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Abundance and distribution of benthic macroinvertebrates in offshore soft sediments in Western Lake Huron, 2001–2007

John R.P. French III [a,*], Jeffrey S. Schaeffer [a], Edward F. Roseman [a], Courtney S. Kiley [a], Alexandria Fouilleroux [b]

[a] United States Geological Survey - Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI 48105, USA
[b] Ecole Nationale Superieure d'Agronomie de Rennes, 65 rue de Saint-Brieuc, 35000 Rennes, France

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ABSTRACT

Invasive species have had major impacts on the Great Lakes. This is especially true of exotic dreissenid mussels which are associated with decreased abundance of native macroinvertebrates and changes in food availability for fish. Beginning in 2001, we added a benthic macroinvertebrate survey to the USGS-Great Lakes Science Center's annual fall prey fish assessment of Lake Huron to monitor abundance of macrobenthos. Mean abundance of *Diporeia*, the most abundant benthic taxon in Lake Huron reported by previous investigators, declined greatly between 2001 and 2007. *Diporeia* was virtually absent at 27-m sites by 2001, decreased and was lost completely from 46-m depths by 2006, but remained present at reduced densities at 73-m sites. Dreissenids in our samples were almost entirely quagga mussels *Dreissena bugensis*. Zebra mussels *Dreissena polymorpha* were virtually absent from our samples, suggesting that they were confined to nearshore areas shallower than we sampled. Loss of *Diporeia* at individual sites was associated with arrival of quagga mussels, even when mussel densities were low. Quagga mussel density peaked during 2002, then decreased thereafter. During the study quagga mussels became established at most 46-m sites, but remained rare at 73-m sites. Length frequency distributions suggest that initial widespread recruitment may have occurred during 2001–2002. Like other Great Lakes, Lake Huron quagga mussels were associated with decreased abundance of native taxa, but negative effects occurred even though dreissenid densities were much lower. Dreissenid effects may extend well into deep oligotrophic habitats of Lake Huron.

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Introduction

Invasive species have had profound effects on the Laurentian Great Lakes. There are currently 183 non-indigenous species, of which 18 substantially influenced the ecosystem (SOLEC 2007). In many cases, proliferation of non-indigenous species was associated with reductions in native species, and although the exact mechanisms have been debated, competition or predation is often inferred (Crowder, 1980). More recently, there has been growing support for the hypothesis that exotic species may disrupt food webs by shunting energy or nutrients, making them less available to native species. This may be the major mechanism underlying system-wide changes associated with recent proliferation of non-indigenous zebra *Dreissena polymorpha* and quagga *Dreissena bugensis* mussels (Hecky et al., 2004).

In particular, *Dreissena* proliferation has been associated temporally with decline of the deepwater amphipods *Diporeia* spp. Dreissenids proliferated throughout all the Great Lakes except Lake Superior during 1988–1992 (Mills et al., 1993a, 1993b) and sudden declines in *Diporeia* followed in both Lakes Michigan and Ontario with more severe loss of *Diporeia* at higher dreissenid densities (Nalepa et al., 1998, Dermott, 2001). Although evidence for a causal mechanism has remained elusive, *Diporeia* densities have continued to decline in Lake Michigan (Nalepa et al., 2006) which was followed by dietary change, reduced growth, and poorer physical condition of lake whitefish *Coregonus clupeaformis* (Pothoven et al., 2001), alewives *Alosa pseudoharengus* (Madenjian et al., 2003), and deepwater sculpins *Myoxocephalus thompsonii* (Hondorp et al., 2005).

During 2000–2001, there was growing concern that Lake Huron's benthic community was changing in the same manner as Lake Michigan, where *Diporeia* had been reduced. *Diporeia* declines in Saginaw Bay had already been well-documented (Nalepa and Fahnenstiel, 1995), and field observations from lake-wide benthic surveys performed by NOAA's Great Lakes Environmental Laboratory indicated that Lake Huron *Diporeia* populations were likely reduced from previous levels (Nalepa et al., 2007). We noticed decreased abundance of demersal fishes in bottom trawl surveys (Schaeffer, 2002) and received anecdotal reports of emaciated lake whitefish *C. clupeaformis* from commercial fishers. Because these observations suggested that food web changes were underway, we added benthic macroinvertebrate sampling to the USGS Great Lakes Science Center

* Corresponding author.
E-mail addresses: frenchjrp@usgs.gov (J.R.P. French), jschaeffer@usgs.gov (J.S. Schaeffer), eroseman@usgs.gov (E.F. Roseman).

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(GLSC) bottom trawl survey to evaluate potential changes in the macroinvertebrate community and document a hypothesized increase in dreissenids and decrease in *Diporeia* occurring offshore. While our sampling was more spatially limited than concurrent benthic surveys and confined to soft-sediment trawl sites, it had the advantage of occurring annually so that temporal trends could be detected. In this paper, we describe annual changes in abundance of major benthic macroinvertebrate groups during 2001–2007, and make comparisons with lakewide sampling during 2000 and 2003 by Nalepa et al. (2007) to evaluate potential mechanisms by which *Dreissena* appears to affect abundance of native taxa, particularly *Diporeia*.

Methods

Benthic macroinvertebrate surveys were conducted annually during 2001–2007 near up to six Lake Huron ports during October–November. Annual collections were made near Detour, Hammond Bay, Thunder Bay, Ausable Point, and Harbor Beach, while collections were made near Goderich, Ontario during 2003 and 2005–2007 (Fig. 1). Collection sites represented a 15-site subset of 46 fixed sites trawled annually in the GLSC bottom trawl survey, and were often located within 20 km of sites sampled by Nalepa et al. (2007) in 2000 and 2003. At each port, three replicate Ponar grabs were taken (0.048 m^2) at three depths (27, 46, and 73 m). Each sample was washed into a bucket with a 0.5 mm sieve and preserved in 5% buffered formalin containing Rose Bengal stain. In the laboratory, benthic macroinvertebrates were picked from the sample, sorted, identified, and counted. Taxonomic level varied among groups; we generally chose identification levels similar to those used by previous researchers. Dreissenids were identified to species and shell lengths (SL) were measured (mm).

We used analysis of covariance (ANCOVA) to compare temporal trends in density of each major taxonomic group among the 15 sites sampled consistently during 2001–2007. Analyses were based on $\log_e + 1$ transformations of density (n/m^2) of each species or group

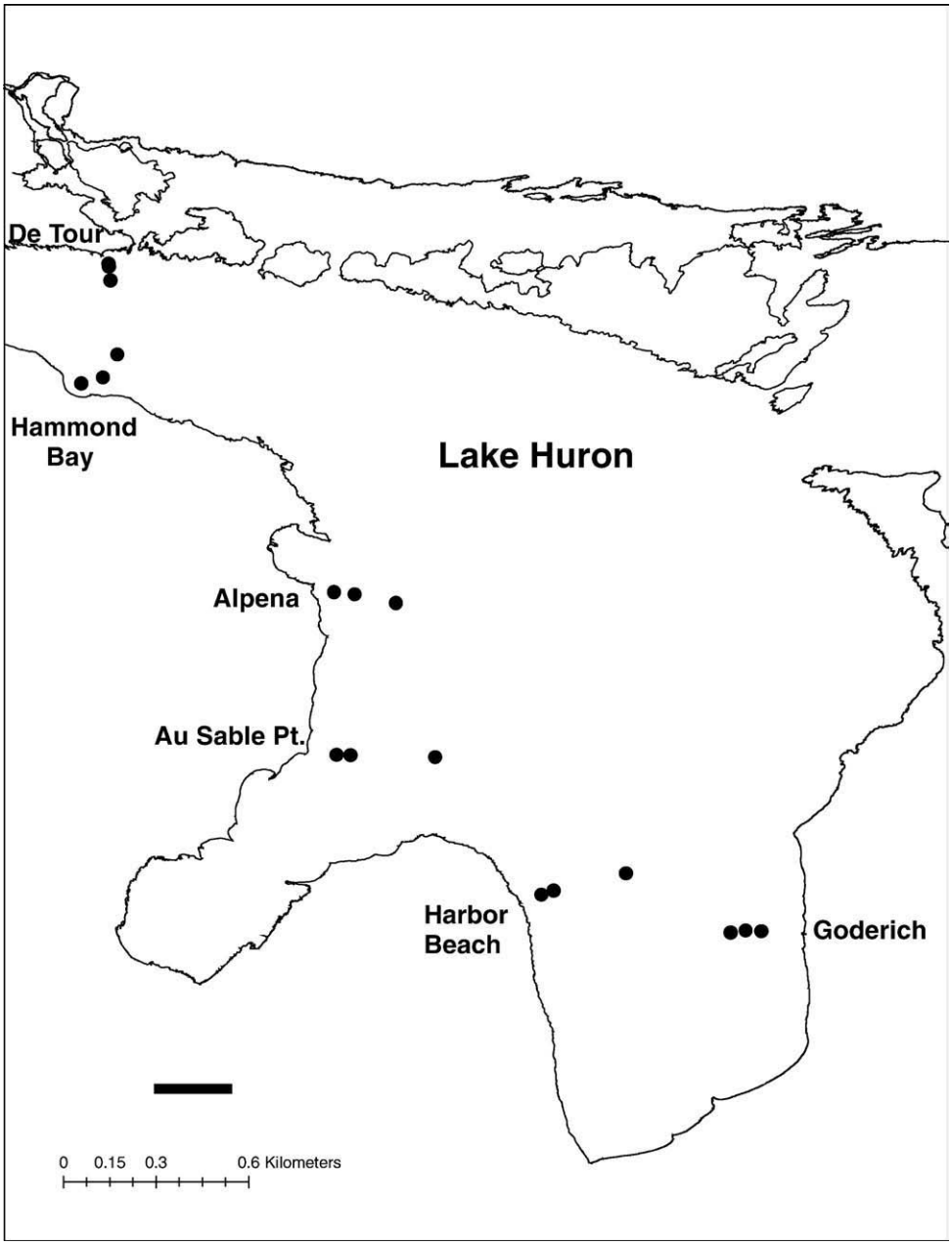

Fig. 1. Benthos sampling stations, western Lake Huron, 2001–2006.