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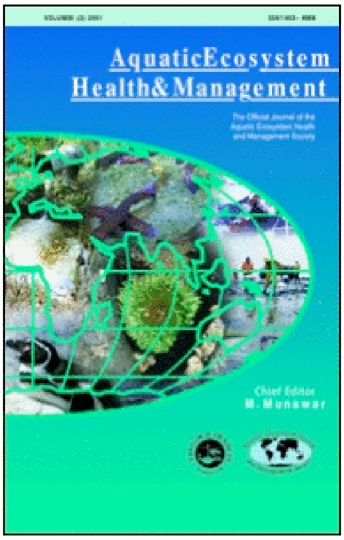

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The distribution of the invasive New Zealand mud snail (*Potamopyrgus antipodarum*) in Lake Ontario

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The invasive New Zealand mud snail, Potamopyrgus antipodarum, *is a world-wide invasive species currently found in Europe, Australia, Japan, and, most recently, North America. It was first discovered in Lake Ontario in 1991. The purposes of this study were to update the current known geographic distribution of the snail, determine the relationship between depth and population densities, and examine the relationship between* Potamopyrgus *and dreissenid mussel densities in Lake Ontario. We sampled several locations in Lake Ontario and determined that the range of* Potamopyrgus *has expanded. However, densities appear to have moderated in the past ten years. In one location (Wilson, NY), the densities of the snail are dependent upon depth with highest densities occurring between 15 and 25 m. At this location, no snails were found at depths of less than 15 m. We found no correlation between the densities of* Potamopyrgus *and invasive mussels. The reasons for apparent reduction in densities over time and the apparent lack of Potamopyrgus in shallow water are discussed.*

Keywords: exotic, *Dreissena*, introduced, gastropod, mollusk

Introduction

The Great Lakes have been inundated with non-indigenous species, and the rate of establishment of those species appears to have increased over time (Mills et al., 1993; Ricciardi and MacIsaac, 2000; Holeck et al., 2004). One of these species, the hydrobiid New Zealand mud snail (*Potamopyrgus antipodarum*), has successfully invaded Europe, Australia (Ponder, 1988), Japan (e.g. Shimada and Urabe, 2003), and, most recently, North America (Bowler, 1991; Zaranko et al., 1997). It was first discovered in the Great Lakes in 1991 in the northeast and southwest corners of Lake Ontario as well as a small portion of the St. Lawrence River (Zaranko et al., 1997). The snail has since expanded its range to include two other Great Lakes: Lake Superior (Grigorovich et al., 2003) and Lake Erie (Levri et al., 2007). Zaranko et al. (1997) noted that the snail was most likely to be found in silt-sand mixture at depths ranging from 4 m to 25 m, and densities typically ranged from about 20 to about 5000 per square meter.

Separate populations of *P. antipodarum* are currently established in rivers and streams of the western United States where they are spreading rapidly and, in some locations, exist in extremely high densities (>500,000 m^2) (Bowler, 1991; Bowler and Frest, 1992; Richards et al., 2001; Richards, 2002; Hall et al., 2003; Kerans et al., 2005) where they are causing substantial ecological changes (Hall et al., 2003; Cada, 2004; Hall et al., 2006; Proctor et al., 2007). In New Zealand, the snail exists in a wide range of habitats: lentic and lotic; freshwater and brackish water; shallow and deep water,

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and on multiple substrates including sand, silt, boulders, and macrophytes (Winterbourn, 1970). *Potamopyrgus* feeds on algae and detritus (Winterbourn, 1970). In New Zealand, the snail exists in mixed populations of sexual and asexual individuals (Lively, 1987). However, all populations in North America are entirely clonal parthenogenetic females (Zaranko et al., 1997; M. Dybdahl, Department of Biological Sciences, Washington State University, Pullman, WA, USA, pers. comm.). There are currently two clones found in the western U.S. In that location the snail was likely introduced by stocking fish (Bowler, 1991; Bowler and Frest, 1992). The primary clone found in the west (US 1) is the same as a clone found in Australia (Emblidge, Fromme and Dybdahl, 2006), thus Australia is the likely source of the introduction. Only one clone is known from the Great Lakes. However, only snails from one site in the Great Lakes have been sampled for their genotypes (Wilson, NY), and multiple introduction events are possible. The clone from Wilson, NY is the same as a clone found in mainland Europe (Euro A) (Emblidge, Fromme and Dybdahl, 2006). Introduction to the Great Lakes likely occurred via transoceanic shipping by transfer of sediment via ballast water or some other mechanism (Zaranko et al., 1997).

In the Great Lakes, *P. antipodarum* appears to be limited to relatively deep water. Zaranko et al. (1997) reported it at depths ranging from 4–25 meters, and other reports also find it at moderate depths of 10 meters or more (Grigorovich et al., 2003; this report). In Lake Superior, it has been found in shallow water in Duluth harbor (<2 m) (M. Neiman, Department of Biology, University of Iowa, Iowa City, IA, USA, pers. comm.). Despite the lack of evidence of the snail in shallow waters of Lake Ontario, the snail has recently been discovered in two streams in New York emptying into Lake Ontario (Levri and Jacoby, 2008). The establishment of the snail in tributary rivers and streams of the Great Lakes may result in extremely high densities and substantial ecological damage similar to what has been observed in the western U.S.

The ecological effects of *Potamopyrgus* in the Laurentian Great Lakes are unknown. Typically, effects of an invader are measured by changes in the biological community since introduction. It is difficult to attribute any ecological changes specifically to *Potamopyrgus* because the timing of the introduction of this species into the Great Lakes coincided or came shortly after the introduction of zebra and quagga mussels (*Dreissena polymorpha* and *Dreissena bugensis*) whose ecological effects are substantial and well-known (MacIsaac, 1996). Likewise data on the density of native gastropods in most areas of the Great Lakes beyond 10 m depth are limited. The ecological impact of this snail has been better studied in lotic habits in Australia and the western United States. In some locations in streams and rivers the snail has been found to exist in extremely high densities ($>500{,}000$ m^{-2}) (Bowler, 1991), consume large amounts of primary production (Hall et al., 2003), compete with native invertebrates (Cada, 2004; Kerans et al., 2005), and negatively influence higher trophic levels (Cada, 2004; Hall et al., 2006). New Zealand mud snails have also been found to substantially alter the nitrogen and carbon cycle in rivers (Hall et al., 2003).

Here we update the known geographic distribution of *P. antipodarum* in Lake Ontario, examine its distribution by depth at one location in Lake Ontario where the snail was first found, and relate its densities to the densities of earlier invaders, zebra and quagga mussels (*D. polymorpha* and *D. bugensis*).

Methods

To determine the distribution of the snail by depth, benthic samples were taken using a ponar dredge from 18 different sites near Wilson, NY, in Lake Ontario (see Figure 1). The sites were along three transects extending from shore out into deeper water. The transects were at least 1 km from each other. Samples were taken at 5 m depth intervals beginning at 10 m depth and extending to 45 m (Table 1). (Previous sampling in 2002 and 2003 did not detect *P. antipodarum* at depths of less than 13 m at this location [see appendix; Levri, unpublished data]). Three ponar dredge samples were taken from each site on each transect over 3 years on 12 and 13 June 2004, 9 July 2005, and 5 June 2006. The three ponar dredge samples per site were combined at the time of sampling; thus variation within site was not examined. The samples were sieved using a fine 2-mm sieve, and preserved in 70% ethanol. All mollusks in the samples were dissected to assess if the snails and mussels were captured alive.

One-way analysis of variance was used to determine if depth had a significant influence on *Potamopyrgus* densities in each year. Univariate analysis of variance was used to determine if densities differed significantly between years considering transect and depth. Loglinear analysis was

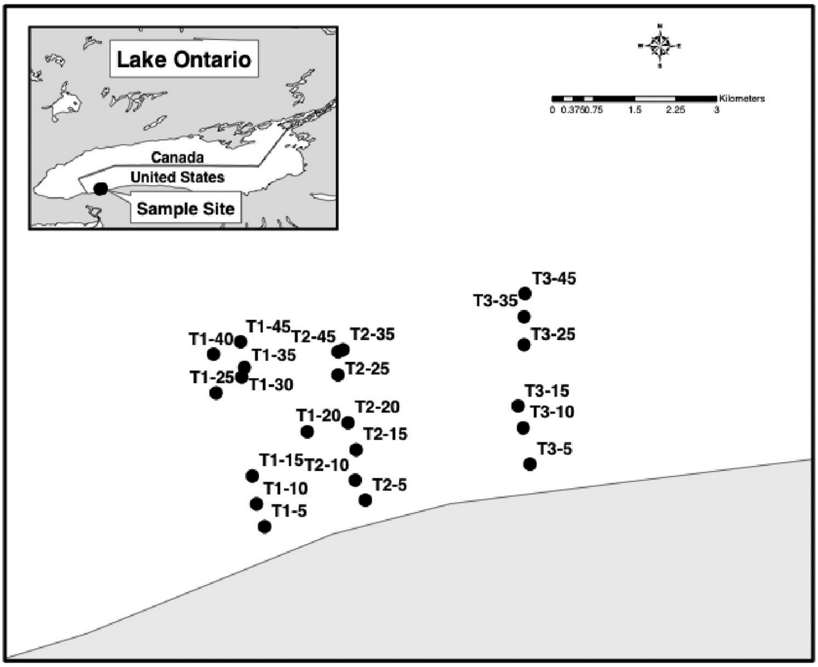

Figure 1. Map of the sites sampled along three transects at Wilson, NY, during the study.

used to determine if the proportion of sites at Wilson, NY, with live *Potamopyrgus* significantly changed over time. Linear regression analysis was used to determine if the densities of *Potamopyrgus* significantly correlated with the densities of dreissenid mussels. ANOVA was used to determine if significant changes in densities occurred across years.

Table 1. Locations of each sampling site along each transect near Wilson, NY, in Lake Ontario.

Transect #	Depth (m)	Latitude	Longitude
1	10	43° 18.51′	78° 54.44′
1	15	43° 18.77′	78° 54.54′
1	20	43° 19.47′	78° 54.54′
1	25	43° 19.65′	78° 54.60′
1	30	43° 19.76′	78° 54.72′
1	35	43° 19.85′	78° 54.63′
1	40	43° 19.97′	78° 54.63′
1	45	43° 20.10′	78° 54.68′
2	10	43° 18.76′	78° 53.57′
2	15	43° 19.01′	78° 53.60′
2	20	43° 19.31′	78° 53.61′
2	25	43° 19.81′	78° 53.70′
2	35	43° 20.01′	78° 53.71′
3	10	43° 19.26′	78° 51.88′
3	15	43° 19.43′	78° 51.91′
3	25	43° 20.08′	78° 51.88′
3	35	43° 20.34′	78° 51.92′
3	45	43° 20.59′	78° 51.86′

Ponar or Ekman samples (0.05 m^2) were also taken from locations in the Bay of Quinte in 1992-2005 (Conway and Lower Quinte), near Kingston, ON, in 2003 and 2004 (Kingston and North Channel), from near Sandy Creek, NY, in 2003, near Burlington, ON, in 2005 (Burlington), and additional samples from Wilson, NY, in 2005. Duplicate dredge samples were collected off Burlington and in the Bay of Quinte, which were seived on a 0.58-mm screen, preserved in 10% buffered formalin and later transferred to alcohol containing a trace of rose bengal to dye the tissue of the molluscs. All molluscs were examined for the presence of dyed tissue or dissected to verify if they were alive when sampled. Sites locations off Burlington were those used by Johnson and Matheson (1968) or Poulton et al. (1988). Those in the Bay of Quinte were locations used by Johnson and McNeil (1986). Hand samples were taken from shallow areas (< 1 m) from several locations along the lake in 2003. Precise coordinates for all samples can be found in the Appendix.

Results

The distribution of *P. antipodarum* in Lake Ontario has increased since the initial report in 1997.

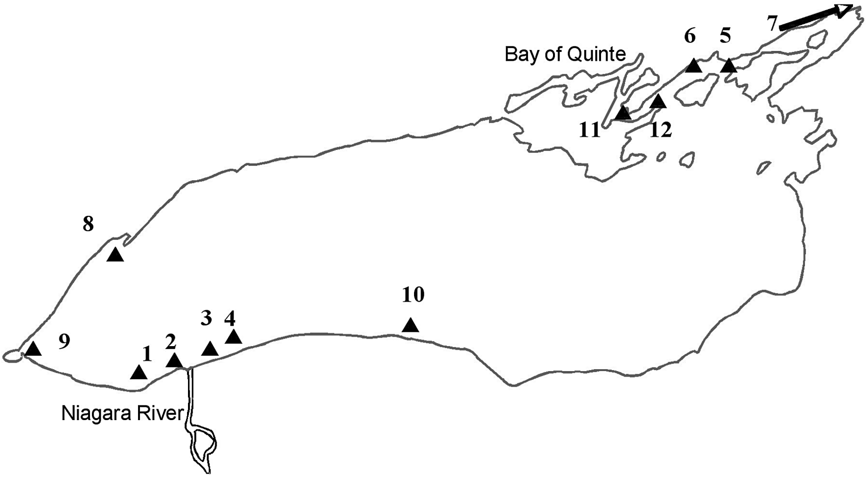

Figure 2. Map of the known findings of *Potamopyrgus antipodarum* in Lake Ontario. Numbers of sites on the map correspond to sites listed in Table 2.

Despite limited sampling, we report *Potamopyrgus* from near Hamilton, ON, Rochester, NY, and in the Bay of Quinte (Fig. 2; Table 2). Densities at these locations (Table 2) are modest compared to the peak densities reported by Zaranko et al. (1997).

Off Wilson, NY (Figure 1), *Potamopyrgus* density peaked between 20 and 25 meters depth in each of the three years sampled (Figure 3). *Potamopyrgus* was not found at depths 10 m or less or greater than 40 m in this study. There was a significant effect of depth on the densities of *Potamopyrgus* in 2004 ($F = 4.57$; $P = 0.026$) and 2005 ($F = 6.73$; $P = 0.004$). No effect of depth on density was found in 2006 ($F = 1.15$; $P = 0.40$). There was a significant reduction in densities at Wilson, NY, between 2004 and 2005 ($F = 15.58$; $P = 0.026$). No difference was found between densities in 2005 and 2006 ($F = 0.001$; $P = 0.978$). Thus, low densities remained in 2006. Significantly fewer sites were found with living *Potamopyrgus* over time (2004 – 12 of 15 sites with *Potamopyrgus*; 2005 – 8 of 16; 2006 – 4 of 17; $X^2 = 10.80$; $P = 0.005$). At Wilson, NY, in both 2004 and 2005, there was not a significant correlation between densities of *Potamopygrus* and dreissenid mussel shells (2004 – $r^2 = 0.024$, $P = 0.61$; 2005 – $r^2 = 0.077$, $P = 0.27$).

Discussion

There have been several new findings of *Potamopyrgus* in Lake Ontario since the original report of the snail in 1997 (Zaranko et al., 1997) (Figure 2; Table 2). Zaranko et al. (1997) sampled extensively in Lake Ontario and found the snail only in the northeast and southwest portions of the lake. These additional findings indicate that this species has spread within Lake Ontario as several of the sites where *Potamopyrgus* was found in this study are very close to sites where *Potamopyrgus* was not found by Zaranko et al. (1997). The snail has also spread to Lakes Erie (Levri et al., 2007) and Superior (Grigorovich et al., 2003), but the possibility remains that these populations in other lakes could be separate introductions. All locations where *Potamopyrgus* has been found in Lake Ontario that we know of can be found in Table 2.

The distribution of *Potamopyrgus* at Wilson, NY, appears highly dependent upon depth (Figure 3). Densities in all three years of the study peaked between 15 and 25 meters, with a steady decline into deeper water. The deepest the snail was found was 40 m. At Wilson, NY, *Potamopyrgus* was not found at 10 m or less at any time during this study. In the study area, the substrate at 8 m and shallower is typically hard substrate which makes Ponar sampling difficult. However extensive qualitative sampling at this site in 2003 and 2006 did not find *Potamopyrgus* at 4, 5, and 10 meters at locations where samples could be taken (see appendix). The findings of *Potamopyrgus* in Lake Erie are also consistent with a relatively deep distribution in the Great Lakes, as the snail was not found in waters shallower than 15 meters (Levri et al., 2007).

There are several possible reasons for the apparent absence of *Potamopyrgus* in shallow water:

1) Wave action may limit the distribution in the near shore habitat of open Lake Ontario. The long fetch across the lake makes the near shore a

Table 2. Sites where *Potamopyrgus antipodarum* has been found in Lake Ontario. Site numbers correspond to Figure 1. Zaranko et al. (1997) densities are mean densities. Data from this report are density ranges.

Site #	Site Name	Depth (m)	Years sampled	Density (m^2)	Source
1	Port Dalhousie	18.5	1994	23–46	Zaranko et al., 1997
2	Port Weller	4.8–13.9	1994	13–327	Zaranko et al., 1997
3	Six Mile Creek	17.8	1994	73–77	Zaranko et al., 1997
4	Wilson	10–40	1990	0	Zaranko et al., 1997
			1991	282–1301	Zaranko et al., 1997
			1992	0–160	Zaranko et al., 1997
			1993	70–760	Zaranko et al., 1997
			1994	77–293	Zaranko et al., 1997
			1995	244–5653	Zaranko et al., 1997
			2003	14–462	Levri et al., this report
			2004	14–588	Levri et al., this report
			2005	0–86	Levri et al., this report
			2006	0–158	Levri et al., this report
5	Kingston	11.6–20	1994	109	Zaranko et al., 1997
			2003	0–28	Levri et al., this report
6	North Channel	18–24.2	1994	104-154	Zaranko et al., 1997
			2003	0–28	Levri et al., this report
7	Prescott	4	1994	15	Zaranko et al., 1997
8	Toronto	n.a.	n.a.	n.a.	D. Zaranko, Zaranko Environmental Assessment Services, Guelph, Ontario, Canada, pers. comm.
9	Burlington	14–31.2	2005	0-60	Levri et al., this report
10	Sandy Creek	30	2003	14	Levri et al., this report
11	Conway	32	1992–2000	0	Levri et al., this report
			2001	4	Levri et al., this report
			2004	8	Levri et al., this report
			2005	0	Levri et al., this report
12	Lower Quinte (9D)	21	1994	160	Levri et al., this report

high-energy zone during storm events. It is possible snail densities are unstable in these wave impacted environments, but wave effects are likely to be minimal at 10 m in depth, and the snail should not be limited by wave action in sheltered bays and inlets, yet up to now the snail has rarely been found in these locations. Zaranko et al. (1997) found the snail at the Port Weller site, which is a sheltered area in the entrance to the Welland Canal, at 4.8 to 9.4 m depth. However, to our knowledge, this is the only sheltered shallow-water site where the snail has been found. 2) The snail may be limited by substrate type. Zaranko et al. (1997) concluded that the snail was more likely to be found in substrates of silty sand rather than the coarse sand and gravels in shallows of the study area. However, the snail is found in many substrates in New Zealand (Winterbourn, 1970). 3) Competitive interactions with native gastropods may limit the distribution. It is possible that native gastropods may be more diverse and exist at higher densities in shallower water and outcompete *Potamopyrgus* in these habitats. Increasing biological diversity is believed to act as a buffer to invasion in other systems (Tilman, 1999; Kennedy et al., 2002). Ponder (1988) found a negative correlation between abundance of *Potamopyrgus* and native hydrobiid snails in Tasmania, and the invasive snail has been shown to compete with other aquatic invertebrates (Aberle et al., 2005). However, other studies have found no relationship (Schreiber

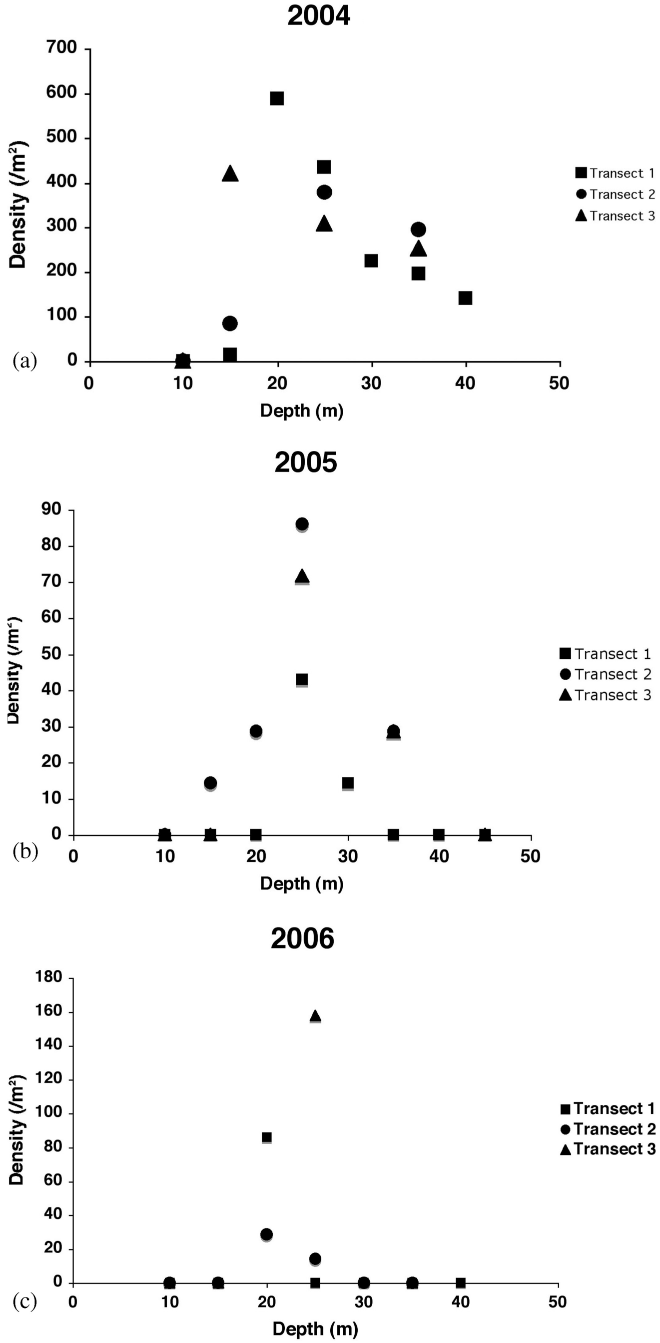

Figure 3. The distribution of *Potamopyrgus* by depth at Wilson, NY, in 2004 (a), 2005 (b) and 2006 (c). Note that the scale of the y-axis varies between graphs.

et al., 2003) or positive correlations (Schreiber et al., 2002) between *Potamopyrgus* abundance and native biodiversity or species densities. The presence of *Potamopyrgus* may also be able to decrease the impact of parasites on populations of native gastropods (Kopp and Jokela, 2007).

Over the three years of the depth study, the density of *Potamopyrgus* significantly decreased at Wilson, NY. In addition, there were three sites that were sampled by Zaranko et al. (1997) and during our study: Wilson, NY, Kingston, ON, and North Channel, ON (Table 1). At all three sites, a general reduction in densities of *Potamopyrgus* was observed over the past 9 years. The reasons for the decreases are unclear, but there are several possibilities. 1) The changes in densities could be natural population fluctuations, and do not represent a trend. Zaranko et al. (1997) reported substantial year-to-year variation in *Potamopyrgus* population sizes in Lake Ontario. 2) This decrease in densities could represent a natural trend seen in many invasive species where initial large population sizes are replaced by more moderate sizes over time (Elton, 1958). 3) The decrease in densities could be in response to an environmental change. The decline in *Potamopyrgus* densities appears to coincide with the expansion of the invasive round goby (*Neogobius melanostomus*) into Lake Ontario (Walsh et al., 2005). Round gobies in the Great Lakes prey on *Dreissena* of < 10 mm length, which would be larger than adult *Potamopyrgus* (Weimer and Sowinski, 1999). It is possible the round goby could be an efficient predator of *Potamopyrgus* as gobioid fish are prominent predators of *Potamopyrgus* in New Zealand (McCarter, 1986; Levri, 1998).

The absence of *Potamopyrgus* in shallow water in Lakes Ontario and Erie probably reduces the rate of establishment of the snail in rivers and streams emptying into the Great Lakes. However, *P. antipodarum* has recently been discovered in two streams emptying into Lake Ontario (Levri and Jacoby, 2008). Thus, the snail must be able to tolerate the conditions of shallow water in the lake to some degree. The same clone that inhabits Lake Ontario (Euro A) is found in a wide variety of habitats in Europe including both lentic and lotic waters (J. Jokela, Institute of Integrative Biology, Swiss Federal Institute of Technology, Zurich, Switzerland, pers. comm.) and including shallow waters of lakes (Dorgelo, 1987). With the recent invasion of *Potamopyrgus* into streams in the Great Lakes region, it is possible that the substantial negative ecological effects of the snail observed in the western US may occur in eastern US rivers and streams. Thus monitoring the distribution of this species in the Great Lakes region is imperative to determine what locations possess the snail so that measures can be taken to reduce its rate of spread.

In the western US, management efforts have focused on reducing the dispersal rate of the snail. The snail appears to be primarily dispersed by attaching to clothing or equipment related to recreational water use. Clothing and equipment should be thoroughly dried or frozen between uses in different water bodies to ensure that mud snails are killed. Treatment with some household cleaners has also been shown to be effective (Proctor et al., 2007).

The presence of invasive mussels (*D. polymorpha* and *D. bugensis*) could, theoretically, facilitate invasion by *Potamopyrgus*. Direct facilitation is possible in this system for two reasons. First, in shallow areas mussel shells (alive and dead) may provide a substrate for meiofaunal colonization and epiphyton, which is a preferred food source for *Potamopyrgus*. Second, in shallow and deep water, mussels may provide fecal matter that *Potamopyrgus* will also ingest. However, our results showed no relationship between mussel density and *Potamopyrgus* density at Wilson, NY. Thus zebra and quagga mussels do not appear to facilitate or limit *Potomopyrgus* populations.

Conclusions

In conclusion, the New Zealand mud snail has expanded its range in Lake Ontario, but it may be moderating in population densities. The densities are correlated with depth, usually peaking between 15 and 25 m. Because of the potential of this species to cause significant ecological change to ecosystems (especially in streams and rivers) it is important that this species be monitored in the Great Lakes region.

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Appendix. Table of sampling locations where samples were taken in this study aside from those used in the Wilson Depth transects (Table 1).

Location	Depth (m)	Years sampled	Latitude	Longitude	*Potamopyrgus* found?
Big Bay (Quinte)	6.5	1992–7; 2001–2; 2004–5	44° 09.305′	77° 10.501′	No
Glenora (Quinte)	23	1992–7; 2001–2; 2004–5	44° 02.692′	77° 01.281′	No
Conway (Quinte)	32	1992–7; 2001–2; 2004–5	44° 06.50′	76° 53.90′	Yes
Lower Quinte (9A)	47	1994–5	44° 05.61′	76° 53.77′	No
Lower Quinte (9B)	40	1994	44° 05.97′	76° 54.20′	No
Lower Quinte (9C)	34	1994	44° 06.25′	76° 54.45′	No
Lower Quinte (9D)	21	1994	44° 06.41′	76° 54.52′	Yes
Lower Quinte (11A)	42	1994–5	44° 06.77′	76° 52.08′	No
Lower Quinte (13A)	48	1994–5	44° 07.90′	76° 50.35′	No
Lower Quinte (13F)	22	1994–5	44° 07.49′	76° 49.620′	No
UpperGap (LOX)	31	1992–7; 2001–2; 2004–5	44° 03.614′	76° 46.575′	No
Main Duck Island (Stn 81)	35	1992–5	43° 58.90′	76° 39.30′	No
Wilson NY (harbor)	4	2003	43° 18.933′	78° 50.305′	No
Wilson NY (shallow)	5	2003; 2006	43° 18.177′	78° 54.517′	No
Wilson NY (shallow)	5	2006	43° 18.907′	78° 51.813′	No
Wilson NY (shallow)	5	2006	43° 18.539′	78° 53.448′	No
Wilson NY (Stn 93)	10	2005	43° 19.275′	78° 51.971′	No
Wilson NY (Stn 93)	18	1992–5; 2005	43° 19.60′	78° 52.10′	Yes
Wilson NY (Stn 93)	30	2005	43° 20.509′	78° 50.502′	Yes
Burlington-54	21.2	2005	43° 18.650′	79° 46.230′	Yes
Burlington-56	15	2005	43° 17.200′	79° 45.100′	Yes
Burlington-60	17.6	2005	43° 17.400′	79° 44.260′	Yes
Burlington-369	4.5	2005	43° 18.300′	79° 47.600′	No
Burlington-371	14	2005	43° 18.317′	79° 46.900′	Yes
Burlington-372	21.2	2005	43° 18.650′	79° 46.230′	Yes
Burlington-378	17.5	2005	43° 18.630′	79° 43.667′	Yes
Burlington-380	9.8	2005	43° 15.580′	79° 45.200′	Yes
Burlington-381	15.3	2005	43° 16.217′	79° 44.233′	No
Burlington-382	21.0	2005	43° 16.816′	79° 43.033′	Yes
Burlington-383	31.2	2005	43° 17.600′	79° 41.550′	No
Sandy Creek, NY	30	2003	43° 22.575′	77° 53.613′	Yes
Sandy Creek, NY	100	2003	43° 25.506′	77° 53.623′	No
Sandy Creek, NY	15	2003	43° 22.007′	77° 53.047′	No
Oswego Harbor	3	2003	43° 27.699′	76° 30.601′	No
Selkirk Shores SP	0.5	2003	43° 33.084′	76° 12.822′	No
Sandy Point	0.5	2003	43° 40.290′	76° 11.087′	No
Henderson Harbor	0.5	2003	43° 50.982′	76° 12.373′	No
Stony Point	0.5	2003	43° 53.229′	76° 13.761′	No
Westcott Beach SP	0.5	2003	43° 54.078′	76° 07.589′	No
Chaumont	0.5	2003	44° 04.089′	76° 08.923′	No
Burnham SP	0.5	2003	44° 09.822′	76° 15.862′	No
Cedar Point SP	0.5	2003	44° 12.332′	76° 11.881′	No
Grass Point SP	0.5	2003	44° 16.868′	75° 59.965′	No
Keewaydin SP	0.5	2003	44° 19.372′	75° 56.054′	No
Dewolf Point SP	0.5	2003	44° 19.922′	75° 59.480′	No
Wellesley Point SP	0.5	2003	44° 20.023′	76° 01.950′	No

(Continued on next page)

Appendix. Table of sampling locations where samples were taken in this study aside from those used in the Wilson Depth transects (Table 1). *(Continued)*

Location	Depth (m)	Years sampled	Latitude	Longitude	*Potamopyrgus* found?
Kingston, ON	10	2003	44° 12.830′	76° 31.303′	Yes
Kingston, ON	15	2003	44° 12.777′	76° 31.258′	No
Kingston, ON	20	2003	44° 12.628′	76° 31.147′	No
Kingston, ON	21	2003	44° 12.709′	76° 31.234′	No
Kingston, ON	18	2003	44° 12.651′	76° 29.187′	Yes
Kingston, ON	19	2003	44° 13.094′	76° 29.521′	Yes
Kingston, ON	13	2003	44° 13.210′	76° 30.003′	No
East Kingston, ON	10	2003	44° 15.174′	76° 23.018′	No
East Kingston, ON	2.5	2003	44° 15.582′	76° 22.743′	No
North Channel, ON	11.5	2003	44° 11.510′	76° 44.096′	No
North Channel, ON	16	2003	44° 11.507′	76° 44.023′	yes
North Channel, ON	17.5	2003	44° 11.410′	76° 44.150′	yes
North Channel, ON	24	2003	44° 10.819′	76° 44.162′	No
North Channel, ON	30	2003	44° 10.500′	76° 44.110′	No