Improvements in Fish Populations of the Monongahela River, West Virginia, after Reduction of Acid Mine Drainage

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Abstract: Historically, degradation of water quality from mining activity in the Monongahela River Basin adversely affected fish populations in the mainstem river. Improvement of water quality since 1971 has resulted in positive changes in fish populations. We assessed changes in the fishery by analyzing rotenone samples in relation to changes in water quality. Before 1970, pH ranged between 3.8 and 5.8 and alkalinity between 0.0 and 2.0 mg/l. After 1980, mean annual pH ranged from 7.0 to 7.3 and alkalinity ranged from 8.7 to 12.9 mg/l. From 1973 to 1990, mean fish biomass increased in nearly every sample from 41 to 355 kg/ha. Fish diversity also increased. The increase in biomass was significantly correlated with mean alkalinity, but not with mean annual river discharge or mean annual pH.

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The physiological responses of fish to environmental acidity and mine drainage from coal mining have been well documented for fish exposed to acid conditions (e.g., Parsons 1977, Fromm 1980, Spry et al. 1981). Potential deleterious effects of coal mining on surface water include depression of pH, as well as increases in iron and other metals, sulfates, and sediment load. The Monongahela River, West Virginia, has been affected by acid mine drainage more than any other river in the United States (U.S. Environ. Protection Agency 1971). Its 3 major tributaries, the Cheat, Tygart Valley, and West Fork rivers, experienced chronic and acute depression of pH (<6.0) for many years as a result of acid mine drainage.

Substantial improvements in water quality occurred after the 1971 West Virginia Surface Mining and Reclamation Act, which increased restrictions on the surface mining industry. In an effort to reduce acid mine drainage into rivers, provisions in the act required identification of acid-producing mine spoils and drainage control plans before the start of mining. As pH in the Monongahela and Tygart Valley rivers increased, fishery management efforts also increased, and the fishery improved significantly (Jernejcic 1978). Our objective was to describe changes that occurred in fish populations of the mainstem Monongahela River since 1971.

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Methods

The Monongahela River Basin occupies about 7,143 ha in north-central West Virginia and is formed from 2 major tributaries, the Tygart Valley and West Fork rivers. The mainstem flows 206 km north to Pittsburgh, Pennsylvania, to become a major tributary of the Ohio River (Fig. 1). Fifty-nine kilometers of the Monongahela River lie in West Virginia, regulated by a series of 3 dams with navigation locks at river kilometers 184.6 (Opekiska), 173.4 (Hildebrand), and 163.2 (Morgantown, Fig. 1).

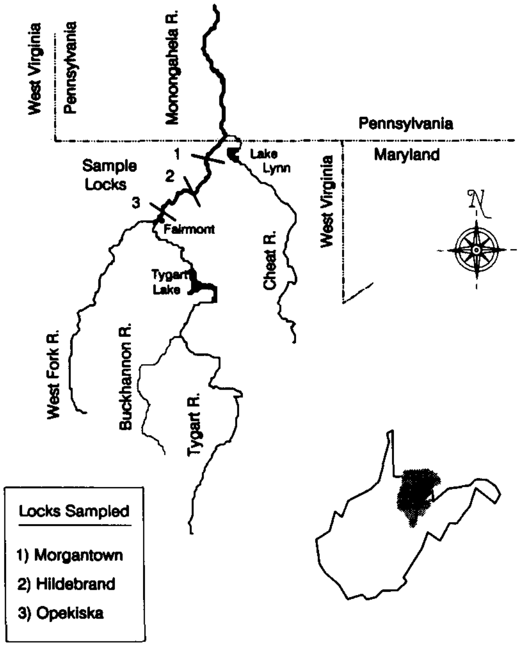

Figure 1. Location of sample sites and tributaries of the Monongahela River, West Virginia.

The lock chambers, with a surface area of 2.8 ha (1.15 acres), were sampled using rotenone to provide quantitative estimates of fish populations. Lock rotenone surveys were conducted each September at 2- or 3-year intervals. All 3 locks were sampled in 1976, 1978, 1980, 1982, 1985, 1988, and 1990. In 1973 and 1984, Opekiska was the only lock sampled.

Twelve to 24 hours before the survey, a fill valve at the head of the chamber was opened slightly while the downstream gate was fully opened. Flow through the lock chamber encouraged fish movement into the chamber. The downstream gate was closed after collecting boats entered the chamber at 0800 hours, and rotenone was applied to achieve a concentration of 1.5 to 2.0 mg/l. Fish collecting continued by boat until all available fish were netted, about 2–4 hours. Water temperatures averaged 24 C. Fish were sorted by species and size class, counted, and weighed.

Water quality data for the Monongahela River have been collected by several agencies, including the West Virginia Division of Natural Resources, U.S. Geological Survey, U.S. Army Corp of Engineers, U.S. Environmental Protection Agency, and the City of Fairmont water plant. Water quality in the Monongahela may be characterized as moderately soft with little buffering capacity. There is no gauge on the Monongahela River, so river discharge was calculated from the sum of flows measured at gauges on the West Fork River at Enterprise, the Tygart Valley River at Colfax, and Buffalo Creek at Barrackville (U.S. Geol. Survey, 1970–1990).

Results and Discussion

The immediate adverse effects of acid mine drainage are often local, affecting streams close to the source (Parsons 1977). Further downstream, impacts from low pH and the subsequent mobilization of potentially toxic metals such as aluminum, zinc, copper, cadmium, and iron may be more subtle, primarily because of dilution from tributaries. Because of the paucity of data on metal concentrations in the Monongahela River, alkalinity and pH were used as the most reliable indexes of water quality.

During the 1960s, mean pH levels in the Monongahela River ranged from 3.8 to 5.8. These values were well below the critical range for reproduction of many warmwater species. Warmwater fish species cannot successfully reproduce below pH 5.5–6.5 (e.g., Katz 1969). After 1971, pH readings for the Monongahela at Fairmont began to increase yearly, from a mean of 6.5 in 1972, to between 7.0 and 7.3 since 1980 (Fig. 2). Alkalinity also generally increased during the period analyzed, from 0.8 mg/l in 1966 to 12.9 mg/l in 1990 (Fig. 2).

The average mean annual discharge in the mainstem from 1966 to 1990 was 3,780 cubic feet per second. In 1988, a low water year, the mean annual discharge was 2,517 cfs, and in 1972, a high water year, the mean was 6,255 cfs.

In general, mean fish biomass at the 3 sample sites increased, from 41 kg/ha in 1973 to 355 kg/ha in 1988 (Fig. 3). In 1984, total mean biomass showed a substantial decrease, which may be attributed to high river turbidity that caused cancellation of the Hildebrand and Morgantown surveys. In the 1978 and 1980

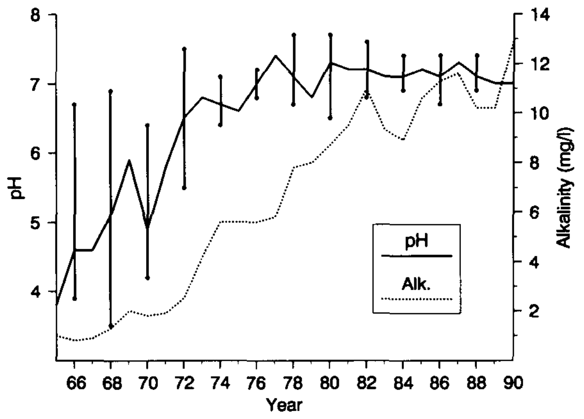

Figure 2. Mean annual pH and ranges and alkalinity (mg/l, $CaCO_3$ equivalents) in the Monongahela River, measured at Fairmont, West Virginia.

samples, biomass of nongame fish declined, while biomass of game fish increased slightly (Fig. 3). The decline in biomass of nongame fish was due to a decrease of gizzard shad (*Dorosoma cepedianum*), possibly a result of severe winters in 1976 and 1977 (Jernejcic 1979). Biomass of game fish increased in most sample years, except for a decrease in 1990 (Fig. 3). In 1988, a low water year, biomass was exceptionally high. Two additional game fish, sauger (*Stizostedion canadense*) and white bass (*Morone chrysops*), contributed to the high 1988 catch.

Species composition in lock rotenone samples (Table 1) also changed from 1973 to 1990. Before 1971, brown bullheads and yellow bullheads (*Ictalurus* spp.) were the only harvestable species in the Monongahela River (Jernejcic 1977). Since 1973, 30 species of fish have been recorded from the Monongahela, excluding minnows, darters, and brook silversides (Jernejcic 1989). Walleye, muskellunge, and gizzard shad were first collected during the 1976 rotenone sample; drum appeared

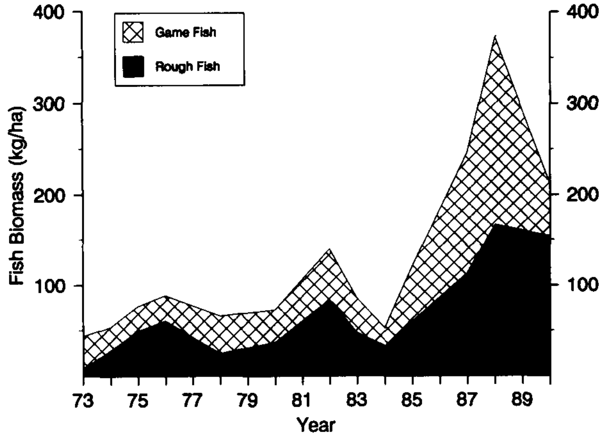

Figure 3. Mean biomass of fish collected during rotenone surveys at three navigation lock and dam facilities on the Monongahela River, West Virginia.

Table 1. Composition of fish collected in lock rotenone samples from the Monongahela River, 1973–1990.

Common name	Scientific name
Nongame fish	
Carp	*Cyprinus carpio*
Gizzard shad	*Dorosoma cepedianum*
Brook silverside	*Labidesthes sicculus*
Log perch	*Percina caprodes*
White sucker	*Catastomus commersoni*
Bluntnose minnow	*Pimephales notatus*
Redhorse	*Moxostoma* spp.
Darters	*Etheostoma* spp.
Shiners	*Notropis* spp.
Game Fish	
Largemouth bass	*Micropterus salmoides*
Smallmouth bass	*Micropterus dolomieui*
Spotted bass	*Micropterus punctatus*
Rock bass	*Ambloplites rupestris*
Walleye	*Stizostedion vitreum*
Sauger	*Stizostedion canadense*
Yellow perch	*Perca flavescens*
White bass	*Morone chrysops*
Black crappie	*Pomoxis nigromaculatus*
White crappie	*Pomoxis annularis*
Bluegill	*Lepomis macrochirus*
Pumpkinseed	*Lepomis gibbosus*
Green sunfish	*Lepomis cyanellus*
Drum	*Aplodinotus grunniens*
Channel catfish	*Ictalurus punctatus*
Brown bullhead	*Ictalurus nebulosus*
Yellow bullhead	*Ictalurus natalis*
Flathead catfish	*Pylodictis olivaris*
Muskellunge	*Esox masquinongy*

in 1978, flathead catfish in 1982, and white bass and sauger in 1988 (scientific names are found in Table 1). Muskellunge have been stocked during most years since 1973 in the Monongahela River. Walleyes were also stocked from 1973 to 1976 in Tygart Lake and have established a reproducing population that migrated downstream to the Monongahela River. Gizzard shad, drum, flathead catfish, sauger, and white bass migrated upstream from the Ohio River as water quality improved.

The most notable changes in percent composition of game fish were observed for drum, channel catfish, largemouth bass, spotted bass, and bullhead catfishes (Fig. 4). Acid-tolerant bullhead catfish declined from 15% in 1973 and 20% in 1978, to <1% in 1988. Drum were not present in samples until 1978 and increased from 2% of the total catch in 1980 to 32% in 1985. Channel catfish also increased from a low of 4% in 1976 to a high of 24% in 1988. Largemouth bass declined from about 10% in 1973 to <1% in 1990. Spotted bass, however, have become slightly more abundant. The increase of spotted bass may be related to habitat preference

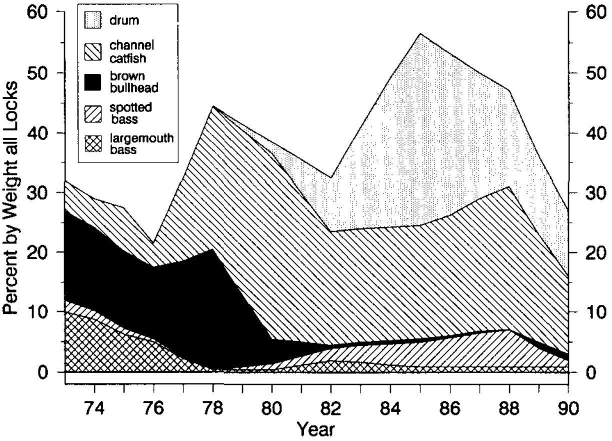

Figure 4. Mean percent composition (by weight) of fish collected at 3 navigation lock and dam facilities on the Monongahela River, West Virginia.

and availability. Spotted bass prefer larger streams and rivers, whereas largemouth bass prefer clear, quiet waters with aquatic vegetation (Robbins and MacCrimmon 1974).

Since 1972 the Monongahela River fishery has changed significantly in total biomass and species composition. Biomass has approximately quadrupled, and 6 new species of game fish have been collected. Improved water quality and active fishery management efforts have resulted in a popular sport fishery. From 1981 to 1985, 77 trophy citations were awarded for 11 species of fish caught in the Monongahela River, dominated by carp (24), muskellunge (13), and channel catfish (15). Between 1986 and 1990, 150 trophy citations were awarded for 13 species, dominated by carp (70), channel catfish (22), and walleye (13). Citations were awarded for 4 additional species from 1986 to 1990, spotted bass (2), white bass (2), hybrid striped bass (2), and sauger (4).

The number of organized bass fishing tournaments is also an indicator of a viable fishery. The number of bass tournaments increased from 2 in 1976 to a high of 50 in 1988. The Opekiska Pool of the Monongahela River was the most used West Virginia tournament site in 1988 and the second highest of all sites for a 1 year period from 1976 through 1990 (Jernejcic 1991).

The increase in fish biomass was correlated with increases in alkalinity (Spearman correlation coefficient = 0.83, $P < 0.05$) but not with pH or mean annual river flow. From 1971 to 1990, pH rose rapidly in response to the buffering effect of increased alkalinity (Fig. 2). This increase in pH suggests that controlling and treating acid mine drainage has played a role in improvement of water quality. The mining industry relies on neutralization of acid mine drainage with addition of alkaline materials. The net alkalinity that results from treatment of surface and deep mine drainages in the Tygart Valley, West Fork, and other mainstem tributaries appears to have relieved some of the acid stress on riverine biota in the West Virginia reach of the Monongahela River.

Despite the dramatic changes in its fish fauna, recovery of the Monongahela River has only begun. Water resources in the basin are still adversely affected by acid drainage from abandoned mines and inadequately treated drainage from active mines. Fish kills as a result of acid mine water still occur frequently in the basin. Neutralization systems at active regulated mines do not eliminate acid sources, which may persist for extremely long periods. In a study of acid drainages from only 4 active and inactive mines, Ramsey and Brannon (1988) concluded that if unneutralized, 40 miles of the lower Buckhannon River, a major tributary of the Tygart Valley River, would be at pH 4.3 to 5.8. A further consequence would be the loss of the Buckhannon River's capacity to buffer periodic acid loads carried to Tygart Lake from the upper Tygart River, and potential loss of fisheries in the Buckhannon River, Tygart River, and Tygart Lake. Should treatment cease in the Buckhannon basin, degradation of water quality would occur in the Monongahela River as well.

As long as water quality continues to improve and alkalinity and pH do not decline from current levels, additional improvement of the fishery in the Monongahela River can be expected. However, recovery and maintenance of fishery resources will be dependent on continued treatment and control of active mine drainages and rehabilitation of abandoned mine drainages in the basin.

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