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# Avian botulism type E in waterbirds of Lake Michigan, 2010–2013

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ABSTRACT

During 2010 to 2013, waterbird mortality surveillance programs used a shared protocol for shoreline walking surveys performed June to November at three areas in northern Lake Michigan. In 2010 and 2012, 1244 total carcasses (0.8 dead bird/km walked) and 2399 total carcasses (1.2 dead birds/km walked), respectively, were detected. Fewer carcasses were detected in 2011 (353 total carcasses, 0.2 dead bird/km walked) and 2013 (451 total carcasses, 0.3 dead bird/km walked). During 3 years, peak detection of carcasses occurred in October and involved primarily migratory diving and fish-eating birds, including long-tailed ducks (*Clangula hyemalis*; 2010), common loons (*Gavia immer*; 2012), and red-breasted mergansers (*Mergus serrator*; 2013). In 2011, peak detection of carcasses occurred in August and consisted primarily of summer residents such as gulls (*Larus* spp.) and double-crested cormorants (*Phalacrocorax auritus*). A subset of fresh carcasses was collected throughout each year of the study and tested for botulinum neurotoxin type E (BoNT/E). Sixty-one percent of carcasses (57/94) and 10 of 11 species collected throughout the sampling season tested positive for BoNT/E, suggesting avian botulism type E was a major cause of death for both resident and migratory birds in Lake Michigan. The variety of avian species affected by botulism type E throughout the summer and fall during all 4 years of coordinated surveillance also suggests multiple routes for bird exposure to BoNT/E in Lake Michigan.

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## Introduction

Avian botulism type E can occur when birds ingest prey items containing botulinum neurotoxin type E (BoNT/E) produced by the bacterium *Clostridium botulinum* (Lafrancois et al., 2011; Rocke and Bollinger, 2007). *Clostridium botulinum* is prevalent in aquatic environments as dormant spores (Bott et al., 1968; Rocke and Bollinger, 2007). *Clostridium botulinum* vegetative growth and toxin production occur when spores are exposed to a suite of environmental conditions, including elevated water temperatures, anoxia, and a protein source (Rocke and Bollinger, 2007). Ingested BoNT/E inhibits neurotransmitter release at neuromuscular junctions in susceptible species, causing loss of muscle control (Clark, 1987; Rocke and Bollinger, 2007). Clinical signs associated with botulinum intoxication in birds include inability to walk or fly, inner eyelid paralysis, and inability to hold head erect (Clark, 1987; Rocke and Bollinger, 2007).

Over the past 50 years, more than 100,000 avian mortalities in the Laurentian Great Lakes have been attributed to botulism type E (full joint report published in 2014 by Environment Canada and the United States Environmental Protection Agency [State of the Great Lakes 2011, Cat No. En161-3/1-2011E-PDF, EPA 950-R-13-002, http://binational.net, accessed February 2014]). In 2006, thousands of dead birds, including Michigan state-threatened common loons (*Gavia immer*), were found on the shoreline of Lake Michigan alone and botulism type E was the primary diagnosis in examined birds (Converse and McLaughlin, 2007). Lake Michigan birds were affected in large numbers again in 2007 (Jankowski et al., 2008) with botulism type E mortality in piping plovers (*Charadrius melodus*) from the federally endangered Great Lakes breeding population (Jankowski et al., 2007). These 2 years of large-scale mortality prompted renewed interest in the ecological significance of avian botulism type E to birds of Lake Michigan.

In 2010, the United States Geological Survey's National Wildlife Health Center (NWHC) collaborated with the National Park Service's Sleeping Bear Dunes National Lakeshore (SLBE), Wisconsin Department of Natural Resources, and Common Coast Research and Conservation to establish a standardized protocol for compiling avian mortality data and collecting carcasses found on Lake Michigan beaches. Here we summarize the species affected, timing and location of carcass deposition, and BoNT/E exposure for examined carcasses from northern Lake Michigan during 2010 to 2013.

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## Methods and results

Lake Michigan shoreline transects were monitored by trained volunteers and professional biologists who recorded numbers and species of sick and dead birds observed between the water and terrestrial vegetation line in three surveillance areas: Door County and neighboring counties in Wisconsin (DOOR), eastern Upper Peninsula of Michigan (EUP), and SLBE (Fig. 1). Transects were surveyed one to four times per month from June to November in each of the years 2010 ($n = 36$ transects; average length = 2.3 km ± 0.4 SE), 2011 ($n = 64$; average length = 1.5 km ± 0.3 SE), 2012 ($n = 74$; average length = 1.6 km ± 0.2 SE), and 2013 ($n = 30$; average length = 2.9 km ± 0.5 SE) (Table 1). Variation in surveillance effort among years within the same area was accounted for by calculating the number of kilometers walked by beach monitors in each area for each year. For example, mortality data from SLBE always corresponds with 51.8 km total transect length, but more effort was invested in 2013 (1036.1 km walked) than 2010 (843.3 km walked).

During 2010 to 2013, a total of 4447 dead birds were reported (Table 1, Fig. 2). The number of carcasses reported and rates of carcass detection were over two times higher in 2010 (1244 total carcasses, 0.8 dead bird/km walked) and 2012 (2399 total carcasses, 1.2 dead birds/km walked) compared to 2011 (353 total carcasses, 0.2 dead bird/km walked) and 2013 (451 total carcasses, 0.3 dead bird/km walked).

Avian carcass condition was assessed to provide a crude estimate of the time since death using the following criteria: dead <24 h (no smell, no maggots, feathers do not pull out easily, eyes clear); dead 24 to 48 h (same as previous category but with cloudy eyes); or dead >48 h, decomposed (did not meet criteria of both previous categories). All carcasses were either moved away from the water line and buried approximately 0.5 m deep, marked with non-toxic spray paint to avoid recount (if burying was not possible), or collected to test for the presence of BoNT/E. To minimize the possibility of detecting BoNT/E produced post-mortem, only carcasses estimated to have been dead <48 h were collected for diagnostic testing. The majority of documented carcasses (71%) were decomposed. Of the carcasses that were found on the beach in good post-mortem condition ($n = 337$ dead <24 h; $n = 949$ dead 24 to 48 h), 95 carcasses (11 species) were collected and frozen until shipment to NWHC.

Full diagnostic examinations, including routine culture-based bacteriological and virological analyses, histology, and evaluation for presence of BoNT/E, were performed on 18 carcasses (ten ring-billed gulls [*Larus delawarensis*], two herring gulls [*L. argentatus*], two double-crested cormorants [*Phalacrocorax auritus*], two horned grebes [*Podiceps auritus*], one red-necked grebe [*P. grisegena*], one common loon)

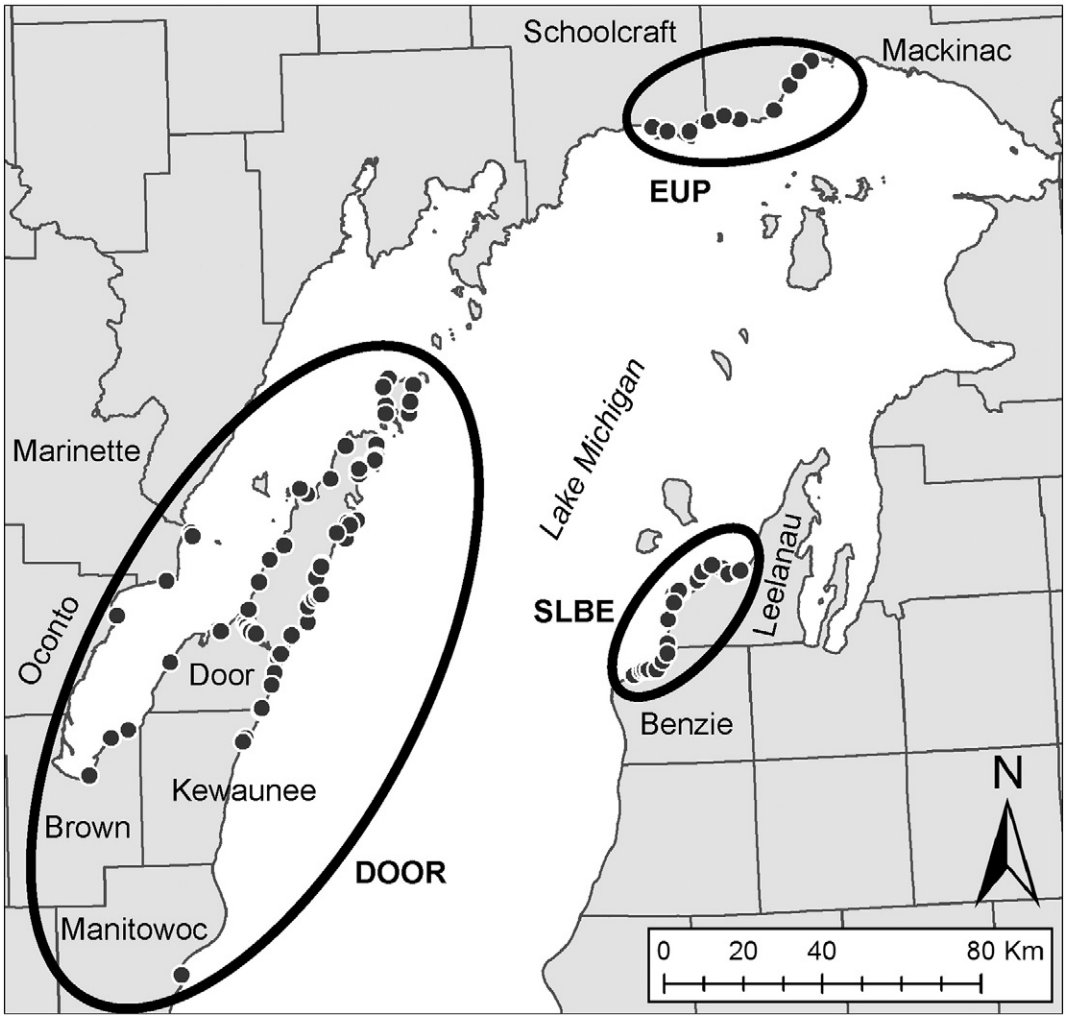


**Fig. 1.** Areas in northern Lake Michigan surveyed for bird mortality during 2010 to 2013. DOOR = Door County, Wisconsin (other nearby counties also surveyed some years), EUP = eastern Upper Peninsula, Michigan, SLBE = Sleeping Bear Dunes National Lakeshore, Michigan. Points on the shoreline represent midpoints of transects surveyed ($n = 103$).