

# The Canadian Field-Naturalist

## A baseline study of the fishes in the north-flowing section of the Rideau River-Canal system, Ontario, 1998–2000

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Phelps, A., C.B. Renaud, and N.R. Alfonso. 2024. A baseline study of the fishes in the north-flowing section of the Rideau River-Canal system, Ontario, 1998–2000. *Canadian Field-Naturalist* 138(4): 319–334. <https://doi.org/10.22621/cfn.v138i4.3131>

### Abstract

Since 1883, 64 fish species belonging to 22 families have been reported from the north-flowing section of the Rideau River-Canal system, Ontario, Canada. Six of these species are non-native, two of which have become established with the remaining four no longer present. A total of 34 species belonging to 11 families were collected in the mainstem north-flowing section of the Rideau River and five of its tributaries during our 1998–2000 study. The fish community along the Rideau River mainstem at sites with adjacent urban land use was distinguishable from sites that were adjacent to agricultural–forested areas. The urban sites cluster was characterized by an abundance of Rock Bass (*Ambloplites rupestris*) and a low abundance of Bluegill (*Lepomis macrochirus*), Pumpkinseed (*Lepomis gibbosus*), Yellow Perch (*Perca flavescens*), Brown Bullhead (*Ameiurus nebulosus*), and White Sucker (*Catostomus commersonii*). The two mixed agricultural–forested site clusters combined were characterized by an abundance of Black Crappie (*Pomoxis nigromaculatus*), Largemouth Bass (*Micropterus nigricans*), Bluegill, Pumpkinseed, Yellow Perch, and Brown Bullhead. Our study is a baseline of the fish community in the Rideau River watershed at the end of the 20th century, with which to compare as the impacts of climate and land use changes continue.

Key words: Rideau River; fishes; land use; species richness; abundance

### Introduction

The Rideau River-Canal system is a 202-km long regulated waterway constructed in 1826–1832, linking the Ottawa River at Ottawa in the north to Lake Ontario and the St. Lawrence River at Kingston in the south via 47 locks (Watson 2024). This engineering feat united the north-flowing Rideau River, which empties into the Ottawa River, and the south-flowing Cataraqui River, which empties into Lake Ontario. Prior to the construction of the Rideau River-Canal system, the natural outlet of the Rideau River was the 15 m Rideau Falls, an impassable barrier to the upstream movement of fishes from the Ottawa River to the Rideau River. In theory, the intermittent locks constructed along the entire length of the waterway allows the movement of fishes into the Rideau system from both the Ottawa River and the St. Lawrence River/Lake Ontario. Regulated waterways are well known for impacting the ichthyofauna (Jungwirth *et al.* 2000; Nunn and Cowx 2012; Birnie-Gauvin *et al.*

2017). Locks can serve as a conduit for invasive fish movement (Bergman *et al.* 2022) and yearly water drawdown can reduce fish overwintering habitat, perhaps by creating shallow-water barriers that decrease connectivity (Bergman *et al.* 2023). The waterway became a National Historic Site of Canada in 1925, a Canadian Heritage River in 2000, and a UNESCO World Heritage Site in 2007 (Watson 2024).

Our study constituted the fish component of the Rideau River Biodiversity Project (Phelps 2001; Johnson *et al.* 2003). We 1. compare the historical ichthyofauna (1883–1997) of the north-flowing section of the Rideau River-Canal system to that we collected from 1998 to 2000; 2. determine if there were differences in fish abundance from sites with different adjacent land uses (i.e., urban, agricultural, forested); 3. compare the ichthyofauna of the mainstem north-flowing section of the Rideau River with that of five of its tributaries; and 4. establish a baseline with which to compare future fish community studies.

## Methods

Thirty-five sites were sampled along the Rideau River and five of its tributaries in the summers of 1998–2000 (Tables 1 and 2). Fourteen sites with an associate land-use category were sampled along the mainstem Rideau River, upstream to downstream, from Smiths Falls (river km [rkm] 97) to Rideau Falls, Ottawa (rkm 0) from mid-July to mid-September 1998 and then again in August–September 2000 using a variety of methods (Table 1, Figure 1). Site numbers run roughly downstream to upstream, from 1 to 14 following Phelps (2001). The land use adjacent to these sites was visually determined in the field to be agricultural, forested, or urban; there were five agricultural and four forested sites from Smiths Falls to Rideau Glen and five urban sites downstream of Black Rapids to Rideau Falls (Table 1). Note that the urban sites were in the downstream part of our study area while the agricultural-forested sites were in the upstream part. Six additional sites were sampled between Smiths Falls and Manotick in 2000 (Table 1). Five tributaries to the Rideau River in this 97-km segment were each sampled at three sites: as close to their source as it was possible to navigate, their confluence with the Rideau, and about midway between these two. Jock River, Stevens Creek, and Kemptville Creek were sampled during the last two weeks of July 1999 while Cranberry Creek and Mosquito Creek were sampled during August–September 2000 (Table 2; Figure 1).

Fishes were identified to species using Scott and Crossman (1973), McAllister and Coad (1974), Bernatchez and Giroux (1991), and Coad (2001). We followed Page *et al.* (2023) as the most current fish nomenclature. Fork or total length (mm), depending on the species, and weight (g) were measured on each captured fish. Most fishes were then released at the site of capture, but those that could not be identified in the field were brought to the lab.

We recorded the following habitat characteristics at each site: water depth, water temperature, and water clarity; percent cover of each substrate type, bank height, percent cover of overhanging vegetation, percent total cover, and percent cover of individual deep aquatic (i.e., 7 m from shoreline) and riparian (i.e., shallow) vegetation also were recorded in 1998. No water physicochemistry or water quality parameters were measured except for temperature and clarity. Substrate was visually estimated at three plots 1 m from the shoreline (i.e., shallow areas) and at three plots 7 m from the shoreline (i.e., deep areas) and averaged. The substrate was classified according to Meador *et al.* (1993) and plant species were identified using Newmaster *et al.* (1997). Seven plant species were common to both shallow and deep areas:

American Eelgrass (*Vallisneria americana* Michaux), Eurasian Water-milfoil (*Myriophyllum spicatum* L.), pondweed (*Potamogeton* L.), Fragrant Water-lily (*Nymphaea odorata* Aiton), Variegated Pond-lily (*Nuphar variegata* Engelmann ex Durand), duckweed (*Lemna* L.), and elodea (*Elodea* Michaux). Various species of algae were only found in shallow areas and Common Hornwort (*Ceratophyllum demersum* L.) was only found in deep areas. Fish species richness (i.e., number of species), abundance for each species, and catch-per-unit effort for each species were recorded at each sampling site. Catch-per-unit effort for each species was calculated at each site by summing the number of individuals captured and dividing by the number of collecting gear used.

Cluster analyses were performed using SYSTAT v5 (SYSTAT 1992); the Visual Basic Application in Microsoft Excel 97 was used to create a Visual Basic Macro to perform the nonparametric Mantel tests. Because urban sites were sequentially distributed downstream while agricultural and forested sites were randomly arranged upstream, Mantel tests were performed between the geographic distance of the 14 sites sampled along the river in 1998 and the abundance of fishes and habitat characteristics at those sites to determine whether these were correlated. A cluster analysis using Pearson distance and Ward joining algorithm was performed between land-use type and habitat characteristics at the 14 sites sampled in 1998 to assess whether these were correlated. Mantel tests were performed between habitat characteristics and fish species richness and abundance at the same sites to assess if these were correlated. A cluster analysis using Pearson distance and Ward joining algorithm was performed between land-use type and abundance of fishes at the same sites to assess if these were correlated.

## Results

In 1998, 6904 fishes (6394 individuals, excluding young-of-the-year centrarchids; Table 3) were captured along the length of the mainstem Rideau River between Smiths Falls and Ottawa (Figure 1). Two individuals were first records for the mainstem Rideau River (Table 4): a Tadpole Madtom (*Noturus gyrinus*, collected 28 August upstream from the Catchall at buoy N211 [site 12], although this species was collected as early as 1976 in Kemptville Creek [Phelps *et al.* 2000a]), and a Freshwater Drum (*Aplodinotus grunniens*) collected 27 July west of Bank Street Bridge [site 3] (Phelps *et al.* 2000b). Only one individual each of Emerald Shiner (*Notropis atherinoides*) and Mottled Sculpin (*Cottus bairdii*) was collected (Table 3), despite intensive effort with a wide array of collection gear; this may be an indication of

**TABLE 1.** Sites along the Rideau River mainstem sampled for ichthyofauna in 1998 and 2000 and their adjacent land uses. Sites are located as indicated in Figure 1. The N values refer to buoys. Land use was not identified for sites 15–20 because they were not part of the analyses that examined the relationship between land use and biological parameters. See table footnotes for sampling gear used.

| Site | Location                                    | Latitude (°N) | Longitude (°W) | Land use     | Dates sampled in 1998*          | Dates sampled in 2000† |
|------|---------------------------------------------|---------------|----------------|--------------|---------------------------------|------------------------|
| 1    | Former Ottawa City Hall                     | 45.4379       | 75.6922        | Urban        | 20, 23, 31 July                 | 10 September           |
| 2    | South of Saint Patrick Street Bridge        | 45.4364       | 75.6754        | Urban        | 20, 22, 31 July                 | 10 September           |
| 3    | West of Bank Street Bridge                  | 45.3867       | 75.6858        | Urban        | 27, 30 July, 20 August          | 10 September           |
| 4    | West of Bronson Street Bridge               | 45.3829       | 75.6914        | Urban        | 27–29, 31 July                  | 10 September           |
| 5    | Downstream of Black Rapids                  | 45.3283       | 75.7003        | Urban        | 3, 5, 21 August                 | 10 September           |
| 6    | Rideau Glen, upstream of N44                | 45.3025       | 75.6975        | Agricultural | 5, 7, 21 August                 | 10 September           |
| 7    | Across from Rideau River Provincial Park    | 45.0539       | 75.6697        | Forested     | 10, 13–14, 27 August            | 3 September            |
| 8    | N207, downstream from the Catchall          | 45.0125       | 75.7331        | Forested     | 13, 27 August                   | 3 September            |
| 9    | N337, upstream from bird sanctuary          | 44.8962       | 75.8786        | Forested     | 17, 19, 24 August               | 3 September            |
| 10   | N320, bird sanctuary                        | 44.9111       | 75.8666        | Forested     | 19, 24 August                   | 3 September            |
| 11   | N183, upstream of Libby Island              | 45.0206       | 75.7173        | Agricultural | 27–28 August, 10 September      | 3 September            |
| 12   | N211, upstream from the Catchall            | 45.0098       | 75.7419        | Agricultural | 28 August, 3, 8–9, 14 September | 3 September            |
| 13   | Upstream of N250                            | 44.9729       | 75.8124        | Agricultural | 1, 4, 15 September              | 4 September            |
| 14   | N253, upstream from Rideau Creek confluence | 44.9895       | 75.7706        | Agricultural | 31 July, 1, 8, 17 September     | 4 September            |
| 15   | Upstream of Manotick Bridge                 | 45.2318       | 75.6758        | —            | —                               | 19 August              |
| 16   | Upstream of Hurst Marina, Manotick          | 45.1595       | 75.6350        | —            | —                               | 19–20 August           |
| 17   | N140, McGahey's Bend                        | 45.0947       | 75.6237        | —            | —                               | 20 August              |
| 18   | Across from Baxter Conservation Area        | 45.0991       | 75.6200        | —            | —                               | 21 August              |
| 19   | 1.7 km east of Kilmarnock Island            | 44.8693       | 75.9000        | —            | —                               | 21, 23–24 August       |
| 20   | Kilmarnock, 500 m downstream of boat ramp   | 44.8853       | 75.8796        | —            | —                               | 21 August              |

\*Collecting gear used at each site in 1998: one of two trap nets (1.83 m<sup>3</sup> box with a multifilament stretched mesh size of 6.4 cm and a 25 m × 1.83 m lead and a 1.20 m<sup>3</sup> box with a multifilament stretched mesh size of 6.4 cm and a 15 m × 1.20 m lead); a hoop/fyke net (9.1 m × 0.9 m lead, mesh size 6 mm, and rings 76 cm in diameter) set perpendicular to the current for 24 h; one unbaited minnow trap 44.5 cm long, 23 cm in diameter, with a 1.1 cm opening set for 24 h; two passes (three at sites 4–6, four at site 14) of a 30-m seine net with mesh size 6 mm and bag weighted down with chain to prevent rolling, operated from a boat in deeper water or by two people in wadeable water; and a backpack DC electrofisher (Model 12-A, Smith-Root Inc., Vancouver, Washington, USA) operated for 1200 s, used in conjunction with fine mesh dipnets.

†Two unbaited minnow traps were used to resample the 1998 sites in 2000. Two boat-operated 30 m seine hauls (four at site 16, none at site 18), three unbaited minnow traps (none at sites 15–17, two at site 19, one at site 20) and 1200 s of electrofishing (none at sites 15–17, 20) were used at the six additional sites sampled only in 2000.

the rarity of the above four species in the mainstem. The most ubiquitous species were members of Centrarchidae, with Pumpkinseed (*Lepomis gibbosus*) and Rock Bass (*Ambloplites rupestris*) found at all 14 sites and Bluegill (*Lepomis macrochirus*) and Black Crappie (*Pomoxis nigromaculatus*) found at 13 sites (Table 3). These sites were adjacent to all three types of land uses (urban, agricultural, and forested; Table

1). These four species accounted for 46.81% of fishes collected (Table 3).

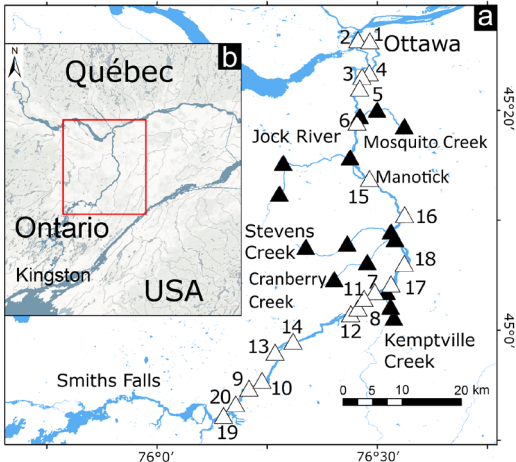
Species richness (presence/absence) and relative abundance (catch-per-unit effort) of fishes and the habitat characteristics for each site were plotted against the distance (in rkm) of each site away from the confluence of the Rideau and Ottawa Rivers, to determine if a longitudinal continuum existed along the length

**TABLE 2.** Ichthyofauna sampling sites along tributaries to the Rideau River, 1999 and 2000. See table footnotes for sampling gear used.

| Site | Tributary        | Location                                 | Latitude (°N) | Longitude (°W) | Dates sampled in 1999* | Dates sampled in 2000†     |
|------|------------------|------------------------------------------|---------------|----------------|------------------------|----------------------------|
| JR1  | Jock River       | Confluence with Rideau River             | 45.2608       | 75.7069        | 22 July                | —                          |
| JR2  | Jock River       | Bow of Jock River Park                   | 45.2536       | 75.8075        | 27 July                | —                          |
| JR3  | Jock River       | Richmond                                 | 45.1872       | 75.8333        | 27 July                | —                          |
| SC1  | Stevens Creek    | Confluence with Rideau River             | 45.1472       | 75.6444        | 28 July                | —                          |
| SC2  | Stevens Creek    | North Gower                              | 45.1299       | 75.7138        | 30 July                | —                          |
| SC3  | Stevens Creek    | At Hwy 4                                 | 45.1398       | 75.7268        | 30 July                | —                          |
| KC1  | Kemptville Creek | Confluence with Rideau River             | 45.0569       | 75.6554        | 21 July                | —                          |
| KC2  | Kemptville Creek | Midway between Kemptville and confluence | 45.0455       | 75.6532        | 20 July                | —                          |
| KC3  | Kemptville Creek | Kemptville                               | 45.0200       | 75.6408        | 19 July                | —                          |
| CC1  | Cranberry Creek  | Confluence with Rideau River             | 45.1383       | 75.6411        | —                      | 30 August                  |
| CC2  | Cranberry Creek  | Midway between confluence and source     | 45.1196       | 75.6671        | —                      | 30 August                  |
| CC3  | Cranberry Creek  | Source                                   | 45.0747       | 75.7369        | —                      | 30 August                  |
| MC1  | Mosquito Creek   | Confluence with Rideau River             | 45.2894       | 75.6963        | —                      | 28 August                  |
| MC2  | Mosquito Creek   | Midway between confluence and source     | 45.2683       | 75.6458        | —                      | 28–29 August               |
| MC3  | Mosquito Creek   | Source                                   | 45.2681       | 75.5979        | —                      | 29 August, 23–24 September |

\*Two passes of a 10 m seine net (one pass at KC2, three at KC3; mesh size not recorded), eight unbaited minnow traps set for 24 h, and 1200 s of electrofishing (2400 s at KC2) were used at each site in the Jock River, Stevens Creek, and Kemptville Creek in 1999.

†Two passes of a handheld seine net (none at CC2, CC3, three passes at MC2; mesh size not recorded), three unbaited minnow traps set for 24 h, and 1200 s of electrofishing were used (none at CC2, CC3, MC1, MC2) at each site in Cranberry Creek and Mosquito Creek in 2000.



**FIGURE 1.** a. North-flowing section of the Rideau River-Canal system between Smiths Falls and Ottawa, Ontario, Canada with b. showing context in southeastern Ontario. Sampling sites (1998–2000) are indicated by the numbered open triangles (mainstem) and closed triangles (tributaries). See Tables 1 and 2 for site details.

of the Rideau River (i.e., if there was an increasing or decreasing trend downstream to upstream or if distance from the river’s confluence plays a role in structuring the fish community). The Mantel tests indicated statistically significant positive correlations between the geographic distance from the confluence of the Rideau and Ottawa Rivers to each of the 14 sites sampled and the abundance of piscivorous ( $Z = 5025, P = 0.002 < \alpha = 0.006$ ) and insectivorous ( $Z = 17\,590, P < 0.001 < \alpha = 0.006$ ) fishes. Piscivorous species were Northern Pike (*Esox lucius*), Rock Bass, Smallmouth Bass (*Micropterus dolomieu*), Largemouth Bass (*Micropterus nigricans*), Black Crappie, and Walleye (*Sander vitreus*). Insectivorous species were White Sucker (*Catostomus commersonii*), Silver Redhorse (*Moxostoma anisurum*), Greater Redhorse (*Moxostoma valenciennesi*), Brown Bullhead (*Ameiurus nebulosus*), Pumpkinseed, Bluegill, and Yellow Perch (*Perca flavescens*). Note that Yellow Perch was grouped with the insectivorous fishes because 91% of individuals collected were <15 cm total length.

There were no significant statistical relationships

**TABLE 3.** Abundance, percent composition, and sampling sites in the mainstem Rideau River, Ontario from which 30 fish species were captured (6394 individuals, excluding young-of-the-year centrarchids), mid-July to mid-September 1998.

| Species                                             | Number of individuals | %      | Number of sites | List of sites       |
|-----------------------------------------------------|-----------------------|--------|-----------------|---------------------|
| Pumpkinseed ( <i>Lepomis gibbosus</i> )             | 1149                  | 17.97  | 14              | 1–14                |
| Bluegill ( <i>Lepomis macrochirus</i> )             | 952                   | 14.89  | 13              | 2–14                |
| Yellow Perch ( <i>Perca flavescens</i> )            | 840                   | 13.14  | 12              | 2, 4–14             |
| Common Shiner ( <i>Luxilus cornutus</i> )           | 717                   | 11.21  | 3               | 4, 6–7              |
| Rock Bass ( <i>Ambloplites rupestris</i> )          | 553                   | 8.65   | 14              | 1–14                |
| Black Crappie ( <i>Pomoxis nigromaculatus</i> )     | 339                   | 5.30   | 13              | 2–14                |
| Logperch ( <i>Percina caprodes</i> )                | 303                   | 4.74   | 9               | 1, 3, 5–9, 13–14    |
| Banded Killifish ( <i>Fundulus diaphanus</i> )      | 283                   | 4.43   | 11              | 2–4, 7–14           |
| Golden Shiner ( <i>Notemigonus crysoleucas</i> )    | 244                   | 3.82   | 10              | 2–6, 8–9, 11–12, 14 |
| Bluntnose Minnow ( <i>Pimephales notatus</i> )      | 162                   | 2.53   | 7               | 7–9, 11–14          |
| Largemouth Bass ( <i>Micropterus nigricans</i> )    | 161                   | 2.52   | 10              | 4, 6–14             |
| Smallmouth Bass ( <i>Micropterus dolomieu</i> )     | 141                   | 2.20   | 11              | 1–7, 11–14          |
| Brook Silverside ( <i>Labidesthes sicculus</i> )    | 134                   | 2.10   | 7               | 5–8, 10–11, 13      |
| Blacknose Shiner ( <i>Notropis heterolepis</i> )    | 106                   | 1.66   | 8               | 7–14                |
| Spottail Shiner ( <i>Hudsonius hudsonius</i> )      | 82                    | 1.28   | 5               | 2, 5–7, 12          |
| Brown Bullhead ( <i>Ameiurus nebulosus</i> )        | 76                    | 1.19   | 9               | 2, 6–13             |
| Tessellated Darter ( <i>Etheostoma olmstedii</i> )  | 54                    | 0.84   | 11              | 1–2, 5–12, 14       |
| Common Carp ( <i>Cyprinus carpio</i> )              | 26                    | 0.41   | 8               | 3, 6–8, 11–14       |
| Northern Pike ( <i>Esox lucius</i> )                | 22                    | 0.34   | 11              | 1, 3–6, 8, 10–14    |
| Greater Redhorse ( <i>Moxostoma valenciennesi</i> ) | 11                    | 0.17   | 3               | 6, 12–13            |
| Blackchin Shiner ( <i>Miniellus heterodon</i> )     | 10                    | 0.16   | 2               | 2, 6                |
| Silver Redhorse ( <i>Moxostoma anisurum</i> )       | 9                     | 0.14   | 4               | 3, 5–6, 14          |
| Fallfish ( <i>Semotilus corporalis</i> )            | 7                     | 0.11   | 4               | 5–6, 8, 12          |
| Walleye ( <i>Sander vitreus</i> )                   | 4                     | 0.06   | 4               | 5–7, 12             |
| White Sucker ( <i>Catostomus commersonii</i> )      | 3                     | 0.05   | 3               | 5, 11–12            |
| Muskellunge ( <i>Esox masquinongy</i> )             | 2                     | 0.03   | 2               | 4, 8                |
| Mottled Sculpin ( <i>Cottus bairdii</i> )           | 1                     | 0.02   | 1               | 3                   |
| Tadpole Madtom ( <i>Noturus gyrinus</i> )           | 1                     | 0.02   | 1               | 12                  |
| Freshwater Drum ( <i>Aplodinotus grunniens</i> )    | 1                     | 0.02   | 1               | 3                   |
| Emerald Shiner ( <i>Notropis atherinoides</i> )     | 1                     | 0.02   | 1               | 6                   |
| Totals                                              | 6394                  | 100.02 |                 |                     |

between geographic distance and the abundance of small-bodied fishes or all fishes combined, nor with any of the habitat characteristics we measured. Small-bodied fishes were Common Shiner (*Luxilus cornutus*), Golden Shiner (*Notemigonus crysoleucas*), Blacknose Shiner (*Notropis heterolepis*), Spottail Shiner (*Hudsonius hudsonius*), Bluntnose Minnow (*Pimephales notatus*), Fallfish (*Semotilus corporalis*), Brook Silverside (*Labidesthes sicculus*), Banded Killifish (*Fundulus diaphanus*), Tessellated Darter (*Etheostoma olmstedii*), and Logperch (*Percina caprodes*).

Habitat characteristics were water depth, percent coverage of shallow and deep aquatic plants, overhanging vegetation, and substrate.

Sites deemed the best along the Rideau River were those with the highest species richness and abundance of fishes. Site 5 (Figure 1), downstream of Black Rapids, was the best urban site (Table 1, Figure 2). Sixteen species belonging to six families were captured at this site: five centrarchids, four percids, three leuciscids, two catostomids, one esocid, and one atherinopsid (Table 3). The best agricultural site was site 6, Rideau

**TABLE 4.** Fish species collected during our study (1998–2000) and reported in the north-flowing section of the Rideau River system according to literature records (1883–1997, with year of first documented collection in brackets)\*. The tributaries we sampled were Jock River, Stevens Creek, Kemptville Creek, Cranberry Creek, and Mosquito Creek, the first three in 1999 and the last two in 2000 (Table 2).

| Family          | Species                                                | 1998–2000                |             | 1883–1997 |
|-----------------|--------------------------------------------------------|--------------------------|-------------|-----------|
|                 |                                                        | Rideau River<br>mainstem | Tributaries |           |
| Petromyzontidae | Silver lamprey ( <i>Ichthyomyzon unicuspis</i> )       |                          |             | + (1883)  |
| Lepisosteidae   | Longnose Gar ( <i>Lepisosteus osseus</i> )             |                          |             | + (1893)  |
| Anguillidae     | American Eel ( <i>Anguilla rostrata</i> )              |                          |             | + (1996)  |
| Alosidae        | Alewife ( <i>Alosa pseudoharengus</i> )                |                          |             | + (1982)  |
| Cyprinidae      | Common Carp ( <i>Cyprinus carpio</i> )                 | +                        |             | + (1957)  |
| Leuciscidae     | Northern Redbelly Dace ( <i>Chrosomus eos</i> )        |                          |             | + (1937)  |
|                 | Finescale Dace ( <i>Chrosomus neogaeus</i> )           |                          |             | + (1974)  |
|                 | Brassy Minnow ( <i>Hybognathus hankinsoni</i> )        |                          | +           | + (1974)  |
|                 | Eastern Silvery Minnow ( <i>Hybognathus regius</i> )   |                          |             | + (1962)  |
|                 | Common Shiner ( <i>Luxilus cornutus</i> )              | +                        | +           | + (1937)  |
|                 | Northern Pearl Dace ( <i>Margariscus nachtriebi</i> )  |                          |             | + (1937)  |
|                 | Golden Shiner ( <i>Notemigonus crysoleucas</i> )       | +                        | +           | + (1937)  |
|                 | Emerald Shiner ( <i>Notropis atherinoides</i> )        | +                        |             | + (1974)  |
|                 | Blackchin Shiner ( <i>Miniellus heterodon</i> )        | +                        | +           | + (1937)  |
|                 | Blacknose Shiner ( <i>Notropis heterolepis</i> )       | +                        | +           | + (1937)  |
|                 | Spottail Shiner ( <i>Hudsonius hudsonius</i> )         | +                        | +           | + (1937)  |
|                 | Rosyface Shiner ( <i>Notropis rubellus</i> )           |                          | +           | + (1883)  |
|                 | Sand Shiner ( <i>Miniellus stramineus</i> )            |                          |             | + (1987)  |
|                 | Mimic Shiner ( <i>Paranotropis volucellus</i> )        |                          | +           | + (1974)  |
|                 | Bluntnose Minnow ( <i>Pimephales notatus</i> )         | +                        | +           | + (1937)  |
|                 | Fathead Minnow ( <i>Pimephales promelas</i> )          |                          |             | + (1937)  |
|                 | Longnose Dace ( <i>Rhinichthys cataractae</i> )        |                          |             | + (1937)  |
|                 | Creek Chub ( <i>Semotilus atromaculatus</i> )          |                          |             | + (1937)  |
|                 | Fallfish ( <i>Semotilus corporalis</i> )               | +                        | +           | + (1937)  |
| Catostomidae    | White Sucker ( <i>Catostomus commersonii</i> )         | +                        | +           | + (1883)  |
|                 | Lake Chubsucker ( <i>Erimyzon sucetta</i> )            |                          |             | + (1883)  |
|                 | Silver Redhorse ( <i>Moxostoma anisurum</i> )          | +                        | +           | + (1937)  |
|                 | Shorthead Redhorse ( <i>Moxostoma macrolepidotum</i> ) |                          |             | + (1937)  |
|                 | Greater Redhorse ( <i>Moxostoma valenciennesi</i> )    | +                        |             | + (1974)  |
| Ictaluridae     | Yellow Bullhead ( <i>Ameiurus natalis</i> )            |                          |             | + (1974)  |
|                 | Brown Bullhead ( <i>Ameiurus nebulosus</i> )           | +                        | +           | + (1906)  |
|                 | Channel Catfish ( <i>Ictalurus punctatus</i> )         |                          |             | + (1995)  |
|                 | Stonecat ( <i>Noturus flavus</i> )                     |                          |             | + (1974)  |
|                 | Tadpole Madtom ( <i>Noturus gyrinus</i> )              | +                        | +           |           |
| Salmonidae      | Rainbow Trout ( <i>Oncorhynchus mykiss</i> )           |                          |             | + (1935)  |
|                 | Brown Trout ( <i>Salmo trutta</i> )                    |                          |             | + (1935)  |
| Esocidae        | Northern Pike ( <i>Esox lucius</i> )                   | +                        | +           | + (1937)  |
|                 | Muskellunge ( <i>Esox masquinongy</i> )                | +                        | +           | + (1883)  |
|                 | Central Mudminnow ( <i>Umbra limi</i> )                | +                        | +           | + (1883)  |
| Percopsidae     | Trout-perch ( <i>Percopsis omiscomaycus</i> )          |                          |             | + (1937)  |
| Gadidae         | Burbot ( <i>Lota lota</i> )                            |                          |             | + (1906)  |
| Atherinopsidae  | Brook Silverside ( <i>Labidesthes sicculus</i> )       | +                        | +           | + (1937)  |
| Gasterosteidae  | Brook Stickleback ( <i>Culaea inconstans</i> )         |                          |             | + (1937)  |
| Fundulidae      | Banded Killifish ( <i>Fundulus diaphanus</i> )         | +                        | +           | + (1974)  |

TABLE 4. Continued.

| Family        | Species                                            | 1998–2000                |             | 1883–1997 |
|---------------|----------------------------------------------------|--------------------------|-------------|-----------|
|               |                                                    | Rideau River<br>mainstem | Tributaries |           |
| Cottidae      | Mottled Sculpin ( <i>Cottus bairdii</i> )          | +                        |             | + (1974)  |
| Centrarchidae | Rock Bass ( <i>Ambloplites rupestris</i> )         | +                        | +           | + (1906)  |
|               | Pumpkinseed ( <i>Lepomis gibbosus</i> )            | +                        | +           | + (1937)  |
|               | Bluegill ( <i>Lepomis macrochirus</i> )            | +                        | +           | + (1937)  |
|               | Smallmouth Bass ( <i>Micropterus dolomieu</i> )    | +                        | +           | + (1883)  |
|               | Largemouth Bass ( <i>Micropterus nigricans</i> )   | +                        | +           | + (1883)  |
|               | Black Crappie ( <i>Pomoxis nigromaculatus</i> )    | +                        | +           | + (1906)  |
|               | Iowa Darter ( <i>Etheostoma exile</i> )            |                          |             | + (1974)  |
| Percidae      | Johnny Darter ( <i>Etheostoma nigrum</i> )         |                          |             | + (1937)  |
|               | Tessellated Darter ( <i>Etheostoma olmstedii</i> ) | +                        | +           | + (1974)  |
|               | Yellow Perch ( <i>Perca flavescens</i> )           | +                        | +           | + (1937)  |
|               | Logperch ( <i>Percina caprodes</i> )               | +                        | +           | + (1883)  |
|               | Sauger ( <i>Sander canadensis</i> )                |                          |             | + (1883)  |
|               | Walleye ( <i>Sander vitreus</i> )                  | +                        | +           | + (1883)  |
| Sciaenidae    | Freshwater Drum ( <i>Aplodinotus grunniens</i> )   | +                        |             |           |

\*Sources: Small (1883, 1893); Halkett (1906); Prince *et al.* (1906); Dymond (1939); McAllister and Coad (1974); Coad (1983, 1987); Settingington (2004).

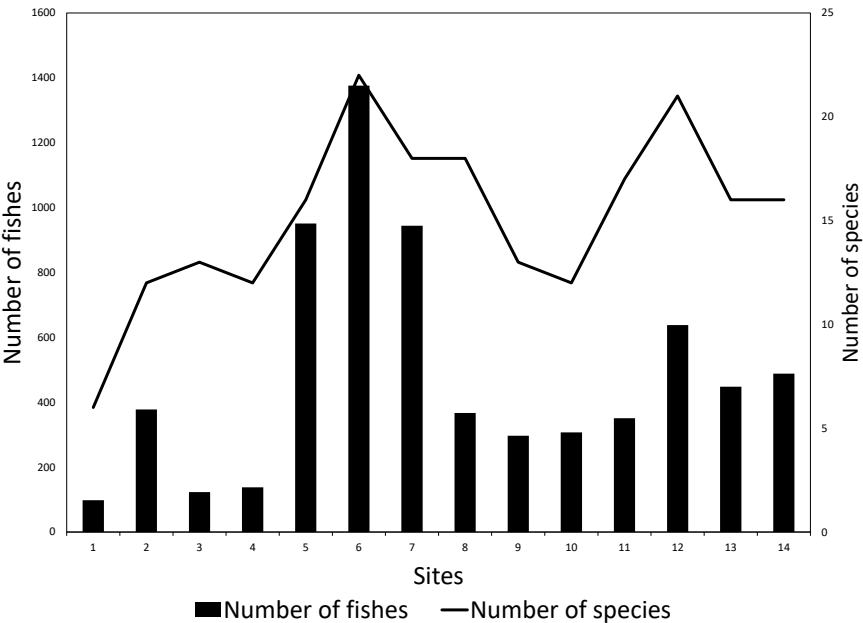


FIGURE 2. Number of fishes captured per site (left axis) and number of fish species captured per site (right axis) along the mainstem Rideau River from mid-July to mid-September 1998.

Glen, in the Black Rapids to Long Island reach of the river (Table 1, Figure 2). Twenty-two species belonging to eight families were captured at this site: six leuciscids, six centrarchids, four percids, two catostomids, one cyprinid, one ictalurid, one esocid, and one atherinopsid (Table 3). The best forested site was site 7, across from Rideau River Provincial Park (Table 1, Figure 2). Eighteen species belonging to seven families were captured at this site: six centrarchids, four leuciscids, four percids, one cyprinid, one ictalurid,

one atherinopsid, and one fundulid (Table 3).

In 1999, 2098 fishes were captured from three tributaries to the Rideau River: 1097 in the Jock River, 747 in Kemptville Creek, and 254 in Stevens Creek. A tiny individual of salamander, Mudpuppy (*Necturus maculosus*) was also collected in a minnow trap in Kemptville Creek, at Kemptville, on 19 July 1999. Three fish species were captured in these tributaries that were not captured in the mainstem Rideau River in 1998 (Table 4): Rosyface Shiner (*Notropis rubellus*) in all three tributaries, Central Mudminnow (*Umbra limi*) in Kemptville Creek and Stevens Creek, and Mimic Shiner (*Paranotropis volucellus*) in Jock River.

In 2000, 1596 fishes were captured from two tributaries to the Rideau River (806 in Cranberry Creek and 790 in Mosquito Creek), 4118 fishes were captured at the six new sites on the Rideau River mainstem between Smiths Falls and Manotick, and 73 fishes were captured at the 14 sites along the Rideau River mainstem that were sampled in 1998. Brassy Minnow (*Hybognathus hankinsoni*) was captured in both these tributaries but was not captured in the mainstem Rideau River in 1998 and 2000 (Table 4) or in the three tributaries (Jock River, Kemptville Creek, and Stevens Creek) sampled in 1999. Central Mudminnow was captured at one of the new mainstem sites (site 20 [Table 1]) and in Cranberry Creek (Table 4) but was not captured in the original 14 sites on the mainstem Rideau River in 1998 or 2000.

Over the three years of our study (1998–2000), 14777 fishes comprising 34 species belonging to 11 families were collected and the great majority released in the mainstem Rideau River and five of its tributaries, but only 26 species (76%) were collected from both the mainstem and tributaries (Table 4). Five species (Common Carp [*Cyprinus carpio*], Emerald Shiner, Greater Redhorse, Mottled Sculpin, and Freshwater Drum) were collected only in the mainstem Rideau River and three species (Brassy Minnow, Rosyface Shiner, and Mimic Shiner) were collected only in one or more of the tributaries surveyed (Table 4).

Supplementary files containing the raw data of habitat characteristics recorded during the 1998 field season (Table S1) and the raw data for the fishes collected during the 1998–2000 field seasons are provided (Tables S2, S3, and S4).

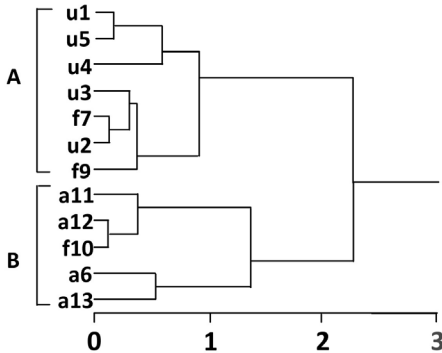
Cluster analysis showed that aquatic habitat characteristics (i.e., abundance of shallow and deep aquatic plants, and substrate type) were correlated with adjacent land-use type. Urban sites clustered separately from agricultural sites, while forested sites were distributed in either cluster (Figure 3). Forested sites possess a mixture of habitat characteristics (i.e.,

abundance of shallow and deep aquatic plants, and substrate type) that align them either with urban or agricultural sites. Thus, forested sites as a whole cannot be separated from other land-use types (i.e., agricultural, urban) based on those characteristics. The urban cluster (A in Figure 3) was characterized by an abundance of American Eelgrass in deep areas, algae in shallow areas, and a primarily sand substrate. The agricultural cluster (B in Figure 3) was characterized by a mixture of American Eelgrass and Variegated Pond-lily and Fragrant Water-lily in deep areas, and a substrate with large woody debris overlying primarily clay, sand, and detritus. The other five habitat characteristics recorded (i.e., water depth, water temperature, water clarity, bank height, and percent cover of overhanging vegetation) did not show significant differences among the three land-use types.

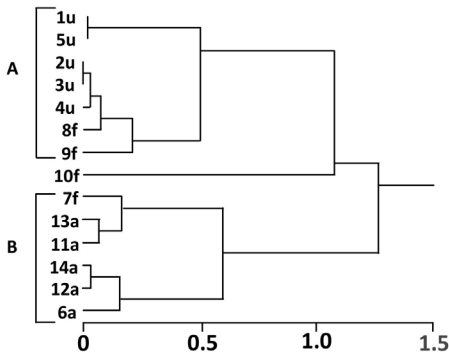
We conducted an in-depth examination of the relationship between land-use type and various aquatic characteristics (i.e., abundance of shallow and deep aquatic plants, substrate type, abundance of all fish species, and abundance of piscivorous and insectivorous fishes separately) at the 14 sites sampled in 1998. The results, detailed below, showed that the five urban sites constituted a single cluster (Figure 4, cluster A and Figure 5, cluster A), although two forested sites were found within the urban group (Figure 4, cluster A), and neither the five agricultural nor the four forested sites could be separated from each other (Figure 4, cluster B and Figure 5, clusters B and C). Therefore, the latter two land-use types were treated as a single grouping with regards to piscivorous and insectivorous fish abundance.

Mantel tests showed statistically significant positive correlations between the fish abundance and the species richness ( $Z = 510, P < 0.001 < \alpha = 0.003$ ) and abundance ( $Z = 112, P < 0.001 < \alpha = 0.004$ ) of deep aquatic plants and the different substrate types ( $Z = 520, P = 0.001 < \alpha = 0.003$ ). No significant correlation existed between habitat characteristics and the species richness of fishes.

The fish abundance data were further broken down into four functional subgroups (i.e., piscivores, insectivores, small-bodied fishes, and young-of-the-year). Mantel tests showed statistically significant positive correlations between the abundance of insectivorous fishes and the species richness ( $Z = 322, P < 0.001 < \alpha = 0.003$ ) and abundance ( $Z = 83, P$  and  $\alpha = 0.004$ ) of deep aquatic plants and the different types ( $Z = 350, P < 0.001 < \alpha = 0.003$ ) and abundance of substrates ( $Z = 138, P < 0.001 < \alpha = 0.004$ ). The abundance of small-bodied fishes (adult total length <20 cm, see above for full list of species) also showed statistically significant positive correlations with the species richness ( $Z = 491, P < 0.001 < \alpha = 0.003$ ) and abundance ( $Z$



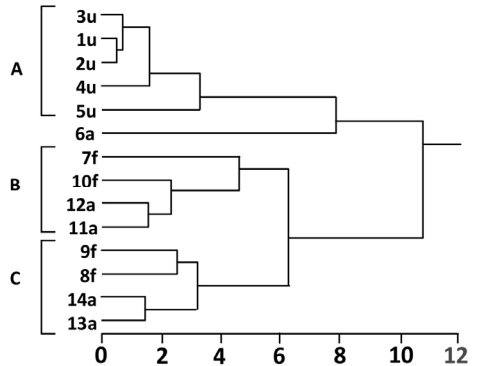
**FIGURE 3.** Clustering tree of ichthyofaunal sampling sites 1–14 along the Rideau River in 1998 (see Table 1 and Figure 1 for locations) according to the relative abundance of deep and shallow aquatic vegetation and substrate type using Pearson distance and Ward joining algorithm. Sites 8 and 14 were removed from the data set because no shallow aquatic vegetation was present at these sites. Group A consists of all urban (symbol u) and two forested (symbol f) sites clustered at a distance of 0.901. Group B consists of four agricultural (symbol a) sites and one forested site clustered at 1.367.



**FIGURE 4.** Clustering tree of ichthyofaunal sampling sites 1–14 along the Rideau River in 1998 (see Table 1 and Figure 1 for locations) according to the relative abundance of piscivorous fish species present at three or more sites using Pearson distance and complete joining algorithm. Young-of-the-year were removed from the data. Group A consists of all urban (symbol u) sites and two forested (symbol f) sites clustered at a distance of 0.492. Group B consists of all agricultural (symbol a) and one forested site clustered at 0.593.

= 142,  $P < 0.001 < \alpha = 0.003$ ) of deep aquatic plants such as American Eelgrass, Variegated Pond-lily, and pondweed spp., and the different types ( $Z = 520$ ,  $P = 0.001 < \alpha = 0.004$ ) and abundance of the following substrates: bedrock, boulders, rubble, gravel, sand, clay, detritus, and large woody debris ( $Z = 229$ ,  $P < 0.001 < \alpha = 0.004$ ).

Cluster analyses showed that the fish community was correlated with adjacent land-use type. Three cluster analyses examining the abundance of all fish



**FIGURE 5.** Clustering tree of ichthyofaunal sampling sites 1–14 along the Rideau River in 1998 (see Table 1 and Figure 1 for locations) according to the relative abundance of insectivorous fish species present at three or more sites using Euclidean distance and complete joining algorithm. Young-of-the-year were removed from the data. Group A consists of all urban (symbol u) sites clustered at a distance of 3.62. Groups B and C each consist of two agricultural (symbol a) sites and two forested (symbol f) sites clustered at 4.616 and 3.198, respectively.

species, as well as two functional subgroups (i.e., piscivores or insectivores) versus land-use type were conducted. The cluster analysis involving all fish species showed that urban sites clustered together, while agricultural and forested sites formed another cluster when using Pearson distance and Ward joining algorithm (results not shown). The cluster analyses examining the subgroups separately showed that the abundance of piscivores produced an urban cluster (A in Figure 4) using Pearson distance and complete joining algorithm characterized by an abundance of Rock Bass, and a combined agricultural-forested cluster (B in Figure 4) characterized by an abundance of Black Crappie and Largemouth Bass. Similarly, the abundance of insectivores produced an urban cluster (A in Figure 5) using Euclidean distance and complete joining algorithm characterized by a low abundance of Bluegill, Pumpkinseed, Yellow Perch, Brown Bullhead, and White Sucker, and two mixed agricultural-forested clusters (B and C in Figure 5) characterized by an abundance of those species minus White Sucker.

## Discussion

### *Temporal changes to fish species richness*

In the 114 years between 1883 and 1997, 57 species of fishes belonging to 18 families were recorded from the north-flowing section of the Rideau River-Canal system (Small 1883, 1893; Prince *et al.* 1906; Halkett 1906, 1908; Dymond 1939; McAllister and Coad 1974; Coad 1983, 1987; Setterington 2004 in

part; see full details below). Despite intensive and extensive sampling effort from mid-July to mid-September during our three-year study (1998–2000) using a wide variety of sampling gear, only 32 (56%) of these previously recorded species belonging to 10 families were captured (Table 4). The eight missing families, represented by one, or in one case two, species, are Petromyzontidae, Lepisosteidae, Anguillidae, Alosidae, Salmonidae, Percopsidae, Gadidae, and Gasterosteidae (Table 4). No scar or wound that would be associated with the attachment and feeding of an adult Silver Lamprey (*Ichthyomyzon unicuspis*; Petromyzontidae) was observed on any of the fishes we collected. Because it was only recorded once by Small (1883), Silver Lamprey is probably no longer present in the system. Likewise, Longnose Gar (*Lepisosteus osseus*; Lepisosteidae) and Burbot (*Lota lota*; Gadidae) were only reported once, by Small (1883) and Halkett (1906), respectively, and are probably no longer present. Two salmonids, Rainbow Trout (*Oncorhynchus mykiss*) and Brown Trout (*Salmo trutta*) were the result of introductions in 1935–1937 (Dymond 1939) and never became established.

By contrast, two additional species, Tadpole Madtom and Freshwater Drum, the latter belonging to a previously undocumented family Sciaenidae, were recorded for the first time during the 1998–2000 study (Phelps *et al.* 2000a,b). Although Tadpole Madtom was first documented as being collected in 1976 (Table 4) based on Canadian Museum of Nature collections, it was first reported in the scientific literature by Phelps *et al.* (2000a).

Our being contacted by members of the public during our study resulted in the addition of two species and families for the Rideau River system, collected in downtown Ottawa. A photograph of a Pacu or Piranha (Serrasalminidae) collected along the eastern shoreline of Dow's Lake was taken in 1994 and an Oscar (*Astronotus ocellatus*; Cichlidae) was collected in 1999 near Landsdowne Park. These two new records from the Rideau Canal were reported by Renaud and Phelps (1999, 2001) and were probably the result of aquarium dumping.

New additions to the Rideau River system have been reported since our study ended. Coad and Alfonso (2005) reported Hornyhead Chub (*Nocomis biguttatus*; Leuciscidae) from the Jock River and its tributary, Kings Creek, both collected 25 June 2004.

COSEWIC (2013) reported Bridle Shiner (*Notropis bifrenatus*; Leuciscidae) at four sites along Cranberry Creek and the Rideau Valley Conservation Authority (2012) collected this species in Stevens Creek. Bridle Shiner's Special Concern status was confirmed in 2013 (COSEWIC 2013) and it is listed as Special Concern under the Canadian *Species*

*at Risk Act* (SARA Registry 2023a).

The presence of the invasive Round Goby (*Neogobius melanostomus*; Gobiidae) was first reported by Bergman and Cooke (2019) in Edmonds Lockstation, downstream of Smiths Falls during water draw-down in 2018. They captured 45 individuals from 9 to 18 July 2019 in the vicinity of Edmonds Dam using backpack electrofishing and tagged them with acoustic transmitters to follow their movement (Bergman *et al.* 2022). An additional 14 specimens of Round Goby were collected 17–25 July 2019 and deposited as vouchers at the Canadian Museum of Nature (Bergman *et al.* 2022: catalogue number CMNFI 2019–0107.1.). More recently, N.R.A. and Sarah E. Steele (Canadian Museum of Nature) captured six individuals on 28 September 2023 at Kilmarnock using an electrofisher. This non-native, invasive species has probably become established.

The new total for the north-flowing section of the Rideau River-Canal system is therefore 64 fish species belonging to 22 families. Bergman *et al.* (2021) incorrectly reported 107 fish species for the Rideau Canal based on Coad (2011). However, Coad (2011) was referring to the National Capital Region and surrounding areas, which encompasses numerous river systems, including the Rideau.

The human population of the city of Ottawa has increased significantly during the period from 1883 to 2021. In 1901 there were 101 102 inhabitants, more than doubling to 206 367 in 1941, again more than doubling to 471 931 in 1971, almost doubling to 934 243 in 2016, and finally reaching 1 017 449 in 2021 (Wikipedia 2024). As early as 1918 there was concern about contamination of the Rideau River in Ottawa South because pipes would discharge domestic sewage directly into the river (A.K.C. 1918). The continued increase of the human population in municipalities along the Rideau River, with all of the associated stressors on the aquatic environment that this entails, is expected to change the fish community in the future.

#### *Historical (1883–1997) ichthyofauna collections from the Rideau River*

Although Van Cortlandt (1859) produced a list of the fishes of the Ottawa Valley that probably included fishes from the north-flowing section of the Rideau River-Canal system, the precise collection locality was not indicated, and, therefore, Small (1883) was the first to compile a list of fishes from the north-flowing section of the Rideau River-Canal system. Small's (1883) list included these 11 species: *Ichthyomyzon argenteus* (see below), Rosyface Shiner (under the genus *Mimilus*, a junior synonym), White Sucker, Lake Chubsucker (*Erimyzon sucetta*), Muskellunge (*Esox masquinongy* as *Esox nobilior*, a

junior synonym), Central Mudminnow, Smallmouth Bass, Largemouth Bass (as *Micropterus salmoides*, a species restricted to southeastern USA; see Kim *et al.* 2022), Logperch, Sauger (*Sander canadensis*), and Walleye both under the genus *Stizostedion*, a junior synonym.

Small (1883: 47) described *I. argenteus* as having parasitic habits, stating that unidentified “dead fish are frequently found with circular wounds on their sides, giving evidence of the cause of death”. *Ichthyomyzon argenteus* is based on *Petromyzon argenteus*, a preoccupied name that was replaced by *Petromyzon bdellium* and later transferred to the genus *Ichthyomyzon*. However, Ohio Lamprey (*Ichthyomyzon bdellium*) does not occur in Canada (Renaud *et al.* 2009) and the only two parasitic lamprey species occurring in the National Capital Region, Chestnut Lamprey (*Ichthyomyzon castaneus*) and Silver Lamprey, are presently restricted to the Ottawa River system (Renaud and de Ville 2000; Renaud 2002). Hubbs and Trautman (1937: 53) stated that the lamprey reported by Small (1883) from the Rideau River system is Silver Lamprey, the “identification based on locality, with more or less evidence of a circumstantial, confirmatory nature”.

Small (1883: 40) stated that Rosyface Shiner was found in “shallow water below locks” and we assumed that the locks were those of the Rideau River-Canal system. According to Dymond (1939), the record of Lake Chubsucker, a catostomid reported by Small (1883) is a probable misidentification of Creek Chub (*Semotilus atromaculatus*), a leuciscid. Additionally, COSEWIC (2008) stated that the disjunct record of Lake Chubsucker by Small (1883), from others in southern Ontario, indicates that it is probably erroneous, but did not provide an alternative identification. However, according to COSEWIC (2008), Lake Chubsucker, assessed and listed as Endangered (SARA Registry 2023b), exhibits a disjunct distribution across its range. Furthermore, Dymond (1939) showed that the disjunct nature of a record is not in of itself evidence of an error. As a case in point, the record by Small (1883) of another catostomid, Quillback (*Carpiodes cyprinus*), in the Ottawa area, was considered an error because at the time the species was only known in Ontario from Lake Erie, until Dymond (1939) collected a specimen from Green’s Creek, a tributary to the Ottawa River. Therefore, we accept the record of Lake Chubsucker by Small (1883). Small (1893) reported that a small Longnose Gar was taken in a scoop net at the foot of the locks in Ottawa (undoubtedly those of the north-flowing section of the Rideau River-Canal system) and kept by him in an aquarium for several weeks.

Halkett (1906, 1908) reported on the fishes at the

Canadian Fisheries Museum, a repository that existed in Ottawa from 1884 to 1918 (Knight 2014). Only three fish species from the Rideau River-Canal system up to Smiths Falls were in this museum: Brown Bullhead, Rock Bass, and Black Crappie (as *Pomoxis sparoides*, a questionable synonym). However, Prince *et al.* (1906), in their report on the fish collection of the museum, that included Halkett as a co-author, omitted Black Crappie and added Burbot (as *Lota maculosa*, a junior synonym) to the list of fishes in the aforementioned area.

Dymond (1939) recorded the following 34 species from the north-flowing section of the Rideau River-Canal system, principally, if not entirely, collected by seining during August 1937: Northern Redbelly Dace (*Chrosomus eos*), Common Shiner (under the genus *Notropis*), Northern Pearl Dace (*Margariscus nachtriebi*; as *Margariscus margarita nachtriebi*), Golden Shiner, Blackchin Shiner (*Minniellus heterodon*, under the genus *Notropis*), Blacknose Shiner, Spottail Shiner (under the genus *Notropis*), Bluntnose Minnow (under the genus *Hyborhynchus*, a junior synonym), Fathead Minnow (*Pimephales promelas*), Longnose Dace (*Rhinichthys cataractae*), Creek Chub, Fallfish (under the genus *Leucosomus*), White Sucker, Silver Redhorse, Shorthead Redhorse (*Moxostoma macrolepidotum* as *Moxostoma lesueurii*, a junior synonym), Brown Bullhead, introduced Rainbow Trout (as *Salmo gairdneri*, a misspelled junior synonym), introduced Brown Trout (as *Salmo fario*, a junior synonym), Northern Pike, Muskellunge, Central Mudminnow, Trout-perch (*Percopsis omiscomaycus*), Brook Silverside, Brook Stickleback (*Culaea inconstans*, under the genus *Eucalia*, a preoccupied name), Slimy Sculpin (*Cottus cognatus*, but see below), Rock Bass, Pumpkinseed (under the genus *Eupomotis*, a junior synonym), Bluegill (under the genus *Helioperca*, a junior synonym), Largemouth Bass (as *Aplites salmoides*, a species restricted to southeastern USA), Black Crappie (as *Pomoxis sparoides*), Johnny Darter (*Etheostoma nigrum*, under the genus *Boleosoma*, a junior synonym), Yellow Perch, Logperch, and Walleye (under the genus *Stizostedion*). According to Dymond (1939: 40), Slimy Sculpin was collected “... from a spring creek near Ellwood station, south of Ottawa”. Sawmill Creek runs through Ellwood neighbourhood, a former railway point situated in the south end of Ottawa, where it enters the Rideau River at Billings Bridge. However, McAllister and Coad (1974) mention only Mottled Sculpin in the Rideau River-Canal system, and furthermore, report the finding on 25 May of an eyed egg mass of this species from Sawmill Creek. Accordingly, McAllister and Coad (1974: 20) deleted “*C. cognatus* from the regional list until a validly identified specimen is

collected”.

McAllister and Coad (1974) reported the following 44 species in the Rideau River-Canal system within a 48.2 km radius of the Peace Tower on Parliament Hill, in Ottawa, reaching at least as far south as Kemptville: Northern Redbelly Dace, Finescale Dace (*Chrosomus neogaeus*), introduced Common Carp, Brassy Minnow, Mississippi Silvery Minnow (*Hybognathus nuchalis*, this species is restricted to central and southern USA and Eastern Silvery Minnow [*Hybognathus regius*] is the correct name for the species found on the Atlantic slope of Canada and USA), Common Shiner (under the genus *Notropis*), Northern Pearl Dace (as Allegheny Pearl Dace [*Semotilus margarita*], a misidentified species with a distribution restricted to the USA), Golden Shiner, Emerald Shiner, Blackchin Shiner (under the genus *Notropis*), Spottail Shiner (under the genus *Notropis*), Rosyface Shiner, Mimic Shiner (under the genus *Notropis*), Bluntnose Minnow, Fathead Minnow, Longnose Dace, Creek Chub, Fallfish, White Sucker, Silver Redhorse, Shorthead Redhorse, Greater Redhorse, Yellow Bullhead (*Ameiurus natalis*), Brown Bullhead (both bullhead under the genus *Ictalurus*), Stonecat (*Noturus flavus*), Northern Pike, Central Mudminnow, Trout-perch, Brook Silverside, Brook Stickleback, Banded Killifish, Mottled Sculpin, Rock Bass, Pumpkinseed, Bluegill, Smallmouth Bass (misspelled *dolomieu*), Largemouth Bass (as *Micropterus salmoides*), Black Crappie, Iowa Darter (*Etheostoma exile*), Johnny Darter, Tessellated Darter, Yellow Perch, Logperch, and Walleye (under the genus *Stizostedion*). McAllister and Coad (1974) used a variety of sources to map the fish distributions, but we included only those species that were collected by National Museum (now Canadian Museum of Nature) and University of Ottawa personnel and excluded those from the Royal Ontario Museum and the literature because the latter were already reported elsewhere (i.e., Small 1883; Halkett 1906; Dymond 1939).

Coad (1983) reported Alewife (*Alosa pseudoharengus*; Alosidae) in the Rideau Canal from immediately below the locks at Hog's Back Road, in Ottawa and Coad (1987) reported Sand Shiner (*Minicellus stramineus*, under the genus *Notropis*; Leuciscidae) from the Jock River at Jockvale.

Settingington (2004) compiled the results of a six-year fisheries assessment (1995–2000) conducted by the City of Ottawa and the Ontario Ministry of Natural Resources for the following six reaches of the Rideau River: Ottawa, Mooney's Bay, Eccolands, Long, Andrews ville, and Kilmarnock. The list of fishes collected included 39 species over that period, but five species were only collected in 1995–1997 (American Eel [*Anguilla rostrata*], Mimic Shiner,

Shorthead Redhorse, Channel Catfish [*Ictalurus punctatus*], and Tessellated Darter) and five were only collected in 1998–2000 (Emerald Shiner, Fallfish, Yellow Bullhead, Tadpole Madtom, and Central Mudminnow). American Eel (in 1996) and Channel Catfish (in 1995), both collected in the Mooney's Bay reach, were new records for the north-flowing section of the Rideau River-Canal system (Table 4). Note that American Eel was assessed as Threatened by COSEWIC (2012) but has yet to be added to the species-at-risk list (SARA Registry 2023c). The remaining 29 species were collected during both periods: Alewife, Common Carp, Eastern Silvery Minnow, Common Shiner, Golden Shiner, Blackchin Shiner (under the genus *Notropis*), Blacknose Shiner, Spottail Shiner (under the genus *Notropis*), Bluntnose Minnow, White Sucker, Silver Redhorse, Greater Redhorse, Brown Bullhead, Northern Pike, Muskellunge, Brook Silverside, Brook Stickleback, Banded Killifish, Mottled Sculpin, Rock Bass, Pumpkinseed, Bluegill, Smallmouth Bass, Largemouth Bass (as *Micropterus salmoides*), Black Crappie, Johnny Darter, Yellow Perch, Logperch, and Walleye.

#### *Non-native species*

There are other non-native species reported from our study area, besides Round Goby and the single Pacu (or Piranha) and Oscar, previously discussed. According to Dymond (1939), six adults each of Brown Trout and Rainbow Trout were released yearly in the Rideau River Canal above Hog's Back Falls (officially known as Prince of Wales Falls) in 1935, 1936, and 1937, and 1600 yearling Brown Trout were planted in the Rideau River Canal below Hog's Back Falls in the early autumn of 1937. Neither species have become established. The earliest record of Common Carp in the system is 1957 (McAllister and Coad 1974) and the species is well established having been collected ever since. Therefore, only two of six non-native species (Common Carp and Round Goby) have become established.

#### *Stocking of native fishes*

A number of species have been stocked in the north-flowing section of the Rideau River-Canal system for the purpose of improving recreational fishing including fishing derbies. Muskellunge fry, Smallmouth Bass and Largemouth Bass fingerlings and adults, and Walleye eggs were stocked annually during the 1940s in the Rideau and Jock Rivers according to newspaper articles in *The Ottawa Citizen* (Phelps 2001). These four species have been recorded in the system since the 1880s (Small 1883).

#### *Management recommendations*

Our data on the fish community composition, abundance, species richness, and associated habitat

characteristics are important for resource management. An understanding of the association between the fish community and land use will enable resource managers to prioritize certain areas for conservation to maintain a diverse and abundant fish community. Moreover, a more in-depth knowledge of the entire fish community will lead to a fuller understanding of the economically and recreationally important sport-fish species (Northern Pike and Muskellunge) for which the Rideau River is reputed (Pankhurst *et al.* 2016). Trophy Muskellunge have long been known to occur in the north-flowing section of the Rideau River system. Bebee (2007) documented the capture between 1891 and 1967 of 24 specimens over 11.3 kg (25 lbs), mostly from the Long Reach (i.e., Burritts Rapids to Manotick), except for one taken at Hog's Back. The record was 26.3 kg (58 lbs) in 1902 from the Long Reach.

The dispersal of Round Goby downstream of Edmonds Lockstation may pose a threat to the Logperch population. Bergstrom and Mensinger (2009) demonstrated through laboratory experiments that Round Goby outcompetes Logperch for food (i.e., amphipods) at a water temperature of  $15 \pm 1^\circ\text{C}$ . While Logperch showed a statistically significant decrease in wet weight, Round Goby showed a significant increase in wet weight. One competitive advantage that Round Goby has over Logperch is that the former is active at night, while the latter is not (Bergstrom and Mensinger 2009). Two other fish species in the Rideau system that may be negatively impacted by Round Goby are Johnny Darter (Lauer *et al.* 2004) and Mottled Sculpin (Dubs and Corkum 1996). Therefore, there needs to be ongoing monitoring of the dispersal of Round Goby. Finally, Bergman *et al.* (2021) have warned of potential invasion of the Rideau River-Canal system by Asian carps (i.e., Grass Carp [*Ctenopharyngodon idella*], Bighead Carp [*Hypophthalmichthys nobilis*], Silver Carp [*Hypophthalmichthys molitrix*], and Black Carp [*Mylopharyngodon piceus*]), species well documented to negatively impact native ecosystems. Our study documents the composition of the north-flowing section of the Rideau River-Canal system ichthyofauna prior to any such invasion.

### Author Contributions

Writing – Original Draft: C.B.R. and A.P.; Writing – Review & Editing: C.B.R., N.R.A., and A.P.; Conceptualization: A.P.; Supervision: C.B.R.; Investigation: A.P., N.R.A., and C.B.R.; Methodology: A.P.; Formal Analysis: A.P.; Visualization: N.R.A.; Funding Acquisition: C.B.R. and N.R.A.

### Acknowledgements

We thank Daryl Seip and Ron Evers (Ontario Ministry of Natural Resources, Kemptville), for issuing A.P. licenses to collect fishes for scientific purposes; François Chapeau (University of Ottawa), Brent Campbell and Annie-Chantal Guibord (formerly University of Ottawa), Naomi de Ville, Mélanie Gaudet, Sylvie Laframboise, Elie Moussalli, Karen Sparks, and Dan Spooner (formerly Canadian Museum of Nature), Chris Moore and François Renaud for field assistance; and Anthony Francis (formerly University of Ottawa), for writing the Mantel test macro. This study was funded by the EJLB Foundation, Montréal.

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Received 14 December 2022

Accepted 28 May 2025

Associate Editor: K.L. Ilves

**SUPPLEMENTARY MATERIALS:**

**TABLE S1.** Habitat characteristics of 14 sites along the Rideau River in 1998. a. Type and percent substrate type, b. Description of substrate classification based on particle size. c. Summary of type and percent vegetation cover in deep and shallow water.

**TABLE S2.** Gear type and fishes collected at sites in the mainstem Rideau River, Ontario between Smiths Falls and Ottawa mid-July to mid-September 1998.

**TABLE S3.** Gear type and fishes collected at sites in the tributaries of the Rideau River, Ontario in 1999.

**TABLE S4.** Gear type and fishes collected at sites in the mainstem Rideau River and in the tributaries of the Rideau River, Ontario in 2000.