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Biological and Habitat Assessment of the Lower Rouge River, Michigan, 2018

Scientific Investigations Report 2020–5009

U.S. Department of the Interior
U.S. Geological Survey

Cover background photograph. Looking downstream at a macroinvertebrate sample site in the concrete channel reach of the Rouge River in 2018. Photograph by the U.S. Geological Survey.

Inset photographs:

Top. Boat electrofishing survey on the Rouge River. Photograph by H. Harrington, U.S. Army Corps of Engineers, 2018.

Center. Spiny softshell turtle basking on a log during the Rouge River herpetofauna survey in June 2018. Photograph by the U.S. Geological Survey.

Bottom. Captured pumpkinseed during boat electrofishing surveys on the Rouge River in June 2018. Photograph by the U.S. Geological Survey.

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U.S. Department of the Interior
DAVID BERNHARDT, Secretary

U.S. Geological Survey
James F. Reilly II, Director

U.S. Geological Survey, Reston, Virginia: 2020

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Conversion Factors

International System of Units to U.S. customary units

Multiply	By	To obtain
	Length	
millimeter (mm)	0.03937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
kilometer (km)	0.5400	mile, nautical (nmi)
meter (m)	1.094	yard (yd)
	Area	
square meter (m^2)	0.0002471	acre
square meter (m^2)	10.76	square foot (ft^2)
	Volume	
liter (L)	33.82	ounce, fluid (fl. oz)
liter (L)	0.2642	gallon (gal)
liter (L)	61.02	cubic inch (in^3)
	Flow rate	
meter per second (m/s)	3.281	foot per second (ft/s)
	Mass	
gram (g)	0.03527	ounce, avoirdupois (oz)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F = (1.8 \times °C) + 32.$$

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

$$°C = (°F - 32) / 1.8.$$

Supplemental Information

Concentrations of chemical constituents in water are given in either milligrams per liter (mg/L) or micrograms per liter (µg/L).

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25 °C).

Abbreviations

CPUE catch per unit effort

IBI Index of biotic integrity

MDEQ Michigan Department of Environmental Quality

spp. species

SWAS Qualitative Biological and Habitat Survey Protocols for Wadable Streams and Rivers

Biological and Habitat Assessment of the Lower Rouge River, Michigan, 2018

By Edward F. Roseman,[1] Jason Fischer,[2] Robin L. DeBruyne,[2] and Scott A. Jackson[2]

Abstract

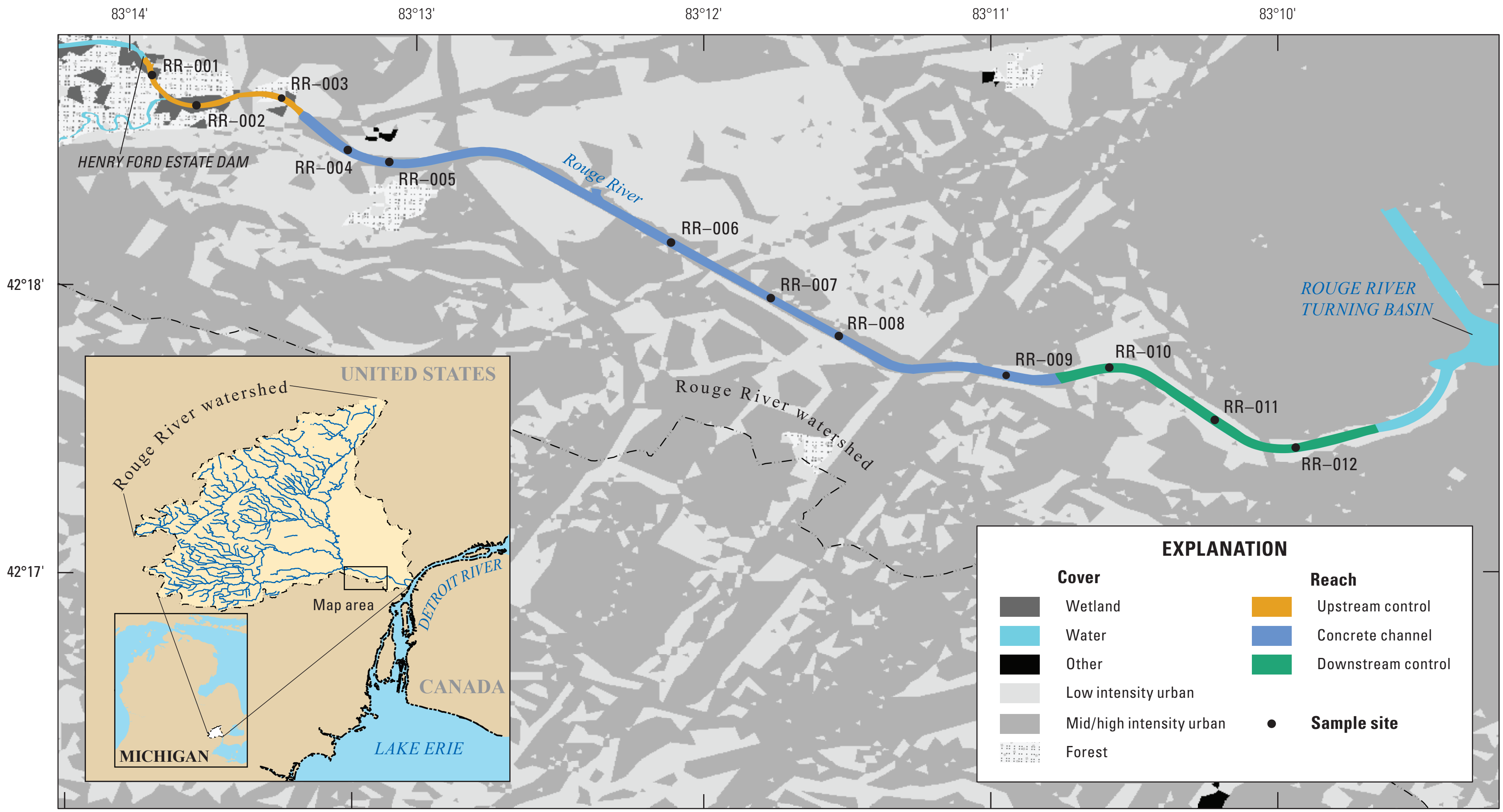
A key component of evaluating the success of habitat remediation projects is determining preremediation conditions, biotic and abiotic, to establish a baseline and compare with postproject conditions. The Rouge River, Michigan, is a Great Lakes Area of Concern with a listed Beneficial Use Impairment related to loss of fish and wildlife habitat. A biological and habitat assessment was completed in the lower Rouge River, focused along a nearly 7-kilometer stretch of river that includes a concrete channel anticipated to be removed by 2022, to determine prerestoration conditions. Surveys documented the presence and quality of physical habitat, presence of herpetofauna, and quantified macroinvertebrate and fish assemblages at 12 sites (3 upstream from the concrete channel, 6 within the concrete channel, and 3 downstream from the concrete channel). Macroinvertebrate assemblages were dominated by Chironomidae and Oligochaeta for June and September. The electrofishing catch per unit effort was driven by *Notropis atherinoides* (emerald shiner) catches in June and emerald shiner and *Dorosoma cepedianum* (gizzard shad) catches in September. *Graptemys geographica* (northern map turtle) was the most common reptile observed throughout the lower Rouge River. No submergent macrophytes were discovered, and riparian vegetation was sparse in the concrete channel section. No sites scored "excellent" (total score greater than 154), upstream control sites scored "good" for overall qualitative habitat assessments (total score 105–154), and all concrete channel and downstream control sites were ranked as "marginal" (total score 56–104) or "poor" habitat (total score 0–55). Results from this assessment can be used to compare with postremediation projects in the lower Rouge River.

[1]U.S. Geological Survey.

[2]University of Toledo.

Introduction

The Rouge River, Michigan, is a major tributary of the Detroit River and historically supported large spawning migrations of potadromous fish including *Sander vitreus* (walleye) and family Catostomidae (suckers) (fig. 1; Beam and Braunscheidel, 1998). Forest and wetlands were historically the dominant land cover types in the watershed; however, the growth of the city of Detroit (not shown) and surrounding area reduced forest and wetland coverage to less than (<) 20 percent of the watershed, and now more than 30 percent of land cover is impervious surface (Beam and Braunscheidel, 1998; U.S. Army Corps of Engineers, 2011). The large proportion of impervious surfaces has increased storm water runoff rates, and the Rouge River has a flashy hydrology with minimal groundwater inputs (Price, 2014). The flashy hydrology is exemplified in the channelized concrete part of the Rouge River downstream from the Henry Ford Estate Dam, where, as part of a 1962 flood control project, more than 6 river kilometers were reconfigured as a paved V-shaped channel with no flood plain (fig. 1; U.S. Army Corps of Engineers, 2011). Water velocities through this part of the river can be particularly elevated, especially during spring snowmelt, which may limit or deter upstream fish migration for spawning and foraging (Beam and Braunscheidel, 1998). Conversely, the flows are depressed during dry periods in summer and early autumn because of the straight and smooth river bottom in the concrete section. Low flows, coupled with a lack of riparian vegetation, can lead to poor water quality (for example, low levels of dissolved oxygen and high water temperatures; Beam and Braunscheidel, 1998). Efforts within the watershed to reduce pollution and combine sewer overflows (Cave and others, 2004; Price, 2014) have provided opportunities for focused habitat restoration in the lower Rouge River.



Base modified from Homer, C.G., Dewitz, J., Yang, L., Jin, S., Danielson, P., Xian, Coulston, J., Herold, N., Wickham, J. and K. Megown, 2015. Completion of the 2011 National Land Cover Database for the conterminous United States—representing a decade of land cover change information, Photogrammetric Engineering and Remote Sensing, v. 81, 345–353. 1:37,000-scale digital data

0 1 2 MILES
0 1 2 KILOMETERS

Figure 1. Locations of fish, macroinvertebrate, herpetofauna, and habitat sampling sites and reaches in the lower Rouge River, Michigan, and surrounding land cover.

The loss of human beneficial uses (for example, fish and wildlife consumption) and ecosystem services (for example, fish and wildlife habitat) from the declines in aquatic habitats and in fish and wildlife populations, coupled with historical environmental degradation, led the Rouge River to be listed as a Great Lakes Area of Concern under the 1987 United States-Canada Great Lakes Water Quality Agreement. Large investments directed at habitat improvements and water quality have been made within the Rouge River Watershed, such as reconnecting diverted meander bends and removing combined sewer overflows. However, removing the beneficial use impairment related to loss of fish and wildlife habitat requires sound scientific assessment of restoration efforts. Riparian and instream habitat enhancement within the concrete part of the lower Rouge River is one such project identified by the 2012 Rouge River Beneficial Use Impairment Delisting Strategy (Craig and others, 2012). Quantifying the baseline fish abundances, assemblages, and environmental metrics (for example, water velocity, dissolved oxygen, and aquatic plant coverage) within the paved and adjacent sections of the river is crucial to guiding the development of restoration projects. Before restoration, quantifying biological and physical conditions is needed to evaluate the efficacy of restoration, inform decisions regarding the beneficial use impairment redesignation, and inform future restoration projects in the Rouge River.

In this report, we present results from assessments completed in 2018 of biotic and abiotic habitat conditions, macroinvertebrate assemblages, fish assemblages, and herpetofauna at 12 sampling sites distributed across 3 reaches (fig. 1, table 1). Objectives for these assessments were

1. Provide photographic documentation of site conditions.
2. Quantify biotic and abiotic components of instream fish habitat upstream, downstream, and within the portion of the concrete channel slated for restoration in the Rouge River.
3. Quantify herpetofauna presence and abundance upstream, downstream, and within the concrete channel slated for restoration.
4. Quantify macroinvertebrate density, assemblage composition, and biotic integrity upstream, downstream, and within the portion of the concrete channel slated for restoration.
5. Quantify fish abundance and species composition upstream, downstream, and within the portion of concrete channel slated for restoration.

Table 1. Coordinates of center points of fish, macroinvertebrate, herpetofauna, and habitat sampling sites in the lower Rouge River, Michigan.

[See figure 1 for a map of site locations. Coordinates are in the geographic coordinate system World Geodetic System 1984.]

Site	Latitude	Longitude
Upstream control reach		
RR–001	42.31212	−83.2320
RR–002	42.31041	−83.2294
RR–003	42.31079	−83.2244
Concrete channel reach		
RR–004	42.30779	−83.2206
RR–005	42.30709	−83.2182
RR–006	42.30246	−83.2018
RR–007	42.29920	−83.1960
RR–008	42.29699	−83.1922
RR–009	42.29481	−83.1824
Downstream control reach		
RR–010	42.29521	−83.1765
RR–011	42.29212	−83.1703
RR–012	42.29055	−83.1657

Stream reaches were defined based on proximity to the concrete channel slated for habitat restoration (upstream control reach, concrete channel reach, and downstream control reach). The 1-km upstream control reach was the only reach without a concrete channel, whereas the 4.2-km concrete channel reach and 1.7-km downstream control reach had been channelized as a V-shaped concrete channel. Three 250-meter (m) long sampling sites were in the upstream control reach, 6 sites in the concrete channel reach, and 3 sites in the downstream control reach (fig. 1).

Methods

This section details methods used during the prerestoration abiotic and biotic assessments in the lower Rouge River, Michigan.

Photographic Monitoring

Photographic monitoring consisted of a series of four photographs taken around a center point at each sampling site (table 1) looking upriver, downriver, and at both banks. Left and right banks were designated while looking in the downstream direction; thus, the left and right banks correspond to the north and south sides of the river corridor, respectively. Two sets of photographs were taken, one on June 21, 2018, and the other on September 13, 2018.

Qualitative Habitat Assessment

Instream habitat was characterized using visual and quantitative methods. Visual assessments were completed following the Michigan Department of Environmental Quality (MDEQ) Qualitative Biological and Habitat Survey Protocols for Wadeable Streams and Rivers (SWAS) for glide/pool streams (Michigan Department of Environmental Quality, 2008). Each site was visually assessed and scored based on the 10 metrics defined by the glide/pool stream assessment protocol by 3 separate assessors during the June and September sampling events (see table 2 for specific metrics). Scores for each metric were based on a 0–20 scale, with larger values indicating a higher quality. The scores from the 10 metrics were then summed to index the overall quality of habitat for aquatic biota at a site, with scores greater than 154 indicating "excellent" habitat, scores between 105 and 154 indicating "good" habitat, scores between 56 and 104 indicating "marginal" habitat, and scores < 55 indicating "poor" habitat. Site scores were averaged across individual sampling events to determine the mean metric and mean site scores. Mean reach scores were calculated from metric scores pooled across assessors, sites, and sampling events.

Quantitative Habitat Assessment

Quantitative measurements of submergent vegetation, water depth, velocity, and water quality parameters (water temperature, water transparency, dissolved oxygen, conductivity, and pH) also were taken at each site during the June and September sampling events. Submergent vegetation was sampled using a grapnel hook lined with 1-centimeter (cm) square wire mesh (Schloesser and Manny, 1982). The grapnel hook was used to make four 10-m tows at each location (two perpendicular to the left bank and two perpendicular to the right bank). Data were summarized as the percentage of grapnel tows where the specific vegetation type was present because periphyton and benthic algae were infrequently collected. Water depth and velocity measurements were taken at the upstream and downstream ends of each site with a Sontek M9 acoustic Doppler current profiler following the U.S. Geological Survey standard methods protocol (Mueller and others, 2013) on June 15, 2018, and September 14, 2018. Four replicate measurements were taken along each acoustic Doppler current profiler transect: two moving from the left to right bank and two moving in the opposite direction. Replicate transects were reviewed to determine if global positioning system (or GPS) or measurement errors were in the data, in which case, data were omitted from further analyses. Mean water depths and velocities were calculated and reported with the standard deviation and coefficient of variation to describe the magnitude and variability at each site and reach. Water temperature at each site was measured with HOBO temperature loggers programed to record a temperature every 30 minutes from June 4, 2018, to October 4, 2018. Additional temperature loggers were deployed from October 4, 2018, to December 11, 2018, at one site in the upstream control reach (RR–002), on in the concrete channel reach (RR–008), and one in the downstream control reach (RR–012). Before and after deployment, temperature loggers were placed in the same location and allowed to record temperature for at least 48 hours to determine if there were any discrepancies in temperature readings. The temperature logger placed in the concrete channel reach from October to December consistently read 0.5 degree Celsius lower than the other loggers and measurements from this logger were therefore increased by 0.5 degrees Celsius to correct the bias. During biotic sampling events, a Secchi disk was used to measure water transparency and an Orion Star A329 multiparameter meter was used to measure dissolved oxygen, conductivity, and pH. Water quality parameters were summarized as site and reach means by sampling month.

Herpetofauna Assessment

Visual encounter surveys were completed for reptiles and amphibians on foot and by boat on June 21, 2018, and September 13, 2018. Boat surveys started at the Henry Ford Estate Dam and proceeded down river using boat engines minimally so as not to disturb animals on the banks. The river was searched with binoculars for any herpetofauna, including any individuals basking along the shoreline and on any structures extending into the water (such as logs or vegetation mats). Terrestrial surveys consisting of 10-minute meandering transects along the river bank were completed at each site by two technicians. Only one bank of the river was assessed at each site (determined by appropriate landing for the boat), and sites RR–011 and RR–012 were not surveyed by land because of the lack of stable ground and dense stands of *Phragmites* (reed) species (spp.) that prevented access to the riparian zone. Reptiles and amphibians were searched for visually, and all groundcover objects were checked.

Table 2. Michigan Department of Environmental Quality qualitative habitat survey scores for glide/pool streams (Michigan Department of Environmental Quality, 2008) from each reach and site in the lower Rouge River. Individual metric scores range from 0 to 20. Scores 17–20 were considered "excellent," 11–16 considered "good," 5–10 considered "marginal," and 0–4 considered "poor." Total scores range from 0–200, with a total score greater than 154 considered "excellent," 105–154 considered "good," 56–104 considered "marginal," and 0–55 considered "poor."

[--, no data]

Metric	Upstream control				Concrete channel							Downstream control			
	RR–001	RR–002	RR–003	Reach mean	RR–004	RR–005	RR–006	RR–007	RR–008	RR–009	Reach mean	RR–010	RR–011	RR–012	Reach mean
Epifaunal substrate	12.3	12.5	12.3	12.4	0.5	0.5	0.7	0.5	0.3	3.7	1.0	3.3	3.8	4.3	3.8
Pool substrate	8.5	7.3	7.8	7.9	0.0	0.0	0.0	0.2	0.0	1.0	0.2	1.5	2.5	2.3	2.1
Pool variability	1.3	1.2	1.8	1.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Sediment deposition	18.2	18.3	17.2	17.9	19.0	18.8	18.7	18.8	18.5	18.7	18.8	17.8	15.5	14.7	16.0
Flow status	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Volume	9.2	9.3	9.2	9.2	7.3	8.7	7.5	7.5	7.5	8.7	7.9	8.5	9.2	7.8	8.5
Flashiness	6.0	6.5	6.0	6.2	1.5	2.2	2.0	2.0	2.2	4.2	2.3	5.7	8.3	7.3	7.1
Channel alteration	15.7	14.3	14.7	14.9	0.3	0.0	0.0	0.2	0.0	1.0	0.3	2.2	2.5	3.7	2.8
Channel sinuosity	8.5	8.3	7.0	7.9	1.0	1.0	0.7	0.3	0.5	1.8	0.9	3.8	3.5	3.3	3.6
Bank stability	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Left bank	4.7	4.3	4.8	4.6	9.8	10.0	10.0	10.0	9.8	9.7	9.9	10.0	9.8	9.8	9.9
Right bank	4.7	4.3	4.8	4.6	9.8	10.0	10.0	10.0	9.8	9.7	9.9	10.0	9.8	9.8	9.9
Vegetative protection	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Left bank	9.3	9.5	9.7	9.5	0.3	0.3	0.5	0.3	0.7	5.5	1.3	3.3	6.2	6.3	5.3
Right bank	9.3	9.5	9.7	9.5	0.3	0.3	0.5	0.3	0.8	1.3	0.6	3.3	6.2	6.3	5.3
Riparian vegetation width	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Left bank	9.5	9.3	8.7	9.2	1.3	1.5	1.5	1.5	1.7	4.3	2.0	5.7	6.0	6.3	6.0
Right bank	9.5	9.3	8.7	9.2	1.3	1.5	1.5	1.5	1.7	2.8	1.7	5.5	6.0	6.2	5.9
Total score	126.7	124.2	122.3	124.4	53.0	55.2	53.8	53.5	53.8	72.7	57.0	81.0	89.7	88.7	86.4

Qualitative Macroinvertebrate Assessment

Macroinvertebrates were sampled at each of the 12 sample sites using qualitative and quantitative methods. Qualitative sampling was completed on June 14 and 21, 2018, and September10 and 13, 2018, following the MDEQ SWAS protocol for macroinvertebrates, using sweep sampling with triangular dip nets. Two technicians swept the substrate, aquatic vegetation, large woody debris, and other instream habitat along the stream banks with dip nets for a total sampling time of 20 minutes. Contents of the nets were placed in a 5-gallon bucket after each sweep, and the contents of the bucket were passed through a 1-millimeter (mm) sieve to separate macroinvertebrates from silt and fine particulate organic matter. Samples were preserved in 95-percent ethanol (June) or 10-percent dyed and buffered formalin (September) and brought back to the laboratory for processing. The first 300 organisms were removed from the sample and identified to the lowest possible taxonomic level. If a sample contained fewer than 300 individuals, all individuals were identified. Following the methods established by the MDEQ SWAS protocol (Creal and others, 1996; Michigan Department of Environmental Quality, 2008), an index of biological integrity (IBI) was calculated for each site. Mean reach IBI scores were compared to the regional standards (Huron/Erie Lake Plains region [not shown]; Omernik and Gallant, 1988) for “poor” to “excellent” macroinvertebrate assemblages, based on taxa richness and abundance of tolerant and intolerant taxa.

Quantitative Macroinvertebrate Assessment

Hester-Dendy colonization samplers were used to collect macroinvertebrates from deeper depths in the river. Hester-Dendy samplers consisted of 14 plates that were 7.5-cm in diameter spaced 3.2 mm (eight plates), 6.4 mm (one plate), 9.5 mm (two plates), and 12.7 mm (two plates) apart, totaling 0.16 square meter of surface area. Samplers were sampled in gangs of three on a 15-m line weighted with an anchor at each end. Hester-Dendy samplers were deployed on June 4, 2018, and August 30, 2018, and soaked for 37 and 35 days, respectively. At the end of each soak period, Hester-Dendy samplers were retrieved, and samples were preserved in 10-percent dyed and buffered formalin. All individuals within a sample were then identified to the lowest taxonomic level possible and enumerated; mean taxon densities and proportions of the total catch were calculated for each site and reach.

Fish Assessment

Sampling was completed using boat electrofishing and minnow traps during June 13–14 and September 10–11. A pulsed-direct current boat electrofishing unit was used to target large-bodied and pelagic fishes at each of the 12 sample sites following American Fisheries Society guidelines for standard sampling methods for nonwadeable rivers (Guy and others, 2009; Miranda, 2009). Electrofishing began at the upstream end of each site and proceeded downriver along a transect parallel to a bank (left or right) that was randomly selected before sampling. Sampling was carried out for 5 minutes, and two technicians with dip-nets were stationed at the bow of the boat to collect immobilized fish. Minnow traps (0.6-cm wire mesh traps, 42 cm long and 23 cm in diameter with a 2.5-cm funneled opening at each end) were used to collect small benthic fishes that were not effectively targeted with boat electrofishing following the methods described by Fischer and others (2018). Minnow traps were set in gangs of five on a 15-m line weighted with an anchor on each end. Each trap was baited with approximately 28 grams of cheese and fished overnight. The catch per unit effort (CPUE) was calculated as the number of fish collected per hour for boat electrofishing and the number of fish collected per 12 hours for minnow traps. Fish were aggregated into functional groups identified by the MDEQ SWAS protocol (table 3), the mean CPUE, and the proportion of the total catch within the three study reaches that was calculated for each functional group. Two additional groups, designated as “other,” also were created to represent fishes not belonging to one of the three feeding groups or two of the tolerance groups identified by the MDEQ SWAS protocol.

Photographic Monitoring of Streambanks

Banks at the three upstream control reach sites were heavily vegetated with a mixture of trees and shrubs that overhung the river channel (figs. 2–4). Large woody debris was present throughout this section of the river, and many fallen trees extended laterally into the river channel. The banks in this section of the river were nearly vertical, with bare patches and erosional scars extending more than 0.23 m above the water surface. In contrast, riparian vegetation was sparse at the six sites within the portion of the concrete channel slated for restoration (figs. 5–10). At these sites, riparian vegetation was limited to patches of *Phragmites* spp. and *Typha* spp. (cattails) that had established within the cracks of the concrete. However, a dense stand of *Phragmites* spp. was along the left bank of site RR–009 (fig. 10), the downstream-most site in this section. The bank vegetation above the concrete part of the channel was dominated by grasses, with a few trees. Patches of *Phragmites* spp. and Carduoideae (thistle) were also above the concrete part of the channel. Large woody debris in this section of the river tended to be oriented parallel to the channel and was limited to the bank and channel edge. The concrete channel did not seem to have changed since being constructed, and the banks were gradually sloped with no evidence of erosion. Water levels increased relative to the top edge of the concrete channel as sites progressed downriver, and this increase was most noticeable in the downstream control reach. Only a few feet of the concrete channel were visible above the water

Table 3. Taxonomy classification; functional groupings; State rare, threatened, or endangered listing status; and native status of fish collected from the lower Rouge River in June and September 2018. Species includes the scientific name and the common name. Tolerance and feed guild classifications were taken from Michigan Department of Environmental Quality (2008).

[RTE, rare, threatened, or endangered]

Family	Scientific name (common name)	Tolerance guild	Feeding guild	Lithophilic spawner	RTE species	Native
Amiidae	*Amia calva* (bowfin)	Tolerant	Piscivore	No	No	Yes
Atherinopsidae	*Labidesthes sicculus* (brook silverside)	Other	Insectivore	No	No	Yes
Catostomidae	*Catostomus commersonii* (white sucker)	Tolerant	Omnivore	Yes	No	Yes
Centrarchidae	*Lepomis macrochirus* (bluegill)	Other	Insectivore	No	No	Yes
Centrarchidae	*Lepomis cyanellus* (green sunfish)	Tolerant	Insectivore	No	No	Yes
Centrarchidae	*Micropterus salmoides* (largemouth bass)	Other	Piscivore	No	No	Yes
Centrarchidae	*Lepomis gibbosus* (pumpkinseed sunfish)	Other	Insectivore	No	No	Yes
Centrarchidae	*Ambloplites rupestris* (rockbass)	Intolerant	Piscivore	No	No	Yes
Centrarchidae	*Micropterus dolomieu* (smallmouth bass)	Intolerant	Piscivore	No	No	Yes
Clupeidae	*Dorosoma cepedianum* (gizzard shad)	Other	Other	No	No	Yes
Cyprinidae	*Pimephales notatus* (bluntnose minnow)	Tolerant	Omnivore	No	No	Yes
Cyprinidae	*Cyprinus carpio* (common carp)	Tolerant	Omnivore	No	No	No
Cyprinidae	*Notropis atherinoides* (emerald shiner)	Other	Insectivore	No	No	Yes
Cyprinidae	*Pimephales promelas* (fathead minnow)	Tolerant	Omnivore	No	No	Yes
Cyprinidae	*Notemigonus crysoleucas* (golden shiner)	Tolerant	Omnivore	No	No	Yes
Cyprinidae	*Carassius auratus* (goldfish)	Tolerant	Omnivore	No	No	No
Cyprinidae	*Cyprinella spiloptera* (spotfin shiner)	Other	Insectivore	No	No	Yes
Cyprinidae	*Notropis hudsonius* (spottail shiner)	Intolerant	Insectivore	No	No	Yes
Esocidae	*Esox lucius* (northern pike)	Other	Piscivore	No	No	Yes
Gobiidae	*Neogobius melanostomus* (round goby)	Other	Insectivore	No	No	No
Ictaluridae	*Ameiurus natalis* (yellow bullhead)	Tolerant	Omnivore	No	No	Yes
Moronidae	*Morone chrysops* (white bass)	Other	Piscivore	No	No	Yes
Moronidae	*Morone americana* (white perch)	Other	Piscivore	No	No	No
Percidae	*Sander vitreus* (walleye)	Other	Piscivore	Yes	No	Yes
Percidae	*Perca flavescens* (yellow perch)	Other	Other	No	No	Yes
Sciaenidae	*Aplodinotus grunniens* (freshwater drum)	Tolerant	Insectivore	No	No	Yes

line at site RR–010, and the concrete channel was completely submerged at sites RR–011 and RR–012 (figs. 11–13). Riparian vegetation was more prevalent in the downstream control reach than in the concrete channel reach slated for restoration and consisted of *Phragmites* spp. and overhanging trees. Large woody debris in the downstream control reach tended to extend laterally into the channel. In general, vegetation, water levels, and bank structure remained similar between June and September at all sites; therefore, the photographs taken in June were representative of conditions in September. The exception was a large amount of riparian vegetation absent from the right (southwest) bank at the upstream end of site RR–001 (fig. 14) as part of construction of a fish passage over the Henry Ford Estate Dam.

Figure 2. Photographs of the most upriver assessment site (RR–001) in the lower Rouge River, upriver from the concrete channel reach and just downriver of the Henry Ford Estate Dam, which is visible in the backdrop of the upriver photograph. Photographs were taken facing upriver, downriver, and the right and left banks. The banks at this site are nearly vertical, with bare patches and erosional scars, which can be seen between the gaps of overhanging vegetation in the photographs of the left and right banks. Photographs taken June 21, 2018, by U.S. Geological Survey.

Figure 3. Photographs of assessment site RR–002 in the lower Rouge River, upriver from the concrete channel reach. Photographs were taken facing upriver, downriver, and the right and left banks. Similar to the other two sites upriver from the concrete channel reach, the banks at this site are nearly vertical, with bare patches and erosional scars, which can be seen among the gaps of overhanging vegetation in the photographs of the left and right bank. Large woody debris extending laterally into the channel also can be seen in the photographs facing upriver and the left bank. Photographs taken June 21, 2018, by U.S. Geological Survey.

Figure 4. Photographs of the lowermost assessment site (RR–003) upriver from the concrete channel reach in the lower Rouge River. The Michigan Avenue Bridge that marks the start of the concrete channel is visible in the backdrop of the downriver photograph. Photographs were taken facing upriver, downriver, and the right and left banks. *Vitis* spp. (grape vines) covered much of the foliage along the left bank. Photographs taken June 21, 2018, by U.S. Geological Survey.

RR–004 June

Figure 5. Photographs of the uppermost assessment site (RR–004) in the concrete channel reach of the lower Rouge River. The Michigan Avenue Bridge that marks the start of the concrete channel is visible in the backdrop of the upriver photograph. Photographs were taken facing upriver, downriver, and the right and left banks. Riparian vegetation was limited to the part of the flood plain above the concrete channel and cracks within the concrete. Photographs taken June 21, 2018, by U.S. Geological Survey.

RR–005 June

Upriver

Left bank

Right bank

Downriver

Figure 6. Photographs of assessment site RR–005 in the concrete channel reach. Photographs were taken facing upriver, downriver, and the right and left banks. The Southfield Freeway Bridge is visible in the backdrop of the downriver photo. Riparian vegetation was limited to the part of the flood plain above the concrete channel and cracks within the concrete. A single *Salix* spp. (willow) growing near the water's edge on the left bank is visible in the middle of the downriver photograph. Photographs taken June 21, 2018, by U.S. Geological Survey.

Figure 7. Photographs of assessment site RR–006 in the concrete channel reach. Photographs were taken facing upriver, downriver, and the right and left banks. The Rotunda Drive bridge is visible in the background of the downriver photograph. Riparian vegetation was limited to the part of the flood plain above the concrete channel and cracks within the concrete. Sparse woody debris can be seen along the banks above the waterline. Photographs taken June 21, 2018, by U.S. Geological Survey.

Figure 8. Photographs of assessment site RR–007 in the concrete channel reach. Photographs were taken facing upriver, downriver, and the right and left banks. Riparian vegetation was limited to the part of the flood plain above the concrete channel and cracks within the concrete. Sparse woody debris can be seen along the banks above the waterline. Photographs taken June 21, 2018, by U.S. Geological Survey.

Figure 9. Photographs of assessment site RR–008 in the concrete channel reach. Photographs were taken facing upriver, downriver, and the right and left banks. The Interstate–94 bridge is visible in the background of the downriver photograph. Riparian vegetation was limited to the part of the flood plain above the concrete channel and cracks within the concrete. Sparse woody debris can be seen along the banks above the waterline. Photographs taken June 21, 2018, by U.S. Geological Survey.

RR–009 June

Upriver

Left bank

Right bank

Downriver

Figure 10. Photographs of assessment site RR–009 in the concrete channel reach. Photographs were taken facing upriver, downriver, and the right and left banks. The Greenfield Road bridge is visible in the background of the downriver photo and the Melvindale Civic Arena is in the background of the photo facing the right bank. Riparian vegetation along the right bank was limited to the part of the flood plain above the concrete channel and cracks within the concrete. However, a dense patch of *Phragmites* spp. (reed) was growing along the left bank of the site. Photographs taken June 21, 2018, by U.S. Geological Survey.

Figure 11. Photographs of the assessment site RR–010 in the downstream control reach. This is the first site immediately downriver of the part of the lower Rouge River concrete channel reach slated for restoration. Photographs were taken facing upriver, downriver, and the right and left banks. Riparian vegetation along the right bank was limited to the part of the flood plain above the concrete channel and cracks within the concrete. However, the distance between the waterline and upper extent of the concrete channel was less than the upriver sites, and trees and other vegetation overhung the channel. Photographs taken June 21, 2018, by U.S. Geological Survey.

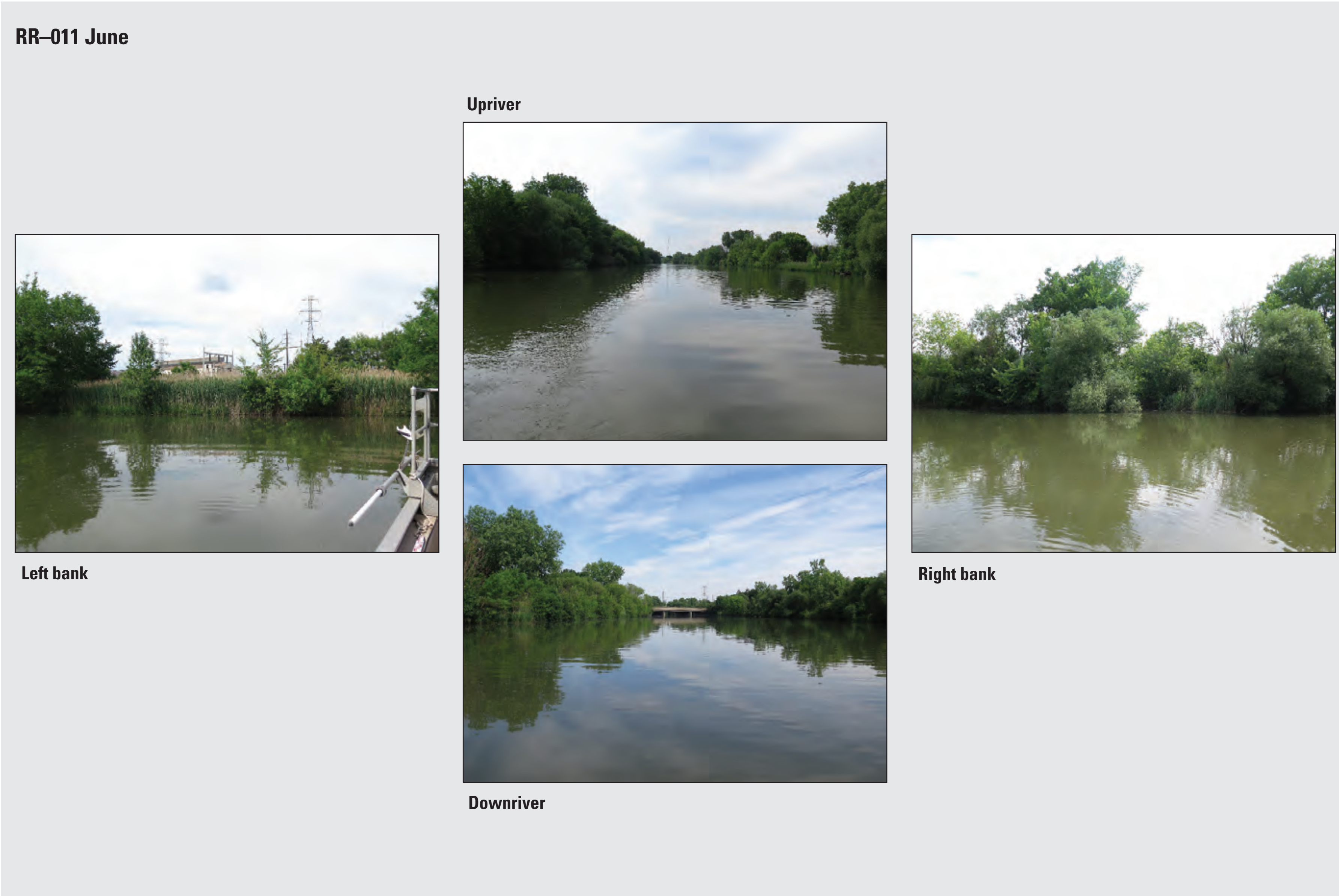


Figure 12. Photographs of the assessment site RR–011 in the downstream control reach. Photographs were taken facing upriver, downriver, and the right and left banks. The Schaefer Highway bridge is visible in the background of the downriver photograph. Trees, shrubs, and *Phragmites* spp.(reed) were growing at the water's edge and overhung the channel. Photographs taken June 21, 2018, by U.S. Geological Survey.

RR–012 June

Upriver

Left bank

Right bank

Downriver

Figure 13. Photographs of the assessment site RR–012 in the downstream control reach. Photographs were taken facing upriver, downriver, and the right and left banks. A pipeline and railway bridge are visible in the background of the upriver photograph. Trees, shrubs, and *Phragmites* spp. (reed) were growing at the water's edge and overhung the channel. Photographs taken June 21, 2018, by U.S. Geological Survey.

RR–001 June

June 21, 2018 | September 12, 2018

10 meters from right bank

20 meters from right bank

Figure 14. Photographs of the right bank at the upstream end of site RR–001, near the Henry Ford Estate Dam, showing the bank before and after riparian vegetation was removed to build a fish passage construction over the dam. Photographs taken by U.S. Geological Survey.

Qualitative Habitat Assessment

The sample sites within the upstream control reach had a mean total score above 120 (“good”; table 2). In general, individual metrics scored within the “good” to “excellent” ranges (11–16 and 17–20, respectively), there was little evidence of sediment deposition, and riparian vegetation was a mixture of mature trees and shrubs that extended into the active channel as overhanging vegetation and large woody debris. However, pool substrate, channel sinuosity, and bank stability scored within the “marginal” range (5–10), and pool variability scored within the “poor” range (0–4). Low water visibility and water depth prevented substrate from being directly visualized, but characterization from a sounding rod, submergent vegetation samples, and macroinvertebrate samples indicated substrates at these sites were a mixture of hardpan clay, silt, and fine gravel < 1 cm). Channel sinuosity at the upstream control reach sites was the greatest across reaches, but the stream length of the upstream control reach was only 1.17 times longer than the straight-line length. The channel within the upstream control reach was incised, and banks along the upstream reaches were nearly vertical with erosional scars extending above the water surface indicating bank erosion has taken place within this reach. Lastly, there was no variability in pool types throughout the study area with all reaches being classified as run habitat. Specific habitat characteristics for each site and sampling date can be found in DeBruyne and others (2020).

The concrete channel reach had a total site habitat score of 57, which was only 2 points above the “poor” habitat quality cutoff (table 2). Site RR–009 (the most downstream site within the concrete channel reach) was the only site with a total score above 56 and was classified as “marginal” habitat. The main difference between site RR–009 and the other sites within the concrete channel reach was the presence of a continuous riparian zone of *Phragmites* spp. along the left bank of site RR–009, whereas the riparian zone in the other sites surveyed within the reach was disconnected from the water’s edge by a slab of concrete. Concrete was the dominant substrate throughout the concrete channel reach, and riparian vegetation was limited to small patches of *Phragmites* spp., *Salix* spp. (willow), and *Typha* spp. growing between cracks in the concrete. Large woody debris was generally absent within the active channel but was present individually and as debris jams along the banks.

The downstream control reach had a mean qualitative habitat score of 86, and all sites within this reach were categorized as “marginal” habitat (table 2). These sites were still within the constructed concrete channel, but the water surface was near (RR–010) or above (RR–011 and RR–012) the top edge of the concrete channel, and riparian vegetation overhung the active channel. Large woody debris occupied the active channel and extended perpendicularly to the bank. The riparian zone was wider than 23 m but was dominated by *Phragmites* spp. and neighbored large industrial complexes.

Habitat metrics and score remained similar between the June and September surveys, except for the most upstream site (RR–001). A large portion of the riparian zone along the right bank had been removed from the upstream edge of site RR–001 between the two surveys as part of ongoing construction of a fish passage over the Henry Ford Estate Dam (fig. 14). Because most of the construction efforts were upstream from the site, these changes were not reflected in the qualitative habitat assessment scores for the site.

Quantitative Vegetation Habitat Assessment

No submergent macrophytes were collected at any sites. Benthic algae and periphyton were collected with the grapnel tows, however, often in quantities too low to obtain an accurate wet weight (< 5 grams). Periphyton was observed more frequently in June than in September. Periphyton was observed in a larger proportion of the samples from the concrete channel reach than the other reaches in June but in September was present in equal proportions in the upstream control and concrete channel reaches, while none was present in the downstream control reach (table 4). Benthic algae were not observed in the upstream control reach but were collected from the concrete channel and downstream control reaches. Tow-specific values for each site and sampling date can be found in DeBruyne and others (2020).

Site-specific Depth and Velocity Characteristics

Water depths and velocities were recorded with a total of 96 acoustic Doppler current profiler measurements (4 replicates at 2 transects within each site) in June and September. In June, GPS errors prevented use of only one replicate measure, which was at the upstream part of site RR–012. In September, GPS and measurement errors (that is, beam separation) were more prevalent, and nine replicates across six transects were unable to be used in the site summaries. However, all transects had at least two replicate measures that meet criteria for inclusion in data summaries.

Mean water depths in the upstream control reach ranged from 1.47 to 2.07 m, and standard deviation was < 0.5 m (table 5). The banks of the upstream control reach were nearly vertical and transitioned to a flat bottom, providing little variation in water depth throughout the cross section (fig. 15). Compared to the downstream and concrete channel reaches, the coefficient of variation in depths was low (nearly half the value of sites in the other reaches), indicating less heterogeneity in water depths at the upstream reach. Cross sections within the concrete channel reach and downstream control

Table 4. Percent of vegetation tow samples where periphyton and benthic algae were observed for each site and reach mean by date. Four samples were conducted at each site in June and September.

Date	Reach	Site	Percent occurrence	
			Algae	Periphyton
June 15, 2018	Upstream control reach	RR–001	0	25
		RR–002	0	25
		RR–003	0	0
		Mean	0	25
	Concrete channel reach	RR–004	0	50
		RR–005	0	75
		RR–006	0	25
		RR–007	25	0
		RR–008	75	25
		RR–009	25	50
		Mean	41.7	45
	Downstream control reach	RR–010	0	25
		RR–011	0	50
		RR–012	0	25
		Mean	0	33.3
September 14, 2018	Upstream control reach	RR–001	0	25
		RR–002	0	0
		RR–003	0	0
		Mean	0	25
	Concrete channel reach	RR–004	25	0
		RR–005	50	0
		RR–006	25	0
		RR–007	0	0
		RR–008	75	0
		RR–009	0	25
		Mean	43.8	25
	Downstream control reach	RR–010	50	0
		RR–011	25	0
		RR–012	0	0
		Mean	37.5	0

Table 5. Summary statistics of water depths and water velocities measured in the lower Rouge River with an acoustic Doppler current profiler.

[m, meter; m/s, meter per second; S.D., standard deviation; C.V., coefficient of variation]

Date	Reach	Site	Depth (m)			Velocity (m/s)		
			Mean	S.D.	C.V.	Mean	S.D.	C.V.
June 15, 2018	Upstream control reach	RR–001	1.47	0.14	0.10	0.11	0.04	0.37
		RR–002	2.02	0.45	0.22	0.08	0.02	0.27
		RR–003	2.07	0.45	0.22	0.07	0.02	0.25
		Mean	1.84	0.46	0.25	0.08	0.03	0.39
	Concrete control reach	RR–004	1.31	0.62	0.47	0.10	0.04	0.41
		RR–005	1.49	0.58	0.39	0.07	0.03	0.41
		RR–006	1.76	0.85	0.48	0.10	0.03	0.35
		RR–007	1.87	0.84	0.45	0.07	0.02	0.29
		RR–008	1.85	0.9	0.49	0.05	0.02	0.42
		RR–009	1.97	0.8	0.41	0.06	0.02	0.37
		Mean	1.75	0.82	0.47	0.07	0.03	0.44
	Downstream control reach	RR–010	2.12	1.02	0.48	0.06	0.03	0.41
		RR–011	2.25	1.05	0.47	0.05	0.02	0.47
		RR–012	2.46	1.11	0.45	0.05	0.02	0.39
		Mean	2.28	1.07	0.47	0.05	0.02	0.44
September 14, 2018	Upstream control reach	RR–001	1.54	0.16	0.11	0.09	0.02	0.21
		RR–002	2.04	0.36	0.18	0.07	0.01	0.18
		RR–003	1.88	0.49	0.26	0.07	0.02	0.29
		Mean	1.85	0.43	0.23	0.07	0.02	0.26
	Concrete control reach	RR–004	1.29	0.46	0.36	0.11	0.03	0.27
		RR–005	1.33	0.52	0.39	0.10	0.004	0.35
		RR–006	1.80	0.75	0.42	0.08	0.02	0.28
		RR–007	1.80	0.68	0.38	0.04	0.02	0.49
		RR–008	1.77	0.81	0.46	0.11	0.03	0.28
		RR–009	2.01	0.94	0.47	0.05	0.02	0.40
		Mean	1.72	0.78	0.46	0.08	0.04	0.47
	Downstream control reach	RR–010	2.12	0.94	0.44	0.04	0.01	0.38
		RR–011	2.22	1.03	0.46	0.06	0.03	0.47
		RR–012	2.32	1.02	0.44	0.05	0.02	0.40
		Mean	2.22	1.00	0.45	0.05	0.02	0.45

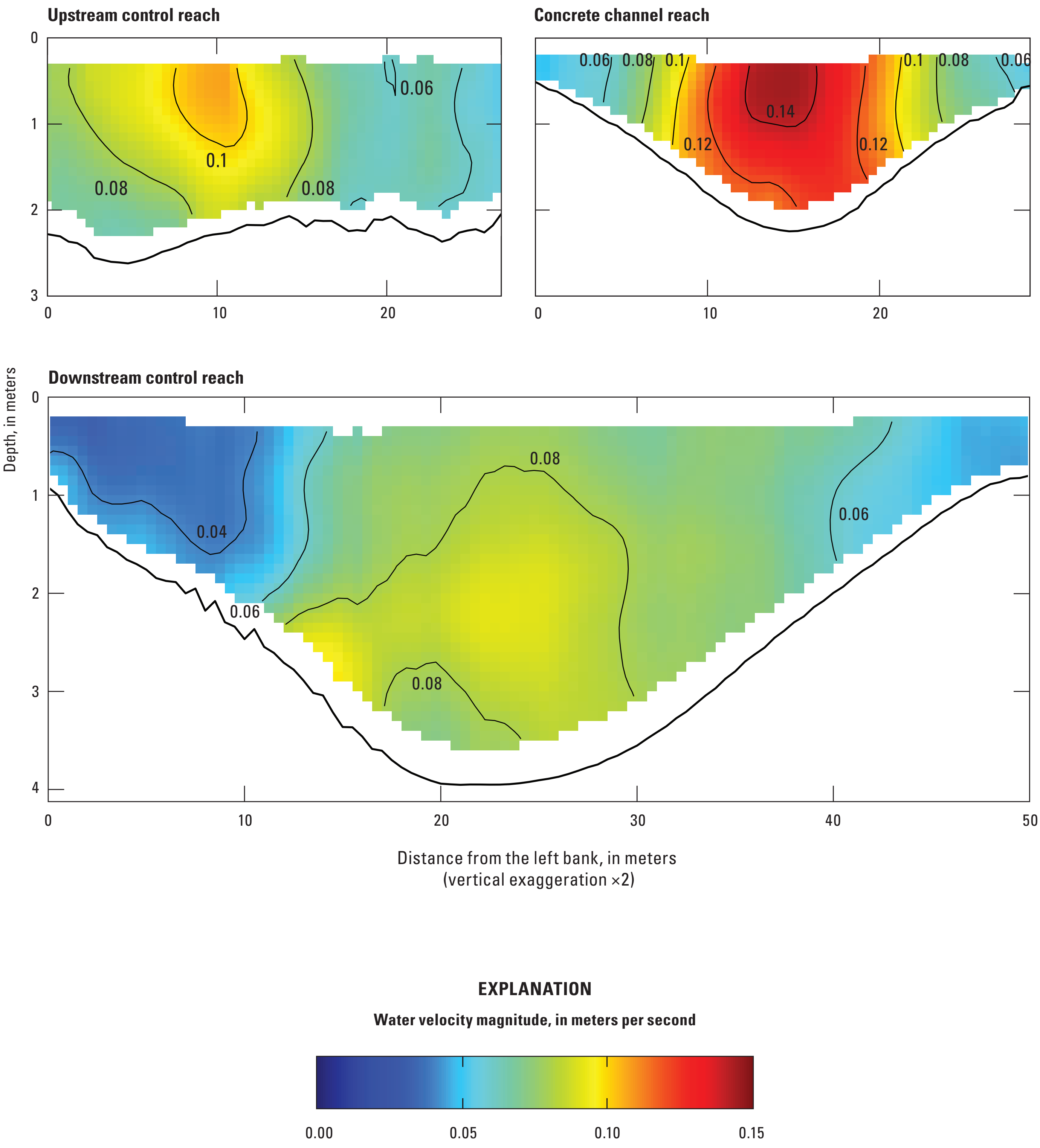


Figure 15. Water velocity at channel cross sections measured with an acoustic Doppler current profiler on June 15, 2018, representative of sites in the upstream control reach (RR–002), concrete channel reach (RR–004), and downstream control reach (RR–012).

reaches had a V-shape created by the concrete slabs used to construct the channel (fig. 15). Mean water depth and standard deviation of depths increased with distance downriver, with the most upstream site within these reaches (RR–004) having a mean depth of 1.31 m in June and 1.29 m in September (table 5). Mean water depths at the most downstream site (RR–012) were 2.46 m and 2.32 m during the June and September surveys, respectively.

In general, depth-averaged water velocities were low among all reaches during the June and September surveys, with the mean water velocities ranging from 0.04 to 0.11 meter per second (table 5). During the June survey, water velocities in the upstream control reach were more variable, and the mean coefficient of variation (0.39) was closer to the mean coefficient of variations for the concrete channel (0.44) and downstream control reaches (0.44). Depth-averaged water velocities were less variable in the upstream control reach than in the other reaches based on the lower coefficient of variation in the upstream control reach compared to the concrete channel and downstream control reaches during the September surveys. Full water column profile data by site and sampling date can be found in DeBruyne and others (2020).

Site-specific Water Quality Characteristics

Water temperatures were similar across the reaches, although during October, the water temperatures in the upstream control and concrete channel reaches became increasingly colder than in the downstream control reach (fig. 16). Mean Secchi depths in the upstream control and concrete channel reaches were 0.4 m and 0.5 m, respectively, in June and September and higher in the downstream control reach where mean Secchi depth was 1.0 m and 0.6 m in June and September, respectively (table 6). Mean dissolved oxygen ranged from 5.6 to 7.5 milligrams per liter during the June sampling period and from 6.5 to 8.0 milligrams per liter during the September sampling period, with lower levels at downstream sites. Mean conductivity ranged from 1,001 to 2,210 microsiemens per centimeter during the June sampling period and from 918 to 1,969 microsiemens per centimeter during the September sampling period. Conductivity was lowest in the downstream control reach, particularly at sites RR–011 and RR–012 (table 6). During the June sampling period, mean pH ranged from 7.3 (site RR–010) to 8.0 (site RR–012). During the September sampling period, mean pH was higher, ranging from 7.9 to 8.1; only site RR–001 had a mean pH below 8. Detailed water quality values for each site and sampling date can be found in DeBruyne and others (2020).

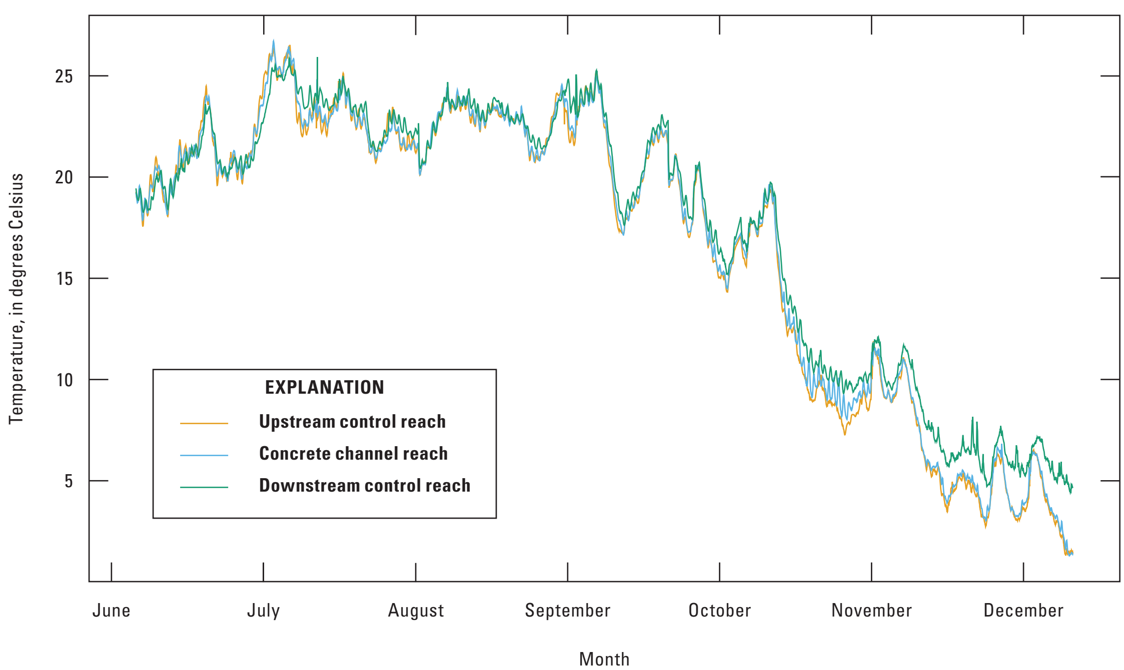


Figure 16. Mean hourly water temperatures in the upstream control, concrete channel, and downstream control reaches of the lower Rouge River from June 4, 2018, to December 10, 2018.

Table 6. Water quality parameters recorded during fish and macroinvertebrate sampling in the lower Rouge River. Mean values are reported by site.

[m, meter; D.O., dissolved oxygen; mg/L, milligram per liter; µS/cm, microsiemens per centimeter; --, no data]

Date	Reach	Site	Secchi depth (m)	D.O. (mg/L)	Conductivity (µS/cm)	pH
June	Upstream control reach	RR–001	0.4	6.8	1,561	7.8
		RR–002	--	6.5	2,210	7.8
		RR–003	--	6.3	2,109	7.8
		Mean	0.4	6.5	1,960	7.8
	Concrete control reach	RR–004	--	6.2	1,454	7.8
		RR–005	--	6.8	1,460	7.7
		RR–006	0.5	6.9	1,438	7.6
		RR–007	0.7	7.1	2,156	7.6
		RR–008	0.5	7.2	1,947	7.7
		RR–009	0.4	7.5	1,520	7.6
		Mean	0.5	6.9	1,675	7.7
	Downstream control reach	RR–010	0.6	5.6	1,386	7.3
		RR–011	0.9	6.1	1,001	7.5
		RR–012	1.2	6.0	1,002	8.0
		Mean	1.0	5.9	1,130	7.6
September	Upstream control reach	RR–001	0.4	8.0	1,683	7.9
		RR–002	0.4	7.7	1,147	8.0
		RR–003	0.5	8.0	1,969	8.0
		Mean	0.4	7.9	1,555	8.0
	Concrete control reach	RR–004	0.4	7.6	1,582	8.0
		RR–005	0.4	7.2	1,966	8.0
		RR–006	0.5	6.8	1,550	8.0
		RR–007	0.5	7.7	1,916	8.0
		RR–008	0.5	7.1	1,120	8.1
		RR–009	0.6	7.0	1,190	8.1
		Mean	0.5	7.2	1,554	8.1
	Downstream control reach	RR–010	0.6	6.9	1,120	8.2
		RR–011	0.5	6.5	1,075	8.1
		RR–012	0.6	6.7	918	8.1
		Mean	0.6	6.7	1,038	8.1

Herpetofauna Assessment

A total of 8 species of herpetofauna was observed during the surveys: 1 amphibian species, 3 snake species, and 4 turtle species. June surveys resulted in observations of 1 amphibian species and 4 reptile species: *Anaxyrus americanus* (eastern American toad), *Thamnophis sirtalis sirtalis* (eastern garter snake), *Storeria dekayi* (Dekay's brown snake), *Graptemys geographica* (northern map turtle), and *Apalone spinifera spinifera* (eastern spiny softshell turtle; table 7). Although no amphibians were observed during September surveys, seven reptile species were recorded: eastern garter snake, DeKay's brown snake, *Thamnophis butleri* (Butler's garter snake), northern map turtle, eastern spiny softshell turtle, *Chrysemys picta* (painted turtle), and *Trachemys scripta elegans* (red-eared slider). Butler's garter snake is listed as a species of special concern and a species of greatest conservation need within the State of Michigan. Furthermore, three observations of 2 turtles and 1 snake were not able to be identified to species in the field. One of the unidentified turtles and the unidentified snake were seen during the June surveys at sites RR–001 and RR–007, respectively. The other unidentified turtle was observed at RR–002 in September. Northern map turtles composed the majority of herpetofauna observed in June (43 individuals, 80 percent of herpetofauna) and September (40 individuals, 70 percent of herpetofauna), with most of the observations of northern map turtles taking place in the upstream control reach (58 percent in June and 73 percent in September) where large woody debris and other basking structures exist in greater densities compared to other reaches. All species occurrences and locations can be found in DeBruyne and others (2020).

Qualitative Macroinvertebrate Assessment

Qualitative macroinvertebrate sampling yielded a total of 6,073 macroinvertebrates representing 19 taxa (excluding one individual from the order Zygoptera that was unable to be identified to family; tables 8–10). Mean taxa richness ranged from 3.3–6.7 taxa in June and 2.7–4 taxa in September. Samples were dominated by Oligochaeta and Chironomidae at all sites during both months, and no other taxa exceeded 5 percent of the total catch. Individual metric scores were equal across sample sites, and the total IBI score was −5 for all sites and reaches (table 11). Following the interpretation of the MDEQ SWAS (Michigan Department of Environmental Quality, 2008) protocol, IBI scores of −5 indicated macroinvertebrate assemblages were "poor" for the region. Detailed macroinvertebrate densities for each site and sampling date can be found in DeBruyne and others (2020).

Hester-Dendy colonization samplers collected a total of 20,153 macroinvertebrates and 16 taxa (excluding 3 individuals belonging to the phylum Mollusca, 3 individuals belonging to the class Gastropoda, and 3 individuals belonging to the order Trichoptera that could not be identified to lower taxonomic levels). Mean taxa richness ranged from 3.7–5.3 taxa in June and 2.3–8 taxa in September. Mean taxa richness was highest in the upstream control reach in September (8 taxa) and lowest in the downstream control reach in September (2.3 taxa). Except for the upstream control reach, mean taxa richness was higher in June than in September (tables 12–13). Similar to the qualitative samples, Chironomidae and Oligochaeta were the dominant taxa (figs. 17–18). Oligochaeta were observed in greater densities and proportions in the downstream control reach in June and September than in the concrete channel and upstream control reaches. Chironomidae were observed in higher mean densities than Oligochaeta in the upstream control and concrete channel reaches in June, but not in September, although mean September densities of Chironomidae (1,231 individuals/square meter) were only marginally higher than mean Oligochaeta densities (1,129 individuals/square meter) in the upstream control reach. Isopoda and Amphipoda were the only other taxa that composed more than 5 percent of the taxa assemblage (with Isopoda composing more than 30 percent of some samples) and were observed in 71 and 33 percent of the samples, respectively. Both taxa were observed in greater densities in June, and neither taxon composed more than 5 percent of a sample in September. Isopoda were the dominant taxon belonging to the isopod, snail, and leech taxonomic group, and isopod, snail, and leech densities and proportional abundances mirrored those of Isopoda. No stoneflies, few mayflies (45 individuals), and few caddisflies (27 individuals) were collected. Mayflies and caddisflies composed 0.4 percent of the total number of macroinvertebrates observed and were only observed in the upstream control and concrete channel reaches. Lastly, no surface-dependent taxa were observed in any of the Hester-Dendy samples.

Table 7. Counts of herpetofauna observed along the lower Rouge River during June and September 2018 surveys.

[Undefined sites were locations of observed individuals between the defined sites in each reach.]

Scientific name (common name)	Upstream control					Concrete channel								Downstream Control					Grand total
	RR–001	RR–002	RR–003	Undefined	Total	RR–004	RR–005	RR–006	RR–007	RR–008	RR–009	Undefined	Total	RR–010	RR–011	RR–012	Undefined	Total	
June 2018																			
Anaxyrus americanus americanus (eastern American toad)	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1
Thamnophis sirtalis sirtalis (eastern garter snake)	1	0	0	0	1	0	1	0	0	0	0	0	1	4	0	0	0	4	6
Thamnophis butleri (Butler's garter snake)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Storeria dekayi (DeKay's brown snake)	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1
Graptemys geographica (Northern map turtle)	15	5	0	5	25	0	0	1	1	0	0	8	10	0	0	6	2	8	43
Apalone spinifera spinifera (eastern spiny softshell turtle)	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Chrysemys picta (painted turtle)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trachemys scripta elegans (red-eared slider)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Unknown turtle	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Unknown snake	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1
September 2018																			
Anaxyrus americanus americanus (eastern American toad)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thamnophis sirtalis sirtalis (eastern garter snake)	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1
Thamnophis butleri (Butler's garter snake)	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	9	9
Storeria dekayi (DeKay's brown snake)	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2	2
Graptemys geographica (Northern map turtle)	4	6	0	19	29	0	0	0	0	0	0	1	1	0	2	0	8	10	40
Apalone spinifera spinifera (eastern spiny softshell turtle)	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Chrysemys picta (painted turtle)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1
Trachemys scripta elegans (red-eared slider)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	2
Unknown turtle	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Unknown snake	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 8. Grouping and taxonomic classification of macroinvertebrates collected from the lower Rouge River in June and September 2018.

[Taxa is the lowest taxonomic level identified; group was defined by the Michigan Department of Environmental Quality (2008) surface water assessment protocol. Insects were classified to the taxonomic family level when possible, and noninsects went to lowest taxonomic level possible. --, no data; ISL, isopoda, snails, and leeches; *, only adults collected]

Taxa	Group	Common name	Phylum	Class	Subclass	Order	Suborder	Family
Amphipoda	Amphipoda	Scuds	Arthropoda	Malacostraca	Eumalacostraca	Amphipoda	--	--
Ancylidae	ISL	Limpet	Mollusca	Gastropoda	--	Basommatophora	--	Ancylidae
Baetidae	Mayflies	Small minnow mayflies	Arthropoda	Insecta	Pterygota	Ephemeroptera	Pisciforma	Baetidae
Ceratopogonidae	Other	Sandflies	Arthropoda	Insecta	Pterygota	Diptera	Nematocera	Ceratopogonidae
Chironomidae	Chironomidae	Nonbiting midges	Arthropoda	Insecta	Pterygota	Diptera	Nematocera	Chironomidae
Coenagrionidae	Other	Narrow-winged damselflies	Arthropoda	Insecta	Pterygota	Odonata	Zygoptera	Coenagrionidae
Corixidae	Surface dependent	Water boatmen	Arthropoda	Insecta	Pterygota	Hemiptera	Heteroptera	Corixidae
Culicidae	Surface dependent	Mosquito	Arthropoda	Insecta	Pterygota	Diptera	Nematocera	Culicidae
Decapoda	Other	Decapoda	Arthropoda	Malacostraca	Eumalacostraca	Decapoda	--	--
Elmidae	Other	Riffle beetles	Arthropoda	Insecta	Pterygota	Coleoptera	Polyphaga	Elmidae
Gastropoda	ISL	Gastropods	Mollusca	Gastropoda	--	--	--	--
Haliplidae*	Surface dependent	Crawling water beetles	Arthropoda	Insecta	Pterygota	Coleoptera	Adephaga	Haliplidae
Heptageniidae	Mayflies	Flat-headed mayflies	Arthropoda	Insecta	Pterygota	Ephemeroptera	Schistonota	Heptageniidae
Hirudinea	ISL	Leeches	Annelida	Clitellata	Hirudinea	--	--	--
Hydridae	Other	Hydra	Cnidaria	Hydrozoa	Hydroidolina	Anthoathecata	Aplanulata	Hydridae
Hydropsychidae	Caddisflies	Net-spinning caddisflies	Arthropoda	Insecta	Pterygota	Trichoptera	Annulipalpia	Hydropsychidae
Isopoda	ISL/Isopoda	Isopoda	Arthropoda	Malacostraca	Eumalacostraca	Isopoda	--	--
Libellulidae	Other	Skimmers or perchers	Arthropoda	Insecta	Pterygota	Odonata	Anisoptera	Libellulidae
Lymnaeidae	ISL	Pond snails	Mollusca	Gastropoda	--	Basommatophora	--	Lymnaeidae
Mollusca	Other	Molluscs	Mollusca	--	--	--	--	--
Nematomorph	Other	Nematomorpha	Nematomorpha	--	--	--	--	--
Oligochaeta	Oligochaeta	Oligochaeta	Annelida	Clitellata	Oligochaeta	--	--	--
Physidae	ISL	Bladder snails	Mollusca	Gastropoda	--	Basommatophora	--	Physidae
Planorbidae	ISL	Ramshorn snails	Mollusca	Gastropoda	--	Basommatophora	--	Planorbidae
Sphaeriidae	Other	Pea clams	Mollusca	Bivalvia	Heterodonta	Veneroida	Sphaeriacea	Sphaeriidae
Trichoptera	Caddisflies	Caddisflies	Arthropoda	Insecta	Pterygota	Trichoptera	--	--
Turbellaria	Other	Flatworms	Platyhelminthes	Turbellaria	--	--	--	--
Zygoptera	Other	Damselflies	Arthropoda	Insecta	Pterygota	Odonata	Zygoptera	--

Table 9. Individuals and taxa richness of macroinvertebrates collected from the lower Rouge River during qualitative sampling in June 2018.

Taxa	Upstream control				Concrete channel							Downstream control			
	RR–001	RR–002	RR–003	Reach mean	RR–004	RR–005	RR–006	RR–007	RR–008	RR–009	Reach mean	RR–010	RR–011	RR–012	Reach mean
Amphipoda	1	1	1	1	5	3	0	0	1	4	2	0	6	1	2
Ancylidae	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Baetidae	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ceratopogonidae	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Chironomidae	237	240	181	219	155	272	284	294	326	237	286	187	145	130	154
Coenagrionidae	0	1	0	0	0	0	0	0	0	0	0	1	1	0	1
Corixidae	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0
Culicidae	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Decapoda	0	2	1	1	6	2	1	0	0	0	0	0	1	4	2
Haliplidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hirudinea	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Isopoda	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Libellulidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lymnaeidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oligochaeta	48	44	99	64	123	20	1	40	2	38	27	88	102	116	102
Physidae	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Planorbidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sphaeriidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Turbellaria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Zygoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Total count	287	289	282	286	291	297	286	334	329	279	314	277	257	256	263
Taxa richness	4	6	4	5	5	4	3	2	3	3	3	4	7	9	7

Table 10. Individuals and taxa richness of macroinvertebrates collected from the lower Rouge River during qualitative sampling in September 2018.

Taxa	Upstream control				Concrete channel							Downstream control			
	RR–001	RR–002	RR–003	Reach mean	RR–004	RR–005	RR–006	RR–007	RR–008	RR–009	Reach mean	RR–010	RR–011	RR–012	Reach mean
Amphipoda	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Ancylidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Baetidae	0	1	0	0	0	0	0	0	0	3	1	0	0	0	0
Ceratopogonidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chironomidae	35	19	9	21	257	108	38	126	49	181	119	62	13	13	29
Coenagrionidae	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0
Corixidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Culicidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Decapoda	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1
Haliplidae	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Hirudinea	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0
Isopoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Libellulidae	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
Lymnaeidae	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Oligochaeta	186	235	196	206	16	41	157	147	142	84	124	93	150	229	157
Physidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Planorbidae	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Sphaeriidae	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Turbellaria	0	0	0	0	0	0	0	0	0	2	1	0	2	1	1
Zygoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total count	221	255	207	228	273	149	196	274	192	274	247	155	165	248	189
Taxa richness	2	3	3	3	2	2	3	3	3	8	5	2	3	7	4

Table 11. Index of biological integrity scores from qualitative macroinvertebrate sampling in the lower Rouge River in June and September 2018. Values for individual taxa groups were from guidelines located in Michigan Department of Environmental Quality (2008).

[IBI, index of biological integrity]

Month	Reach	Site	Total taxa	Mayfly	Caddisfly	Stonefly	Percent mayfly	Percent caddisfly	Percent dominant taxa	Percent isopod, snail, leeches	Percent surface dependent	IBI score
June	Upstream control reach	RR–001	−1	−1	−1	−1	−1	−1	−1	1	1	−5
		RR–002	−1	−1	−1	−1	−1	−1	−1	1	1	−5
		RR–003	−1	−1	−1	−1	−1	−1	−1	1	1	−5
		Mean	−1	−1	−1	−1	−1	−1	−1	1	1	−5
	Concrete control reach	RR–004	−1	−1	−1	−1	−1	−1	−1	1	1	−5
		RR–005	−1	−1	−1	−1	−1	−1	−1	1	1	−5
		RR–006	−1	−1	−1	−1	−1	−1	−1	1	1	−5
		RR–007	−1	−1	−1	−1	−1	−1	−1	1	1	−5
		RR–008	−1	−1	−1	−1	−1	−1	−1	1	1	−5
		RR–009	−1	−1	−1	−1	−1	−1	−1	1	1	−5
		Mean	−1	−1	−1	−1	−1	−1	−1	1	1	−5
	Downstream control reach	RR–010	−1	−1	−1	−1	−1	−1	−1	1	1	−5
		RR–011	−1	−1	−1	−1	−1	−1	−1	1	1	−5
		RR–012	−1	−1	−1	−1	−1	−1	−1	1	1	−5
		Mean	−1	−1	−1	−1	−1	−1	−1	1	1	−5
September	Upstream control reach	RR–001	−1	−1	−1	−1	−1	−1	−1	1	1	−5
		RR–002	−1	−1	−1	−1	−1	−1	−1	1	1	−5
		RR–003	−1	−1	−1	−1	−1	−1	−1	1	1	−5
		Mean	−1	−1	−1	−1	−1	−1	−1	1	1	−5
	Concrete control reach	RR–004	−1	−1	−1	−1	−1	−1	−1	1	1	−5
		RR–005	−1	−1	−1	−1	−1	−1	−1	1	1	−5
		RR–006	−1	−1	−1	−1	−1	−1	−1	1	1	−5
		RR–007	−1	−1	−1	−1	−1	−1	−1	1	1	−5
		RR–008	−1	−1	−1	−1	−1	−1	−1	1	1	−5
		RR–009	−1	−1	−1	−1	−1	−1	−1	1	1	−5
		Mean	−1	−1	−1	−1	−1	−1	−1	1	1	−5
	Downstream control reach	RR–010	−1	−1	−1	−1	−1	−1	−1	1	1	−5
		RR–011	−1	−1	−1	−1	−1	−1	−1	1	1	−5
		RR–012	−1	−1	−1	−1	−1	−1	−1	1	1	−5
		Mean	−1	−1	−1	−1	−1	−1	−1	1	1	−5

Table 12. Taxa total densities (in individuals per square meter) and richness of macroinvertebrates on Hester-Dendy colonization samplers in the lower Rouge River during June 2018.

Taxa	Upstream control				Concrete channel							Downstream control			
	RR–001	RR–002	RR–003	Reach mean	RR–004	RR–005	RR–006	RR–007	RR–008	RR–009	Reach mean	RR–010	RR–011	RR–012	Reach mean
Amphipoda	44	100	113	85	0	19	75	0	0	13	18	0	6	0	2
Baetidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chironomidae	838	1,038	1,513	1,129	2,319	1,194	1,244	1,144	356	1,300	1,259	525	306	25	285
Coenagrionidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Decapoda	0	0	6	2	0	0	0	6	0	6	2	0	13	0	4
Elmidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	0	0	0	0	6	0	0	0	0	0	1	0	0	0	0
Gastropoda	0	0	0	0	0	0	0	0	0	6	1	0	0	0	0
Heptageniidae	6	6	6	6	6	19	0	0	0	6	5	0	0	0	0
Hirudinea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydra	0	0	0	0	0	6	0	0	0	0	1	0	0	0	0
Hydropsychidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isopoda	188	269	206	221	56	669	319	6	6	100	193	0	269	0	90
Mollusca	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nematomorph	0	0	0	0	0	0	0	0	6	0	1	13	0	0	4
Oligochaeta	0	156	75	77	25	31	113	94	138	144	91	381	681	1,981	1,015
Planorbidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	6	0	0	2	0	0	0	0	0	0	0	0	0	0	0
Turbellaria	0	0	0	0	0	0	0	0	0	0	0	0	13	0	4
Total density	1,081	1,569	1,919	1,523	2,413	1,938	1,750	1,250	506	1,575	1,572	919	1,288	2,006	1,404
Taxa richness	5	5	6	5	4	5	4	4	4	7	5	3	6	2	4

Table 13. Taxa total densities (individuals per square meter) and richness of macroinvertebrates on Hester-Dendy colonization samplers in the lower Rouge River in September 2018.

Taxa	Upstream control				Concrete channel							Downstream control			
	RR–001	RR–002	RR–003	Reach mean	RR–004	RR–005	RR–006	RR–007	RR–008	RR–009	Reach mean	RR–010	RR–011	RR–012	Reach mean
Amphipoda	0	0	13	4	0	0	0	0	0	0	0	0	0	0	0
Baetidae	6	0	0	2	6	0	0	0	0	0	1	0	0	0	0
Chironomidae	1,188	600	1,906	1,231	1,181	1,156	56	56	163	169	464	25	13	0	1,260
Coenagrionidae	38	0	6	15	6	0	0	0	6	0	2	0	0	0	0
Decapoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elmidae	6	0	6	4	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gastropoda	25	0	0	8	0	6	0	0	0	0	1	0	0	0	0
Heptageniidae	0	6	0	2	6	13	0	0	0	0	3	0	0	0	0
Hirudinea	0	6	0	2	0	0	0	0	0	0	0	0	0	0	0
Hydra	0	0	13	4	0	0	0	0	0	0	0	0	0	0	0
Hydropsychidae	13	0	25	13	0	6	0	0	6	0	2	0	0	0	0
Isopoda	19	6	38	21	6	6	0	0	25	0	6	6	0	0	2
Mollusca	0	0	19	6	0	0	0	0	0	0	0	0	0	0	0
Nematomorph	6	0	0	2	0	0	0	0	0	0	0	0	0	0	0
Oligochaeta	381	1,906	1,100	1,129	56	1,163	819	619	481	2,869	1,001	3,413	2,006	2,050	2,490
Planorbidae	0	0	0	0	0	0	0	0	0	0	0	0	0	6	2
Trichoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Turbellaria	13	0	0	4	0	0	0	0	0	0	0	0	0	0	0
Total density	1,694	2,525	3,125	2,448	1,263	2,350	875	675	681	3,038	1,480	3,444	2,019	2,056	2,506
Taxa richness	10	5	9	8	6	4	2	2	5	2	4	3	2	2	2

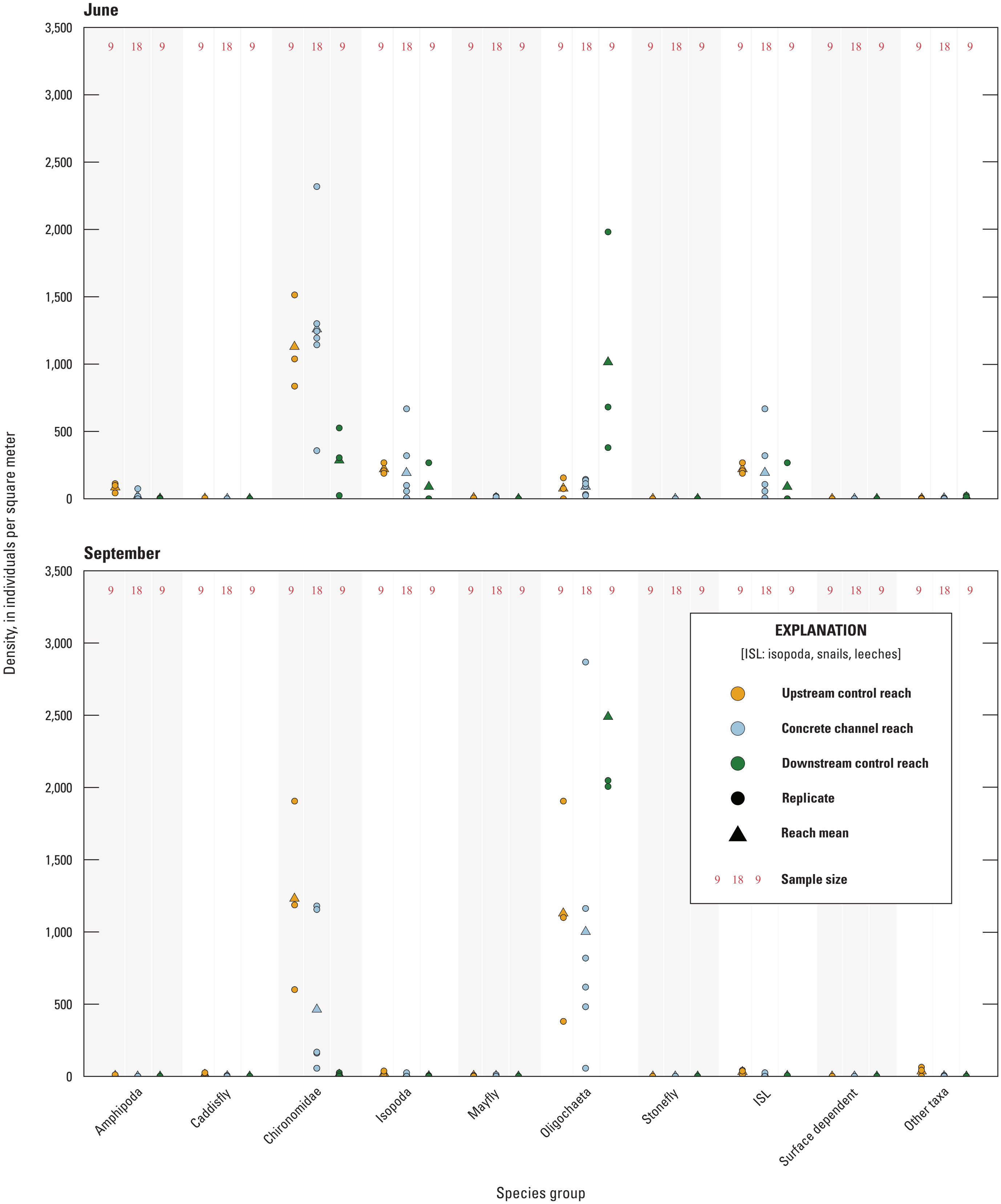


Figure 17. Mean macroinvertebrate densities by reach and month collected with Hester-Dendy samplers. Taxonomic groups are summarized in table 3 and are expanded from the Michigan Department of Environmental Quality Qualitative Biological and Habitat Survey Protocols for Wadable Streams and Rivers protocol to also include taxa that composed more than 5 percent of the assemblage.

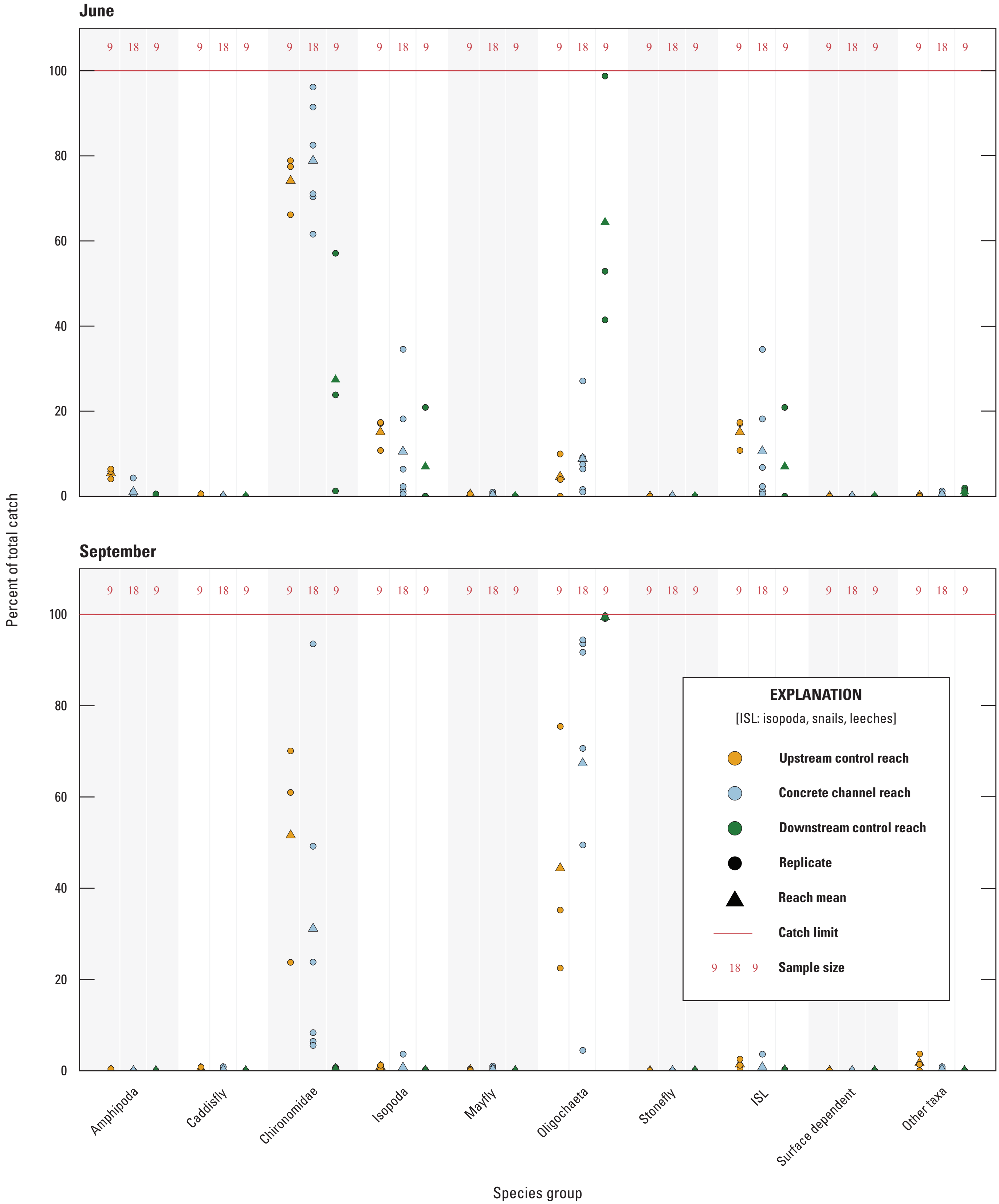


Figure 18. Mean percentage of the total Hester-Dendy catch composed by each taxonomic group. Taxonomic groups are summarized in table 3 and are expanded from the Michigan Department of Environmental Quality Qualitative Biological and Habitat Survey Protocols for Wadable Streams and Rivers protocol to also include taxa that composed more than 5 percent of the assemblage.

Fisheries Electrofishing Assessment

A total of 1,068 fish (24 species) were collected with boat electrofishing. Mean species richness by reach ranged from 5–8 in June and 5–9 in September (tables 14–15). The mean CPUE of four functional feeding groups was highest for insectivores in the three reaches in June but varied in September, when the “other” feeding group had the highest CPUE in the concrete channel reach (fig. 19). The mean proportional abundance of insectivores was greatest in the concrete channel reach (76 percent of the catch), followed by the downstream control reach (69 percent of the catch) and the upstream control reach (65 percent of the catch; fig. 20). *Notropis atherinoides* (emerald shiner) was the dominant species (56 percent of the mean catch) collected in June and composed the bulk of the insectivorous fishes collected (table 14). Emerald shiner also had the highest CPUE of insectivorous fish collected in September, but high CPUE of *Dorosoma cepedianum* (gizzard shad) also was observed (table 15). Gizzard shad drove patterns in CPUE of fishes belonging to the “other” feeding guild, and September catches of gizzard shad were composed primarily of juvenile (fig. 21; < 305 mm; Trautman, 1981) individuals. Of the three tolerance groups summarized, the tolerance group “other” had the highest CPUE and composed most of the catch among the three reaches in June and September, heavily affected by catches of emerald shiner and gizzard shad. The mean CPUE of tolerant fishes was comparatively low against the other tolerance types; however, tolerant fishes were observed in a higher proportion of the catch from the upstream control reach (June: 22 percent; September: 14 percent) than in the concrete channel reach (June: 6 percent; September: 2 percent) and downstream control reach (June: 5 percent; September: 7 percent; fig. 19). Intolerant fishes were infrequently observed; however, fishes belonging to this group, primarily juvenile *Micropterus dolomieu* (smallmouth bass; < 254 mm; Trautman, 1981), composed a mean of 29 percent of the fish collected from the downstream control reach in September (figs. 20, 22). *Catostomus commersonii* (white sucker) was the primary lithophilic spawning fish observed with boat electrofishing, although a single *Sander vitreus* (juvenile walleye, < 280 mm; Trautman, 1981) was collected from the downstream control reach in September. Three nonnative fishes *Cyprinus carpio* (common carp), *Carassius auratus* (goldfish), and *Morone americana* (white perch) were observed with boat electrofishing. Mean CPUE of nonnative fishes was higher in June (24 individuals per hour [individuals/h], 6 individuals/h, and 12 individuals/h in the upstream control, concrete channel, and downstream control reaches, respectively), and nonnative fishes were only observed in the downstream control reach in September (mean CPUE of 12 individuals/h). No rare, threatened, or endangered species were collected with boat electrofishing. Detailed fish captures at each site and sampling date can be found in DeBruyne and others (2020).

Table 14. Catch per unit effort standardized as number of fish per hour and species richness of fish collected with boat electrofishing from the lower Rouge River in June 2018.

[--, no data]

Scientific name (common name)	Upstream control				Concrete channel							Downstream control			
	RR–001	RR–002	RR–003	Reach mean	RR–004	RR–005	RR–006	RR–007	RR–008	RR–009	Reach mean	RR–010	RR–011	RR–012	Reach mean
Lepomis macrochirus Rafinesque (bluegill)	48	0	0	16	12	0	36	36	24	24	22	0	0	0	0
Pimephales notatus (bluntnose minnow)	0	0	0	0	36	48	12	12	12	0	20	0	0	0	0
Amia calva Linnaeus (bowfin)	0	11	0	4	0	0	0	0	0	0	0	0	0	0	0
Labidesthes sicculus (Brook silverside)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cyprinus carpio Linnaeus (common carp)	12	0	48	20	0	0	0	0	0	0	0	0	36	0	12
Notropis atherinoides Rafinesque (emerald shiner)	311	134	36	160	336	768	358	249	672	372	459	144	132	12	96
Pimephales promelas Rafinesque (fathead minnow)	0	0	0	--	96	0	0	0	0	0	--	0	0	0	--
Aplodinotus grunniens Rafinesque (freshwater drum)	12	0	0	4	0	0	0	0	0	0	0	0	0	0	0
Dorosoma cepedianum (gizzard shad)	12	22	0	11	24	24	95	107	60	72	64	24	72	0	32
Carassius auratus (goldfish)	0	0	12	4	0	0	0	0	0	0	0	0	0	0	0
Notemigonus crysoleucas (golden shiner)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lepomis cyanellus Rafinesque (green sunfish)	12	0	0	4	0	0	12	0	0	0	2	0	0	0	0
Micropterus salmoides (largemouth bass)	36	0	12	16	12	12	24	0	0	0	8	12	12	12	12
Esox lucius Linnaeus (northern pike)	0	0	0	0	0	0	0	0	0	0	0	12	0	0	4
Lepomis gibbosus (pumpkinseed)	24	11	36	24	12	12	0	0	12	60	16	12	0	24	12
Ambloplites rupestris Rafinesque *(*rock bass)	24	0	0	8	0	0	0	0	0	0	0	0	0	0	0
Cyprinella spiloptera (spotfin shiner)	12	11	24	16	0	0	12	24	0	60	16	12	0	12	8
Micropterus dolomieu Lacepède (smallmouth bass)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sander vitreus (walleye)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Morone chrysops (white bass)	0	0	0	0	36	0	0	0	0	0	6	0	0	0	0
Morone americana (white perch)	0	0	0	0	36	0	0	0	0	0	6	0	0	0	0

Table 14. Catch per unit effort standardized as number of fish per hour and species richness of fish collected with boat electrofishing from the lower Rouge River in June 2018.—Continued

[--, no data]

Scientific name (common name)	Upstream control				Concrete channel							Downstream control			
	RR–001	RR–002	RR–003	Reach mean	RR–004	RR–005	RR–006	RR–007	RR–008	RR–009	Reach mean	RR–010	RR–011	RR–012	Reach mean
Catostomus commersonii (white sucker)	0	22	24	15	24	0	0	0	0	0	4	0	0	0	0
Ameiurus natalis (yellow bullhead)	12	0	0	4	0	0	0	0	0	0	0	0	0	0	0
Perca flavescens (yellow perch)	0	34	0	11	144	36	0	0	12	12	34	12	0	0	4
Total catch	514	246	192	318	768	900	548	428	792	600	673	228	252	60	180
Species richness	11	7	7	8	11	6	7	5	6	6	7	7	4	4	5

Table 15. Catch per unit effort standardized as number of fish per hour and species richness of fish collected with boat electrofishing from the lower Rouge River in September 2018.

[--, no data]

Scientific name (common name)	Upstream control				Concrete channel							Downstream control			
	RR–001	RR–002	RR–003	Reach mean	RR–004	RR–005	RR–006	RR–007	RR–008	RR–009	Reach mean	RR–010	RR–011	RR–012	Reach mean
Lepomis macrochirus Rafinesque (bluegill)	0	12	0	4	0	0	24	0	0	0	4	0	0	0	0
Pimephales notatus (bluntnose minnow)	0	0	0	0	0	0	0	60	0	0	10	24	24	0	16
Amia calva Linnaeus (bowfin)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Labidesthes sicculus (Brook silverside)	0	0	0	0	0	0	0	0	0	0	0	0	0	12	4
Cyprinus carpio Linnaeus (common carp)	0	0	0	0	0	0	0	0	0	0	0	0	12	24	12
Notropis atherinoides Rafinesque (emerald shiner)	180	168	24	124	60	60	168	72	108	372	140	72	108	168	116
Pimephales promelas Rafinesque (fathead minnow)	0	0	0	--	0	0	0	12	0	0	--	0	0	0	--
Aplodinotus grunniens Rafinesque (freshwater drum)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dorosoma cepedianum (gizzard shad)	12	264	0	92	588	1,297	948	432	168	264	616	156	12	144	104
Carassius auratus (goldfish)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Notemigonus crysoleucas (golden shiner)	0	24	0	8	0	0	0	12	0	0	2	0	12	12	8
Lepomis cyanellus Rafinesque (green sunfish)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Micropterus salmoides (largemouth bass)	12	12	0	8	36	12	12	12	0	24	16	36	24	36	32
Esox lucius Linnaeus (northern pike)	12	12	12	12	0	0	0	0	0	0	0	0	0	0	0
Lepomis gibbosus (pumpkinseed)	0	0	0	0	0	0	0	24	12	0	6	36	48	48	44
Ambloplites rupestris Rafinesque *(*rock bass)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cyprinella spiloptera (spotfin shiner)	0	0	0	0	0	0	0	0	0	24	4	0	0	0	0
Micropterus dolomieu Lacepède (smallmouth bass)	12	0	0	4	0	0	0	12	0	48	10	120	348	24	164
Sander vitreus (walleye)	0	0	0	0	0	0	0	0	0	0	0	0	0	12	4
Morone chrysops (white bass)	0	0	0	0	0	0	0	0	0	0	0	12	0	0	4

Table 15. Catch per unit effort standardized as number of fish per hour and species richness of fish collected with boat electrofishing from the lower Rouge River in September 2018.—Continued

[--, no data]

Scientific name (common name)	Upstream control				Concrete channel							Downstream control			
	RR–001	RR–002	RR–003		RR–004	RR–005	RR–006	RR–007	RR–008	RR–009		RR–010	RR–011	RR–012	
Morone americana (white perch)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Catostomus commersonii (white sucker)	24	12	12	16	0	0	0	0	0	0	0	0	0	0	0
Ameiurus natalis (yellow bullhead)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Perca flavescens (yellow perch)	0	24	0	8	0	0	12	0	0	0	2	24	12	0	12
Total catch	252	528	48	276	684	1,369	1,164	636	288	732	812	480	600	480	520
Species richness	6	8	3	6	3	3	5	8	3	5	5	8	9	9	9

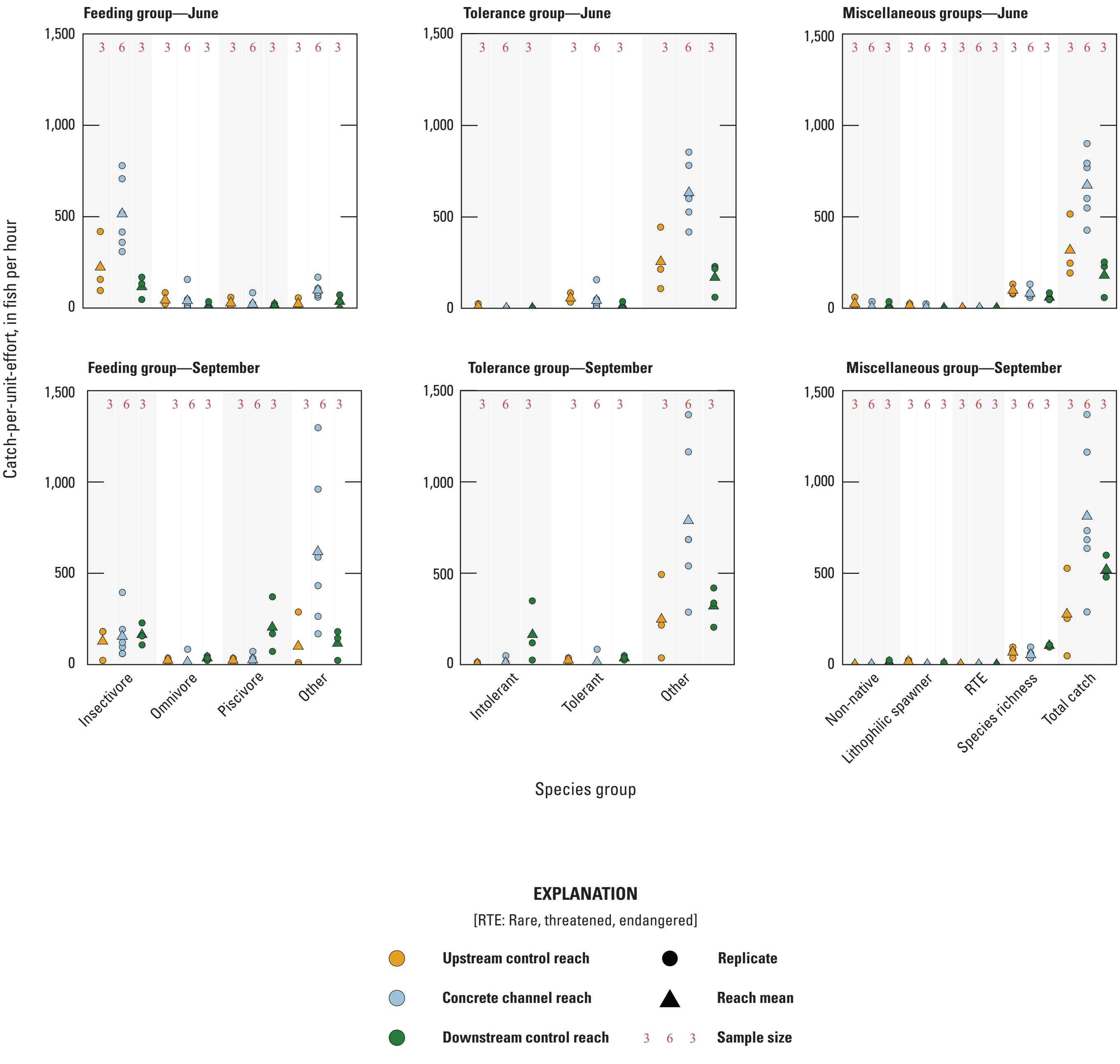


Figure 19. Mean catch per unit effort of fish collected with boat electrofishing upstream, downstream, and within the Rouge River concrete channel slated for restoration. Species are aggregated into feeding, tolerance, and other (for example, nonnative, lithophilic spawning, and rare, threatened, or endangered species) groups identified by the Michigan Department of Environmental Quality surface water assessment protocol (Michigan Department of Environmental Quality, 2008).

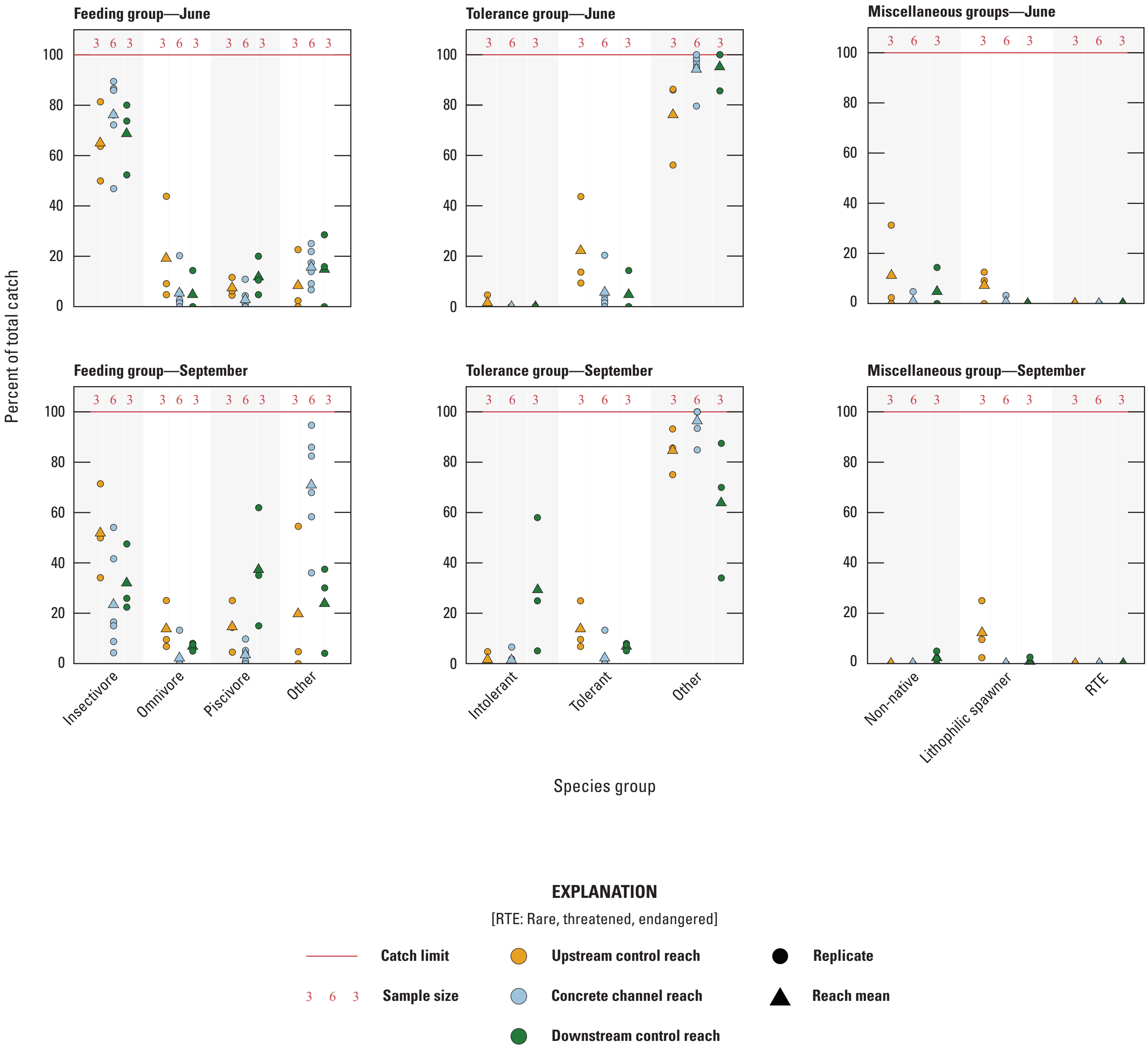


Figure 20. Mean percentage of the total boat electrofishing catch composed by feeding, tolerance, and other (for example, nonnative, lithophilic spawning, and rare, threatened, or endangered species) groups, identified by the Michigan Department of Environmental Quality surface water assessment protocol, upstream, downstream, and within the lower Rouge River concrete channel (Michigan Department of Environmental Quality, 2008).

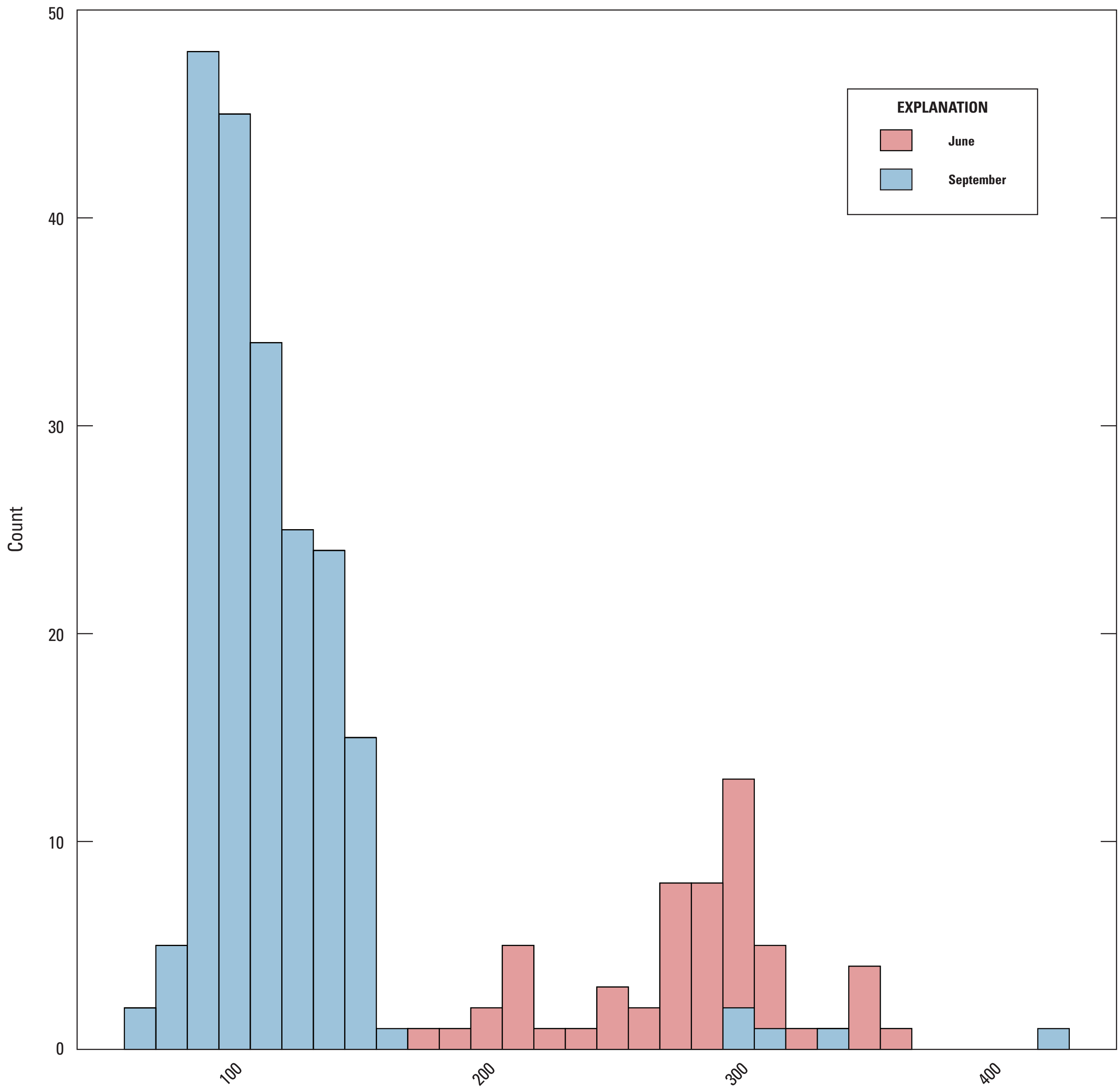


Figure 21. Length-frequency histogram of *Dorosoma cepedianum* (gizzard shad) collected with boat electrofishing during June and September fish collections in the lower Rouge River. Bar height represents the total number of individuals within a length bin collected during sampling events.

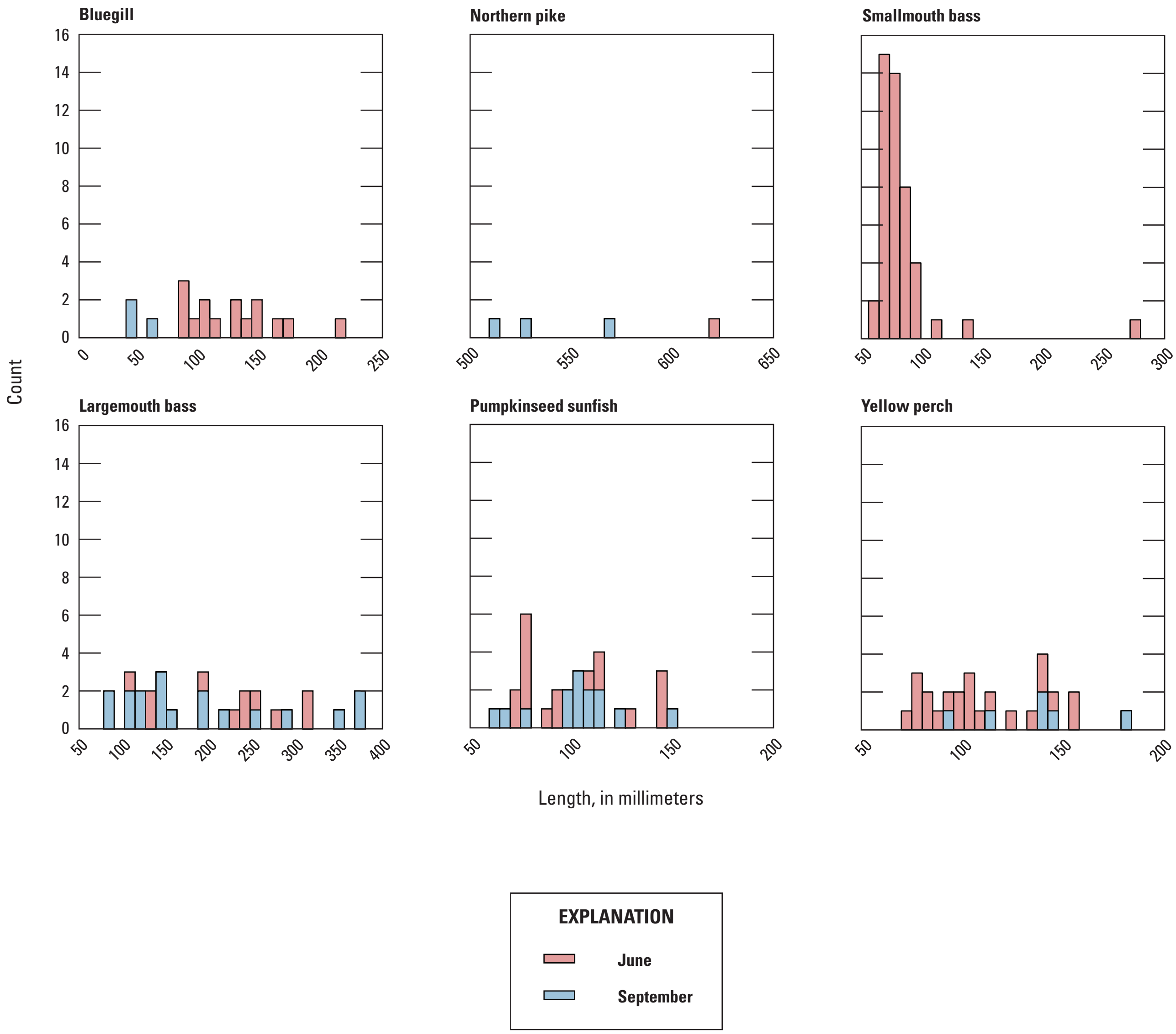


Figure 22. Length-frequency histograms of game fish collected with boat electrofishing and minnow traps during June and September fish collections in the lower Rouge River. Bar height represents the total number of individuals within a length bin collected during sampling events.

Fisheries Minnow Trap Assessment

A total of 69 fish (6 species) and 5 crayfish (Order Decapoda) were collected with minnow traps. Mean species richness ranged from 0 to 0.8 in June and from 1 to 1.8 in September (fig. 23). Two fish species, *Neogobius melanostomus* (round goby) and *Notropis hudsonius* (spottail shiner), were unique to the minnow trap collections, and the other four fishes: (*Lepomis macrochirus* (bluegill sunfish), *Lepomis gibbosus* (pumpkinseed sunfish), *Perca flavescens* (yellow perch), and *Pimephales notatus* (bluntnose minnow) also were observed in boat electrofishing collections (tables 16–17). Only three fish were collected with minnow traps in June; the other 66 fish observed in minnow traps were collected in September. The insectivore feeding group and the tolerance group “other” were the dominant functional groups collected from all three reaches in September (figs. 23–24; table 17). A single spottail shiner collected from the downstream control reach was the only intolerant species collected with minnow traps in September. Round goby was the only nonnative species observed with minnow traps and composed a mean of 92 percent, 86 percent, and 56 percent of the September catch from the upstream control, concrete channel, and downstream control reaches, respectively. No lithophilic spawning or rare, threatened, or endangered species were observed with minnow traps.

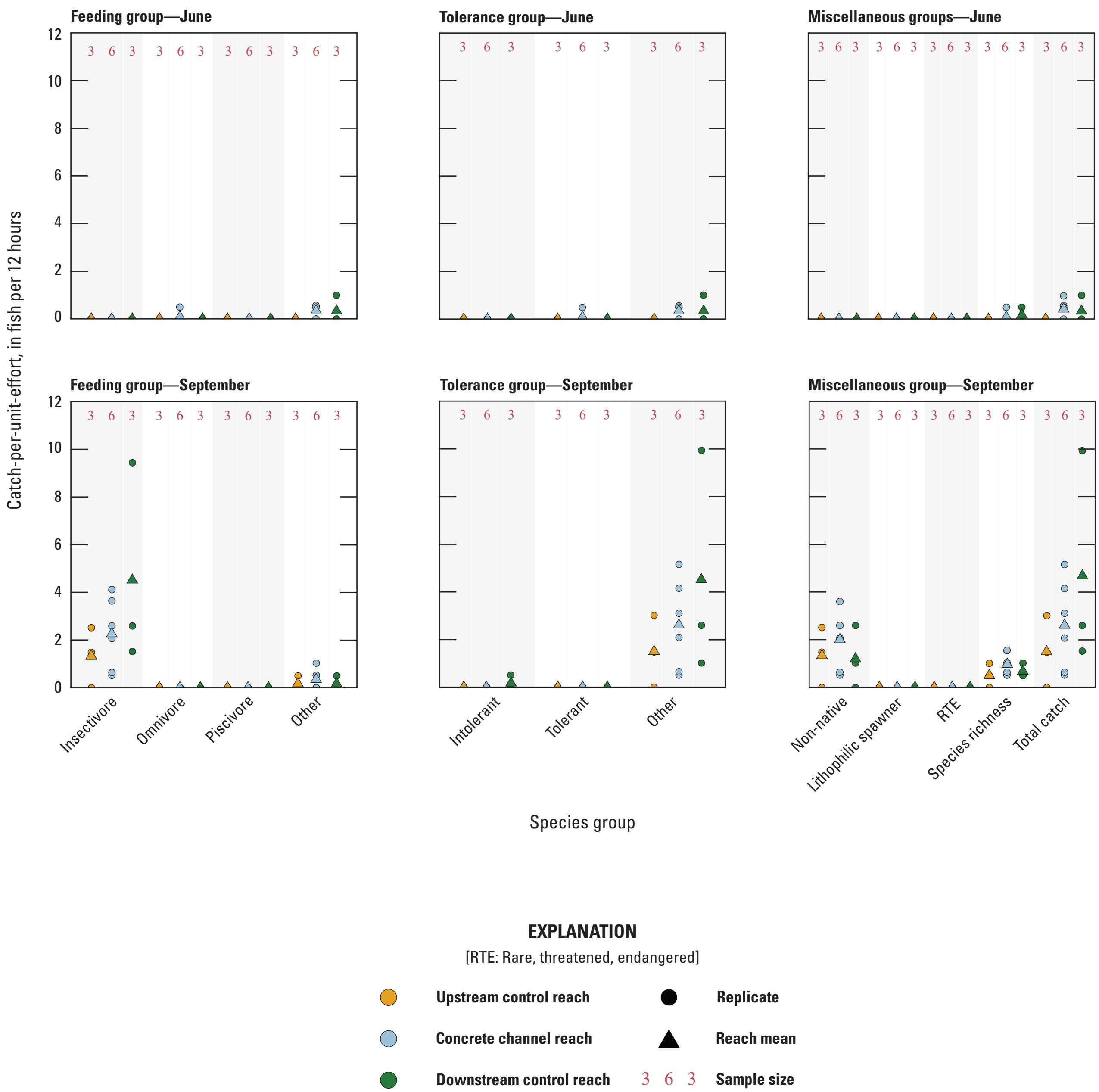


Figure 23. Mean catch per unit effort of fish collected with minnow traps upstream, downstream, and within the Rouge River concrete channel. Species are aggregated into feeding, tolerance, and other (for example, nonnative lithophilic spawning and rare, threatened, or endangered species) groups identified by the Michigan Department of Environmental Quality surface water assessment protocol (Michigan Department of Environmental Quality, 2008). Species richness and total catch also are shown.

Table 16. Catch per unit effort standardized as number of fish per 12 hours, and species richness of fish collected in minnow traps from the lower Rouge River in June 2018.

Scientific name (common name)	Upstream control				Concrete channel							Downstream control			
	RR–001	RR–002	RR–003	Reach mean	RR–004	RR–005	RR–006	RR–007	RR–008	RR–009	Reach mean	RR–010	RR–011	RR–012	Reach mean
Lepomis macrochirus Rafinesque (bluegill)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pimephales notatus (bluntnose minnow)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Crayfish (Order Decapoda)	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.5	0.6	0.5	0.3	0.0	0.0	0.0	0.0
Lepomis gibbosus (pumpkinseed)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Neogobius melanostomus (round goby)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Notropis hudsonius (spottail shiner)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Perca flavescens (yellow perch)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.3
Total catch	0.0	0.0	0.0	0.0	0.0	0.5	0.0	1.0	0.6	0.5	0.4	0.0	1.0	0.0	0.3
Species richness	0.0	0.0	0.0	0.0	0.0	1.0	0.0	2.0	1.0	1.0	0.8	0.0	1.0	0.0	0.3

Table 17. Catch per unit effort standardized as number of fish per 12 hours and species richness of fish collected in minnow traps from the lower Rouge River in September 2018.

Scientific name (common name)	Upstream control				Concrete channel							Downstream control			
	RR–001	RR–002	RR–003	Reach mean	RR–004	RR–005	RR–006	RR–007	RR–008	RR–009	Reach mean	RR–010	RR–011	RR–012	Reach mean
Lepomis macrochirus Rafinesque (bluegill)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.2	0.0	0.0	9.4	3.1
Pimephales notatus (bluntnose minnow)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Crayfish (Order Decapoda)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.2
Lepomis gibbosus (pumpkinseed)	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Neogobius melanostomus (round goby)	0.0	1.5	2.5	1.3	3.6	0.5	2.6	2.6	2.1	0.6	2.0	2.6	1.0	0.0	1.2
Notropis hudsonius (spottail shiner)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.2
Perca flavescens (yellow perch)	0.0	0.0	0.5	0.2	1.0	0.0	0.5	0.5	0.0	0.0	0.3	0.0	0.0	0.0	0.0
Total catch	0.0	1.5	3.0	1.5	5.1	0.5	3.1	4.1	2.1	0.6	2.6	2.6	1.5	9.9	4.7
Species richness	0.0	1.0	2.0	1.0	3.0	1.0	2.0	3.0	1.0	1.0	1.8	1.0	2.0	2.0	1.7

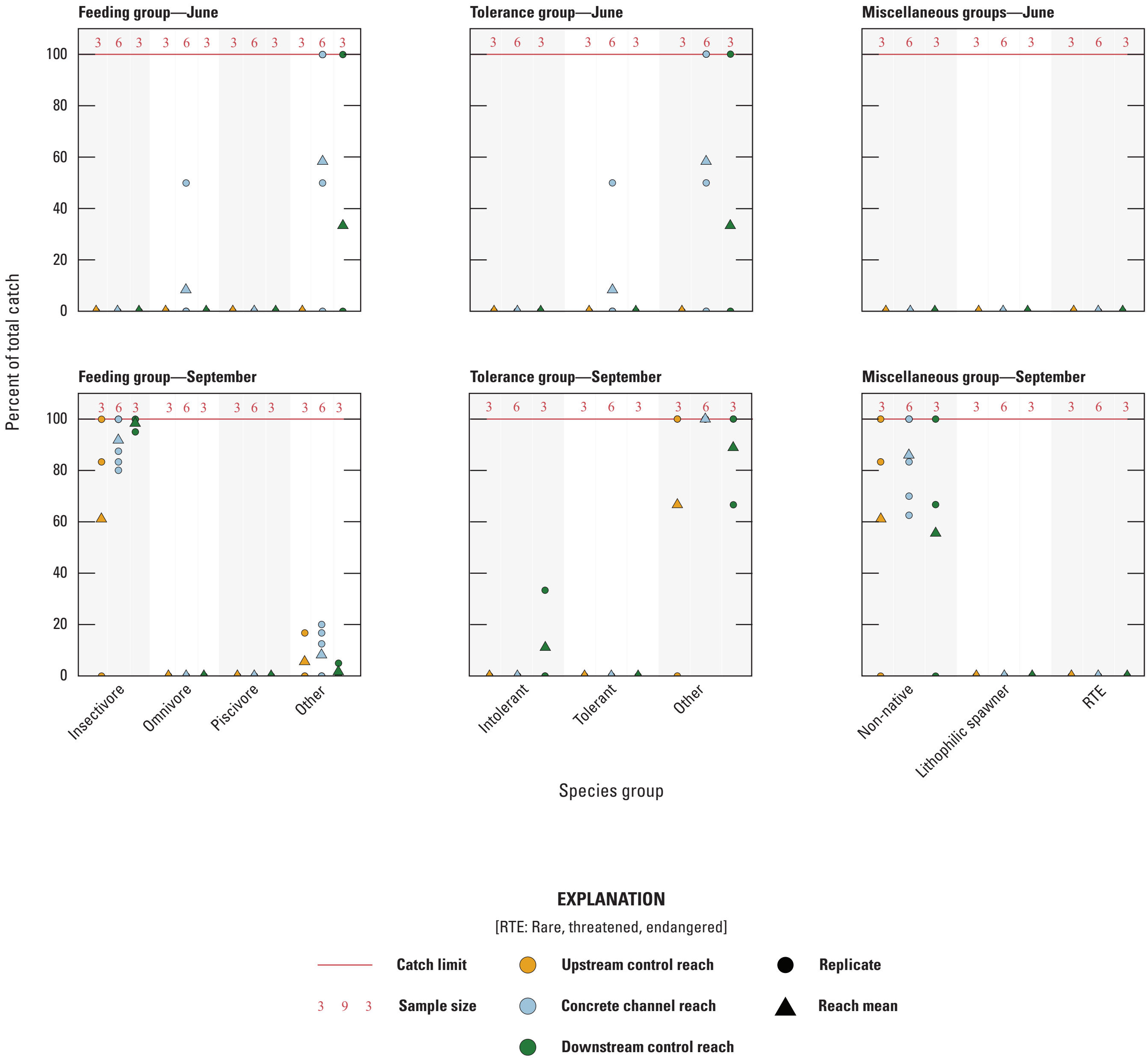


Figure 24. Mean percentage of the total minnow trap catch composed by feeding, tolerance, and other (for example, nonnative, lithophilic spawning, and rare, threatened, or endangered species) groups, identified by the Michigan Department of Environmental Quality surface water assessment protocol (Michigan Department of Environmental Quality, 2008), from the upstream control, concrete channel, and downstream control reaches.

Discussion

Our 2018 study of the lower Rouge River concrete channel aquatic community and habitat supplements historic surveys and provides a contemporary assessment of ecosystem conditions to be used to assess effectiveness of habitat restoration efforts. Based on the Michigan Department of Environmental Quality Qualitative Biological and Habitat Survey Protocols for Wadeable Streams and Rivers for glide/pool streams (Michigan Department of Environmental Quality, 2008), the Rouge River concrete channel habitat is considered “marginal” to “poor” compared to some upper reaches of the river and to other riverine systems in Michigan. Similar to earlier studies (Manny and others, 1988; Beam and Braunscheidel, 1998; Price, 2014), conditions in the concrete channel remain classified as poor from degraded water quality, low dissolved oxygen, and low habitat heterogeneity due to the monotonous physical environment and lack of aquatic vegetation. These factors limit aquatic organism production at all trophic levels.

Surveys of aquatic organisms in the lower Rouge River showed results similar to earlier investigations reported by Beam and Braunscheidel (1998). Observations of amphibians and reptiles during 2018 showed similar species and higher abundances in upper reaches of the river than in the concrete channel area. Quantitative and qualitative assessment of aquatic macroinvertebrates during 2018 were consistent with those reported by Beam and Braunscheidel (1998) with the lower river concrete channel dominated by oligochaetes and chironomids, taxa indicative of degraded habitats and poor water quality (Carter and others, 2017). Fish community composition and catch per unit effort were similar to previous surveys with low fish diversity, few game/sport fishes, and low numbers of those that were collected. The fish community remained dominated by forage species such as shiners, *Pimephales promelas* (fathead minnows), and *Dorosoma cepedianum* (gizzard shad).

The purpose of completing a biological and habitat assessment of the lower Rouge River was to provide a suite of preremediation conditions that can be used to compare and evaluate changes in the project area post remediation. In addition, information from this report can be used to assess the progress toward mitigating and redesignating the beneficial use impairment related to losses of fish and wildlife habitat in the Rouge River. Since our 2018 study, a fish passageway was constructed at the Henry Ford Estate Dam to allow migrating fish access to the upper reaches of the river (Alliance of Rouge Communities, 2019) and oxbow side channel habitats have been reconnected to the main channel (Environmental Consulting & Technology, 2015; Great Lakes Restoration Initiative, 2019). The passageway and oxbow projects are expected to positively impact 80 kilometers of main river and 160 kilometers of connected tributary waters for fish migration by increasing aquatic diversity throughout the Rouge River for fish species, macroinvertebrates, mussels, and other aquatic life. In addition to the planned remediation of portions of the concrete channel area that was the focus of our 2018 study, these restoration projects are part of the management actions intended to remove Rouge River Area of Concern Beneficial Use Impairments related to Loss of Fish and Wildlife Habitat, Degradation of Fish and Wildlife Populations, and Degradation of Benthos.

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Appendix 1. Supplementary Information

Appendix 1 includes supplementary photographic vouchers for the herpetofauna assessment conducted on the Rouge River.

Figure 1.1. *Thamnophis sirtalis (*eastern garter snake) observed during terrestrial herpetofauna surveys. Photograph by the U.S. Geological Survey.

Figure 1.2. *Graptemys geographica* (northern map turtles) basking on a log in the river. Photograph by the U.S. Geological Survey.

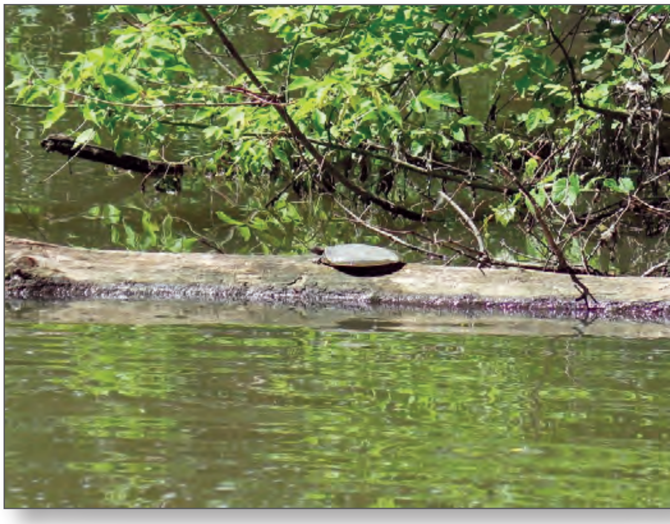

Figure 1.3. *Apolone spinifiera* (eastern spiny softshell turtle) basking on a log. Photograph by U.S. Geological Survey.

Figure 1.4. *Thamnophis butleri* (Butler's garter snake) observed during terrestrial herpetofauna surveys. Photograph by the U.S. Geological Survey.

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