Journal of Great Lakes Research 40 (2014) 58–63

Contents lists available at ScienceDirect

Journal of Great Lakes Research

journal homepage: www.elsevier.com/locate/jglr

# The importance of island surveys in documenting disease-related mortality and Botulism E in Great Lakes colonial waterbirds

J. Laird Shutt [a,1], David W. Andrews [b,2], D.V. Chip Weseloh [c,*], David J. Moore [d,3], Craig E. Hebert [a,4], G. Douglas Campbell [e,5], Kim Williams [a,6]

[a] Environment Canada, Wildlife and Landscape Science, National Wildlife Research Centre, Carleton University, Ottawa, ON K1A 0H3, Canada
[b] Canadian Wildlife Service, 6 Bruce St., Mount Pearl, NL A1N 4T3, Canada
[c] Environment Canada, Canadian Wildlife Service, 4905 Dufferin St., Toronto, ON M3H 5T4, Canada
[d] Canadian Wildlife Service, Canadian Centre for Inland Waters, 867 Lakeshore Rd., Burlington, ON L7R 4A6, Canada
[e] Canadian Cooperative Wildlife Health Centre, Department of Pathobiology, Ontario Veterinary College, University of Guelph, Guelph, ON N1G 2W1, Canada

ARTICLE INFO

*Article history:*
Received 1 February 2013
Accepted 6 December 2013
Available online 4 February 2014

Communicated by Francesca Cuthbert

*Keywords:*
Botulism
Waterbirds
Lake Ontario
Extirpate
Mortality

ABSTRACT

Type E Botulism is an important source of mortality for waterbirds on the lower Great Lakes. The purpose of this study was to determine: 1) the spatial distribution of waterbird mortality and 2) if that mortality possibly impacted the breeding colonial waterbird populations in eastern Lake Ontario. Six islands in eastern Lake Ontario, Canada, were searched, July–November, 2004–2009, for dead/moribund waterbirds. Over 6600 dead/dying birds were located; five species accounted for >98% of the birds found: double-crested cormorant (*Phalacrocorax auritus*), herring, ring-billed and great black-backed gulls (*Larus argentatus*, *Larus delawarensis*, *Larus marinus*, respectively) and Caspian tern (*Hydroprogne caspia*). Cormorants accounted for 65–78% of all birds annually. Mortality was greatest in 2005 (7.5%). Most carcasses (91%) were documented on four islands. Most necropsied carcasses (58%, N = 95) were confirmed/suspected to have died from Type E Botulism; it was the only mortality factor identified in all years and in all five main species. These results produced a different guild of affected birds from previous beached bird surveys; virtually no birds that roost on water (loons and waterfowl) were found. Deaths reported here had minimal impact to herring and ring-billed gull, double-crested cormorant and Caspian tern populations nesting in eastern Lake Ontario. However, they accounted for >100% of the great black-backed gulls breeding there. The species was extirpated from Lake Ontario during the study period. When assessing mortality in aquatic birds, it is crucial to examine off-shore islands, where birds roost, to fully document this critical demographic parameter.



## Introduction

Disease is a significant cause of mortality in some species of birds. In the case of colonial waterbirds, diseases such as botulism, avian paramyxovirus-1 (known as Newcastle Disease Virus (NDV) in its most virulent form), Salmonellosis and Avian Cholera are known to cause extensive mortality (Friend et al., 1999; Green and Elmberg, http://onlinelibrary.wiley.com/doi/10.1111/brv.12045/pdf, accessed 20 December 2013). On the Great Lakes, botulism has been documented in waterbirds such as, cormorants, gulls, herons, loons and ducks (Glaser et al., 1999; Velarde, 2002; Domske, 2003; Parks, 2008), while NDV has been observed in cormorants only. Salmonellosis and Avian Cholera are rarely observed in waterbirds on the Great Lakes but are significant causes of mortality elsewhere in North America (Friend et al., 1999). Type E Botulism has been the cause of repeated large scale die-offs on the lower Great Lakes (Domske, 2003). This disease is caused by a toxin produced by the bacterium, *Clostridium botulinum*. The bacterium normally occurs as a spore and produces the toxin in warm, protein-rich anaerobic environments, conditions frequently encountered during late summer in oxygen-depleted waters (Friend et al. 1999).

There are seven types of *C. botulinum* (A–G), with types C and E, most common among waterbirds (Brand et al., 1983). Type C occurs as a warm weather disease, driven by a carcass-maggot cycle that may produce extremely large scale mortality. It was first isolated from wild birds in 1930 (Giltner and Couch, 1930), and is typically associated with major waterfowl mortalities and occurs on a global scale (Rosen,

* Corresponding author. Tel.: +1 416 739 5846.
*E-mail addresses:* Laird.Shutt@ec.gc.ca (J.L. Shutt), David.Andrews@ec.gc.ca (D.W. Andrews), Chip.Weseloh@ec.gc.ca (D.V.C. Weseloh), Dave.Moore@ec.gc.ca (D.J. Moore), Craig.Hebert@ec.gc.ca (C.E. Hebert), dgcampbe@uoguelph.ca (G.D. Campbell), Kim.Williams@ec.gc.ca (K. Williams).
[1] Tel.: +1 613 998 7379.
[2] Tel.: +1 416 889 9112.
[3] Tel.: +1 905 315 5234.
[4] Tel.: +1 613 998 6693.
[5] Tel.: +1 519 824 4120x54556.
[6] Tel.: +1 613 998 8506.

0380-1330/$ – see front matter. 
http://dx.doi.org/10.1016/j.jglr.2014.01.001

1971). Type E, confined to the Great Lakes region, has been found in many piscivorous waterbirds including cormorants, loons and gulls as well as numerous species of diving ducks (Friend et al., 1999).

Fish-eating birds are neurologically impaired through ingestion of pre-formed botulinum toxin. The source of toxin will vary with food habits of the species; possible sources include live fish containing the toxin, dead fish, mudpuppies and invertebrates, particularly mussels (Perez-Fuentetaja et al., 2006). Symptoms include loss of muscular coordination, flaccid paralysis of the neck, wings and legs and loss of control of the nictitating membrane (Friend et al., 1999). If untreated, the toxin is usually fatal.

Type E Botulism was first reported in birds in 1963 and 1964 by Herman (1964) and Kaufman and Fay (1964), respectively, when common loons (*Gavia immer*) and several gull species were recovered from the shores of south-eastern Lake Michigan. More recently, avian mortality associated with exposure to Type E Botulism occurred in Lake Erie in 1999 and affected loons and thousands of other fish-eating birds, primarily red-breasted mergansers (*Mergus serrator*). Significant mortality of ring-billed and herring gulls (*Larus delawarensis* and *Larus argentatus*, respectively) and common loons was noted first in western Lake Ontario in 2002 and again in 2003 (Adams et al., 2004). In response to these die-offs, surveys for dead/moribund birds were initiated on six islands in eastern Lake Ontario. Our goals were to document mortality in fish-eating birds associated with the occurrence of Type E Botulism, look for spatial patterns in the distribution of mortality and to determine if the number and species of dead/moribund birds were sufficient to be impacting any of the breeding colonial waterbird populations in eastern Lake Ontario.

## Methods

A survey route of six offshore islands was established on the Canadian side of eastern Lake Ontario. The six islands surveyed were: Pigeon, Snake, Salmon, and False Duck (Swetman) islands, and False Duck Shoal in the eastern basin of Lake Ontario, and Scotch Bonnet Island in the central basin (Fig. 1). These islands were chosen because they are primary breeding and/or nocturnal roosting sites for the following colonial waterbirds: double-crested cormorant (DCCO, *Phalacrocorax auritus*) (henceforth cormorant), herring gull (HERG), ring-billed gull (RBGU), great black-backed gull (GBBG, *Larus marinus*), Caspian tern (CATE, *Hydroprogne caspia*) and common tern (COTE, *Sterna hirundo*) (Weseloh and Shutt, 2008). From 2004 to 2009, these islands were surveyed for dead and dying waterbirds. The intended sampling scheme was to conduct surveys at approximately 10 day intervals (three times per month) from July to November. However, due to logistical constraints such as weather and inconsistent funding, the sampling scheme was often variable. A consequence of this was significantly fewer surveys during the years of 2004, 2007 and 2009. Each island was surveyed seven times per year, on average, which equated to a total of 244 island visits during our six year study period. The number of dead/moribund birds found at any site following a survey period that was missed was divided by the number of survey periods since the last successful one and distributed evenly among the missed survey periods. Typically, a two person team accessed each island by boat. As each island was approached, the approximate number of colonial waterbirds, categorized as either "gulls" or cormorants that flushed from the island was recorded as an index of island use during the survey period (with the exception of 2004, when these data were not recorded). Each entire island (with the exception of False Duck Island) was searched on foot and the number of dead and dying (immobilized) birds was recorded. Due to its size, dense vegetation and partially precipitous shoreline, only the western third of False Duck Island and shoreline were surveyed for dead/moribund birds. It was presumed that most birds would have died close to shore, therefore, only the perimeter of the False Duck Island with exposed beach/shoreline was surveyed. Bird species were identified during all years, but from 2005 onwards, age (adult, post-fledging juvenile and immature birds) was recorded as well. In general, the islands had little vegetation and the likelihood of detecting all dead/moribund birds was high. However, it is possible that birds were missed between sampling dates due to scavenging and/or storm activity which could rid beaches of carcasses. All birds found dead were sprayed with permanent paint to identify them as having been counted.

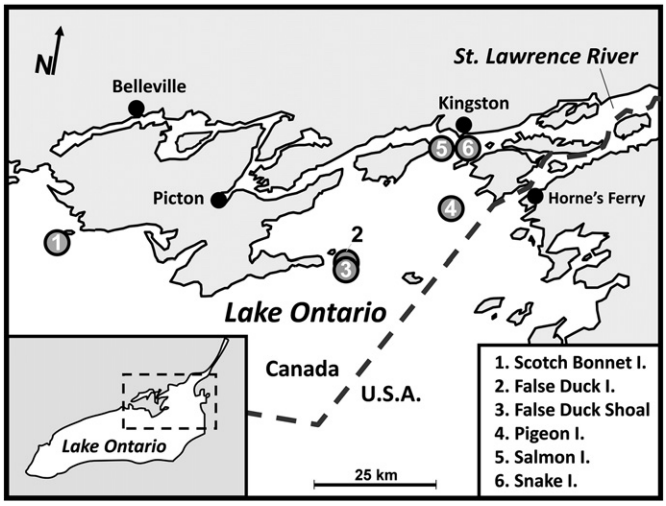


**Fig. 1.** Islands surveyed for dead/moribund waterbirds in eastern Lake Ontario.

Occasionally, moribund birds showing signs of exposure to botulism were sacrificed by decapitation. Blood serum was collected and refrigerated and the body stored frozen for subsequent necropsy and health assessment by staff at the Canadian Cooperative Wildlife Health Centre (CCWHC) at the Ontario Veterinary College (OVC), University of Guelph. Also, occasionally, fresh dead specimens encountered on or near the islands were taken directly to the CCWHC for diagnosis during all years (except 2007) of the study ($n = 108$). Fifty percent of all birds submitted to the CCWHC for necropsy were double-crested cormorants. All specimens submitted to CCWHC were screened for Avian Influenza Virus (AIV), using a polymerase chain reaction test (Spackman et al., 2002). Birds were tested for Newcastle Disease Virus (NDV) using a virus isolation test (Senne, 1989) and by routine histopathology. Types E and C Botulism were tested using a mouse bioassay (Austin and Blanchfield, 1996). Dying birds exhibiting symptoms of botulism were tested by a mouse bioassay, using either serum collected at the time of death or liver or heart blood collected post-mortem as the test substrate.

The number of dead/moribund birds of each species from 2005 to 2009 was compared to the number of loafing birds that were flushed from each island and to the total number of nests for that species in the eastern Basin of Lake Ontario, east of, and including Scotch Bonnet Island (Weseloh et al., 2003; Canadian Wildlife Service, unpublished data), including both American and Canadian colonies. Because birds roost and nest on these islands, the number of dead/moribund birds should be related to the numbers of birds present at any given time. Therefore, the number of dead/moribund birds was compared to the number of loafing birds flushed upon arrival. Because flushed birds could only be identified as either cormorants or gulls (*Larus* spp.) all comparisons between the numbers of dead/moribund as a percentage of the number flushed, were limited to cormorants and all gull species combined.

## Results

A total of 6622 dead/moribund birds was found over the six year study period. Five species accounted for >98% of the birds found: double-crested cormorant, herring, ring-billed and great black-backed