A survey of freshwater mussels (Unionidae) in eastern Ontario (South Nation River, Lyn Creek, and Jones Creek) in 2009

M.N. Sheldon and T.J. Morris

Fisheries and Oceans Canada
Great Lakes Laboratory for Fisheries and Aquatic Sciences
867 Lakeshore Road
Burlington, ON
L7S 1A1

2018

Canadian Manuscript Report of Fisheries and Aquatic Sciences 3155

Canadian Manuscript Report of Fisheries and Aquatic Sciences

Manuscript reports contain scientific and technical information that contributes to existing knowledge but which deals with national or regional problems. Distribution is restricted to institutions or individuals located in particular regions of Canada. However, no restriction is placed on subject matter, and the series reflects the broad interests and policies of Fisheries and Oceans Canada, namely, fisheries and aquatic sciences.

Manuscript reports may be cited as full publications. The correct citation appears above the abstract of each report. Each report is abstracted in the data base *Aquatic Sciences and Fisheries Abstracts*.

Manuscript reports are produced regionally but are numbered nationally. Requests for individual reports will be filled by the issuing establishment listed on the front cover and title page.

Numbers 1-900 in this series were issued as Manuscript Reports (Biological Series) of the Biological Board of Canada, and subsequent to 1937 when the name of the Board was changed by Act of Parliament, as Manuscript Reports (Biological Series) of the Fisheries Research Board of Canada. Numbers 1426 - 1550 were issued as Department of Fisheries and Environment, Fisheries and Marine Service Manuscript Reports. The current series name was changed with report number 1551.

Rapport manuscrit canadien des sciences halieutiques et aquatiques

Les rapports manuscrits contiennent des renseignements scientifiques et techniques qui constituent une contribution aux connaissances actuelles, mais qui traitent de problèmes nationaux ou régionaux. La distribution en est limitée aux organismes et aux personnes de régions particulières du Canada. II n'y a aucune restriction quant au sujet; de fait, la série reflète la vaste gamme des intérêts et des politiques de Pêches et Océans Canada, c'est-à-dire les sciences halieutiques et aquatiques.

Les rapports manuscrits peuvent être cités comme des publications à part entière. Le titre exact figure au-dessus du résumé de chaque rapport. Les rapports manuscrits sont résumés dans la base de données *Résumés des sciences aquatiques et halieutiques.*

Les rapports manuscrits sont produits à l'échelon régional, mais numérotés à l'échelon national. Les demandes de rapports seront satisfaites par l'établissement auteur dont le nom figure sur la couverture et la page du titre.

Les numéros 1 à 900 de cette série ont été publiés à titre de Manuscrits (série biologique) de l'Office de biologie du Canada, et après le changement de la désignation de cet organisme par décret du Parlement, en 1937, ont été classés comme Manuscrits (série biologique) de l'Office des recherches sur les pêcheries du Canada. Les numéros 901 à 1425 ont été publiés à titre de Rapports manuscrits de l'Office des recherches sur les pêcheries du Canada. Les numéros 1426 à 1550 sont parus à titre de Rapports manuscrits du Service des pêches et de la mer, ministère des Pêches et de l'Environnement. Le nom actuel de la série a été établi lors de la parution du numéro 1551.

Canadian Manuscript Report
of Fisheries and Aquatic Sciences 3155

2018

A SURVEY OF FRESHWATER MUSSELS (UNIONIDAE) IN EASTERN ONTARIO (SOUTH NATION RIVER, LYN CREEK, AND JONES CREEK) IN 2009

by

M.N. Sheldon and T.J. Morris

Fisheries and Oceans Canada
Great Lakes Laboratory for Fisheries and Aquatic Sciences
867 Lakeshore Road
Burlington, ON
L7S 1A1

Cat. Fs97-4/3155E-PDF ISBN 978-0-660-26272-7 ISSN 1488-5387

Correct citation for this publication:

Sheldon, M.N. and Morris, T.J. 2018. A survey of freshwater mussels (Unionidae) in eastern Ontario (South Nation River, Lyn Creek, and Jones Creek) in 2009. Can. Manuscr. Rep. Fish. Aquat. Sci. 3155: v + 20 p.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Sheldon, M.N. and Morris, T.J. 2018. A survey of freshwater mussels (Unionidae) in eastern Ontario (South Nation River, Lyn Creek, and Jones Creek) in 2009. Can. Manuscr. Rep. Fish. Aquat. Sci. 3155: v + 20 p.

Timed-search surveys were completed at five sites on the South Nation River (SNR), one site on Lyn Creek and one site on Jones Creek by Fisheries and Oceans Canada (DFO) in 2009. These surveys aimed to augment or determine information regarding the freshwater mussel populations in these three waterbodies as DFO had not previously surveyed these rivers. A total of 1230 live individuals were observed across the three waterbodies, representing nine species including one Species at Risk (SAR). *Elliptio complanata* was the most abundant species (758 individuals) in the SNR occurring at 80% of sites. *Lampsilis radiata* was the most abundant species (175 individuals) in Lyn Creek and ten endangered *Ligumia nasuta* were also observed in this waterbody, representing the only SAR observation during the Eastern Ontario surveys. *Elliptio complanata* (8 individuals) was the only species found in Jones Creek. DFO succeeded in strengthening mussel species inventory records in the SNR and Lyn Creek as well as generating baseline data for the relatively under-studied Jones Creek.

RÉSUMÉ

Sheldon, M.N. and Morris, T.J. 2018. A survey of freshwater mussels (Unionidae) in eastern Ontario (South Nation River, Lyn Creek, and Jones Creek) in 2009. Can. Manuscr. Rep. Fish. Aquat. Sci. 3155: v + 20 p.

Des relevés en un temps déterminé ont été effectués dans cinq sites de la rivière Nation (RN), un site du ruisseau Lyn et un site du ruisseau Jones par Pêches et Océans Canada (MPO) en 2009. Ces relevés visaient à accroître ou cerner les renseignements concernant les populations de moules d'eau douce dans ces trois cours d'eau, car le MPO n'avait jamais échantillonné ces rivières auparavant. Au total, 1 230 individus vivants ont été observés dans les trois cours d'eau, représentant neuf espèces, dont l'une est une espèce en péril (EP). *Elliptio complanata* était l'espèce la plus abondante (758 individus) dans la RN, présente dans 80 % des sites. *Lampsilis radiata* était l'espèce la plus abondante (175 individus) dans le ruisseau Lyn et dix individus de *Ligumia nasuta*, une espèce en voie de disparition, ont été observés dans ce cours d'eau, représentant la seule EP observée au cours des relevés dans la région est de l'Ontario. *Elliptio complanata* (8 individus) était la seule espèce recensée dans le ruisseau Jones. Le MPO a réussi à renforcer les registres d'inventaire des espèces de moules dans la RN et le ruisseau Creek, et à générer des données de référence pour le ruisseau Jones qui est relativement peu étudié.

INTRODUCTION

The South Nation River (SNR), Lyn Creek and Jones Creek are each located in eastern Ontario within the St. Lawrence River drainage basin. The SNR travels northeast from its source north of Brockville before draining its waters into the Ottawa River near Plantagenet. Its length stretches 180 km, including a North, Middle and South branch, draining a 4,200 km^2 watershed across an almost flat plain (SNC 2014). The mere 80 m change in elevation from the source of the SNR to its mouth results in this waterbody being prone to flooding (SNC 2014). The SNR runs through areas with large amounts of highly unstable quick clay, or glaciomarine clay, which was deposited by glaciers and contributes to the turbid conditions of the SNR as it erodes (Evans and Brooks 1994). Much of the SNR, especially in the river's lower reaches, consists of deep stretches with hard clay substrate. Near the source of the SNR, the small and naturally turbid Lyn Creek travels through lands mostly under private ownership; it has remained relatively undisturbed compared to other eastern Ontario areas (BMNHC 2006; COSEWIC 2007). Lyn Creek is a tributary of Jones Creek (BMNHC 2006), which is a popular location for boating within Thousand Islands National Park in Mallorytown, Ontario. Jones Creek runs southward through the park before draining into the upper St. Lawrence River near Brockville shortly after its point of connection with Lyn Creek (COSEWIC 2007).

Fisheries and Oceans Canada (DFO) had not previously surveyed any sites on the SNR, Lyn Creek or Jones Creek. Baseline surveys had been completed in the SNR by other organizations prior to the current survey (Picard et al. 2009; Schueler 1997) (Figure 1). Table 1 lists the nine live common species and the additional three common species found as shells that were recorded from the SNR before the current 2009 survey (Picard et al. 2009; F.W. Schueler, Fragile Inheritance Natural History, Oxford Station, Ontario, personal communication, 2018). Another two live common species have been observed in the SNR since the current survey (Schueler 2010; F.W. Schueler, Fragile Inheritance Natural History, Oxford Station, Ontario, personal communication, 2018). Zebra Mussels (*Dreissena polymorpha*) have been present in the lower SNR since 2000 (Benson 2013). The lower reaches of this river are heavily infested by the invasive species (F.W. Schueler, Fragile Inheritance Natural History, Oxford Station, Ontario, personal communication, 2018) and they have been observed as far upstream as the Crysler Dam (Schueler 2010). Although the current survey focused on augmenting the general mussel inventories of the SNR, the potential presence of *Obovaria olivaria* (Hickorynut) within this waterbody was considered. This species has been assessed as Endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (Table 2) and has been found in the Ottawa River (Lower Great Lakes Unionid Database 2017). As the SNR is a tributary of the Ottawa River, there is the potential for *O. olivaria* to inhabit the SNR.

There is less known about the mussel communities in Lyn Creek and, especially, Jones Creek (Table 1). Recent surveys have occurred in Lyn Creek as it is home to *Ligumia nasuta* (Eastern Pondmussel) (Figure 2). This species was formerly listed as Endangered under the Species at Risk Act (SARA) but was recently reassessed by COSEWIC as Special Concern (COSEWIC 2017) (Table 2). *Ligumia nasuta* was first recorded live in Lyn Creek in 2006 by Frederick Schueler (BMNHC 2006). Five live

common species were also recorded in Lyn Creek prior to 2009 (McNichols et al. 2009; F.W. Schueler, Fragile Inheritance Natural History, Oxford Station, Ontario, personal communication, 2018). Due to the physical connection between the two waterbodies, Jones Creek was formally surveyed for the first time by DFO to investigate the potential presence of *L. nasuta*. Prior to this survey, weathered shells of four identified Unionid species had been observed in Jones Creek (Lower Great Lakes Unionid Database 2017; F.W. Schueler, Fragile Inheritance Natural History, Oxford Station, Ontario, personal communication, 2018) (Table 1; Figure 2).

The objective of the 2009 sampling events was to increase information regarding the status of the freshwater mussel populations in the SNR and Lyn Creek and to further investigate the freshwater mussel community in Jones Creek, where formal surveys had not been completed.

METHODS

Five sites on the SNR (one site on the North Branch, three sites on the Middle Branch, and one site on the South Branch) and one on each of Lyn Creek and Jones Creek, were sampled between August 11 – 12, 2009 by DFO (Table 3; Figure 3). Timed-search surveys were completed using a combination of tactile and visual techniques, depending on water clarity. Clear water allowed the use of viewing boxes, while turbid water required tactile techniques. The standard 4.5 person-hours of search effort was completed at each of the seven sites (Metcalfe-Smith et al. 2000). Every animal found was identified, measured, sexed (if possible) and released. Due to the morphological similarities between *Pyganodon grandis* (Giant Floater) and *P. cataracta* (Eastern Floater) in this region of overlap, genetic testing would be required to accurately differentiate between these species (Cyr et al. 2007). As such, individuals of this genera observed in the SNR were identified only to genus to avoid inaccurate species identification based on morphology. For sites where no live individuals of a given species were found, valves/shells were noted; for sites where live individuals and valves/shells of a species were found, only live individuals were noted.

In addition to the information collected on the mussel community, several physical and environmental variables were also recorded at each site. These included substrate composition (%), water clarity (m), length (m) and width (m) of reach, and mean stream depth (m). Substrate composition was visually estimated while water clarity was measured using a turbidity tube. Length and width of reach were measured with a range finder and mean depth was measured using a metre stick. Definitions of substrate sizes were modified from those of Wentworth (1922): boulder (>250 mm in diameter), rubble (60-250 mm), gravel (20-50 mm), sand (<2 mm), clay (1/256 mm) and “other” material (mud, muck, silt, and detritus).

For species found in high enough abundance within a waterbody, length frequency distributions were generated and a Shapiro-Wilks test was used to investigate the normality of the size distributions as an indication of recruitment. A Chi-Square Goodness of Fit test was used to analyze the observed sex ratios of a species within a waterbody. All data analyses were completed in R Studio 0.99.896.

RESULTS

FRESHWATER MUSSEL COMMUNITY

Across the five SNR sites, 870 live individuals were observed, representing seven species (Table 4). Total live abundance ranged widely across sites from one individual at SN1 to 393 individuals at SN4. Species richness ranged from one live species at SN1 to seven at SN3; this includes the *Pyganodon* sp. individuals. *Elliptio complanata* (Eastern Elliptio) was the most abundant species with 758 individuals occurring across 80% of the sites. It should be noted that at SN2, *E. complanata* were collected for two person-hours (not 4.5 person-hours) due to their high abundance. Individuals of the *Pyganodon* genus were the second most abundant, numbering 57 individuals, and were the most widespread occurring at 100% of the SNR sites. Length frequency distributions were generated for *E. complanata* in the SNR and were analyzed for indications of recruitment within the population (Figure 4A). Lengths of *E. complanata* ranged from 48 – 112 mm (n = 758) and were normally distributed (W = 0.8971, p = 0.3136). The range of lengths varied among the remaining species found: *Lampsilis cardium* (Plain Pocketbook) ranged from 75 – 140 mm (n = 11); *Lampsilis radiata* (Eastern Lampmussel) ranged from 37 – 111 mm (n = 13); the single *Lasmigona costata* (Flutedshell) was 93 mm; *Ligumia recta* (Black Sandshell) ranged from 107 – 161 mm (n = 15); *Pyganodon* sp. individuals ranged from 35 – 106 mm; and *Strophitus undulatus* (Creeper) ranged from 24 – 69 mm (n = 15). Three sexually dimorphic species were found in the SNR: *L. cardium, L. radiata* and *L. recta*. A total of eight male and three female *L. cardium* were observed in the SNR representing a statistically equal sex ratio of 1:2.7 ($\chi^2_{0.05,1} = 2.2727$, p = 0.1317). Similarly, *L. radiata* also had a statistically equal male to female sex ratio of 1:3 ($\chi^2_{0.05,1} = 3$, p = 0.0833), with nine males and three females observed. Analysis was not performed on the 15 *L. recta* individuals observed as nine were of undetermined sex, while the remaining six individuals were identified as female. No evidence of Zebra Mussels was observed at any of the five SNR sites.

At the single site surveyed in Lyn Creek, 352 live individuals were found, representing five species; this includes the single SAR observed during the 2009 surveys, *L. nasuta* (Table 4). *Lampsilis radiata* was the most abundant species represented by 175 individuals, followed by *E. complanata* with 156 individuals. Ten *L. nasuta* were observed with lengths ranging from 66 – 93 mm. The lengths of *P. grandis* ranged from 52 – 98 mm (n = 10) and the single *Anodontoides ferussacianus* (Cylindrical Papershell) was 46 mm in length. Length frequency distributions were generated for *E. complanata* (Figure 4B) and *L. radiata* (Figure 5) in Lyn Creek. Lengths of *E. complanata* ranged from 49 – 109 mm and represented a normal distribution (W = 0.8292, p = 0.0786). Of the 175 sexually dimorphic *L. radiata* observed in Lyn Creek, 80 were male with lengths ranging from 41 – 94 mm and 95 were female with lengths ranging from 45 – 90 mm. This represented a statistically equal male to female sex ratio of 1:1.2 ($\chi^2_{0.05,1} = 1.2857$, p = 0.2568). The lengths of the males did not represent a normal distribution (W = 7654, p = 0.0281) but the lengths of the females did represent a normal distribution (W = 0.7939, p = 0.0518). No evidence of Zebra Mussels was observed at LC1.

Eight live *E. complanata* were found at the single site surveyed in Jones Creek. Lengths of these eight individuals ranged from 72 – 143 mm (Table 4). No evidence of Zebra Mussels was observed at JC1.

ABIOTIC FACTORS

A summary of the physical data collected at each site is provided in Table 5. Not all of the data were collected at all seven sites; the means presented below do not include sites where the data were not collected. In the SNR, substrate varied across the four sites data were collected at, ranging from a high percentage of bedrock to clay. One site was dominated by coarse substrate (SN2) and three by fine-textured substrate (SN3, SN4 and SN5). High percentages of clay, for which the SNR is known, were observed at two sites (SN4 and SN5). Mean water clarity was 0.72 m and the mean depth searched was 0.66 m. Site length and mean width ranged from 95 – 260 m and 7 – 30 m, respectively.

Substrate data were not collected at Lyn Creek; however, the Jones Creek site was dominated by coarse substrate. Water clarity at Lyn Creek and Jones Creek was 1 m and 0.5 m, respectively. Mean depth searched was 1.2 m in Lyn Creek and 0.75 m in Jones Creek. Site length and mean width were 151 m and 13 m in Lyn Creek and 82 m and 4 m in Jones Creek.

DISCUSSION

SPECIES AT RISK OCCURRENCES

Ligumia nasuta was a historically widespread species in the lower Great Lakes region until Dreissenid mussels (Zebra and Quagga (*D. rostriformis bugensis*) mussels) invaded 90% of its range, rendering these waters uninhabitable by the formerly Endangered species (COSEWIC 2007). Historically, *L. nasuta* occurred in lakes St. Clair, Erie and Ontario, including their connecting channels and some lower tributaries (COSEWIC 2007). Until recently, the current distribution of *L. nasuta* was thought to be restricted to the Lake St. Clair delta and Lyn Creek, which is the farthest east this species has been observed in Canada. Recent surveys have also found this species throughout a number of coastal wetland areas of lakes Ontario and Erie (Reid et al. 2014) and Coyle Creek, a tributary of the Welland River (Wright et al. 2017). The discovery of these new populations contributed to the reassessment of this species as Special Concern by COSEWIC (2017). Shells of *L. nasuta* were first recorded in Golden Creek, a tributary of Lyn Creek, in 2005 before live individuals were observed in Lyn Creek in 2006 (BMNHC 2006; COSEWIC 2007). Surveys by the University of Guelph in late May 2008 showed the presence of gravid females in Lyn Creek, which suggests that reproduction is occurring at some level in this system (McNichols et al. 2009). Despite the connection between Lyn Creek and Jones Creek, no evidence of *L. nasuta* was found in Jones Creek. JC1, as well as all previous surveys in the waterbody (Schueler 2014), was upstream of Jones Creek's more estuarine habitat. *Ligumia nasuta* is known to prefer sheltered, slack-water areas in rivers with finer substrates (COSEWIC 2007), which is characteristic of estuarine areas such as those found in lower Jones Creek. This habitat is not present in the upper reaches of the waterbody that have been surveyed. The *L. nasuta* observed during the current study in Lyn Creek support the findings of previous studies; however, further surveys are required to

determine the densities of this species using quantitative surveys and to determine if recruitment is occurring in this system. Future surveys should also focus on the lower reaches of Jones Creek to target the preferred habitat of *L. nasuta*.

No *O. olivaria* were observed in the SNR despite its connection with the Ottawa River. While *O. olivaria's* only known host fish species, *Acipenser fulvescens* (Lake Sturgeon), has been recorded in the SNR (COSEWIC 2011; SNC 2013), the host's range is not known to overlap with the locations surveyed in 2009. The most upstream observation of this species occurred in the mid-1970s just below Casselman, ON, which is located over 50 km downstream of SN4 (E. Grégoire, Environment and Climate Change Canada, Ottawa, Ontario, personal communication, 2018; N. Langlois-Anderson, South Nation Conservation, Finch, Ontario, personal communication, 2018). The only location in the SNR that *A. fulvescens* is currently known to inhabit is the bay at Jessups Falls (N. Langlois-Anderson, South Nation Conservation, Finch, Ontario, personal communication, 2018). Jessups Falls' bay is located in the extreme lower reaches of the SNR, only 3 km upstream from its confluence with the Ottawa River. *Acipenser fulvescens* is most likely not travelling into the upper reaches of the SNR due to its preference for deeper water habitats, typically being found at depths of 5 to 10 m (COSEWIC 2011). Additionally, the seven water control structures along the SNR, including two dams at Crysler and Chesterville, could be hindering the upstream movement of *A. fulvescens* (SNC 2018). The distribution of *O. olivaria* is limited by the movement of their host species so the lack of *O. olivaria* at these upstream sites is not surprising (Strayer et al. 2004). The absence of *O. olivaria* could also be attributed to the lack of suitable habitat at the sites surveyed. This mussel species is considered a deep water species, preferring depths beyond 2 to 3 m (COSEWIC 2011).The average depth of the five SNR sites was much shallower, averaging only 0.70 m. Additionally, *O. olivaria* prefers sandy substrate, which was lacking at three of the four sites where substrate data were collected at (COSEWIC 2011). Future surveys targeting the preferred habitat of *O. olivaria* habitat (e.g., lower, deeper reaches of the SNR) where there is an increased likelihood of encountering *A. fulvescens* could shed light on the presence of this endangered species in the SNR. Standard mussel surveys techniques are not suitable for searching deep water areas and alternative techniques, such as mussel brail or SCUBA diving, would have to be employed in the lower SNR.

COMMON SPECIES OCCURRENCES

The previous data collected in the SNR provides the opportunity for the comparison of results with the current survey to investigate changes in the mussel community over time. Of the nine live species known from prior surveys of the SNR, five of these were also found live during the current survey. *Lasmigona compressa* (Creek Heelsplitter), *Potamilus alatus* (Pink Heelsplitter) and *Utterbackia imbecillis* (Paper Pondshell) were not observed during the current survey despite evidence of these species from previous surveys (Picard et al. 2009; Schueler 1997; F.W. Schueler, Fragile Inheritance Natural History, Oxford Station, Ontario, personal communication, 2018). The former surveys had identified *P. grandis* individuals to species but the current survey did not identify *Pyganodon* individuals beyond genus in this waterbody. Since there is distributional overlap of *P*. *grandis* and *P*. *cataracta* in this area, and it is difficult to distinguish the two species based on morphology (Cyr et al. 2007), further genetic studies should be completed in order to verify which species, if not both, is

present in the waterbody. The *L. recta* individuals found at two sites during the current survey represent the first live record of this species in the SNR after shells were observed during previous surveys (Picard et al. 2009; F.W. Schueler, Fragile Inheritance Natural History, Oxford Station, Ontario, personal communication, 2018). A weathered *L. recta* shell was observed at the mouth of the SNR in 2001 but this specimen was attributed to the Ottawa River population (F.W. Schueler, Fragile Inheritance Natural History, Oxford Station, Ontario, personal communication, 2018). This was the only species found live during the current survey that had not been observed before in the SNR. Although there was no evidence of *Alasmidonta undulata* (Triangle Floater) and *Anodontoides ferussacianus* (Cylindrical Papershell) during the 2009 survey, these species have since been recorded in the upper SNR within the area of the current surveys (Schueler 2010; F.W. Schueler, Fragile Inheritance Natural History, Oxford Station, Ontario, personal communication, 2018). Zebra Mussels do not seem to have spread as far upstream as the survey sites as no evidence of this species was found at any site.

The results of the 2009 DFO survey of Lyn Creek reflected those of both the 2006 and 2008 surveys in the waterbody. No new species were observed during the 2009 surveys; the single *A. ferussacianus* found in 2009 represented the only species that was not found in 2006; however, this species was observed in 2008 (McNichols et al. 2009; F.W. Schueler, Fragile Inheritance Natural History, Oxford Station, Ontario, personal communication, 2018). The similarity of the mussel community in Lyn Creek between sampling events suggests no significant changes have occurred within the waterbody over this short time span. Future quantitative surveys would allow for further investigation of the *L. nasuta* population in Lyn Creek and the continued comparison of population trends overtime. Surveys of the Lyn Creek tributary Golden Creek, in which shells of *L. nasuta* have been observed on numerous occasions, could provide further insight into this SAR.

Four species were observed as shells in Jones Creek in the 1940s: *E. complanata, Lampsilis siliquoidea* (Fatmucket)*, L. radiata* and *Pyganodon* sp. (Lower Great Lakes Unionid Database 2017). There was no information regarding the specific location in Jones Creek at which these shells were found. Only one of these species, *E. complanata*, was observed in the current survey. No evidence of the other three species was found. Since 2009, only weathered unidentified Unionid shell fragments have been observed in Jones Creek (Schueler 2014). Lack of host fish presence does not seem to account for the low abundance and species richness of mussels as over ten fish species, including hosts for the common mussel species and *L. nasuta* found in Lyn Creek, have also been observed in Jones Creek (Great Lakes Biodiversity Science Database 2017). The lack of native mussels observed in Jones Creek does not appear to be associated with the presence of Dreissenid mussels as no live individuals were observed during the current survey or previous surveys. However, an abundance of weathered Zebra Mussel shells have been observed near the mouth of Jones Creek, downstream of JC1 (Schueler 2014) (Figure 2).

Analysis of the length frequency distributions for *E. complanata* in the SNR and Lyn Creek and *L. radiata* in Lyn Creek provided insight into population recruitment. The lengths of both populations of *E. complanata* as well as the lengths of the female *L. radiata* from Lyn Creek represented a normal distribution. Only the lengths of male *L.*

radiata from Lyn Creek did not represent a normal distribution. However, the *E. complanata* populations in both the SNR and Lyn Creek as well as the *L. radiata* population in Lyn Creek lack individuals with small shell lengths. Haag and Warren (2007) state that generally, individuals with shell lengths of less than 25 mm represent those recruited into the population within the last 2 – 3 years. None of the three populations for which length distributions were analyzed had individuals below 25 mm. While size at this age varies drastically between Unionid mussel species, applying this general guideline to the observed animals suggests no individuals have been recruited into these populations within the last few years, indicating limited population growth (Haag and Warren 2007). This trend could, however, also be explained by the nature of the timed-search survey technique used. This technique relies on visual and tactile methods for collection, which are biased towards the detection of larger mussels (Strayer and Smith 2003). Individuals of small shell length are often missed when this technique is used, potentially accounting for the paucity of smaller individuals in all three populations which provides a skewed estimation of recruitment.

Although *L. radiata* in Lyn Creek did not have a normal length frequency distribution, there was a statistically equal male to female sex ratio. A 1:1 ratio between males and females is expected in species whose sex is determined genetically and not influenced by the environment, as is the case with freshwater mussels (Morton 1991). Both the *L. radiata* and *L. cardium* populations in the SNR were also represented by a statistically equal male to female sex ratio; however, these results should be interpreted with caution due to the small sample size. These ratios should be recalculated using larger datasets from future surveys to provide more accurate estimates.

It should be noted that while the current surveys aimed to generate a more robust inventory of the freshwater mussel populations within these waterbodies, these surveys do not represent a complete assessment of the rivers. The survey of a single site (e.g., Lyn and Jones creeks) does not represent a full understanding of the mussel community within the entire waterbody as rivers, and the mussel communities within them, vary drastically throughout their course; a single site only represents a localized snapshot of the mussel population within a waterbody (Morris et al. 2018). Additionally, while the surveys in the SNR were more extensive, the selected sites were restricted to the upper portion of the watershed where water levels supported wadeable conditions. The deeper, lower portions of the SNR, which have hard clay substrate, remain under-studied as these conditions are not ideal for traditional mussel survey techniques. Other survey methods, such as a mussel brail or SCUBA diving, would be required to effectively survey these stretches. It is imperative that these deep water areas be surveyed as some mussel species prefer deep water habitats, including *O. olivaria* which generally inhabits depths of 2 – 3 m that are well outside of the wadeable depth limit (COSEWIC 2011).

CONCLUSION

Fisheries and Oceans Canada surveyed seven sites across the SNR, Lyn Creek and Jones Creek in 2009 in order to investigate the status of freshwater mussel populations in these waterbodies. A total of 1230 live individuals were collected at the seven sites, representing nine species including one SAR, as well as additional *Pyganodon* sp. individuals. The survey of five sites in the SNR provided additional

information on the freshwater mussel population in this system. Notably, this included the first live record of *L. recta* in the SNR. The presence of *L. nasuta* in Lyn Creek continues and represents the only SAR found during the eastern Ontario surveys. The observation of live *E. complanata* in Jones Creek was the first live record of a Unionid species in this waterbody.

While these surveys augmented the information regarding Unionid mussels in Eastern Ontario, many knowledge gaps still surround these populations. The lower, deeper reaches of the SNR and the estuarine habitat in lower Jones Creek must be the focus of future surveys to fully investigate the potential for *O. olivaria* and *L. nasuta* populations, respectively. Larger datasets are required to generate a more accurate estimate of the health of mussel populations in these rivers, garnered from recruitment estimates and sex ratios. Quantitative surveys would provide further insight on the status of these populations through the determination of species densities. Despite the remaining knowledge gaps, DFO succeeded in gathering additional data on the mussel communities in the SNR, Lyn Creek and Jones Creek.

ACKNOWLEDGEMENTS

The authors would like to thank Vanessa Minke-Martin, Amy Robinson, Izabel Sagan and John Simzer for providing field assistance during this study. We thank Brydon MacVeigh for creating the GIS maps. We also thank Kelly McNichols-O'Rourke and Frederick Schueler for reviewing this manuscript. Financial support for this project was provided by Fisheries and Oceans Canada's Species at Risk Program.

REFERENCES

Benson, A.J. 2013. Chronological history of zebra and quagga mussels (Dreissenidae) in North America, 1988-2010. Quagga and zebra mussels; Biology, impacts and control. CRC Press Taylor & Francis Group, Florida, USA. 21 + 26 pp.

BMNHC. 2006. Press Release 16 August 2006: Rare mussel found in Lyn Creek. The Bishops Mills Natural History Centre. Available from http://pinicola.ca/nasuta.htm [Accessed January 2017].

COSEWIC. 2007. COSEWIC assessment and status report on the Eastern Pondmussel *Ligumia nasuta* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 34 pp.

COSEWIC. 2011. COSEWIC assessment and status report on the status report on the Hickorynut *Obovaria olivaria* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. x + 46 pp.

COSEWIC. 2017. COSEWIC assessment and status report on the Eastern Pondmussel *Ligumia nasuta* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xii + 61 pp.

Cyr, F., Paquet, A., Marte, A.L. and Angers, B. 2007. Cryptic lineages and hybridization in freshwater mussels of the genus *Pyganodon* (Unionidae) in northeastern North America. Can. J. Zool. 85(12):1216-1227.

Evans, S.G. and Brooks, G.R. 1994. An earthflow in sensitive Champlain Sea sediments at Lemieux, Ontario, June 20, 1993, and its impact on the South Nation River. Can. Geotech. J. 31(3):384-394.

Government of Canada. 2018. Species at Risk Public Registry. Available from http://www.sararegistry.gc.ca/sar/index/default_e.cfm?stype=species&lng=e&index=1&common=&scientific=&population=&taxid=9&locid=5&desid=0&schid=0&desid2=0& [Accessed April 2018].

Great Lakes Biodiversity Science Database. 2017. Great Lakes Biodiversity Science Database. Microsoft Access 2010. Department of Fisheries and Oceans, Great Lakes Laboratory of Fisheries and Aquatic Sciences, Burlington, Ontario.

Haag, W.R. and Warren, M.L. 2007. Freshwater mussel assemblage structure in a regulated river in the Lower Mississippi River Alluvial Basin, USA. Aquatic Conserv: Mar. Freshw. Ecosyst. 17(1):25-36.

Lower Great Lakes Unionid Database. 2017. Lower Great Lakes Unionid Database. Microsoft Access 2010. Department of Fisheries and Oceans, Great Lakes Laboratory of Fisheries and Aquatic Sciences, Burlington, Ontario.

McNichols, K. A., Zanatta, D.T., Wilson, C.C., and Ackerman, J.D. 2009. Investigating Research Gaps for the Recovery of Unionid Mussel Species at Risk in Canada. 2008/09 Final Report (Project # ESR1509), Endangered Species Recovery Fund. 22 pp.

Metcalfe-Smith, J.L., Di Masio, J., Staton, S.K., and Mackie, G.L. 2000. Effect of sampling effort on the efficiency of the timed search method for sampling freshwater mussel communities. J. N. Am. Benthol. Soc. 19(4):725-732.

MNRF. 2018. Species at risk in Ontario list. Available from https://www.ontario.ca/environment-and-energy/species-risk-ontario-list [Accessed April 2018].

Morris, T.J., McNichols-O'Rourke, K.A., and Reid, S.M. (Editors). 2018. Proceedings of the 2017 Canadian Freshwater Mollusc Research Meeting: November 8-9, 2017, Burlington, Ontario. Can. Tech. Rep. Fish. Aquat. Sci. 3246: viii + 26 pp.

Morton, B. 1991. Do the Bivalvia demonstrate environment-specific sexual strategies? A Hong Kong model. J. Zool. 223(1):131-142.

Picard, I., Desroches, J, Schueler, F.W. and Martel, A.L. 2009. Modern records of the Pink Heelsplitter mussel, *Potamilus alatus* (Say, 1817), in the Ottawa River drainage, Quebec and Ontario, Canada. BioOne. 16(3):335-364.

Porto-Hannes, I. 2017. Use of molecular genetics for the conservation of North American freshwater mussels (Bivlavia: Unionidae). Thesis (PhD) Buffalo University, Buffalo, New York.

Reid, S. M., Brumpton, A., Hogg, S. and Morris, T. 2014. A comparison of two timed search methods for collecting freshwater mussels in Great Lakes coastal wetlands. Walkerana. 17(1):16-23.

Schueler, F. 1997. Another year surveying the distribution of Unionids in Eastern Ontario. Triannual Unionid Report 12:15. 15 pp.

Schueler, F. 2010. Preliminary Unionid results from the Eastern Ontario Species at Risk Project. Report to Ontario Freshwater Mussel Recovery Team. December 14 2010 meeting. 3, 5, 15 + 16 p.

Schueler, F. 2014. *Jones Creek in November*. Chorus: Newsletter of the Ottawa Amphibian and Reptile Association. 30(2):4-6.

SNC. 2013. Fish Species List. Available from http://www.nation.on.ca/water/reports/fish-species-list. [Accessed May 10, 2017].

SNC. 2014. State of the Nation Report. South Nation Conservation, Finch, Ontario. 1 + 32 pp.
SNC. 2018. Water Control Structures. Available from http://www.nation.on.ca/water/projects/water-control-structures. [Accessed March 14, 2018].
Strayer, D.L. and Smith, D.R. 2003. A guide to sampling freshwater mussel populations. American Fisheries Society, Bethesda, Maryland. 48 pp.
Strayer, D.L., Downing, J.A., Haag, W.R., King, T.L., Layzer, J.B., Newton, T.J. and Nichols, S.J. 2004. Changing perspectives on Pearly Mussels, North America's most imperiled animals. BioScience. 54(5):429-439.
Wentworth, C.K. 1922. A scale of grade and class terms for clastic sediments. J. Geol. 30(5):377-392.
Wright, K.A., McNichols-O'Rourke, K.A., Sheldon, M.N. and T.J. Morris. 2017 Freshwater mussel surveys of the Welland River watershed: 2014-16. Can. Manuscr. Rep. Fish. Aquat. Sci. 3115: v + 30 p.

Table 1. Species observed in the SNR, Lyn Creek and Jones Creek before the current 2009 surveys and after the current 2009 surveys. Data from Lower Great Lakes Unionid Database (2017), McNichols et al. (2009), Picard et al. (2009), Schueler (2010) or F.W. Schueler (Fragile Inheritance Natural History, Oxford Station, Ontario, personal communication, 2018). Species observed alive are represented by "Y" and species observed as shells only are represented by "SH". Species at Risk are highlighted.

Scientific Name	SNR		Lyn Creek		Jones Creek	
	Before	After	Before	After	Before	After
Alasmidonta undulatus	-	Y	-	-	-	-
Anodontoides ferussacianus	SH	Y	Y	-	-	-
Elliptio complanata	Y	Y	Y	-	SH	SH
Lampsilis cardium	Y	Y	-	-	-	-
Lampsilis radiata	Y	Y	Y	-	SH	-
Lampsilis siliquoidea	-	-	-	-	SH	-
Lampsilis sp.	-	-	Y	-	-	SH
Lasmigona compressa	Y	-	-	-	-	-
Lasmigona costata	Y	Y	-	-	-	-
Leptodea fragilis	SH	-	-	-	-	-
Ligumia nasuta	-	-	Y	Y	-	-
Ligumia recta	SH	-	-	-	-	-
Potamilus alatus	Y	-	-	-	-	-
Pyganodon grandis	Y	Y	Y	-	-	-
Pyganodon sp.	-	-	SH	-	SH	-
Strophitus undulatus	Y	Y	-	-	-	-
Utterbackia imbecillis	Y	-	-	-	-	-

Table 2. Species at Risk in Ontario and their current COSEWIC assessment and federal and provincial designation status as of April 2018.

Scientific Name	COSEWIC assessment[1]	SARA status[1]	ESA status[2]
Epioblasma rangiana	Endangered	Endangered	Endangered
Epioblasma triquetra	Endangered	Endangered	Endangered
Lampsilis fasciola	Special Concern	Special Concern	Threatened
Ligumia nasuta	Special Concern	Endangered	Endangered
Obliquaria reflexa	Threatened	Under consideration	Threatened
Obovaria olivaria	Endangered	Under consideration	Endangered
Obovaria subrotunda	Endangered	Endangered	Endangered
Pleurobema sintoxia	Endangered	Endangered	Endangered
Ptychobranchus fasciolaris	Endangered	Endangered	Endangered
Quadrula quadrula	Special Concern (ON) Threatened (MB)	Threatened	Threatened
Simpsonaias ambigua	Endangered	Endangered	Endangered
Toxolasma parvum	Endangered	Under consideration	Threatened
Truncilla donaciformis	Endangered	Under consideration	Endangered
Villosa fabalis	Endangered	Endangered	Endangered
Villosa iris	Special Concern	Endangered	Special Concern

[1]Government of Canada 2018
[2]MNRF 2018

Table 3. Information on the seven sites across the South Nation River, Lyn Creek and Jones Creek surveyed by Fisheries and Oceans Canada in 2009 using timed-searches. South Nation River sites are presented in downstream to upstream order (north to south).

Site Code	Drainage	Waterbody	Latitude	Longitude	Date (yyyymmdd)
SN4	Ottawa River	South Nation River (North Branch)	45.03037	-75.41285	20090812
SN3	Ottawa River	South Nation River (Middle Branch)	45.00372	-75.41183	20090811
SN2	Ottawa River	South Nation River (Middle Branch)	44.88433	-75.52505	20090811
SN5	Ottawa River	South Nation River (South Branch)	44.85180	-75.46352	20090812
SN1	Ottawa River	South Nation River (Middle Branch)	44.70815	-75.63747	20090811
LC1	St. Lawrence River	Lyn Creek	44.52546	-75.80488	20090811
JC1	St. Lawrence River	Jones Creek	44.51416	-75.83058	20090812

Table 4. Sampling results of timed-search surveys at seven sites across the South Nation River, Lyn Creek and Jones Creek by Fisheries and Oceans Canada in 2009. South Nation River sites are presented in downstream to upstream order (north to south). Species at Risk are highlighted.

Scientific Name	SN4	SN3	SN2	SN5	SN1	LC1	JC1	Total
Anodontoides ferussacianus	-	-	-	-	-	1	-	1
Elliptio complanata	369	208	179*	2	-	156	8	922
Lampsilis cardium	-	7	4	-	-	-	-	11
*Lampsilis radiata***	3	3	5	2	-	175	-	188
Lasmigona costata	-	1	-	-	-	-	-	1
Ligumia recta	1	14	-	-	-	-	-	15
Ligumia nasuta	-	-	-	-	-	10	-	10
Pyganodon grandis	-	-	-	-	-	10	-	10
Pyganodon sp.	19	13	7	17	1	-	-	57
Strophitus undulatus	1	1	-	13	-	-	-	15
Total live abundance	393	247	195	34	1	352	8	1230
Total live species richness	5	7	4	4	1	5	1	
Effort (person-hours)	4.5	4.5	4.5	4.5	4.5	4.5	4.5	

**Elliptio complanata* collected for 2 person-hours due to high abundance.
**It should be noted that this area of eastern Ontario is a potential region of hybridization between *L. siliquoidea* and *L. radiata* (Porto-Hannes 2017). For the purpose of this report, these individuals will be considered *L. radiata* in concordance with the in-field identification. However, without genetic verification, these individuals could be *L. siliquoidea* or hybridizations of the two species.

Table 5. Physical characteristics of the sites surveyed in the South Nation River, Lyn Creek and Jones Creek in 2009 by Fisheries and Ocean Canada. South Nation River sites are presented in downstream to upstream order (north to south). Substrate types are modified from Wentworth (1922): boulder is >250 mm in size, rubble is between 60-250 mm in size, gravel is between 20-50 mm in size, sand is <20 mm in size, and clay is 1/256 mm in size. "Other" includes muck, mud, silt, and detritus. "-" represents data that were not collected at a site.

	Substrate (%)											Stream Morphology			
Site Code	**Bedrock**	**Boulder**	**Rubble**	**Gravel**	**Sand**	**Clay**	**Other**	**Water clarity (m)**	**Site length (m)**	**Mean width (m)**	**Mean depth searched (m)**	**Riffle**	**Run**	**Pool**	**Flat**
SN4	0	0	30	0	0	50	20	0.15	104	14	0.6	0	0	0	100
SN3	0	0	20	0	70	0	10	-	106	30	1	0	0	0	100
SN2	50	0	30	20	0	0	0	1	95	28	0.75	0	0	0	100
SN5	0	0	10	15	0	45	30	1	112	7	0.3	20	10	70	0
SN1	-	-	-	-	-	-	-	-	260	-	-	-	-	-	-
LC1	-	-	-	-	-	-	-	1	151	13	1.2	0	0	0	100
JC1	0	80	10	0	0	10	0	0.5	82	4	0.75	40	20	40	0

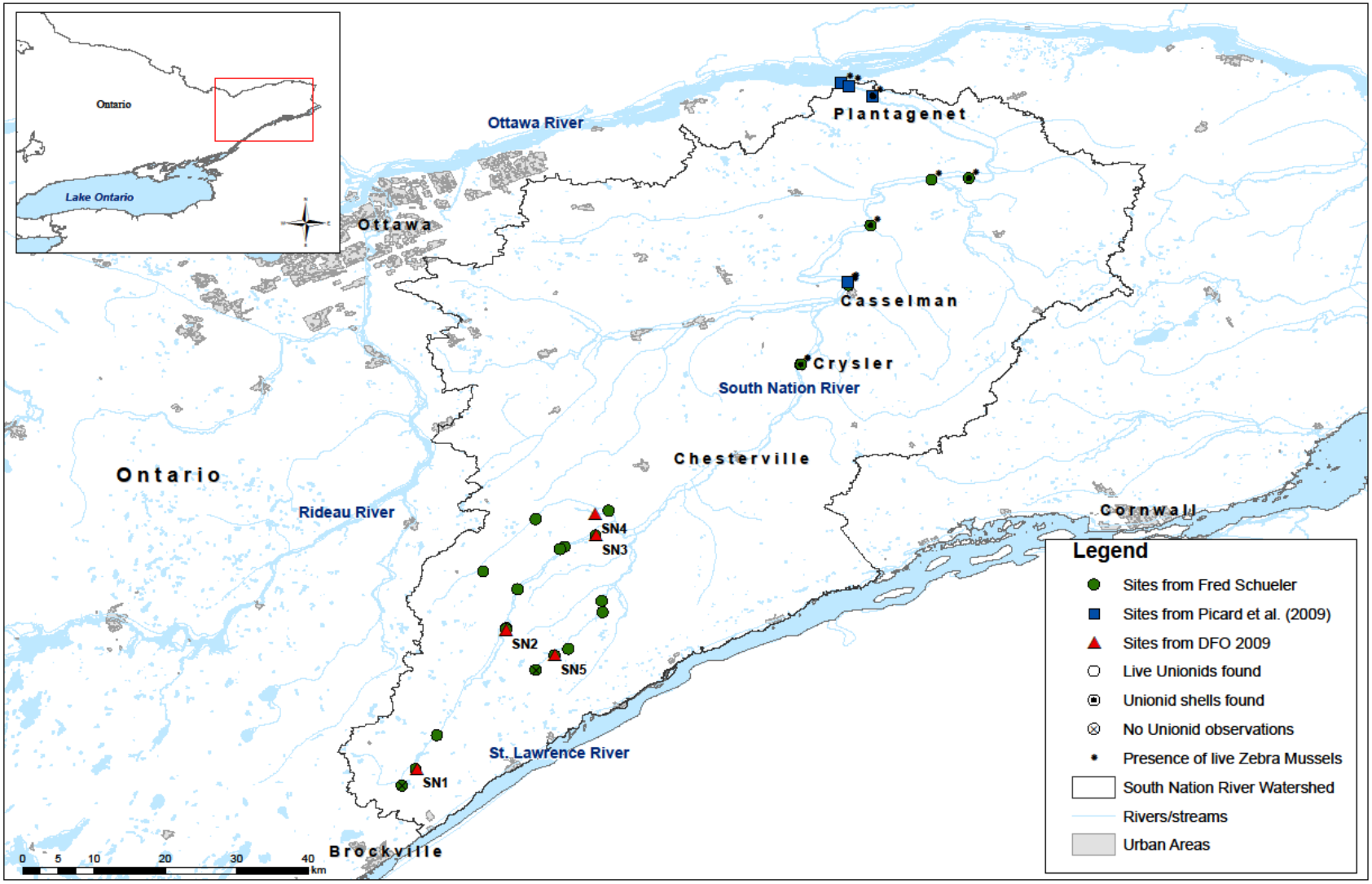

Figure 1. Sites surveyed for freshwater mussels by Fisheries and Oceans Canada, Fred Schueler or Picard et al. (2009) in the South Nation River.

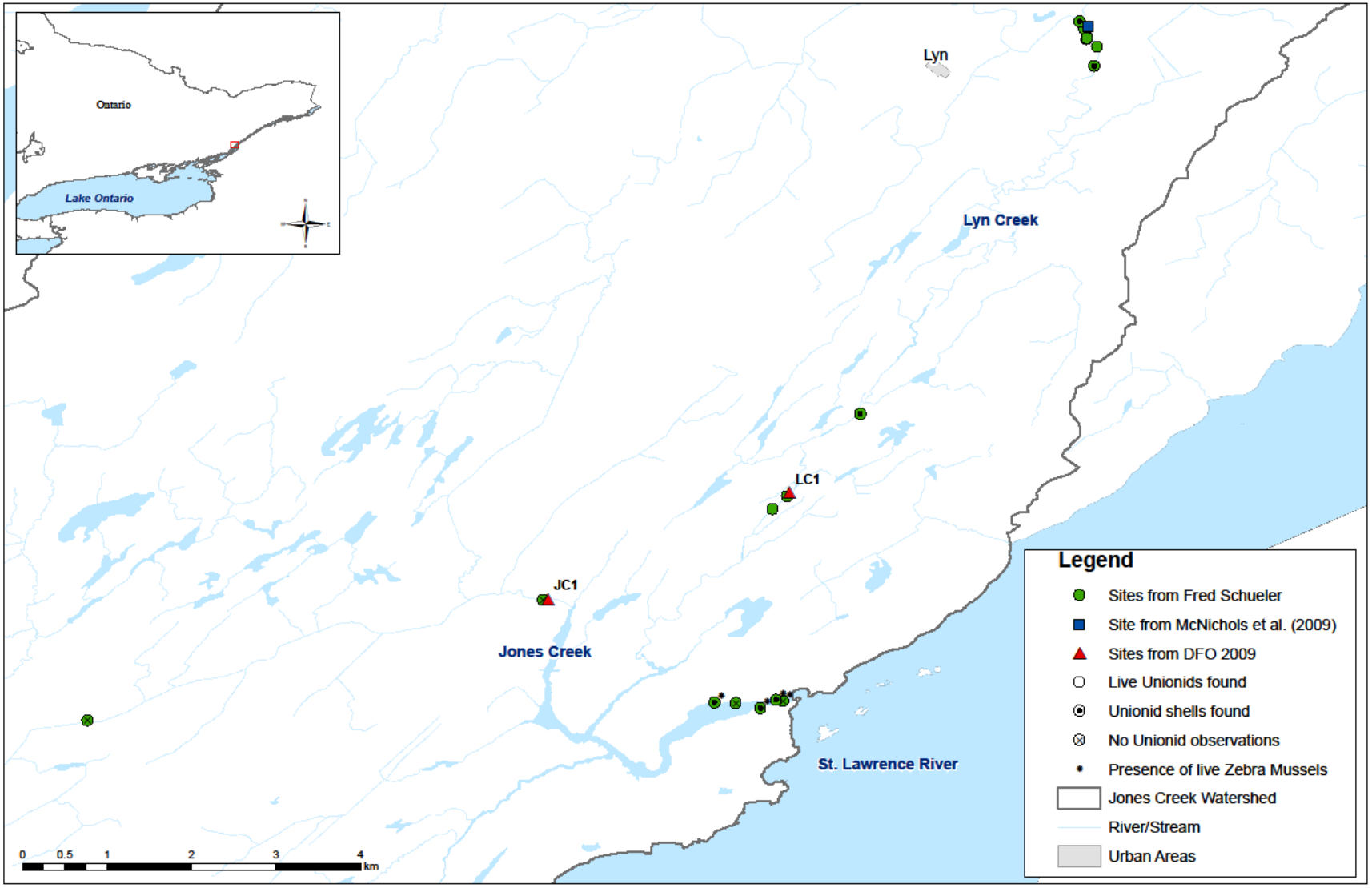

Figure 2. Sites surveyed for freshwater mussels by Fisheries and Oceans Canada, Fred Schueler or McNichols et al. (2009) in Lyn Creek and Jones Creek.

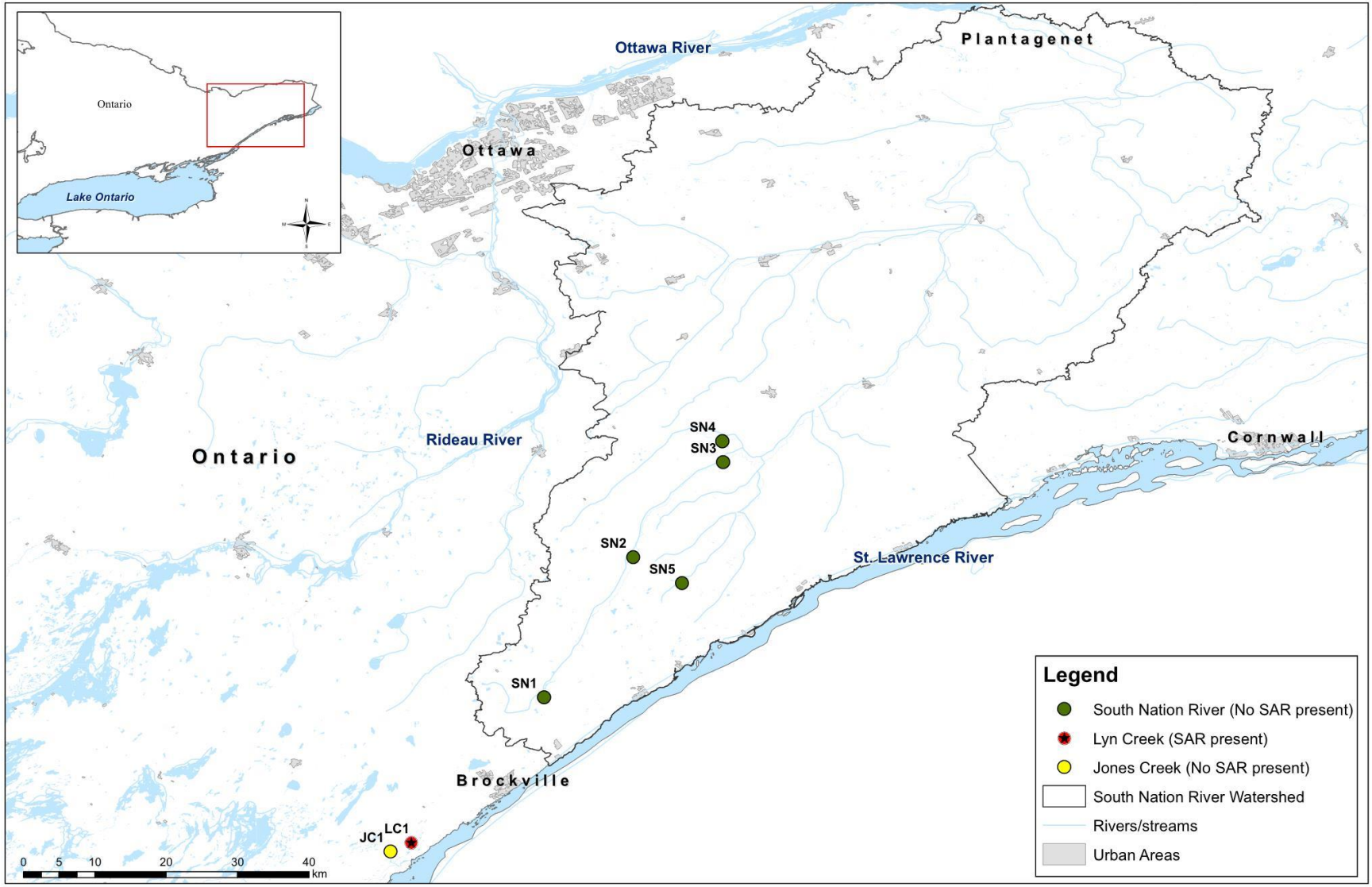

Figure 3. Seven sites across the South Nation River (SN), Lyn Creek (LC) and Jones Creek (JC) sampled using timed-search surveys by Fisheries and Oceans Canada in 2009. See Table 2 for site specific details.

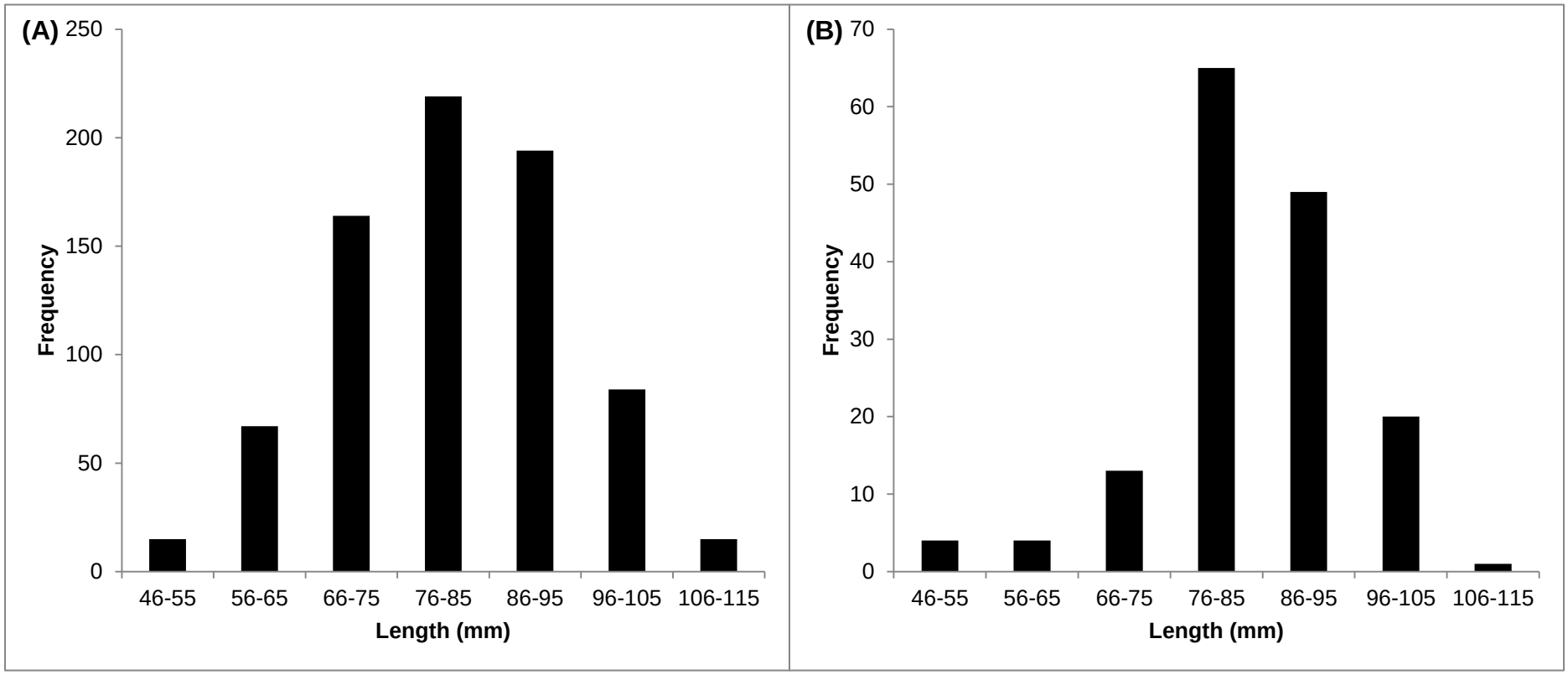

*Figure 4. Length (mm) frequency distribution of Elliptio complanata (*Eastern Elliptio*) observed at (A) five sites in the South Nation River (n = 758) and (B) one site in Lyn Creek (n = 156) during timed-search suveys in 2009.*

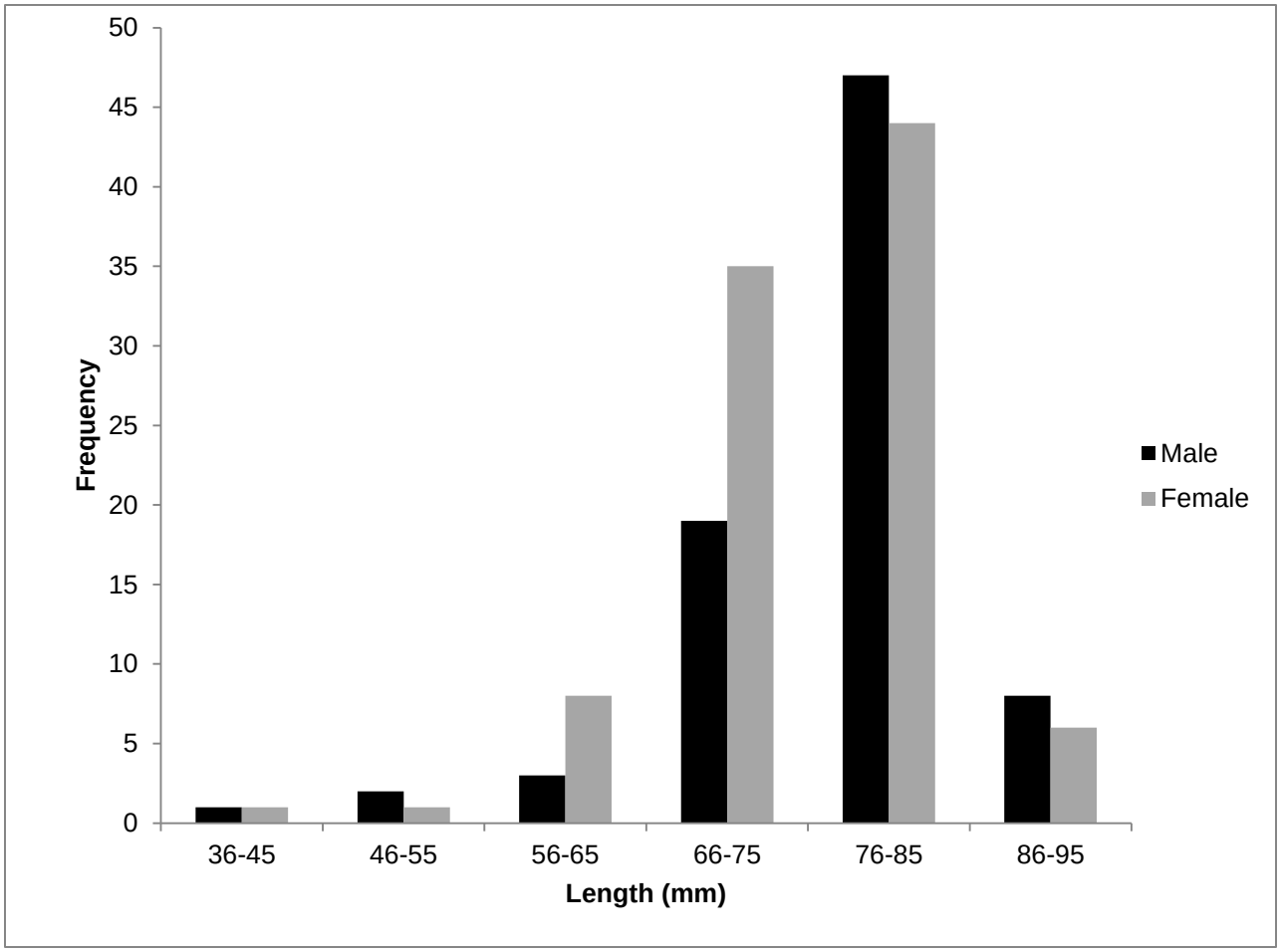

Figure 5. Length (mm) frequency distribution of male (n = 80) and female (n = 95) Lampsilis radiata (Eastern Lampmussel) *at one site in Lyn Creek (n =175) observed during timed-search surveys in 2009.*