"A Comparison of the Effects of Mining Over a Ten Year Period on the Fisheries, Macroinvertebrates, and Water Chemistry Within the Tributaries of East Fork Twelvepole Creek"

Paper Presented at the 2011 West Virginia Mine Drainage Task Force Symposium

March 29-30, 2011

Morgantown, WV

Jonny Hart[1], Ed J. Kirk[2], & Randall Maggard[3]

[1] Fisheries Biologist, REI Consultants, Inc., 225 Industrial Park Rd., Beaver, WV 25813 (jhart@reiclabs.com).

[2] Director – Biological Division, REI Consultants, Inc., 225 Industrial Park Rd., Beaver, WV 25813 (ekirk@reiclabs.com).

[3] Manager of Environmental Compliance, Argus Energy-WV, LLC, 9104 Twelvepole Creek Road, P.O. Box 200, Dunlow, WV 25511 (randy@arguswv.net).

Abstract: Four streams in southern West Virginia were sampled over ten years to assess the effects of mining and anthropogenic influences on fisheries and macroinvertebrates. Fish communities were sampled in the Spring & Fall of 2000 and 2010. Water chemistry and macroinvertebrates were sampled biannually each year and used to evaluate stream condition and aquatic health. Fish index of biotic integrity values were used in conjunction with the West Virginia Stream Condition Index (WV-SCI) to evaluate any correlation with Specific Conductance measurements. Coefficient of community loss (*I*) was used to reference fish community assemblage shifts between 2000 and 2010. Fish communities and WV-SCI values were found to be fair and unimpaired respectively, despite elevated conductivity in the watershed from mining and anthropogenic influences. These findings suggest conductivity is a poor primary indicator of aquatic health in certain reaches of central Appalachian streams.

Introduction

Surface coal mining, like any large earthmoving project, has the potential to affect headwater streams. Mining operations in steep slope areas such as southern West Virginia are challenged by the expansion of rock and soil (overburden swell) as it is removed from atop recoverable coal seams. For decades, rock and soil in excess of that which may be replaced in the mining area to restore the approximate original contour has been placed in a controlled manner in heads of hollows as engineered “valley fills”. Hollows in Appalachia are erosional features in sedimentary rock. The drainage naturally contains calcium, sulfate and other dissolved materials, even with no mining in the watershed. These dissolved solids include minerals that are essential nutrients for aquatic life and provide buffering for the stream. Any land disturbance, whether mining, highway, industrial, or residential construction, will increase the dissolved material (or Total Dissolved Solids) in the stream, and this will increase the ability of the water to conduct electricity (specific conductance). A recent USEPA study (in draft form) has identified that certain species of intolerant mayfly are not present in streams with elevated dissolved solids, and concurrent elevated electrical conductance (USEPA 2010). Studies by others document healthy ecosystems where all the functional members are present (Davenport & Morse 2010). Few available studies involve large watersheds with extensive mining operations where fish and macroinvertebrates inventories have been collected over a period of several years. This study, initiated in 2000, documents temporal trends which are invaluable for an evaluation of the long term effects of mining concurrent with increased specific conductivity. Specific Conductivity has historically been a valuable field diagnostic tool for quickly identifying drainage with elevated Total Dissolved Solids.

The objective of this paper is to present a case study where extensive, prolonged mining activities and other anthropogenic activities have increased specific conductance levels in receiving streams. Shifts in fish and macroinvertebrate communities are presented for conditions where only limited mining occurred and again, a decade later when mining was much more extensive. This paper presents conditions and biological indices in several streams in the Twelvepole Creek watershed in southwest West Virginia over a ten year period. Diverse anthropogenic activities have occurred within the watershed during the study period. Mining operations have produced approximately twenty million tons of coal. This coal mining is evenly split between surface and underground mining methods. The watershed also contains all facilities associated with a large scale coal mining operation such as a preparation plant, coarse refuse fill, slurry impoundment, and miles of coal haul roads. Timber operations not associated with mining have logged roughly 5,000 acres. Further, approximately 250 oil and gas wells were drilled during the study period with associated access road and pipeline installations. Each of these activities reasonably can be expected to increase dissolved solids in the receiving streams.

The West Virginia Stream Condition Index (WV-SCI) is a biological criterion of stream condition used for identifying ecosystem health. The index assesses six biological attributes of macroinvertebrate assemblages. The core metrics used for calculation of the 0-100 scale (worst to best) are EPT taxa (mayfly, stonefly, and caddisfly families), Total taxa, % EPT, % Chironomidae (midges), % Top 2 Dominant taxa, and HBI (Family biotic index) (Tetra Tech, Inc 2000). Stream Condition Index (WV-SCI) scores are strongly influenced by the presence of mayflies (Order: Ephemeroptera) which represent some of the most pollution intolerant genera found within a natural stream ecosystem. Recent research indicated mayfly abundances were strongly correlated to specific conductance when compared to land use (Pond 2010). Yet other research has noted that percent mayflies may not be significantly correlated to Total Dissolved Solids concentrations, of which conductivity is a primary constituent (Timpano et al. 2010). The WV-SCI threshold of possible impairment lies at 68.0, although the West Virginia Department of Environmental Protection (WVDEP) cites scores less than 60.6 as having the 'highest degree of confidence in the validity of the listed biological impairments'. The WVDEP has listed WV-SCI scores under 60.6 as being 'impaired' and as candidates for listing on the EPA 303(d) list of impaired streams.

Further biological data, such as fish population estimates, habitat assessment and monitoring of physical and chemical water quality parameters, ultimately influence the permit review processes and assist in establishing NPDES discharge limitations. These data comparisons act as a powerful monitoring tool helping to identify possible pollutant sources and/or habitat alterations and their subsequent effects. Indices of Biological Integrity are used to evaluate stream condition health based on the diversity of fishery populations within aquatic systems. The western portion of West Virginia lies within the EPA's region III mid-Atlantic ecoregion. This ecoregion classifies western West Virginia and Eastern Kentucky under the Central Appalachian Plateau (EPA). Two popular Biotic Integrity Indices based on fish communities for this ecoregion include the Mid-Atlantic Index of Biotic Integrity (MA-IBI) and the Kentucky Index of Biotic Integrity (KIBI). This study utilized a modified Kentucky Index of Biotic Integrity to fully evaluate the fisheries population in the given study area. Modification was done by extending the Mountain Ichthyoregion of Kentucky along the EPA's Central Appalachian Plateau ecoregion as originally defined. Metrics of both indices include very similar components and were both extensively evaluated for effectiveness and correlation in development. The primary reason for modification in our study is the inclusion of watershed drainage area in metric calculation (Angermeier & Smogor 1995). The MA-IBI found little metric variance of scores for watersheds as small as to two square miles (5.2 square kilometers) and attributed no change in the index to account for watershed size.

The KIBI includes a separate metric index of watersheds under six square miles as having "Headwater Characteristics." Streams of this caliber often include species which are atypical in watersheds greater than 10 square miles or would only represent two percent of the community in larger streams (Compton et al. 2003). Two of our four streams in this study fall within the headwater stream category. For adequate comparison of stream health and watershed basin size, this metric was utilized. The metrics for the KIBI are as follows: Native Taxa Richness; Darter, Madtom, Sculpin Richness; Intolerant Species Richness; Simple Lithophilic Spawning Species

Richness; Relative Abundance of Insectivorous individuals; and Relative Abundance of Tolerant individuals. In headwater reaches, the KIBI substitutes Facultative Headwater Individuals for Native Species Richness. Differences between these two indices in headwater reaches were varied, and illustrate a need for further research incorporating drainage basin size into environmental monitoring.

Methods

The region evaluated is located in Wayne, Mingo, Lincoln, and Logan Counties of southwestern West Virginia. REI Consultants has been evaluating the water quality, physical habitat, and macroinvertebrate populations associated with Argus Energy-WV, LLC since 1995. Extensive stream and macroinvertebrate data has been collected from four watersheds which include East Fork of Twelvepole Creek, Kiah Creek, Trough Fork, and Big Laurel Creek. These four watersheds were the primary focus of our evaluation of fish population fluctuations. Originally Big Laurel Creek was utilized as a reference stream for the project area but recent mining activity has compromised the watershed distinction as a viable reference stream. Each of the streams was sampled for fish communities in Spring and Fall of 2000, and again in 2010 at two separate locations per stream. The evaluated sites were located at or downstream of mining activity and again upstream of mining activity in the same watershed.

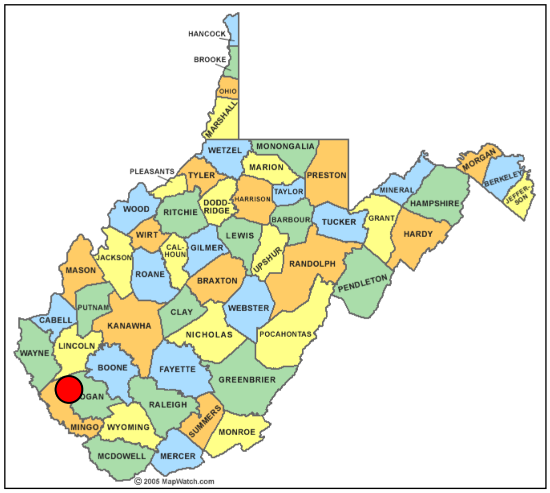
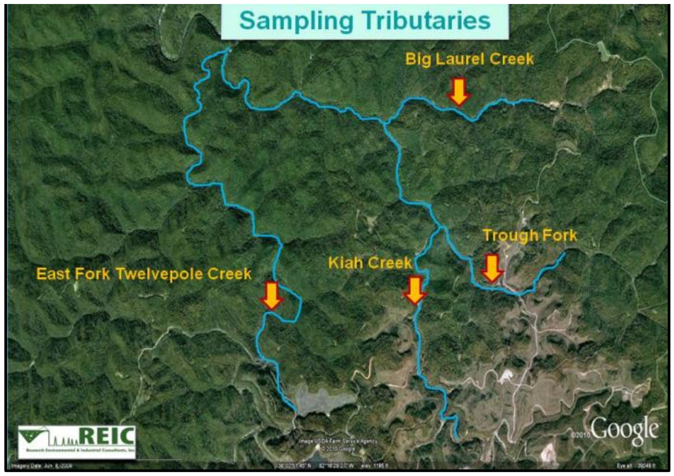


FIGURE 1. General vicinity of study area within West Virginia shown in red.

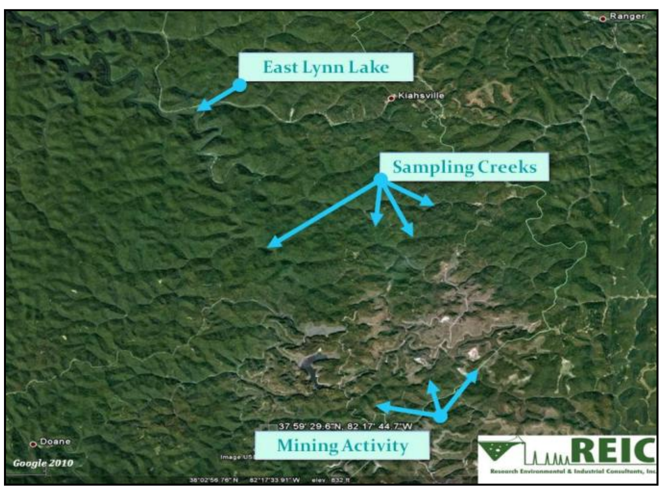
Fisheries

Fisheries collections were conducted following the EPA's Rapid Bioassessment Protocols For Use in Streams and Wadeable Rivers (EPA 841-B-99-002). Block nets were placed at each end of a 100-meter sampling reach to prevent immigration or emigration within the sampling reach. Each reach included at least one riffle/run/pool sequence. A Smith-Root™ battery powered backpack electrofishing unit was used to conduct triple pass depletion. Collected fishes were identified to species, numerated, measured to the nearest millimeter total length, and weighted to the nearest 1.0 or 0.1 gram total weight depending on fish size. A subsample of fishes was preserved in 10% formalin for voucher specimens and species identification verification. Total abundance, total taxa, mean length, mean weight, and standing crop was calculated for comparison between 2000 and 2010 populations for each species at each sampling station. In addition, a sensitivity index was assigned to each species based on the "Tolerance and Trophic Guilds of Selected Fish Species" from the EPA's Rapid Bioassessment Protocols For Use in Streams and Wadeable Rivers (EPA 841-B-99-002). Biotic index metrics and species tolerances from the Kentucky Biotic Index of Integrity were modified for use due to proximity of Kentucky Mountain Icthyoregion (<10 miles) and inclusion of drainage basin size. Number and percent of fishes classified as pollution intolerant, intermediate tolerant, and tolerant were calculated at each station. Coefficient of community loss was calculated to compare community changes between 2000 and 2010. Utilizing methods described by Courtemarch & Davies 1987 and Kimmel & Argent 2010, fishery communities in 2010 were evaluated using taxa collected in 2000 to assess the changes that may have occurred in the last ten years from mining & other anthropogenic influences.



Google Earth (Version 5.1.3533.1731) [Software]. Mountain View, CA: Google Inc. (2009

FIGURE 2. Aerial photography showing vicinity of sampling tributaries.



Google Earth (Version 5.1.3533.1731) [Software]. Mountain View, CA: Google Inc. (2009

FIGURE 3. Aerial photography depicting mining activity upstream of sampling reaches.

Fisheries Metrics

Metric 1. Native Taxa Richness - Reflects the health of the community through a measurement of the variety of native taxa present. Generally increases with increasing water quality, habitat diversity, and habitat suitability. Habitat alterations impair habitat quality which allows non-native species to occur. This metric is a modification of Karr's original (1981) total number of species and has been utilized in several indices of integrity. This metric is positively correlated with epifaunal substrate, riparian zone, width, channel alteration, pool variability, pool substrate characterization, and total habitat score.

Metric 2. Darter, Madtom, and Sculpin Richness - Represents the total number of species present within the taxa Etheostomatini (darters), the genus *Noturus* (madtoms), and the genus *Cottus* (Sculpins). These groups of fish are sensitive to pollution, and are usually intolerant or intermediately sensitive. This is a modification of Karr's (1981) original Darter Richness metric. This metric is highly correlated with similar metrics of Native Taxa Richness.

Metric 3. Intolerant Species Richness - This is the number of pollution intolerant species present in a sample. This metric has been widely used in biotic indices and is an original Karr (1981) metric. Species in this group are the most sensitive to pollution and are often the first signs of impairment in a system. Total number of intolerant species has been positively correlated with all habitat parameters except for channel flow.

Metric 4. Simple Lithophilic Spawning Species Richness - This is the total number of simple lithophilic spawning species present in a sample. This metric indicates the relative quality of gravel substrate in the habitat required for simple lithophilic spawning. This metric is highly sensitive to siltation and is highly correlated with all habitat parameters except channel flow, embeddedness, and velocity depth regime.

Metric 5. Relative Abundance of Insectivorous Individuals - This is the relative abundance of insectivorous individuals in a sample with the exception of tolerant individuals. This is a modification of Karr's (1981) original abundance of insectivorous cyprinids and Ohio EPA's (1987) abundance of insectivorous individuals.

Metric 6. Relative Abundance of Tolerant Individuals - This metric is an original Karr (1981) indices and represents the proportion of individuals which are pollution tolerant. This number often will increase with stream impairment. The scoring of this metric is inversed to respond positively to the index.

Metric 7. Relative Abundance of Facultative Headwater Individuals – This metric was used in substitution for Native Species richness in stream reaches under six square miles. This metric is based on the abundance of atypical headwater stream species which respond in increasing numbers as negative impairment affects the stream.

TABLE 1. Fisheries Index of Biotic Integrity scores for the Central Appalachian Ecoregion and Mountain Ichthyoregion based on Kentucky Index of Biotic Integrity scoring.

Fisheries Index of Biotic Integrity	
IBI Score	Rank
$\geq$ 71	Excellent
59-70	Good
39-58	Fair
19-38	Poor
0-18	Very Poor

(Compton et al. 2003)

Benthic Macroinvertebrates

Macroinvertebrates were collected from riffle areas of a 100-m stream reach using a 0.5-m wide rectangular-frame kicknet (500-µm mesh). Four semi-quantitative kick-net samples were composited from a riffle/run area to equal 1-m^2 sampling area. Samples were placed in 1-liter plastic containers, preserved in either 10% formalin or 70% ethanol, and returned to the laboratory for processing. Samples were then picked under microscope and detrital material was discarded only after a second check to insure that no macroinvertebrates had been missed. The WV-SCI score was calculated using the "200 organism" method. The whole kick sample was spread onto a 100-gridded sieve. Grids were selected at random and picked under dissecting scopes, until 200 (+/- 10%) insects were obtained. Those insects were then identified to the lowest possible taxonomic level, and although genus level was typically achieved, the data is lumped to the family level to calculate the WV-SCI score. Then, at least 25% of the 100 grids were picked and identified, and then extrapolated to determine the number of insects in the total kick sample. All macroinvertebrates were identified to lowest practical taxonomic level, usually genus, and were enumerated. Chironomids were identified only to family level. Several benthic macroinvertebrate metrics were then calculated for each station. The rating utilized by WVDEP for the WV-SCI follows as Table 2.

Table 2. West Virginia Stream Condition Index (WV-SCI) criteria ranking for assessing stream health and impairment.

WV-SCI Range	Rank	Impairment
78.01 to 100	"Very Good"	Not Impaired
68.01 to 78.00	"Good"	
60.61 to 68.00	"Gray Zone"	
45.01 to 60.60	"Slightly Impaired"	Impaired
22.01 to 45.00	"Moderately Impaired"	
0 to 22.00	"Severely Impaired"	

(WVDEP)

Water Quality

Physical water quality was analyzed on-site at each station. Water temperature, pH, and specific conductivity were measured with an Oakton 300 series pH/CON multi-parameter probe. Dissolved Oxygen was measured using a Hach HQ30d flexi LDO meter. Flow was measured with a Marsh-McBirney™ Model 2000 portable flow meter. Stream cross section widths, depths, and velocities were measured, and the resulting average discharge was reported for each station. Water chemistry samples were collected at each station and returned to REI Consultants, Incorporated for analysis. Parameters analyzed included acidity, alkalinity, total hardness, nitrate/nitrite, chloride, sulfate, Total Suspended Solids (TSS), Total Dissolved Solids (TDS), total phosphorus, dissolved organic carbon, total metals including aluminum, antimony, arsenic, beryllium, cadmium, calcium, chromium, copper, iron, lead, manganese, magnesium, mercury, nickel, potassium, selenium, silver, sodium, thallium, zinc, dissolved metals including aluminum, manganese, and iron. Selected sites included fecal and total coliform analysis. The premise of contention involves specific conductance as an indicator of overall stream health, therefore only this parameter is presented against the biotic indices and physical habitat scores.

Data Analysis

Water chemistry and macroinvertebrate indices data from 15 years of biannual sampling in the study area was compiled for stream reaches where recent fish sampling was conducted. Stream averages were based on April and October sampling, and were combined to provide realistic stream conditions eliminating extraneous data characteristics from seasonal variations. WV-SCI values were averaged in the same manner. IBI scores for given years were combined between April and October of given year for the upstream and downstream sampling sites post metric calculation to provide realistic stream scoring.

The coefficient of community loss was calculated to assess stream condition change of fisheries as illustrated in Kimmel & Argent 2010 and Courtemanch & Davies 1987. The total species collected in April and October 2000 were combined and evaluated against the total species collected in April and October 2010. This measure, typically used to evaluate population change against reference, was modified to evaluate temporal community changes from 2000 to 2010, using the following equation:

$$I = (a - c)/ b$$

Where:

I represents the coefficient of community loss

a represents the number of taxa collected in October and April 2000 combined

b represents the number of taxa collected in October and April 2010 combined

c represents the number of taxa in common to a and b.

The resultant coefficient then represents a ratio of taxa loss due to impairment over a given time period. As illustrated by Courtemanch & Davies 1987, sites with community loss ratios ranging between 0.15 to 0.83 against a reference reach were valued as ‘pristine’ though variability may incur when associated with rare taxa collections. Since our ratio measurements were temporal rather than areal, the limitation of rare taxa was not a perceivable issue. By definition, a community loss ratio of zero represents no taxa change. Ratio values under 0.8 were considered having acceptable levels of fisheries taxa change in relation to given reference (Kimmel & Argent 2010).

Results and Discussion

The mean fisheries index of biotic integrity scores in 2010 for the four streams ranked as "Fair" across the board. Of the four streams surveyed, two streams had higher mean IBI scores in 2010, than in 2000 (East Fork of Twelvepole Creek and Big Laurel Creek). Of the 8 total sites surveyed within the four streams, two sites showed increased IBI scores compared to 2000, (also in Twelvepole and Big Laurel -Table 3). In 2000, IBI scores ranked four sites as "Good", three sites ranked as "Fair" and one site ranked as "Poor" based on fisheries populations. The 2010 survey indicated two sites ranked "Good" while 6 sites ranked "Fair" (Table 3).

Table 3. Fisheries index of biotic integrity scores (IBI), conductivity (µs/cm), and West Virginia Stream Condition Index averages based upon 3 year bi-annual sampling.

		2000			2010		
Stream	Station	IBI	Cond. (Ave.)	WV-SCI (Ave.)	IBI	Cond. (Ave.)	WV-SCI (Ave.)
East Fork Twelvepole Creek	BM-001	36.0	177.1	70.8	63.0	306.5	75.9
	BM-002	63.0	306.5	75.9	54.0	387.7	77.5
Kiah Creek	BM-003	56.0	639.5	51.7	46.5	803.5	61.5
	BM-004	55.0	921.0	53.1	40.5	991.2	65.6
Trough Fork	BM-005	66.0	328.6	76.1	56.0	542.5	73.7
	BM-006	60.5	815.3	62.7	50.0	1257.7	72.9
Big Laurel Creek	BM-UBLC	42.0	193.5	73.8	50.0	193.5	73.8
	BM-DBLC	62.0	171.7	77.0	60.0	131.8	83.8

Two of the four streams sampled, Trough Fork and Big Laurel Creek, are considered headwater streams, with watershed basins comprising less than six square miles. Very similar in size to Trough Fork, Big Laurel Creek has experienced very limited mining influence as seen by conductivity levels below 200 µs/cm on average. Both streams rated a "Fair" index of biotic integrity based upon fisheries community compositions despite the elevated conductivity levels on Trough Fork (FIGURE 7). 2010 WV-SCI scores indicate that despite having conductivity levels consistently above 600 µs/cm, Trough Fork was categorized as unimpaired (Table 3). Big Laurel and Trough Fork WV-SCI scores were within 10 points despite an average conductivity increase of 400 µs/cm (TABLE 3). The fisheries communities ranked very similarly, indicating no significant change between streams regardless of specific conductance (Figure 4).

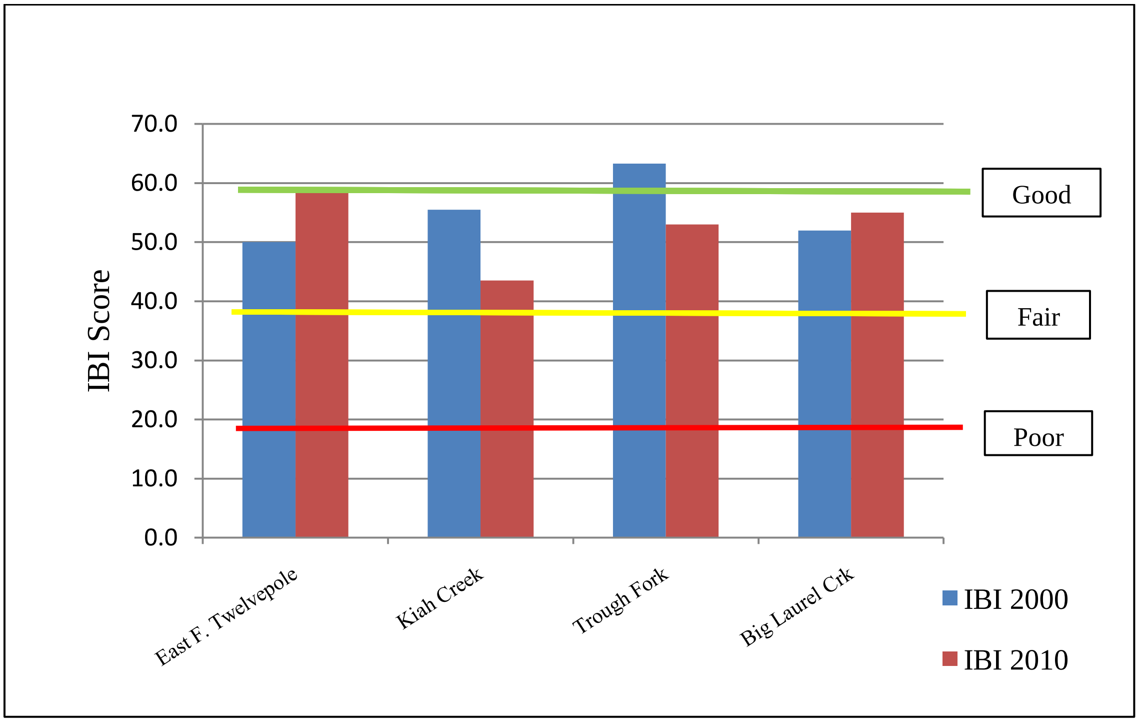


FIGURE 4. Mean Index of Biotic Integrity (IBI) scores based on fisheries community

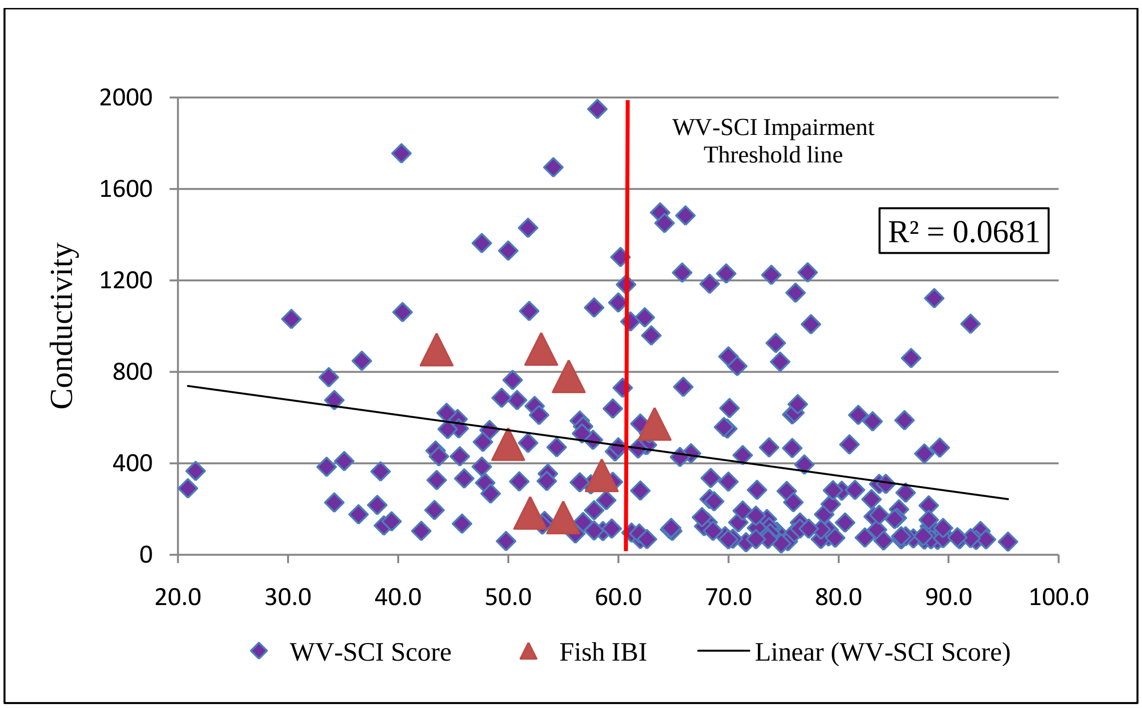


FIGURE 5. Scatter plot of biannual WV-SCI scores versus specific conductivity (µs/cm) over ten years compared to Fisheries IBI of 2000 and 2010 for East Fork Twelvepole Creek, Kiah Creek, Trough Fork, and Big Laurel Creek.

Sampling trend lines of WV-SCI scores plotted against conductivity indicate that a conductivity level of 474.5 µs/cm was the transition point for WV-SCI impairment (60.6) with an r-squared value of 0.0681 (Figure 5). This indicates a weak correlation of conductivity and WV-SCI scores. Fisheries Index of Biotic Integrity plotted against specific conductivity produces a similar trend (FIGURE 5). The variance among macroinvertebrate data remains quite large and thus discourages the use of conductance as a primary indicator of stream quality.

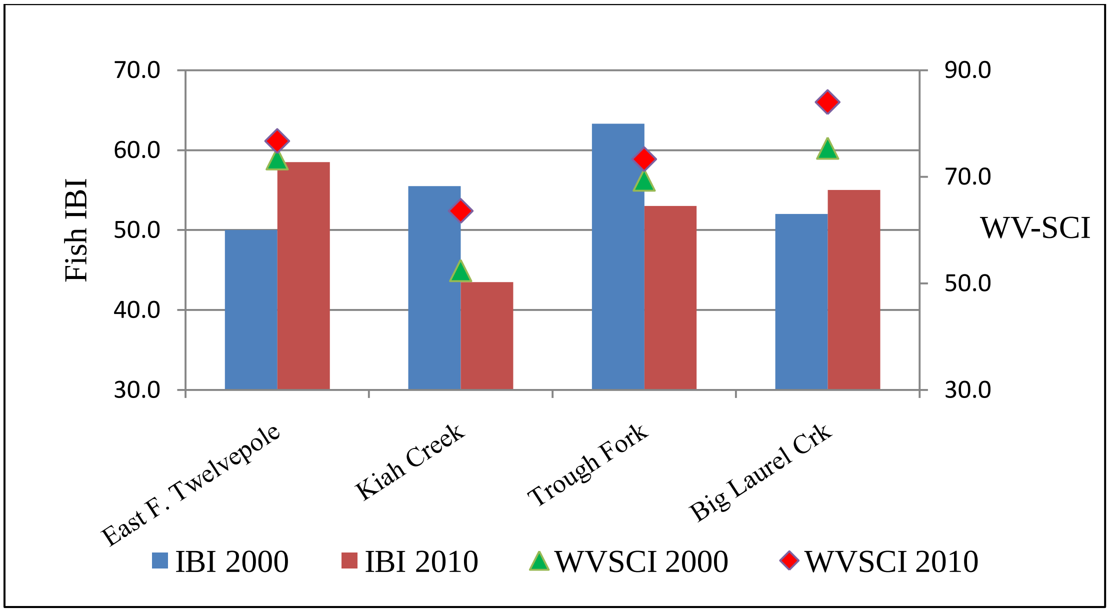


FIGURE 6. Fisheries Index of Biotic Integrity (IBI) scores compared to 3-yr averaged West Virginia Stream Condition Index (WV-SCI) scores.

The West Virginia Stream Condition Index for 2010 showed unimpaired stream scores across the four sampled streams. The WV-SCI of each stream had improved over the ten year period (FIGURE 6). Two of the four streams showed increased fisheries IBI scores. Two of the four IBI scores decreased over the ten year period but still ranked within the "Fair" category (FIGURE 4) . The downstream station on Trough Fork showed a lowered average WV-SCI score in 2010 compared to 2000 but was still far above the impaired threshold with a score of 73.7. In 2000, Kiah Creek's average WV-SCI score was 51.7 and has since risen to 61.5 (Table 3). Although Kiah Creek's macroinvertebrate scores have increased since 2000, the stream's average fish community score lowered from 55.5 to 43.5. Kiah Creek's fish population still ranked as "Fair" between 2000 and 2010. Trough Fork also showed declines in fish IBI scores, but WV-SCI scores showed slight average improvement, and stayed well within the unimpaired category (Figure 6).

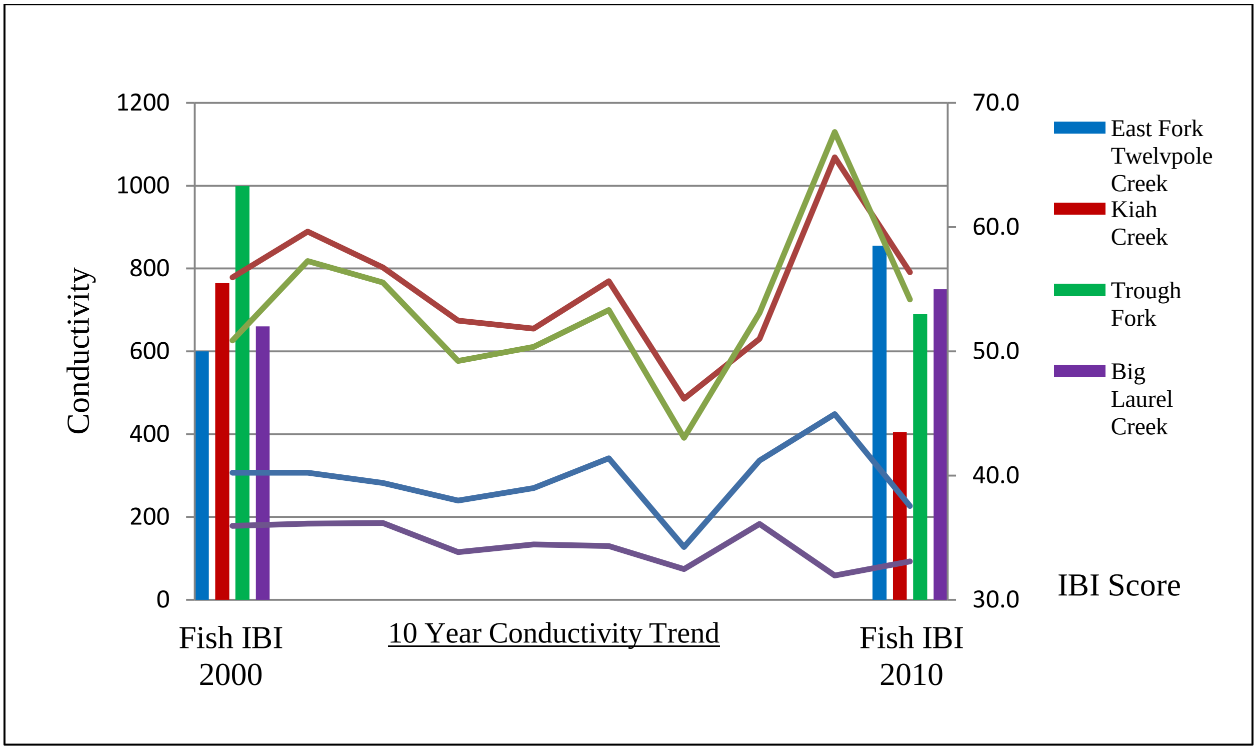


FIGURE 7. 10-year conductivity (µs/cm) trend data of biannual sampling compared to fisheries Index of Biotic Integrity (IBI) scores .

A comparison of specific conductivity data over ten years between the four sampling streams shows that Trough Fork and Kiah Creek are consistently averaging greater than 500 µs/cm conductivity levels while maintaining WV-SCI scores above impairment cutoffs. These streams infrequently exceed established threshold levels, and yet continue to maintain or improve fisheries populations (FIGURE 7). Specific conductivities ranging between 3,000-3,500 µs/cm have been suggested as being the impairment threshold for fisheries in West Virginia (Kimmel & Argent 2010). Findings in East Fork Twelvepole Creek suggest that specific conductivity of this magnitude is having limited effect on fisheries (Figure 8).

The WV-SCI assessment of these streams shows that elevated conductivities have not limited macroinvertebrate assemblages (FIGURES 6, 7 & 8). Use of multi-metric indicators based upon macroinvertebrate and fisheries provide a broad and dynamic evaluation of biotic responses to environmental stressors, more so than measuring just specific conductivity. This has been recognized historically by investigators and is the reason multi- metric indices for ecological monitoring are the current tools in investigating environmental stressors in state and federal aquatic monitoring programs. It has been argued that macroinvertebrates as biological indicators are limited as short term indicators of stressors, whereas fish may be better indicators of long term and chronic stressors in an aquatic habitat (Freund & Petty 2007). The West Virginia Stream Condition Index (WV-SCI) as well as Fisheries Index of Biotic Integrities (IBI) were developed to measure environmental stressors in the aquatic environment, and their continued use in evaluating specific conductivity as an environmental indicator is imperative.

Table 4. Total taxa collected at sampling stations combined, spring and fall collection, and the associated coefficient of community loss ratio.

Stream	Station	2000 Taxa	2010 Taxa	(*I*) Coef.
East Fork Twelvepole Creek	BM-001	14	32	0.0938
	BM-002	20	25	0.2800
Kiah Creek	BM-003	24	19	0.5789
	BM-004	21	17	0.4118
Trough Fork	BM-005	12	9	0.5556
	BM-006	15	14	0.6667
Big Laurel Creek	BM-UBLC	3	4	0.0000
	BM-DBLC	20	21	0.1904

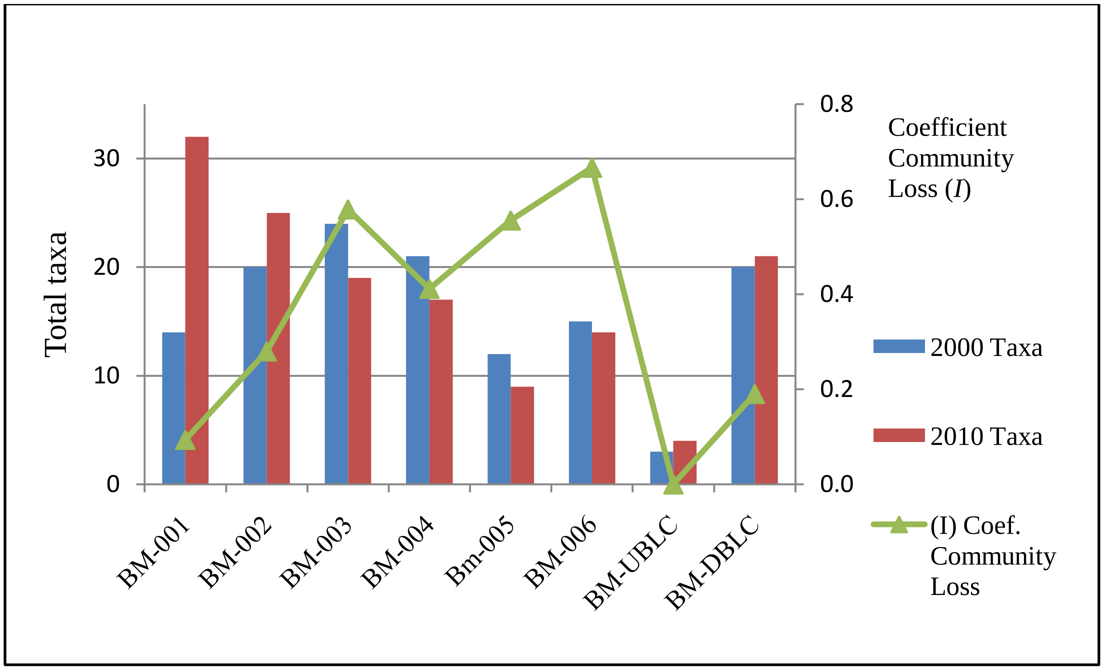


FIGURE 8. Coefficient of community loss ratios compared to total taxa collected from April and October of 2000 and 2010.

The coefficient of community loss for fisheries in these streams illustrates that limited impact has occurred in fish communities during the study period. The upper sample site of Big Laurel Creek was located above all mining influence and showed zero impact to the fisheries community over the ten year period. Among the streams studied the highest (*I*) value recorded was 0.667at the upper Twelvepole Creek reach. A value below the 0.8 (*I*) value has been suggested as showing signs of detrimental effect in stream communities (Kimmel & Argent 2010) (Courtemanch & Davies 1987). As no reliable reference site could be located to accurately depict reference conditions in streams near Twelvepole Creek across multiple watershed sizes, our coefficient of community loss analysis focused upon changes to community loss. The coefficient illustrates temporal changes in the fisheries community. East Fork of Twelvepole Creek had increased number of taxa and showed a small coefficient of community loss value (TABLE 4). Trough Fork and Kiah Creek had decreased numbers of taxa yet very similar species bringing a subdued (*I*) value (TABLE 4). Big Laurel Creek, originally sampled as a reference stream, showed little signs of community change and remained near reference condition despite the increased mining activity and increased specific conductivity in the watershed in recent years (Figure 8).

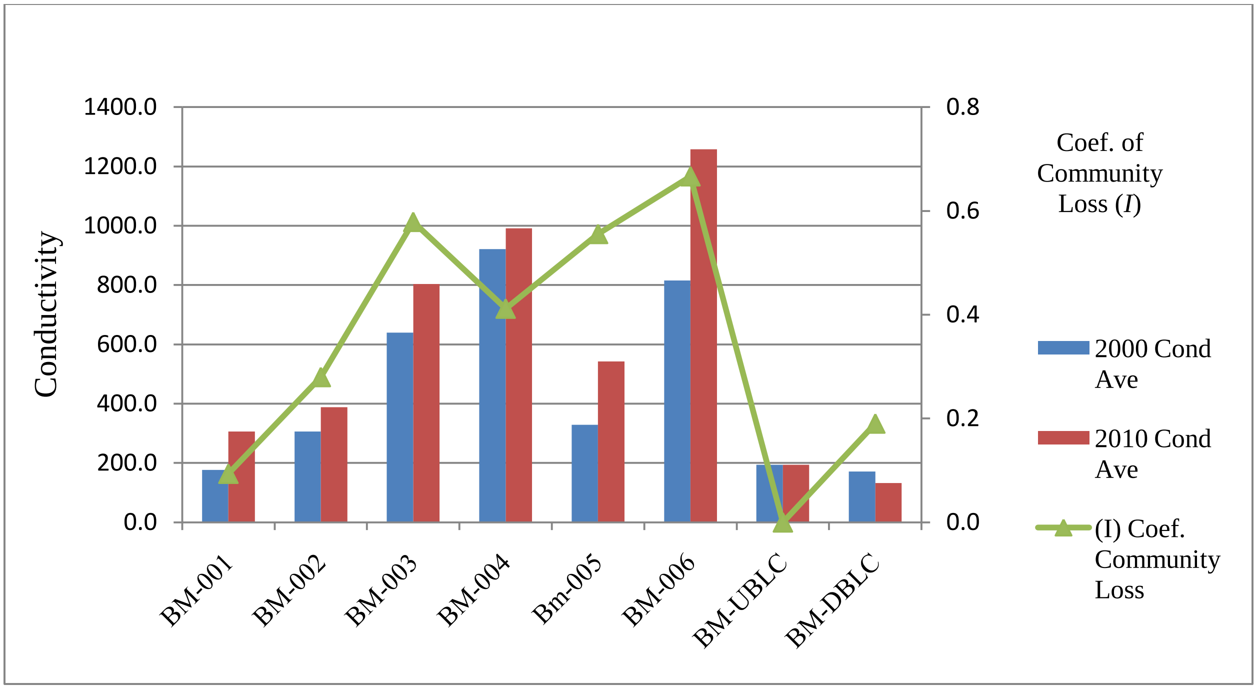


FIGURE 9. Coefficient of community loss ratios compared to 3 year mean conductivity levels

Average values of the four streams show that specific conductivity has been gradually increasing over the decade. Big Laurel Creek had limited increase in specific conductivity despite the recent introduction of mining into the watershed. The coefficient of community loss shows that the (*I*) values nearly mimic the increased levels of conductivity yet indicate no change above 0.8 ratio values (Figure 9). This data indicates that influences may be affecting fisheries populations at low indicator levels (Kimmel & Argent 2010). Downstream sampling reaches of all four streams indicated lower community loss coefficients irrespective of location downstream of mining influence. This may be a product of the increased taxa collected in a larger segment of the stream, as taxa diversity has been shown to increase with larger watershed drainage areas providing more habitat and a larger diversity of fish assemblage naturally (Fausch et al. 1984).

Table 5. Summary of fish species collected in 2000 and 2010. Station 01 &02 (E. Fork Twelvepole Creek), Station 03 & 04 (Kiah Creek), Station 05 &06 (Trough Fork), Station UBLC & DBLC (Big Laurel Creek).

		Station:															
		2000								2010							
Common Name	Scientific Name	01	02	03	04	05	06	UBLC	DBLC	01	02	03	04	05	06	UBLC	DBLC
Rockbass	Ambloplites rupestruis	x	x	x	x		x			x	x	x	x				
Yellow Bullhead	Ameiurus natalis		x												x		x
Central stoneroller	Campostoma anomalum		x	x	x	x	x		x	x	x	x	x	x	x		x
White Sucker	Catostomus commersonii			x		x	x		x	x		x			x		x
Rosyside Dace	Clinostomus funduloides					x	x	x	x					x		x	x
Silverjaw minnow	Ericymba buccata	x		x	x	x	x		x			x		x			
Greenside darter	Etheostoma blennioides	x			x					x	x		x				
Rainbow darter	Etheostoma caeruleum	x	x	x	x	x	x		x	x	x	x	x	x	x		x
Fantail darter	Etheostoma flabellare	x	x	x	x	x	x		x	x	x			x	x	x	x
Johnny darter	Etheostoma nigrum	x	x	x	x	x			x	x	x	x	x	x	x		x
Banded darter	Etheostoma zonale				x					x	x	x					
Northern hogsucker	Hypentelium nigricans		x	x	x		x		x	x	x	x	x		x		x
Mtn. brook lamprey	Ichthyomyzon greeleyi									x	x	x					x
Least Brook Lamprey	Lampetra aepyptera	x	x	x					x								x
Green sunfish	Lepomis cyanellus			x	x	x	x		x	x	x	x	x		x		x
Pumpkinseed	Lepomis gibbosus	x		x	x					x		x					
Pumpkinseed Hybrid	Lepomis gibbosus xxxx											x					
Orangespotted sunfish	Lepomis humilis									x	x	x	x		x		x
Orangespotted hybrid	Lepomis humilis xxxx									x	x		x		x		x
Bluegill	Lepomis macrochirus	x	x	x	x				x	x			x		x		x
Longear Sunfish	Lepomis megalotis		x	x					x	x							
Redear sunfish	Lepomis microlophus									x							
Lepomis spp.	Lepomis spp.		x	x													
Striped shiner	Luxilus chrysocephalus	x	x	x	x		x		x	x	x	x	x	x	x		x
Smallmouth bass	Micropterus dolomieu			x						x							
Spotted Bass	Micropterus punctulatus		x	x					x	x							x
Largemouth bass	Micropterus salmoides									x							
Golden Redhorse	Moxostoma erythrurum		x	x	x	x				x	x						
River chub	Nocomis micropogon	x	x	x	x		x			x	x	x	x				
Sand shiner	Notropis stramineus			x							x						
Popeye shiner	Notropis ariommus			x													
Emerald shiner	Notropis atherinoides									x	x	x					
Silverjaw minnow	Notropis buccatus										x						
Common shiner	Notropis cornutus									x							
Spottail shiner	Notropis hudsonius								x								
Rosyface shiner	Notropis rubellus									x	x						
Telescope shiner	Notropis telescopus									x							
Mimic shiner	Notropis volucellus		x														
Brindled Madtom	Noturus miurus				x				x				x				x
Brindled madtom	Noturus miurus		x		x					x	x		x				
Logperch	Percina caprodes		x	x	x	x	x		x	x	x		x				x
Bluntnose minnow	Pimephales notatus	x	x	x	x	x	x		x	x	x	x	x		x		x
Fathead Minnow	Pimephales promelas										x						
Black crappie	Poxomis nigromaculatus									x							
Blacknose dace	Rhinichthys atratulus	x			x	x	x	x	x		x	x		x		x	x
Creek chub	Semotilus atromaculatus	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

Conclusion

It is likely that environmental stressors do exist in these streams which have been historically degraded from anthropogenic effects. This study demonstrates that specific conductance measurement is a poor indicator of aquatic fauna impairment in certain reaches of the state. This follows recent research indicating many components influencing the WV-SCI may not be significantly attributed to total dissolved ion concentrations, of which conductivity is a major component (Timpano et al. 2010). It is noted that the highly variable conditions of Appalachian streams makes direct comparisons difficult with short lived organisms such as macroinvertebrates and highly mobile fisheries populations (Freund & Petty 2007). Nonetheless, this extended term trend data does indicate that the WV-SCI scores can be maintained unimpaired despite sustained elevated levels of specific conductivity in streams directly affected by mining or other anthropogenic activities (FIGURES 6, 7 & 8). Fisheries analysis indicates that fish populations have not been extensively degraded based upon multi-metric indices designed to evaluate wellbeing. Many of the previous studies designed to evaluate potential biotic harm have utilized single point data inferences which may not have been indicative of normalcy. We have utilized bi-annual sampling across multiple years to eliminate data trend possibilities from seasonal variations to provide a long term aquatic health study. The use of specific conductance as a distinct measure of aquatic health has shown limited correlation against macroinvertebrate and fish community integrity in southwestern West Virginia.

References

Angermeier, P. L., and R. A. Smogor. 1995. Estimating number of species and relative abundances in stream-fish communities: effects of sampling effort and discontinuous spatial distributions. Canadian Journal of Fisheries and Aquatic Sciences 52:936–949.

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

Compton, M. C., G. J. Pond, and J. F. Brumley. 2003 Development and application of the Kentucky index of biotic integrity (KIBI). Department of Environmental Protection, Division of Water, Water Quality Branch, Frankfort, Kentucky.

Davenport, L.J. and K.J. Morse, 2010. An Assessment of Conductivity and Benthic Macroinvertebrate Health and diversity in Alabama Streams in Ecoregion 68. Submitted to the Alabama Coal Association, August 2010.

Fausch, K. D., J. R. Karr, and P. R. Yant. 1984. Regional application of an index of biotic integrity based on stream fish communities. Trans. Amer. Fish. Soc. 113:39-55.

Freund, J. G. and J. T. Petty. 2007. Response of fish and macroinvertebrate bioassessment indices to water chemistry in a mined Appalachian watershed. Environmental Management 39:707–720.

Karr, J.R. 1981. Assessment of biotic integrity using fish communities. Fisheries. 6: 21-27.

Kimmel, W.G., and D.G. Argent. 2010. Stream Fish Community Responses to a Gradient of Specific Conductance. Water, Air, and Soil Pollution 206:49-56.

Level III Ecoregions of the Continental United States. National Health and Environmental Effects Research Laboratory, U.S. Environmental Protection Agency. Revised March 2007. http://www.epa.gov/wed/pages/ecoregions.htm.

Pond, G. J. (2010) Patterns of Ephemeroptera taxa loss in Appalachian headwater streams (Kentucky, USA). Hydrobiologia 641:1, 185-201.

Tetra Tech, Inc. 2000. A stream condition index for West Virginia wadeable streams. Prepared for U.S. EPA Region 3 Environmental Services Division, and U.S. EPA Office of Science and Technology, Office of Water.

Timpano, A.J., Schoenholtz, S.H., Zipper, C.E., Soucek, D.J. (2010). Isolating effects of total dissolved solids on aquatic life in central Appalachian coalfield streams. Paper presented at the 2010 National Meeting of the American Society of Mining and Reclamation, Pittsburgh, PA, Bridging Reclamation, Science and the Community June 5 - 11, 2010.R.I. Barnhisel (Ed. Published by ASMR, 3134 Montavesta Rd., Lexington, KY 40502

USEPA, 2010. A Field-Based Aquatic Life Benchmark for Conductivity in Central Appalachian Streams (EPA/600/R-10/023A). Draft. 75 FR 18499, April 12, 2010