2022 freshwater mussel timed-search surveys in the Sydenham River watershed, Ontario

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ABSTRACT

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The Sydenham River of southwestern Ontario has the largest number of extant species of freshwater mussels (Bivalvia: Unionidae) in all of Canada. There are currently 33 extant species residing in this river system, 14 of which are considered species at risk (SAR). The Sydenham River is subject to extensive long-term surveys, aiming to understand the threats facing the current unionid assemblage. In 2022, Fisheries and Oceans Canada (DFO) and the University of Guelph surveyed eight sites across the Sydenham River watershed to assess the presence and species composition of freshwater mussels. Each site was surveyed by a crew of three to five people using a 4.5 person-hour semi-quantitative approach. A total of 1,108 mussels across 24 species were collected, including 286 individuals of eight SAR. Four hundred and fifteen individuals were found in the North Sydenham River watershed and 639 in the East Sydenham River watershed. Twelve and 22 species were found in the North and East Sydenham River, respectively. The 2022 surveys provide updated presence/absence and species richness data, imparting insight into the current state of unionid populations in the Sydenham River watershed.

RÉSUMÉ

Maclennan-Nobrega, E., Lu, A., Gibson, M., McNichols-O'Rourke, K.A., and Morris, T.J. 2024. 2022 freshwater mussel timed-search surveys in the Sydenham River watershed, Ontario. Can. Data. Rep. Fish. Aquat. Sci. 1367: vii + 29 p.

La rivière Sydenham, dans le sud-ouest de l'Ontario, compte le plus grand nombre d'espèces de moules d'eau douce (*Bivalvia* : *Unionidae*) dans tout le Canada. Ce réseau hydrographique abrite actuellement 33 espèces, dont 14 sont considérées comme en péril. La rivière Sydenham fait l'objet de relevés approfondis à long terme, dont l'objectif est de comprendre les menaces qui pèsent sur l'assemblage actuel d'unionidés. En 2022, Pêches et Océans Canada (MPO) et l'Université de Guelph ont réalisé des relevés sur huit sites dans le bassin versant de la rivière Sydenham en vue d'évaluer la présence et la composition des espèces de moules d'eau douce. Une équipe de 3 à 5 personnes a effectué des relevés sur chaque site en utilisant une approche semi-quantitative de 4,5 heures-personnes. Au total, 1 108 moules de 24 espèces ont été recueillies, dont 286 moules de 8 espèces en péril. Au total, 415 individus ont été trouvés dans le bassin versant de la rivière North Sydenham, et 639 dans le bassin versant de la rivière East Sydenham. Plus précisément, 12 et 22 espèces ont été trouvées dans les rivières North Sydenham et East Sydenham, respectivement. Les relevés de 2022 fournissent des données à jour sur la présence, l'absence et la richesse des espèces et donnent un aperçu de l'état actuel des populations d'unionidés dans le bassin versant de la rivière Sydenham.

INTRODUCTION

Freshwater mussels are the most imperiled fauna globally, where 70% of native freshwater mussels are threatened, endangered or extinct in North America (Williams et al. 1992). Despite this rapid decline, there has been few long-term monitoring surveys conducted in North America prior to the 1990s (Lopes-Lima et al. 2018). This is especially a concern in Southwestern Ontario, where historical records are sparse and will sometimes have a 15 to 50 year gap between sampling events (Sheldon et al. 2020, LGLUD 2022). The paucity of data describing unionid populations in their historical form provides a challenge in describing the requirements of a healthy population under current conditions. Comprehensive, ongoing monitoring and systematic sampling will be critical to tracking recovery into the future and defining healthy, recovered populations.

Freshwater mussels of the Family Unionidae are often long-lived with lifespans typically encompassing multiple decades (Haag 2012). This longevity, in addition to their obligate host dependent reproduction strategy, leaves unionids extremely vulnerable to abiotic and biotic changes in their ecosystems (Metcalfe-Smith et al. 1999). Such changes are increasingly evident in North American watersheds, where mussels are threatened by the invasion of non-native species, loss of habitat, decreasing water quality, and, at least historically, overharvesting (Ricciardi et al. 1998, Metcalfe-Smith et al. 1999). The effects of these threats on unionids are prevalent in Canada, where 38% of the 55 species have been assessed as at-risk (Metcalfe-Smith et al. 2005; Government of Canada 2021).

The Sydenham River is the most species-rich river in Canada, historically containing 35 unionid species, with 33 remaining in the system (Clarke 1992; McNichols-O'Rourke et al. 2012). There are 14 species at risk (SAR) in this watershed (Table 1) which makes it a vital refuge for unionids (Clarke, 1992; Goguen et al. 2022). Fisheries and Oceans Canada (DFO) and previously Environment Canada (now Environment and Climate Change Canada) have been monitoring freshwater mussel recovery in this river over the past two decades as part of the Unionid Monitoring and Biodiversity Observation (UMBO) network (Metcalfe-Smith et al. 2003; Metcalfe-Smith et al. 2007; McNichols O'Rourke et al. 2012; Goguen et al. 2022; DFO, unpublished data).

There are two main branches of the Sydenham River, the North Sydenham River and East Sydenham River, which are referred to in this report as the North and East Branch, respectively. The smaller North Branch is characterized by lower quality unionid habitat when compared to the larger East Branch, reflected by a smaller diversity and abundance of unionids (Metcalfe-Smith et al. 2007; Staton et al. 2003). As a result, the East Branch has been surveyed more frequently than the North, with Tognelli et al. (2017) identifying this Branch as a Key Biodiversity Area (KBA) for Canada.

In 2022, as part of a project to evaluate the applicability of riparian buffer strips in maintaining juvenile mussel habitat (Lu 2023), DFO and the University of Guelph

conducted surveys on the North and East Sydenham River branches. Species counts and length data were used to determine species richness, relative abundances, and length frequencies to provide data on the mussel community at the project sites. In addition to providing project data, these data will provide further information to assist in species assessments by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and will assist in achieving recovery strategy goals for Canadian SAR (DFO 2013; 2016; 2018; 2019, 2022).

METHODS

SITE SELECTION

The Sydenham River is located within the Lake St. Clair drainage, draining a land area of 2,725 km^2 (Dextrase et al. 2003). In June 2022, DFO and the University of Guelph surveyed eight sites in the Sydenham River watershed (Table 2). Four sites were selected in Bear Creek, which is part of the North Branch, and four sites were selected in the East Branch (Figure 1). Sites were paired into *a priori* groups of intact or fragmented riparian buffer zones (Lu 2023), with two sites of each site type (intact/fragmented) located in each branch.

FRESHWATER MUSSEL COLLECTION

A semi-quantitative 4.5 person-hour timed-search survey was completed with a crew of three to five people conducting each survey. Although timed-searches are known to detect higher rates of larger and sculptured individuals (Sanchez 2018), they are also known to detect higher numbers of rare species, therefore, it was the most suitable method for this project given the objectives and available resources (Strayer et al. 1997, Metcalfe-Smith et al. 2000). Seven of the eight sites were surveyed using solely tactile methods (i.e., racooning/hand searching). One site was surveyed using a combination of tactile and mussel scoops (a long-handled scoop made of 7 mm wire mesh) due to a higher water depth. Live mussels were collected, identified to species, measured (maximum length), and visually sexed when sexually dimorphic. Digital vouchers were captured for each species following Morris et al. (2022) and all mussels were returned to the river after processing. In addition, shells of species not found live were collected, identified to species, and recorded.

POPULATION SIZE STRUCTURE

Length frequency distributions were developed to analyze the community structure of species with high abundance (i.e., > 27 individuals at a site). Length frequency distributions were generated using 10 mm size classes with the first size class adjusted to ensure that subsequent classes could be clearly separated into juveniles and adults. Break points for juvenile to adult transitions were determined differently depending upon available data: 1) for sexually dimorphic species (*Epioblasma rangiana* (Northern Riffleshell)) sexual maturity was assumed to occur at the size where the first morphologically identifiable female occurred using data from the Lower Great Lakes Unionid Database (LGLUD 2022); 2) for non-sexually dimorphic species where Ontario-

specific size-at-age data (DFO unpublished data) were available (i.e., *Cyclonaias tuberculata* (Purple Wartyback)*, Ptychobranchus fasciolaris* (Kidneyshell)), size at first maturity was calculated following the methods of Haag (2012); 3) for species without Ontario-specific age data, species-specific data from the literature were used when available (*Quadrula quadrula* (Mapleleaf) from COSEWIC (2016)); 4) for all other species a general size at maturity of 25 mm was selected as suggested by Haag and Warren (2007).

ENVIRONMENTAL DATA COLLECTION

Environmental data were also collected at each survey site. Prior to initiating the unionid survey, air temperature and windspeed (Kestrel 2000 Pocket Wind Meter), water velocity (OTT MF Pro flow meter), and water clarity (0.60 m turbidity tube) were measured. Water temperature and water chemistry were collected using an EXO2 Multiparameter YSI which included conductivity (µs/cm), total dissolved solids (TDS), dissolved oxygen (ODO% and ODO mg/L), and turbidity. Substrate composition was determined visually post survey and modified from Stanfield (2010): bedrock, boulder (> 250 mm in diameter), cobble (65 – 250 mm), gravel (2 – 65 mm), sand (grainy, 0.06 – 2 mm), silt (floury, < 0.06mm), clay, muck (soft substrate), and detritus (plant matter). Site dimensions (i.e., length of river searched, minimum, maximum and average river width) were collected using Nikon Laser 1200S waterproof laser range finder. Minimum and maximum depth searched was determined using a standard meter stick.

STATISTICAL ANALYSIS AND DATA VISUALIZATION

A Welch's two-sample t-test was performed using R v4.2.2 software (R Core Team 2022) to determine significant differences in water metric data and unionid community composition data (i.e., species abundance and richness) between the North and East branches. Sites were mapped using cowplot (Wilke 2020), ggplot2 (Wickham 2016), ggspatial (Dunnington 2022), maptiles (Giraud 2022), sf (Pebesma 2018), terra (Hijmans 2022), and tidyterra (Hernangomez 2022).

RESULTS

FRESHWATER MUSSELS

Across all eight sites, 1,108 mussels from 24 species were collected alive. In addition, shells from *Obovaria subrotunda* (Round Hickorynut), *Truncilla donaciformis* (Fawnsfoot) and *Utterbackia imbecillis* (Paper Pondshell) were also observed, bringing the total species count to 27 (Table 3). The most abundant species, with 231 observations, was *Lasmigona complanata* (White Heelsplitter); 228 of these observed individuals were from the North Branch. Live species richness at sites ranged between 5 to 20 species and the most widespread species were *Amblema plicata* (Threeridge),

L. complanata, L. costata (Flutedshell), and *Q. quadrula*, which were found alive at 75% (6/8) of sites. About one quarter (25.8%) of all individuals found were SAR, comprised of *C. tuberculata*, *E. rangiana*, *Epioblasma triquetra* (Snuffbox), *Paetulunio fabalis* (Rayed Bean), *Pleurobema sintoxia* (Round Pigtoe), *Ptychobranchus fasciolaris* (Kidneyshell), *Q. quadrula*, and *Simpsonaia ambigua* (Salamander Mussel). *Cyclonaias tuberculata* was the most abundant SAR species, with an overall relative abundance of 9.93% and SAR relative abundance of 38.5%. Relative abundance of SAR was 8.67% (n=36) in the North Branch and 36.08% (n=250) in the East Branch. The most abundant SAR in the North Branch was *Q. quadrula* which made up 97.2% of the SAR abundance. The most abundant SAR in the East Branch was *C. tuberculata*, which had a SAR relative abundance of 44%. Mean (± 1 standard error) species richness was significantly lower in the North Branch (6.25 ± 0.63) than in the East (16 ± 1.96) ($t_{1,6}$ = -4.741; p = 0.00319; Table 3, Figure 2). Mean SAR richness in the North Branch (0.75 ± 0.25) was also significantly lower than in the East Branch (5.5 ± 0.65) ($t_{1,6}$ = -6.862; p = 0.000472).

Mean species abundance (all species included) across sites in the North Branch was 103.75 ± 65.17 and in the East Branch was 173.25 ± 50.08; no significant difference was found ($t_{1,6}$ = -0.846; p = 0.430). Mean SAR abundance was 9 ± 5.12 in the North Branch and 62.5 ± 24.07 in the East Branch and they did not significantly differ between branches ($t_{1,6}$ = -2.174; p = 0.0727; Table 3, Figure 3). It should also be noted that all but one individual SAR found in the North Branch were *Q. quadrula.*

There were also differences in the species assemblages observed between the North and East branches. Ten species were detected in both river branches with an additional two unique species in the North Branch (total of 12 species) and additional 12 unique species in the East Branch (total of 22 species). Only two SAR were found in the North Branch whereas eight were found in the East Branch. There were observed variations in the abundances of the shared species within the two river branches, where few species had similar total abundances (Figure 4).

POPULATION SIZE STRUCTURE

There was an observable difference in the length frequency distribution between the two branches for *A. plicata* (n = 186), where the North Branch (n = 72) population appears to have larger individuals and a smaller range in sizes than the East Branch (n = 114), which includes juveniles (Figure 5). The inverse is true for *Q. quadrula* (n = 61), where the North Branch population (n = 33) was relatively smaller in size and included juveniles, with a wider length range than the East Branch (n = 28; Figure 6). There were two additional species that had sufficient records in the North Branch to complete length frequency distributions: *L. complanata* (n = 228; Figure 7) and *Pyganodon grandis* (Giant Floater) (n = 44; Figure 8), ranging in size from 33.8 – 200 mm, and 24 – 55.2 mm, respectively. Three common species had sufficient records in the East Branch to

complete length frequency distributions: *Eurynia dilatata* (Spike) (n = 39; Figure 9), *L. costata* (n = 66; Figure 10), and *Ortmanniana ligamentina* (Mucket) (n = 144; Figure 11). Their lengths ranged from 38 – 92.6 mm, 61.8 – 113.8 mm, and 15.5 – 170 mm, respectively.

In addition, three additional SAR had sufficient numbers in the East Branch to include a length frequency distribution: *C. tuberculata* (n = 110; Figure 12) where length ranged from 53 – 128.6 mm, *P. fasciolaris* (n = 51[3]; Figure 13) with lengths ranging from 25.9 – 118.7 mm, and the sexually dimorphic *E. rangiana* (n = 34; Figure 14) where length ranged from 19.9 – 56.6 mm.

ENVIRONMENTAL DATA

Table 4 shows the values of the relevant environmental data collected at each site. There were no significant differences found between the North and East branches for water clarity ($t_{1,6}$ = -0.275; p = 0.792), water velocity ($t_{1,6}$ = -0.501; p = 0.634), TDS ($t_{1,6}$ = -1.781; p = 0.125), ODO% ($t_{1,6}$ = -0.349; p = 0.739), ODO mg/L ($t_{1,6}$ = 1.190; p = 0.279), or turbidity ($t_{1,6}$ = 0.469; p = 0.659; Table 5). Water temperature in the North Branch (18.745 ± 0.79) was significantly lower than in the East Branch (23.390 ± 0.88) ($t_{1,6}$ = -3.907; p = 0.008; Table 5). Conductivity was also significantly lower in the North Branch (573 ± 33.03) compared to the East Branch (675 ± 15.11) and ($t_{1,6}$ = -2.801; p = 0.031; Table 5).

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Table 1. Species at risk in Ontario and their current COSEWIC assessment (Government of Canada 2021), federal *Species at Risk Act* (SARA) listing (Government of Canada 2021), and provincial *Endangered Species Act* listing (Government of Ontario 2023) as of May 2023. UC indicates species that are under consideration for SARA listing. The historical (H) and current (C) occurrence of each SAR in the Sydenham River watershed is indicated as summarized in McNichols-O'Rourke et al. (2012). Species found live in the watershed are indicated by Y and species known only as shells/valves in the watershed are indicated by SH. Nomenclature here and throughout follows MolluscaBase eds. (2022). Table updated from Goguen et al. (2022).

Scientific Name	Common Name	COSEWIC	SARA (Federal)	ESA (Provincial)	H	C
[1]*Cambarunio iris*	Rainbow	Special Concern	Special Concern	Special Concern	Y	Y
Cyclonaias tuberculata	Purple Wartyback	Threatened	UC	Threatened	Y	Y
Epioblasma rangiana	Northern Riffleshell	Endangered	Endangered	Endangered	Y	Y
Epioblasma triquetra	Snuffbox	Endangered	Endangered	Endangered	Y	Y
Lampsilis fasciola	Wavyrayed Lampmussel	Special Concern	Special Concern	Threatened	Y	Y
Obliquaria reflexa	Threehorn Wartyback	Threatened	Threatened	Threatened	-	Y
Obovaria olivaria	Hickorynut	Endangered	Endangered	Endangered	-	-
Obovaria subrotunda	Round Hickorynut	Endangered	Endangered	Endangered	Y	Y
[2]*Paetulunio fabalis*	Rayed Bean	Endangered	Endangered	Endangered	Y	Y
Pleurobema sintoxia	Round Pigtoe	Endangered	Endangered	Endangered	Y	Y
Ptychobranchus fasciolaris	Kidneyshell	Endangered	Endangered	Endangered	Y	Y
Quadrula quadrula	Mapleleaf	[4]Special Concern	[4]Special Concern	Special Concern	Y	Y
[3]*Sagittunio nasutus*	Eastern Pondmussel	Special Concern	Special Concern	Special Concern	Y	-
Simpsonaias ambigua	Salamander Mussel	Endangered	Endangered	Endangered	Y	Y
Toxolasma parvum	Lilliput	Endangered	Endangered	Threatened	Y	Y
Truncilla donaciformis	Fawnsfoot	Endangered	Endangered	Endangered	SH	Y

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. Site locations and sample dates for sites sampled in the North and East Sydenham River. Sites are listed in upstream to downstream order. *Only accessible with landowner permission.

Site Code	Drainage	Waterbody	Branch	Latitude	Longitude	Date	Riparian Vegetation (Lu 2023)
SR-09	Lake St. Clair	Bear Creek	North Sydenham	42.975000	-81.970830	06-Jun-22	Intact
LSC-BRC-14*	Lake St. Clair	Bear Creek	North Sydenham	42.988564	-81.953538	06-Jun-22	Fragmented
LSC-BRC-35*	Lake St. Clair	Bear Creek	North Sydenham	42.858380	-82.200690	24-Jun-22	Fragmented
SR-13	Lake St. Clair	Bear Creek	North Sydenham	42.848660	-82.213800	07-Jun-22	Intact
SR-17*	Lake St. Clair	Sydenham	East Sydenham	42.680090	-82.016330	23-Jun-22	Intact
SR-05*	Lake St. Clair	Sydenham	East Sydenham	42.650200	-82.008970	23-Jun-22	Intact
LSC-SYR-40*	Lake St. Clair	Sydenham	East Sydenham	42.604500	-82.062930	22-Jun-22	Fragmented
SR-DM*	Lake St. Clair	Sydenham	East Sydenham	42.587230	-82.135280	23-Jun-22	Fragmented

Table 3. Number of live mussels found at each site surveyed in the North and East Sydenham River. 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. Shells and valves are not included in the total abundance, relative abundance, or frequency of occurrence. Unknown individuals are included in the abundance total, but not in the species richness totals. All shells/valves are in weathered condition unless otherwise indicated as fresh (*).

Scientific Name	Common Name	North				East						
		SR-09	LSC-BRC-14	LSC-BRC-35	SR-13	SR-17	SR-05	LSC-SYR-40	SR-DM	Total	Relative Abundance (%)	Frequency of Occurrence (%)
Amblema plicata	Threeridge	1	71	S(1)		24	51	14	25	**186**	**16.79**	**75.00**
Alasmidonta marginata	Elktoe					V(1)	2			**2**	**0.18**	**12.50**
Cyclonaias pustulosa	Pimpleback					2	3	2	14	**21**	**1.89**	**50.00**
Cyclonaias tuberculata	Purple Wartyback					14	62	13	21	**110**	**9.93**	**50.00**
Epioblasma rangiana	Northern Riffleshell					9	25	S(2)	S(1)	**34**	**3.07**	**25.00**
Epioblasma triquetra	Snuffbox					1	16	V(1)	3	**20**	**1.80**	**37.50**
Eurynia dilatata	Spike	3		V(1)	S(1)	9	29	V(1)	2	**43⁺**	**3.88**	**50.00**
Fusconaia flava	Wabash Pigtoe	1	12	V(1)		1	4		4	**22**	**1.99**	**62.50**
Lampsilis cardium	Plain Pocketbook					1	2	V(1)	1	**4**	**0.36**	**37.50**
Lampsilis siliquoidea	Fatmucket	2	7	1	3					**13**	**1.17**	**50.00**
Lasmigona complanata	White Heelsplitter	1	172	27	28	1		S(2)	2	**231**	**20.85**	**75.00**
Lasmigona costata	Flutedshell	1	1		S(1)	20	36	7	3	**68**	**6.14**	**75.00**
Ligumia recta	Black Sandshell					7	7	1	1	**16**	**1.44**	**50.00**
Obovaria subrotunda	Round Hickorynut							V(1)	V(1)	**-**	**-**	**-**
Ortmanniana ligamentina	Mucket			1		52	36	23	33	**145**	**13.09**	**62.50**
Paetulunio fabalis	Rayed Bean					V(1)*	2	1	V(2)	**3**	**0.27**	**25.00**
Pleurobema sintoxia	Round Pigtoe	1	S(1)	V(1)		1			1	**3**	**0.27**	**37.50**
Potamilus alatus	Pink Heelspliter				1	2	3	3	2	**11**	**0.99**	**62.5**
Potamilus fragilis	Fragile Papershell			1		1	3	3	V(1)*	**8**	**0.72**	**50.00**
Ptychobranchus fasciolaris	Kidneyshell					13	22	3	14	**52⁺**	**4.69**	**50.00**
Pyganodon grandis	Giant Floater	1	34	4	5	S(1)*	S(1)*	S(1)	V(1)	**44**	**3.97**	**50.00**
Quadrula quadrula	Mapleleaf			14	21	2	4	6	16	**63⁺**	**5.69**	**75.00**
Simpsonaias ambigua	Salamander Mussel						1	V(1)	S(1); V(1)	**1**	**0.09**	**12.50**
Strophitus undulatus	Creeper					1	4		S(1)*	**5**	**0.45**	**25.00**
Truncilla donaciformis	Fawnsfoot								V(4)	**-**	**-**	**-**
Truncilla truncata	Deertoe						1	S(1)	V(1)	**1**	**0.09**	**12.50**
Utterbackia imbecillis	Paper Pondshell		S(1)							**-**	**-**	**-**
Unknown Juvenile		1				1				**2**	**0.18**	**25.00**
Total abundance		**12**	**297**	**48**	**58**	**162**	**313**	**76**	**142**	**1108**		
Live species richness		**8**	**6**	**6**	**5**	**18**	**20**	**11**	**15**	**24**		
Total species richness		**8**	**8**	**10**	**7**	**21**	**21**	**20**	**24**	**27**		

⁺ Total number of individuals observed may not match the numbers used in the length frequency distributions as length data were not available (e.g., mussel was returned to river bed before measurement occurred or was removed during the data audit process).

Table 4. Relevant environmental data collected at each site in the Sydenham River watershed. Sites are presented in upstream to downstream order.

		North				East			
		SR-09	**LSC-BRC-14**	**LSC-BRC-35**	**SR-13**	**SR-17**	**SR-05**	**LSC-SYR-40**	**SR-DM**
Site Measurements	**Length of Reach Searched (m)**	49	46	50	26.5	62.5	56.5	-	32
	Min Width of Reach (m)	4.9	4	8	10	20	18	18	22
	Max Width of Reach (m)	6.35	6	14	10	22	19	19	22
	Avg Width (m)	5.5	4.5	10	10	21	18.5	18.5	22
	Max Depth Searched (m)	0.42	0.65	-	1	0.6	0.55	0.85	0.95
	Avg Depth Searched (m)	0.19	0.45	-	0.8	0.5	0.45	0.7	0.7
	Water Clarity (m)	0.2	0.182	0.07	0.035	0.15	0.128	0.145	0.11
	Water Velocity (m/s)	0.426	0.07	0.148	0.059	0.225	0.438	0.081	0.187
YSI Measurements	**Water Temperature (°C)**	18.308	17.978	21.089	17.603	21.062	23.209	25.273	24.014
	Conductivity (µs/cm)	558	525	670	539	632	680	703	684
	TDS (mg/L)	415.902	394.315	470.409	408.153	444.392	457.357	454.402	453.085
	ODO (%)	81.9	67	81.4	82.5	74.7	77.4	78.9	88.5
	ODO (mg/L)	7.69	6.32	7.21	7.83	6.62	6.6	6.47	7.43
	Turbidity (FNU)	12.97	22.33	156	-	51.89	49.85	38	42.5
Stream Morphology	**Riffle (%)**	70	0	0	0	0	0	0	0
	Pool (%)	0	30	0	0	0	0	0	0
	Run (%)	30	70	100	100	100	100	100	100
	Flat (%)	0	0	0	0	0	0	0	0
Substrate Composition	**Bedrock (%)**	0	0	0	0	0	0	0	0
	Boulder (%)	5	0	5	0	5	0	0	5
	Rubble (%)	45	0	20	0	20	20	60	20
	Gravel (%)	40	0	40	50	40	70	20	40
	Sand (%)	10	0	35	10	35	10	20	30
	Silt (%)	0	0	0	0	0	0	0	5
	Clay (%)	0	30	0	30	0	0	0	0
	Muck (%)	0	5	0	0	0	0	0	0
	Detritus (%)	0	65	0	10	0	0	0	0

Table 5. Relevant environmental data (mean ± SE) and results from a Welch's two-sample t-test used to detect differences between the North and East Sydenham River. * represents a significant difference.

	North		East		Test Statistic		
Parameter	**Mean**	**SE**	**Mean**	**SE**	**df**	**t**	**p value**
Water clarity	0.12	0.041	0.13	0.0091	6	-0.275	0.792
Water velocity	0.18	0.086	0.23	0.075	6	-0.501	0.634
Water temperature	18.745	0.79	23.390	0.88	6	-3.907	0.008*
Conductivity	573	33.03	675	15.11	6	-2.801	0.031*
TDS	422.195	16.68	452.309	2.79	6	-1.781	0.125
ODO%	78.2	3.74	79.88	3.00	6	-0.349	0.739
ODO mg/L	7.26	0.34	6.78	0.22	6	1.190	0.279
Turbidity	63.77	46.20	45.56	3.23	6	0.469	0.659

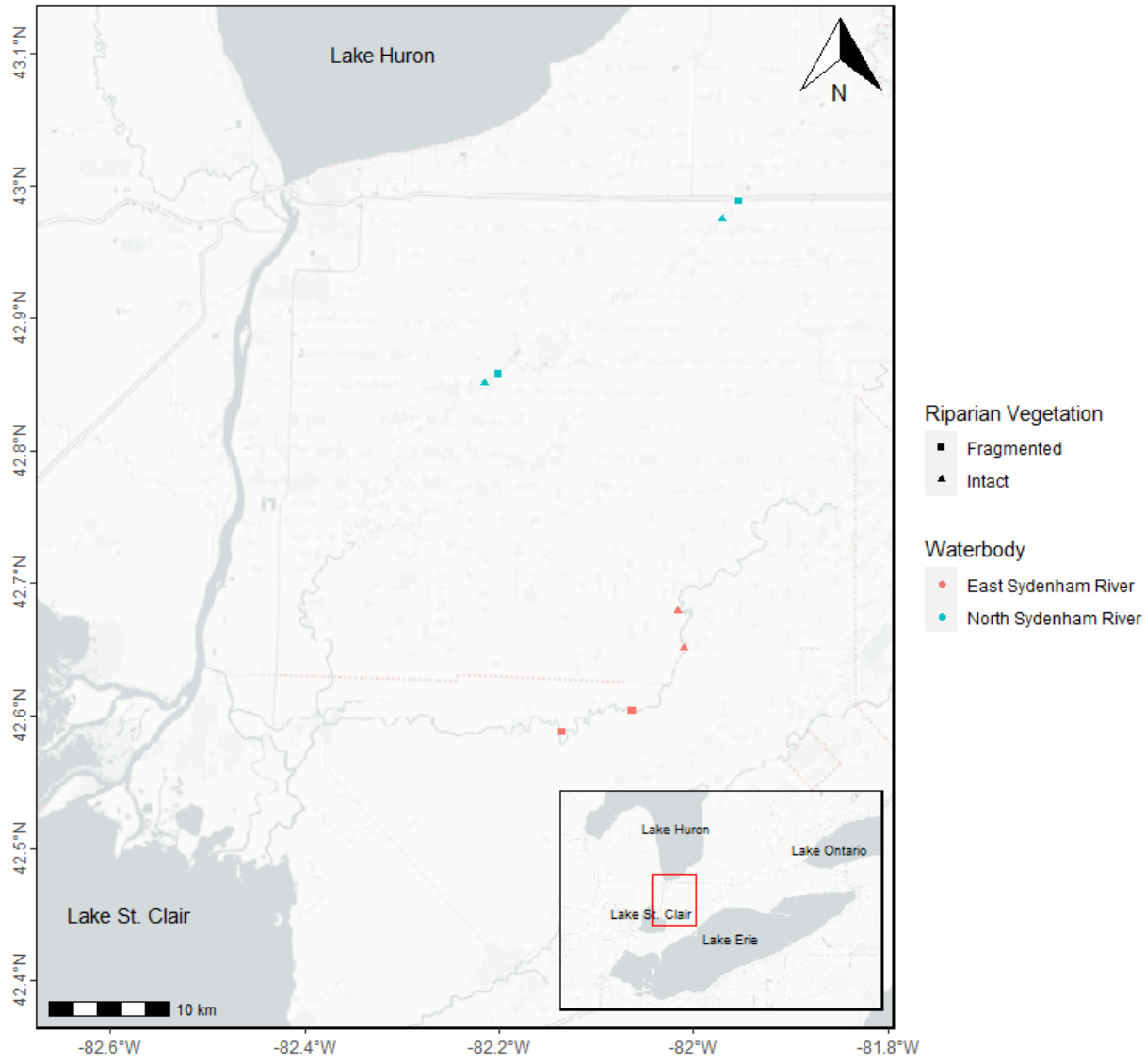

Figure 1. Sites surveyed in the Sydenham River watershed in June 2022. Map tiles by CartoDB, under CC BY 3.0. Data by OpenStreetMap, under ODbL.

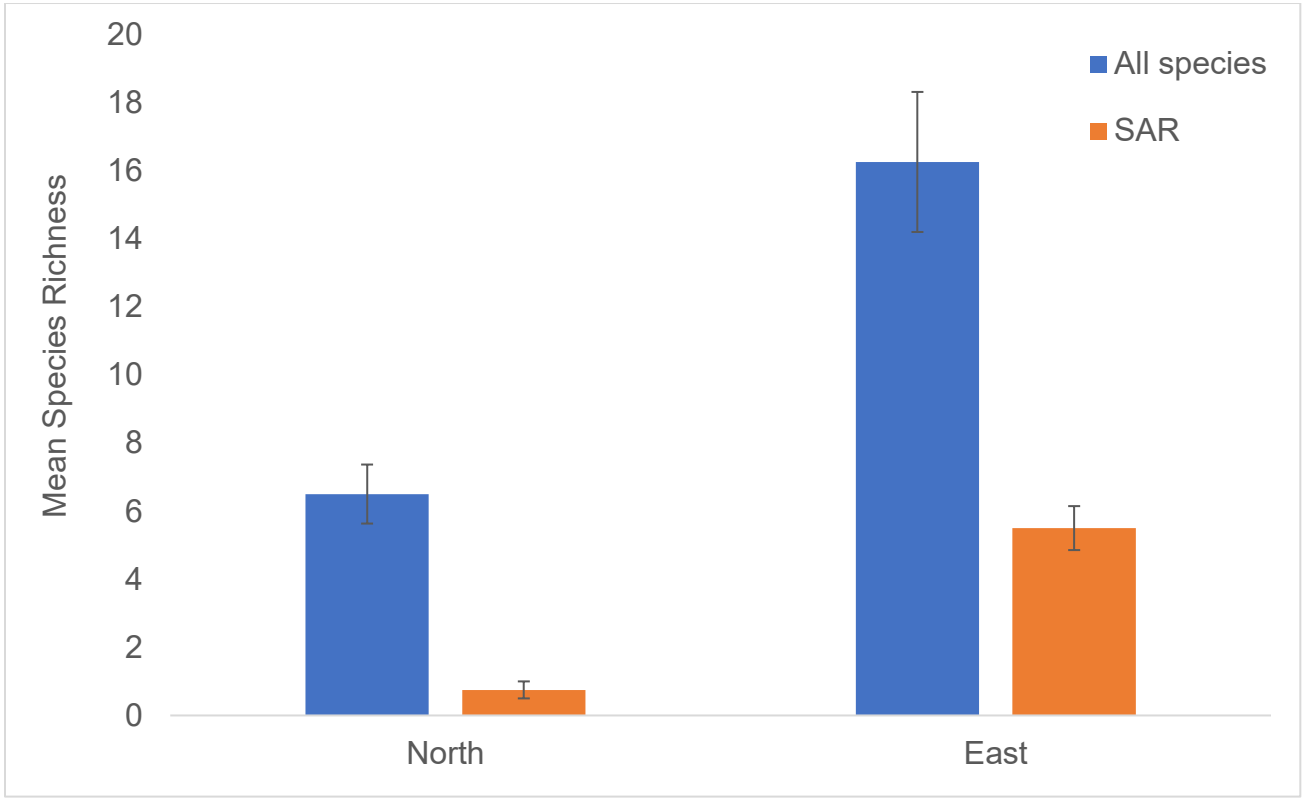

Figure 2. Mean species richness (mean ± 1 SE) of all species in the North (6.5 ± 0.87) and East (16.25 ± 2.06) branches of the Sydenham River. Mean species richness of species at risk (SAR) in the North (0.75 ± 0.25) and East (5.5 ± 0.65) branches of the Sydenham River. Mean species richness for all species and for SAR was significantly lower in the North Branch than in the East Branch.

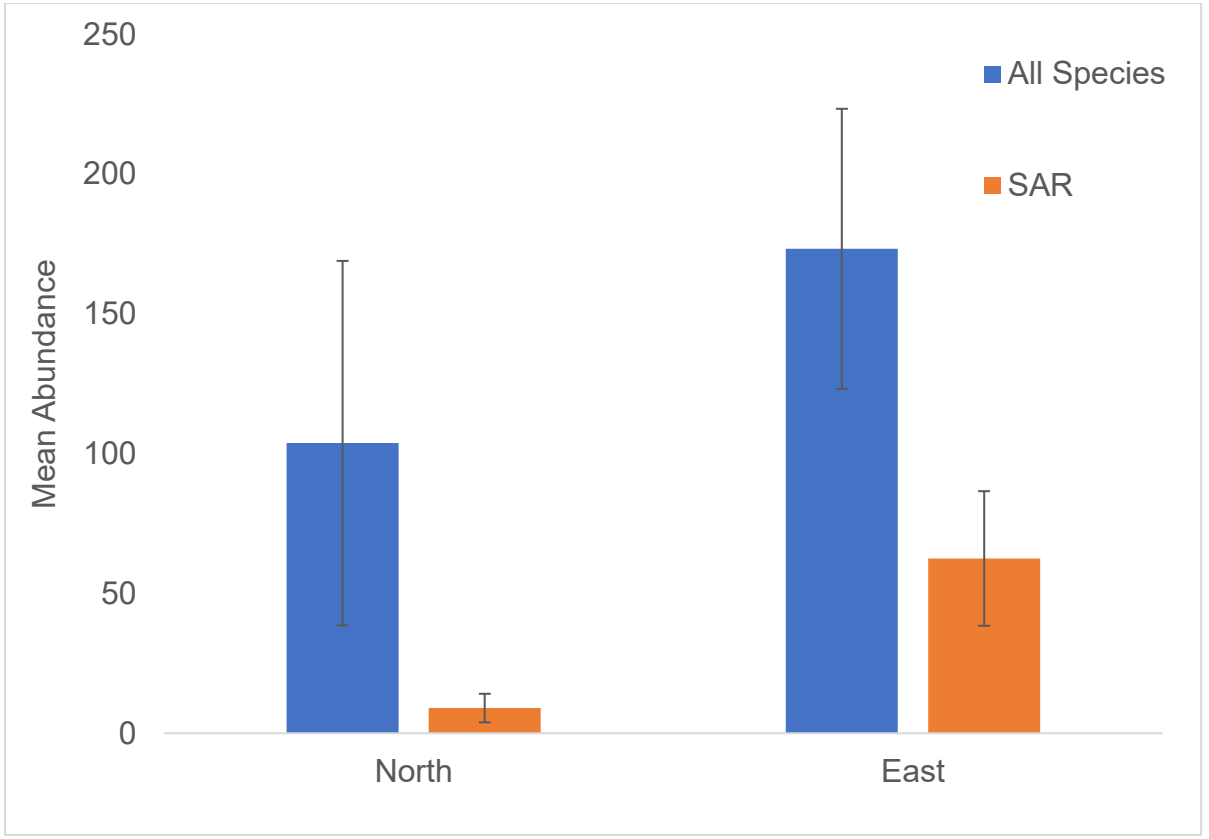

Figure 3. Mean abundance (mean ± SE) of all species in the North (103.75 ± 65.17) and East (173.25 ± 50.08) branches of the Sydenham River; mean abundance of species at risk in the North (9 ± 5.12) and East (62.5 ± 24.07) branches of the Sydenham River.

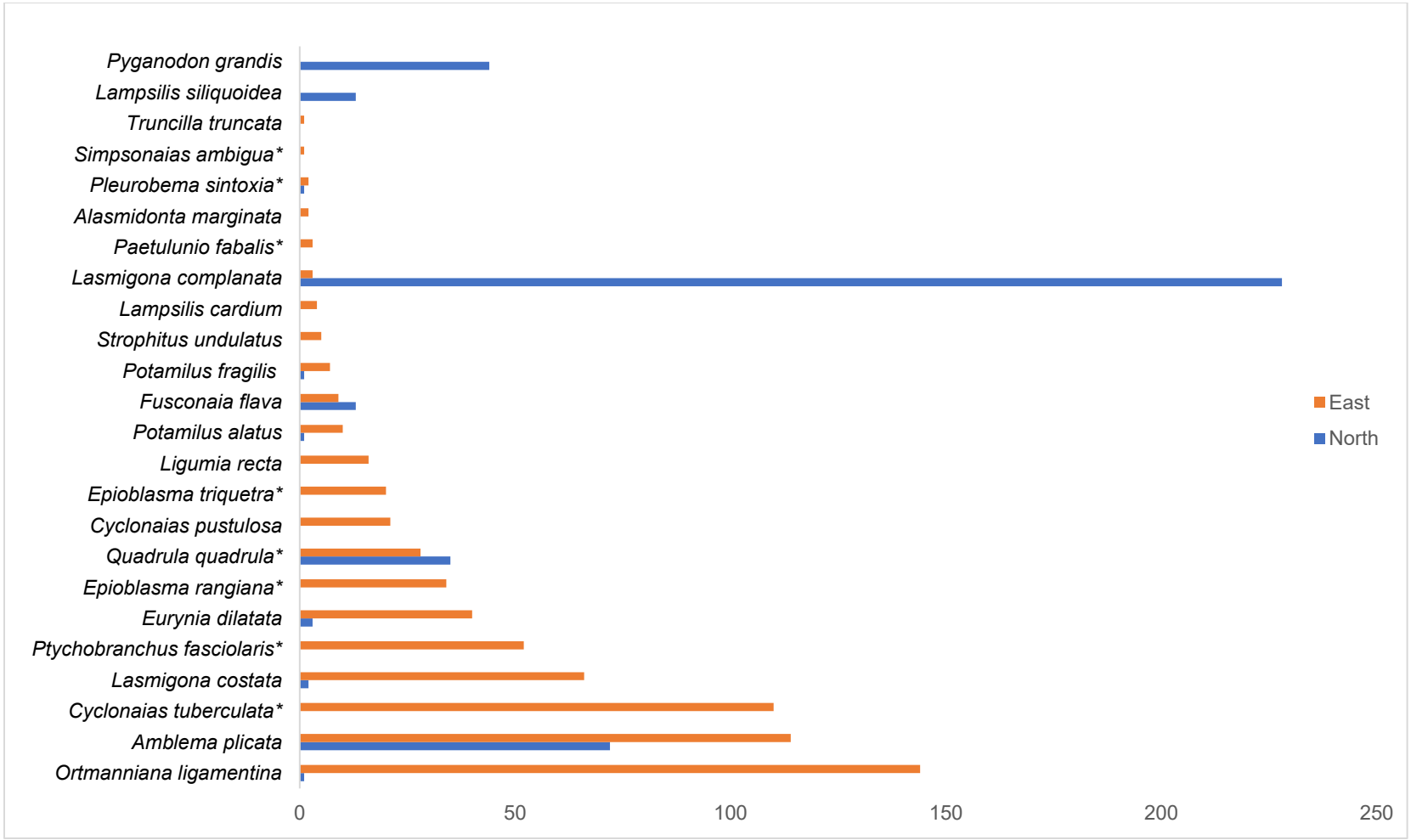

Figure 4. Comparison of species abundance between the North and East branches of the Sydenham River. Species at risk are represented by *.

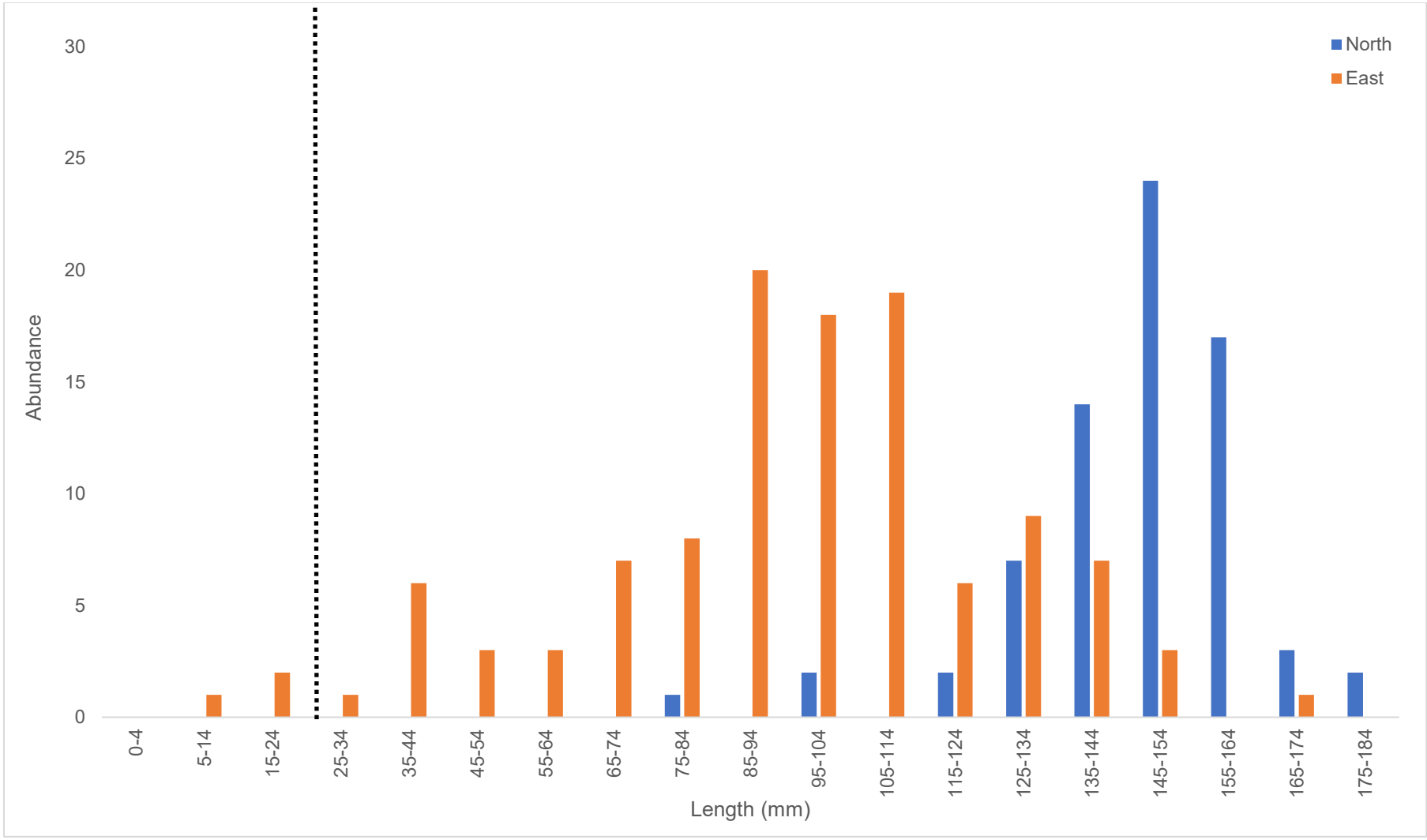

Figure 5. Length frequency distribution for *Amblema plicata* (Threeridge) (n = 186) collected from the North (n = 72) and East (n = 114) branches of the Sydenham River in June 2022. The dashed vertical line represents the separation of juveniles (< 25.0 mm) and adults (≥ 25.0 mm), following the standard juvenile cut off point of Haag and Warren (2007).

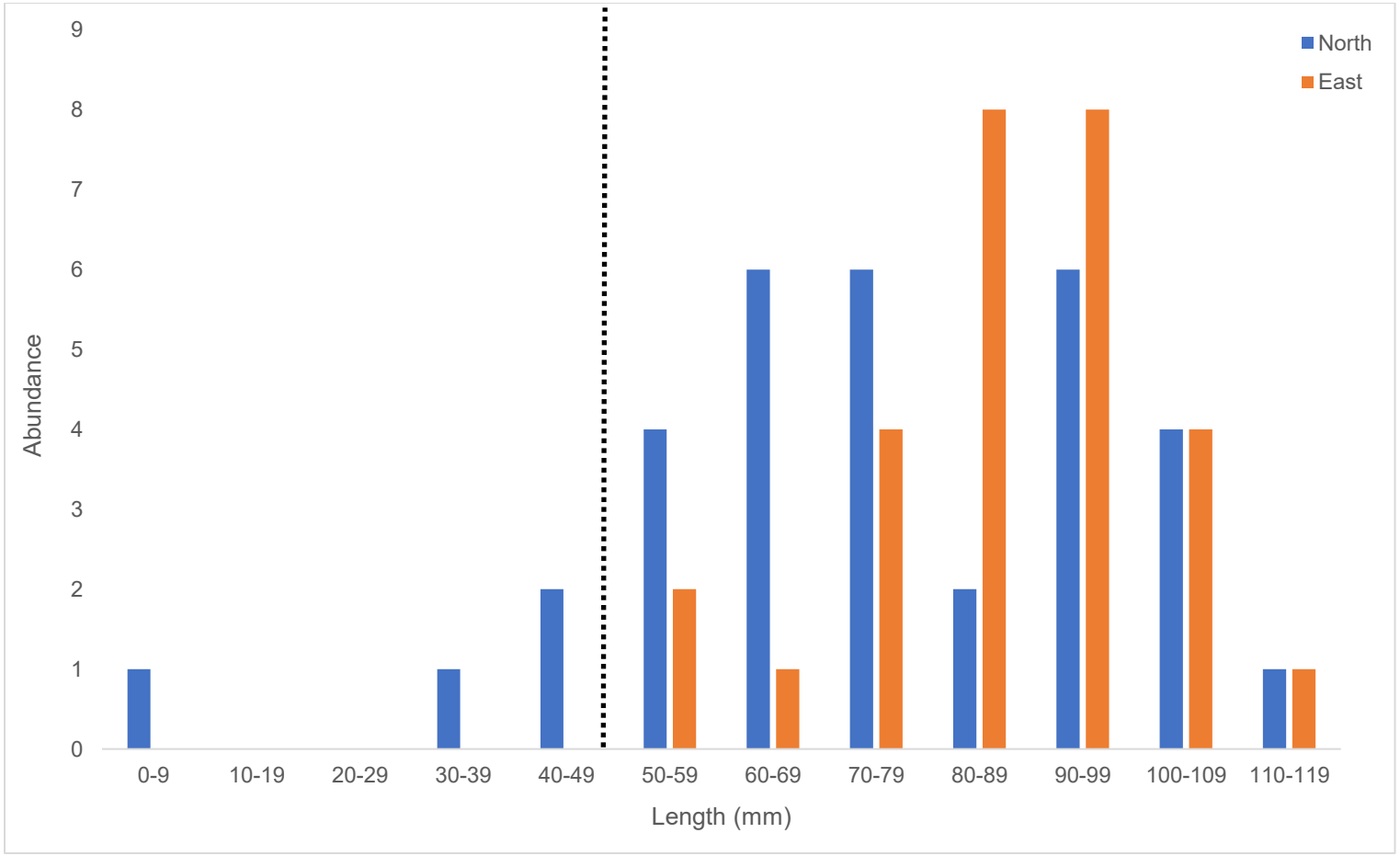

Figure 6. Length frequency distribution for *Quadrula quadrula* (Mapleleaf) (n = 61) collected from the North (n = 33) and the East (n = 28) branches of the Sydenham River in June 2022. The dashed vertical line represents the separation of juveniles (< 50.0 mm) and adults (≥ 50.0 mm), determined through current literature (COSEWIC 2016).

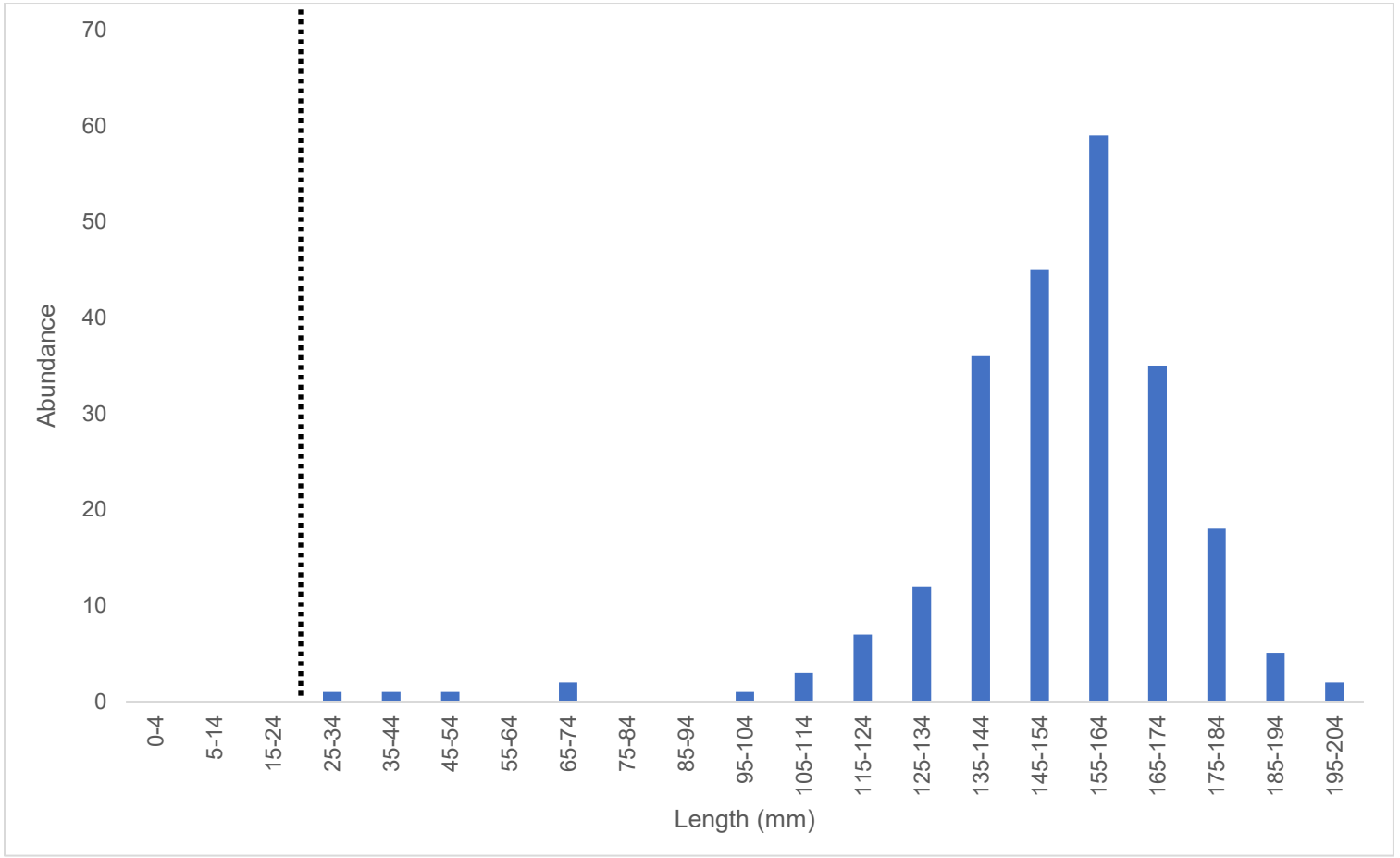

Figure 7. Length frequency distribution for *Lasmigona complanata* (White Heelsplitter) collected from the North Branch of the Sydenham River (n = 228) in June 2022. The dashed vertical line represents the separation of juveniles (< 25.0 mm) and adults (≥ 25.0 mm), following the standard juvenile cut off point of Haag and Warren (2007).

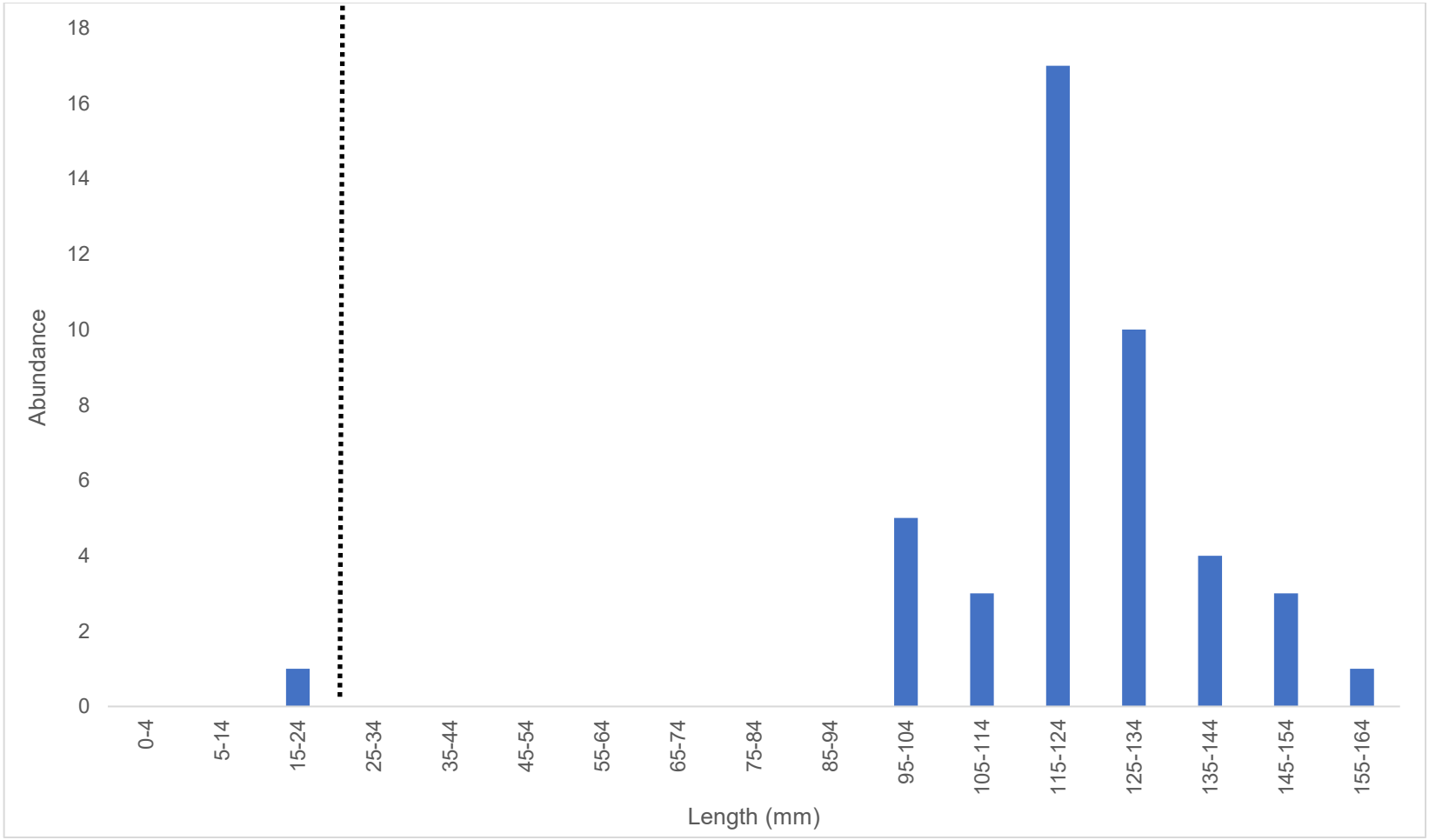

Figure 8. Length frequency distribution for *Pyganodon grandis* (Giant Floater) collected from the North Branch of the Sydenham River (n = 44) in June 2022. The dashed vertical line represents the separation of juveniles (< 25.0 mm) and adults (≥ 25.0 mm), following the standard juvenile cut off point of Haag and Warren (2007).

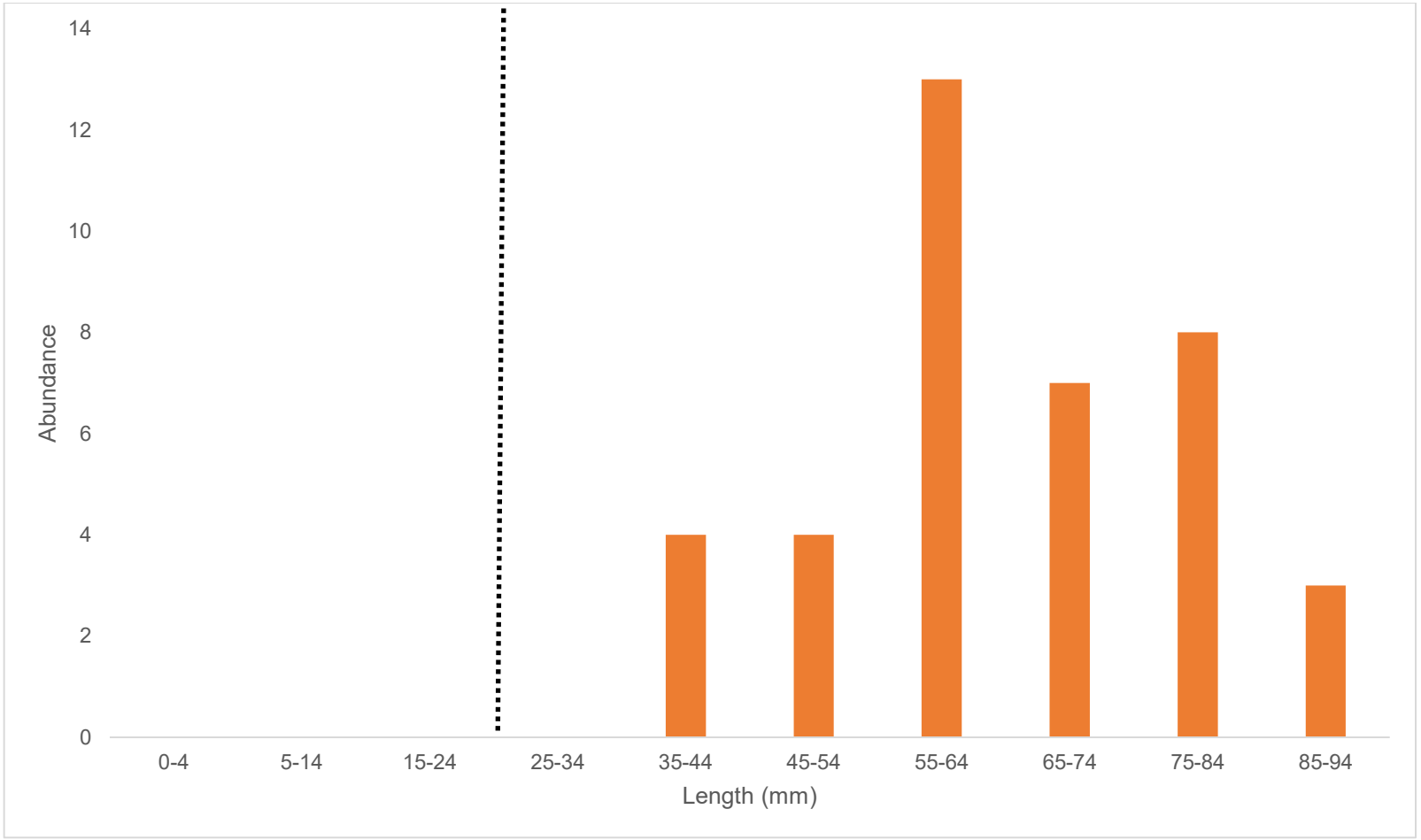

Figure 9. Length frequency distribution for *Eurynia dilatata* (Spike) collected from the East Branch of the Sydenham River (n = 39) in June 2022. The dashed vertical line represents the separation of juveniles (< 25.0 mm) and adults (≥ 25.0 mm), following the standard juvenile cut off point of Haag and Warren (2007).

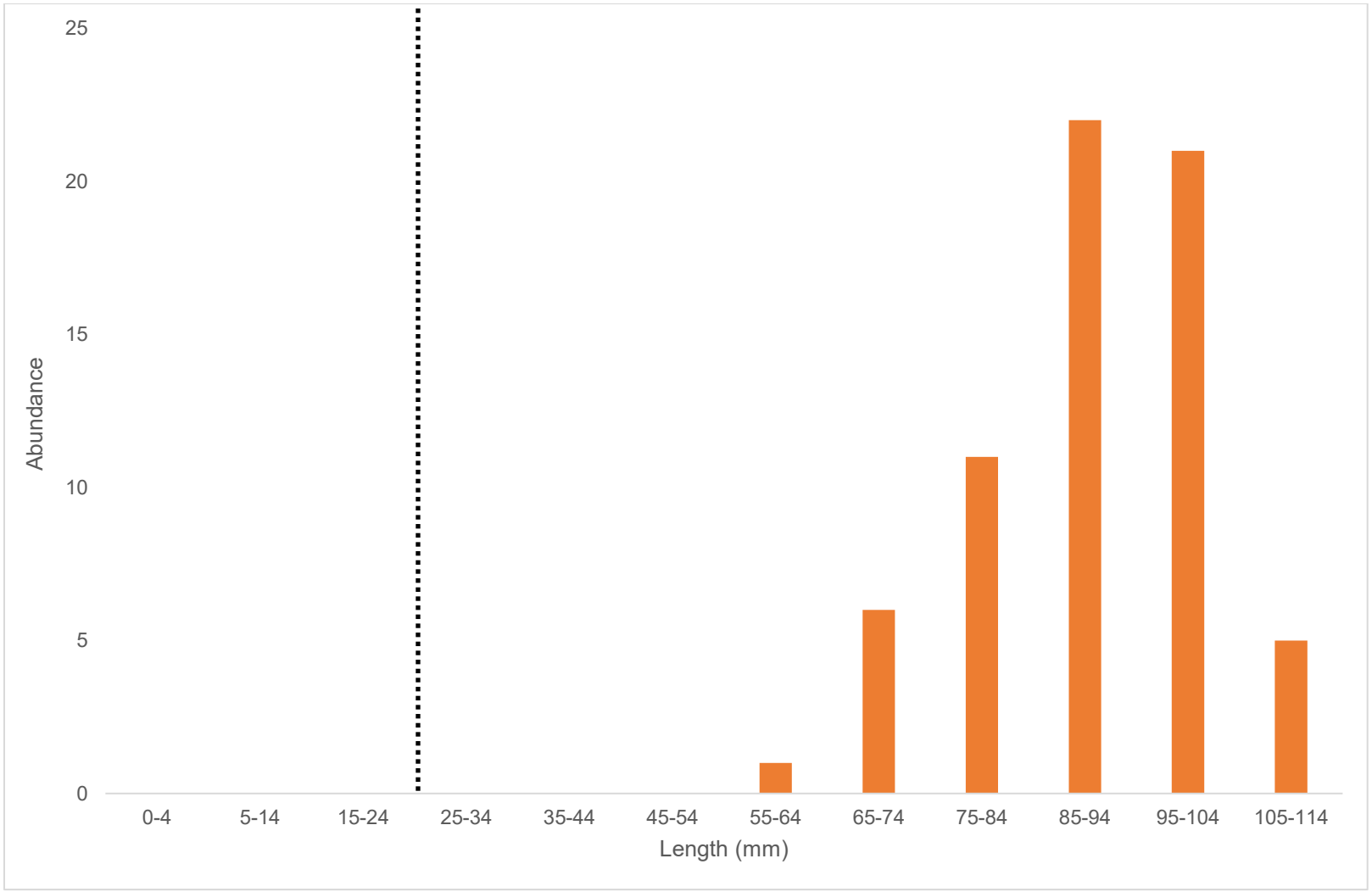

Figure 10. Length frequency distribution for *Lasmigona costata* (Flutedshell) collected from the East Branch of the Sydenham River (n = 66) in June 2022. The dashed vertical line represents the separation of juveniles (< 25.0 mm) and adults (≥ 25.0 mm), following the standard juvenile cut off point of Haag and Warren (2007).

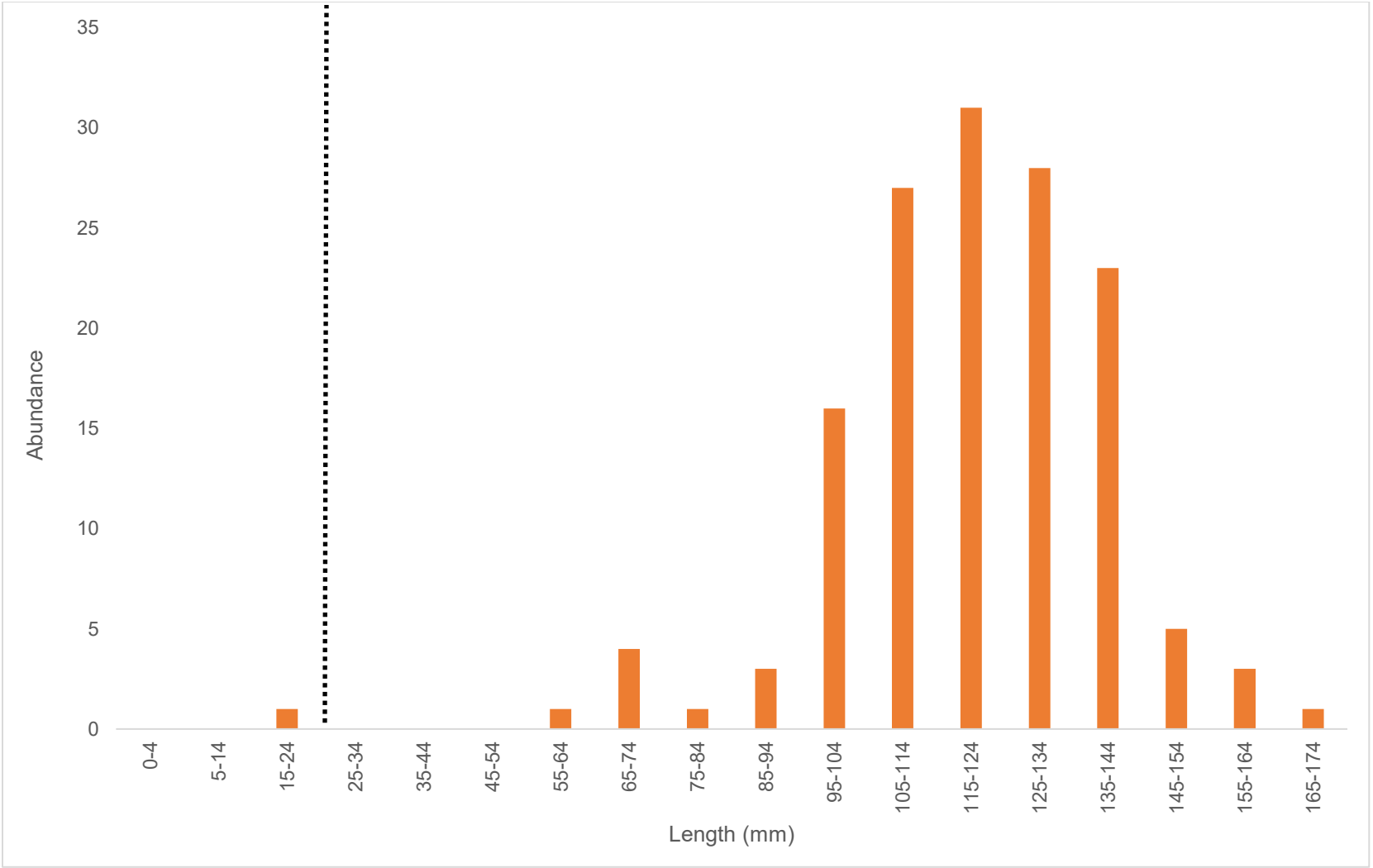

Figure 11. Length frequency distribution for *Ortmanniana ligamentina* (Mucket) collected from the East Branch of the Sydenham River (n = 144) in June 2022. The dashed vertical line represents the separation of juveniles (< 25.0 mm) and adults (≥ 25.0 mm), following the standard juvenile cut off point of Haag and Warren (2007).

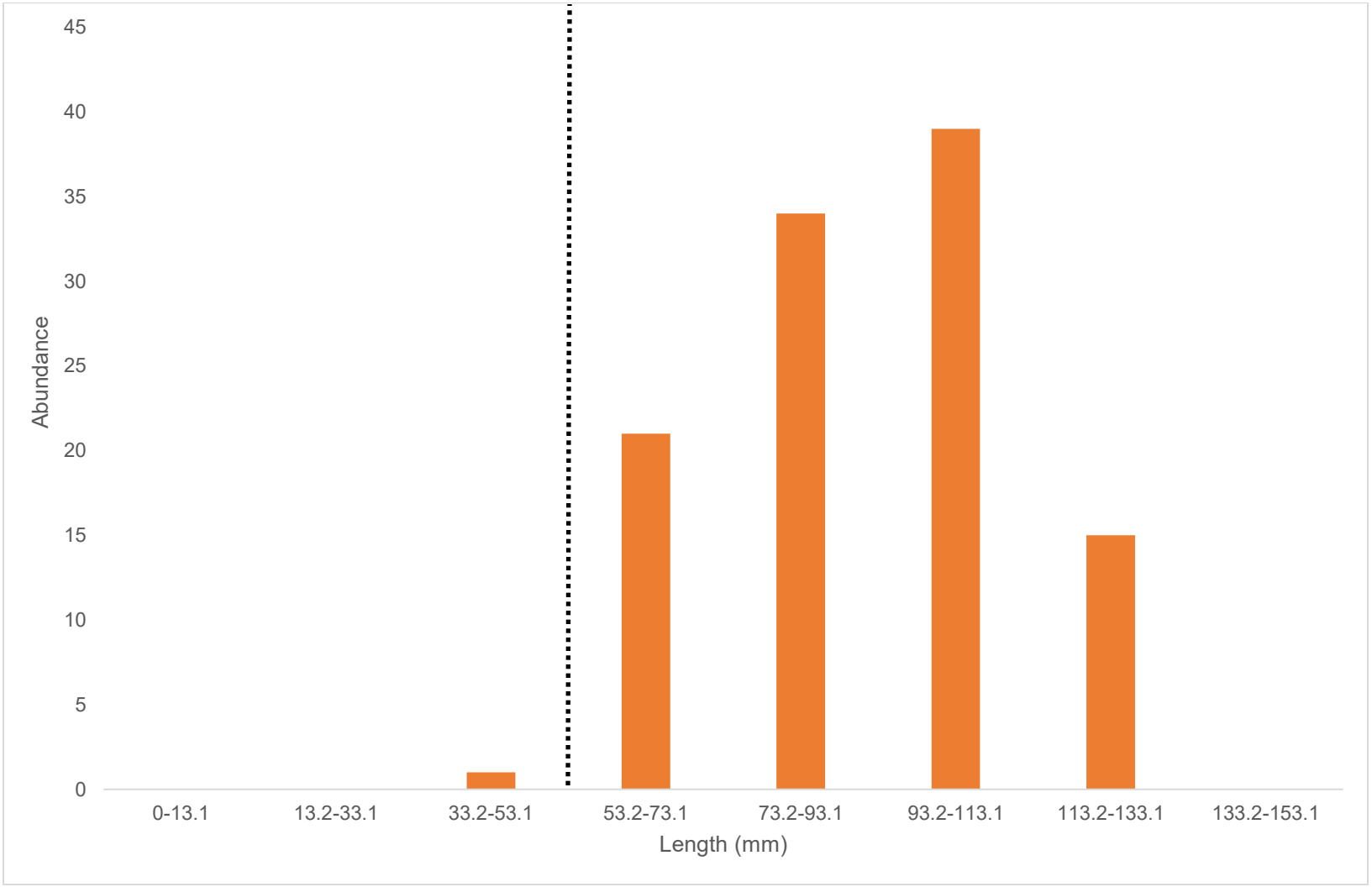

Figure 12. Length frequency distribution for *Cyclonaias tuberculata* (Purple Wartyback) collected from the East Branch of the Sydenham River (n = 110) in June 2022. The dashed vertical line represents the separation of juveniles (< 53.2 mm) and adults (≥ 54.5 mm), determined using Ontario-specific size-at-age data following Haag (2012).

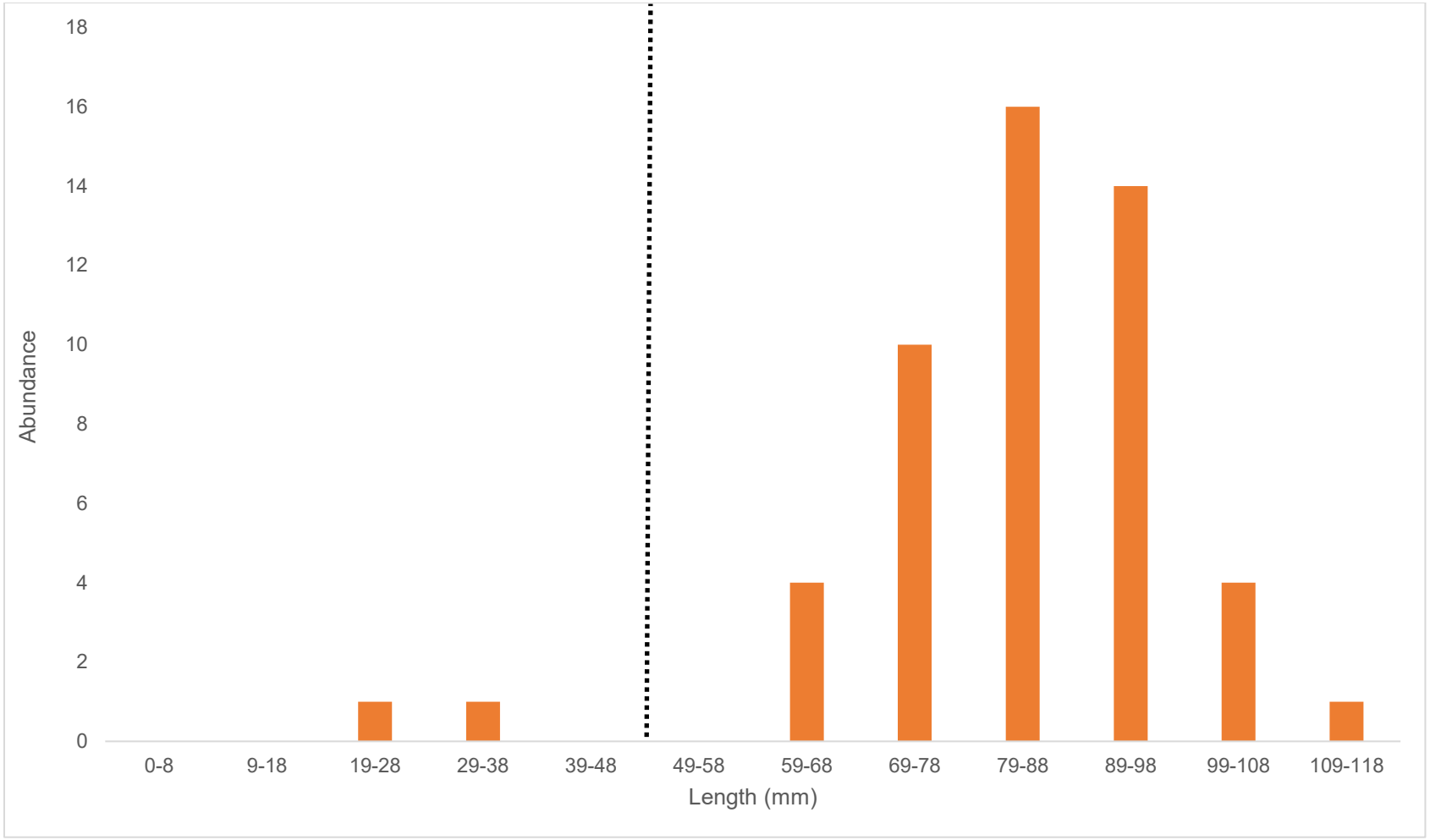

Figure 13. Length frequency distribution for *Ptychobranchus fasciolaris* (Kidneyshell) collected from the East Branch of the Sydenham River (n = 51) in June 2022. The dashed vertical line represents the separation of juveniles (< 49.0 mm) and adults (≥ 49.0 mm), determined using Ontario-specific size-at-age data following Haag (2012).

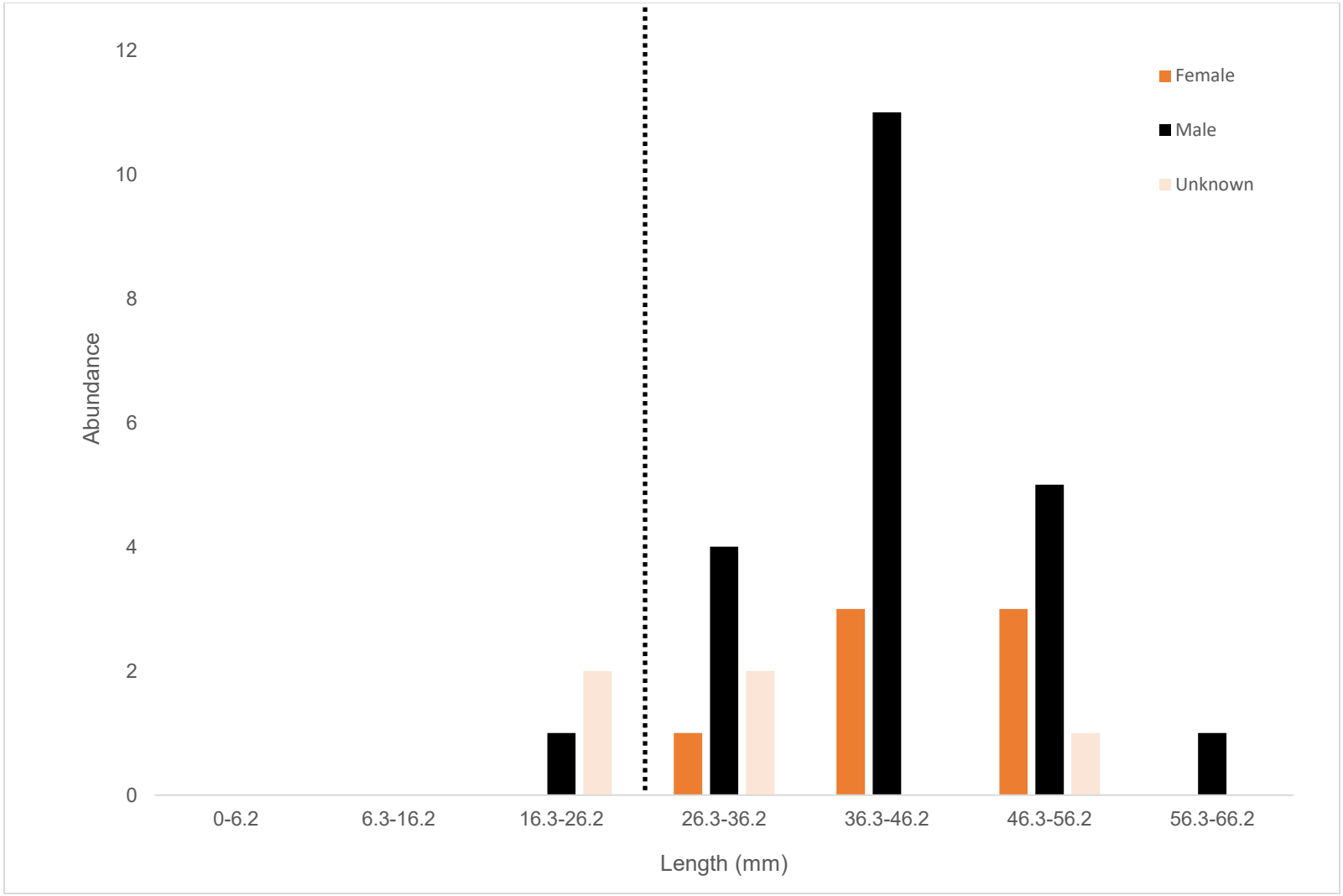

Figure 14. Length frequency distribution for *Epioblasma rangiana* (Northern Riffleshell) collected from the East Branch of the Sydenham River (n = 34) in June 2022. The dashed vertical line represents the separation of juveniles (< 26.3-mm) and adults (≥ 26.3 mm), determined using the smallest identified female in data from LGLUD (2022).