

First records of two freshwater mussel Species at Risk, Mapleleaf (*Quadrula quadrula*) and Lilliput (*Toxolasma parvum*), in the Canard River, Ontario, with implications for freshwater mussel recovery in the Detroit River

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Abstract

Freshwater mussels of the family Unionidae are among the world's most imperilled animals. A third of Canadian species have been assessed by the Committee on the Status of Endangered Wildlife in Canada as Extirpated, Endangered, Threatened, or Special Concern, with losses attributed to natural system modifications such as damming, pollution, exploitation for buttons and pearls, urbanization, and the introduction and subsequent effects of aquatic invasive species. In the Great Lakes basin, the introduction of dreissenid mussels in the 1980s caused catastrophic declines, with remnant populations restricted to lotic riverine habitats. In southwestern Ontario, the Canard River is the largest remaining direct tributary of the Detroit River that could provide a source of mussels to aid natural recovery. In 2019, nine sites in the Canard River were sampled using a timed-search approach (4.5 person-hours/site) with a combination of tactile searching by hand and mussel scoops (7-mm mesh) or underwater viewers. The search yielded 362 individuals of eight species, including two Species at Risk, Mapleleaf (*Quadrula quadrula*) and Lilliput (*Toxolasma parvum*), which had never been previously recorded in the Canard River.

Key words: Bivalve; Unionidae; Great Lakes; Zebra Mussel; *Dreissena polymorpha*; Quagga Mussel; *Dreissena rostriformis bugensis*; Asian Clam; *Corbicula fluminea*

Introduction

Freshwater bivalves have undergone large-scale global declines and are now among the most imperilled taxa in the world with ~40% of species considered at risk (Lopes-Lima *et al.* 2018). Within this group, the freshwater mussels of the order Unionida and family Unionidae are the most at risk. Lopes-Lima *et al.* (2018) report that 45% of the more than 800 species of Unionida have undergone assessment by the International Union for Conservation of Nature and are considered Near-Threatened, Threatened, or Extinct while at least two-thirds of the ~300 North American members of the family Unionidae are considered at risk (Williams *et al.* 1993; Lopes-Lima *et al.* 2018). In Canada, 46% of Unionida are considered vulnerable to extirpated (CESCC 2016) and 19 species (35%) of Unionidae have already been assessed as Extirpated, Endangered, Threatened, or Special Concern by the Committee on the Status of

Endangered Wildlife in Canada (COSEWIC).

Global declines have been attributed to a variety of causes including natural system modifications, such as damming, pollution, exploitation for buttons and pearls, urbanization, and the introduction and subsequent effects of aquatic invasive species (COSEWIC 2016; Lopes-Lima *et al.* 2018). Although all of these have contributed to the decline of Canadian freshwater mussels, the arrival and establishment of dreissenid mussels (Zebra Mussel [*Dreissena polymorpha*] and Quagga Mussel [*Dreissena rostriformis bugensis*]) in the Great Lakes basin in the mid-1980s proved particularly catastrophic (Mackie 1991; Ricciardi *et al.* 1998). In little more than a decade after their arrival, dreissenids had contributed to the near total extirpation of freshwater unionid mussels from Lake St. Clair (Nalepa *et al.* 1996), the Detroit River (Schloesser *et al.* 1998, 2006), and the western basin of Lake Erie (Schloesser and Nalepa 1994).

As the planktonic veliger larvae of dreissenid mussels are not well adapted to establishment in lotic systems, it was recognized early that upstream riverine habitats would represent important refuges for Ontario mussels (Clarke 1992). Two major river systems (Sydenham and Thames Rivers) and several smaller ones (Belle, Puce, and Ruscom Rivers for Lake St. Clair; Canard River for the Detroit River; Big Creek and Clear Creek in the western basin of Lake Erie) provide Canadian refuges for freshwater mussels of Lake St. Clair, the Detroit River, and the western basin of Lake Erie. The Sydenham and Thames Rivers represent Canada's most speciose rivers, with historical complements of 35 species in each system and relatively intact assemblages of 34 and 32 species remaining in each system, respectively (McNichols-O'Rourke *et al.* 2012). The smaller tributaries of the southern shore (Belle, Puce, and Ruscom Rivers) have comparably smaller and less speciose assemblages (4–8 species; McNichols-O'Rourke *et al.* 2012; Fisheries and Oceans Canada unpubl. data); however, these five systems all represent potential sources of recolonizers for the Lake St. Clair system.

In contrast to the multiple rivers of the Lake St. Clair drainage, the Canard River represents the one river system in Canada that drains directly into the Detroit River. Morris and Di Maio (1998–1999) provided the only available information on the Canard River mollusc fauna when they surveyed three sites on the river in 1993, collecting only 15 individuals of five species. Despite the low species richness and abundance, the direct outflow of the Canard River into the Detroit River makes it a potentially important source of natural recolonizers of the Detroit River if recovery is likely to occur. The study described here was designed to assess the current status and distribution of the freshwater mussel assemblage of the Canard River with the goal of understanding the potential for this assemblage to contribute to future natural recolonization of the Detroit River.

Methods

The Canard River, located in southwestern Ontario on the Essex Clay Plain, is a small low-gradient river draining an area of 347 km². Land use in Essex County, including the Canard River watershed, is primarily agricultural (80–85%); only 4.5% of the watershed is forested and <1% is considered wetland (Essex Region Conservation Authority 2015). Riparian forest is sparse in the Canard River watershed with only 7.9% of riverbanks forested. Natural flow patterns in the system have been heavily altered in some areas through realignment by artificial means to support agriculture, and provincial guidelines for nitrates, nitrites, ammonia, total phosphorus, and suspended solids are regularly exceeded (Essex Region Conservation Authority 2015).

On 15 July 2019, visual reconnaissance of the watershed was conducted to determine which sites would be sampled between 16 and 18 July 2019. Sites were evaluated based on location in the watershed (coverage and proximity to other sites), access, water depth, turbidity, substrate type, and any evidence of the presence of mussels (e.g., shells or middens). The three sites surveyed by Morris and Di Maio (1998–1999) in 1993 were revisited during this reconnaissance trip. In total, nine sites were selected for a full survey based on the parameters outlined above: two represented the historical sites of Morris and Di Maio (1998–1999) and seven were new. These sites were arranged such that seven, including both historical sites, were located in the main branch of the Canard River and two were located in the south branch (Table 1; Figure 1).

Physical data were collected at each site using a range of equipment. Air temperature (Hanna HI98311 DiST 5 EC/TDS/Temperature Tester; ITM Instruments Inc., Newmarket, Ontario, Canada), wind speed (Kestrel 2000 Pocket Wind Meter; ITM Instruments Inc., Newmarket, Ontario, Canada), and weather by visual observation were recorded from the side of the river before the survey began. Additional

TABLE 1. Sites, in upstream to downstream order, and dates of surveys by Fisheries and Oceans Canada in 2019.

Site code	Drainage	Water body	Latitude, °N	Longitude, °W	Survey date
CRD-CRD-01	Lake Erie	Canard River (main branch)	42.12329	82.84820	18 July
CRD-CRD-09	Lake Erie	Canard River (main branch)	42.13216	82.87779	17 July
CRD-CRD-08	Lake Erie	Canard River (main branch)	42.14094	83.00359	17 July
CRD-CRD-02	Lake Erie	Canard River (main branch)	42.15915	83.01888	18 July
CRD-CRD-06	Lake Erie	Canard River (main branch)	42.17483	83.03442	16 July
CRD-CRD-05	Lake Erie	Canard River (main branch)	42.18673	83.07065	16 July
CRD-CRD-10	Lake Erie	Canard River (south branch)	42.14268	83.06861	18 July
CRD-CRD-07	Lake Erie	Canard River (south branch)	42.16492	83.07537	17 July
CRD-CRD-04	Lake Erie	Canard River (main branch)	42.16947	83.09765	16 July

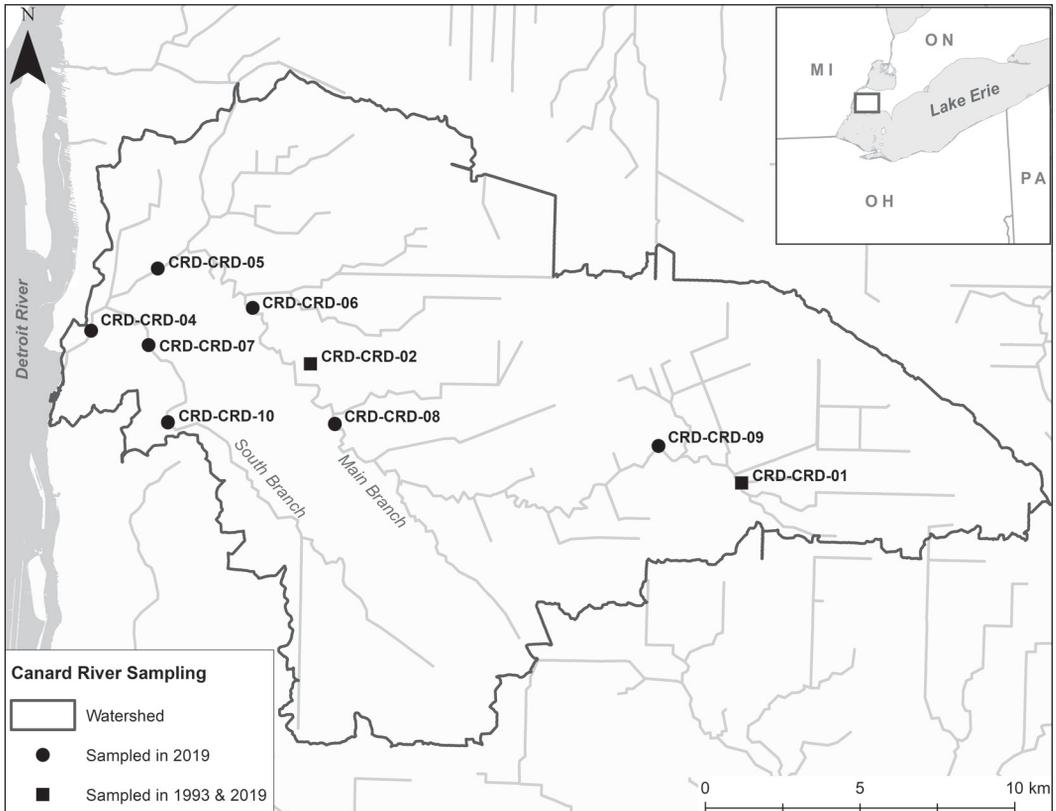


FIGURE 1. Location of nine sites surveyed in the Canard River by Fisheries and Oceans Canada in 2019.

parameters were collected from the river: water clarity (60-cm turbidity tube; Hoskin Scientific Ltd., Oakville, Ontario, Canada), water velocity (OTT MF Pro Flow Meter; OTT HydroMet, Loveland, Colorado, USA), and water chemistry, including water temperature, conductivity, total dissolved solids, optical dissolved oxygen, pH, and turbidity (EXO handheld display and EXO2 Multiparameter Sonde; YSI Inc., Yellow Springs, Ohio, USA). These measurements were made at a single point in the search area before the survey began. Once the survey was complete, the length of reach searched was measured using a laser 1200s range finder 7×25 (Nikon Corporation, Melville, New York, USA). The average depth throughout the search area was measured using a metre stick. Degree of siltation, stream habitat type as per the Ontario Stream Assessment Protocol (Stanfield 2010), and substrate composition were estimated visually and averaged across the search area. Definitions of substrate sizes were taken from Stanfield (2010): boulder (>250 mm in diameter), rubble (65–250 mm), gravel (2–65 mm), sand (<2 mm), and “other” material (mud, muck, silt, and detritus).

Surveys were conducted in wadable habitats (maximum depth searched = 1.56 m) following the timed-search methods of Metcalfe-Smith *et al.* (2000), whereby each site was surveyed for 4.5 person-hours (p-h) by a four- or five-person crew using a combination of mussel viewers, mussel scoops (7-mm mesh; Wright *et al.* 2017), and tactile searching. Each animal found alive was identified (Clam Counter, version 1.3.4, Toronto Zoo, Toronto, and Fisheries and Oceans Canada, Ottawa, Ontario, Canada; <https://play.google.com/store/apps/details?id=com.torontozoo.clamcounter&hl=en>), counted, measured using calipers (maximum length), and visually sexed (if sexually dimorphic) before being returned to the river. Shells of species not observed alive at the site were also counted and recorded. Evidence of dreissenid mussel infestation (presence of live animals or remnant byssal threads attached to individual mussels) was recorded for each site.

When at least 100 individuals of a species were collected, length–frequency distributions were examined using a Shapiro-Wilk test for normality in RStudio version 1.1.383 (RStudio Team 2016).

Normality tests were used to assist with interpreting the length–frequency distributions. Recent recruitment was assessed by determining the proportion of individuals of each species considered to be juveniles, based on shell length less than an established cut-off value. For Mapleleaf (*Quadrula quadrula*), the cut-off value was 50 mm as stated in COSEWIC (2016). For Giant Floater (*Pyganodon grandis*), the general cut-off of 25 mm as outlined in Haag and Warren (2007) was used as no species-specific data were available.

Results

The Canard River sites can be characterized as having little flow (<0.07 m/s), poor visibility, moderate to high turbidity, soft substrates, and a moderate to high degree of siltation (Table 2). In all, 362 live individuals representing eight species were observed across the nine sites (Table 3, Figures S1–S8). Site abundance and species richness were greatest at sites in the middle portion of the main branch (sites CRD-CRD-02, 08, and 09; sites 02 and 08 are rather unremarkable with regard to the physical data shown in Table 2). Of these 362 individuals, 119 (33%) were Species at Risk (SAR) representing two species: Mapleleaf (federally Special Concern, SARA Registry 2019a) and Lilliput (*Toxolasma parvum*; federally Endangered, SARA Registry 2019b; Figure 2). Giant Floater was the most abundant species (140 individuals) representing 39% of all unionids detected. Mapleleaf was the most abundant SAR (105 individuals) and the second-most abundant species overall representing 29% of unionids found. Paper Pondshell (*Utterbackia imbecillis*), although low in abundance (<4% of all individuals), was the most widespread species, as it was found at five of the nine sites (55%). Total unionid species richness ranged from zero at CRD-CRD-01 to eight species at CRD-CRD-02 and CRD-CRD-08. Live SAR richness at a site ranged from zero (four sites) to two species at CRD-CRD-02 and CRD-CRD-08. No additional species were detected as only shells/valves. Four of the species found, including both SAR, had not been detected in the Canard River previously (*Q. quadrula*, *T. parvum*, *T. truncata*, and *U. imbecillis*). One live Fatmucket (*Lampsilis siliquoidea*) was found during the 1993 surveys but no evidence of this species was detected in 2019. Evidence of dreissenid infestation (live animals or byssal threads attached to individual mussels; proportion of animals infested not recorded) was found at the two most downstream sites on the main branch (CRD-CRD-04 and CRD-CRD-05) as well as the most upstream site in the south branch (CRD-CRD-10). Although no evidence of dreissenids was found at the downstream site on the south branch

TABLE 2. Physical data collected at each site surveyed in the Canard River by Fisheries and Oceans Canada in 2019.

Parameter	Sites, in upstream to downstream order									
	CRD-CRD-01	CRD-CRD-02	CRD-CRD-03	CRD-CRD-04	CRD-CRD-05	CRD-CRD-06	CRD-CRD-07	CRD-CRD-08	CRD-CRD-09	CRD-CRD-10
Weather	Clear/sunny	Sunny, hot, humid	Overcast, some sun	Clear/sunny	Overcast, humid	Overcast, slight rain	Clear, sunny	Overcast, rain	Cloud, overcast	
Air temperature, °C	28.6	35.8	25.7	23.4	27.7	26.7	24.3	24.5	26.1	
Wind speed, km/h	2.5	1.5	0.0	2.0	2.4	5.7	0.0	0.0	1.9	
Length of reach searched, m	120	288	140	186	73.5	78	74	57	42	
Average depth searched, m	0.48	0.66	0.10	0.55	1.25	1.35	0.75	1.44	1.45	
Water clarity, m	0.060	0.100	0.090	0.020	0.268	0.171	0.051	0.297	0.342	
Water velocity, m/s	0.061	0.010	0.005	0.031	0.008	0.007	0.069	0.007	0.007	
Water temperature, °C	24.10	27.90	25.60	25.40	26.60	27.20	22.80	24.64	26.20	
Conductivity, µS/cm	952.0	1014.0	841.0	2488.0	1215.0	623.0	579.0	620.0	350.1	

TABLE 2. Continued.

Parameter	Sites, in upstream to downstream order									
	CRD-CRD-01	CRD-CRD-02	CRD-CRD-03	CRD-CRD-04	CRD-CRD-05	CRD-CRD-06	CRD-CRD-07	CRD-CRD-08	CRD-CRD-09	CRD-CRD-10
Total dissolved solids, mg/L	610.160	643.146	542.266	1629.274	790.125	387.150	396.346	405.456	222.393	
Optical dissolved oxygen, %	80.6	43.2	53.0	66.7	53.2	54.1	73.9	61.8	47.6	
Optical dissolved oxygen, mg/L	6.65	3.47	4.16	5.40	4.30	4.28	6.40	5.11	3.78	
pH	7.94	7.67	7.85	7.87	7.68	7.95	8.00	7.99	7.73	
Turbidity, FNU	59.40	60.42	120.67	54.5	26.68	33.55	79.52	13.72	11.77	
Degree of siltation	Slight	Slight	Heavy	Heavy	Medium	Medium	Medium	Heavy	Heavy	
Riffle, %	0	0	0	0	0	0	0	0	0	
Pool, %	0	10	0	0	0	0	0	0	0	
Run, %	0	0	0	0	0	100	0	0	100	
Flat, %	100	90	100	100	100	0	100	100	0	
Bedrock, %	0	0	0	0	0	0	0	0	0	
Boulder, %	0	5	0	0	0	0	0	5	0	
Rubble, %	5	5	0	0	0	0	0	0	0	
Gravel, %	10	15	5	0	0	0	1	10	0	
Sand, %	0	10	10	5	0	0	1	0	0	
Silt, %	0	0	0	0	0	0	0	35	0	
Clay, %	50	50	30	40	0	0	35	5	0	
Muck, %	35	15	35	50	80	60	40	30	80	
Detritus, %	0	0	20	5	20	40	23	15	20	

TABLE 3. Results of timed-search surveys at nine sites in the Canard River by Fisheries and Oceans Canada in 2019.

Scientific name	Common name	Sites, in upstream to downstream order														Total	Relative abundance, %	Frequency of occurrence, %
		CRD-CRD-01	CRD-CRD-09	CRD-CRD-08	CRD-CRD-02	CRD-CRD-06	CRD-CRD-05	CRD-CRD-10	CRD-CRD-07	CRD-CRD-04								
<i>Lasmigona complanata</i>	White Heelsplitter	—	38	13	5	—	1	—	—	—	—	—	—	—	57	15.75	44.44	
<i>Leptodea fragilis</i>	Fragile Papershell	—	3	7	12	—	—	—	—	—	—	—	—	—	22	6.08	33.33	
<i>Potamilus alatus</i>	Pink Heelsplitter	—	—	1	1	—	—	—	—	—	S(1)	—	—	—	2	0.55	22.22	
<i>Pyganodon grandis</i>	Giant Floater	S(3), V(4)	9	61	64	S(1)	—	2	4	—	—	—	—	—	140	38.67	55.56	
<i>Quadrula quadrula</i>	Mapleleaf	—	—	65	34	2	—	—	—	—	—	—	4	—	105	29.01	44.44	
<i>Toxolasma parvum</i>	Lilliput	V(1)	—	8	5	—	1	—	—	—	V(2)	—	—	—	14	3.87	33.33	
<i>Truncilla truncata</i>	Deertoe	—	—	1	7	—	—	—	—	—	—	—	—	—	8	2.21	22.22	
<i>Utterbackia imbecillis</i>	Paper Pondshell	—	—	4	4	2	2	—	—	—	—	—	2	—	14	3.87	55.56	
Total abundance		0	50	160	132	4	4	2	4	2	4	4	6	6	362			
Live species richness		0	3	8	8	2	3	1	1	1	1	1	2	2	8			
Total species richness		2	3	8	8	3	3	1	3	1	3	2	2	2	8			
Effort, person-h		4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	40.5			

Note: Species at Risk are in bold. S(#) represents individuals that were detected as a shell (both valves) and the number of shells detected. V(#) represents individuals that were detected as a single valve and the number of valves detected. Voucher photographs are available in Figures S1–S8.



FIGURE 2. Two federally listed mussel Species at Risk were found in the Canard River: a. Mapleleaf (*Quadrula quadrula*) and b. Lilliput (*Toxolasma parvum*). Photos: Fisheries and Oceans Canada.

(CRD-CRD-07), shells of the invasive Asian Clam (*Corbicula fluminea*) were found there.

Mapleleaf were 23.3–114.4 mm (mean 82 mm) in length and represented a non-normal, left-skewed distribution ($W = 0.76, P = 0.003$; Figure 3). Juveniles recently recruited into the population represented 4.7% (five individuals) of the observed Mapleleaf. Giant Floater lengths were 52.2–170.0 mm (mean 114.9 mm) and represented a non-normal, left-skewed distribution ($W = 0.657, P < 0.001$; Figure 4). No individuals below the 25 mm length threshold representing juveniles were detected, although Giant Floater is a very fast-growing species and perhaps not well represented by that generalized cut-off threshold length.

Discussion

In contrast with the severe impacts of the dreissenid invasion observed in the nearby Detroit River (Schloesser *et al.* 2006), it is clear that the Canard River still maintains a relatively intact mussel assemblage. Morris and DiMaio (1998–1999) collected only 15 specimens of five species from three sites in 1993, whereas our study collected over 20 times the number of individuals (362) and four additional spe-

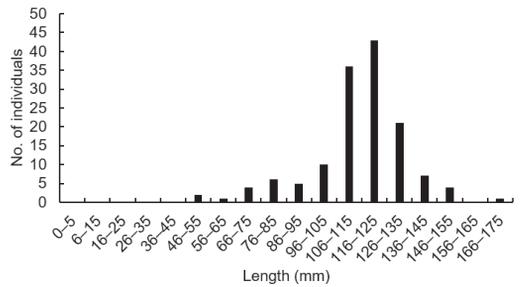


FIGURE 4. Frequency distribution of length of Giant Floater (*Pyganodon grandis*) observed in the Canard River ($n = 140$) by Fisheries and Oceans Canada in 2019.

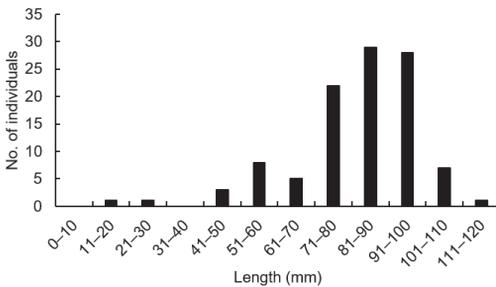


FIGURE 3. Frequency distribution of length of Mapleleaf (*Quadrula quadrula*) observed in the Canard River ($n = 105$) by Fisheries and Oceans Canada in 2019.

cies. However, we are cautious in interpreting this as a meaningful change because of the difference in effort between this study and that of Morris and DiMaio (1998–1999). Our study employed the 4.5 p-h effort recommended by Metcalfe-Smith *et al.* (2000) for sampling freshwater mussel communities in southern Ontario, whereas the earlier study used only a 1 p-h effort, and we surveyed three times as many sites. In terms of catch-per-unit-effort (CPUE), that of the historical study was 5 individuals/h, while that of the current study was 8.9 individuals/h. By comparison, the similarly sized Ruscom and Belle rivers on the nearby south shore of Lake St Clair support eight and four species respectively, with CPUE of 15 and 1.6 animals/h (McNichols-O’Rourke *et al.* 2012).

The discovery of new occurrences for two SAR in the Canard River is important as neither Mapleleaf nor Lilliput was detected during the 1993 sampling of Morris and DiMaio (1998–1999). Metcalfe-Smith *et al.* (2000) indicated that increasing the search effort from 1.5 p-h (slightly more than used in the historical survey) to the 4.5 p-h used here can result in a doubling of the detection of rare species and an over-

all species detection increase of 37%. It is possible that the detection of these two SAR may simply be the result of increased effort as predicted by Metcalfe-Smith *et al.* (2000). Lilliput fits the Metcalfe-Smith *et al.* (2000) definition of a rare species and only represented <4% of mussels at any site. However, given that Mapleleaf was the second-most abundant species found during this study, it does not meet the definition of a rare species; it was found to occur at a rate of 7.5 individuals/h at a site that was sampled in 1993 without detection. Thus, it seems likely that there has been a change in its distribution and/or abundance over the last 16 years.

In a large study looking at the distribution of mussels on the United States side of the Lake St. Clair/Detroit River/western Lake Erie corridor, Zanatta *et al.* (2015) surveyed 141 sites at 48 separate locations and found that Mapleleaf was the most abundant species, particularly in the western basin of Lake Erie. After looking at the historical work of Nalepa and Gauvin (1988) and Clark (1944), Zanatta *et al.* (2015) suggested that this dominance by Mapleleaf represented a real change from historical conditions, facilitated by the ability of the species to shed attached dreissenid mussels and its short brooding time (e.g., equilibrium life history strategy of Haag 2012). New locations for Mapleleaf have recently been found in other Canadian waters, including several coastal wetlands of Lake Ontario (Wright *et al.* 2020), and Hoffman *et al.* (2018) have shown that Mapleleaf likely moved into Lake Ontario after the opening of the Welland Canal by way of its highly vagile host Channel Catfish (*Ictalurus punctatus*). COSEWIC recently reassessed the status of the Great Lakes–Upper St. Lawrence designatable unit of Mapleleaf in Canada and recommended a change in status from Threatened to Special Concern in part because of the discovery of new locations for the species (COSEWIC 2016). All of these lines of evidence support the conclusion that Mapleleaf is expanding its range in southern Ontario and the discovery in the Canard River likely represents a new occurrence.

The significance of refuge sites for the preservation and eventual recovery of unionid mussels in the Great Lakes basin has been known for some time. Early in the dreissenid invasion process, Clarke (1992) recognized that Ontario's Sydenham River and its rich mussel fauna would likely act as an important repository for mussel diversity as dreissenids spread throughout the Great Lakes basin. Coastal wetland habitats in Lake St. Clair and Lake Erie were identified early as important habitats because of a combination of flow patterns and physical habitat properties that combine to keep dreissenid settlement rates low (Nichols and Amberg 1999; Zanatta *et al.* 2002;

Bowers and Szalay 2004). Early in the response to the dreissenid invasion, the National Native Mussel Conservation Committee (1998) in the United States developed a national strategy that included recognition of the importance of riverine refuges. Cope *et al.* (2003) assessed whether *in situ* refuges were an effective means to protect threatened mussel populations, and recent efforts have been made to predict where these refuges may occur in the lower Great Lakes (Bossenbroek *et al.* 2018).

Schloesser *et al.* (2006) concluded that there were no natural refuges for native mussels along the main channel of the Detroit River and that native mussels were extirpated from the system. However, in the face of declines in dreissenid mussels in Lake St. Clair (the main source population) during the 1990s and projected continued declines, they believed that recovery might be possible if a refuge could be found. The discovery of a refuge population in the Canard River in 2019, so closely associated with the Detroit River, represents a significant source of potential recolonizers of the Detroit River. Eight years earlier, Zanatta *et al.* (2015) found no sign of live mussels at three of four locations in the Detroit River drainage on the United States side. Only the furthest downstream location, at the mouth of the Huron River near the outflow of the Detroit River, yielded live unionids. However, its extreme downstream location and the low abundance of mussels (nine) bring into question the importance of this location to recovery of the Detroit River fauna. Recently, Allred *et al.* (2020) initiated the first native mussel surveys of the Detroit River itself since Schloesser *et al.* (2006). Surveying 56 sites, they found live unionids at only five, with two (both immediately downstream of the Canard River outflow) yielding 96% (212/220) of all individuals, further supporting the idea that the Canard River may be an important source of individuals for future recovery in the Detroit River.

The presence of an intact mussel assemblage in the Canard River is an encouraging sign for future recovery of freshwater mussels throughout the Lake St. Clair/Detroit River/western Lake Erie corridor. Additional sampling in the Canard River system and other nearby rivers and wetlands, including those of the southern Lake St. Clair shoreline (e.g., Puce River) and western Lake Erie (e.g., Big Creek complex), will help evaluate the ongoing status of this assemblage and determine whether other Canadian refuges exist. The simultaneous discovery of new populations of two federally listed SAR in the Canard River will support the recovery of these species and indicates that the Canard River will likely play an important role in the restoration and recovery of Canada's freshwater mussel fauna in the future.

Author Contributions

Writing – Original Draft: T.J.M. and M.N.S.; Writing – Review & Editing: T.J.M., K.A.M.-O., and M.N.S.; Conceptualization: T.J.M.; Investigation: T.J.M., K.A.M.-O., and M.N.S.; Methodology: T.J.M., K.A.M.-O., and M.N.S.; Formal Analysis: T.J.M. and M.N.S.; Funding Acquisition: T.J.M.

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SUPPLEMENTARY MATERIAL:

Digital Voucher Specimens.

FIGURE S1. White Heelsplitter (*Lasmigona complanata*). Photos: Fisheries and Oceans Canada.

FIGURE S2. Fragile Papershell (*Leptodea fragilis*). Photos: Fisheries and Oceans Canada.

FIGURE S3. Pink Heelsplitter (*Potamilus alatus*). Photos: Fisheries and Oceans Canada.

FIGURE S4. Giant Floater (*Pyganodon grandis*). Photos: Fisheries and Oceans Canada.

FIGURE S5. Mapleleaf (*Quadrula quadrula*). Photos: Fisheries and Oceans Canada.

FIGURE S6. Lilliput (*Toxolasma parvum*). Photos: Fisheries and Oceans Canada.

FIGURE S7. Deertoe (*Truncilla truncata*). Photos: Fisheries and Oceans Canada.

FIGURE S8. Paper Pondshell (*Utterbackia imbecillis*). Photos: Fisheries and Oceans Canada.