

## **Factors Contributing to Type E Botulism Outbreaks at Sleeping Bear Dunes National Lakeshore**

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### **Abstract:**

In autumn of 2006, a large die-off of native fish-eating birds occurred in Lake Michigan, almost exclusively within the boundaries of Sleeping Bear Dunes National Lakeshore. Nearly 3,000 dead birds were documented, along with many fish. Necropsies of a subset of the dead birds indicated type E botulism poisoning, and gut content analysis showed that some of the affected birds had consumed invasive dreissenid mussels and/or round gobies. Recent changes in nearshore food webs, associated with invasive dreissenid mussels and round gobies, have been implicated in this resurgence of type E botulism. The hypothesized pathway begins with dreissenid mussels facilitating the excess growth of *Cladophora*, a native benthic macroalga, by increasing water clarity and nutrient regeneration. As the *Cladophora* decays, it creates nutrient-rich, anoxic conditions on the lake bottom, which facilitates the growth of *Clostridium botulinum* and the production of the type E toxin. *C. botulinum* is nearly ubiquitous, but its toxin is only produced under conditions of anoxia and high nutrients. The toxin is then concentrated by dreissenid mussels, which are consumed heavily by the round goby, and passed via the infected gobies to piscivorous fish and fish-eating birds. During summer 2007, type E botulism poisoning continued to affect fish, fish-eating birds, and even shorebirds at Sleeping Bear Dunes National Lakeshore. A study was commenced to explore this hypothesized pathway for botulism transfer to fish and fish-eating birds, by continuously monitoring key water chemistry conditions on the lake bottom (temperature, pH, conductivity, and dissolved oxygen), determining toxin concentrations in food web components suspected in botulism transfer, determining toxin concentrations in dead fish and fish-eating birds, reviewing gut contents of dead fish and fish-eating birds, and assessing trophic connections via carbon and nitrogen stable isotope analysis. Results will provide insights into conditions facilitating toxin production and clarify the potential for several benthic food web components to contribute to trophic transfer of the toxin to birds.

### **Keywords:**

Botulism E, trophic transfer, dissolved oxygen, Lake Michigan