The Impact of Above Grade Sewerline Crossings on the Distribution and Abundance of Fishes in Recovering Small Urban Streams of the Upper Ohio River Valley

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ABSTRACT

The distribution and abundance of fishes along four small urban streams in western Pennsylvania and northern West Virginia were examined. The water quality of three of these streams was moderately to severely degraded along various reaches. While resident fish communities in the degraded streams were depauperate, reaches with access were nonetheless routinely used by transient species from the nearby navigation system. Species richness and biomass of the fish communities dropped abruptly upstream of above grade, concrete-encased sewerline crossings. Similar abrupt declines in diversity and biomass were also apparent upstream of a sewerline crossing in a non-degraded stream with a high quality fishery. Where access for transient fishes from larger downstream waters was denied, index of biotic integrity scores declined by 26% to 43%, and species diversity declined by 39% to 69%. Also, partly because of the tendency for the transients to be larger than resident fishes of small streams, there was a biomass reduction between downstream and upstream sites of 81% to 87%.

INTRODUCTION

Streams draining urban industrial portions of the upper Ohio River Valley can suffer from a plethora of insults including: a legacy of polluted drainage from past mining and industrial activities; leakage of sanitary wastes from old and poorly maintained sewer systems; combined storm/sanitary sewer overflows; shock loads of deicing chemicals from airports and highways following winter thaws; filling, channelization and culverting; dry weather desiccation from extensive drainage activities; and sudden and violent storm surges from impervious urban surfaces that tend to downcut channels and degrade habitat.

Previously, the waters of many of these smaller local urban streams, and also the Monongahela River and upper Ohio River to which they are tributary, were water quality limited (Shapiro et al. 1967) and did not support any significant fisheries. The demise of fishes from rivers of the region during the late nineteenth and most of the twentieth centuries has been examined in detail by the Ohio River Valley Water Sanitation Commission (1962), Trautman (1981), Preston and White (1978), Pearson and Krumholz (1994), and others. Species of smaller rivers and stream habitats persisted in more remote, unurbanized and unpolluted refuge headwaters. However, those species associated with large river ecosystems such as sauger (*Stizostedion vitreum*), spotted bass (*Micropterus punctulatus*), drum (*Aplodinotus grunniens*), mooneye (*Hiodon tergisus*), goldeneye (*Hiodon alosoides*), river carpsucker (*Carpiodes carpio)*, silver chub (*Hybopsis storeriana*), the buffalofishes (*Ictiobus*

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spp.), the sturgeons (*Acipenser fulvescens* and *Scaphirhynchus platorynchus*) and paddlefish (*Polyodon spathula*) became locally extinct due to the pollution. Historically, the water quality of five Corps of Engineers reservoirs and two large private utility hydropower reservoirs in the upper Ohio River drainage basin was so grossly degraded that these systems were completely devoid of fish life.

The improvements in water quality that began in the 1970s allowed fish to invade and recolonize reclaimed waters. This restoration of local fisheries has been discussed by Preston and White (1978), Pearson and Krumholz (1984), Koryak and Hoskin (1994), and others. The first species to appear were those that had persisted in upstream refuges. Recolonization by many of the large river species occurred later and apparently originated from distant downstream areas.

Holland et al. (1984) showed that, depending on their design and operation, navigation dams on larger rivers can be relatively pervious to fish passage. Our observations of recolonization rates along the mainstem Ohio River, lower Monongahela River and lower Allegheny River, which have very heavy commercial barge traffic and frequent year-round lockages, suggest that fishes can generally move upstream through the navigation locks. Along the five pools of the upper Allegheny River navigation system, however, where winter and spring lockages are very infrequent, extirpated fishes were not recolonizing the upstream navigation pools until a program of fish passage lockages was initiated.

Formerly extirpated species of fish are also returning to smaller tributaries of the Allegheny River, Monongahela River, and Ohio River, but are notably absent as a group from the Beaver-Mahoning River basin reservoir tailwaters (Ohio Environmental Protection Agency, 1996, and Koryak and Hoskin, 1994). Along the Beaver River there are three low head water supply/hydropower dams, and along the Mahoning River there are 12 low head water supply dams. These structures are blocking, or at least significantly delaying, recolonization of the Beaver-Mahoning River basin.

As water quality conditions continue to improve, the focus on physical obstacles to local fish passage has moved down in scale from navigation dams on large rivers, to water supply dams on smaller rivers and intermediate size streams, to habitat fragmentation patterns now being noted relative to hydraulic obstacles on even small urban drainages. Our objectives were to characterize the resident and transient fish populations of four small recovering urban streams and to relate fish distribution and abundance to hydraulic barriers to fish access.

STUDY STREAMS

The four streams examined and their drainage areas were Nine Mile Run (19.4 km^2), Montour Run (94.8 km^2), Kings Creek (129.0 km^2), and Turtle Creek (383.3 km^2) (Figure 1). Except for Kings Creek, the water quality of the study streams is degraded but recovering.

All four streams receive varying quantities of urban runoff, which range from near negligible for Kings Creek to intense for Nine Mile Run. Bituminous coal has been mined in the basins of all four streams, which are still relatively mineralized. All are now net alkaline, although Turtle Creek is still degraded by iron and Montour Run by high aluminum in the study reaches (U.S. Army Corps of Engineers, 1987 and Koryak et al, 1998). All four streams are influenced by sanitary sewage. Ammonia is a very serious seasonal problem in the study reach of Montour Run. Lower Montour Run is seriously impacted by airport runway deicing runoff during the colder months of the year. Except for Kings Creek, while the resident fish communities of these streams are water quality stressed and limited, historically these streams have not supported any resident reproducing fish communities. The limited resident fish communities of these streams make identification of transient species less ambiguous.

There are no serious hydraulic barriers to fish passage between the receiving rivers and the selected stations along either Montour Run or Turtle Creek. On Kings Creek there is a high concrete-encased sewerline crossing located 3.5 km upstream of the confluence of Kings Creek and the Ohio River. At base flows, the minimum vertical difference between the surface elevation of the downstream scour pool and the crest of this Kings Creek barrier is 0.7 m. Along 3 km of Nine Mile Run there are eight significant hydraulic barriers to fish passage which are higher than 0.6 m. Six of these are concrete-encased sewerline crossings and two are the broken ends of paved channel sections. However, the first of these sewerline crossings, located only 0.33 km upstream from the mouth of Nine Mile Run, is emphasized in this report because it was the first fish passage limiting barrier on this stream. Between the water surface elevation of the downstream scour pool and the lowest invert of this crossing at base flows, the height of this barrier was 0.7 m. Depending upon Monongahela River flows and elevations, about the last 120 m of Nine Mile Run is influenced by Monongahela River backwater and can be considered to be a shallow embayment of the Monongahela River.

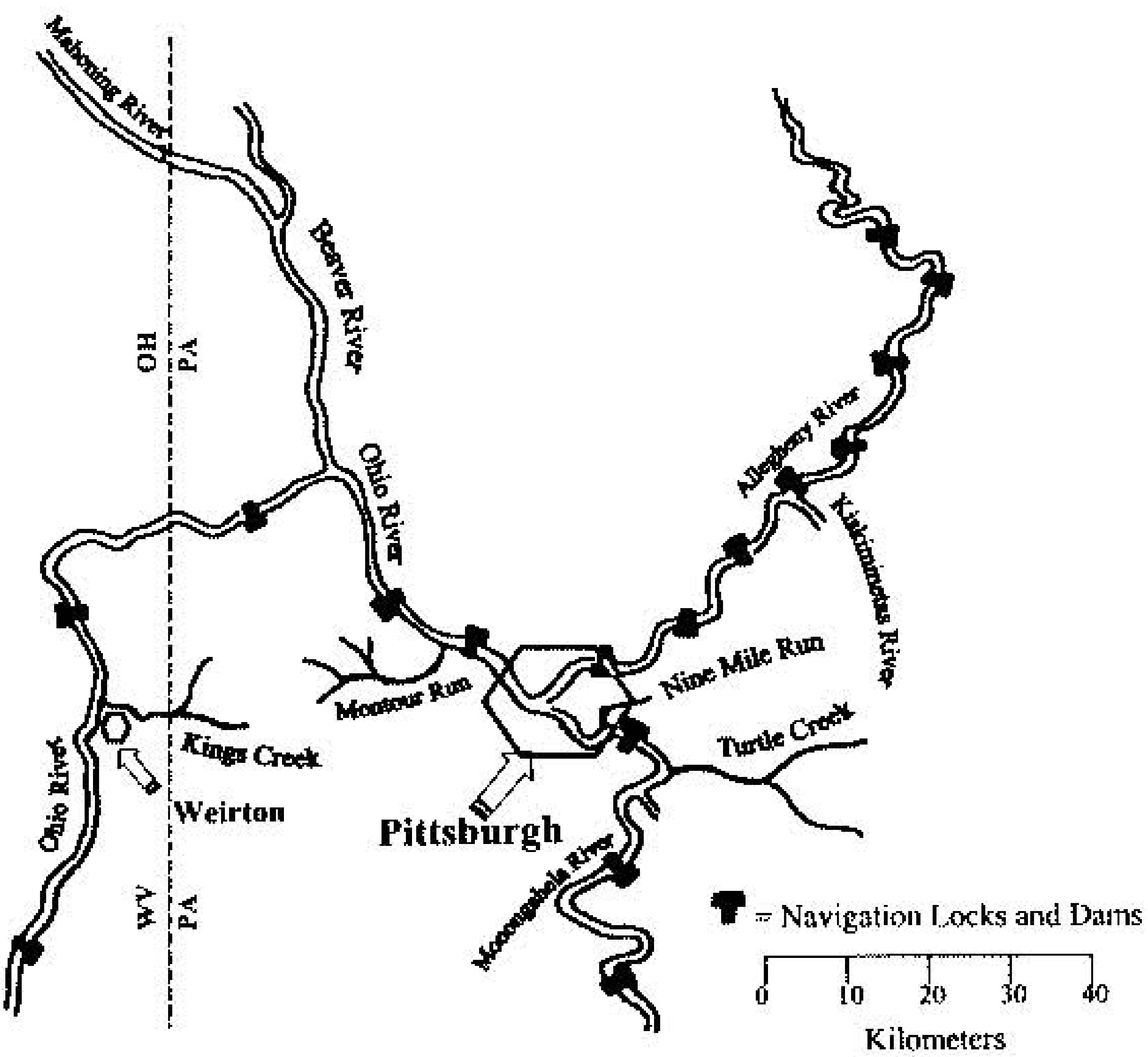

Figure 1. Study area of the lower Monongahela/ upper Ohio River navigation system in western Pennsylvania and northern West Virginia.

METHODS

This analysis is based on the results of single-pass electrofishing conducted along 17 station reaches covering the entire 3.1 km unculverted stream length of Nine Mile Run, along three station reaches of Montour Run, seven station reaches along Turtle Creek, and four reaches of Kings Creek. An operator used a backpack electrofishing unit powered by a 120-watt generator to stun fish. To characterize and rate the fish communities of these waters, indices of biotic integrity (IBI) were computed from the fish data using modified Ohio Environmental Protection Agency (1988) assessment protocols.

RESULTS AND DISCUSSION

A total of 1,395 fish of 32 combined species was collected by an electrofishing effort of 8.9 hr along the three water quality limited study streams; 435 fish of 14 species from Nine Mile Run (140/hr), 174 fish of 18 species from Montour Run (102/hr), and 786 fish of 24 species from Turtle Creek (192/hr). In contrast, along Kings Creek, the non-degraded control stream, 1,133 fish of 28 species were collected (1,259/hr).

The Montour Run watershed appears to have two distinct fish communities. The first is the headwaters and headwater tributaries fishery, dominated exclusively by large numbers of creek chubs (*Semotilus atromaculatus*), blacknose dace (*Rhinichthys atratulus*) and white sucker (*Catostomus commersoni*). Their headwater distribution and the wide size ranges observed are good indications that several year classes were present and that the three species were reproducing residents of the upper Montour Run basin. Downstream of tributaries that contributed airport runway deicing runoff to Montour Run, the pollution tolerant headwaters species were eliminated, and apparent transient fishes from the Ohio River dominated the fishery. These were adult quillback carpsucker (*Carpiodes cyprinus*) numerically 25.0% and 35.0% by weight, carp (*Cyprinus carpio*) numerically 12.5% and 32.6% by weight, and drum numerically 18.8% and 18.7% by weight of the sample. Farther downstream closer to the Ohio River at Montour km 0.15, adult golden, shorthead, and black redhorses (*Moxostoma erythorurum, M. macrolepidotum*, and *M. duquesnei*, respectively) and smallmouth bass (*Micropterus dolomieui*) were also present. Adults of these species are typical of larger stream habitat and almost certainly were transient from the nearby Ohio River.

At Turtle Creek, the fish community was dominated by sand shiners (*Notropis stramineus*), 30.2% numerically; gizzard shad (*Dorosoma cepedianum*), 21.0%; emerald shiners (*Notropis atherinoides*), 17.9%; white bass (*Morone chrysops*), 0.5%; and channel catfish (*Ictalurus punctatus*), 0.5%, all of which were likely transient.

In Nine Mile Run, upstream of the sewerline crossing obstacle at km 0.3 and over the entire remaining 2.8 km unculverted length of the stream, only four resident species of fish were present- creek chub, 78.6%; blacknose dace 9.9%; white sucker 8.4%; and bluntnose minnow (*Pimephales notatus*), 0.8%. Downstream of the initial sewerline crossing and including the embayment, there were 13 species of fish. The fish community of this lower reach was composed of emerald shiners, 42.3%; young-of-year (YOY) gizzard shad, 40.8%; sand shiners, 7.2%; blacknose dace, 2.2%; YOY smallmouth bass, 1.7%; YOY bluegill (*Lepomis macrochirus*), 1.3%; YOY white bass, 0.9%; creek chub, 0.9%; YOY green sunfish (*Lepomis cyanellus*), 0.9%; white sucker, 0.6%; stoneroller (*Campostoma anomalum*), 0.6%; mimic shiner (*Notropis volucellus*), 0.3%; and YOY largemouth bass (*Micropterus salmoides*), 0.3%. The catch per unit effort (CPUE) in the Nine Mile Run reaches above the sewerline crossing was only 43.3 fish/hr. In the lower reach downstream of the first hydraulic obstacle, however, the CPUE was 1,063 fish/hr. In terms of biomass, we collected 4.56 kg/hr below the sewerline, but only 0.86 kg/hr in the reaches upstream of the obstacle. The stressed fishery of the upper reaches of Nine Mile Run was clearly a reflection of its degraded water quality, while the much more diverse assemblage below km 0.3 was a reflection of the Monongahela River fishery.

The impact of the km 3.5 sewerline crossing barrier over Kings Creek was not complicated by degraded water quality. The 28 species collected in Kings Creek included pollution intolerant fishes such as smallmouth bass, native lamprey (Petromyzontidae g. sp.), longnose dace (*Rhinichthys cataractae*), redside dace (*Clinostomus elongatus*), rosyface shiners (*Notropis rubellus*), river chub (*Nocomis micropogon*), and five species of darters. It is notable that pollution intolerant species such as hog sucker (*Hypentelium nigricans*), rainbow darter (*Etheostoma caeruleum*), and mottled sculpin (*Cottus bairdi*) were found at all four Kings Creek stations.

The greatest diversity of fish in Kings Creek (23 species) was found in the reach below a concrete encased sewerline crossing that functioned as an obstacle to upstream passage of fish from the nearby Ohio River. At the next station upstream of this sewerline crossing, in spite of good water quality and habitat, only 14 species of fish were present. Likely transients from the Ohio River such as shorthead redhorse, golden redhorse, drum, sauger, and smallmouth bass were found only in the reach downstream of the sewerline crossing.

Upstream of the sewerline crossing of Kings Creek, we caught 12.0 kg/hr and the fish biomass of the stream was 89.8 kg/ha. At the station downstream of the sewerline, we captured 84.0 kg/hr and the biomass was 693.3 kg/ha. The downstream station included the deep scour pool below the crossing which held a majority of the fish collected. This one station held 91% of all sport fish collected and 95% of the weight of all sport fish captured during the Kings Creek survey. Smallmouth bass were numerically 11.3% of the sample at this station, and accounted for 50.2% of the sample weight. The high biomass at this location was probably an artifact of both the scour pool habitat provided downstream of the sewerline crossing, and the accumulation of fishes moving upstream to the barrier.

Multiple fishery metrics were utilized to compute index of biotic integrity (IBI) values in order to allow simplified numeric score comparisons of various reaches of the four study streams (Table 1). In spite of their degraded water quality, both Montour Run and Turtle Creek, which were accessible to fish from the navigation system, had FAIR IBI condition scores (29 and 31, respectively). While lower Nine Mile Run near the Monongahela River had a GOOD score of 35, above its first sewerline crossing obstacle at km 0.3 the IBI score was VERY POOR (20). Similarly, the portion of Kings Creek accessible from the Ohio River showed an EXCEPTIONAL score of 54 but dropped to a GOOD score of 40 upstream of its first barrier to upstream fish passage.

Hydraulic obstacles to passage along streams and rivers have long and widely been recognized as critical factors for salmonid and other migratory fishes. The results of this study demonstrated that even relatively low barriers can adversely influence the diversity of small urban stream fisheries, often involving species not normally considered to be highly mobile. At Kings Creek, an above grade concrete-encased sewerline crossing obstacle caused species richness to abruptly decrease by 39% (from 23 to 14 species), biomass by 87%, (from 693.3 kg/h to 89.8 kg/h) and IBI scores by 26% (from 54 to 40). The adverse impacts of a similar sewerline crossing were even more extreme along water quality degraded Nine Mile Run.

Because small urban waterways by definition drain predominantly impervious surfaces, they demonstrate very sharp hydrographs with short duration but high peak flows and erosive velocities. For this reason small urban streams tend to develop deeply incised, downcut and oversized channels. The sewerline crossings we examined, however, provided grade controls to channel head cutting and developed deep downstream scour pools that were excellent fish habitat. Therefore, removal of older sewerline crossing obstacles and replacement with below grade lines would not only be extremely expensive and difficult, but would result in some negative habitat impacts. A more economical and better solution might be to build low step weirs to solve the fish passage problems at these obstacles.

Table 1. Comparison of fishery index of biotic integrity (IBI)[a] values for tributaries of the Ohio/Monongahela River navigation system.

IBI METRIC	IBI METRIC VALUE( ) and SCORE					
	Turtle Creek @ km 2.7	Montour Run @ km 4.5	Nine Mile Run above km 0.3 Sewerline Obstacle	Nine Mile Run below km 0.3 Sewerline Obstacle	Kings Creek above km 3.5 Sewerline Obstacle	Kings Creek below km 3.5 Sewerline Obstacle
Total Number of Species	(11)3	(7)1	(4)1	(13)4	(14)3	(23)5
Number of Darter Species	(1)1	(0)1	(0)1	(0)1	(4)5	(5)5
Number of Sunfish Species	(0)1	(1)1	(0)1	(2)3	(1)1	(2)3
Number of Sucker Species	(2)1	(2)3	(1)1	(1)1	(2)3	(4)5
Number of Intolerant Species	(1)1	(0)1	(0)1	(0)1	(3)3	(4)3
Percent Tolerant Species	(23.1)3	(12.5)5	(100)1	(100)1	(3.0)3	(20.1)5
Percent Omnivores	(44.1)1	(50.0)0	(100)1	(42.8)1	(20.2)3	(16.4)5
Percent Insectivorous Species	(53.6)5	(56.2)5	(0)1	(53.7)5	(44.0)3	(41.2)3
Percent Top Carnivores	(1.0)2	(0)1	(0)1	(2.9)3	(0.0)1	(11.7)5
Number of Individuals >300 mm	(195)3	(24)1	(<10)1	(>1000)5	(1102)5	(272)5
Percent Hybrids	(0)5	(0)5	(0)5	(0)5	(0)5	(0)5
Percent DELT Anomalies	(0)5	(0)5	(0)5	(0)5	(0)5	(0)5
Percent Species of Fish Likely Transient	45.5	42.8	0	76.9	0	26.1
SCORE	31	29	20	35	40	54
RATING	FAIR	FAIR	POOR	GOOD	GOOD	EXCEPTIONAL

[a] IBI determined from criteria established by the Ohio Environmental Protection Agency for data collected by wading from streams with drainage areas between 52 and 774 km^2, with each station drainage area weighted for each metric (Ohio Environmental Protection Agency 1988). Cumulative score ratings are as follows: >50 exceptional, 35-49 good, 25-34 fair, 15-24 poor, and <14 very poor.

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