2012 – 2015 Unionid monitoring and biodiversity observation (UMBO) Network assessment in the Sydenham River watershed, Ontario

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Freshwater mussel surveys were conducted in the Sydenham River watershed between June 26, 2012 and August 24, 2015 as part of the first monitoring event of Fisheries and Oceans Canada's Unionid Monitoring and Biodiversity Observation (UMBO) network. A systematic sampling approach was employed by dividing the area (375 m^2) into 25 blocks, each 3 m x 5 m in size. Three quadrats were randomly selected for excavation, and those same three quadrats were excavated within each block. A total of 10,277 individuals representing 31 live species were found across 13 sites (three on Bear Creek and 10 on the East Sydenham River). Twelve species at risk (SAR) were detected and represented 37% of all individuals found. The most abundant common species and SAR in Bear Creek were *Amblema plicata* (Threeridge) and *Quadrula quadrula* (Mapleleaf). In the East Sydenham River, the most common species and SAR were *Lasmigona costata* (Flutedshell) and *Cyclonaias tuberculata* (Purple Wartyback). In addition, one UMBO site was completely sampled for mussels (i.e., all 375 m^2 excavated) and over 6,000 individuals representing 25 species, including 10 SAR, were observed. This monitoring event represents an important step in the collection of trend-through-time data and is imperative to understanding and managing mussel species in the Sydenham River watershed.

RESUMÉ

McNichols-O'Rourke, K.A. and Morris, T.J. 2024. 2012–2015 Unionid Monitoring and Biodiversity Observation (UMBO) network assessment in the Sydenham River watershed, Ontario. Can. Data Rep. Fish. Aquat. Sci. 1413: ix + 50 p.

Des relevés des moules d'eau douce ont été effectués dans le bassin versant de la rivière Sydenham entre le 26 juin 2012 et le 24 août 2015 dans le cadre de la première activité de surveillance du réseau de surveillance des unionidés et d'observation de la biodiversité (UMBO) de Pêches et Océans Canada. Une méthode d'échantillonnage systématique a été utilisée et la zone a été divisée en 25 blocs (d'une superficie de 375 m^2) de 3 m sur 5 m. Dans chaque bloc, trois quadrats ont été sélectionnés au hasard pour une excavation complète. Au total, 10 278 individus représentant 31 espèces vivantes ont été observés sur 13 sites (trois sur le ruisseau Bear et dix sur la rivière East Sydenham). Douze espèces en péril ont été détectées et représentaient 37 % de tous les individus observés. Les espèces communes et les espèces en péril les plus répandues dans le ruisseau Bear étaient l'amblème à trois côtes et la mulette feuille-d'érable. Dans la rivière East Sydenham, les espèces communes et les espèces en péril les plus courantes étaient la lasmigone cannelée et la mulette verruqueuse. Un site de l'UMBO a également fait l'objet d'un échantillonnage complet (visant la totalité des 375 m^2 excavés) pour la recherche de moules et plus de 6 000 individus représentant 25 espèces, dont 10 espèces en péril, ont été observés. Cette activité de surveillance marque une étape importante dans la collecte de données sur l'évolution des tendances dans le temps et elle est essentielle à la compréhension et à la gestion des espèces de moules présentes dans le bassin hydrographique de la rivière Sydenham.

INTRODUCTION

Freshwater mussels (Bivalvia; Unionida) play an important ecological and engineering role in aquatic ecosystems (Vaughn 2018) by providing chemical and physical habitat, cycling nutrients, modifying food webs, and biofiltration to name a few. They are also one of the most globally imperiled taxa with declines attributed to pollution, habitat degradation and modification, degraded water quality, invasive species, climate change, and loss of host fishes (Ferreira-Rodríguez et al. 2019; Böhm et al. 2020; COSWIC 2021). Ferreira-Rodríguez et al. (2019) noted that ~57% of the 535 freshwater mussel species assessed by the International Union for Conservation of Nature in 2017 were either considered at-risk (~40%) or data deficient (~17%). According to Lopes-Lima et al. (2018), 67% of North American species are threatened and near-threatened. In Canada, there are 55 species of freshwater mussels and 37% of those have been assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as at-risk (extinct, endangered, threatened, or special concern; Government of Canada 2023).

Ontario is considered the Canadian “hotspot” for freshwater mussels as it is home to 41 species, 16 of which have been assessed as species at risk (SAR) by COSEWIC (Table 1; Government of Canada 2023). Despite their place at the centre of Canadian mussel richness, Ontario rivers received little survey attention during the first half of the last century. Detweiler (1918) undertook the first broadscale surveys across southwestern Ontario in 1916 and Larocque and Oughton (1937) summarized the state of the fauna for much of the province two decades later. While scattered surveys occurred over the subsequent decades (e.g., Kidd 1973; Mackie and Topping 1988; Mackie 1996, Morris 1996; Metcalfe-Smith et al. 1998; 1999; Morris and Di Maio 1998-1999; Metcalfe-Smith et al. 2000 a;b) it wasn’t until the early part of the current century that survey efforts became more intensive (McGoldrick and Metcalfe-Smith 2004; Morris et al. 2012a; b; McNichols-O’Rourke et al. 2012; Minke-Martin et al. 2012; Sheldon et al. 2020). One important exception to this pattern is the Sydenham River, which received more survey attention than most (Clarke 1973; Mackie and Topping 1988; Clarke 1992; Dextrase et al. 2003; Metcalfe-Smith et al. 2003; Staton et al. 2003; Metcalfe-Smith et al. 2007; McNichols 2007; Woolnough 2002).

The Sydenham River supports one of the most diverse mussel and fish communities in all of Canada (Dextrase et al. 2003). Clarke (1992) referred to it as “…the richest system for Unionidae in Canada and one of the richest small river systems in North America”. As such, in 1999, the Sydenham River Recovery Team was formed to create a National Recovery Strategy for Species at Risk in the Sydenham River using an ecosystem approach (Dextrase et al. 2003). Since 1997, 33 extant freshwater mussel species have been observed in the Sydenham River, including 14 that are considered at-risk (Table 1). Given the importance of this river, a long-term monitoring program, now known as the Unionid Monitoring and Biodiversity Observation (UMBO) network, was established within the watershed in 1999 by Environment Canada. The goal of the network was to collect baseline information to track changes through time for a number of variables (e.g., species density and richness, habitat

changes). Fifteen sites were selected in the Sydenham River watershed and originally surveyed between 1999–2003: three in Bear Creek and 12 in the East Sydenham River (Figure 1; Metcalfe Smith et al. 2007). Thirteen of these sites (all three in Bear Creek and 10 in the East Sydenham River) were surveyed a second time between 2012–2015; however, these surveys were completed by Fisheries and Oceans Canada (DFO). DFO became responsible for the protection, recovery, and conservation of all aquatic species listed under the federal *Species at Risk Act* (SARA) when it came into effect in 2003. Given this responsibility, freshwater mussel survey responsibilities transitioned from Environment Canada to DFO in 2004.

The information in this data report summarizes results of the second survey (first monitoring event) for 13 UMBO network sites in the Sydenham River sampled between 2012 and 2015.

METHODS

SYDENHAM RIVER

The Sydenham River watershed is part of the Lake Erie basin and is located in southwestern Ontario. It drains an area of approximately 2,700 km^2 and is relatively undisturbed by industrial development as land use is over 85% agricultural (SCRCA 2024). The Sydenham River has two main branches—the North Sydenham River and the East Sydenham River—that meet in Wallaceburg, Ontario and drain into Lake St. Clair (Dextrase et al. 2003). The East Sydenham River, the larger of the two branches, has a higher number of mussel species (SCRCA 2024). This has been attributed in part to the difference in substrates and therefore available habitat (SCRCA 2024). The East Sydenham River is made up of a variety of substrates (e.g., gravel, sand, silt, clay) and habitat (e.g., riffle, run, pool) types, whereas the North Sydenham River is largely silt and clay substrate with only few riffle habitats that are considered low quality (Fisheries and Oceans Canada 2018). There are two main tributaries on the North Sydenham River: Bear Creek and Black Creek. All three UMBO sites on the North Sydenham River are located in Bear Creek. Although the East Sydenham River has a number of smaller tributaries, all UMBO sites were located on the main stem.

SAMPLING METHODS

Sampling followed the methods of Metcalfe-Smith et al. (2007) in areas previously surveyed using the same technique that was employed in 1999–2003 (see Appendix A for a list of original site coordinates). A visual search of the area was used to confirm the continued presence of mussels within the plot area before setup occurred. The sampling protocol delineated a 375 m^2 area, where a systematic sampling approach was employed by dividing the area into 25 blocks, each 3 m x 5 m in size. Three 1 m^2 quadrats were randomly selected, using a random number generator, for complete excavation (Figure 2). Those same three quadrats were excavated in each block at a given site. The surveyed area was always sampled in the upstream direction and each quadrat was surveyed using four different techniques in the following order: (1) visual search with the naked eye; (2) visual search with a viewing box/aquascope; (3) excavation to a depth of 10-15 cm; and (4) final search with a viewing box/aquascope to see if any mussels were missed or dislodged during excavation. All mussels found at each step were identified to species, sexed visually (if possible), and

measured (maximum length) using Vernier calipers. Species that were not sexually dimorphic were not sexed. Any shells or valves found were also identified to species and recorded if no live individuals of the species were observed. Vouchers were collected following the methods of Morris et al. (2022). After processing, all live mussels were returned to the same 1 m^2 area from which they were collected.

Prior to mussel sampling, site data including air temperature, wind speed (Kestrel 2000 Pocket Wind Meter), water temperature and chemistry (EXO2 multiparameter YSI) were collected. Different information for each specific quadrat was collected before and after excavation. Prior to excavation, water velocity (m/s) using an OTT MF Pro flow meter (OTT HydroMet, Kempten, Germany), depth (m) using a metre stick, and water clarity (m) using a 0.60 m turbidity tube were recorded. Information collected after quadrat excavation included a visual estimate of substrate composition (%) using Stanfield (2010) substrate class categories, degree of siltation (absent, slight, medium, heavy), degree of algal growth (absent, present, abundant [> 50% coverage]), shading (dense, partly open, open), and the presence or absence of aquatic macrophytes. Any information not collected or mis-collected were not included in summaries.

In 2012, one site (SR-06) was completely excavated and sampled for mussels throughout the entire 375 m^2 area to evaluate the quadrat-based protocol (see Reid and Morris 2017). Methods for mussel excavation and identification were followed as described above for all 375 m^2; however, specific quadrat habitat information was only collected for the three randomly sampled quadrats in each block.

DATA ANALYSIS

Site Density

As described in Goguen et al. (2022), mean site density (mussels/m^2) was calculated for each site. Density of each block (D_{block}) at each site was calculated from Thompson (1992) using the following formula:

$$[1] \quad D_{block} = \frac{\tau}{A}$$

where τ is the total number of freshwater mussels in the block and A is the total area sampled (i.e., 3 m^2). Equation [1] was then used to calculate the mean site density using:

$$[2] \quad D_{site} = \frac{\sum D_{block_i}}{n}$$

where $\sum D_{block_i}$ is the summation of block densities within a site and n is the total number of blocks surveyed at the site (i.e., 25). Standard error was calculated by dividing the standard deviation by the square root of the number of samples (i.e., the number of blocks sampled; Zar 1999).

Population Size Structure

Length frequency distribution graphs were created for two species: the most abundant common species and the most abundant SAR in each of Bear Creek and the East Sydenham River.

The proportion of juveniles observed was calculated for *Cyclonaias tuberculata* (Purple Wartyback) in the East Sydenham River as species-specific juvenile length data were available from van der Lee et al. (2024) for the Sydenham River population. The proportion of juveniles was calculated by combining the total number of *C. tuberculata* across all sites in the East Sydenham River and comparing this to the number of juvenile *C. tuberculata*.

$$[3] \propto juveniles = \frac{\sum J_i}{n}$$

where $\sum J_i$ is the number of juvenile *C. tuberculata* (individuals under a length of 53.2 mm) and *n* is the total number of *C. tuberculata* found from all sites within the East Sydenham River.

RESULTS

Between June 26, 2012 and August 24, 2015, 13 sites were sampled in the Sydenham River watershed. Three sites were located in the North Sydenham River on Bear Creek and 10 sites were located in the East Sydenham River (Table 2, Figure 1). Two sites, SR-20 and SR-21, were not sampled due to the difficult and expensive survey requirements (use of SCUBA gear). A total of 10,277 mussels representing 31 live species, including 12 SAR, were found across all 13 UMBO sites using the standard protocol (three 1 m^2 quadrats excavated in each block at each; Tables 3, 4). One additional species, *Lampsilis fasciola* (Wavyrayed Lampmussel), was detected as a weathered shell. Appendix B contains detailed species information on each site including the year sampled, number of blocks and quadrats, abundance, relative abundance, density, frequency of occurrence, and minimum and maximum lengths (mm) for each species.

BEAR CREEK

A total of 640 individuals were found across three sites (Table 2) in Bear Creek, representing 16 species (Table 3). Three of these species were SAR (*Cambarunio iris* [Rainbow], *Pleurobema sintoxia* [Round Pigtoe], and *Quadrula quadrula* [Mapleleaf]) which made up ~9% of all individuals found. A weathered shell from *Ortmanniana ligamentina* (Mucket) was also found.

Abundance and species richness across the three sites in Bear Creek ranged from 129–373 and 5–11, respectively. Site SR-15 had the highest abundance (n = 373) making up 58% of the mussels found in Bear Creek. The site with the lowest abundance (n = 129) was SR-09. Species richness was lowest at SR-13 (n = 5) and highest at SR-15 (n = 11), with *O. ligamentina* represented as a shell only (Table 3). Mean site density (± standard error) ranged from 1.79 (± 0.36) mussels/m^2 at SR-09 to 4.97 ± 0.62 mussels/m^2 at SR-15 (Table 5).

The most abundant common species in Bear Creek was *Amblema plicata* (Threeridge), with 240 individuals observed and a relative abundance of 37.5%. *Amblema plicata* lengths ranged from 27.1–171.4 mm (Figure 3). The most abundant SAR was *Q. quadrula* with 57 individuals observed and a relative abundance of almost 9%. All of these individuals occurred at a single site, SR-13, with lengths ranging from 26.7–122.22 mm (Figure 4, Appendix B).

Air temperature and water quality measurements were not consistently recorded at all sites on Bear Creek (Table 6). Air temperature at SR-15 in 2015 was recorded at 30.2 °C. Water temperature ranged from 20.4–26.8 °C at the two sites where it was recorded. Conductivity and total dissolved solids (TDS), ranged from 575 to 702.1 µs/cm, and 410 to 456 mg/L, respectively. Salinity was recorded as 031 psu at a single site. Dissolved oxygen (% and mg/L) ranged from 64.5–71.7% and 5.14–6.46 mg/L at two sites, respectively, and pH ranged from 7.94–8.61 when recorded. Turbidity was recorded at a single site and was 40.5 fnu. Table 7 summarizes the mean water velocity, depth, water clarity, and substrate composition per square metre across all three sites sampled. SR-09 had the highest mean water velocity at 0.09 ± 0.02 m/s and mean water clarity at 0.83 ± 0.01 m. SR-15 was the deepest site averaging 0.53 ± 0.03 m across quadrats. Gravel and clay were the most abundant substrate across all three sites, making up over 50% of the substrate. Siltation, algal growth, shading, and the presence of aquatic macrophytes varied across quadrats and sites (Table 7).

EAST SYDENHAM RIVER

A total of 9,637 individuals representing 31 live species were found at the 10 sites surveyed in the East Sydenham River (Table 4). Thirteen of these were SAR with 3,745 individuals observed, making up ~39% of the assemblage. On additional species, *L. fasciola*, was collected as a weathered shell brining the total species richness count to 32.

Abundance and species richness across the 10 sites in the East Sydenham River ranged from 165–2,309 and 18–27 species, respectively. Site SR-19 had the highest abundance (n = 2,309) making up 24% of the mussels found in the East Sydenham River, whereas SR-03 had the lowest abundance (n = 165). The site with the lowest species richness was SR-02 (n = 18) and the highest was SR-12 (n = 27), with four species (*Obovaria subrotunda* [Round Hickorynut], *Pyganodon grandis* [Giant Floater], *Simpsonaias ambigua* [Salamander mussel], and *Utterbackia imbecillis* [Paper Pondshell]) observed as shells/valves only (Table 4). Mean site density (± standard error) on the East Sydenham River ranged from 2.39 (± 0.44) mussels/m^2 at SR-03 to 30.79 (± 2.44) mussels/m^2 at SR-19 (Table 8).

Lasmigona costata (Flutedshell) was the most common species observed in the East Sydenham River with 2,003 individuals found across all 10 sites (Table 4). Lengths ranged from 11–196.7 mm (Figure 5). *Cyclonaias tuberculata* was the most abundant SAR with 1,896 individuals observed. Lengths ranged from 12–198.9 mm with almost 11% (n = 221) classified as juveniles (< 53.2 mm; Figure 6).

Environmental data collected once at each site prior to quadrat sampling were not consistently recorded. Table 9 summarizes the information recorded at each of the

10 sites. Air and water temperature ranged from 14.5–25.2 °C and 18.50–24.90 °C, respectively. EXO2 multiparameter YSI water quality measurements were only measured for four sites and details can be found in Table 9. In the East Sydenham River, mean (± standard error) water velocity ranged from 0.24 (± 0.02) m/s at SR-10 to 0.44 (± 0.02) m/s at SR-19, mean depth from 0.15 (± 0.01) m at SR-07 to 0.61 (± 0.01) m at SR-12, and mean water clarity from 0.05 (± 0.001) m at SR-03 to 0.26 (± 0.01) m at SR-17 (Table 10). Eighty percent of substrate in the East Sydenham River was made up of sand, gravel, and cobble (Table 10). Descriptive ranges of siltation, algal growth, shading, and presence of aquatic macrophytes were variable among sites and are shown in Table 10.

FULL EXCAVATION – SR-06

A single site, SR-06, was fully excavated (all 375 m^2) for mussels during the 2012 sampling. This was done to create a census dataset to use as a comparison to the standard protocol (three 1 m^2 quadrats excavated per block = 75 m^2) described above (Reid and Morris 2017). Twenty-five species, including 10 SAR, were found, totalling 6,178 mussels (Table 11). Species at risk represented 56% of the mussels detected. The dominant species observed was the threatened *C. tuberculata* (n = 2,616), which had a relative abundance of 42%. The second most abundant species was the common *L. costata* (n = 746) with a relative abundance of 12%. Mean density (± standard error) at SR-06 was 16.47 (± 1.72) mussels/m^2 (Table 12).

The only water quality parameter recorded at SR-06 was air temperature, which was 24.1°C at the start of the sampling period (Table 9). Habitat data were only collected for the three random quadrats (i.e., not all quadrats excavated) chosen before the survey began and are presented in Table 10.

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Table 1. Mussel species found in Ontario and the current and historic (before 1997) occurrence of these species in the Sydenham River (updated from McNichols-O'Rourke et al. 2012). Species at Risk (SAR) are highlighted with their current COSEWIC assessment, federal *Species at Risk Act* (SARA) listing (Government of Canada 2023), and provincial *Endangered Species Act* (ESA) listing (Government of Ontario 2023) as of February 2024. UC indicates species that are under consideration for listing. Species found live in the watershed are indicated by Y, species not found by N, and species known only as shells/valves in the watershed by SH. Nomenclature here and throughout follows MolluscaBase eds. (2023).

Scientific Name	Common Name	Ontario	Sydenham River Historic	Sydenham River Current	COSEWIC	SARA (Federal)	ESA (Provincial)
Alasmidonta marginata	Elktoe	Y	Y	Y			
Alasmidonta undulata	Triangle Floater	Y	N	N			
Alasmidonta viridis	Slippershell	Y	Y	SH			
Amblema plicata	Threeridge	Y	Y	Y			
Anodontoides ferussacianus	Cylindrical Papershell	Y	Y	Y			
Cambarunio iris[1]	Rainbow	Y	Y	Y	Special Concern	Special Concern	Special Concern
Cyclonaias pustulosa	Pimpleback	Y	Y	Y			
Cyclonaias tuberculata	Purple Wartyback	Y	Y	Y	Threatened	UC	Threatened
Elliptio complanata	Eastern Elliptio	Y	N	N			
Epioblasma rangiana	Northern Riffleshell	Y	Y	Y	Endangered	Endangered	Endangered
Epioblasma triquetra	Snuffbox	Y	Y	Y	Endangered	Endangered	Endangered
Eurynia dilatata	Spike	Y	Y	Y			
Fusconaia flava	Wabash Pigtoe	Y	Y	Y			
Lampsilis cardium	Plain Pocketbook	Y	Y	Y			
Lampsilis fasciola	Wavyrayed Lampmussel	Y	Y	Y	Special Concern	Special Concern	Threatened
Lampsilis radiata	Eastern Lampmussel	Y	N	N			
Lampsilis siliquoidea	Fatmucket	Y	Y	Y			
Lasmigona complanata	White Heelsplitter	Y	Y	Y			
Lasmigona compressa	Creek Heelsplitter	Y	Y	Y			
Lasmigona costata	Flutedshell	Y	Y	Y			
Ligumia recta	Black Sandshell	Y	Y	Y			
Obliquaria reflexa	Threehorn Wartyback	Y	N	Y	Threatened	Threatened	Threatened

Table 1. Continued.

Scientific Name	Common Name	Ontario	Sydenham River Historic	Sydenham River Current	COSEWIC	SARA (Federal)	ESA (Provincial)
Obovaria olivaria	Hickorynut	Y	N	N	Endangered	Endangered	Endangered
Obovaria subrotunda	Round Hickorynut	Y	Y	Y	Endangered	Endangered	Endangered
Ortmanniana ligamentina	Mucket	Y	Y	Y			
Paetulunio fabalis[2]	Rayed Bean	Y	Y	Y	Endangered	Endangered	Endangered
Pleurobema sintoxia	Round Pigtoe	Y	Y	Y	Endangered	Endangered	Endangered
Potamilus alatus	Pink Heelsplitter	Y	Y	Y			
Potamilus fragilis	Fragile Papershell	Y	Y	Y			
Ptychobranchus fasciolaris	Kidneyshell	Y	Y	Y	Endangered	Endangered	Endangered
Pyganodon cataracta	Eastern Floater	Y	N	N			
Pyganodon grandis	Giant Floater	Y	Y	Y			
Pyganodon lacustris	Lake Floater	Y	N	N			
Quadrula quadrula	Mapleleaf	Y	Y	Y	[4]Special Concern	[4]Special Concern	Special Concern
Sagittunio nasutus[3]	Eastern Pondmussel	Y	Y	N	Special Concern	Special Concern	Special Concern
Simpsonaias ambigua	Salamander Mussel	Y	Y	Y	Endangered	Endangered	Endangered
Strophitus undulatus	Creeper	Y	Y	Y			
Toxolasma parvum	Lilliput	Y	Y	Y	Endangered	Endangered	Threatened
Truncilla donaciformis	Fawnsfoot	Y	SH	Y	Endangered	Endangered	Endangered
Truncilla truncata	Deertoe	Y	Y	Y			
Utterbackia imbecillis	Paper Pondshell	Y	Y	Y			
Species Richness		41	34	34			
Overall Species Richness		41	35				

Species currently listed under SARA and formerly known as:
[1]*Villosa iris*
[2]*Villosa fabalis*
[3]*Ligumia nasuta*
[4]Great Lakes – Upper St. Lawrence population

Table 2. Unionid Monitoring and Biodiversity Observation (UMBO) network sites and dates sampled (DD-MMM-YY) in Bear Creek and East Sydenham River in southwestern Ontario between 2012–2015 within the Lake St. Clair Drainage. Sites are presented in upstream to downstream order. *Only accessible with landowner permission.

	Site Code	Waterbody	Latitude	Longitude	Date Surveyed	Original Survey Date
Bear Creek	SR-09	Bear Creek	42.975	-81.97083	09-Jul-2012	12-Sep-2001
	SR-15	Bear Creek	42.9062	-82.11107	17-Jul-2013	12-Aug-2002
	SR-13	Bear Creek	42.84866	-82.2138	24-Aug-2015	12-Aug-2003
East Sydenham River	SR-01	Sydenham River	42.86063	-81.78848	04-Jul-2012	26-Aug-2002
	SR-10	Sydenham River	42.8472	-81.82283	19-Aug-2013	07-Aug-2001
	SR-02	Sydenham River	42.80654	81.84698	22-Jul-2013	02-Sep-2003
	SR-03	Sydenham River	42.77887	-81.83517	26-Jun-2012	09-Aug-1999
	SR-07*	Sydenham River	42.699	-81.989	14-Aug-2013	26-Aug-2003
	SR-17*	Sydenham River	42.677687	-82.010922	25-Jul-2012	30-Jul-2001
	SR-05	Sydenham River	42.65007	-82.00903	10-Aug-2015	13-Aug-2003
	SR-19*	Sydenham River	42.62678	-82.02304	29-Jul-2013	19-Aug-2002
	SR-06*	Sydenham River	42.60517	-82.07483	07-Aug-2012	22-Jul-2002
	SR-12	Sydenham River	42.5892	-82.12808	27-Jul-2015	27-Jul-1999

Table 3. Species information for each Unionid Monitoring and Biodiversity Observation (UMBO) site surveyed in Bear Creek between 2012–2015. All species recorded from the Sydenham River watershed are listed. Sites are presented in upstream to downstream order. Species at risk are highlighted. S(#) represents species found as complete shells and the number of shells found. V(#) represents species found as valves (one half of a complete shell) and the number of valves found. Unknown individuals (could not be identified to species) are included in the abundance total, but not in the species richness totals. All shells/valves were in weathered condition.

Scientific name	Common Name	SR-09	SR-15	SR-13	Grand Total
Alasmidonta marginata	Elktoe	0	0	0	0
Alasmidonta viridis	Slippershell	0	0	0	0
Amblema plicata	Threeridge	64	176	0	240
Anodontoides ferussacianus	Cylindrical Papershell	2	0	0	2
Cambarunio iris	Rainbow	1	0	0	1
Cyclonaias pustulosa	Pimpleback	0	1	0	1
Cyclonaias tuberculata	Purple Wartyback	0	0	0	0
Epioblasma rangiana	Northern Riffleshell	0	0	0	0
Epioblasma triquetra	Snuffbox	0	0	0	0
Eurynia dilatata	Spike	23	0	0	23
Fusconaia flava	Wabash Pigtoe	10	34	0	44
Lampsilis cardium	Plain Pocketbook	0	1	0	1
Lampsilis fasciola	Wavrayed Lampmussel	0	0	0	0
Lampsilis siliquoidea	Fatmucket	6	50	7	63
Lasmigona complanata	White Heelsplitter	11	29	41	81
Lasmigona compressa	Creek Heelsplitter	0	0	0	0
Lasmigona costata	Flutedshell	0	2	0	2
Ligumia recta	Black Sandshell	0	0	0	0
Obliquaria reflexa	Threehorn Wartyback	0	0	0	0
Obovaria subrotunda	Round Hickorynut	0	0	0	0
Ortmanniana ligamentina	Mucket	0	S(1)	0	S(1)
Paetulunio fabalis	Rayed Bean	0	0	0	0
Pleurobema sintoxia	Round Pigtoe	1	2	0	3
Potamilus alatus	Pink Heelsplitter	0	0	0	0
Potamilus fragilis	Fragile Papershell	0	0	2	2
Ptychobranchus fasciolaris	Kidneyshell	0	0	0	0
Pyganodon grandis	Giant Floater	6	72	31	109
Quadrula quadrula	Mapleleaf	0	0	57	57
Sagittunio nasutus	Eastern Pondmussel	0	0	0	0

Table 3. Continued.

Scientific name	Common Name	SR-09	SR-15	SR-13	Grand Total
Simpsonaias ambigua	Salamander Mussel	0	0	0	0
Strophitus undulatus	Creeper	5	6	0	11
Toxolasma parvum	Lilliput	0	0	0	0
Truncilla donaciformis	Fawnsfoot	0	0	0	0
Truncilla truncata	Deertoe	0	0	0	0
Utterbackia imbecillis	Paper Pondshell	0	0	0	0
Unknown	Unknown	V(1)	0	0	V(1)
	Total Abundance	**129**	**373**	**138**	**640**
	Live Species Richness	**10**	**10**	**5**	**15**
	Total Species Richness	**10**	**11**	**5**	**16**

Table 4. Species information for each Unionid Monitoring and Biodiversity Observation (UMBO) site surveyed in the East Sydenham River between 2012–2015. All species recorded from the Sydenham River watershed are listed. Sites are presented in upstream to downstream order. Species at risk are highlighted. S(#) represents species found as complete shells and the number of shells found. V(#) represents species found as valves (one half of a complete shell) and the number of valves found. Unknown individuals (could not be identified to species) are included in the abundance total, but not in the species richness totals. All shells/valves were in weathered condition.

Scientific name	Common Name	SR-01	SR-10	SR-02	SR-03	SR-07	SR-17	SR-05	SR-19	SR-06	SR-12	Grand Total
Alasmidonta marginata	Elktoe	6	17	6	2	13	23	33	20	17	1	138
Alasmidonta viridis	Slippershell	0	0	0	0	0	0	0	0	0	0	0
Amblema plicata	Threeridge	58	98	27	27	133	100	116	123	116	66	864
Anodontoides ferussacianus	Cylindrical Papershell	0	1	0	0	0	0	1	0	0	0	2
Cambarunio iris	Rainbow	1	0	1	1	0	0	0	0	0	0	3
Cyclonaias pustulosa	Pimpleback	1	0	0	2	10	12	7	12	7	38	89
Cyclonaias tuberculata	Purple Wartyback	23	41	125	30	95	166	251	646	395	124	1,896
Epioblasma rangiana	Northern Riffleshell	6	25	7	24	11	104	181	90	11	20	479
Epioblasma triquetra	Snuffbox	2	11	5	8	15	34	98	21	13	69	276
Eurynia dilatata	Spike	6	72	46	5	47	128	167	465	120	61	1,117
Fusconaia flava	Wabash Pigtoe	19	21	9	1	28	26	64	41	26	30	265
Lampsilis cardium	Plain Pocketbook	0	3	1	2	0	3	3	9	3	1	25
Lampsilis fasciola	Wavrayed Lampmussel	0	0	0	S(1)	0	0	0	0	0	0	S(1)
Lampsilis siliquoidea	Fatmucket	1	2	0	1	1	0	0	1	0	0	6
Lasmigona complanata	White Heelsplitter	5	5	7	2	61	7	18	18	8	19	150
Lasmigona compressa	Creek Heelsplitter	0	1	0	1	0	0	0	0	0	0	2
Lasmigona costata	Flutedshell	55	67	144	18	603	161	408	334	134	79	2,003
Ligumia recta	Black Sandshell	2	11	2	8	15	12	17	38	16	9	130
Obliquaria reflexa	Threehorn Wartyback	0	0	0	0	0	0	V(1)	S(1)	0	2	2
Obovaria subrotunda	Round Hickorynut	V(1)	0	0	0	0	V(1)	V(4)	0	1	V(9)	1
Ortmanniana ligamentina	Mucket	6	30	6	9	29	57	182	250	31	148	748
Paetulunio fabalis	Rayed Bean	6	34	4	1	66	49	38	19	50	5	272
Pleurobema sintoxia	Round Pigtoe	3	7	3	1	1	6	10	24	3	25	83

Table 4. Continued.

Scientific name	Common Name	SR-01	SR-10	SR-02	SR-03	SR-07	SR-17	SR-05	SR-19	SR-06	SR-12	Grand Total
Potamilus alatus	Pink Heelsplitter	3	3	0	S(1)	13	7	13	18	5	14	76
Potamilus fragilis	Fragile Papershell	9	4	1	7	23	8	29	19	10	14	124
Ptychobranchus fasciolaris	Kidneyshell	5	20	8	12	4	54	69	107	35	147	461
Pyganodon grandis	Giant Floater	24	32	0	1	1	1	3	5	0	S(1) V(1)	67
Quadrula quadrula	Mapleleaf	0	2	0	1	58	29	23	33	42	72	260
Sagittunio nasutus	Eastern Pondmussel	0	0	0	0	0	0	0	0	0	0	0
Simpsonaias ambigua	Salamander Mussel	0	0	0	V(1)	5	S(5) V(18)	1	1	S(2) V(2)	V(3)	7
Strophitus undulatus	Creeper	1	0	1	0	0	8	39	12	3	10	74
Toxolasma parvum	Lilliput	0	0	0	0	0	0	0	0	0	0	0
Truncilla donaciformis	Fawnsfoot	0	0	0	0	0	0	0	0	1	4	5
Truncilla truncata	Deertoe	0	0	0	S(1) V(2)	0	0	1	1	0	4	6
Utterbackia imbecillis	Paper Pondshell	0	0	0	0	1	0	0	0	0	V(1)	1
Unknown	Unknown	0	0	0	1	0	2	0	1	0	1	5
Total Abundance		**242**	**507**	**403**	**165**	**1,233**	**997**	**1,772**	**2,308**	**1,047**	**963**	**9,637**
Live Species Richness		**21**	**22**	**18**	**22**	**22**	**21**	**24**	**24**	**22**	**23**	**31**
Total Species Richness		**22**	**22**	**18**	**26**	**22**	**23**	**26**	**25**	**23**	**27**	**32**

Table 5. Block density (mussels/m^2) and mean site density ± standard error (mussels/m^2) for each Unionid Monitoring and Biodiversity Observation (UMBO) network site sampled in Bear Creek between 2012–2015 in the North Sydenham River, Ontario. Dashes represent blocks that were not sampled. Sites are presented in upstream to downstream order.

Block	SR-09	SR-15	SR-13
1	1.67	4.33	2.00
2	1.00	0.67	1.67
3	1.33	3.67	6.00
4	0.67	2.67	2.00
5	2.00	4.00	2.00
6	1.33	1.33	2.67
7	0.00	4.00	2.00
8	1.00	3.67	2.67
9	1.00	3.00	3.00
10	0.33	4.00	1.00
11	0.00	7.33	3.00
12	0.67	0.67	2.67
13	0.67	3.33	1.33
14	1.33	3.33	2.67
15	2.00	4.67	0.33
16	4.67	4.00	1.00
17	2.00	7.67	0.33
18	1.33	4.67	1.67
19	2.33	9.33	0.67
20	6.33	7.00	3.00
21	1.33	9.33	0.33
22	7.00	10.67	1.33
23	1.33	3.00	0.33
24	1.67	13.00	1.33
25	-	5.00	1.00
Mean	1.79	4.97	1.84
Standard Error	0.36	0.62	0.25

Table 6. Site data collected once (before excavation) at each Unionid Monitoring and Biodiversity Observation (UMBO) network site during surveys between 2012–2015 in Bear Creek on the North Sydenham River, Ontario. Data were not recorded for all measurements (-). Sites are presented in upstream to downstream order.

Water Quality Parameter	SR-09	SR-15	SR-13
Air Temperature (°C)	-	30.2	-
Water Temperature (°C)	-	26.8	20.4
Wind Speed (km/h)	-	-	4.75
Conductivity (µs/cm)	-	702.1	575
Total Dissolved Solids (mg/L)	-	456	410
Salinity (psu)	-	-	0.31
Dissolved Oxygen (%)	-	64.5	71.7
Dissolved Oxygen (mg/L)	-	5.14	6.46
pH	-	7.94	8.61
Turbidity (fnu)	-	40.5	-

Table 7. The mean ± standard error or descriptive range of quadrat data (per m^2) collected before or after quadrat excavation at each Unionid Monitoring and Biodiversity Observation (UMBO) network site sample between 2012–2015 in Bear Creek on the North Sydenham River, Ontario. Dashes indicate that data were not collected. Sites are presented in upstream to downstream order.

	Quadrat Data		SR-09	SR-15	SR-13
Before	Water Velocity (m/s)		0.09 ± 0.02	0.06 ± 0.01	-
	Depth (m)		0.13 ± 0.01	0.53 ± 0.03	0.18 ± 0.01
	Water Clarity (m)		0.83 ± 0.01	0.10 ± 0.003	0.06 ± 0.001
After	Substrate Composition (%)	Bedrock	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
		Boulder (>250 mm)	19.59 ± 1.91	2.43 ± 0.60	1.40 ± 0.61
		Cobble (65–250 mm)	23.80 ± 1.45	11.60 ± 2.21	8.80 ± 1.63
		Gravel (2–65 mm)	23.83 ± 1.00	25.13 ± 2.60	45.43 ± 2.50
		Sand (0.06–2 mm)	16.16 ± 1.13	8.63 ± 1.18	15.97 ± 2.04
		Silt (<0.06 mm)	11.73 ± 0.97	3.47 ± 1.11	6.70 ± 1.03
		Clay	0.32 ± 0.17	48.20 ± 5.41	14.53 ± 2.83
		Muck	0.07 ± 0.07	0.00 ± 0.00	1.27 ± 0.76
		Marl	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
		Detritus	1.72 ± 0.42	2.53 ± 1.06	5.90 ± 2.31
	Siltation		slight–heavy	absent–heavy	slight–medium
	Algal Growth		absent–heavy	absent–slight	absent–slight
	Shading		dense–open	dense–open	partly open–open
	Aquatic Macrophytes		absent–present	absent–present	absent

Table 8. Block density (mussels/m^2) and site density ± standard error (mussels/m^2) for each Unionid Monitoring and Biodiversity Observation (UMBO) network site sampled in the East Sydenham River between 2012–2015. Dashes represent blocks that were not sampled. Sites are presented in upstream to downstream order.

Block	SR-01	SR-10	SR-02	SR-03	SR-07	SR-17	SR-05	SR-19	SR-06	SR-12
1	0.67	9.00	5.67	5.00	28.00	15.67	33.33	33.33	14.00	15.33
2	1.00	5.00	2.33	0.67	35.67	12.00	44.33	18.33	11.00	22.67
3	2.00	5.67	15.67	1.67	21.00	16.33	24.67	14.33	6.33	11.00
4	1.67	7.33	0.67	8.00	12.00	12.00	16.00	37.33	14.67	13.00
5	0.67	6.00	2.00	5.00	9.33	9.67	9.33	27.33	8.67	11.33
6	2.33	15.00	2.33	0.33	25.00	9.00	28.00	13.00	3.00	10.00
7	2.00	10.33	2.33	1.33	23.67	13.00	44.00	32.33	31.00	20.00
8	4.00	10.00	1.67	0.67	19.67	13.00	23.00	27.33	13.00	20.00
9	6.67	8.67	3.67	0.00	21.67	14.00	9.00	12.00	8.33	10.00
10	1.33	9.33	2.33	5.33	22.00	7.33	13.67	44.00	16.33	14.67
11	3.00	10.00	7.67	1.67	9.33	11.67	34.67	18.33	10.67	11.00
12	1.00	4.67	2.00	0.67	11.67	5.67	34.67	23.00	19.67	9.33
13	2.33	6.33	6.67	1.67	13.00	13.00	18.33	39.00	14.33	9.33
14	4.33	6.00	3.00	1.33	19.33	11.33	6.67	33.67	18.00	5.67
15	2.00	10.33	11.33	4.00	10.00	14.67	10.00	23.00	21.67	8.00
16	0.67	5.33	4.67	1.33	10.33	14.67	23.33	54.33	11.00	16.67
17	5.00	4.00	6.00	1.33	19.00	14.33	26.33	33.67	7.33	18.33
18	2.33	5.33	4.00	1.67	7.67	14.67	37.33	26.67	28.33	19.33
19	4.00	7.00	4.33	0.00	12.67	17.33	28.67	59.00	15.00	13.33
20	3.67	4.67	4.00	5.33	21.67	22.00	25.33	48.67	15.00	8.33
21	10.33	3.00	15.00	2.67	10.33	13.33	17.67	30.33	6.00	8.33
22	6.33	5.33	6.00	1.67	9.33	13.00	7.33	35.67	22.33	12.00
23	6.67	4.33	9.67	3.67	19.00	18.00	30.67	37.33	2.67	10.67
24	6.67	3.67	4.33	-	8.67	10.00	32.67	22.33	23.00	9.67
25	-	2.67	7.00	-	11.00	16.67	11.67	25.00	7.67	13.00
Mean	3.36	6.76	5.37	2.39	16.44	13.29	23.63	30.77	13.96	12.84
Standard Error	0.51	0.58	0.79	0.44	1.46	0.70	2.27	2.44	1.48	0.89

Table 9. Site data collected once (before excavation) at each Unionid Monitoring and Biodiversity Observation (UMBO) network site during surveys between 2012–2015 in the East Sydenham River. Data were not recorded for all measurements (-). Sites are presented in upstream to downstream order.

Water Quality Parameter	SR-01	SR-10	SR-02	SR-03	SR-07	SR-17	SR-05	SR-19	SR-06	SR-12
Air Temperature (°C)	-	21.70	24.50	-	14.5	-	24.4	19.00	24.1	25.2
Water Temperature (°C)	24.30	18.50	23.70	24.0	19.7	-	23.7	19.20	-	24.9
Wind Speed (km/h)	-	-	-	-	-	-	-		-	0
Conductivity (µs/cm)	-	-	639.4	445	-	-	603.0	557.2	-	652.6
Total Dissolved Solids (mg/L)	-	-	412.0	-	-	-	403	36.20	-	426
Salinity (psu)	-	-	-	-	-	-	0.30	-	-	0.32
Dissolved Oxygen (%)	-	-	103.3	-	-	-	97.3	88.10	-	87.2
Dissolved Oxygen (mg/L)	-	-	8.71	-	-	-	8.24	8.12	-	7.20
pH	-	-	8.33	-	-	-	8.54	8.19	-	8.49
Turbidity (fnu)	-	-	20.70	-	-	-	17.27	22.45	-	17.50

Table 10. The mean ± standard error or descriptive range of environmental data (per m^2) collected before or after quadrat excavation at each Unionid Monitoring and Biodiversity Observation (UMBO) network site sampled between 2012–2015 in the East Sydenham River, Ontario. Dashes indicate that data were not collected. Sites are presented in upstream to downstream order.

Quadrat Data			SR-01	SR-10	SR-02	SR-03	SR-07
Before	Water Velocity (m/s)		0.25 ± 0.02	0.24 ± 0.02	0.40 ± 0.03	-	0.33 ± 0.02
	Depth (m)		0.32 ± 0.01	0.26 ± 0.02	0.25 ± 0.01	0.40 ± 0.02	0.15 ± 0.01
	Water Clarity (m)		0.075 ± 0.001	0.21 ± 0.01	0.24 ± 0.01	0.05 ± 0.00	0.22 ± 0.01
After	Substrate Composition (%)	Bedrock	0.00 ± 0.00	0.00 ± 0.00	14.33 ± 4.26	0.00 ± 0.00	0.60 ± 0.37
		Boulder (>250 mm)	6.67 ± 1.56	21.53 ± 2.48	7.91 ± 1.51	25.88 ± 3.13	7.67 ± 1.92
		Cobble (65–250 mm)	15.19 ± 1.80	15.00 ± 1.86	34.31 ± 2.33	32.59 ± 1.85	23.39 ± 3.52
		Gravel (2–65 mm)	30.63 ± 1.84	32.77 ± 1.41	28.76 ± 1.90	29.98 ± 2.34	37.69 ± 2.16
		Sand (0.06–2 mm)	28.73 ± 2.94	24.57 ± 2.08	12.44 ± 1.05	7.91 ± 1.33	23.84 ± 1.73
		Silt (<0.06 mm)	9.34 ± 1.14	0.57 ± 0.22	0.20 ± 0.11	2.33 ± 0.47	1.47 ± 0.42
		Clay	4.23 ± 1.09	3.17 ± 0.47	1.03 ± 0.27	0.65 ± 0.31	4.67 ± 0.68
		Muck	4.17 ± 2.47	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
		Marl	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
		Detritus	1.04 ± 0.31	2.41 ± 0.67	1.03 ± 0.69	0.65 ± 0.23	0.67 ± 0.25
	Siltation		absent–heavy	absent–medium	absent–heavy	slight	absent–medium
	Algal Growth		absent–slight	absent–medium	absent–slight	slight	absent–slight
	Shading		dense–open	partly open–open	dense–open	dense	dense–open
	Aquatic Macrophytes		present	absent–present	absent–present	absent	absent–present

Table 10. Continued.

Quadrat Data			SR-17	SR-05	SR-19	SR-06	SR-12
Before	Water Velocity (m/s)		-	-	0.44 ± 0.02	0.26 ± 0.03	0.31 ± 0.04
	Depth (m)		0.26 ± 0.01	0.43 ± 0.03	0.27 ± 0.01	0.33 ± 0.01	0.61 ± 0.01
	Water Clarity (m)		0.26 ± 0.01	0.19 ± 0.01	0.21 ± 0.01	0.16 ± 0.01	0.20 ± 0.01
After	Substrate Composition (%)	Bedrock	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.07 ± 0.07
		Boulder (>250 mm)	15.17 ± 1.84	18.06 ± 3.20	11.87 ± 1.93	8.47 ± 1.54	14.63 ± 2.03
		Cobble (65-250 mm)	20.04 ± 1.60	21.01 ± 1.82	30.60 ± 0.97	32.07 ± 2.12	13.92 ± 0.82
		Gravel (2-65 mm)	30.11 ± 1.46	34.94 ± 2.68	31.67 ± 1.35	32.93 ± 1.56	52.29 ± 2.61
		Sand (0.06-2 mm)	26.48 ± 2.26	24.46 ± 1.68	23.13 ± 1.76	26.40 ± 2.49	15.55 ± 1.04
		Silt (<0.06 mm)	4.74 ± 0.61	1.08 ± 0.28	0.00 ± 0.00	0.00 ± 0.00	2.83 ± 0.81
		Clay	0.40 ± 0.24	0.00 ± 0.00	2.73 ± 0.48	0.00 ± 0.00	0.67 ± 0.37
		Muck	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
		Marl	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
		Detritus	3.06 ± 0.86	0.46 ± 0.41	0.00 ± 0.00	0.13 ± 0.13	0.04 ± 0.04
	Siltation		slight–heavy	slight	absent–slight	slight–medium	slight–medium
	Algal Growth		absent–slight	absent–slight	absent–medium	slight	absent–slight
	Shading		partly open–open	dense–open	partly open–open	dense–open	partly open–open
	Aquatic Macrophytes		absent	absent	absent–present	absent	absent–present

Table 11. Total abundance of each species found during a full excavation (25 blocks, 375 m^2) at site SR-06 in 2012 in the Sydenham River. All species recorded from the Sydenham River watershed are listed.

Scientific name	Common Name	Abundance
Alasmidonta marginata	Elktoe	65
Alasmidonta viridis	Slippershell	0
Amblema plicata	Threeridge	668
Anodontoides ferussacianus	Cylindrical Papershell	0
Cambarunio iris	Rainbow	0
Cyclonaias pustulosa	Pimpleback	62
Cyclonaias tuberculata	Purple Wartyback	2616
Epioblasma rangiana	Northern Riffleshell	61
Epioblasma triquetra	Snuffbox	71
Eurynia dilatata	Spike	527
Fusconaia flava	Wabash Pigtoe	162
Lampsilis cardium	Plain Pocketbook	6
Lampsilis fasciola	Wavrayed Lampmussel	0
Lampsilis siliquoidea	Fatmucket	0
Lasmigona complanata	White Heelsplitter	44
Lasmigona compressa	Creek Heelsplitter	0
Lasmigona costata	Flutedshell	746
Ligumia recta	Black Sandshell	89
Obliquaria reflexa	Threehorn Wartyback	0
Obovaria subrotunda	Round Hickorynut	1
Ortmanniana ligamentina	Mucket	202
Paetulunio fabalis	Rayed Bean	257
Pleurobema sintoxia	Round Pigtoe	29
Potamilus alatus	Pink Heelsplitter	28
Potamilus fragilis	Fragile Papershell	69
Ptychobranchus fasciolaris	Kidneyshell	172
Pyganodon grandis	Giant Floater	4
Quadrula quadrula	Mapleleaf	274
Sagittunio nasutus	Eastern Pondmussel	0
Simpsonaias ambigua	Salamander Mussel	5
Strophitus undulatus	Creeper	15

Table 11. Continued.

Scientific name	Common Name	Abundance
Toxolasma parvum	Lilliput	0
Truncilla donaciformis	Fawnsfoot	3
Truncilla truncata	Deertoe	2
Utterbackia imbecillis	Paper Pondshell	0
Unknown	Unknown	0
	Total Abundance	**6178**
	Live Species Richness	**25**
	Total Species Richness	**25**

Table 12. Density (mussels/m^2) and mean density ± standard error (mussels/m^2) at site SR-06 during the full excavation where all 375 m^2 was excavated in 2012 in the Sydenham River, Ontario.

Block	Density
1	14.40
2	12.87
3	6.47
4	16.20
5	9.87
6	4.67
7	20.80
8	15.67
9	9.73
10	19.27
11	11.33
12	24.00
13	15.47
14	22.73
15	16.13
16	20.53
17	13.60
18	27.80
19	13.13
20	22.20
21	6.93
22	37.40
23	7.73
24	36.20
25	6.73
Mean	16.47
Standard Error	1.72

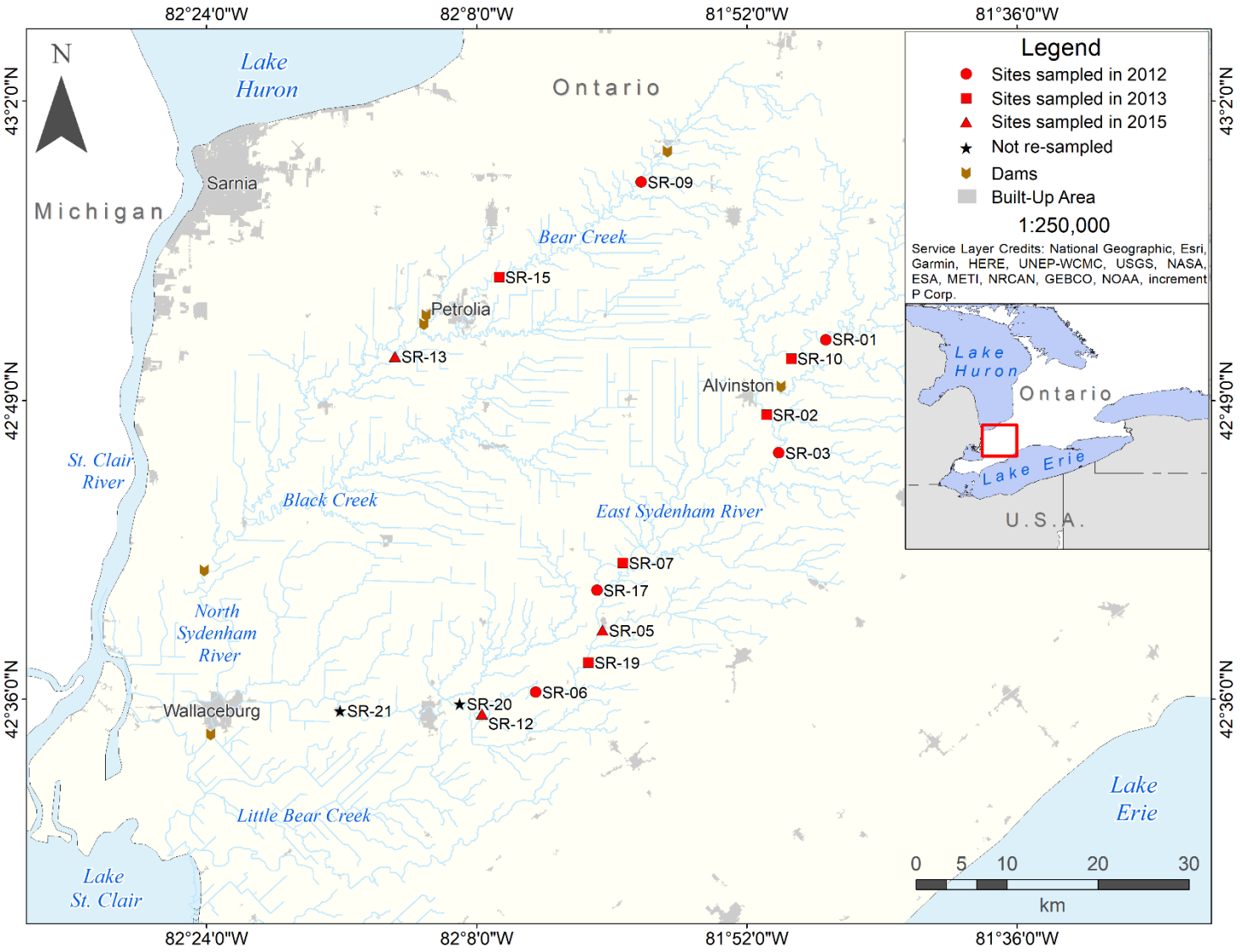

Figure 1. Fifteen Unionid Monitoring and Biodiversity Observation (UMBO) network sites established between 1999–2003. Black stars represent sites that were not resurveyed between 2012–2015.

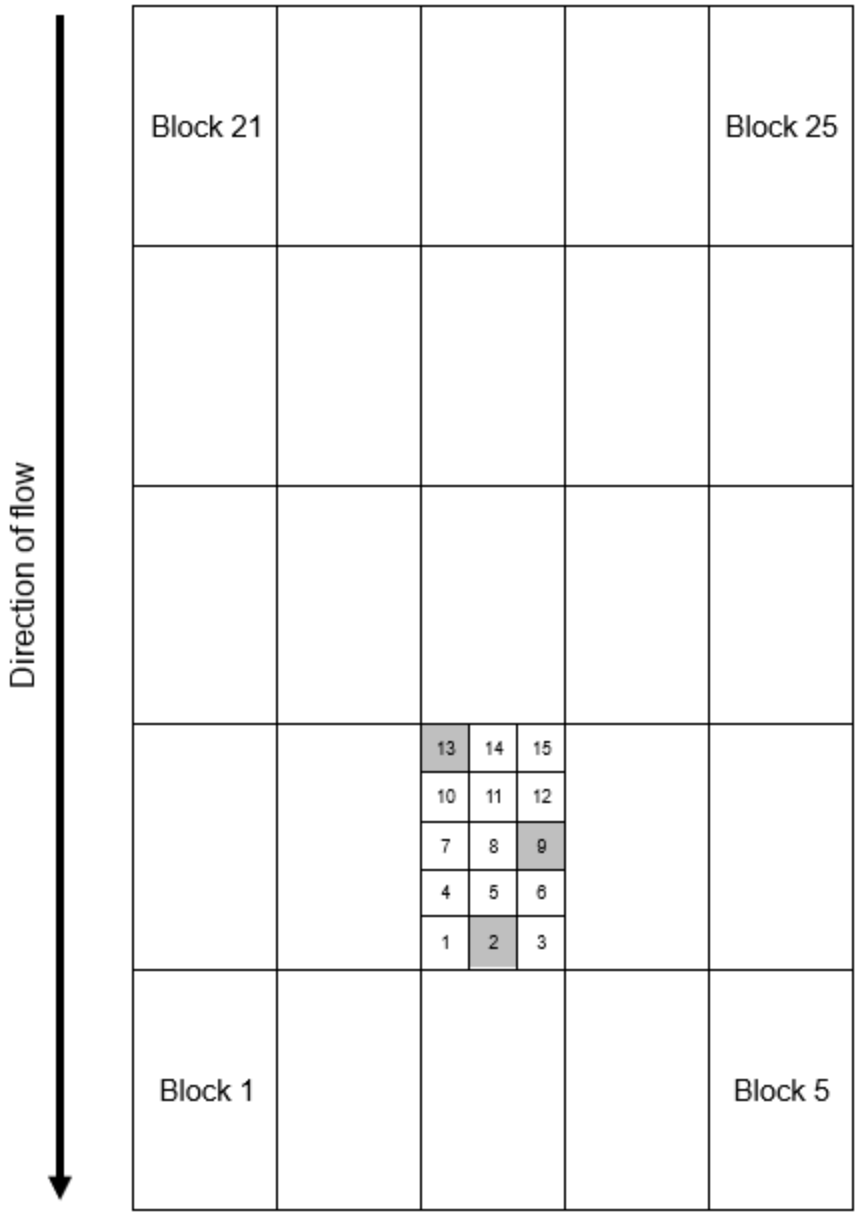

Figure 2. Systematic sampling design (Metcalfe-Smith et al. 2007) implemented at Unionid Monitoring and Biodiversity Observation (UMBO) network sites surveyed in the Sydenham River using 3 1-m^2 quadrats within a block setup. The shaded boxes represent an example of the randomly selected quadrats for excavation within each block, which were the same for each block at a site.

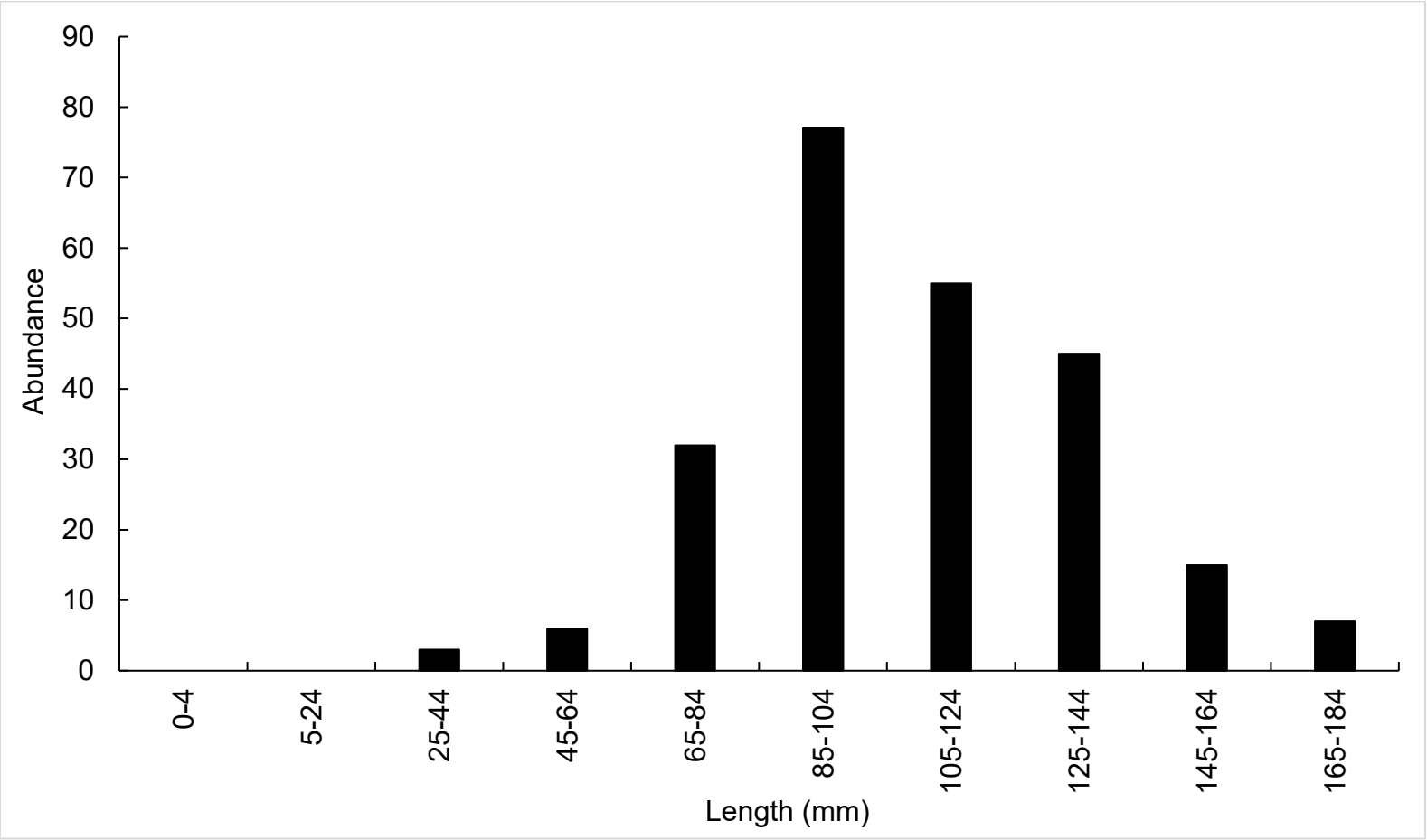

Figure 3. Length distribution (n = 240) of *Amblema plicata* (Threeridge) found in Bear Creek during the 2012–2015 Unionid Monitoring and Biodiversity Observation (UMBO) surveys.

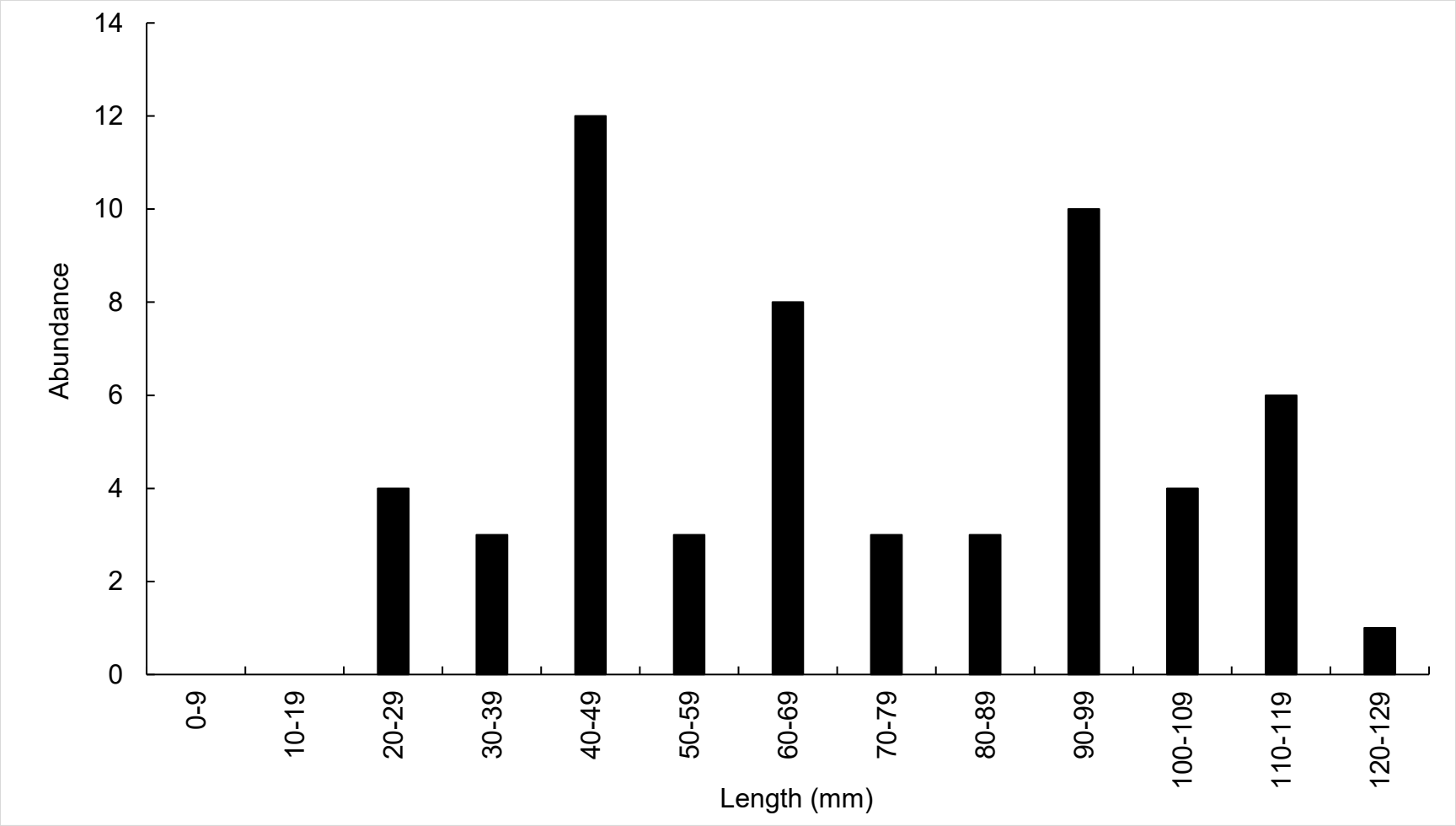

Figure 4. Length distribution (n = 57) of *Quadrula quadrula* (Mapleleaf) found in Bear Creek at SR-13 during 2012–2015 Unionid Monitoring and Biodiversity Observation (UMBO) surveys.

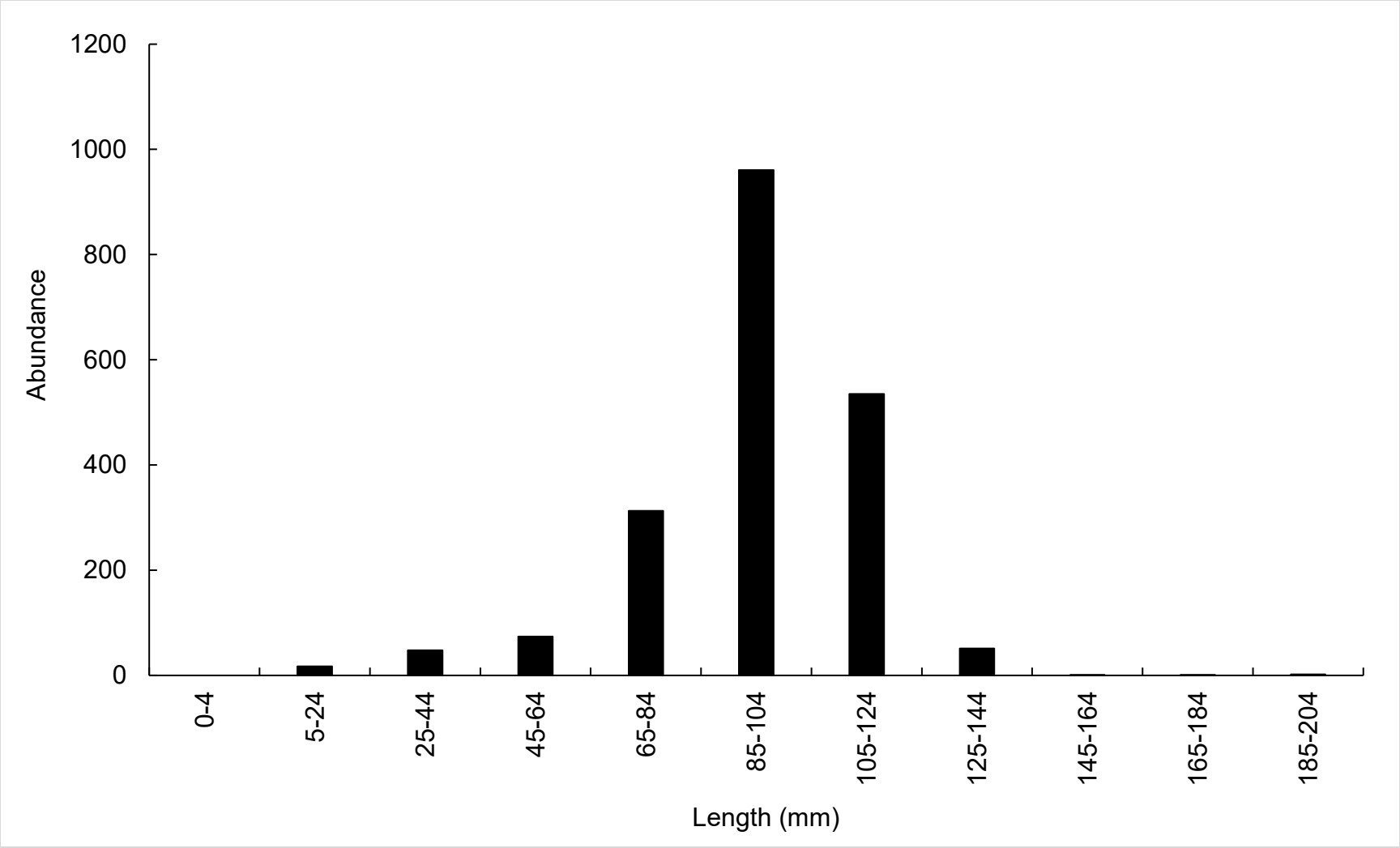

Figure 5. Length distribution (n = 2,003) of *Lasmigona costata* (Flutedshell) found in the East Sydenham River during 2012–2015 Unionid Monitoring and Biodiversity Observation (UMBO) surveys.

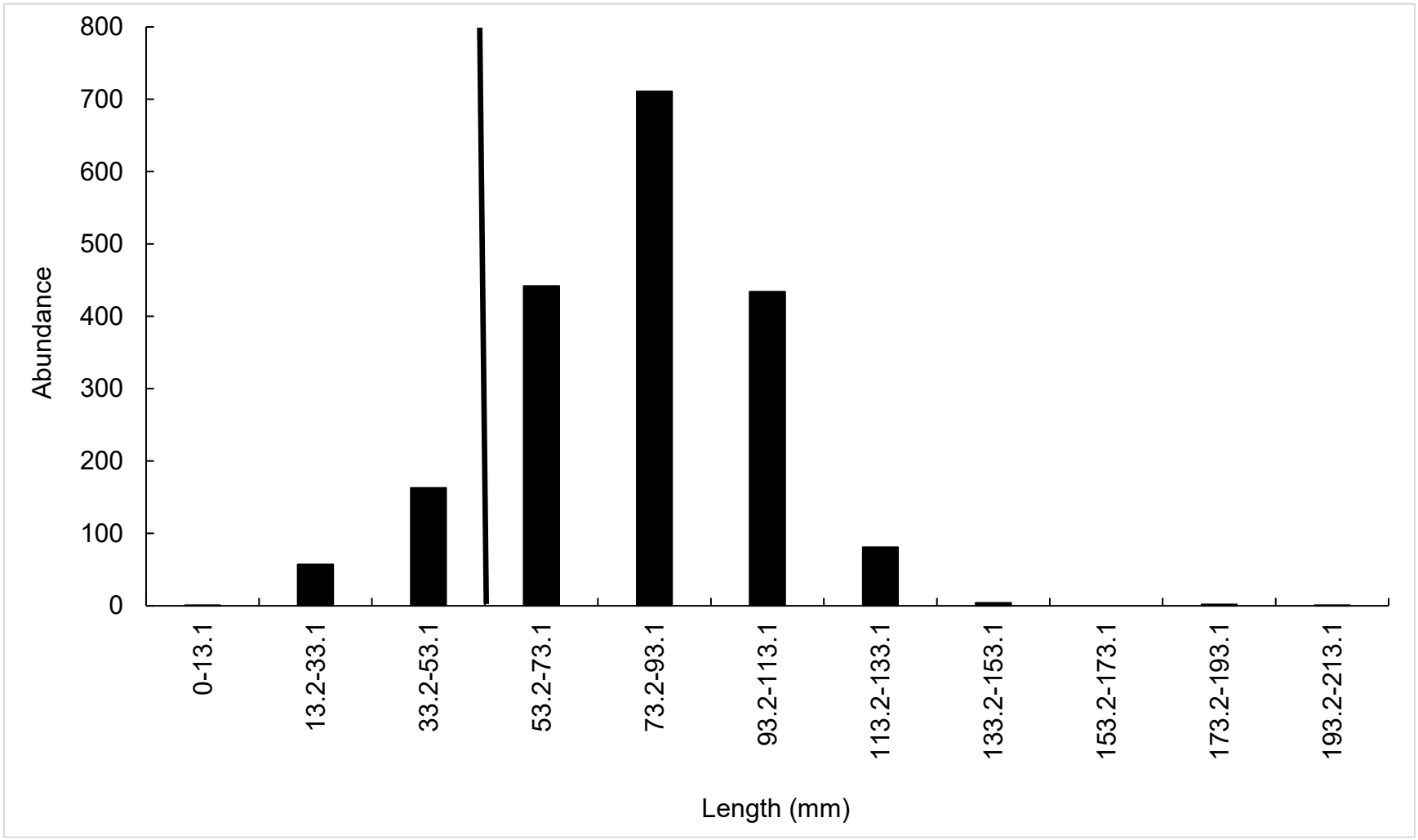

Figure 6. Length distribution (n = 1,896) of *Cyclonaias tuberculata* (Purple Wartyback) found in the East Sydenham River during the 2012–2015 Unionid Monitoring and Biodiversity Observation (UMBO) surveys. The vertical line represents the cut-off where individuals are classified as juveniles to the left (< 53.2 mm) based on van der Lee et al. (2024).

Appendix A. Original Unionid Monitoring and Biodiversity Observation (UMBO) site coordinates sampled between 1999–2003 in the Sydenham River watershed (Metcalfe-Smith et al. 2007).

	Site Code	Year	Latitude	Longitude
Bear Creek	SR-09	2001	42.975	-81.97083
	SR-15	2002	42.9062	-82.11107
	SR-13	2003	42.84895	-82.21327
East Sydenham River	SR-01	2003	42.86063	-81.78848
	SR-10	2001	42.84583	-81.825
	SR-02	2003	42.80663	-81.84691
	SR-03	1999	42.77917	-81.83528
	SR-07	2003	42.69901	-81.98938
	SR-17	2001	42.67917	-82.01667
	SR-05	2003	42.65001	-82.00874
	SR-19	2002	42.6265	-82.0231
	SR-06	2002	42.60517	-82.07483
	SR-12	1999	42.58916	-82.12639
	SR-20	2002	42.59658	-82.14986
	SR-21	2003	42.59155	-82.2681

Appendix B. Site specific information on species abundance, relative abundance (%), density (mussels/m^2), frequency of occurrence (% of quadrats in which a species is found), and maximum and minimum lengths (mm) of each species. Species at risk are highlighted. S(#) represents species found as complete shells and the number of shells found. V(#) represents species found as valves (one half of a complete shell) and the number of valves found. All shells/valves were in weathered condition and were not measured.

Site SR-09 (2012): 24 Blocks, 73 Quadrats*					
Species	**Abundance**	**Relative Abundance**	**Density**	**Occurrence**	**Length**
Alasmidonta marginata	0	0.00	0.00	0.00	-
Alasmidonta viridis	0	0.00	0.00	0.00	-
Amblema plicata	64	49.61	0.88	38.36	62–170
Anodontoides ferussacianus	2	1.55	0.03	2.74	61–66
Cambarunio iris	1	0.78	0.01	1.37	48
Cyclonaias pustulosa	0	0.00	0.00	0.00	-
Cyclonaias tuberculata	0	0.00	0.00	0.00	-
Epioblasma rangiana	0	0.00	0.00	0.00	-
Epioblasma triquetra	0	0.00	0.00	0.00	-
Eurynia dilatata	23	17.83	0.32	27.40	48–117
Fusconaia flava	10	7.75	0.14	10.96	35–94
Lampsilis cardium	0	0.00	0.00	0.00	-
Lampsilis fasciola	0	0.00	0.00	0.00	-
Lampsilis siliquoidea	6	4.65	0.08	6.85	50–108
Lasmigona complanata	11	8.53	0.15	15.07	18–119
Lasmigona compressa	0	0.00	0.00	0.00	-
Lasmigona costata	0	0.00	0.00	0.00	-
Ligumia recta	0	0.00	0.00	0.00	-
Obliquaria reflexa	0	0.00	0.00	0.00	-
Obovaria subrotunda	0	0.00	0.00	0.00	-
Ortmanniana ligamentina	0	0.00	0.00	0.00	-
Paetulunio fabalis	0	0.00	0.00	0.00	-
Pleurobema sintoxia	1	0.78	0.01	1.37	56
Potamilus alatus	0	0.00	0.00	0.00	-
Potamilus fragilis	0	0.00	0.00	0.00	-
Ptychobranchus fasciolaris	0	0.00	0.00	0.00	-
Pyganodon grandis	6	4.65	0.08	8.22	28–74
Quadrula quadrula	0	0.00	0.00	0.00	-
Sagittunio nasutus	0	0.00	0.00	0.00	-
Simpsonaias ambigua	0	0.00	0.00	0.00	-
Strophitus undulatus	5	3.88	0.07	6.85	33–84
Toxolasma parvum	0	0.00	0.00	0.00	-

*One extra quadrat was completed in block 20

Site SR-09 (2012): 24 Blocks, 73 Quadrats Continued					
Species	**Abundance**	**Relative Abundance**	**Density**	**Occurrence**	**Lengths**
Truncilla donaciformis	0	0.00	0.00	0.00	-
Truncilla truncata	0	0.00	0.00	0.00	-
Utterbackia imbecillis	0	0.00	0.00	0.00	-
Unknown	V(1)	0.00	0.00	0.00	-

Site SR-15 (2013): 25 Blocks, 75 Quadrats					
Species	**Abundance**	**Relative Abundance (%)**	**Density (mussels/m^2)**	**Occurrence (%)**	**Lengths (mm)**
Alasmidonta marginata	0	0.00	0.00	0.00	-
Alasmidonta viridis	0	0.00	0.00	0.00	-
Amblema plicata	176	47.18	2.35	81.33	27.1–171.4
Anodontoides ferussacianus	0	0.00	0.00	0.00	-
Cambarunio iris	0	0.00	0.00	0.00	-
Cyclonaias pustulosa	1	0.27	0.01	1.33	116.1
Cyclonaias tuberculata	0	0.00	0.00	0.00	-
Epioblasma rangiana	0	0.00	0.00	0.00	-
Epioblasma triquetra	0	0.00	0.00	0.00	-
Eurynia dilatata	0	0.00	0.00	0.00	-
Fusconaia flava	34	9.12	0.45	34.67	9–98
Lampsilis cardium	1	0.27	0.01	1.33	79.3
Lampsilis fasciola	0	0.00	0.00	0.00	-
Lampsilis siliquoidea	50	13.40	0.67	46.67	46.5–158
Lasmigona complanata	29	7.77	0.39	25.33	46–180
Lasmigona compressa	0	0.00	0.00	0.00	-
Lasmigona costata	2	0.54	0.03	2.67	113.4–127
Ligumia recta	0	0.00	0.00	0.00	-
Obliquaria reflexa	0	0.00	0.00	0.00	-
Obovaria subrotunda	0	0.00	0.00	0.00	-
Ortmanniana ligamentina	S(1)	0.00	0.00	0.00	-
Paetulunio fabalis	0	0.00	0.00	0.00	-
Pleurobema sintoxia	2	0.54	0.03	2.67	83–85
Potamilus alatus	0	0.00	0.00	0.00	-
Potamilus fragilis	0	0.00	0.00	0.00	-
Ptychobranchus fasciolaris	0	0.00	0.00	0.00	-
Pyganodon grandis	72	19.30	0.96	53.33	52.4–143.1
Quadrula quadrula	0	0.00	0.00	0.00	-
Sagittunio nasutus	0	0.00	0.00	0.00	-
Simpsonaias ambigua	0	0.00	0.00	0.00	-
Strophitus undulatus	6	1.61	0.08	8.00	70.5–80
Toxolasma parvum	0	0.00	0.00	0.00	-
Truncilla donaciformis	0	0.00	0.00	0.00	-
Truncilla truncata	0	0.00	0.00	0.00	-
Utterbackia imbecillis	0	0.00	0.00	0.00	-
Unknown	0	0.00	0.00	0.00	-

Site SR-13 (2015): 25 Blocks, 75 Quadrats					
Species	**Abundance**	**Relative Abundance (%)**	**Density (mussels/m^2)**	**Occurrence**	**Lengths (mm)**
Alasmidonta marginata	0	0.00	0.00	0.00	-
Alasmidonta viridis	0	0.00	0.00	0.00	-
Amblema plicata	0	0.00	0.00	0.00	-
Anodontoides ferussacianus	0	0.00	0.00	0.00	-
Cambarunio iris	0	0.00	0.00	0.00	-
Cyclonaias pustulosa	0	0.00	0.00	0.00	-
Cyclonaias tuberculata	0	0.00	0.00	0.00	-
Epioblasma rangiana	0	0.00	0.00	0.00	-
Epioblasma triquetra	0	0.00	0.00	0.00	-
Eurynia dilatata	0	0.00	0.00	0.00	-
Fusconaia flava	0	0.00	0.00	0.00	-
Lampsilis cardium	0	0.00	0.00	0.00	-
Lampsilis fasciola	0	0.00	0.00	0.00	-
Lampsilis siliquoidea	7	5.07	0.09	8.00	45.8–106
Lasmigona complanata	41	29.71	0.55	32.00	59.3–188
Lasmigona compressa	0	0.00	0.00	0.00	-
Lasmigona costata	0	0.00	0.00	0.00	-
Ligumia recta	0	0.00	0.00	0.00	-
Obliquaria reflexa	0	0.00	0.00	0.00	-
Obovaria subrotunda	0	0.00	0.00	0.00	-
Ortmanniana ligamentina	0	0.00	0.00	0.00	-
Paetulunio fabalis	0	0.00	0.00	0.00	-
Pleurobema sintoxia	0	0.00	0.00	0.00	-
Potamilus alatus	0	0.00	0.00	0.00	-
Potamilus fragilis	2	1.45	0.03	2.67	84.4–132
Ptychobranchus fasciolaris	0	0.00	0.00	0.00	-
Pyganodon grandis	31	22.46	0.41	34.67	22.2–130
Quadrula quadrula	57	41.30	0.76	41.33	26.7–122.2
Sagittunio nasutus	0	0.00	0.00	0.00	-
Simpsonaias ambigua	0	0.00	0.00	0.00	-
Strophitus undulatus	0	0.00	0.00	0.00	-
Toxolasma parvum	0	0.00	0.00	0.00	-
Truncilla donaciformis	0	0.00	0.00	0.00	-
Truncilla truncata	0	0.00	0.00	0.00	-
Utterbackia imbecillis	0	0.00	0.00	0.00	-
Unknown	0	0.00	0.00	0.00	-

Site SR-01 (2012): 24 Blocks, 72 Quadrats					
Species	**Abundance**	**Relative Abundance (%)**	**Density (mussels/m^2)**	**Occurrence (%)**	**Lengths (mm)**
Alasmidonta marginata	6	2.48	0.08	8.33	53–76
Alasmidonta viridis	0	0.00	0.00	0.00	-
Amblema plicata	58	23.97	0.81	45.83	43–155
Anodontoides ferussacianus	0	0.00	0.00	0.00	-
Cambarunio iris	1	0.41	0.01	1.39	33
Cyclonaias pustulosa	1	0.41	0.01	1.39	66
Cyclonaias tuberculata	23	9.50	0.32	27.78	46–108
Epioblasma rangiana	6	2.48	0.08	8.33	16–45
Epioblasma triquetra	2	0.83	0.03	2.78	43–45
Eurynia dilatata	6	2.48	0.08	8.33	48–78
Fusconaia flava	19	7.85	0.26	25.00	53–93
Lampsilis cardium	0	0.00	0.00	0.00	-
Lampsilis fasciola	0	0.00	0.00	0.00	-
Lampsilis siliquoidea	1	0.41	0.01	1.39	107
Lasmigona complanata	5	2.07	0.07	6.94	56–114
Lasmigona compressa	0	0.00	0.00	0.00	-
Lasmigona costata	55	22.73	0.76	33.33	35–119
Ligumia recta	2	0.83	0.03	2.78	129–161
Obliquaria reflexa	0	0.00	0.00	0.00	-
Obovaria subrotunda	V(1)	0.00	0.00	0.00	-
Ortmanniana ligamentina	6	2.48	0.08	8.33	91–165
Paetulunio fabalis	6	2.48	0.08	8.33	18–31
Pleurobema sintoxia	3	1.24	0.04	4.17	70–92
Potamilus alatus	3	1.24	0.04	4.17	108–155
Potamilus fragilis	9	3.72	0.13	9.72	82–120
Ptychobranchus fasciolaris	5	2.07	0.07	6.94	52–112
Pyganodon grandis	24	9.92	0.33	27.78	38–101
Quadrula quadrula	0	0.00	0.00	0.00	-
Sagittunio nasutus	0	0.00	0.00	0.00	-
Simpsonaias ambigua	0	0.00	0.00	0.00	-
Strophitus undulatus	1	0.41	0.01	1.39	70
Toxolasma parvum	0	0.00	0.00	0.00	-
Truncilla donaciformis	0	0.00	0.00	0.00	-
Truncilla truncata	0	0.00	0.00	0.00	-
Utterbackia imbecillis	0	0.00	0.00	0.00	-
Unknown	0	0.00	0.00	0.00	-

Site SR-10 (2013): 25 Blocks, 75 Quadrats					
Species	**Abundance**	**Relative Abundance (%)**	**Density (mussels/m^2)**	**Occurrence (%)**	**Lengths (mm)**
Alasmidonta marginata	17	3.35	0.23	18.67	52.2–79.7
Alasmidonta viridis	0	0.00	0.00	0.00	-
Amblema plicata	98	19.33	1.31	69.33	21–160
Anodontoides ferussacianus	1	0.20	0.01	1.33	90
Cambarunio iris	0	0.00	0.00	0.00	-
Cyclonaias pustulosa	0	0.00	0.00	0.00	-
Cyclonaias tuberculata	41	8.09	0.55	38.67	33–115
Epioblasma rangiana	25	4.93	0.33	26.67	18.2–62
Epioblasma triquetra	11	2.17	0.15	12.00	19.6–45.4
Eurynia dilatata	72	14.20	0.96	52.00	36–115.1
Fusconaia flava	21	4.14	0.28	22.67	40–89.4
Lampsilis cardium	3	0.59	0.04	4.00	69.9–98
Lampsilis fasciola	0	0.00	0.00	0.00	-
Lampsilis siliquoidea	2	0.39	0.03	2.67	70.3–83.5
Lasmigona complanata	5	0.99	0.07	6.67	95.3–114.6
Lasmigona compressa	1	0.20	0.01	1.33	56
Lasmigona costata	67	13.21	0.89	58.67	13–128.7
Ligumia recta	11	2.17	0.15	13.33	123–173
Obliquaria reflexa	0	0.00	0.00	0.00	-
Obovaria subrotunda	0	0.00	0.00	0.00	-
Ortmanniana ligamentina	30	5.92	0.40	26.67	93.6–145.2
Paetulunio fabalis	34	6.71	0.45	32.00	11.7–28
Pleurobema sintoxia	7	1.38	0.09	9.33	74–118.3
Potamilus alatus	3	0.59	0.04	4.00	107.5–123.4
Potamilus fragilis	4	0.79	0.05	5.33	68–91.7
Ptychobranchus fasciolaris	20	3.94	0.27	24.00	14–101.5
Pyganodon grandis	32	6.31	0.43	33.33	50.2–109.5
Quadrula quadrula	2	0.39	0.03	2.67	79–102
Sagittunio nasutus	0	0.00	0.00	0.00	-
Simpsonaias ambigua	0	0.00	0.00	0.00	-
Strophitus undulatus	0	0.00	0.00	0.00	-
Toxolasma parvum	0	0.00	0.00	0.00	-
Truncilla donaciformis	0	0.00	0.00	0.00	-
Truncilla truncata	0	0.00	0.00	0.00	-
Utterbackia imbecillis	0	0.00	0.00	0.00	-
Unknown	0	0.00	0.00	0.00	-

Site SR-02 (2013): 25 Blocks, 75 Quadrats					
Species	**Abundance**	**Relative Abundance (%)**	**Density (mussels/m^2)**	**Occurrence (%)**	**Lengths (mm)**
Alasmidonta marginata	6	1.49	0.08	6.67	35–68.3
Alasmidonta viridis	0	0.00	0.00	0.00	-
Amblema plicata	27	6.70	0.36	28.00	47.4–149
Anodontoides ferussacianus	0	0.00	0.00	0.00	-
Cambarunio iris	1	0.25	0.01	1.33	49.1
Cyclonaias pustulosa	0	0.00	0.00	0.00	-
Cyclonaias tuberculata	125	31.02	1.67	70.67	15–109
Epioblasma rangiana	7	1.74	0.09	9.33	44–50.7
Epioblasma triquetra	5	1.24	0.07	5.33	26.9–37
Eurynia dilatata	46	11.41	0.61	36.00	35–118
Fusconaia flava	9	2.23	0.12	9.33	46.7–78.3
Lampsilis cardium	1	0.25	0.01	1.33	112.4
Lampsilis fasciola	0	0.00	0.00	0.00	-
Lampsilis siliquoidea	0	0.00	0.00	0.00	-
Lasmigona complanata	7	1.74	0.09	2.67	57.3–89
Lasmigona compressa	0	0.00	0.00	0.00	-
Lasmigona costata	144	35.73	1.92	62.67	11.1–108
Ligumia recta	2	0.50	0.03	2.67	127.2–166
Obliquaria reflexa	0	0.00	0.00	0.00	-
Obovaria subrotunda	0	0.00	0.00	0.00	-
Ortmanniana ligamentina	6	1.49	0.08	6.67	55.5–150.5
Paetulunio fabalis	4	0.99	0.05	5.33	16.6–24.6
Pleurobema sintoxia	3	0.74	0.04	4.00	37.3–77.3
Potamilus alatus	0	0.00	0.00	0.00	-
Potamilus fragilis	1	0.25	0.01	1.33	70.4
Ptychobranchus fasciolaris	8	1.99	0.11	9.33	53.2–85.3
Pyganodon grandis	0	0.00	0.00	0.00	-
Quadrula quadrula	0	0.00	0.00	0.00	-
Sagittunio nasutus	0	0.00	0.00	0.00	-
Simpsonaias ambigua	0	0.00	0.00	0.00	-
Strophitus undulatus	1	0.25	0.01	1.33	61.5
Toxolasma parvum	0	0.00	0.00	0.00	-
Truncilla donaciformis	0	0.00	0.00	0.00	-
Truncilla truncata	0	0.00	0.00	0.00	-
Utterbackia imbecillis	0	0.00	0.00	0.00	-
Unknown	0	0.00	0.00	0.00	-

Site SR-03 (2012): 23 Blocks, 69 Quadrats					
Species	**Abundance**	**Relative Abundance (%)**	**Density (mussels/m^2)**	**Occurrence (%)**	**Lengths (mm)**
Alasmidonta marginata	2	1.21	0.03	2.90	67–74
Alasmidonta viridis	0	0.00	0.00	0.00	-
Amblema plicata	27	16.36	0.39	26.09	21–154
Anodontoides ferussacianus	0	0.00	0.00	0.00	-
Cambarunio iris	1	0.61	0.01	1.45	52
Cyclonaias pustulosa	2	1.21	0.03	2.90	12–62
Cyclonaias tuberculata	30	18.18	0.43	27.54	65–108
Epioblasma rangiana	24	14.55	0.35	24.64	23–51
Epioblasma triquetra	8	4.85	0.12	11.59	23–34
Eurynia dilatata	5	3.03	0.07	7.25	44–81
Fusconaia flava	1	0.61	0.01	1.45	73
Lampsilis cardium	2	1.21	0.03	2.90	95–124
Lampsilis fasciola	S(1)	0.00	0.00	0.00	-
Lampsilis siliquoidea	1	0.61	0.01	1.45	89
Lasmigona complanata	2	1.21	0.03	2.90	19–68
Lasmigona compressa	1	0.61	0.01	1.45	51
Lasmigona costata	18	10.91	0.26	18.84	36–123
Ligumia recta	8	4.85	0.12	11.59	119–175
Obliquaria reflexa	0	0.00	0.00	0.00	-
Obovaria subrotunda	0	0.00	0.00	0.00	-
Ortmanniana ligamentina	9	5.45	0.13	7.25	53–144
Paetulunio fabalis	1	0.61	0.01	1.45	12
Pleurobema sintoxia	1	0.61	0.01	1.45	70
Potamilus alatus	S(1)	0.00	0.00	0.00	-
Potamilus fragilis	7	4.24	0.10	7.25	19–93
Ptychobranchus fasciolaris	12	7.27	0.17	15.94	23–96
Pyganodon grandis	1	0.61	0.01	1.45	76
Quadrula quadrula	1	0.61	0.01	1.45	89
Sagittunio nasutus	0	0.00	0.00	0.00	-
Simpsonaias ambigua	V(1)	0.00	0.00	0.00	-
Strophitus undulatus	0	0.00	0.00	0.00	-
Toxolasma parvum	0	0.00	0.00	0.00	-
Truncilla donaciformis	0	0.00	0.00	0.00	-
Truncilla truncata	S(1),V(2)	0.00	0.00	0.00	-
Utterbackia imbecillis	0	0.00	0.00	0.00	-
Unknown	1	0.61	0.01	1.45	18

Site SR-07 (2013): 25 Blocks, 75 Quadrats					
Species	**Abundance**	**Relative Abundance (%)**	**Density (mussels/m^2)**	**Occurrence (%)**	**Lengths (mm)**
Alasmidonta marginata	13	1.05	0.17	16.00	25–75.4
Alasmidonta viridis	0	0.00	0.00	0.00	-
Amblema plicata	133	10.79	1.77	76.00	12–192.4
Anodontoides ferussacianus	0	0.00	0.00	0.00	-
Cambarunio iris	0	0.00	0.00	0.00	-
Cyclonaias pustulosa	10	0.81	0.13	9.33	40.7–106.3
Cyclonaias tuberculata	95	7.70	1.27	61.33	19.5–176
Epioblasma rangiana	11	0.89	0.15	13.33	15.5–61
Epioblasma triquetra	15	1.22	0.20	14.67	31.5–58
Eurynia dilatata	47	3.81	0.63	41.33	29–167.7
Fusconaia flava	28	2.27	0.37	28.00	22.5–103.6
Lampsilis cardium	0	0.00	0.00	0.00	-
Lampsilis fasciola	0	0.00	0.00	0.00	-
Lampsilis siliquoidea	1	0.08	0.01	1.33	53
Lasmigona complanata	61	4.95	0.81	53.33	37.9–171.7
Lasmigona compressa	0	0.00	0.00	0.00	-
Lasmigona costata	603	48.91	8.04	97.33	30–196.7
Ligumia recta	15	1.22	0.20	18.67	78–185.5
Obliquaria reflexa	0	0.00	0.00	0.00	-
Obovaria subrotunda	0	0.00	0.00	0.00	-
Ortmanniana ligamentina	29	2.35	0.39	26.67	38.3–179
Paetulunio fabalis	66	5.35	0.88	44.00	11.4–35
Pleurobema sintoxia	1	0.08	0.01	1.33	78
Potamilus alatus	13	1.05	0.17	16.00	63.5–168.1
Potamilus fragilis	23	1.87	0.31	26.67	25.5–197.7
Ptychobranchus fasciolaris	4	0.32	0.05	5.33	23–95.7
Pyganodon grandis	1	0.08	0.01	1.33	121.4
Quadrula quadrula	58	4.70	0.77	40.00	18–128
Sagittunio nasutus	0	0.00	0.00	0.00	-
Simpsonaias ambigua	5	0.41	0.07	5.33	22.5–29.7
Strophitus undulatus	0	0.00	0.00	0.00	-
Toxolasma parvum	0	0.00	0.00	0.00	-
Truncilla donaciformis	0	0.00	0.00	0.00	-
Truncilla truncata	0	0.00	0.00	0.00	-
Utterbackia imbecillis	1	0.08	0.01	1.33	55.2
Unknown	0	0.00	0.00	0.00	-

Site SR-17 (2012): 25 Blocks, 75 Quadrats					
Species	**Abundance**	**Relative Abundance (%)**	**Density (mussels/m^2)**	**Occurrence (%)**	**Lengths (mm)**
Alasmidonta marginata	23	2.31	0.31	25.33	20–81
Alasmidonta viridis	0	0.00	0.00	0.00	-
Amblema plicata	100	10.03	1.33	74.67	21–148
Anodontoides ferussacianus	0	0.00	0.00	0.00	-
Cambarunio iris	0	0.00	0.00	0.00	-
Cyclonaias pustulosa	12	1.20	0.16	14.67	44–107
Cyclonaias tuberculata	166	16.65	2.21	82.67	16–121
Epioblasma rangiana	104	10.43	1.39	66.67	11–66
Epioblasma triquetra	34	3.41	0.45	33.33	19–62
Eurynia dilatata	128	12.84	1.71	76.00	20–111
Fusconaia flava	26	2.61	0.35	34.67	22–89
Lampsilis cardium	3	0.30	0.04	4.00	95–123
Lampsilis fasciola	0	0.00	0.00	0.00	-
Lampsilis siliquoidea	0	0.00	0.00	0.00	-
Lasmigona complanata	7	0.70	0.09	9.33	100–155
Lasmigona compressa	0	0.00	0.00	0.00	-
Lasmigona costata	161	16.15	2.15	78.67	33–141
Ligumia recta	12	1.20	0.16	14.67	64–170
Obliquaria reflexa	0	0.00	0.00	0.00	-
Obovaria subrotunda	V(1)	0.00	0.00	0.00	-
Ortmanniana ligamentina	57	5.72	0.76	50.67	60–200
Paetulunio fabalis	49	4.91	0.65	44.00	10–29
Pleurobema sintoxia	6	0.60	0.08	8.00	46–101
Potamilus alatus	7	0.70	0.09	9.33	94–152
Potamilus fragilis	8	0.80	0.11	9.33	39–94
Ptychobranchus fasciolaris	54	5.42	0.72	52.00	17–111
Pyganodon grandis	1	0.10	0.01	1.33	94
Quadrula quadrula	29	2.91	0.39	36.00	17–103
Sagittunio nasutus	0	0.00	0.00	0.00	-
Simpsonaias ambigua	S(5), V(18)	0.00	0.00	0.00	-
Strophitus undulatus	8	0.80	0.11	10.67	60–82
Toxolasma parvum	0	0.00	0.00	0.00	-
Truncilla donaciformis	0	0.00	0.00	0.00	-
Truncilla truncata	0	0.00	0.00	0.00	-
Utterbackia imbecillis	0	0.00	0.00	0.00	-
Unknown	2	0.20	0.03	2.67	12

Site SR-05 (2015): 25 Blocks, 75 Quadrats					
Species	**Abundance**	**Relative Abundance (%)**	**Density (mussels/m^2)**	**Occurrence (%)**	**Lengths (mm)**
Alasmidonta marginata	33	1.86	0.44	25.33	21.5–73.3
Alasmidonta viridis	0	0.00	0.00	0.00	-
Amblema plicata	116	6.55	1.55	72.00	8.2–153.4
Anodontoides ferussacianus	1	0.06	0.01	1.33	94.4
Cambarunio iris	0	0.00	0.00	0.00	-
Cyclonaias pustulosa	7	0.40	0.09	8.00	18–85.4
Cyclonaias tuberculata	251	14.16	3.35	81.33	16.2–134.4
Epioblasma rangiana	181	10.21	2.41	77.33	10.2–61.1
Epioblasma triquetra	98	5.53	1.31	62.67	12–64
Eurynia dilatata	167	9.42	2.23	80.00	19.4–113.4
Fusconaia flava	64	3.61	0.85	50.67	12–87.3
Lampsilis cardium	3	0.17	0.04	4.00	26.5–123.5
Lampsilis fasciola	0	0.00	0.00	0.00	-
Lampsilis siliquoidea	0	0.00	0.00	0.00	-
Lasmigona complanata	18	1.02	0.24	21.33	86.5–145
Lasmigona compressa	0	0.00	0.00	0.00	-
Lasmigona costata	408	23.02	5.44	89.33	15.1–126
Ligumia recta	17	0.96	0.23	20.00	55–195
Obliquaria reflexa	V(1)	0.00	0.00	0.00	-
Obovaria subrotunda	V(4)	0.00	0.00	0.00	-
Ortmanniana ligamentina	182	10.27	2.43	74.67	22–175
Paetulunio fabalis	38	2.14	0.51	40.00	11–26
Pleurobema sintoxia	10	0.56	0.13	10.67	22–95
Potamilus alatus	13	0.73	0.17	17.33	69.6–146.2
Potamilus fragilis	29	1.64	0.39	29.33	43.5–123.9
Ptychobranchus fasciolaris	69	3.89	0.92	60.00	8–111.5
Pyganodon grandis	3	0.17	0.04	4.00	57–89.6
Quadrula quadrula	23	1.30	0.31	25.33	13.7–117.1
Sagittunio nasutus	0	0.00	0.00	0.00	-
Simpsonaias ambigua	1	0.06	0.01	1.33	23.1
Strophitus undulatus	39	2.20	0.52	32.00	24–83.6
Toxolasma parvum	0	0.00	0.00	0.00	-
Truncilla donaciformis	0	0.00	0.00	0.00	-
Truncilla truncata	1	0.06	0.01	1.33	44.1
Utterbackia imbecillis	0	0.00	0.00	0.00	-
Unknown	0	0.00	0.00	0.00	-

Site SR-19 (2013): 25 Blocks, 75 Quadrats					
Species	**Abundance**	**Relative Abundance (%)**	**Density (mussels/m^2)**	**Occurrence (%)**	**Lengths (mm)**
Alasmidonta marginata	20	0.87	0.27	22.67	51–73.5
Alasmidonta viridis	0	0.00	0.00	0.00	-
Amblema plicata	123	5.33	1.64	74.67	23.5–160
Anodontoides ferussacianus	0	0.00	0.00	0.00	-
Cambarunio iris	0	0.00	0.00	0.00	-
Cyclonaias pustulosa	12	0.52	0.16	16.00	52–83.1
Cyclonaias tuberculata	646	27.98	8.61	100.00	16–198.9
Epioblasma rangiana	90	3.90	1.20	65.33	10–113
Epioblasma triquetra	21	0.91	0.28	25.33	10.4–57.6
Eurynia dilatata	465	20.14	6.20	97.33	24–118
Fusconaia flava	41	1.78	0.55	37.33	23–96.4
Lampsilis cardium	9	0.39	0.12	10.67	84.9–132.4
Lampsilis fasciola	0	0.00	0.00	0.00	-
Lampsilis siliquoidea	1	0.04	0.01	1.33	84.9
Lasmigona complanata	18	0.78	0.24	16.00	87–137
Lasmigona compressa	0	0.00	0.00	0.00	-
Lasmigona costata	334	14.47	4.45	92.00	11–192.6
Ligumia recta	38	1.65	0.51	36.00	69–182
Obliquaria reflexa	S(1)	0.00	0.00	0.00	-
Obovaria subrotunda	0	0.00	0.00	0.00	-
Ortmanniana ligamentina	250	10.83	3.33	93.33	23.5–161
Paetulunio fabalis	19	0.82	0.25	20.00	12-28
Pleurobema sintoxia	24	1.04	0.32	26.67	35.7–100
Potamilus alatus	18	0.78	0.24	21.33	79–160
Potamilus fragilis	19	0.82	0.25	22.67	47–105
Ptychobranchus fasciolaris	107	4.63	1.43	70.67	23–108.7
Pyganodon grandis	5	0.22	0.07	6.67	56.4–116.5
Quadrula quadrula	33	1.43	0.44	34.67	11–104
Sagittunio nasutus	0	0.00	0.00	0.00	-
Simpsonaias ambigua	1	0.04	0.01	1.33	25.4
Strophitus undulatus	12	0.52	0.16	12.00	56–79.4
Toxolasma parvum	0	0.00	0.00	0.00	-
Truncilla donaciformis	0	0.00	0.00	0.00	-
Truncilla truncata	1	0.04	0.01	1.33	-
Utterbackia imbecillis	0	0.00	0.00	0.00	-
Unknown	1	0.04	0.01	1.33	21.4

Site SR-06 Standard Survey (2012): 25 Blocks; 75 Quadrats					
Species	**Abundance**	**Relative Abundance (%)**	**Density (mussels/m^2)**	**Occurrence (%)**	**Lengths (mm)**
Alasmidonta marginata	17	1.62	0.23	21.33	28–75
Alasmidonta viridis	0	0.00	0.00	0.00	-
Amblema plicata	116	11.08	1.55	65.33	19–160
Anodontoides ferussacianus	0	0.00	0.00	0.00	-
Cambarunio iris	0	0.00	0.00	0.00	-
Cyclonaias pustulosa	7	0.67	0.09	9.33	45–78
Cyclonaias tuberculata	395	37.73	5.27	94.67	12–133
Epioblasma rangiana	11	1.05	0.15	13.33	25–57
Epioblasma triquetra	13	1.24	0.17	14.67	30–65
Eurynia dilatata	120	11.46	1.60	74.67	18–116
Fusconaia flava	26	2.48	0.35	25.33	44–84
Lampsilis cardium	3	0.29	0.04	4.00	93–118
Lampsilis fasciola	0	0.00	0.00	0.00	-
Lampsilis siliquoidea	0	0.00	0.00	0.00	-
Lasmigona complanata	8	0.76	0.11	10.67	60–151
Lasmigona compressa	0	0.00	0.00	0.00	-
Lasmigona costata	134	12.80	1.79	70.67	56–125
Ligumia recta	16	1.53	0.21	18.67	55–180
Obliquaria reflexa	0	0.00	0.00	0.00	-
Obovaria subrotunda	1	0.10	0.01	1.33	61
Ortmanniana ligamentina	31	2.96	0.41	26.67	75–153
Paetulunio fabalis	50	4.78	0.67	44.00	13–25
Pleurobema sintoxia	3	0.29	0.04	4.00	40–70
Potamilus alatus	5	0.48	0.07	6.67	86–133
Potamilus fragilis	10	0.96	0.13	12.00	37–118
Ptychobranchus fasciolaris	35	3.34	0.47	33.33	16–120
Pyganodon grandis	0	0.00	0.00	0.00	-
Quadrula quadrula	42	4.01	0.56	37.33	16–175
Sagittunio nasutus	0	0.00	0.00	0.00	-
Simpsonaias ambigua	S(2),V(2)	0.00	0.00	0.00	-
Strophitus undulatus	3	0.29	0.04	4.00	68–78
Toxolasma parvum	0	0.00	0.00	0.00	-
Truncilla donaciformis	1	0.10	0.01	1.33	17
Truncilla truncata	0	0.00	0.00	0.00	-
Utterbackia imbecillis	0	0.00	0.00	0.00	-
Unknown	0	0.00	0.00	0.00	-

Site SR-06 Full Survey (2012): 25 Blocks; 375 Quadrats					
Species	**Abundance**	**Relative Abundance (%)**	**Density (mussels/m^2)**	**Occurrence (%)**	**Lengths (mm)**
Alasmidonta marginata	65	1.05	0.17	15.20	20–93
Alasmidonta viridis	0	0.00	0.00	0.00	-
Amblema plicata	668	10.81	1.78	70.93	14–160
Anodontoides ferussacianus	0	0.00	0.00	0.00	-
Cambarunio iris	0	0.00	0.00	0.00	-
Cyclonaias pustulosa	62	1.00	0.17	14.40	18–96
Cyclonaias tuberculata	2616	42.34	6.98	96.00	12–193
Epioblasma rangiana	61	0.99	0.16	14.13	22–57
Epioblasma triquetra	71	1.15	0.19	16.80	12–65
Eurynia dilatata	527	8.53	1.41	68.27	10–123
Fusconaia flava	162	2.62	0.43	31.20	19-98
Lampsilis cardium	6	0.10	0.02	1.60	93–120
Lampsilis fasciola	0	0.00	0.00	0.00	-
Lampsilis siliquoidea	0	0.00	0.00	0.00	-
Lasmigona complanata	44	0.71	0.12	10.67	60–151
Lasmigona compressa	0	0.00	0.00	0.00	-
Lasmigona costata	746	12.08	1.99	68.80	32–132
Ligumia recta	89	1.44	0.24	19.47	55–205
Obliquaria reflexa	0	0.00	0.00	0.00	-
Obovaria subrotunda	1	0.02	0.00	0.27	61
Ortmanniana ligamentina	202	3.27	0.54	31.73	28–162
Paetulunio fabalis	257	4.16	0.69	41.87	12–50
Pleurobema sintoxia	29	0.47	0.08	6.93	17–106
Potamilus alatus	28	0.45	0.07	6.93	73–175
Potamilus fragilis	69	1.12	0.18	16.27	37–132
Ptychobranchus fasciolaris	172	2.78	0.46	36.00	16–120
Pyganodon grandis	4	0.06	0.01	1.07	64–119
Quadrula quadrula	274	4.44	0.73	42.13	14–175
Sagittunio nasutus	0	0.00	0.00	0.00	-
Simpsonaias ambigua	5	0.08	0.01	1.33	20–34
Strophitus undulatus	15	0.24	0.04	4.00	51–78
Toxolasma parvum	0	0.00	0.00	0.00	-
Truncilla donaciformis	3	0.05	0.01	0.80	17–30
Truncilla truncata	2	0.03	0.01	0.53	37–56
Utterbackia imbecillis	0	0.00	0.00	0.00	-
Unknown	0	0.00	0.00	0.00	-

Site SR-12 (2015): 25 Blocks, 75 Quadrats					
Species	**Abundance**	**Relative Abundance (%)**	**Density (mussels/m^2)**	**Occurrence (%)**	**Lengths (mm)**
Alasmidonta marginata	1	0.10	0.01	1.33	59.3
Alasmidonta viridis	0	0.00	0.00	0.00	-
Amblema plicata	66	6.85	0.88	61.33	22.6–137.2
Anodontoides ferussacianus	0	0.00	0.00	0.00	-
Cambarunio iris	0	0.00	0.00	0.00	-
Cyclonaias pustulosa	38	3.95	0.51	37.33	24.9–94
Cyclonaias tuberculata	124	12.88	1.65	77.33	27–134.4
Epioblasma rangiana	20	2.08	0.27	24.00	10–48
Epioblasma triquetra	69	7.17	0.92	56.00	12–58
Eurynia dilatata	61	6.33	0.81	50.67	22.2–105.1
Fusconaia flava	30	3.12	0.40	32.00	21.5–79
Lampsilis cardium	1	0.10	0.01	1.33	111
Lampsilis fasciola	0	0.00	0.00	0.00	-
Lampsilis siliquoidea	0	0.00	0.00	0.00	-
Lasmigona complanata	19	1.97	0.25	21.33	92–148.5
Lasmigona compressa	0	0.00	0.00	0.00	-
Lasmigona costata	79	8.20	1.05	61.33	33.4–128
Ligumia recta	9	0.93	0.12	10.67	96.6–170
Obliquaria reflexa	2	0.21	0.03	2.67	24–50.5
Obovaria subrotunda	V(9)	0.00	0.00	0.00	-
Ortmanniana ligamentina	148	15.37	1.97	81.33	17.3–152
Paetulunio fabalis	5	0.52	0.07	6.67	13–19
Pleurobema sintoxia	25	2.60	0.33	26.67	19–100.4
Potamilus alatus	14	1.45	0.19	18.67	43.3–137.8
Potamilus fragilis	14	1.45	0.19	13.33	33–95.7
Ptychobranchus fasciolaris	147	15.26	1.96	86.67	6–105
Pyganodon grandis	S(1), V(1)	0.00	0.00	0.00	-
Quadrula quadrula	72	7.48	0.96	61.33	16–110.7
Sagittunio nasutus	0	0.00	0.00	0.00	-
Simpsonaias ambigua	V(3)	0.00	0.00	0.00	-
Strophitus undulatus	10	1.04	0.13	13.33	37.2–78.5
Toxolasma parvum	0	0.00	0.00	0.00	-
Truncilla donaciformis	4	0.42	0.05	5.33	18–38.8
Truncilla truncata	4	0.42	0.05	4.00	24.7–42.8
Utterbackia imbecillis	V(1)	0.00	0.00	0.00	-
Unknown	1	0.10	0.01	1.33	-