The frequency and severity of Type E botulism outbreaks have gone through cycles over the last several decades (see Figure 1). Outbreaks have been documented in the Great Lakes region as far back as 1963 (Kaufmann and Fay 1964), and annual die-offs of birds and fish on the shores of Lake Huron began again in 1998, along Lake Erie in 1999, and along Lake Ontario in 2002 (CCWHC 2007). Recent increases and expansion of affected areas and species, however, have led to concern for the ecological health of the nearshore waters.

Over the past few years, botulism outbreaks have been particularly severe in Lake Michigan. Sleeping Bear Dunes National Lakeshore underwent an extensive botulism-related waterbird die-off in 2006 that killed nearly 3,000 birds (Michigan Sea Grant 2007). In 2007, the Lake Michigan die-off impacted a much larger geographical area from Ludington State Park north, including most of the Michigan beaches in the Upper Peninsula. The total estimates for that year reached 17,125 avian mortalities for the entire Great Lakes region. Figure 2 shows the estimated avian mortalities attributed to Type E botulism from data obtained from the National Wildlife Health Center and the Eastern Lake Ontario Colonial Waterbird Survey.

According to estimates compiled from the U.S. Geological Survey (USGS) National Wildlife Health Center's databases, a total of approximately 96,900 avian mortalities were attributed to Type E botulism from 1963 through 2007 in the Great Lakes (USGS-NWHC 2008), although the actual number of deaths is likely much higher due to inconsistencies in monitoring and reporting. These outbreaks involved a variety of species, including those of special interest such as loons and endangered piping plovers. The mortalities of recent years could decrease population levels and should be an important focus for future monitoring efforts. Figure 3 describes the birds generally affected by Type E botulism.

Importantly, historical botulism mortality data vary widely, and the numbers may be underestimated if dead birds or fish with botulism are not found and/or reported to authorities. The mortality estimates in this report are not presented as actual counts, but should serve to highlight the overall magnitude of potential effects from botulism.

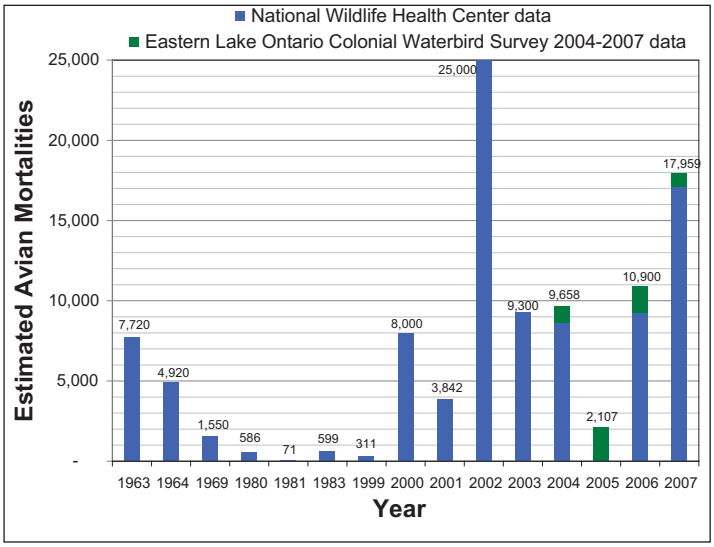


Figure 2. Estimated avian mortalities attributed to Type E botulism (Zuccarino-Crowe 2009)

Disease Transmission

There are a few potential pathways for botulism transmission. The carcass-maggot cycle is one possible route (see Figure 4). Dead fish and birds that wash up on the beach can become sources for *C. botulinum* growth, and shorebirds may ingest the toxins as they feed on maggots and carrion beetles within the decaying carcasses. Several thousand toxic maggots can be produced from a single waterfowl carcass. At least for Type C, consumption of as few as two to four toxic maggots can kill a bird and further perpetuate the cycle. Waterfowl and other birds are known to feed on maggots, which is consistent with common observations of recently dead birds very close to an older carcass full of maggots.

Invasive species may also play a key role in the transmission of botulism. Current hypotheses under study are whether invasive quagga mussel beds may create additional habitat for *C. botulinum* and accumulate the toxin. The mussels may then facilitate the transport of the toxin up the food chain as they are consumed by fish, especially by the invasive round goby which feeds heavily on Dreissenid mussels (Getchell and Bowser 2006). The gobies and native forage fish, after ingesting toxin-laden food, are in turn consumed by larger predatory fish and fish-eating water birds. Obvious signs of such a nearshore outbreak are numerous stretches of beach with dead and dying birds and fish strewn along the water's edge.

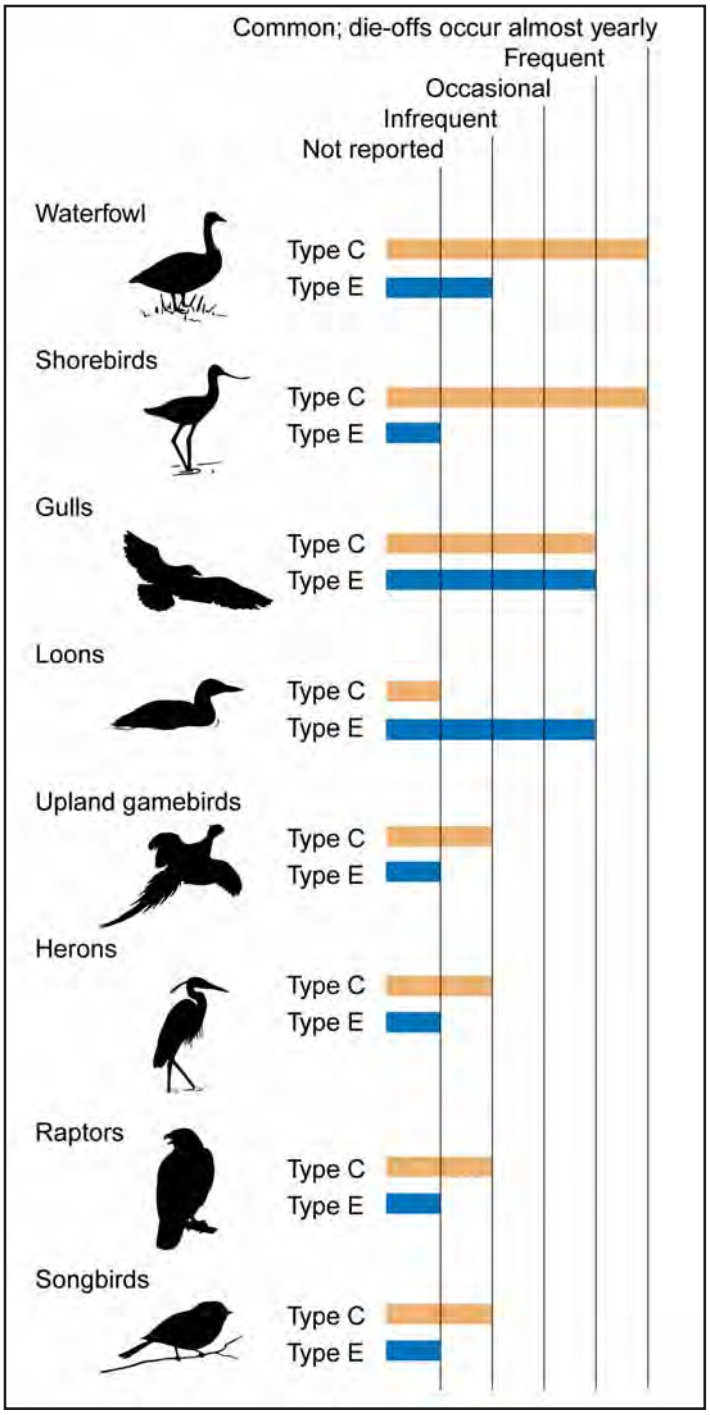


Figure 3. Frequency of botulism in major groups of wild birds (USGS 1999)

Dreissenid mussels are implicated in another transmission route as well. The prolific growth of the native *Cladophora* algae (see Figure 5) is believed to occur because of increased water clarity and sunlight penetration due to the invasive Dreissenid mussels' water filtration capabilities. This prolific growth likely contributes to a botulism outbreak because

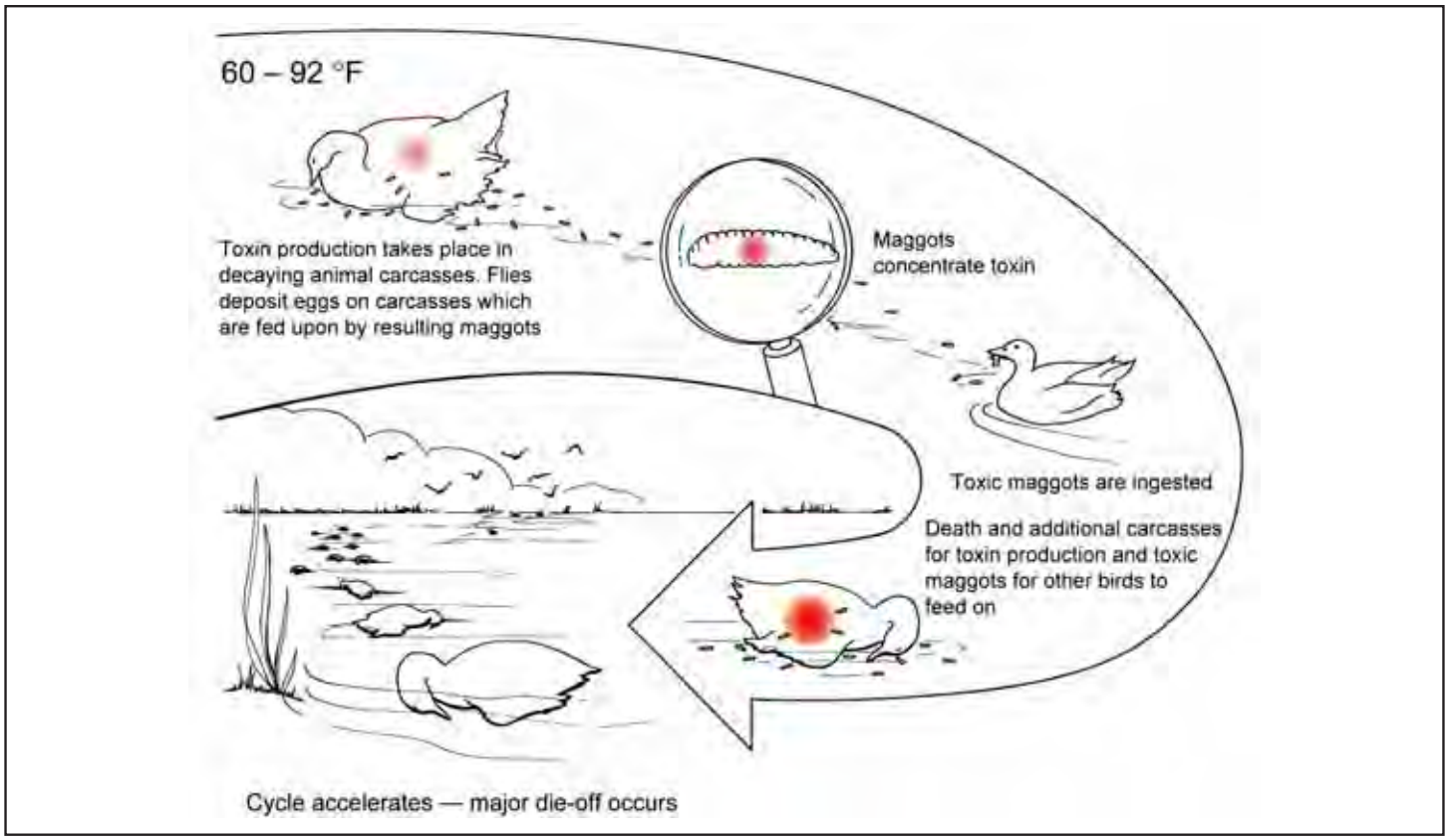


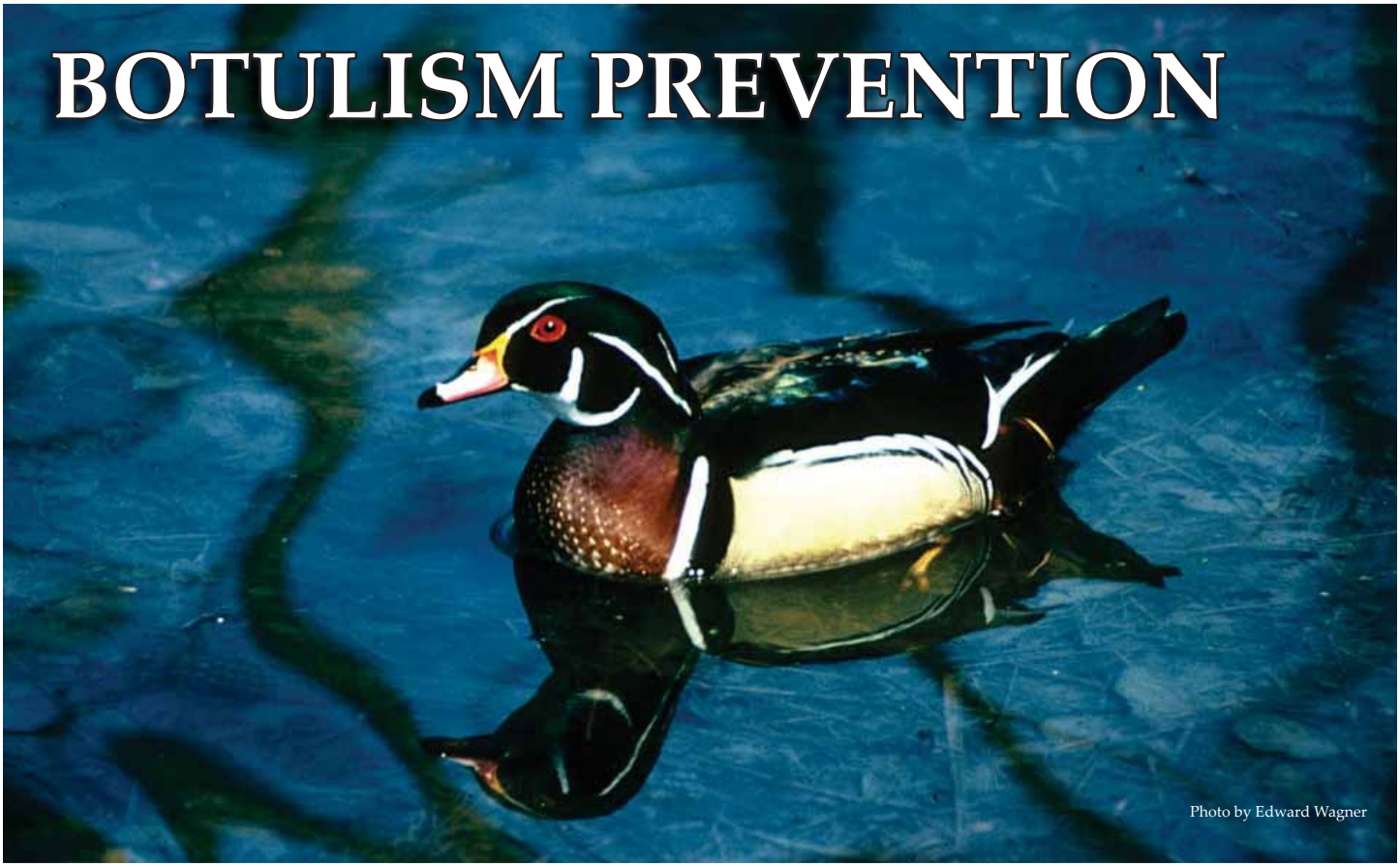
Figure 4. Carcass-maggot cycle of avian botulism (USGS 1999)

Figure 5. ***Cladophora*** **mats on underwater rocks. Inset: a single** ***cladophora*** **plant**

the decaying large mats of sloughed algae in the nearshore area may lead to pockets with low oxygen and a rich growth medium. This creates an ideal environment for the vegetative state of *C. botulinum* and resultant toxin production (Hecky et al. 2004). Additionally, other pressures linked to the growth of *Cladophora*, such as nearshore nutrient levels, may influence botulism outbreaks.

Despite evidence that the suspected current ecological pathway of botulism is closely related to impacts from a host of invasive species, the exact mechanism that transports it through the food chain has not been scientifically documented; nor were the causes of past historical botulism outbreaks in the 1960s (possibly linked with alewife die-offs, [Fay 1966]) fully understood.

BOTULISM PREVENTION



Although we don't know all the environmental triggers that cause *C. botulinum* to start producing toxin, we do know that if mortalities are detected early enough, certain management techniques, if implemented quickly, could possibly stop and/or mitigate the magnitude of waterfowl mortality. These measures include monitoring, detection, removal, carcass handling and disposal, carcass reporting, wetland management, bird rehabilitation, and bird hazing, as discussed below.

Monitoring

Monitoring and surveillance of areas can often be the first line of defense against botulism outbreaks because many outbreaks can occur in the same areas year after year. Outbreaks also often follow a fairly consistent and predictable time frame. These conditions have direct management implications that should be applied toward minimizing losses. Specific actions that should be taken include accurately documenting conditions and dates of outbreaks in problem areas, planning for and implementing intensified surveillance, and then choosing the best management options during the botulism "season." Surveillance and carcass pickup should be implemented 10-15 days prior to the earliest documented case of the season in a known botulism area, and 10-15 days after the end of the botulism season in a known area.

Detection

Outbreaks generally occur from June through November. Thousands of birds may die during a single outbreak. No lesions are specifically associated with this disease; however, some visual signs of botulism infection are typically evident.

Affected birds often have trouble holding up their heads, a condition known as "limber neck," which can lead to drowning. They may also exhibit an inability to fly or walk, or may appear emaciated if they have been poisoned over an extended period of time. Birds that have lost the power of flight and use of their legs often attempt escape by propelling themselves across the water as shown in Figure 6. Another common sign in botulism-intoxicated birds is paralysis of the inner eyelid, as shown in Figure 7. Dead birds often appear in good body condition because botulism toxin generally

Figure 6. Duck unable to fly uses legs to escape

Figure 7. Duck showing signs of inner eye paralysis

kills rapidly after intoxication. Affected fish lose their equilibrium and may be found floating or swimming erratically near the surface. This behavior may actually attract birds to prey upon these fish, further spreading botulism.

Diagnosis of botulism requires animal testing and is based on evidence of the toxin in the blood serum or in tissue samples of dead birds, such as from the heart or liver. The heart from a carcass suspected of botulism intoxication is preferred for testing because this organ contains a significant amount of blood, which is where the toxin is found.

Removal

Prompt removal and proper disposal of fish and bird carcasses by burial or burning (in accordance with applicable ordinances) is highly effective in removing toxin and maggot sources from the environment. *C. botulinum* needs protein to produce the botulism toxin; removal and disposal of animal carcasses removes this protein source and thus reduces the resources the bacterium needs to produce the toxin and further the spread of the disease. Because sick birds (with botulism) often hide in vegetation, thorough carcass retrieval is critical. A single carcass left in the water or on the beach could prolong an outbreak.

Carcass Handling and Disposal

Each state may have varying procedures for proper disposal of bird or fish carcasses suspected of having botulism. Contact the proper authorities immediately upon discovery of a carcass for further direction. A contact list is included with this document. The following tips are suggested for handling bird* or fish carcasses:

- Discovered carcasses should not be handled with bare hands. Wear rubber, plastic or disposable gloves or a use a garbage bag over your hands. Wash hands after handling.
- Carcasses should be placed in garbage bags (double bagging may be required).
- Once you finish handling carcasses, dispose of your gloves in a garbage bag and place them in the trash.
- If you are burying the carcasses, do so away from the shoreline, remove them from the garbage bag(s), and bury them at least 2 feet deep. Burying them to this depth will discourage other animals from unearthing them. Do not compost carcasses.

**Inspect carcasses for leg bands and other devices (e.g., geolocator tags and radiotransmitters) and report marked birds to U.S. Geological Survey Bird Banding Laboratory (www.reportband.gov).*

Cleanup kits can be created with the following items:

- Plastic garbage bags
- Latex gloves
- Duct tape
- Paper and pencil to report—what died, how many, where, and when
- List of contacts for carcass reporting

Carcass Reporting

Persons that encounter a live animal suspected of botulism intoxication or a dead fish or bird should immediately contact their State Department of Natural Resources or Environment. A complete contact list is provided as part of this manual.

Wetland Management

Draining or flooding wetland areas where a botulism outbreak has occurred can change the environmental conditions sufficiently so as to stop production of toxin by *C. botulinum*. However, use caution when employing this method, and avoid altering water depth during hot weather. This may increase invertebrate and fish die-offs, providing another protein source for the bacteria and prolonging an outbreak.

Bird Rehabilitation

Providing mildly affected birds with fresh water, shade, and protection from predators may help them recover from the intoxication. Under special circumstances, such as for the treatment of endangered birds, a botulism antitoxin may be available, but its use requires veterinary training and must be administered soon after intoxication. Birds that survive a botulism outbreak are not immune to the botulism toxin during subsequent outbreaks.

Bird Hazing

If other management techniques fail, hazing birds away from a hot spot until toxin production stops may be an option. This action should be taken in consultation with the U.S. Fish and Wildlife Service (FWS) to avoid violation of the Endangered Species Act if endangered birds are known to be present in the area. In some areas, wetland impoundments can be constructed to facilitate rapid and complete drainage to encourage bird movement to alternate areas.

Summary

The numerous fish and wildlife mortalities caused by botulism across a widening geographic region are a continuing cause for concern and highlight the need for botulism management. Botulism is affecting native and sensitive wildlife populations, and it has implications for the overall ecological health of the Great Lakes. It may also impact tourism and the enjoyment of the many visitors to local beaches. Taking action to prevent botulism outbreak is an important way to reduce these impacts.

Photo by Dave Menke

Human and Pet Health

Photo by Wikimedia Commons user Sharingknowledge

Botulism in humans is usually the result of eating improperly home-canned foods and is most often caused by Type A or Type B botulinum toxin. Type E botulinum toxin poisoning cases in humans are extremely rare; the only documented cases originating in the Great Lakes region resulted from consumption of cold-smoked, vacuum-packed fish during the 1960s.

Recent laboratory-based studies investigating botulism's effects on fish and resulting toxin levels in their organs and tissues have further supported the assumption that Type E botulism associated with Great Lakes wildlife poses minimal human health risks (Yule et al. 2006). However, additional laboratory and field research and definitive government health agency statements regarding consumption of sport fish and waterfowl during an outbreak would help ensure delivery of a cohesive message to the general public about their safety.

Most available safety-related information includes general food handling and preparation guidelines by state agencies or refers to cases in which specific fish curing and preparation methods led to production of the toxin under conditions of non-environmental outbreak.

Botulinum toxins can be inactivated by heat during cooking, if cooked at the right temperature and for the right amount of time. Thus, using common safety precautions when handling fish or waterfowl and following correct food preparation guidelines will help ensure maximum protection from the toxin.

Consider the following general precautions to protect human and pet health:

- Do not handle dead fish or birds with your bare hands.
- Beware of fish that are floating—if they are not fighting, they are likely not healthy and should not be consumed.
- Do not eat undercooked or improperly prepared fish or waterfowl.
- Hunters should never harvest birds that appear to be sick or are dying.
- Do not let your pets eat dead fish or birds.

Suggested Cooking Temperatures

Currently, the federal government does not provide any cooking temperature advice for fish or waterfowl. Most states that provide advice note that cooking may not destroy the Type E botulism toxin, if not cooked at the proper temperature and length of time. Therefore, if a species is demonstrating symptoms or is thought to have died of Type E botulism, it should not be consumed. Table 2 lists cooking temperatures for waterfowl and/or fish recommended by various states and federal agencies.

Table 2. Agency-Recommended Cooking Temperatures for Waterfowl and/or Fish

State	Temperature	Comments	Reference
Illinois	Not available	No existing information for this state	-----
Indiana	Not available	No existing information for this state	-----
Pennsylvania	180 °F	At least this temperature to destroy the toxin	*www.pserie.psu.edu/seagrant/publications/fs/Botulism_12-2003.pdf*
Ohio	Not available	No existing information for this state	-----
New York	140 °F (fish), 165 °F (birds)	Cooking may not destroy Type E botulism toxin	*www.dec.ny.gov/animals/28433.html*
Minnesota	Not available	If suspicious or dead, do not eat it	Minnesota Department of Public Health
Michigan	165 °F	Cooking may not destroy Type E botulism toxin	*www.miseagrant.umich.edu/news/2008/10-handling-birds-avian-botulism.html*
Wisconsin	Not available	WI DNR website provides an external link to a Michigan webpage with cooking temperature advice.	-----
USDA's Food Safety and Inspection Service (FSIS)	Not available	FSIS does not have any "recommended cooking temperatures for...birds exposed to botulism". FSIS recommends that no one eat anything that is questionable as a food source.	Kristin G. Holt, DVM, MPH U.S. Dept. of Health and Human Services Food and Drug Administration, FSIS Liason to CDC 404-639-3379 kristin.holt@fsis.usda.gov
*U.S. Food and Drug Administration /Center for Food Safety and Applied Nutrition	-----	Do not eat foods at risk	Dr. Morris Potter Lead Scientist for Epidemiology U.S. Dept. of Health and Human Services Food and Drug Administration 404-253-1225 morris.potter@fda.hhs.gov

* Notes:

Dr. Donald Zink (Senior Science Advisor for U.S. Dept. of Health and Human Services) had this to say: "The vegetative cells are killed by the same cooking procedures that are effective against other vegetative bacterial pathogens such as Salmonella. The spores can be killed (6 log reduction) by heating for 6 minutes at 195 °F. This heat treatment will also completely inactivate any pre-formed toxin. As a practical matter, boiling is probably the best way for a consumer to cook foods that are at risk."

°F Degrees Fahrenheit
USDA United States Department of Agriculture
FSIS Food Safety and Inspection Service
WI DNR Wisconsin Department of Natural Resources

Frequently Asked Questions (FAQ)


Photo by Donna Dewhurst

This information was compiled by the Great Lakes Sea Grant Network and U.S. EPA GLNPO to answer questions that arise when a botulism outbreak occurs in a specific area of the Great Lakes, and to explain the associated ecological implications. Recent botulism outbreaks have primarily impacted bird populations, although some species of bottom-dwelling fish have suffered localized die-offs.

The threat to human health is minimal, and the only documented cases of human sickness resulting from Type E botulism were caused by consumption of cold-smoked, vacuum-packed fish during the 1960s. This information is provided so that hunters, recreational anglers, coastal residents, and interested citizens can take simple, common sense precautions to reduce or eliminate any risk from handling or consuming waterfowl or fish that have been exposed to botulism toxin.

General Botulism Information

What is botulism?

Botulism is a serious neuromuscular illness caused by a toxin that is produced by the bacterium *Clostridium botulinum*. Avian botulism has been recognized as a major cause of mortality in migratory birds since the 1900s. Human botulism is typically caused by eating improperly canned or stored foods. The bacterium is classified into seven types (A-G) by characteristics of the neurotoxins that are produced. Four of these types (A, B, E, and rarely F) cause human botulism, while types C, D, and E cause illness in mammals, birds, and fish. All types of botulism may cause paralysis to some degree, due to the nature of the neurotoxins produced by the bacteria. The following are the four most common types of botulism:

- Type A or Type B botulism is most commonly caused by consumption of bacteria in improperly home-canned foods. Diluted and purified forms of the type A and B toxins are also used in certain facial aesthetic products.

- Type C and Type E botulism are responsible for extensive waterfowl and some fish kills. They are both brought on by consumption of these particular types of the botulinum toxin through food-web interactions. Type C botulism mostly impacts waterfowl (especially ducks) and is typically restricted to marshes and wetlands in prairie regions, primarily west of the Mississippi River. Type E botulism is more prevalent in the Great Lakes, but has also been documented in California.

What species are affected by Type E botulism? Type C botulism?

A large number of bird and fish species are susceptible to the Type E botulinum toxin, as are some amphibians, like mudpuppies, and most mammals. A few cases of Type E botulism in humans have been reported in North America and were the result of eating improperly smoked or cooked fish, but these types of cases in humans are rare.

Loons, mergansers, long tail ducks, grebes, scaup, cormorants, and gulls in particular are the bird species affected by Type E botulism. Commonly affected fish species include freshwater drum (sheepshead), smallmouth bass, rock bass, stonecats, round gobies, channel catfish and sturgeon (Pennsylvania Sea Grant and Penn State Erie, 2003).

Type C botulism outbreaks on prairie wetlands have mainly affected ducks, coots, grebes, gulls, and other shorebirds (Leighton 2000).

Is Type E botulism responsible for the recent bird and fish kills?

Yes. Pathology conducted on victims of the recent die-offs points to Type E botulism as the cause. Type E botulism is contracted by ingesting invertebrates, fish, or birds contaminated with the botulinum toxin.

Where does botulism come from?

Botulism spores (the resting stage of the bacteria) are abundant in anaerobic habitats (lacking oxygen), such as soils, and aquatic sediments of many lakes, and can be readily found in the gills and digestive tracts of fish living in those lakes. The spores can remain in the ecosystem for extended periods of time, even years, and are quite resistant to temperature changes and drying. These spores, themselves, are harmless until the correct environmental factors and anaerobic conditions prompt them to germinate and begin vegetative growth of the toxin-producing bacterial cells (Leighton 2000).

The active bacteria that cause botulism grow only in a nutrient-rich substrate, such as areas with large amounts of decaying plant growth, which are anaerobic. Fish that die for any reason and that contain the bacterial spores in their tissues are also suitable substrates for growth and toxin production by the bacteria (Leighton 2000).

How do birds end up dying as a result of the botulism toxin?

Fish-eating birds that die of Type E botulism are poisoned by eating fish that contain the toxin. However, it is not clear exactly how this happens. Birds such as loons and mergansers normally capture and eat only live fish. Yet, *Clostridium botulinum* Type E should not grow and produce the actual toxin in living fish (Leighton 2000). (See also: *Where does botulism come from?*).

Possibly, circumstances can cause toxin production in the tissues and digestive tracts of live, perhaps dying, fish. Alternatively, it may be that the fish captured alive and eaten by the birds had themselves fed on a source of Type E toxin. In these cases, the toxin in the digestive tracts of the live fish would be the source of toxin for the birds (Leighton 2000).

It is also possible that the live fish captured by the birds already were partially paralyzed by the Type E toxin and were therefore particularly easy prey for the birds. This might account for preferential feeding on toxin-containing fish by the affected birds (Leighton 2000).

Scientists also think that ingestion of maggots from the carcass of an infected animal can continue the spread of botulism, which may be responsible for large kills of shorebirds.

Why are we so concerned about avian botulism outbreaks?

Natural resource managers, environmental organizations, and others are concerned about

the thousands of migrating birds that have died, including loons and other species. According to estimates compiled from the USGS National Wildlife Health Center's databases, about 52,140 avian deaths on the Great Lakes were attributed to Type E botulism from 2002 to 2006 (USGS - National Wildlife Health Center, 2007). Recent reports from the Sleeping Bear Dunes National Lakeshore also estimate that an additional 3,000 avian botulism-related mortalities occurred in 2006 on Lake Michigan (Michigan Sea Grant 2009). Some fish species, such as Lake Sturgeon, that have been listed as threatened, endangered or of special concern are also now at an increased risk because of botulism. Additionally, dead wildlife may contain toxin levels that could harm other animals, including pets.

Has botulism always been in the Great Lakes?

While botulism has been around for a long time, records of it did not appear on the Great Lakes until recently. Type C botulism was first identified in the Great Lakes in 1936 on Lake Michigan (Michigan Department of Natural Resources, 2011a), and Type E botulism in the Great Lakes was first documented on Lake Michigan in 1964 regarding a 1963 outbreak (Kaufmann and Fay, 1964). Since 1999, significant die-offs of birds and fish have occurred regularly in Lake Erie and Lake Ontario, with estimated avian mortalities coming to about 61,630 Type E botulism-attributed deaths for 1999 through 2006 (USGS - National Wildlife Health Center 2007).

Different types of avian botulism have had destructive effects on birds throughout the U.S. for a considerable time, and probably predate written records. One of the earliest major reported die-offs of a large number of waterfowl was encountered in the Great Salt Lake area of the United States in the early 1900s. Because early observations occurred on alkaline lakes in areas of western North America, the phenomenon was suspected of being a form of alkali poisoning and became known as Western Duck Sickness. Not until a quarter of a century later was the cause of these die-offs determined to be Type C botulism poisoning (Canadian Cooperative Wildlife Health Centre 2000).

Why are botulism outbreaks occurring now?

Scientists believe that outbreaks of Type E botulism happen only when a variety of particular ecological factors occur concurrently, such as warmer water temperatures, anoxic (oxygen-deprived) conditions, and adequate levels of bacterial substrate. As average air and water temperatures have risen on a global scale, warmer temperatures and anoxic conditions have been occurring more frequently on the Great Lakes, possibly resulting in the increase of avian botulism (Lafrancois et al. 2010). Once these factors lead to production of the toxin in food material eaten by fish, the toxin can be passed up the food chain as birds consume the infected fish or eat maggots from the decaying carcasses of infected individuals (Leighton 2000).

Invasive species may also play a role. Current hypotheses under study are whether zebra and quagga mussel beds may create additional habitat for the bacterium that causes botulism. Many scientists believe that quagga mussels also can filter the bacteria and pass it up the food chain when the quagga mussels are eaten by fish such as the round goby.

Invasive mussels may also be responsible for the increase in growth of the algae *Cladophora* (a species also potentially tied to botulism outbreaks). The mussels filter the water which makes it clearer, therefore prompting increased algal growth. This increase in algal growth and the subsequent decay of the algae can increase oxygen demand in the ecosystem, leading to possible oxygen-deprived conditions necessary for botulism toxin production.

Is there a link between botulism outbreaks and fluctuating water levels?

There is some evidence that outbreaks correspond to low water level events. Historically, larger bird die-offs as a result of Type E botulism have occurred during periods of low or rapidly declining water levels, and water level fluctuations and drawdown events in wetlands have also correlated with Type C botulism outbreaks. Research into the mechanism behind this possible link is required, but the mechanism likely is related to warmer water and sediment temperatures during low water events.

What are some symptoms that an animal with botulism may display?

As Type E botulism results in paralysis, infected species begin to exhibit unusual behavior. Water birds may not be able to hold their head up and as a result, often drown. Gulls can often walk, but not fly. Other birds may drag one or both wings (poor posture) while standing.

Once infected with Type E botulism, fish may flounder or swim erratically near the surface of the water. Their equilibrium may be affected, and they may have trouble staying right-side up. "Breaching" may also occur, during which a fish will float with its head near the surface and tail end lowered below. Infected fish usually die quickly and are most likely to be seen washed up on shore (New York State Department of Environmental Conservation, no date).

Note: ANY fish or waterfowl that seem sick should not be harvested or eaten.

Why is it difficult for scientists to positively determine if birds died from Type E botulism?

Both Type C and Type E botulism, as well as a few other types of poisoning, can produce similar symptoms in affected wildlife. Definitive diagnosis of Type E botulism requires that the Type E botulinum toxin be found in the blood of a live, sick bird. Although finding the toxin in a recently dead bird may be evidence that the bird died of botulism, it is also possible that the toxin detected was produced after death, during putrefaction, and may not have been the cause of the bird's death (Leighton, 2000).

Do the recent algal blooms of the macro algae *Cladophora* play any role in the botulism outbreaks?

The recent increases in the growth of *Cladophora* ultimately result in increased decaying plant matter in some areas of the Great Lakes. This decomposition can create an oxygen-deprived environment suitable to the bacterium that produces the Type E botulism toxin. (See also: *Why are botulism outbreaks occurring now?*)

Are inland lakes susceptible to Type E botulism outbreaks?

The Michigan Department of Natural Resources has cited rare reports of Type E botulism on the state's inland lakes. Scientists believe that the threat of botulism outbreak transfer from the Great Lakes to inland lakes is minimal because the disease itself is not transferable. The likelihood of an infected animal getting from the Great Lakes to an inland lake is small because it would probably be too incapacitated by the toxin to travel.

With botulism spores already existing everywhere, the most likely way an outbreak would occur in a new location is if the optimal environmental factors exist that allow the bacteria to enter a vegetative state and produce the toxin. *(See also: Why are botulism outbreaks occurring now?*)

Human and Pet Health

Is it safe to eat fish or waterfowl?

When fishing or hunting on the Great Lakes, you should harvest only fish and waterfowl that act and look healthy. Don't take any fish or game that show signs of illness, and follow good sanitary practices when preparing them (New York State Department of Environmental Conservation, no date). It is especially important to stay away from the gut area when cleaning fish; filleting is recommended. Similarly, when preparing waterfowl, the gut should be immediately removed and care should be taken to not disturb the gut contents. (See also: *What steps should I take when preparing healthy fish or birds for consumption to ensure maximum safety?*)

Can I get botulism?

Botulism in humans is usually caused by consumption of improperly home-canned foods, and is most often a result of the Type A or Type B botulinum toxin. A few cases of Type E botulism in humans have been reported in North America as the result of eating improperly smoked or cooked fish, but these cases are very rare (Leighton, 2000).

Thorough cooking is necessary to destroy the bacteria and bacterial toxins. Consult your local health agency for recommended cooking temperatures.

As a precaution, any fish or waterfowl that are sick or act abnormally should not be harvested or eaten because cooking may not destroy the Type E botulism toxin (New York State Department of Environmental Conservation no date). More information on botulism from a human health and food safety standpoint can be obtained through

the United States Department of Agriculture [USDA] Food Safety Research Information Office's *Clostridium botulinum* resource list (fsrio.nal.usda.gov). (See also: *What steps should I take when preparing healthy fish or birds for consumption to ensure maximum safety?*)

Can I swim in the water?

You are not at risk for botulism poisoning by swimming in Great Lakes waters. Botulism is contracted only by ingesting fish or birds contaminated with the toxin. If you have concerns about water quality, contact your local health department or swim in a regulated beach area. Remember that beaches sometimes close for other reasons such as fecal contamination. More information regarding beach advisories can be found through the U.S. EPA's Beaches website (water.epa.gov/type/oceb/beaches/index.cfm).

Is it safe to walk dogs on the beach after a bird kill?

If you bring pets to the shore, keep them away from dead animals on the beach.

Will my dog get sick if it eats a dead bird?

Dead wildlife may contain potentially harmful bacteria or toxins. If you think your pet may have ingested a contaminated carcass, monitor it for signs of sickness, and contact a veterinarian if you suspect your pet is falling ill.

Do I have to wash my hands after I touch a dead bird?

Yes, you should always wash your hands after handling any wildlife. Ideally, you should also wear gloves to handle any dead animal.

What steps should I take when preparing healthy fish or birds for consumption to ensure maximum safety?

Wear rubber or plastic protective gloves while filleting, field dressing, skinning, or butchering.

Remove the intestines of birds soon after harvest; don't eat the intestines and avoid direct contact with intestinal contents. Fish should be filleted, and contact with any gut material should be avoided. Hands, utensils, and work surfaces should be washed before and after handling any raw food, including fish and game meat.

Please remember that proper and thorough cooking is necessary to destroy disease causing organisms that occur naturally or that can be introduced during handling, storage, or preparation.

Contact your local health agency for more detailed information on suggested cooking temperatures and other possible health and fish consumption advisories.

General information on food preparation is also available through the Food Safety Research Information Office of the USDA (fsrio.nal.usda.gov).

Information on Great Lakes fish consumption advisories is available through the Great Lakes Information Network (GLIN) website (www.great-lakes.net/envt/flora-fauna/wildlife/fishadv.html).

What Can I Do to Help?

What steps I can take to help stop the spread of botulism?

Identifying possible cases of avian botulism at the early stages is the key to effective control. Public awareness of the conditions that lead to avian botulism and prompt corrective action can greatly reduce the epidemics that now claim hundreds of thousands of birds each year. Sick and dead birds in areas of avian botulism epidemics should be reported immediately to state and federal wildlife agencies (Michigan Department of Natural Resources, 2011b). Contacting your local education and outreach organization may also aid in its efforts to track outbreaks, and it can provide you with answers to additional questions. (Please see contact information on page ii).

Immediate removal of dead birds and fish can also help prevent the spread of botulism, as the bacteria in the carcasses can serve as the source of outbreaks for months. Follow appropriate safety and disposal methods. (See also: *How can people who want to help clean up the beach after a bird kill best protect themselves?* and *What is the best way to dispose of dead fish/birds in my area, especially after a botulism outbreak?)*

How should I notify authorities of a potential botulism-related fish or bird kill?

In case of a die-off, individuals are urged to contact local agencies responsible for fish and wildlife management to report fish and bird mortalities. (Refer to page ii for specific contact information). It is important to record the location, type of birds or fish, and number of carcasses found (New York, Pennsylvania, and Ohio Sea Grant 2006). By reporting accurate information about botulism, you will assist natural resources managers and others involved in wildlife conservation planning.

How can people who want to help clean up the beach after a bird kill best protect themselves?

People who handle dead wildlife should wear protective gear, such as disposable rubber gloves or an inverted plastic bag over their hands. If a diseased or dead bird is handled without gloves, hands should be thoroughly washed immediately thereafter with hot, soapy water or an anti-bacterial cleaner.

For advice on wildlife disposal methods, refer to: *What is the best way to dispose of dead fish/birds in my area, especially after a botulism outbreak?*

What is the best way to dispose of dead fish or birds in my area, especially after a botulism outbreak?

Be sure to follow local wildlife agency (e.g., Natural Resources, Fish and Wildlife, etc.) recommendations in handling dead fish and wildlife. Wear disposable, rubber or plastic gloves or invert a plastic bag over your hands when handling sick, dead, or dying fish, birds, or other animals. In certain areas, burying the carcasses is allowed, while 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 (New York, Pennsylvania, and Ohio Sea Grant, 2006).

The major goal should be to protect yourself, while also ensuring that the dead birds or fish are not available for consumption by other wildlife.

Is rehabilitation of sick birds possible? If so, how, and who should I contact about it?

Rehabilitation is unusual, but may be possible if birds did not ingest a large amount of the toxin. Recovery can be aided by providing these birds with rest, fresh water, and shade. They should be protected from predators during this process.

Under special circumstances, such as for the treatment of endangered species, a botulism antitoxin is available, but it requires special handling and must be given early on. Surviving an outbreak will NOT give birds immunity to botulism (USGS – National Wildlife Health Center 2006).

Please remember that extreme caution should be practiced when handling wildlife. Contact the local office of your state's wildlife management agency for more information about rehabilitation possibilities. (Refer to page ii for specific contact information).

Calling all beachcombers!

Get involved in an effort to improve the health of the Great Lakes!

With support from a grant from the Great Lakes Restoration Initiative at EPA, the Wildlife Data Integration Network (a partnership between the UW Madison Nelson Institute for Environmental Studies and the USGS National Wildlife Health Center) has launched an application, the Great Lakes Restoration Initiative – Wildlife Health Event Reporter (GLRI-WHER), for reporting wildlife health and algal bloom events observed around the Great Lakes. The system is available online at glri.wher.org.

In the interest of protecting waterfowl and other wildlife, scientists working in state, federal and non-profit agencies are looking for your help to identify events that could be important in research on avian botulism and algal bloom outbreaks. In the years 1998 through 2001, botulism was responsible for the deaths of thousands of birds in Lakes Huron and Erie. Since then, the incidence of botulism in the Great Lakes has increased steadily. For a healthy Great Lakes ecosystem, do your part and share what you see!

Coordinators: If your volunteer network would like to utilize the toolset for reporting, get in touch at botnet@wdin.org!

Citizen scientists: If you want to start reporting as an individual, sign up at glri.wher.org!

For more detailed information about GLRI-WHER see the Appendix.

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Appendix Contents

- GLRI-WHER fact sheet
- GLRI-WHER tear sheet
- GLRI business card handout sheet, front and back

Wildlife Health Event Reporter

A Component of the Wildlife Health Monitoring Network

For a Healthy Great Lakes Ecosystem

Share What You See

Great Lakes Restoration Initiative - Wildlife Health Event Reporter

An online tool for the general public & volunteer groups to record environmental and wildlife health events around the Great Lakes

Great Lakes Restoration Initiative—Wildlife Health Event Reporter (GLRI - WHER)

With the input of members from the Great Lakes Botulism Coordination Network (GLBCN) organized by the US Environmental Protection Agency, this new citizen science application, GLRI-WHER, was launched and made available online at http://glri.wher.org.

It was designed for the everyday citizen to report individual events as well as for volunteer groups doing periodic monitoring and surveillance on the Great Lakes shorelines looking for evidence of avian botulism or algal bloom outbreaks.

Who Developed GLRI-WHER?

With support from a grant from the GLRI at EPA, the Wildlife Disease Information Node (WDIN), a partnership between the USGS National Wildlife Health Center and the UW Madison Nelson Institute for Environmental Studies, developed this user-friendly system.

Why Collect this Information?

Injured or dead wildlife, as well as evidence of algal blooms, can be an indication that an area is being affected by a Botulism outbreak. Over the years, incidences of botulism in the Great Lakes has increased steadily, and in the 1998-2001 period was responsible for the deaths of thousands of birds in Lakes Huron and Erie.

After being recorded, these observations of dead/sick wildlife and algae can be joined and viewed with other event sightings, enabling people to see where similar events are happening.

Who Wants this Information?

Scientists working in state, federal and non-profit agencies are looking for your help to identify events that could be important in research on Avian Botulism and protecting waterfowl from this disease.

This information is being used to promote a healthy Great Lakes ecosystem by:

- Assisting in detection of avian botulism , algal blooms outbreaks and other risks to human and animal health
- Aiding in timely communications to the public about beach health and water conditions
- Helping to design and coordinate disease control and prevention strategies

Figure 1: Points on the GLRI-WHER map depict reports of dead or sick wildlife.

Great Lakes Beachcombing Citizens

The ordinary Great Lakes beachcomber can help to improve this important ecosystem by reporting their sightings of sick/dead wild animals to GLRI-WHER. After creating an account, users can enter their observations (e.g. date, location, species of animal(s) involved) using a simple step-by-step form.

Furthermore, they can see their individual reporting history separately or joined with reports made by other users.

Great Lakes Volunteer Group Coordinators

In addition to offering a place for public individuals to enter animal and algal blooms observations, GLRI-WHER was also designed as an online solution for data collection for volunteer groups doing periodic monitoring and surveillance on Great Lakes shorelines.

Incorporating recommendations provided by GLBCN members, GLRI-WHER's online form was designed to specifically meet the data collection needs of any organized Great Lakes volunteer group. To begin using GLRI-WHER, volunteer coordinators need only request that their organization name be added to the established list within the application.

If your volunteer network already has a system or data management solution in place, get in touch and we will work on a process to get your data included. Your group will benefit from seeing your data joined with data contributed by the public and other Great Lakes volunteer groups.

Figure 2: Sceenshots of GLRI-WHER features. From top to bottom: data entry form, reports, and search tool. .

GLRI-WHER Features: Maps, Reports, Email Alerts and More

Once data are entered, they are available to registered users for review in reports, maps and querying tools.

Anyone can sign up to receive daily email alerts from the site or grab the URL for a GeoRSS feed to plug into their own feed readers to stay up to date as reports are made.

Getting Started – It is Easy

Beachcombing enthusiasts can start reporting as soon as they sign up at http://glri.wher.org!

Volunteer coordinators get in touch with us at botnet@wdin.org to set up your group account and learn how to manage it. Training assistance is available as needed.

This application is a beta version. If you encounter any problems let us know! You can also share your feedback with us at botnet@wdin.org.

For More Information

Visit the WHER web site at http://glriwher.blogspot.com/p/about.html or contact us:

Wildlife Disease Information Node
Nelson Institute for Environmental Studies
University of Wisconsin
550 North Park Street, Room 60
Madison, WI, 53706 USA

Phone: +1.608-616-WHER
E-mail: botnet@wdin.org

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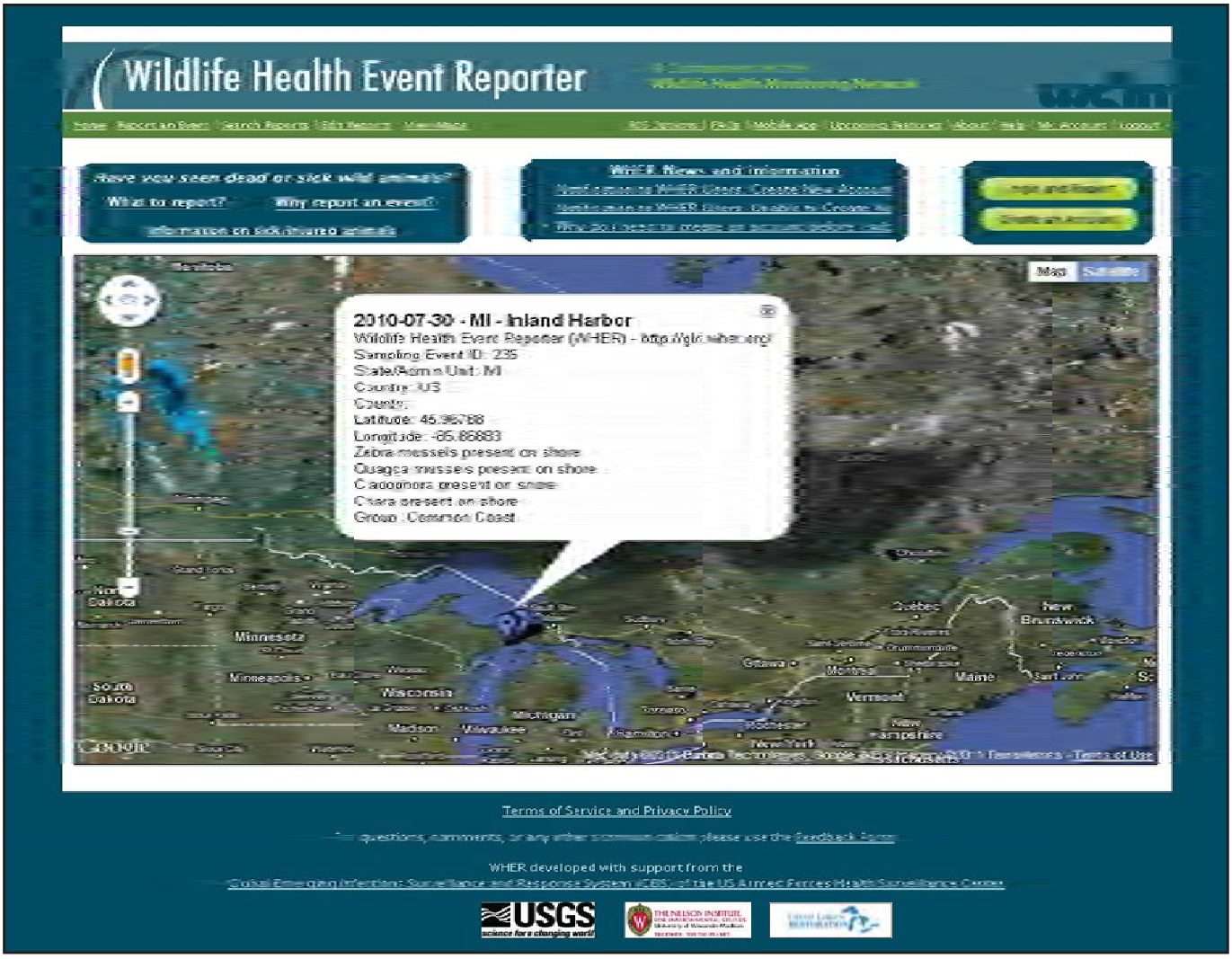

For a Healthy Great Lakes Ecosystem

Share What You See

Concerned about the Great Lakes? Consider using the online Great Lakes Restoration Initiative Wildlife Health Event Reporter (GLRI-WHER) to report dead/sick wildlife, algal bloom outbreaks or other unusual environmental activity that you observe along the shore. Your reports will help local, state or federal government researchers, scientists and non-profit agencies who are working to restore our Great Lakes ecosystem. Check out the site to see what other Great Lakes advocates are reporting!

Report observations around the Great Lakes to : http://glri.wher.org

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Wildlife Health Event Reporter

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Questions? Email: botnet@wdin.org →

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This citizen science application, the Great Lakes Restoration Initiative – Wildlife Health Event Reporter (GLRI-WHER):

- Provides a simple method to share sightings of unusual wildlife and/or environmental activity
- Offers daily email alerts as reports are made
- Makes recorded sightings available for review in reports, maps and querying tools

This application is made possible through a grant from

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- Provides a simple method to share sightings of unusual wildlife and/or environmental activity
- Offers daily email alerts as reports are made
- Makes recorded sightings available for review in reports, maps and querying tools

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Photo by Dr. Thomas G. Barnes