EVALUATING IMPACTS OF MOUNTAIN TOP REMOVAL/VALLEY FILL COAL MINING ON STREAM FISH POPULATIONS[1]

C. Paola Ferreri, Jay R. Stauffer, and Timothy D. Stecko[2]

Abstract. Little information exists regarding the effects of mountain top removal/valley fill coal mining on stream fish populations in West Virginia and Kentucky. To address this knowledge gap, we conducted a study in cooperation with U.S. Environmental Protection Agency (USEPA) Region III to characterize the fish communities that exist in these regions and to evaluate the effects of these mining operations on fish populations. During 1999-2000, fish assemblages were sampled in 58 sites in West Virginia and in 15 sites in Kentucky. Results from this sampling effort indicated that not enough reference (unmined) sites were included to adequately assess the potential effects of mountain top mining/valley fill operations on fish communities in the area. We found a strong relationship between stream size (as described by stream order) and the total number of fish species present that confounded the effects of mining. As a result, in Fall 2001, we sampled 13 sites in the Guyandotte River drainage, including eight sites in the Mud River that were classified as filled or filled/residential and five reference (unmined) sites in the Big Ugly. Both the number of species and the number of benthic species present were greater in the reference sites than in the filled sites in 2001. Water chemistry analysis revealed that five of the Mud River sites sampled in 2001 had detectable levels of selenium (9.5 – 31.5 μg/l). Sites that were associated with valley fills that had detectable levels of selenium seemed to be more impaired than sites associated with valley fills that had no detectable levels of selenium. Clearly, careful site selection and a multiple year collecting regimen are needed to determine the effects of these mining operations on stream fish assemblages.

Additional Key Words: fish communities, selenium

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Introduction

The State of West Virginia encompasses 62,890 km^2 and is drained by over 45,000 km of streams. The primary region of mountain top removal/valley fill (MTM/VF) coal mining in West Virginia concentrates on coal seams that overlay the Kanawha Formation and the Allegheny Formation (Fedorko and Blake 1998) and encompasses an important region for fish diversity (Stuaffer et al. 1995). The Kanawha River harbors 105 native species, the New River has 56 native species (six of which are endemic), and the Guyandotte River is home to 90 native species (Stuaffer et al. 1995). Although the region is unique and important in the evolution and speciation of North American freshwater fishes, little historical information exists regarding stream fish populations in the primary region of MTM/VF coal mining. As a result, in 1999 the U.S. Fish and Wildlife Service requested that we conduct a study to characterize the fish communities that exist in the primary region of MTM/VF coal mining in West Virginia and to evaluate the effects of these mining operations on fish populations residing in downstream areas as part of the development of an Environmental Impact Statement (EIS). Our study was to be executed in tandem with another study designed to evaluate the effects of MTM/VF mining on stream benthic macroinvertebrates, and fish communities were to be characterized at study sites that had already been selected for the study of benthic macroinvertebrates.

During 1999-2000, we sampled fish assemblages in 58 sites in West Virginia located on 1st through 5th order streams. Sites were assigned an EIS Classification based on U.S. EPA Region III classification (Green et al. 2000): "unmined" (EIS Class = 0, reference sites that did not have any mining activity in the watershed), "mined" (EIS Class = 1, sites that had surface mining activity in the watershed), "filled" (EIS Class = 2, sites that had MTM/VF coal mining occurring in the watershed), and "filled/residential" (EIS Class = 3, sites that had MTM/VF coal mining in the watershed and also had residents living in the watershed). Unfortunately, evaluation of MTM/VF coal mining operations on fish communities in this region of West Virginia was confounded by differences in stream order (Fig. 1). In general, the total number of fish species present is expected to increase as stream size (measured by stream order) increases (Fausch et al. 1984, Messinger and Chambers 2001). In our samples from West Virginia, a significant relationship exists between stream order and the total number of species collected at a particular site ($R^2 = 0.5849$; $P < 0.001$). The fact that unmined sites were only available in 1st and 2nd order streams (Fig. 1), limited our ability to compare unmined to filled sites directly in most cases indicating that not enough reference sites were included in the sampling effort to adequately assess the potential effects of MTM/VF operations on fish communities in the area. All of the unmined sites that were to serve as reference sites were located on 1st and 2nd order streams, while sites classified as mined, filled, and filled/residential occurred primarily on 3rd and 4th order streams making direct comparisons between mined and filled sites difficult. In an effort to elucidate the effects of MTM/VF operations on fish populations, we sampled 13 sites in the

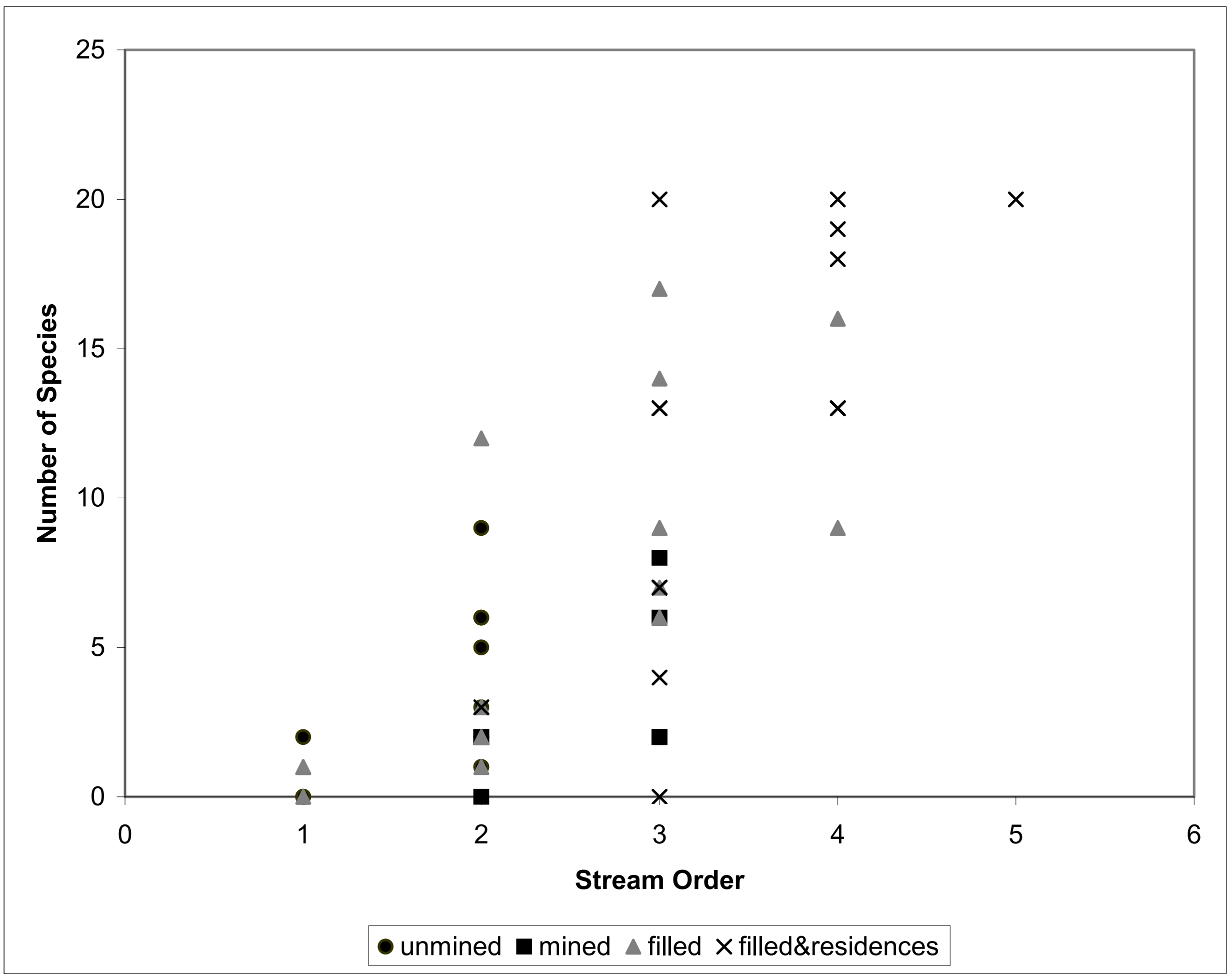

Figure 1. Relationship between total number of fish species collected and stream order sampled by EIS classification for 58 sites sampled in the primary region of MTM/VF coal mining in West Virginia during 1999/2000. As stream order increases, the total number of species present increases ($R^2 = 0.5849$; $P < 0.001$). Unmined sites are located only on 1st and 2nd order streams while most of the mined, filled, filled/residential sites occur on 3rd, 4th, and 5th order streams.

Guyandotte River drainage, including eight sites in the Mud River watershed that were classified as filled (EIS class = 2) or filled/residential (EIS class = 3) and five reference (unmined) sites (EIS class = 0) in the Big Ugly watershed.

We proposed to evaluate the effects of MTM/VF coal mining on fish communities at these sites by comparing different attributes of the fish community between unmined and filled sites. The use of particular attributes of a fish community, such as total number of species or total number of benthic species, to evaluate stream condition is becoming widely accepted (e.g., Karr 1981, Leonard and Orth 1986, Ohio EPA 1987, Davis and Simon 1995, Angermeier et al. 2000). A recent study testing the ability of potential metrics based on attributes of the fish community to distinguish between sites of differing quality in Mid-Atlantic Highland streams found that the number of species and the number of benthic species present were most consistently related to site quality (Angermeier et al. 2000). In general, the total number of fish species is expected to decrease with increasing degradation (Barbour et al. 1999). This number will also vary with stream size (generally increases as stream size increases, e.g. Fausch et al. 1984, Messinger and Chambers 2001), however, so comparisons of condition between EIS classes must be analyzed within similar stream orders. Benthic species are generally sensitive to degradation resulting from siltation and benthic oxygen depletion because they feed and reproduce in benthic habitats; thus, we expect the total number of benthic species to decrease with increasing degradation (Barbour et al. 1999). Like the total number of species, the total number of benthic species will also vary with stream size and comparisons between EIS classes must be made between sites in similar stream orders. For the purposes of this study, benthic species included darter (*Etheostoma* spp. and *Percina* spp.), sculpin (*Cottus* spp.), and madtom (*Noturus* spp.) species.

Methods

Sample Site Selection Fall 2001

In Fall 2001, we selected eight sites in the Mud River that were classified as either "filled" or "filled/residential " in 2nd, 3rd, and 4th order streams for further study (Table 1). In consultation with the USEPA, USFWS, and representatives of the mining companies, we selected sites outside the immediate region of MTM/VF coal mining to serve as reference sites that would characterize the "unmined" condition within the Guyandotte River drainage. Five sites in the Big Ugly watershed in 2nd, 3rd, and 4th order streams were selected (Table 1).

Table 1. PSU collection number, station number, stream name, watershed, stream order, EIS Class (0=unmined, 2=filled, 3=filled/residential), and sample date for fish collections completed during Fall 2001 in the primary region of MTM/VF coal mining in the Guyandotte River drainage of West Virginia.

Collection #	Station number	Stream Name	Watershed	Stream order	EIS Class	Sample Date
JRS-01-84	7	Sugartree Branch	Mud River	2	2	9/14/2001
JRS-01-87	12	Ballard Fork	Mud River	2	2	9/14/2001
JRS-01-85	17	Stanley Fork	Mud River	3	2	9/14/2001
JRS-01-86	18	Stanley Fork	Mud River	3	2	9/14/2001
JRS-01-88	19	Mud River	Mud River	3	3	9/14/2001
JRS-01-89	20	Mud River	Mud River	3	3	9/14/2001
JRS-01-82	22	Mud River	Mud River	4	3	9/14/2001
JRS-01-83	23	Mud River	Mud River	4	3	9/14/2001
JRS-01-90	74	Big Ugly	Big Ugly	4	0	9/15/2001
JRS-01-91	75	Big Ugly	Big Ugly	4	0	9/15/2001
JRS-01-92	76	Back Fork	Big Ugly	2	0	9/15/2001
JRS-01-93	77	Laurel Creek	Big Ugly	2	0	9/15/2001
JRS-01-94	78	Laurel Creek	Big Ugly	3	0	9/15/2001

Water Chemistry Analysis – Fall 2001

During Fall 2001, we collected water samples at each of the 13 stations where we sampled fish communities. A single water sample was collected at each site (according to directions provided by the EPA) and sent to the Research Environmental & Industrial Consultants, Inc (REIC) for laboratory analysis of total metals (mg/L of aluminum, iron, arsenic, copper, and selenium) and hardness (as mg/L CaCO3). In addition to the water samples, we measured pH and conductivity in-situ using an Oakton pH testr and TDS Testr 20 respectively.

Characterization of Fish Communities

At each site, a section of stream that included representative habitat types (riffle, pool, and run habitats) was selected for sampling the fish community. The length of the study reach was at least 40 times the stream width (Lyons 1992), but no longer than 150m. We used depletion sampling to estimate the abundance of fishes present (Zippin 1958). Thus, fishes were collected at each site by making three passes using a backpack electrofishing unit starting at the downstream end of the section and proceededing upstream for the entire section. Fishes caught during each pass were preserved separately in 10% formalin and transferred to The Pennsylvania State University Fish Museum for permanent storage in 50% isopropanol. Fishes from each sample were identified to species, enumerated, measured (standard length, mm), and weighed (nearest 0.01g).

Evaluation of Mining Effects

To evaluate differences in attributes of the fish community between EIS classes, we used box-and-whisker plots that display the median (solid line in box), the upper (75th percentile) and lower (25th percentile) quartiles (the solid box), the 10th and 90th percentiles (the whiskers), and any outliers of a population of sites. We used the degree of overlap of the attribute ranges to visually assess differences between the EIS classes. The greatest degree of difference is indicated by no overlap of the interquartile ranges. Overlap between the interquartile ranges that excludes the medians indicates the next greatest difference between EIS classes. Extensive overlap of the interquartile range that includes both medians within the overlap indicates little or no difference between EIS classes (Barbour et al. 1999). Where we had a large enough sample size within EIS class ($n>2$), we also calculated the Mann-Whitney U Test probability to test for statistical significance.

Results

Water Chemistry Analysis – Fall 2001

Water chemistry analysis detected selenium in five of the eight sites in the Mud River watershed associated with valley fills (Table 2). Stations 7, 17, 18, 22, and 23 all had detectable levels of selenium present, while stations 12, 19, and 20 did not. Station 18 also had elevated levels of aluminum (10.4 mg/L), iron (43.6 mg/L), and copper (0.027 mg/L) as compared to the other filled or unmined sites. It is interesting to compare these values to those measured at station 17 which was located upstream of station 18 and upstream of the valley fill above station 18 (i.e., stations 17 and 18 essentially bracket a valley fill with station 17 at the upstream end and station 18 at the immediate downstream end). Levels of all detectable metals were lower at station 17 (upstream of the valley fill) than at station 18 (Table 2).

Table 2. Water chemistry measurements for sites sampled in September 2001 in the Guyandotte River drainage (Mud River and Big Ugly watersheds). EIS Classes are as follows: 0=unmined, 2=filled, 3=filled/residential. Chemical analyses were conducted in the laboratories of Research Environmental & Industrial Consultants, Inc (Beaver, WV). The abbreviation "ND" indicates levels "not detected at the PQL (practical quantitation limit) or MDL (minimum detection limit)". In-situ pH and conductivity were measured on site using an Oakton pH Testr and an Oakton TDS Testr 20.

Station	EIS Class	Stream Order	Total Al mg/L	Total Fe mg/L	Total As mg/L	Total Cu mg/L	Total Se mg/L	Hardness mg/L as CaCO3	In-situ pH	In-situ Conduct. μmhos/cm
Mud River Stations										
7	2	2	0.147	0.308	ND	ND	0.0315	1510.0	7.6	2290
12	2	2	0.514	1.440	ND	ND	ND	1330.0	7.9	1953
17	2	3	0.437	0.854	ND	ND	0.0095	1520.0	8.2	2330
18	2	3	10.400	43.600	ND	0.027	0.0158	1660.0	8.3	2160
19	3	3	0.117	0.318	ND	ND	ND	267.0	8.0	530
20	3	3	0.174	1.330	ND	ND	ND	245.0	7.3	513
22	3	4	0.177	0.250	ND	ND	0.0121	1140.0	7.9	1836
23	3	4	0.154	0.398	ND	ND	0.0107	1380.0	8.1	2120
Big Ugly Stations										
74	0	4	0.077	1.060	ND	ND	ND	72.9	7.1	210
75	0	4	0.138	0.560	ND	ND	ND	76.7	7.0	206
76	0	2	0.092	0.125	ND	ND	ND	73.6	7.2	137
77	0	2	0.296	1.330	ND	ND	ND	60.4	7.0	143
78	0	3	0.064	0.500	ND	ND	ND	48.8	7.0	125

Like the related benthic macroinvertebrate studies in West Virginia (Green et al. 2000) and Kentucky (Howard et al. 2000), we found elevated values of conductivity and pH at sites associated with valley fills as compared to the unmined sites (Table 2). Conductivity values at the filled and filled/residential sites in the Mud River watershed ranged from 513 to 2330 μmhos/cm with an average of 1716.5 μmhos/cm. These values are substantially higher than conductivity values at the five unmined sites that ranged from 125 to 210 μmhos/cm with an average of 164.2 μmhos/cm. The range of pH values at sites associated with valley fills was higher (7.3 to 8.3) than the range of pH at the reference sites (7.0 to 7.2).

<u>Characterization of Fish Communities – Fall 2001</u>

Collections in five "unmined" (reference) sites in the Big Ugly watershed and eight "filled" and "filled/residential" sites in the Mud River watershed yielded 2,739 fishes distributed among 35 species (Table 3). In general, sites that were categorized as filled or filled/residential yielded fewer species than unmined sites (Table 3). We collected fishes at four stations in 2nd order streams. Two unmined sites yielded 12 and 13 species, while two "filled" sites yielded 2 and 6 species. We sampled five 3rd order streams – one unmined, two filled, and two filled/residential. The unmined site yielded 17 species, while the filled sites only yielded 6 and 9 species. The filled/residential sites yielded 8 and 18 species. We collected fishes at four 4th order sites, two unmined and two filled/residential. The unmined sites yielded 21 and 24 species, while the filled/residential sites yielded only 8 and 12 species. Of interest, we collected *Lepomis cyanellus* (green sunfish), a species often indicative of environmental degradation (Karr 1981, Barbour et al. 1999), at seven of the eight Mud River stations and at none of the reference sites (Table 3).

<u>Evaluation of Effects of Mining</u>

We compared the total number of species and total number of benthic species collected at five unmined sites on 2nd, 3rd, and 4th order streams in the Big Ugly watershed with collections from eight sites on 2nd, 3rd, and 4th order streams in the Mud River watershed that were classified either as filled or filled/residential (Fig. 2 & 3). Both the number of species and the number of benthic species present were greater in the unmined sites than in the filled sites (total species: unmined median = 17, filled median = 8, Mann-Whitney U Test $P=0.0093$; benthic species: unmined median = 6, filled median = 1.5, Mann-Whitney U Test $P=0.0088$). The total number

Table 3. Total number of individuals of each species collected during Fall 2001 in the Guyandotte River Drainage by station number, stream order, and EIS classification (0=unmined, 2=filled, 3=filled/residential). Benthic species (*Etheostoma* spp., *Percina* spp., and *Noturus* spp.) are highlighted in gray.

Stream Order		2	2	3	3	3	3	4	4	4	4	2	2	3
EIS Class		*2*	*2*	*2*	*2*	*3*	*3*	*3*	*3*	*0*	*0*	*0*	*0*	*0*
STATION		**7**	**12**	**17**	**18**	**19**	**20**	**22**	**23**	**74**	**75**	**76**	**77**	**78**
Lampetra aepyptera	Least brook lamprey						2			30	4		1	4
Campostoma anomalum	Central stoneroller		2	1	1		11	29	1	11	56	13	3	29
Clinostomus funduloides	Rosyside dace						2						5	
Cyprinella spiloptera	Spotfin shiner									11				
Luxilus chrysocephalus	Striped shiner						1	1	1	81	207	9	2	47
Notropis buccatus	Silverjaw minnow					1	8			29	16	23	17	50
Notropis rubellus	Rosyface shiner									4	3			
Notropis stramineus	Sand shiner							1		2	14			
Pimephales notatus	Bluntnose minnow		1			1	4			80	174	4	5	66
Pimephales promelas	Fathead minnow			2	3									
Rhinichthys atratulus	Blacknose dace					6	3					29	18	2
Semotilus atromaculatus	Creek chub	3	13	11	2	50	115	12	4	46	54	50	57	74
Catostomus commersoni	White sucker		2	2			13		2				2	
Hypentelium nigricans	Northern hog sucker				1			2		9	24		1	7
Moxostoma erythrurum	Golden redhorse									17				
Ameiurus melas	Black bullhead			1										
Ameiurus natalis	Yellow bullhead							1	2					
Ameiurus nebulosus	Brown bullhead				1									
Noturus miurus	Brindled madtom									4				
Labidesthes sicculus	Brook silverside						16							
Ambloplites rupestris	Rock bass								1	1	2			7
Lepomis cyanellus	Green sunfish	6	2	12	12	22	38	16						
Lepomis gibbosus	Pumpkinseed										3			
Lepomis macrochirus	Bluegill			1			1		1	4				
Lepomis megalotis	Longear sunfish						1		17	19	12	2		23
Micropterus dolomieu	Smallmouth bass									1	4	2		5
Micropterus punctulatus	Spotted bass						3	1		19	4			
Etheostoma blennioides	Greenside darter			1				10		7	26			5
Etheostoma caeruleum	Rainbow darter		1	1		10	4	22		22	77	30	24	144
Etheostoma flabellare	Fantail darter					12	16			11	15	5	5	14
Etheostoma nigrum	Johnny darter					5	10	2		84	89	2	5	36
Etheostoma variatum	Variegate darter									4	14			6
Etheostoma zonale	Banded darter							10		5	16			
Percina caprodes	Logperch						3							
Percina maculata	Blackside darter									3	4	2		6
TOTAL INDIVIDUALS		9	21	32	20	107	251	107	29	504	818	171	145	525
TOTAL SPECIES		**2**	**6**	**9**	**6**	**8**	**18**	**12**	**8**	**24**	**21**	**12**	**13**	**17**

of species collected at the unmined sites (median = 17) was also greater than the total number of species collected at the same set of Mud River sites (filled and filled/residential) during the Fall 1999/Spring 2000 period (median = 12.5). The total number of species collected at the Mud River sites during Fall 1999/Spring 2000 was considerably higher (median = 12.5) than the total number of species collected during Fall 2001 (median = 8; Fig. 2). The same trend holds for the total number of benthic species (Fig. 3). The total number of benthic species collected at the unmined sites is greater (median = 6) than the number of benthic species collected in the Mud River during Fall 1999/Spring 2000 (median = 4), but this number is greater than the number of benthic species collected at the same stations in Fall 2001 (median = 1.5).

Water chemistry analysis revealed that five of the Mud River sites sampled in Fall 2001 had detectable levels of selenium (range from 9.5 to 31.5 µg/L). Selenium has been documented to have toxic effects on aquatic life (Lemly 1993). In fact, mortality of rainbow trout, chinook salmon, striped bass, and bluegill has been documented at concentrations of selenium ranging from 4 to 10 µg/L (Kennedy et al. 2000). As such, we grouped the Mud River sites according to presence (n=5) or absence (n=3) of selenium and repeated the analysis of total number of species and total number of benthic species (Fig. 4 & 5). Sites that were associated with valley fills and had detectable levels of selenium supported fewer species than sites solely associated with valley fills. Although the medians of total number of species present in both groups were equal (median = 8 in both cases), the range associated with sites that had fills and selenium was lower than sites with fills alone (Fig. 4). Total number of species was dramatically lower in both, sites classified as filled that had selenium present (Mann-Whitney U Test P=0.008) and sites classified as filled that did not have selenium present (Mann-Whitney U Test P=0.0179), than in unmined sites (median = 17). Total number of benthic species followed a similar trend (medians: unmined = 6, filled & selenium = 0, filled & no selenium = 3; Fig. 5).

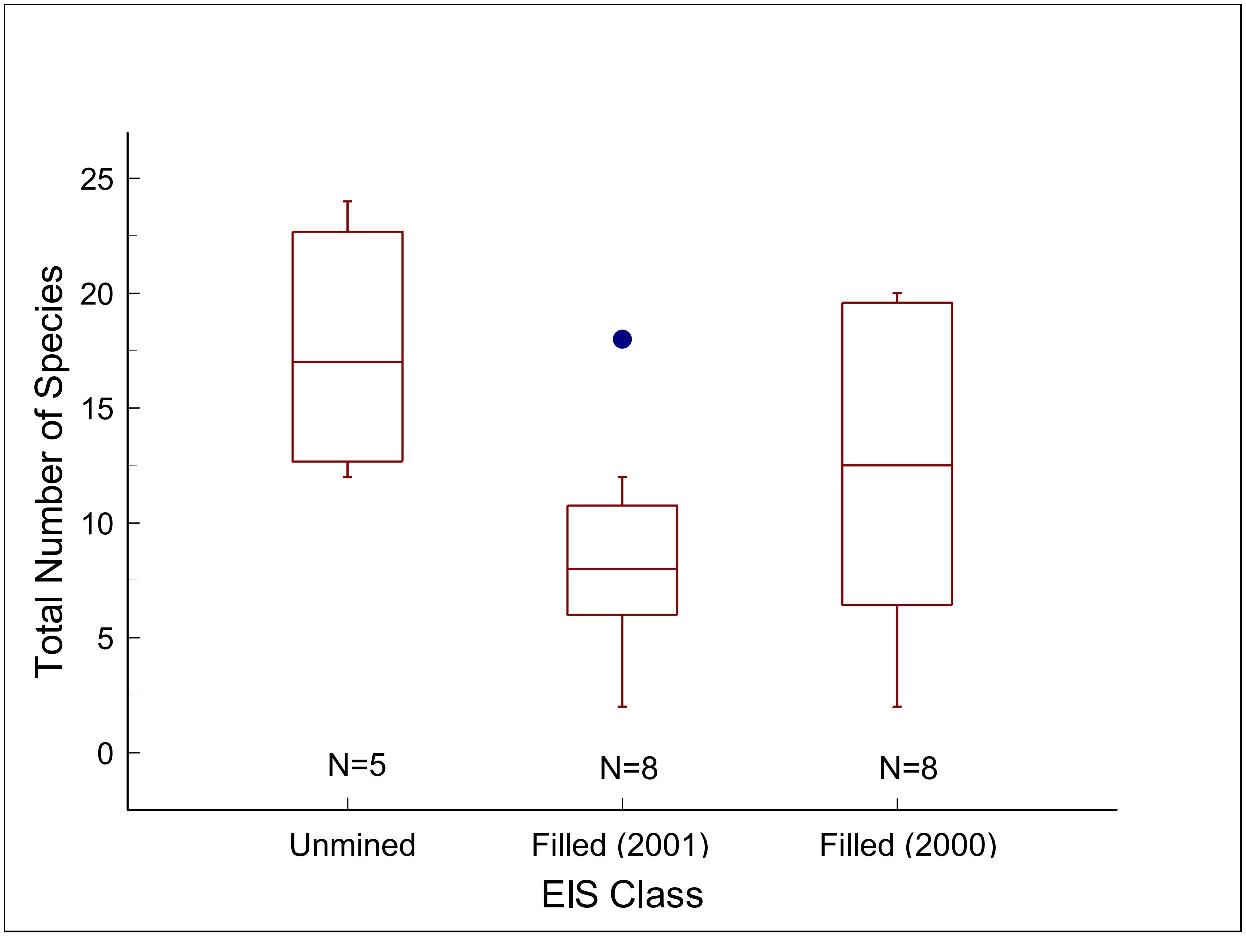

Figure 2. Comparison of total number of species between unmined sites (EIS Class=0) in the Big Ugly watershed and filled sites (combined filled (EIS = 2) and filled/residential (EIS=3)) in the Mud River watershed, West Virginia. The eight sites in the Mud River were sampled both in Fall 2001 (Filled 2001) and in Fall 1999 and Spring 2000 (Filled 2000). Sites in the Big Ugly (unmined) were only sampled in Fall 2001. Comparison of collections in unmined and filled sites in Fall 2001 indicate that unmined sites had greater number of species than filled sites (unmined median = 17, filled (Filled 2001) = 8, Mann-Whitney U Test P=0.0093).

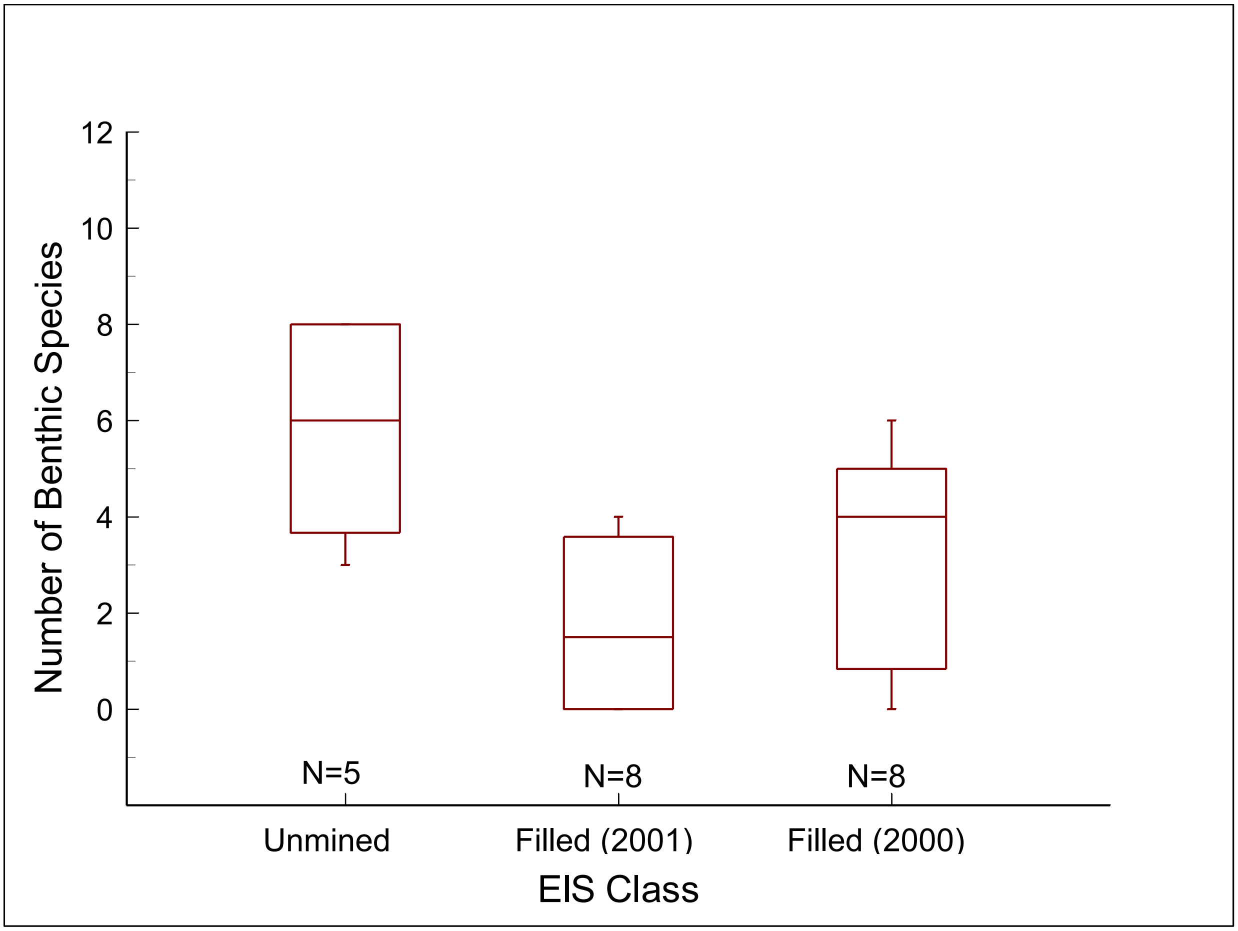

Figure 3. Comparison of total number of benthic species between unmined sites (EIS Class=0) in the Big Ugly watershed and filled sites (combined filled (EIS = 2) and filled/residential (EIS=3)) in the Mud River watershed, West Virginia. The eight sites in the Mud River were sampled both in Fall 2001 (Filled 2001) and in Fall 1999 and Spring 2000 (Filled 2000). Sites in the Big Ugly were only sampled in Fall 2001. Comparison of collections in unmined and filled sites in Fall 2001 indicate that unmined sites had greater number of benthic species than filled sites (unmined median = 6, filled (Filled 2001) = 1.5, Mann-Whitney U Test P=0.0088).

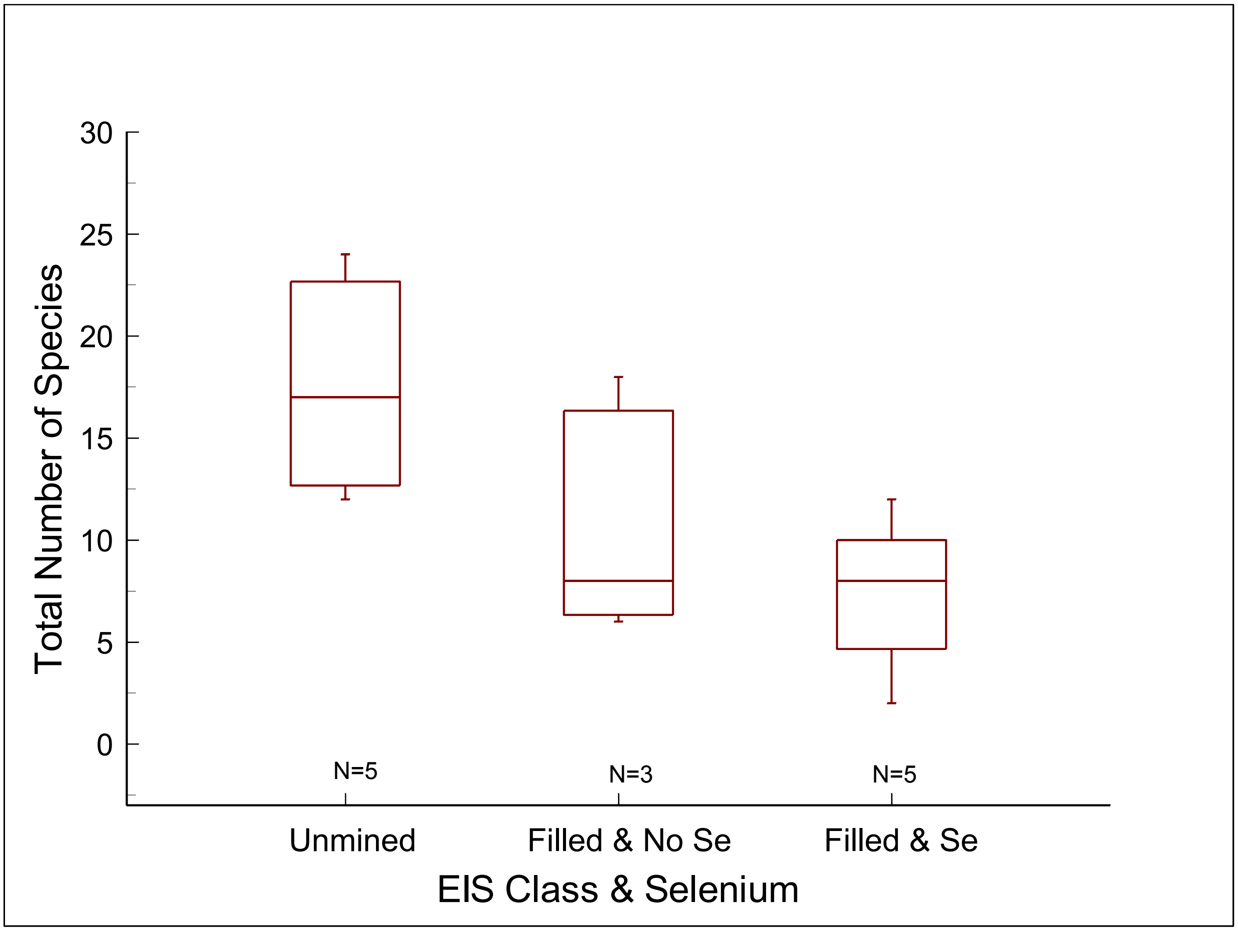

Figure 4. Comparison total number of species collected in Fall 2001 in the Big Ugly and Mud River watersheds. Sites in the Big Ugly were unmined (EIS Class=0) and had no detectable selenium. Sites in the Mud River were a combination of filled (EIS = 2) and filled/residential (EIS=3) categories. Three stations sampled in Fall 2001 in the Mud River did not have detectable levels of selenium (PSU stations 12, 19, 20) while five sites had detectable levels of selenium (PSU stations 7, 17, 18, 22, 23). Total number of species was dramatically lower in sites classified as filled with selenium (median = 8, Mann-Whitney U Test P=0.008) and sites classified as filled without selenium (median = 8, Mann-Whitney U Test P=0.0179) than in unmined sites (median = 17).

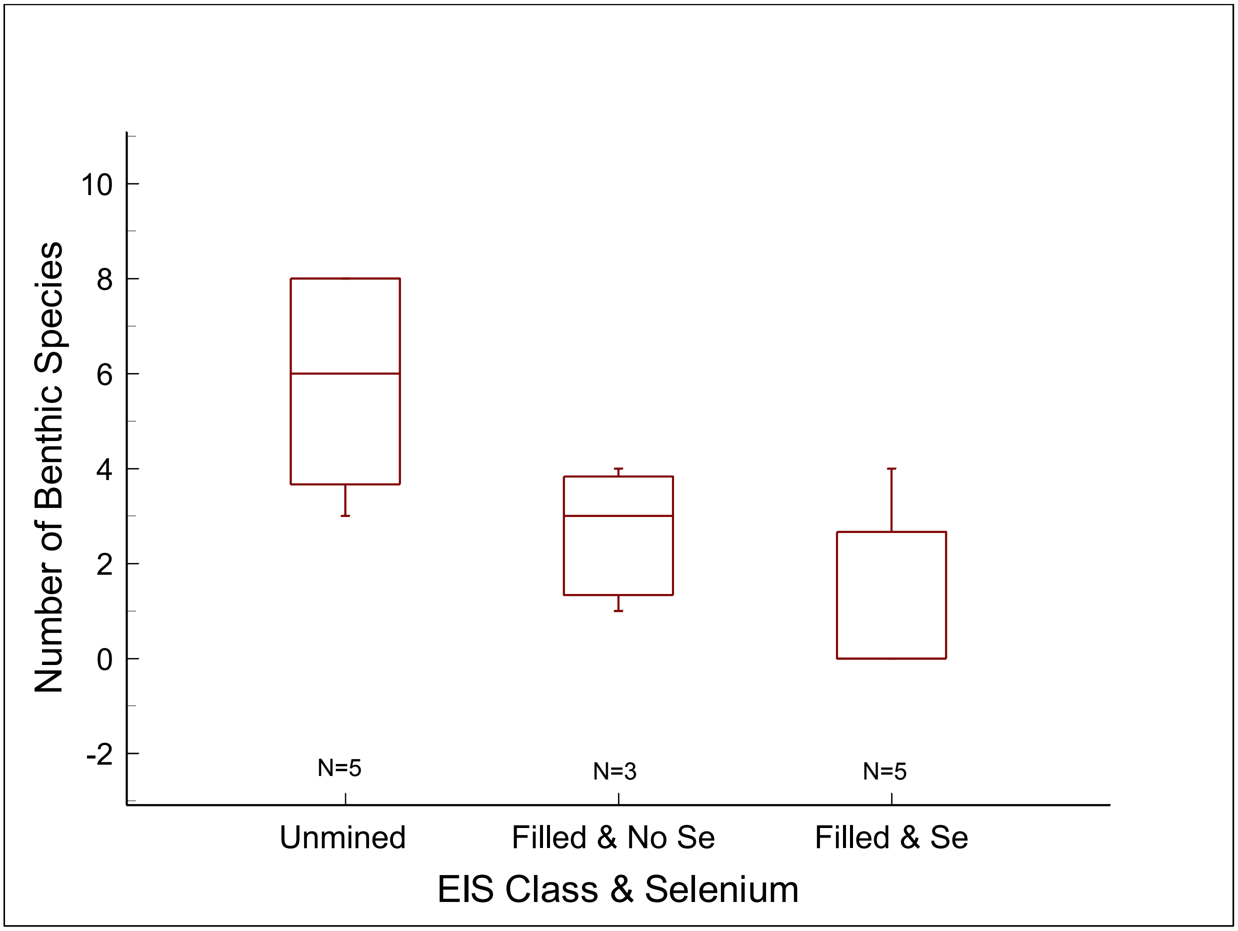

Figure 5. Comparison total number of benthic species collected in Fall 2001 in the Big Ugly and Mud River watersheds. Sites in the Big Ugly were unmined (EIS Class=0) and had no detectable selenium. Sites in the Mud River were a combination of filled (EIS = 2) and filled/residential (EIS=3) categories. Three stations sampled in Fall 2001 in the Mud River did not have detectable levels of selenium (PSU stations 12, 19, 20) while five sites had detectable levels of selenium (PSU stations 7, 17, 18, 22, 23).

Discussion

Determining the effects of MTM/VF coal mining operations on stream fishes in West Virginia was difficult. In the five watersheds we studied during 1999/2000, unmined sites (reference condition) were limited to 1st and 2nd order streams (Stauffer and Ferreri 2002). This was primarily because there were no higher order streams in this area that had not been mined in this manner. Unfortunately, it is clear that these sites on small streams do not adequately portray a reference condition, one where fish communities would not be disturbed, because fish diversity generally increases with increasing stream order (Fausch et al. 1984, Messinger and Chambers 2001). Thus, our findings based on our sampling in 1999/2000 were confounded by stream order – a general increase in the number of species found in filled sites relative to unmined sites is really due to the fact that we sampled filled sites in 2nd through 5th order streams which naturally have a higher diversity of fishes as stream order increases.

To control for the effect of stream size, we designed a smaller scale study within the Guyandotte River drainage in Fall 2001. We re-sampled eight sites within the Mud River watershed where there is active MTM/VF coal mining, but chose sites outside of that watershed, but within the drainage, to serve as reference sites of the unmined condition. Ideally, the reference sites would occur in the same watershed, but this was not possible in the Mud River watershed as most of the watershed had been mined at some time using the MTM/VF method. Choosing sites within the same major drainage basin (the Guyandotte River) is important as fish distributions are affected by drainage divides (Stauffer et al. 1995). Using this approach allowed us to choose unmined sites that occurred on similar stream sizes as the filled sites in the Mud River and would be expected to support similar fish communities.

Our findings indicate that water chemistry and fish community structure are affected by the presence of valley fills in the Guyandotte River drainage. Sites associated with valley fills had elevated values of conductivity and pH as compared to the unmined sites. In addition, several of the filled sites had detectable levels of selenium. Both the total number of fish species and the total number of benthic species were greater in the reference sites than in the filled sites. Further, sites that were filled and had selenium present were more impaired than filled sites that did not have selenium present. Clearly, a multiple year study, using appropriate reference sites to portray the fish community in an unmined condition, is needed to see if there is a continued decrease in the number of species over time at sites associated with valley fills.

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