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Dreissenid mussels are not a "dead end" in Great Lakes food webs

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ABSTRACT

Dreissenid mussels have been regarded as a "dead end" in Great Lakes food webs because the degree of predation on dreissenid mussels, on a lakewide basis, is believed to be low. Waterfowl predation on dreissenid mussels in the Great Lakes has primarily been confined to bays, and therefore its effects on the dreissenid mussel population have been localized rather than operating on a lakewide level. Based on results from a previous study, annual consumption of dreissenid mussels by the round goby (*Neogobius melanostomus*) population in central Lake Erie averaged only 6 kilotonnes (kt; 1 kt = one thousand metric tons) during 1995–2002. In contrast, our coupling of lake whitefish (*Coregonus clupeaformis*) population models with a lake whitefish bioenergetics model revealed that lake whitefish populations in Lakes Michigan and Huron consumed 109 and 820 kt, respectively, of dreissenid mussels each year. Our results indicated that lake whitefish can be an important predator on dreissenid mussels in the Great Lakes, and that dreissenid mussels do not represent a "dead end" in Great Lakes food webs. The Lake Michigan dreissenid mussel population has been estimated to be growing more than three times faster than the Lake Huron dreissenid mussel population during the 2000s. One plausible explanation for the higher population growth rate in Lake Michigan would be the substantially higher predation rate by lake whitefish on dreissenid mussels in Lake Huron.

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Introduction

Dreissenid mussels invaded the Laurentian Great Lakes from the late 1980s through the 1990s (Nalepa et al., 2005). The dreissenid mussel invasions in Lakes Michigan, Huron, Erie, and Ontario have been linked to declines in the abundance of the amphipod *Diporeia*, although the mechanism by which the mussels are negatively affecting *Diporeia* abundance remains unidentified. Decreases in lake whitefish (*Coregonus clupeaformis*) condition and growth in Lakes Michigan, Huron, and Ontario have been attributed, at least in part, to the *Diporeia* abundance declines (Nalepa et al., 2005). In addition, the dreissenid mussel invasions of the Great Lakes have been associated with other changes in the benthic macroinvertebrate community structure as well as changes in the zooplankton community (Haynes et al., 1999; Johannsson et al., 2000). Further, Hecky et al. (2004) proposed that dreissenid mussels act as ecosystem engineers responsible for a nearshore phosphorus shunt. In their conceptual model, dreissenid mussels redirected energy and nutrients such as phosphorus to the nearshore zone, while offshore phosphorus remained low.

Several ecologists have regarded dreissenid mussels as a "dead end" in Great Lakes food webs because the degree of predation on dreissenid mussels, on a lakewide basis, is believed to be limited (Arney and Grubbs 2001; Environment Canada and U. S. Environmental Protection Agency 2003). Diving ducks, such as the greater scaup (*Aythya marila*), lesser scaup (*Aythya affinis*), and white-winged scoter (*Melanitta deglandi*), do feed on dreissenid mussels in bays and selected nearshore areas of Lake Erie during the fall, but their predation effects are quite localized (Mitchell et al., 2000). Further, this predation effect was found to be temporary, because the dreissenid mussel population had the ability to recover from the predation by the following fall (Mitchell et al., 2000). Bunnell et al. (2005) used bioenergetics modeling to estimate annual consumption of dreissenid mussels by the round goby (*Neogobius melanostomus*) population in the central basin of Lake Erie during 1995–2002. Because annual consumption averaged only 6 kilotonnes (kt; 1 kt = one thousand

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metric tons), which was more than 100 times lower than the standing stock biomass estimate of dreissenid mussels in central Lake Erie, Bunnell et al. (2005) concluded that round gobies were having a minimal effect on dreissenid mussel population dynamics in central Lake Erie.

During the 2000s in Lakes Michigan and Huron, dreissenid mussels have become an important component of lake whitefish diet, representing up to 80% of the diet for some age groups (Pothoven and Madenjian 2008). Lake whitefish is one of the most abundant benthivores in Lakes Michigan and Huron (Nalepa et al., 2005). Therefore, we may expect a relatively strong trophic link between dreissenid mussels and lake whitefish within these two lake ecosystems.

As a consequence of the 2000 Consent Decree between the Chippewa Ottawa Resource Authority and the State of Michigan, an opportunity now exists to estimate the degree of predation on dreissenid mussels by lake whitefish populations in Lakes Michigan and Huron. One of the actions taken under the 2000 Consent Decree was to begin applying statistical catch-at-age (SCAA) models to the lake whitefish populations in both lakes in order to better manage the fisheries (Ebener et al. ,2005). Application of the SCAA models requires an intensive, multiagency effort each year to summarize the various types of fishery data for each of the management units and then integrate these data into the SCAA models to generate estimates of population sizes and biomasses by age, age-specific total mortalities, and age-specific fishing mortalities. A bioenergetics model for lake whitefish has been evaluated, and then modified to improve the accuracy of predictions of food consumption (Madenjian et al., 2006). In sum, the data and appropriate modeling tools needed to estimate consumption of dreissenid mussels by lake whitefish populations in Lakes Michigan and Huron are now available.

The primary objective of this study was to estimate annual consumption of dreissenid mussels by lake whitefish populations in Lakes Michigan and Huron. The secondary objective of this study was to discuss the potential for lake whitefish predation to slow the population growth rate of dreissenid mussels.

Methods

For each of the lake whitefish management units in Lakes Michigan and Huron, an SCAA model was fitted to lake whitefish fishery data, provided that the fishery data were sufficient for model application (Ebener et al., 2005). The lake whitefish management units in Lake Michigan with sufficient data for SCAA model applications included WFM-00, WFM-01, WFM-02, WFM-03, WFM-04, WFM-05, WFM-06, and WFM-08 (Fig. 1). The lake whitefish management units in Lake Huron with sufficient data for SCAA model applications included WFH-01, WFH-02, WFH-04, WFH-05, QMA 4-2, QMA 4-3, QMA 4-4, QMA 4-5, QMA 4-7, QMA 5-8, QMA 5-9, and QMA 6-1. Estimates of population sizes by age and age-specific mortalities were generated from each SCAA model application, and growth trajectories were estimated from the commercial catch and fishery-independent data. Each SCAA model application yielded population size estimates and mortality estimates for each of years of fishery data included in the model application. Diet data for lake whitefish from Lakes Michigan and Huron were available for the 1998–2005 and 2002–2004 periods,

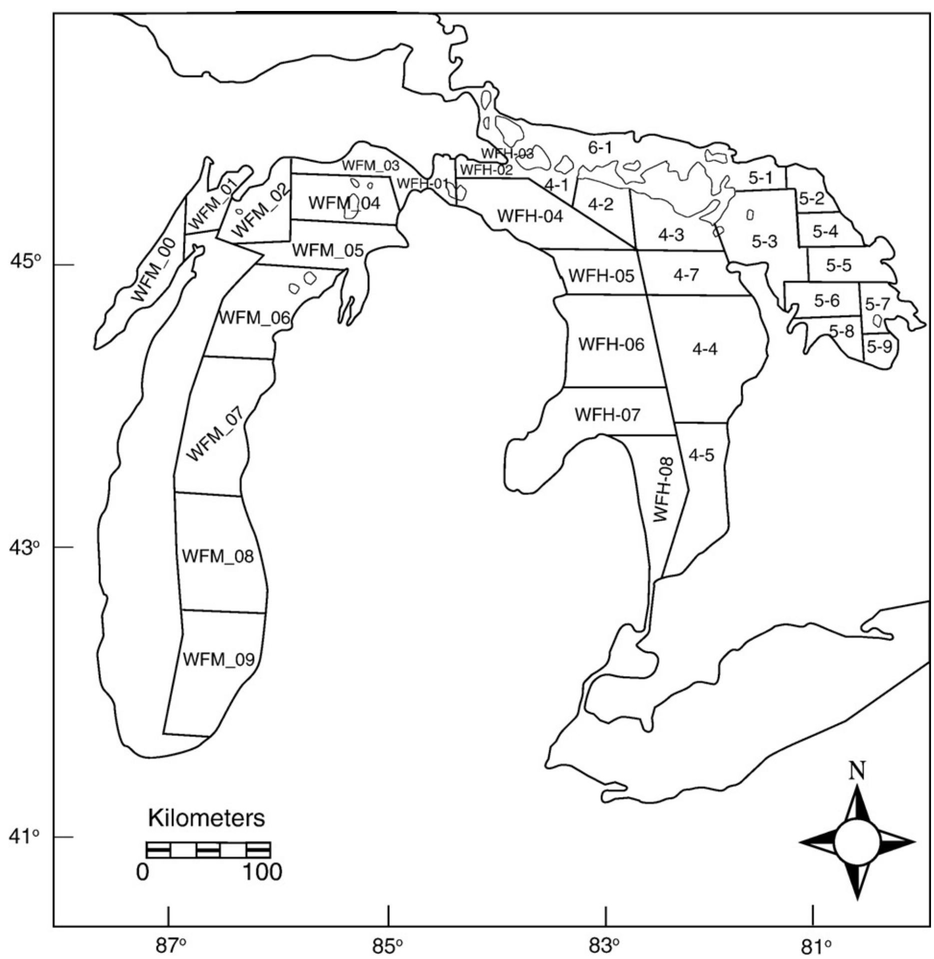

Fig. 1. Map showing the lake whitefish management units in Lakes Michigan and Huron. The QMA management units were designated by an integer followed by a hyphen and a second integer.