

Prepared in cooperation with the Milwaukee Metropolitan Sewerage District

Summary of Fish Communities along Underwood Creek, Milwaukee, Wisconsin, 2004–2019



Open-File Report 2020–1112

Front cover. Reconstruction of Underwood Creek Reach B, Milwaukee, WI, May 2017. Photograph taken by Barbara C. Scudder Eikenberry, U.S. Geological Survey.

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By Amanda H. Bell, Daniel J. Sullivan, and Barbara C. Scudder Eikenberry

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**U.S. Department of the Interior
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Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
	Area	
square mile (mi ²)	2.590	square kilometer (km ²)
	Flow rate	
cubic foot per second (ft ³ /s)	0.02832	cubic meter per second (m ³ /s)

International System of Units to U.S. customary units

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch (in.)
meter (m)	3.281	foot (ft)
	Area	
square kilometer (km ²)	0.3861	square mile (mi ²)

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

$$^{\circ}\text{F} = (1.8 \times ^{\circ}\text{C}) + 32.$$

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

$$^{\circ}\text{C} = (^{\circ}\text{F} - 32) / 1.8.$$

Abbreviations

IBI	Index of Biotic Integrity
MMSD	Milwaukee Metropolitan Sewerage District
SEWRPC	Southeastern Wisconsin Regional Planning Commission
USACE	U.S. Army Corp of Engineers
USGS	U.S. Geological Survey

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Abstract

Beginning in 2010, sections of Underwood Creek in Milwaukee County, Wisconsin, have undergone reconstruction to allow for improved fish habitat and better management of storm flows. In addition, dam and drop structures were removed to help improve fish migration while reintroducing several native fish species. With the reconstruction of Underwood Creek underway, the Milwaukee Metropolitan Sewerage District sought to evaluate if these measures have resulted in improvements to the fish community in the upstream parts of the watershed. The U.S. Geological Survey began sampling fish communities in 2004 at the farthest downstream site on Underwood Creek (Reach A) which was reconstructed in 2017. Reach B, which is slightly upstream, had undergone reconstruction in 2010 and fish community sampling began in 2016. A third reach farther upstream near Elm Grove was scheduled to begin reconstruction in 2019. To compare the fish before and after reconstruction at the Elm Grove Reach, a fish community survey was conducted in spring of 2019 at Elm Grove and Reach B. This document describes the fish community from this sampling in comparison to previous surveys. Before reconstruction, Elm Grove Reach contained fish species more indicative of a slower, stagnant, warmwater stream than the other two rehabilitated reaches. Although six of the eight species found in Elm Grove Reach have been found at the lower reaches, all but two of the species are considered tolerant. Reconstruction of Elm Grove Reach to a similar habitat as the lower reaches will likely support a more diverse fish community.

Introduction

Underwood Creek is an 8-mile long, small, wadable stream in Milwaukee County, Wisc., and is a major tributary to the Menomonee River. The 20-square mile watershed is mostly composed of urban land including dense residential, commercial, and industrial (Scudder Eikenberry and others, 2020b). During the 1960s and 1970s, sections of Underwood Creek were modified from its natural bed into a

wider, concrete-lined, straightened channel with multiple drop structures in an effort to mitigate flooding (U.S. Army Corps of Engineers, 2015). However, 50 years of increased urban development created larger overland flows than the modified channel was designed to manage. In 1999, the Milwaukee Metropolitan Sewerage District (MMSD) began work with the Southeastern Wisconsin Regional Planning Commission (SEWRPC) to develop a flood mitigation plan and management alternatives for the concrete-lined sections and drop structures along the creek (Southeastern Wisconsin Regional Planning Commission, 2000). In 2006, the MMSD and the U.S. Army Corps of Engineers (USACE) developed a plan to begin reconstruction of 6,600 linear feet of Underwood Creek from the confluence of the Menomonee River upstream to U.S. Highway 100 (fig. 1; Sear and others, 2010; Sear and Fowler, 2006; U.S. Army Corps of Engineers, 2015). This reconstruction effort replaces the concrete-lined channel and drop structures, which prevent fish from migrating from Lake Michigan to the headwaters to spawn, with a more natural boulder and stone-lined channel and a riffle-pool-run design. It also widens the floodplain area and reestablishes native vegetation in the riparian corridor. The first phase of the reconstruction was completed in 2010 and restored 2,200 linear feet of Underwood Creek between the Canadian Pacific Railroad and Mayfair Road (Highway 100) which encompassed Reach B (USGS station number 04087088-Reach B; U.S. Army Corps of Engineers, 2015). The second phase, completed in 2017 and encompassing Reach A, included the section of Underwood Creek from Highway 45 downstream to the confluence with the Menomonee River adjacent to Hansen Golf Course (USGS station number 04087088-Reach A; U.S. Army Corps of Engineers, 2015). With the lower section of Underwood Creek reconstructed to improve flood mitigation and storage, fish passage, and habitat restoration, a feasibility study began in 2018 to remove an additional 12,600 linear feet of concrete and 5 drop structures in Upper Underwood Creek upstream of Mayfair Road (U.S. Army Corps of Engineers, 2018). The goal of this project is to reconnect anadromous fish with historical spawning habitat in the headwater of Underwood Creek by reducing creek velocities to allow northern pike (*Esox lucius*) and nonjumping fish species (*Oncorhynchus mykiss* [steelhead]) passage and provide rest areas and areas to reduce predation.

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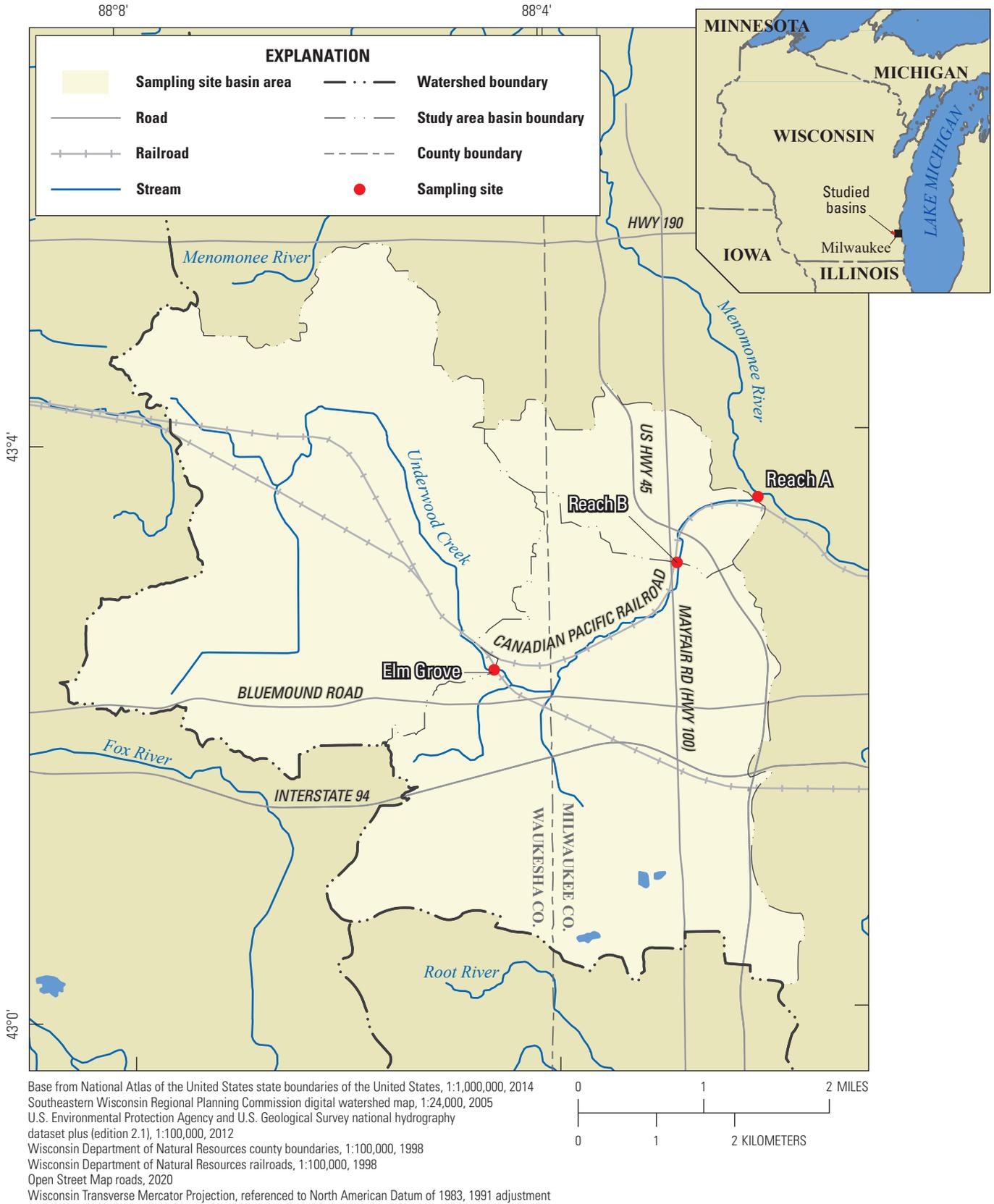


Figure 1. Map of Underwood Creek in Milwaukee, Wisconsin. The three reaches sampled for this report are noted as Reach A, Reach B, and Elm Grove Reach.

Fish community surveys at the farthest downstream site (Reach A) have been conducted by the USGS every three years since 2004, as part of a larger MMSD and USGS cooperative project. In 2016, fish community sampling also began the 3-year sampling schedule in Reach B after the reconstruction of the channel and reinstallation of the USGS streamgage (04087088). The water flowing through the pre-reconstruction concrete-lined channels of Underwood Creek was shallow (except during storm runoff periods) with warm water temperatures, little or no canopy cover of the stream channel, and no habitat structure for fish cover. During storm events, the stream levels would rise and fall quickly, carrying pollutants and debris that washed off from the watershed. These conditions limited the fish community in Underwood Creek to small minnow species (Cyprinidae) and occasional other small fish species that are tolerant of warm temperatures, low dissolved oxygen, and high pollution concentrations (Becker, 1983; Lyons, 1992). With the reconstruction of Underwood Creek, MMSD wanted to verify that improvements increased fish habitat and allowed passage to the upstream parts of the watershed. Therefore, in the spring of 2019 a third reach near Elm Grove, immediately upstream from the county line between Milwaukee and Waukesha Counties near Bluemound Road (USGS station number 0408708567; hereafter Elm Grove Reach), was sampled to compare the fish before and after reconstruction. Reach B was sampled the same day as Elm Grove to compare to the downstream sites. This report describes the fish community in these two reaches during April 2019 and community data collected from 2004 through 2019 from Reach A and B. This information will serve as a baseline comparison for sampling after the reconstruction downstream of the Elm Grove Reach is complete.

Methods

The methods used to survey the fish community are based on Moulton II and others (2002). Briefly, a representative fish community sample was collected using backpack-mounted electrofishing units and a minnow seine with ¼-inch mesh along a 150-meter reach at each location. Two electrofishing passes of the sampling reach were supplemented with three seine hauls per site. The sampling effort was consistent for all sampling events. One backpack shocker using a pulsed direct-current was operated by certified and experienced personnel. Two additional personnel used nets with ¼-inch mesh to capture the fish and place them in buckets with battery-operated aerators to minimize stress on the fish. Identification was determined by one of two aquatic biologists. Fish were identified to the lowest practical taxonomic level (generally species), counted, and released to the stream. Those few fish that could not be identified in the field were identified later in the lab. In the case of gamefish, the fish total length and weight were recorded for the first 30 fish of each species.

All field-level information was recorded on paper field sheets and were reviewed twice for completeness and accuracy: once before leaving the sampling location and again at the USGS office during database entry. Sampling information and fish data were entered into the USGS BioData database where other MMSD fish data currently reside (U.S. Geological Survey, 2020a). Field sheets were scanned electronically and stored at the USGS Upper Midwest Water Science Center in Middleton, Wisconsin, and the original hard copies of the sheets will be kept for 5 years. All fish data were reviewed and compared with any previous USGS fish data for the sampled locations or nearby locations on Underwood Creek. Data were entered into a program that computes the fish Index of Biotic Integrity (IBI) for Wisconsin warmwater streams. This index returns a relative score to assess the condition of the fish assemblage that is based on biological measures or metrics including: the number of species and individuals; native species; predator fish; number of fish in certain groups such as sunfishes (Centrarchidae), suckers (Catostomidae); pollution-sensitive and pollution-tolerant fish; and the fish IBI for Wisconsin warmwater streams (Lyons, 1992). R version 3.6.1 programming language was used for summarizing the data (R Core Team, 2013).

The warmwater IBI was used for Underwood Creek based on temperature and flow data from the USGS streamgage at Underwood Creek (04087088; US Geological Survey, 2020b). The stream temperature model predicts that Underwood Creek would be in the warm-transition range (Stewart and others, 2015; Wisconsin Department of Natural Resources, 2020). However, based on the daily (beginning around June 18 through September 7) temperature data at the USGS station 04087088 from 2010 to 2015, many (39 of 82) of the daily maximum temperatures are greater than 24.6 degrees Celsius (°C, 76 degrees Fahrenheit [°F]). The maximum for the time frame is 28.8 °C (83.8 °F). The 90th percentile for flow during that same period ranges from 11 to 120 cubic feet per second (average 33.7 cubic feet per second). These two variables indicate that Underwood Creek would fall into a warm main stem category, which is why the warmwater IBI is used for these reaches.

Abundance data were summarized for similarity using Primer 6 software (Clarke and Gorley, 2006). The relative abundance of each taxon was determined for each sample and then fourth-root transformed before a Bray-Curtis Similarity was performed to determine similarity between each of the samples. Similarities range from zero (having no similarity) to 100 (samples are perfectly equal). A fourth-root transformation decreases the effects of common taxa and increases the effects of intermediate and rare taxa such that more taxa have an effect in the final multivariate analyses (Clarke and Gorley, 2006). Due to the nature of sampling fish communities, including annual variation in water temperatures, dissolved oxygen, flow, specific conductance, fish migration, timing of sampling, among others, we have selected a cut off of similarities of 50 or greater to be indicative of having similar communities.

Fish Communities along Underwood Creek

The following discussion is a summarization and interpretation of the fish community data collected at the three reaches of Underwood Creek: (1) Reach A was sampled in the late summer every 3 years from 2004 through 2019; (2) Reach B was sampled in the late summer of 2016 and 2019, in addition to the spring of 2019; and (3) Elm Grove Reach was sampled in the spring of 2019. These sections include comparisons of the species composition, community traits, and similarities within and among the three reaches.

Species Composition

All the fish community data for the three reaches are summarized in [table 1](#). A total of 21 different fish taxa were found in the three reaches. Six of the eight fish species found at Elm Grove Reach have been found in the other two reaches at least once in previous surveys. *Semotilus atromaculatus* (creek chubs) were found during every survey at all three sites. The creek chub is a native Wisconsin species, but it has been called “a native fish with the tenacity of a weed,” and it is known to be tolerant to pollution (Becker, 1983, p. 437). Additionally, the creek chub has no preference for streambed type, water clarity, or water temperature, and it is found in medium and small streams across the state. The next two most commonly found species at all three reaches were *Rhinichthys obtusus* (blacknose dace) and *Catostomus commersonii* (white sucker). Both species are ubiquitous across Wisconsin’s lakes and rivers. They are tolerant to a wide range of temperature fluctuations, dissolved oxygen concentrations, substrate types, and pollution conditions (Becker, 1983). Although native to Wisconsin, blacknose dace and white sucker are often abundant in disturbed urban streams such as Underwood Creek because of their ability to thrive in a variety of stream conditions.

The *Rhinichthys cataractae* (longnose dace) is similar in appearance to the blacknose dace but was not found in Underwood Creek during USGS sample collection in any year. The Underwood Creek Great Lakes Fishery and Ecosystem Restoration Project document from the U.S. Army Corps of Engineers (US Army Corps of Engineers, 2015) states:

“Success is defined as the presence of white sucker or members of the sucker family (Catostomidae) and longnose dace within the reconstructed stream channel (presence/absence), the presence of white sucker or members of the Catostomidae family in the upstream river segment or the presence of 50 [percent] of the fish species found in the downstream sampling segment.”

The longnose dace is found in fast water, medium-sized streams in northern Wisconsin and in small, fast streams in southwestern Wisconsin (Becker, 1983). However, according

to descriptions by both Becker (1983) and Smith (2002), the longnose dace that occur in southeastern Wisconsin and north-eastern Illinois are commonly found “in wave-swept shallows” (Becker, 1983, p.472) and “along the turbulent pebble beaches” (Smith, 2002, p. 86) of Lake Michigan. Smith (2002, p. 86) notes that “longnose dace is common along the shoreline of Lake Michigan but extremely rare in inland streams.” Based on the published distribution, an occasional longnose dace may be found in streams in the area; however, the small, gravel and cobble streambed of the restored and un-restored reaches of Underwood Creek will not likely house a sustainable population of longnose dace.

Two species that were found in Elm Grove Reach but were not found in Reaches A and B were *Umbra limi* (central mudminnow) and *Etheostoma flabellare* (fantail darter). Based on fish community surveys of other streams in the Milwaukee area including Little Menomonee River and Willow Creek, both the fantail darter and central mudminnow are found in slow-moving streams with warmer temperatures and soft sediments such as mud and detritus (Scudder Eikenberry and others, 2020a; Scudder Eikenberry and others, 2020b). The occurrence of these two species indicate that the present conditions of Elm Grove Reach are more similar to slow velocity, warm, muddy streams than to the faster flowing Reaches A and B. This is consistent with field observations made by the researchers who have conducted the fish community survey of these and the other Milwaukee-area streams for MMSD since 2004. With the reconstruction of the first two reaches, the streams were designed to include coarser cobble substrate and to have diverse geomorphological riffle-run-pool habitat types, which encourage a more diverse aquatic community. If similar materials are used during reconstruction of Elm Grove Reach the fish community will likely shift to include additional species and greater abundance. Species that will likely begin to inhabit Elm Grove Reach after reconstruction include *Lepomis cyanellus* (green sunfish), *L. macrochirus* (bluegill), and *Campostoma anomalum* (central stoneroller), as these are species that have been found in both Reach A and B along with other streams in the Milwaukee area.

In 2007, the majority of fish collected at Reach A were *Margariscus margarita* (pearl dace) accounting for 47.76 percent of the 1,051 total fish caught. These dace were collected during seining of a large and deep pool at the downstream end of the reach. Additionally, the abundance of fish caught during the 2007 Reach A survey was more than double the abundance of any other sampling at any of the reaches, and pearl dace have not been recaptured during any other surveys. Although pearl dace are found in southeastern Wisconsin, their preferred habitat is small cool water streams (Becker, 1983), so their presence was unexpected in the shallow, concrete-lined, warmwater reach of Underwood Creek. The relative abundance of the pearl dace increased the IBI score and rating by negating the effect of other species that are considered tolerant of disturbed habitats, low dissolved oxygen, or exotic. Because we have not captured any pearl dace since 2007,

Table 1. Raw counts and percent relative abundance (in parentheses) of the fish communities at three locations in Underwood Creek, Milwaukee, Wisconsin, 2004–2019.

[m/d/yyyy, date in month, day, year; %, percent, -, not applicable]

Fish species	Underwood Creek at Wauwatosa, Wisconsin						Underwood Creek at Wauwatosa, Wisconsin			Underwood Creek at unnamed road, Elm Grove, Wisconsin
	Reach A						Reach B			
	10/8/2004	9/4/2007	9/8/2010	9/10/2013	7/25/2016	7/25/2019	7/27/2016	4/22/2019	7/24/2019	4/22/2019
Blacknose dace <i>Rhinichthys obtusus</i>	67 (26%)	85 (8.1%)	3 (5.1%)	5 (3.7%)	-	7 (1.8%)	69 (52%)	29 (44%)	38 (38%)	37 (42%)
Bluegill <i>Lepomis macrochirus</i>	-	2 (0.19%)	2 (3.4%)	2 (1.5%)	3 (1.3%)	17 (4.4%)	12 (9.1%)	-	7 (7.1%)	-
Bluntnose minnow <i>Pimephales notatus</i>	-	77 (7.3%)	-	7 (5.2%)	-	-	-	1 (1.5%)	-	-
Brook stickleback <i>Culaea inconstans</i>	-	-	-	-	-	4 (1.0%)	-	-	-	1 (1.1%)
Central mudminnow <i>Umbra limi</i>	-	-	-	-	-	-	-	-	-	3 (3.4%)
Central stoneroller <i>Camptostoma anomalum</i>	-	62 (5.9%)	1 (1.7%)	8 (5.9%)	12 (5.2%)	86 (22%)	-	7 (11%)	6 (6.1%)	-
Common carp <i>Cyprinus carpio</i>	1 (0.39%)	-	-	-	-	3 (0.78%)	-	-	-	-
Common shiner <i>Luxilus cornutus</i>	-	11 (1.0%)	-	91 (67%)	13 (5.6%)	-	-	-	-	-
Common sunfishes <i>Lepomis spp.</i>	-	-	1 (1.7%)	-	2 (0.86%)	-	-	-	-	-
Creek chub <i>Semotilus atromaculatus</i>	159 (62%)	211 (20%)	26 (44%)	1 (0.74%)	2 (0.87%)	37 (9.6%)	12 (9.1%)	10 (15%)	21 (21%)	19 (22%)
Fantail darter <i>Etheostoma flabellare</i>	-	-	-	-	-	-	-	-	-	5 (5.7%)

Table 1. Raw counts and percent relative abundance (in parentheses) of the fish communities at three locations in Underwood Creek, Milwaukee, Wisconsin, 2004–2019.—Continued

[m/d/yyyy, date in month, day, year; %, percent, -, not applicable]

Fish species	Underwood Creek at Wauwatosa, Wisconsin						Underwood Creek at Wauwatosa, Wisconsin			Underwood Creek at unnamed road, Elm Grove, Wisconsin
	Reach A						Reach B			
	10/8/2004	9/4/2007	9/8/2010	9/10/2013	7/25/2016	7/25/2019	7/27/2016	4/22/2019	7/24/2019	4/22/2019
Fathead minnow <i>Pimephales promelas</i>	6 (2.3%)	-	13 (22%)	4 (3.0%)	28 (12%)	-	-	3 (4.6%)	-	2 (2.3%)
Golden shiner <i>Notemigonus crysoleucas</i>	-	-	-	3 (2.2%)	-	-	-	-	-	-
Green sunfish <i>Lepomis cyanellus</i>	10 (3.9%)	1 (0.095%)	8 (14%)	-	-	56 (14%)	-	-	14 (14%)	-
Hornyhead chub <i>Nocomis biguttatus</i>	-	1 (0.095%)	-	-	-	-	-	1 (1.5%)	-	-
Johnny darter <i>Etheostoma nigrum</i>	-	-	1 (1.7%)	-	15 (6.5%)	8 (2.1%)	2 (1.5%)	-	1 (1.0%)	2 (2.3%)
Largemouth bass <i>Micropterus salmoides</i>	1 (0.39%)	2 (0.19%)	1 (1.7%)	6 (4.4%)	1 (0.43%)	3 (0.78%)	-	-	-	-
Northern pike <i>Esox Lucius</i>	-	-	-	1 (0.74%)	-	-	-	-	-	-
Pearl dace <i>Margariscus margarita</i>	-	502 (48%)	-	-	-	-	-	-	-	-
Pumpkinseed <i>Lepomis gibbosus</i>	1 (0.39%)	-	3 (5.1%)	-	-	-	-	-	-	-
White sucker <i>Catostomus commersonii</i>	11 (4.3%)	97 (9.2%)	-	7 (5.2%)	155 (67%)	166 (43%)	37 (28%)	15 (23%)	12 (12%)	19 (22%)
Grand total	256 (100%)	1,051 (100%)	59 (100%)	135 (100%)	231 (100%)	387 (100%)	132 (100%)	66 (100%)	99 (100%)	88 (100%)

it is likely that there is not a breeding population within the reach, and this population may have sought refuge from the Menomonee River.

Additionally, in 2013 in Reach A, two species were found that have not been found in other USGS surveys or reaches at Underwood Creek: *Esox lucius* (northern pike) and *Notemigonus crysoleucas* (golden shiner). The northern pike is a top carnivore and sport fish, along with the *Micropterus salmoides* (largemouth bass). Finding these species indicates the stream has a complex food web and ample habitat suitable for refuge. Largemouth bass have been captured every year in Reach A indicating there is a reproducing population; however, no additional northern pike have been found since 2013. Both largemouth bass and northern pike have also been found in the Menomonee River, the confluence of which is less than 200 meters downstream (Scudder Eikenberry and others, 2020b). It is likely that these larger sport fish were seeking refuge in these reaches or looking for spawning locations now that fish barriers are being removed with the reconstruction of Underwood Creek. Removing fish barriers and drop structures to allow for predator passage to spawning location in the headwaters is a goal of the reconstruction effort (Alec D. Higgins, U.S. Army Corps of Engineers, written communication, May 19, 2020). Additionally, the presence of young of year (juvenile) northern pike was a measure of success for lower reaches (U.S. Army Corps of Engineers, 2015). Northern pike spawn in emergent aquatic vegetation of flooded marshes (Becker, 1983), which is difficult to achieve in the confines of the current footprint of Underwood Creek. However, removing drop structures and designing the channel so that there are slower velocity areas along the bank where emergent vegetation is allowed to grow may provide enough habitat to encourage migration farther upstream. Using the guidelines in the U.S. Army Corps of Engineers document, Elm Grove Reach does have a population of *Catostomus commersonii* (white suckers) that constitute “50 [percent] of the fish species found in the downstream sampling segment” (U.S. Army Corps of Engineers, 2015, p. 7).

Community Traits and Index of Biotic Integrity

Of the 21 species found at the three Underwood Creek reaches, 10 species are considered tolerant of pollution and are relatively common species in Milwaukee-area streams (table 2; Becker, 1983; Lyons, 1992). The tolerant fish species found in Underwood include: blacknose dace, *Pimephales notatus* (bluntnose minnow), *Culaea inconstans* (brook stickleback), central mudminnow, *Cyprinus carpio* (common carp), creek chub, *Pimephales promelas* (fathead minnow), golden shiner, green sunfish, and white sucker (Ball, 1982; Michael Shupyrt and Jonathon Kult, Wisconsin Department of Natural Resources, written commun., October 21, 2019). During the April 2019 sampling event, the percentages of tolerant fish found at Reach B and Elm Grove Reach were 88 percent and 92 percent, respectively (table 3).

The only exotic species, common carp, has been captured twice in Reach A where one individual was collected in 2004 and three individuals in 2019.

Feeding groups are an important distinction in fish communities and each feeding category fills a unique role in the food web. Invertivore species feed mainly on aquatic insects, but may eat other invertebrates such as snails, clams, and crustaceans including crayfish. There are 10 invertivore species found in Underwood Creek (table 2). When a stream undergoes reconstruction, it may take several years to stabilize and reestablish the food web. Algae and plant communities are often populated by downstream drift or carried by animals and humans. Invertebrates take longer to repopulate because their small size limits the extent of their mobility but are also introduced through either downstream drift or wildlife and human interaction. Until these foundational members of the food web are well established, the fish diversity will be limited to those species that consume the available food. In general, rivers that have higher percentages of invertivore fish (greater than 30 percent) have a more diverse food web and can support the higher trophic level fish such as northern pike and largemouth bass (Goldstein and others, 1999). The fish communities in Reach B and Elm Grove were composed of less than 25 percent invertivore species.

Game fish and sport fish are definitions used by the Wisconsin Department of Natural Resources for fishing regulation. The game fish found in Underwood Creek are northern pike and largemouth bass, but other species of game fish include other top carnivores such as *Esox masquinongy* (muskellunge), *Micropterus dolomieu* (smallmouth bass), members of the trout and salmon families (Salmonidae), and sturgeon family (Acipenseridae), among others. Sport fish include the game fish but also include some members of the sunfish family (Centrarchidae), perch family (Percidae), and bullhead and catfish family (Ictaluridae). Sport fish, in general, are species that are targeted for recreational fishing. In contrast, forage fish are those that are not considered sport fish. The forage fish account for the majority of the abundance across all samples (88 percent or greater). These forage fish provide food for the top carnivores and are mostly invertivores and omnivores.

The IBI for Wisconsin warmwater streams is a multimetric index derived from a series of 10 metrics and is standardized to 100 such that scores range from 0 (“very poor” rating) to 60 or greater (“excellent” rating; Lyons, 1992). The metrics used to calculate the IBI include tolerance to pollution, disturbance, and low oxygen; feeding group; native species; abundance; and species richness. For the 2019 samples, Underwood Creek Elm Grove Reach had an IBI rating of “very poor,” Reach B had ratings of “very poor” (April) and “poor” (July), and Reach A had a rating of “very poor” (table 3). With the exception of Reach A in 2007 and 2013, the calculated IBI score for all fish community surveys at all the reaches have been 20 or below. Both the 2007 and 2013 surveys at Reach A had lower percentage of tolerant fish compared to surveys in other years (table 2). In 2007 and 2013, the two most common fish recorded—pearl dace at 47.76

Table 2. Fish species attributes used to calculate metrics for the warmwater Index of Biotic Integrity (Lyons, 1992).

Fish species	Native	Exotic ¹	Intolerant to pollution	Tolerant to pollution	Game fish ²	Sport fish ³	Forage fish ⁴	Omnivore fish	Invertivore fish	Top carnivore	Simple lithophilous	Low dissolved oxygen tolerant	Disturbed habitat tolerant	Darter	Sucker	Salmon	Sunfish
Blacknose dace	X			X			X				X		X				
Bluegill	X					X			X								X
Bluntnose minnow	X			X			X	X					X				
Brook stickleback	X			X			X		X			X					
Central mudminnow	X			X			X		X			X					
Central stoneroller	X						X										
Common carp		X		X			X	X				X					
Common shiner	X						X		X		X						
Common sunfishes	X					X			X								X
Creek chub	X			X			X						X				
Fantail darter	X						X		X								
Fathead minnow	X			X			X	X				X					
Golden shiner	X			X			X	X				X					
Green sunfish	X			X		X			X			X					X
Hornyhead chub	X						X		X								
Johnny darter	X						X		X					X			
Largemouth bass	X				X	X				X							
Northern pike	X				X	X				X							
Pearl dace	X						X		X								
Pumpkinseed	X					X			X								X
White sucker	X			X			X	X			X		X		X		

¹Exotic species are those not native to Wisconsin.²Game fish include top carnivore and species such as trout that are often targeted by anglers.³Sport fish include game fish, pan fish, bullheads, and catfish.⁴Forage fish are those that are not top carnivore or salmon.

Table 3. Selected metrics of the fish communities at three locations in Underwood Creek, Milwaukee, Wisconsin, 2004–2019. Several of these metrics are used to calculate the fish Index of Biotic Integrity (IBI) for Wisconsin warmwater streams (Lyons, 1992). Cells include raw value and percent of total (in parentheses).

[m/d/yyyy, date in month/day/year; %, percent, IBI, Index of Biological Integrity]

Number of:	Underwood Creek at Wauwatosa, Wisconsin						Underwood Creek at Wauwatosa, Wisconsin			Underwood Creek at unnamed road, Elm Grove, Wisconsin
	Reach A						Reach B			
	10/8/2004	9/4/2007	9/8/2010	9/10/2013	7/25/2016	7/25/2019	7/27/2016	4/22/2019	7/24/2019	4/22/2019
Species	8	11	10	11	10	10	5	7	7	8
Fish	256	1051	59	135	231	387	132	66	99	88
Exotic species ¹	1 (12%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (10%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Exotic fish ¹	1 (0.39%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	3 (0.78%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Native species	7 (88%)	11 (100%)	10 (100%)	11 (100%)	10 (100%)	9 (90%)	5 (100%)	7 (100%)	7 (100%)	8 (100%)
Native fish	255 (100%)	1051 (100%)	59 (100%)	135 (100%)	231 (100%)	384 (99%)	132 (100%)	66 (100%)	99 (100%)	88 (100%)
Tolerant species	6 (75%)	5 (45%)	4 (40%)	6 (55%)	3 (30%)	6 (60%)	3 (60%)	5 (71%)	4 (57%)	6 (75%)
Tolerant fish	254 (99%)	471 (45%)	50 (85%)	27 (20%)	185 (80%)	273 (71%)	118 (89%)	58 (88%)	85 (86%)	81 (92%)
Intolerant species	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Nontolerant species ²	2 (25%)	6 (55%)	6 (60%)	5 (45%)	7 (70%)	4 (40%)	2 (40%)	2 (29%)	3 (43%)	2 (25%)
Nontolerant fish	2 (0.78%)	580 (55%)	9 (15%)	108 (80%)	46 (20%)	114 (29%)	14 (11%)	8 (12%)	14 (14%)	7 (7.9%)
Game species ²	1 (12%)	1 (9.1%)	1 (10%)	2 (18%)	1 (10%)	1 (10%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Game fish ²	1 (0.39%)	2 (0.19%)	1 (1.7%)	7 (5.2%)	1 (0.43%)	3 (0.78%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Sport species ³	2 (25%)	2 (18%)	4 (40%)	3 (27%)	3 (30%)	2 (20%)	1 (20%)	0 (0%)	1 (14%)	0 (0%)

Table 3. Selected metrics of the fish communities at three locations in Underwood Creek, Milwaukee, Wisconsin, 2004–2019. Several of these metrics are used to calculate the fish Index of Biotic Integrity (IBI) for Wisconsin warmwater streams (Lyons, 1992). Cells include raw value and percent of total (in parentheses).—Continued

[m/d/yyyy, date in month/day/year; %, percent, IBI, Index of Biological Integrity]

Number of:	Underwood Creek at Wauwatosa, Wisconsin						Underwood Creek at Wauwatosa, Wisconsin			Underwood Creek at unnamed road, Elm Grove, Wisconsin
	Reach A						Reach B			
	10/8/2004	9/4/2007	9/8/2010	9/10/2013	7/25/2016	7/25/2019	7/27/2016	4/22/2019	7/24/2019	4/22/2019
Sport fish ³	2 (0.78%)	4 (0.38%)	7 (12%)	9 (6.7%)	5 (2.2%)	20 (5.2%)	12 (9.1%)	0 (0%)	7 (7.1%)	0 (0%)
Forage species ⁴	6 (75%)	9 (82%)	6 (60%)	8 (73%)	7 (70%)	8 (80%)	4 (80%)	7 (100%)	6 (86%)	8 (100%)
Forage fish ⁴	254 (99%)	1047 (100%)	52 (88%)	126 (93%)	226 (98%)	367 (95%)	120 (91%)	66 (100%)	92 (93%)	88 (100%)
Omnivore species	3 (38%)	2 (18%)	1 (10%)	4 (36%)	2 (20%)	2 (20%)	1 (20%)	3 (43%)	1 (14%)	2 (25%)
Omnivore fish	18 (7.0%)	174 (17%)	13 (22%)	21 (16%)	183 (79%)	169 (44%)	37 (28%)	19 (29%)	12 (12%)	21 (24%)
Invertivore species	2 (25%)	5 (45%)	5 (50%)	2 (18%)	5 (50%)	4 (40%)	2 (40%)	1 (14%)	3 (43%)	4 (50%)
Invertivore fish	11 (4.3%)	517 (49%)	15 (25%)	93 (69%)	33 (14%)	85 (22%)	14 (11%)	1 (1.5%)	22 (22%)	11 (12%)
Top carnivore species	1 (12%)	1 (9.1%)	1 (10%)	2 (18%)	1 (10%)	1 (10%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Top carnivore fish	1 (0.39%)	2 (0.19%)	1 (1.7%)	7 (5.2%)	1 (0.43%)	3 (0.78%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Simple lithophilous species	2 (25%)	3 (27%)	1 (10%)	3 (27%)	2 (20%)	2 (20%)	2 (40%)	2 (29%)	2 (29%)	2 (25%)
Simple lithophilous fish	78 (30%)	193 (18%)	3 (5.1%)	103 (76%)	168 (73%)	173 (45%)	106 (80%)	44 (67%)	50 (51%)	56 (64%)
Low dissolved oxygen tolerant species	3 (38%)	1 (9.1%)	2 (20%)	2 (18%)	1 (10%)	3 (30%)	0 (0%)	1 (14%)	1 (14%)	3 (38%)
Low dissolved oxygen tolerant fish	17 (6.6%)	1 (0.095%)	21 (36%)	7 (5.2%)	28 (12%)	63 (16%)	0 (0%)	3 (4.5%)	14 (14%)	6 (6.8%)

Table 3. Selected metrics of the fish communities at three locations in Underwood Creek, Milwaukee, Wisconsin, 2004–2019. Several of these metrics are used to calculate the fish Index of Biotic Integrity (IBI) for Wisconsin warmwater streams (Lyons, 1992). Cells include raw value and percent of total (in parentheses).—Continued

[m/d/yyyy, date in month/day/year; %, percent, IBI, Index of Biological Integrity]

Number of:	Underwood Creek at Wauwatosa, Wisconsin						Underwood Creek at Wauwatosa, Wisconsin			Underwood Creek at unnamed road, Elm Grove, Wisconsin
	Reach A						Reach B			
	10/8/2004	9/4/2007	9/8/2010	9/10/2013	7/25/2016	7/25/2019	7/27/2016	4/22/2019	7/24/2019	4/22/2019
Disturbed habitat tolerant species	3 (38%)	4 (36%)	2 (20%)	4 (36%)	2 (20%)	3 (30%)	3 (60%)	4 (57%)	3 (43%)	3 (38%)
Disturbed habitat tolerant fish	237 (93%)	470 (45%)	29 (49%)	20 (15%)	157 (68%)	210 (54%)	118 (89%)	55 (83%)	71 (72%)	75 (85%)
Darter species	0 (0%)	0 (0%)	1 (10%)	0 (0%)	1 (10%)	1 (10%)	1 (20%)	0 (0%)	1 (14%)	2 (25%)
Darter fish	0 (0%)	0 (0%)	1 (1.7%)	0 (0%)	15 (6.5%)	8 (2.1%)	2 (1.5%)	0 (0%)	1 (1.0%)	7 (8.0%)
Sucker species	1 (12%)	1 (9.1%)	0 (0%)	1 (9.1%)	1 (10%)	1 (10%)	1 (20%)	1 (14%)	1 (14%)	1 (12%)
Sucker fish	11 (4.3%)	97 (9.2%)	0 (0%)	7 (5.2%)	155 (67%)	166 (43%)	37 (28%)	15 (23%)	12 (12%)	19 (22%)
Salmon species	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Sunfish species	2 (25%)	2 (18%)	4 (40%)	1 (9.1%)	3 (30%)	2 (20%)	1 (20%)	0 (0%)	2 (29%)	0 (0%)
Sunfish fish	11 (4.3%)	3 (0.28%)	14 (24%)	2 (1.5%)	5 (2.2%)	73 (19%)	12 (9.1%)	0 (0%)	21 (21%)	0 (0%)
IBI Warmwater Score	10	30	7	44	22	10	7	5	20	7
IBI Warmwater Rating	VERY POOR	FAIR	VERY POOR	FAIR	POOR	VERY POOR	VERY POOR	VERY POOR	POOR	VERY POOR

¹Exotic species are those not native to Wisconsin.

²Nontolerant fish are those that are neither intolerant or tolerant to pollution.

³Game fish include top carnivore and species such as trout that are often targeted by anglers.

⁴Sport fish include game fish, pan fish, bullheads, and catfish.

⁵Forage fish are those that are not sport fish.

percent and *Luxilus cornutus* (common shiner) at 67.41 percent, respectively—are both considered moderately tolerant and are invertivores. Because these two traits are a positive component of IBI scores, when fish with these characteristics are dominant in the community it results in increased scores; therefore, both the 2007 and 2013 samples have slightly higher IBI scores.

Similarity Comparison

Using a Bray-Curtis similarity measure of 50 percent or greater, the fish community in Elm Grove Reach is more similar to Reach B's fish community than to Reach A (table 4). All three surveys from Reach B have similarities of 58 percent or greater to the Elm Grove Reach sample. Within the Reach A surveys, about half of the comparisons were greater than 50 percent, and 10 of the 18 similarities were greater than 50 percent between Reach A and Reach B. This indicates that annual variability within Reach A is about the same as the variability between Reach A and Reach B. All surveys from 2019 have similarities greater than 50 percent, indicating that the streams have fish communities with similar species and the contributions of those species are comparable to the overall structure of the community.

Summary

Beginning in 2010, sections of Underwood Creek in Milwaukee County, Wisconsin, have undergone reconstruction to allow for improved fish habitat and better management of storm flows. In addition, dam and drop structures were removed to help improve fish migration while reintroducing several native fish species. With the reconstruction of Underwood Creek underway, the Milwaukee Metropolitan Sewerage District sought to evaluate if these measures have resulted in improvements to the fish community in the upstream parts of the watershed. The USGS began sampling fish communities in 2004 at the farthest downstream site on Underwood Creek (Reach A) which was reconstructed in 2017. Reach B, which is slightly upstream, had undergone

reconstruction in 2010 and fish community sampling began in 2016. A third reach farther upstream near Elm Grove was scheduled to begin reconstruction in 2019. To compare the fish before and after reconstruction at the Elm Grove Reach, a fish community survey was conducted in spring of 2019 at Elm Grove and Reach B. This document describes the fish community from this sampling in comparison to previous surveys. Before reconstruction, Elm Grove Reach contained fish species more indicative of a slower, stagnant, warmwater stream than the other two rehabilitated reaches. Although six of the eight species found in Elm Grove Reach have been found at the lower reaches, all but two of the species are considered tolerant. Reconstruction of Elm Grove Reach to a similar habitat as the lower reaches will likely support a more diverse fish community.

Based on the fish community surveys, Underwood Creek Elm Grove Reach is more representative of a slow, stagnant, warmwater stream whereas Reach A and B are home to a fish community typical of the other riffle-run-pool sequence streams in the Milwaukee area. In general, the Index of Biotic Integrity scores for Underwood Creek are all relatively low considering that scores can range from 0 (“very poor”) to 100 (“excellent”). By reconstructing the channel to a more diverse and natural bed, and removing drop structures that prevent fish migration, it provides the aquatic community in Underwood Creek the habitat to establish a more complex food web. With the reconstruction of Elm Grove Reach designed to be similar to the other two reaches with a constructed combination of riffles, pools, and runs, the fish community will likely change to include bluegill, central stoneroller, and green sunfish, among other fish species. If habitat conditions in Elm Grove Reach after reconstruction are similar to those in Reaches A and B, it is plausible that additional fish species from upper or lower reaches may begin to populate this area. The Menomonee River contains many fish species that are able to migrate to these reaches when fish passage barriers are removed and the habitat is improved. These fish may use these newly accessible reaches as places to spawn or seek refuge; therefore, any additional habitat improvement will likely support additional diversity in this reach. Additional improvement to water quality would also support more pollution-intolerant or pollution-moderate fish species and game fish species.

Table 4. Bray-Curtis similarity matrix of the fish communities at three sampling locations in Underwood Creek, Milwaukee, Wisconsin.

[Similarities greater than 50 are bolded; m/d/yyyy, date in month/day/year]

		Underwood Creek at Wauwatosa, Wisconsin						Underwood Creek at Wauwatosa, Wisconsin			Underwood Creek at unnamed road, Elm Grove, Wisconsin
		Reach A						Reach B			
		10/8/2004	9/4/2007	9/8/2010	9/10/2013	7/25/2016	7/25/2019	7/27/2016	4/22/2019	7/24/2019	4/22/2019
Underwood Creek at Wauwatosa, Wisconsin	Reach A	10/8/2004									
		9/4/2007	49								
		9/8/2010	61	44							
		9/10/2013	42	60	45						
		7/25/2016	34	47	55	60					
Underwood Creek at Wauwatosa, Wisconsin	Reach B	7/25/2019	55	54	61	47	58				
		7/27/2016	52	48	45	39	48	63			
		4/22/2019	58	64	44	56	48	50	60		
Underwood Creek at unnamed road, Elm Grove, Wisconsin		7/24/2019	60	61	64	46	50	77	79	64	
		4/22/2019	57	40	42	35	42	51	66	62	58

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