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Distribution, abundance and production of *Hemimysis anomala* in Lake Ontario

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ABSTRACT

Hemimysis anomala is one of the latest macroinvertebrates to invade the Laurentian Great Lakes. Since first reported in 2006, *Hemimysis* have been confirmed in several locations within the Great Lakes basin. However, little is known about the seasonal and spatial variation in demographics and dynamics of *Hemimysis* populations. We used a standardised pier-based methodology to describe the distribution of *Hemimysis* at 29 locations around the shoreline of Lake Ontario in 2009. Samples were collected in spring, summer, and fall at most locations, and bi-weekly at one site (Bronte Creek) over a 12-month period in 2009. For each site, we estimated abundance by sex and size. The more temporally intensive sampling at Bronte Creek enabled us to estimate production. *Hemimysis* were found at 83% of the sites visited, with densities generally highest in the northwest and lower at the other sites. Production estimates (2.67–14.09 mg dry weight$\cdot m^{-2}\cdot d^{-1}$) were higher than that of other common zooplankton species in the Great Lakes. We provide important life history parameters that will help ecologists better understand the potential impacts of *Hemimysis* on Great Lakes ecosystems.

Introduction

Hemimysis anomala (hereafter *Hemimysis*) is one of the latest macroinvertebrates to invade the Laurentian Great Lakes from the Ponto-Caspian region of eastern Europe. Since the late 1950s at least 43 aquatic non-indigenous species (including 30 invertebrates, half being crustacean species) have become established in the Great Lakes basin. Most of the invasive invertebrates arrived via ballast transport (Grigorovich et al., 2003), including *Hemimysis* (Kipp and Ricciardi, 2007). The arrival of *Hemimysis* in the Great Lakes was predicted by Ricciardi and Rasmussen (1998) and the first report of *Hemimysis* in Lake Ontario occurred in the fall of 2006 near Oswego, New York (Kipp and Ricciardi, 2007). In the same year, a large number of individuals were discovered in a channel connecting Lake Michigan to Lake Muskegon (Pothoven et al., 2007a). Currently the presence of *Hemimysis* has been confirmed for all of the Great Lakes except for Lake Superior (Marty et al., 2010), the St. Lawrence River (Kestrup and Ricciardi, 2008), and Oneida (Brooking et al., 2010) and Seneca (Brown et al., 2012-this issue) lakes in New York.

The potential effects of the *Hemimysis* invasion in the Great Lakes are unclear. Introduced mysids have historically had negative impacts on resident species (Chipps and Bennett, 2000; Lasenby et al., 1986; Northcote, 1991; Spencer et al., 1991, 1999). Negative effects of invasive *Hemimysis* were observed in the Netherlands, where several species of cladocerans, ostracods and rotifers significantly declined and one species of Cladocera (i.e. *Chydorus sphaericus*) disappeared after the introduction of *Hemimysis* (Ketelaars et al., 1999). In contrast, Borcherding et al. (2006) reported a positive effect on young-of-the-year perch (*Perca fluviatilis*) where predation on *Hemimysis* by perch resulted in an increase on the lipid content of the fish. The magnitude of any impact associated with an invasion process can be related to the life history traits of the invasive species in question. Ecological characteristics of *Hemimysis* include a wide tolerance of environmental conditions, high reproductive rates, omnivory, high feeding rates, and a concealment behaviour to avoid predation (reviewed by Marty, 2008), which together suggest *Hemimysis* may be able to quickly establish a population. Unlike the native mysid *Mysis diluviana* (hereafter *Mysis*) whose density increases with depth peaking at depths >100 m (Johannsson, 1995), *Hemimysis* occupy shallower depths (<10 m) and warmer temperatures (Borcherding et al., 2006; Marty, 2008). Mysids are important in food webs around the world (reviewed by Rudstam, 2009) and densities of these taxa can exceed 1000 m^{-2} (Johannsson, 1995; Rudstam and Johannsson, 2009). The absence of similar native nearshore mysid species in the Great Lakes basin creates greater uncertainty surrounding the potential impact of *Hemimysis* in the Great Lakes ecosystem (Kestrup and Ricciardi, 2008).

Several studies describe the distribution of *Hemimysis* in the Great Lakes basin (Marty et al., 2010; Walsh et al., 2010) but little is known about the demographics and seasonal dynamics of the populations. Different sampling methodologies can provide highly variable

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estimates of density, and *Hemimysis* behaviours (diel vertical migrations and swarming) (Borcherding et al., 2006; Boscarino et al., 2012-this issue; Salemma and Hietalahti, 1993) may further confound efforts to accurately characterise the population. If a representative sample of the population can be obtained, vital rates (growth rate, generation time, and production) can be estimated. An understanding of the ecology of the new invader will be important when evaluating the associated impacts in the food web (Reid et al., 2007; Walsh et al., 2010). Our objectives were therefore to: 1) apply a standardised methodology to describe the distribution of *Hemimysis* along the shoreline of Lake Ontario, 2) estimate *Hemimysis* abundance based on sex and size, and 3) estimate *Hemimysis* seasonal production during one complete annual cycle in 2009.

Methods

Field collections

In 2009, *Hemimysis* were sampled at 20 Canadian sites by the Ontario Ministry of Natural Resources and at 9 US sites by Cornell University, using standardised night-time shore based sampling (Fig. 1). This lake-wide sampling was performed in the spring (April 20 to June 5), summer (July 20 to Aug 28) and fall (Oct. 19 to Nov 23) of 2009.

The Bronte Creek site (site 2, Fig. 1) was selected for a higher resolution sampling to gather information on *Hemimysis* production. The selection of this site was based on previous sampling that showed high *Hemimysis* density. At the Bronte Creek site, Fisheries and Oceans

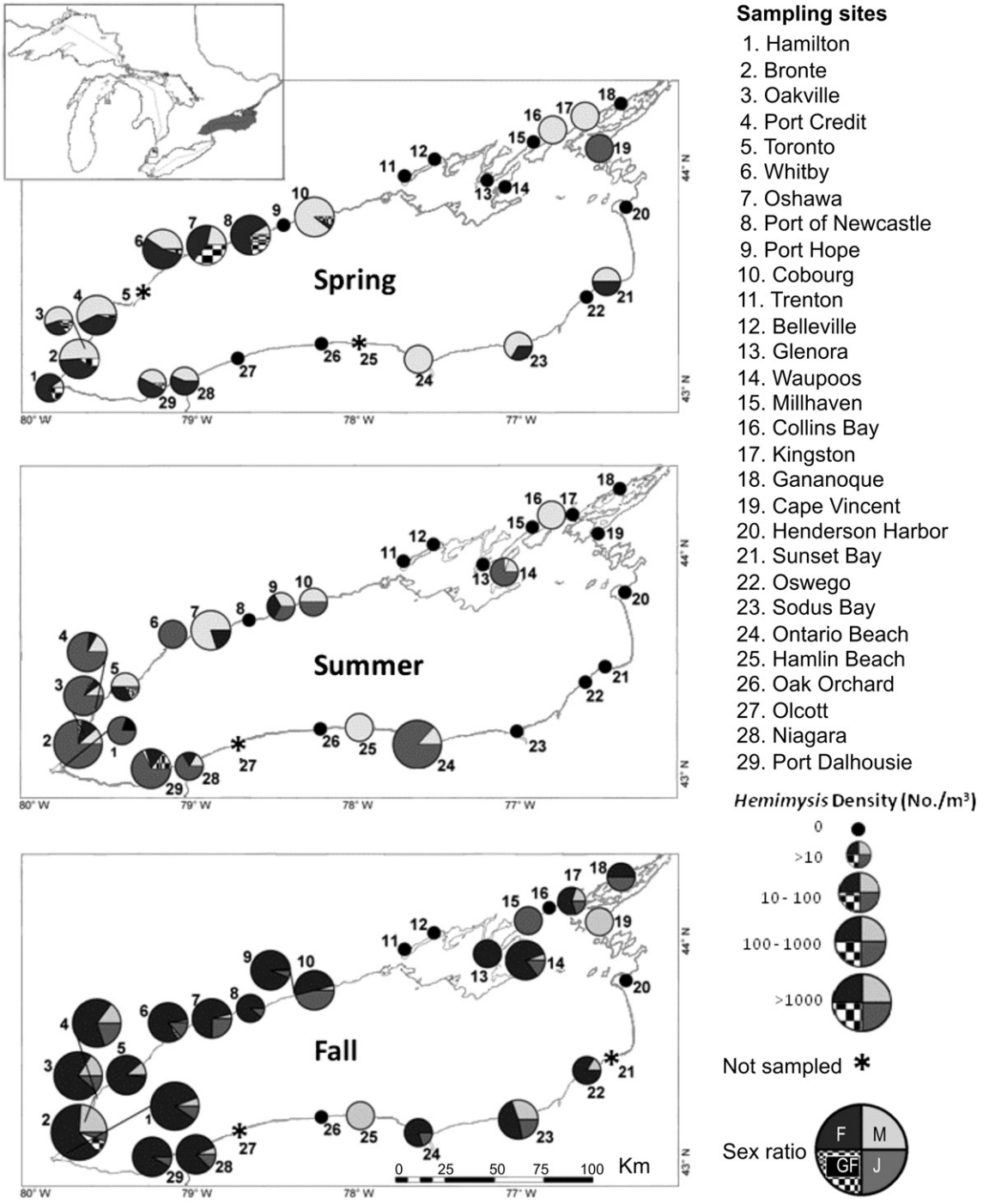

Fig. 1. Distribution and density of *Hemimysis* across Lake Ontario during spring, summer and fall of 2009. F = female, M = male, GF = gravid female and J = juvenile.