# Living Rivers School

## Report #1

## Aquatic Ecology of the Groff Park Reach, Fort River, Amherst, MA

**For**

**Biocitizen, Inc.**
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**Westhampton, MA**

**By**

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**7 February 2022**

## EXECUTIVE SUMMARY

Boyd and Brian Kynard and students from the Living Rivers School of Biocitizen, Inc. studied the aquatic ecology of a 204-ft-long reach of the Fort River at Groff Park during 2-14 August 2021. Water quality was excellent for fish and aquatic life at Groff Park: water temperature was less than 25$^{o}$ C, dissolved oxygen was greater than 7 mg/L, conductivity was 133-173 micromhos/cm, and pH was 7.4-7.5. Drift-net sampling for drifting macroinvertebrates found none were drifting past Groff Park in the daytime. Quantitative Surber sampling of the river bottom for macroinvertebrates found a low diversity (eight Orders) with Ephemeroptera (mayflies) most abundant in both riffle and raceway habitats. Fish flies (Order Megaloptera) and crayfish (Class Crustacea) captured in fish seine nets were abundant and these predaceous invertebrates may control the abundance of slow-moving larval aquatic insects, like dragon flies (Odonata), which were absent at Groff Park. Small numbers of diverse fish groups live in the Groff Park reach – we captured 53 individuals belonging to eight freshwater species, four individuals of one anadromous species (Sea Lamprey), and one individual of a catadromous species (American Eel). The freshwater Blacknose Dace was the most abundant species (44.8% of total catch). The mean size of freshwater fish species and the anadromous species was small (less than 10 cm = 4 3/16 inches). In August 2021, the riffles and raceways at Groff Park provided habitats used by small freshwater fish species and by small life stages of large anadromous, catadromous, and freshwater species.

## INTRODUCTION

This report is the product of research conducted by the Living Rivers School (LRS) of Biocitizen, Inc. The LRS provides training each summer for middle and high school students on conservation biology principles and scientific methods used to conduct aquatic ecology research and test hypotheses in riverine ecosystems. Students also learn about environmental issues (river damming, pollution, and fish passage for migratory fish) in streams where the students live. Fish scientists from the migratory fish behavior - fish passage business, BK-Riverfish,llc, (Boyd Kynard, Ph.D. - 1971; Brian Kynard, B.S. Biology - 2004), lead students who participate fully in all aspects of field studies.

In August 2021, the research plan was to gather a second year of data on the use of submerged aquatic vegetation for rearing habitat of American shad and diverse freshwater fishes in the Hadley reach of the Connecticut River. However, record rainfall during July 2021 resulted in high river discharge that prevented us from conducting research on the Connecticut River.

The alternative plan for 2021 was to conduct research in a Connecticut River tributary, where high river flows were not present. We selected the Fort River, Amherst, MA, because Boyd Kynard was familiar with the river, having studied nesting of the anadromous Sea Lamprey, *Petromyzon marinus*, and other fishes in the Fort River for 40+ years (Kynard and Horgan 2019). Further, information on aquatic ecology of the Fort River would be of interest to the Conservation Commission, Town of Amherst, MA, and the Fort River Watershed Association. We selected the Groff Park reach on the Fort River for study because this reach runs through a public park (Groff Park), which provided a place to meet for LRS, and also, facilitated daily access for parents to drop-off and pick-up students.

## Study Site

The 204-ft-long-study reach was composed of two riffle reaches and two slower velocity raceway reaches (Figure 1). GPS location of the reach taken mid-river at the most upstream cross section on the downstream rapids (Rapids - 2) was (N 42. 21.456; W 72 31.130).

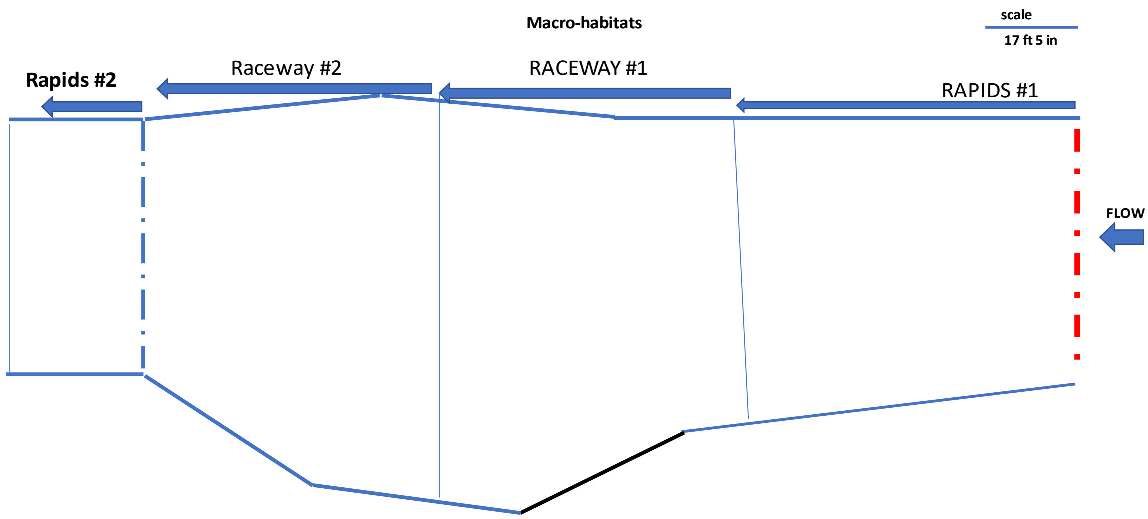
## METHODS

We conducted research in six subject areas on the aquatic ecology of the Groff Park study reach:

1. ***Monitor*** **w*ater depth & temperature during the study period***. **—**We used a water depth-temperature data-logger (HOBO U20L-04) to monitor water temperature and psi pressure each 20 minutes during the two-week study to show the natural diel variation in these factors. We

**Figure 1. Map of the 204-ft-long Groff Park study reach showing two riffle and two raceway reaches.**

Figure 1. 200 ft. long Groff Park Reach showing two macrohabitats: Riffle and Raceway habitats.




anchored the data logger in the riverbank of the Raceway-2 section. During analysis, we converted psi measurements to water depth (meters) using a known depth at time. We display results as a figure with daily plots of temperature, water depth, and psi.

**2.** ***Monitor Daily water quality***. **—**At 1000-1100 hr daily, we monitored four water quality factors in the river at the downstream end of the Rapids-2 reach (Figure 1). These factors give data on pollution and quality of the water for aquatic life. We used electronic instruments to monitor **pH** (1-14 units of acidity-alkalinity of water), **Conductivity** (micromhos per centimeter that measures the amount of total dissolved solids and minerals in water), and **Dissolved Oxygen** (mg/L) that measures the level of oxygen in the water, which is a critical water quality element for fish life, and **water temperature** ($^{o}$C). Daily monitoring shows the natural variation in these factors during the peak of summer temperature conditions, when fish may seek a cooler summer temperature refuge. We displayed the daily data for each factor in a table.

**3**. ***Characterize mean velocity (0.6 water depth), dominant bottom substrate type, and dominant submerged aquatic vegetation*.—**We used an electronic velocity meter to measure mean velocity in riffle and raceway habitats. We measured velocity at the upstream center of each habitat type. We visually estimated the dominant bottom substrate type using the modified Wentworth sale (Cummins 1962). We identified to Genus the dominant aquatic vegetation.

**4. *Determine macroinvertebrate presence and abundance in the substrate of riffle vs. raceway habitats*.—**We sampled benthic macroinvertebrate abundance in the substrate of two riffles and two raceways using random sampling at four stations in each riffle and raceway using a $1ft^2$ Surber sampler. Thus, we sampled a total of $8\ ft^2$ of substrate in riffle habitat and in raceway habitats. We identified aquatic macroinvertebrates to Order using (Merritt and Cummins 1978), and we counted the total number of organisms per Order in each sample. Finally, we calculated the percent of each Order in the two major habitat types: Riffle 1 and 2 combined vs. Raceway 1 and 2 combined.

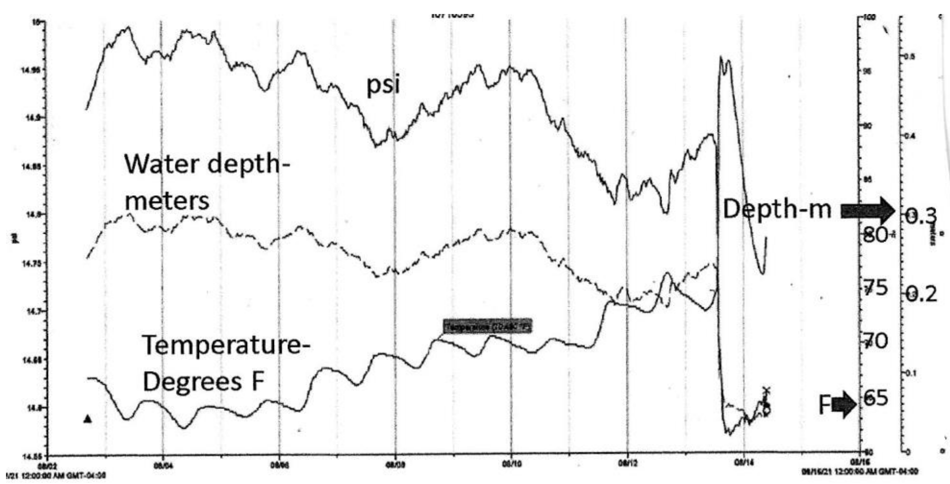
**5. *Determine the daytime macroinvertebrate drift identification and abundance*.—**We sampled day-time macroinvertebrate drift using a pair of D-shaped drift nets. (Drift is always greatest at night (Hynes 1972, Schwoebel 1970, Barnes and Mann 1991); however, given the public location of our study reach, we could not leave the nets set overnight for fear of theft.) Thus, our sampling was more to demonstrate the technique than to collect drift data. We anchored two bottom-set D-shaped drift nets (16-inches wide x 14-inches tall; area = 0.35 $m^3$ ; 243 µm pore size) in the center of Rapids -1 in the morning of two days and fished the nets until the daily class was over in the afternoon (1400-1500 hrs). We attached a General Oceanics flowmeter in the center of each drift net to record velocity and enable us to calculate the volume of water sieved during each sampling period. We identified aquatic insects captured to Order and counted the total number of organisms. We used this data to calculate the average number of drifting organisms per $m^3$ of water sieved for each sample period.

**6. *Determine the presence and abundance of fish species in riffle vs. raceway habitats*.—**We collected fishes in the two riffle and two raceways using two methods: 1. Kick and disturb substrate from 5-6-ft upstream of a fixed 10-ft long x 4-ft deep seine net downstream, and then, lift the net to capture fish (and benthic macroinvertebrates) that drift onto the seine; 2. Backpack electroshocking (only used by BK-Riverfish personnel -- students watched from the shore). After we sampled riffle and raceway reaches using the kick and seine method, we sampled the entire reach of each Rapids and Raceway by electro-shocking with a SAMUS 1000 electrofisher. Additionally, we shocked 300-ft upstream of Rapids-1 and 300-ft downstream of Rapids-2 to sample other habitat types not in the study area and capture fish species that were not present in the 204-ft-long study reach. The SAMUS settings were set to stun small fish, 3-4-inches long (as used by BK-Riverfish during previous electrofishing bouts). We identified fish to species using Hartel et al. (2002), and then, we measured the total length of each fish. We placed fish of each species in a small plexiglass container with water so students could clearly see the color and characters of each species and so they could take pictures of fish. We instructed students in useful characteries used to identify fishes and noted the ecological role and life history of each species.

## RESULTS & DISCUSSION

**1. *Water depth & temperature during the study period*.—**Figure 2 shows the daily variation in water temperature and water depth in the study reach. Temperature gradually increased daily during the study from 65-77 $^{o}$F. The daily day maximum to night minimum variation was 2-4ºF. Water depth gradually decreased during the study with increases and decreases in daily variation closely following rainfall (anecdotal observation). Variation of water depth during the study was small with depth varying between 0.2-0.25 m (8-10 inches).

**Figure 2. Daily temperature and water depth in the study area during 2-14 August 2021.**




**2 4 6 8 10 12 14 AUGUST**

**2. *Daily water quality*.—** Stream pH was stable at 7.4-7.6. Conductivity varied from 133.5 to 173.0. pH and conductivity levels were good for fish growth and production (Lagler 1952; Table 1). Dissolved oxygen was 7.7 – 8.7 mg/l, a level excellent for fish life (Lagler 1952).

We sampled water quality in the morning, so we do not know how much dissolved oxygen levels decrease at night, but oxygen levels may remain high because night-time temperatures are similar to daytime temperatures and aeration of water flow by rapids occurs day and night. The data from the first two weeks of August 2021 indicate dissolved oxygen levels are sufficiently high for all fish species, even during summer.

**Table 1. Water quality in the study reach. Temperatures are in in degrees Centigrade and Fahrenheit.**

| Date | Time | Temperature °C and °F | pH | Conductivity | Dissolved Oxygen |
|---|---|---|---|---|---|
| 8-3 | 1100 | 17.3 C (63.1 F) | 7.5 | 133.5 | Not measured |
| 8-4 | 1050 | 17.3 C (63.1 F) | 7.4 | 136.6 | " |
| 8-5 | 1035 | 17.6 C (63.7 F) | 7.4 | 138.1 | " |
| 8-6 | 1015 | 18.4 C (65.1 F) | 7.4 | 148.9 | " |
| 8-9 | 1021 | 21.2 C (70.2 F) | 7,6 | 160.8 | " |
| 8-10 | 1030 | 21.3 C (70.3 F) | 7.5 | 164.1 | 7.7 |
| 8-11 | 1018 | 21.8 C (71.2 F) | 7.4 | 165.3 | 7.9 |
| 8-12 | 1030 | 23.7 C (74.7 F) | 7.4 | 167.1 | 8.6 (9.4 @1430hr) |
| 8-13 | 1100 | 24.0 C (75.2 F) | 7.5 | 173.0 | 8.7 |

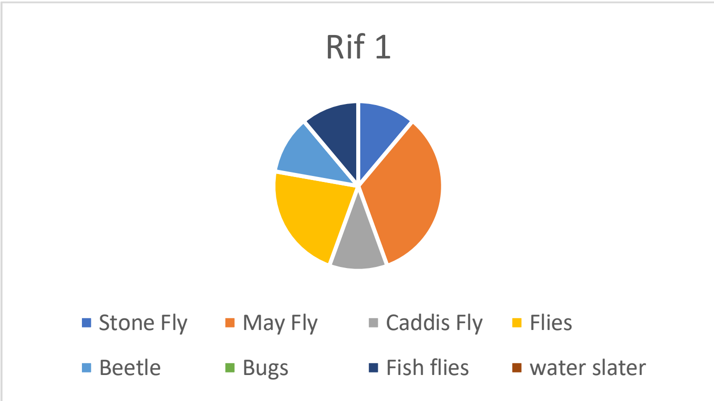
Water quality of the Groff Park reach in summer is good for growth and survival of fish (Lagler 1952). Dissolved oxygen is greater than 5 mg/L the minimum required for Massachusetts streams. The Groff Park reach has acceptable water quality for all aquatic life. This is likely one environmental reason small fish are foraging and rearing in this reach.

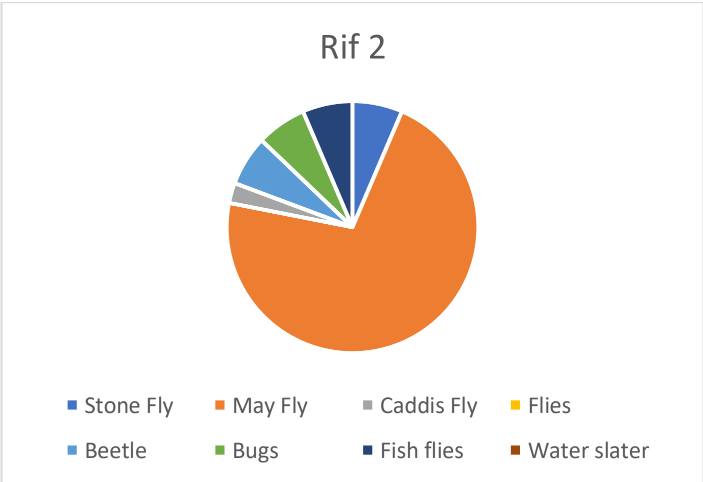
**3**. ***Characterize mean velocity (0.6 water depth) bottom substrate type, and vegetation type*.—** On 4 August, velocity at 0.6 water depth in the center of the upstream limit of Riffle 1 = 58.5 cm/s and in Riffle 2 mean velocity = 56.2 cm/s. Mean velocity in the center of the upstream limit of Raceway 1 = 23.7 cm/s and in Raceway 2, velocity = 18.7 cm/s. These moderate velocities are not a barrier to upstream migration of small fish in this reach.

Rocks of gravel to small rubble size (modified Wentworth scale; Schwoerbel 1970) dominated substrate in riffle habitat. Rocks also were present in raceway habitat but sand was the dominant substrate. Typical maximum water depth follow: riffles = 15 cm, raceway = 45 cm. The algae and moss-covered rocks provide habitat for macroinvertebrates. Dominant aquatic vascular plants were stonewort *Chara sp* and wild celery *Vallisneria americana.*

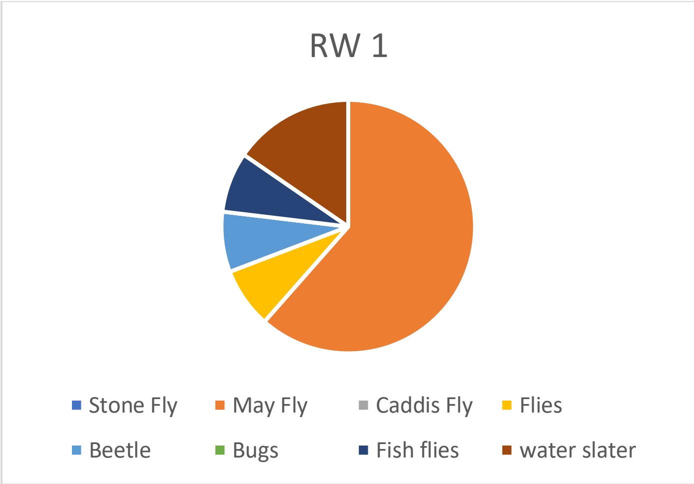
**4. *Macroinvertebrate presence and abundance in riffles vs. raceways*.—**Comparative abundance of eight macroinvertebrates collected by the Surber sampler in the two riffles (Rif 1 and Rif 2) is shown below:

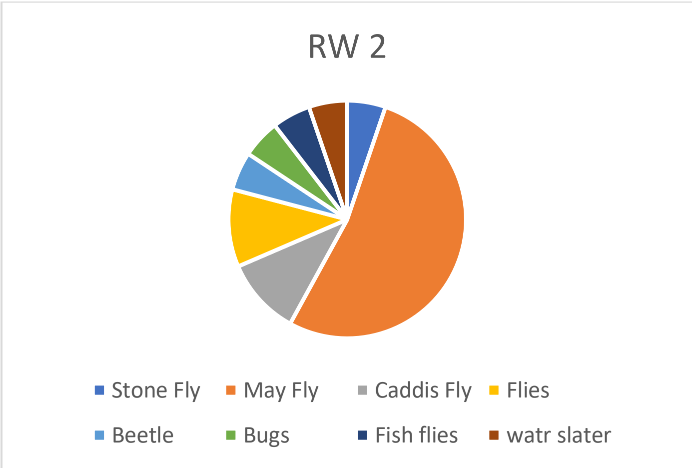
**Figures 3 and 4. Percent abundance of macroinvertebrates captured by Surber sampler in Riffles 1 and 2 (Rif 1, Rif 2).**



**Figures 5 and 6. Percent abundance of macroinvertebrates captured in Surber sampler in Raceways 1 and 2 (RW 1, RW 2).**




Surber samples in the two riffle and two raceway habitats captured macroinvertebrates from only eight Orders: mayflies (Ephemeroptera), stoneflies (Plecoptera), fish flies (Megaloptera), bugs (Hemiptera), beetles (Coleoptera), caddis flies (Trichoptera), two-wing flies (Diptera), and water slater (Isopoda). Figures 3-6 show mayflies dominated abundance in riffle and raceway habitats. Water slaters were only found in raceway habitat.

The Surber samples did not capture many fish fly larvae (typically, 4-5-cm long) in either habitat type. However, seine netting for fish captured a larval fish fly in most net sets (total fish flies = 23 captured in 26 net sets = 0.88 fish flies captured per seine net set). This data shows fish flies were one of the dominant macroinvertebrates at Groff Park. Further, Surber samples also did not capture crayfish (Order Decapoda), which we captured during seining for fish (total, 78 crayfish captured in 26 seine net sets = 3 crayfish/ seine net set). Thus, crayfish are also one of the dominant macroinvertebrates at Groff Park. Freshwater mussels were also present in the study reach, but we did not quantify their abundance. We captured no damselflies or dragonflies (Order Odonata) in Surber or seine net sampling. This was unexpected because adults were seen daily flying near the river. Could the abundant predatory fish flies and crayfish capture and eat all of the dragon fly larvae in the Groff Park reach?

**Table 1. Percent abundance of macroinvertebrates captured by four Surber samples in each of the two riffle and two raceway habitats (total of eight ft$^2$ sampled in riffles and in raceways).**

| Order | n | Total % in Riffles 1, 2 | Density/ ft$^2$ | | n | Total % in Raceways 1, 2 | Density/ ft$^2$ |
|---|---|---|---|---|---|---|---|
| Ephemeroptera | 14 | 48.3 | 1.75 | | 19 | 59.3 | 2.4 |
| Plecoptera | 2 | 6.9 | 0.25 | | 1 | 3.1 | 0.13 |
| Trichoptera | 6 | 20.7 | 0.75 | | 2 | 6.3 | 0.25 |
| Diptera | 2 | 6.9 | 0.25 | | 3 | 9.3 | 0.38 |
| Coleoptera | 2 | 6.9 | 0.25 | | 2 | 6.3 | 0.25 |
| Hemiptera | 2 | 3.4 | 0.25 | | 2 | 6.3 | 0.25 |
| Megaloptera | 2 | 6.9 | 0.25 | | 2 | | 0.25 |
| Isopoda | 0 | 0 | 0 | | 3 | 9.4 | 0.38 |

Mayflies dominated abundance in Surber samples in both riffle and raceway habitats -- 48 % of all macroinvertebrates in riffles and 59% in raceways (Table 1). Mayfly density in riffles was slightly less than the density of mayflies in raceways: 1.75 mayflies per ft$^2$ in riffles and 2.4 mayflies per ft$^2$ in raceways (Table 1). Trichoptera (caddis flies) were three times more abundant in riffles than in raceways. Water slaters (Isopoda) only occurred in raceways. Abundance of the remaining Orders was small in both riffle and raceway habitats. Density of each order in riffles vs. raceways is shown in Table 1. We sampled eight ft$^2$ of bottom habitat in the two habitat types with the quantitative Surber sampler. Given the low diversity of aquatic invertebrates and the need to sample using two methods to capture bottom macroinvertebrates, the Surber plus seine net sampling likely correctly sampled the presence of aquatic macroinvertebrates.

**5.** ***Daytime macroinvertebrate drift identification and abundance*****.—**Drift-net sampling in the day on 4 and 9 August from 1030-1400 hrs collected zero live drifting macroinvertebrates. We carefully examined the four samples but found only exoskeletons of aquatic insects, no live macroinvertebrates. This result was expected in the Fort River because insect drift is low or zero in the daytime in all streams studied (Barnes and Mann 1991, Hynes 1972). Students gained experience setting drift nets, examining the exoskeleton cases of aquatic insects, and learning that aquatic insects do not drift in the day.

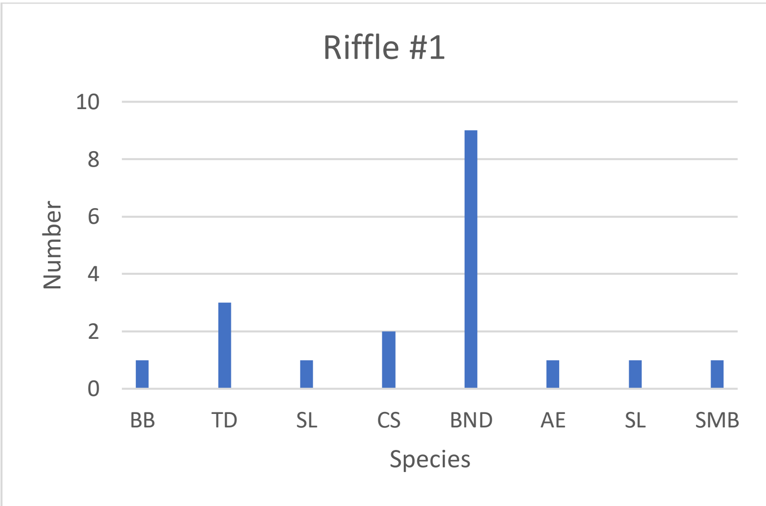
**6.** ***Fish species presence and abundance in two riffle vs. two raceway habitats***. **—**The following abbreviations are used for the 10 fish species collected at Groff Park: AE = American Eel *Anguilla rostrata* ; BB = Brown Bullhead Catfish *Ameiurus nebulosus* ; BND = Blacknose Dace *Rhinichthys atratulus* ; CS = Common Shiner *Luxilus cornutus* ; CM = Central Mudminnow *Umbra limi* ; RB = Rock Bass *Ambloplites rupestris* ; SL = Sea Lamprey *Petromyzon marinus* ; SMB = Smallmouth Bass *Micropterus dolomieu* ; TD = Tessellated Darter *Etheostoma olmsstedi ;* and WS = White Sucker *Catostomus commersoni* .

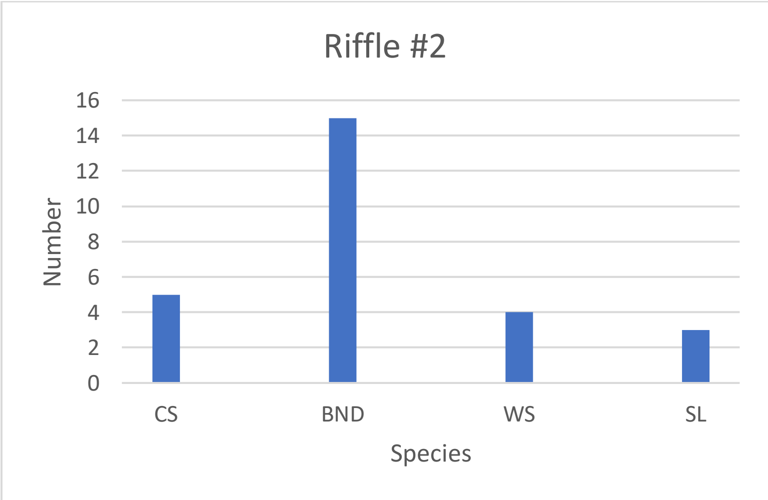
Of the ten fish species captured, eight species were potamodromous (freshwater), one species was anadromous (Sea Lamprey) and one species was catadromous (American Eel; Figures 7-10). Thus, even in this short 204-ft-long reach of the Fort River, habitat is available for a diverse fish community with low abundance.

Fish abundance and diversity was greatest in riffle habitats (eight or four species in the two riffles vs. six or three species in the two raceways; Figures 7-10). Other studies have found greater fish abundance in riffle habitats (Hynes 1970). However, we found no example of greater fish diversity in riffles compared to raceways.

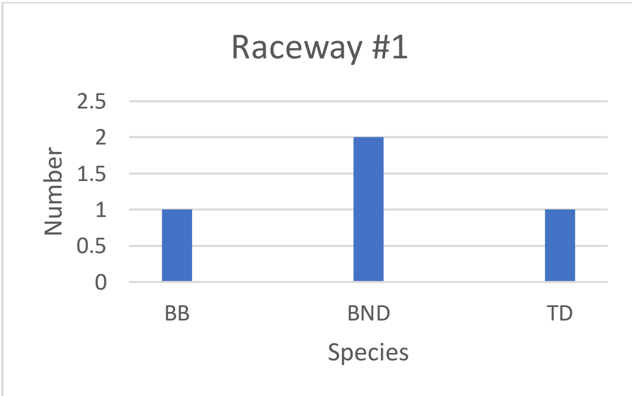
Blacknose Dace dominated fish abundance in both riffles (Figures 7, 8) and in raceway 1, but they were absent from raceway 2, where Common Shiner dominated abundance (Figure 10). Abundance of the remaining freshwater fishes was low with 1 or 2 individuals per species present except for riffle 2, where the three species present with Blacknose Dace had 3-5 individuals/species (Figure 8).

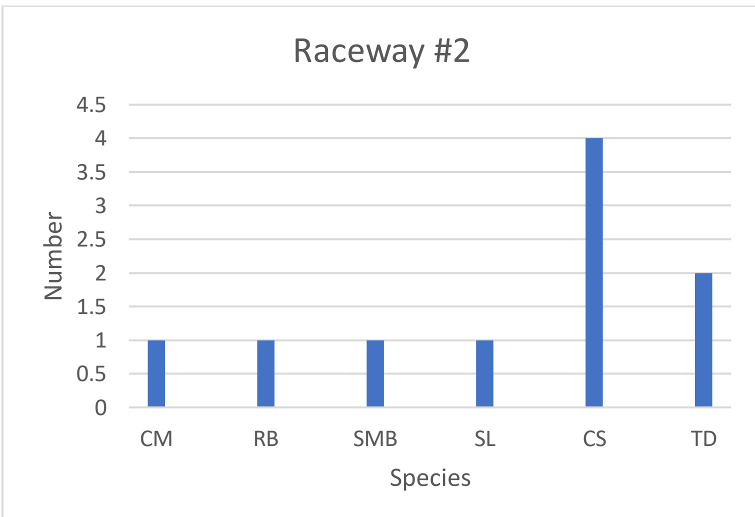
**Figures 7 and 8. Abundance of fish by species captured in Riffles 1 and 2.**



**Figures 9 and 10. Abundance of fish by species captured in Raceway 1 and 2.**




The Fort River is a spawning site for Sea Lamprey adults (Kynard and Horgan 2019) and a rearing stream for Sea Lamprey larvae, which remain for 5 years before migrating to the Atlantic Ocean (Kynard and Horgan 2019, B. Kynard unpublished data). Thus, the size range of Sea Lamprey we captured reflects larvae of different ages. The American Eel was likely a female who will remain in the Fort River for 20 years or more before migrating to the Sargasso Sea to spawn and die. American Eel restoration is occurring in many rivers on the Atlantic coast and the Fort River provides habitat for rearing juvenile eels.

Diversity of freshwater fish species at Groff Park was low, with only eight species in this river reach in August. Low freshwater fish diversity is typical of streams in the glaciated Connecticut River basin (Hartel et al. 2002). Additional electrofishing upstream and downstream of Groff Park captured no new species; thus, the short 204-ft-long-Groff Park reach contained all fish species present in this reach of the Fort River in August 2021. Do additional freshwater species use Groff Park during other seasons or is species use of Groff Park stable?

Size of freshwater fishes captured at Groff Park was small (mean total length of most species was less than 10-cm (4 inches; Table 2). All data show riffle and raceway habitats are home to small species, like Common Shiner, Tessellated Darter, Blacknose Dace, and Central Mudminnow, and also, to small rearing juveniles of large adult freshwater species, like Rock Bass, Smallmouth Bass, and White Sucker.

**Table 2. Total length (mean, range) of fish from the ten species captured at Groff Park.**

| Species | N (sample size) | Mean Total Length (cm) | Range Total Length (cm) |
|---|---|---|---|
| CS | 10 | 8.4 | 4.5-12.3 |
| BND | 26 | 3.9 | 2-9.2.0 |
| WS | 5 | 8.8 | 4.2-14.5 |
| BB | 2 | 10.1 | 6.9-13.3 |
| SL | 4 | 6.1 | 2-5.2.0 |
| TD | 6 | 5.8 | 3.5-9.0 |
| AE | 1 | 48 | -------- |
| SMB | 2 | 11.7 | 11.5-11.9 |
| RB | 1 | 11.6 | --------- |
| CM | 1 | 9.3 | --------- |

**Figure 11. Boyd Kynard points out identification characters for Rock Bass held in a small aquaria. We encouraged students to photograph fish in the aquaria.**

**Figure 12. Boyd Kynard instructs three students sampling macroinvertebrates in Raceway 2. One student is setting the 1 $ft^2$ Surber sampler on the bottom where he will disturb the bottom within the 1 $ft^2$ metal frame dislodging invertebrates into the capture net; one student holds the bucket to receive material in the sampler net; and one student holds a garden sprayer he will use to wash invertebrates from the sampler net into the bucket.**

## ACKNOWLEDGMENTS

Biocitizen, Inc  supported the research presented in this Report. Field work was done with the help of Asher Davis (Counselor, Biocitizen, Inc.) and the Living Rivers School students listed below:

Week 1: Dov Sirulnik, Magnus Harrison, Caleb Brechner, Leo Jellison, Levi Jellison

Week 2:  Armand Brummett, Raihan Bair, Magnus Harrison, Raihan Bair, Mason Senecal, Caleb Kemp, Alessandra St. Germain, Sable Abbe, Keegan Pitre, Robert Brooks

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