BIOASSESSMENT OF BENTHIC MACROINVERTEBRATES OF THE MIDDLE PENNS CREEK, PENNSYLVANIA WATERSHED†

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ABSTRACT

During October and November 2011, an assessment of the benthic macroinvertebrate assemblage was conducted in the middle Penns Creek (PA) watershed. The survey consisted of 10 tributary sites within a 40km portion of the watershed. The goals were to establish baseline conditions for headwater streams in this section of the watershed, determine their current biotic health, and suggest possible designated use upgrades. All sample sites were low-order (1-3) streams typically of higher gradient. We calculated the Pennsylvania Benthic Macroinvertebrate Index of Biotic Integrity at each site based on the following biotic indices: Beck’s Index, Total Taxa Richness, EPT (Ephemeroptera + Plecoptera + Trichoptera) Taxa Richness (Pollution Tolerance Values 0-4), Shannon Diversity Index, Hilsenhoff Biotic Index, and Percent Sensitive Individuals (Pollution Tolerance Values 0-3). All study streams are currently designated by Pennsylvania Department of Environmental Protection (PA DEP) as Cold Water Fish (1), High Quality (6), or Exceptional Value (3) streams. We found six streams to be of highest biotic quality (IBI score >80). Benthic macroinvertebrate IBI scores for Little Poe Creek (93.2) exceeded the current designated use of High Quality by PA DEP, and should be considered for a re-designated increase to Exceptional Value. Panther Run (51.9) received the lowest benthic macroinvertebrate IBI score, possibly due to low total organisms which may suggest it could be experiencing ecological stressors. Our overall results indicate these Penns Creek streams to currently be of good biotic health, however long-term monitoring may be necessary to further assess anthropogenic impacts within the watershed.

INTRODUCTION

Headwater streams tend to be highly susceptible to environmental changes due to their small drainage area and size, making natural and anthropogenic impacts more intense than in larger systems (Wallace et al. 1996; Angradi 1999; Pond 2010). Both physicochemical properties and aquatic biota have been shown to be negatively altered from anthropogenic stressors (Woodcock and Huryn 2007). Benthic macroinvertebrate have been found to be excellent indicators of water quality due to their limited mobility, short life spans, and varying sensitivity to pollutants (Fore et al. 1996). By analyzing the diversity of taxa, an understanding of various environmental stressors can be determined which may be impacting watersheds (Rosenberg and Resh 1993; Barbour et al. 1999). Various biotic indices and calculations can be used to assess these impacts. In Pennsylvania, selected indices are integrated into a benthic macroinvertebrate Index of Biotic Integrity (PA DEP 2012). The benthic macroinvertebrate Index of Biotic Integrity (IBI) calculation is a widely used biologically based metric that allows aquatic scientists to determine the integrity of fluvial systems, and is an accepted determinant for the designated usage of that waterway (Goodnight 1973; Barbour et al. 1999; PA DEP 2012).

The Pennsylvania Department of Environmental Protection (PA DEP) is the chief governing agency of water quality in the state, and issues varying levels of stream protection based on calculation of a benthic macroinvertebrate IBI and other water quality standards (PA DEP 2012). PA DEP’s highest protection is awarded under the classifications of Exceptional Value (EV), High Quality (HQ), and Cold Water Fish (CWF); these classifications provide varying levels of protection for waterways (PA Code 2009; PA DEP 2012). By definition, an EV stream has excellent water quality, resulting in the highest environmental protection. A HQ stream has slightly lower water quality, and will only be altered under social or economic justification. CWF designation allows for the protection of salmonids and other biota indigenous to cold water habitat (PA Code 2009; PA DEP 2012).

During October and November 2011, 10 headwater streams in the middle Penns Creek (PA) watershed were assessed to determine the biotic health of the middle Penns Creek drainage. The 40km area of study is of major ecological,
sociological, and economic importance, yet still remains largely undeveloped making its protection necessary for the future. The goals of the study were to catalogue headwater stream benthic macroinvertebrate communities, to determine a Pennsylvania benthic macroinvertebrate Index of Biotic Integrity for those streams and to evaluate study streams for possible change in designated use by PA DEP.

MATERIALS AND METHODS

Study sites

Penns Creek is located in central Pennsylvania with the headwaters originating in Centre County. The creek flows nearly due east through Mifflin, Union, and Snyder Counties emptying into the Susquehanna River just below Selinsgrove, PA. The middle Penns Creek drainage is comprised of a mosaic of residential areas, agricultural land, and forested mountain terrain. The area was once historically logged, and extensive agriculture continues throughout the watershed. Ten streams, all tributaries of middle Penns Creek were chosen within the watershed: Cherry Run, Elk Creek, Furnace Run, Laurel Run, Little Poe Creek, Panther Run, Pine Creek, Poe Creek, Swift Run, and Weikert Run (Figure 1). A 100m reach was established on each stream nearest the confluence with Penns Creek. Streams selected were located within the Approved Trout Water or Class A Wild Trout sections of Penns Creek (PA FBC 2013).

Benthic macroinvertebrate sampling

Benthic macroinvertebrates were collected from October 15 and November 22, 2011 following the procedures established by Barbour et al. (1999) and PA DEP (2012). Six kick composite benthic macroinvertebrates samples were taken from riffle habitat within the 100m reach using a 12 inch wide x 10 inch high 500-micron mesh D-frame net. Sampling areas were 1 m², and the substrate was disturbed for one minute to a depth of 10 cm. Composite samples were placed into a 500-micron sieve bucket, rinsed, and then transferred into a wide mouth jar and preserved in 95% ethanol (Barbour et al. 1999). Large sticks, rocks, and plant materials were rinsed with stream water, examined for organisms and then discarded. To prevent site-to-site contamination the net was thoroughly checked for attached benthic macroinvertebrates and vigorously rinsed prior to leaving the site.

Data analysis

To develop the benthic macroinvertebrate IBI, the following indices were calculated: Total Taxa Richness; Ephemeroptera, Plecoptera, and Trichoptera (EPT) Taxa Richness (Pollution Tolerance Values 0-4); Modified Beck’s Index; Hilsenhoff Biotic Index; Shannon Diversity Index; Total Percent Sensitive Individuals (Pollution Tolerance Values 0-3); and a benthic macroinvertebrate IBI utilizing the six combined metrics (Appendix 1). All indices were calculated using the most current PA DEP protocols and tolerance values (PA DEP 2012). The IBI scores for all streams in the study, except Elk Creek were calculated using the small-stream IBI standardization values (PA DEP 2012). Due to the watershed size (~ 50 m²) at the sampling location we used the large-stream IBI standardization values for Elk Creek (PA DEP 2012). The possible designated stream use was determined by the total calculated benthic macroinvertebrate IBI scores (HQ+EV: IBI ≥ 80); and CWF attaining use with an IBI ≥ 63 (PA DEP 2012). Data was then given to the appropriate county Conservation District who forwarded it PA DEP to determine final designated use.

RESULTS AND DISCUSSION

Results

Overall macroinvertebrate biodiversity in the study streams was of high biotic quality as six of the ten streams exceeded an overall IBI score of 80. Ten genera (Epeorus, Leuctra, Sweltsa, Tallaperla, Acronura, Pteronarcy, Agapetus, Dolophilodes, Wormaldla, and Diplectrona) were
identified with a pollution tolerance value of 0; and all study sites had at least one of these genera present (Appendix 1). Two streams, Little Poe Creek and Weikert Run, had a benthic macroinvertebrate IBI Score ≥92, the minimum for classification to be considered as EV. Both received an exceptionally high calculated benthic macroinvertebrate IBI score (Table 1), exceeding their current designated usage of HQ by PA DEP. Little Poe Creek had present, nine of the ten genera with a pollution tolerance value of 0 (Appendix 1). Two streams currently designated HQ, Pine Creek and Swift Run, had an IBI score >90, which are close to the EV threshold set by PA DEP. Two tributaries, Cherry Run and Furnace Run, had a benthic macroinvertebrate IBI score ≥80, the minimum for designation as HQ by PA DEP. Elk Creek, Laurel Run and Poe Creek had a benthic macroinvertebrate IBI score >63 and <80; the necessary score for designation as CWF (Table 1). Panther Run received the lowest benthic macroinvertebrate IBI scores of our sample set with an IBI of 51.9.

Six streams (Cherry Run, Furnace Run, Little Poe Creek, Pine Creek, Swift Run, and Weikert Run) had adjusted standardized Total Taxa Richness of at least 75.0 (Table 1) with Cherry Run a maximum of 100.0. Six streams (Cherry Run, Furnace Run, Little Poe Creek, Pine Creek, Swift Run, and Weikert Run) had an adjusted standardized EPT Taxa richness greater than 70.0 with Swift Run the maximum of 100.0. Nine streams (Cherry Run, Elk Creek, Furnace Run, Laurel Run, Little Poe Creek, Pine Creek, Poe Creek, Swift Run, and Weikert Run) had an adjusted standardized Beck’s Index metric score exceeding 50.0; both Little Poe Creek and Swift Run had a maximum value of 100.0 (Table 1). We found that seven streams (Furnace Run, Laurel Run, Little Poe Creek, Panther Run, Pine Creek, Poe Creek, and Weikert Run) had adjusted standardized Hilsenhoff Biotic Index scores exceeding 90.0 with Furnace Run and Weikert Run a maximum of 100.0. In regards to species diversity, six streams (Cherry Run, Furnace Run, Little Poe Creek, Pine Creek, Swift Run, and Weikert Run) had adjusted standardized Shannon Diversity Indexes greater than 90.0, with Pine Creek a maximum of 100.0. Finally, we found in regards to sensitive genera, that seven streams (Furnace Run, Laurel Run, Little Poe Creek, Pine Creek, Poe Creek, Swift Run, and Weikert Run) had adjusted standardized Percent Sensitive Individuals score greater than 70.0 (Table 1).

**Discussion**

We used six accepted metrics developed by PA DEP (Total Taxa Richness, Total EPT Taxa Richness (PTV 0-4), Modified Beck’s Index, Hilsenhoff Biotic Index, Shannon Diversity Index, and Percent Sensitive Individuals (PTV 0-3)) to determine the Pennsylvania benthic macroinvertebrate Index of Biotic Integrity for each stream. Our benthic macroinvertebrate IBI calculations showed that the majority of streams (9 of 10) should be under the designations of Cold Water Fishes, High Quality waters, or Exceptional Value waters.

Panther Run, did not meet the minimum for any of these classifications based on the Benthic Macroinvertebrate IBI scores, even though it is currently under designated use by PA DEP as HQ. Our Benthic Macroinvertebrate IBI score was much lower than the minimum necessary for HQ (Table 1). The sample had less than 160 organisms, and a low frequency of individuals and pollution sensitive genera. Location of this stream is in a remote section of the wilderness which is

<table>
<thead>
<tr>
<th>Stream Name</th>
<th>Total Taxa Richness</th>
<th>EPT Taxa Richness</th>
<th>Beck’s Index</th>
<th>Hilsenhoff Biotic Index</th>
<th>Shannon Diversity Index</th>
<th>Percent Sensitive Individuals</th>
<th>Benthic Macroinvertebrate IBI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cherry Run</td>
<td>100.0</td>
<td>78.9</td>
<td>65.8</td>
<td>88.3</td>
<td>99.4</td>
<td>55.5</td>
<td>81.8</td>
</tr>
<tr>
<td>Elk Creek</td>
<td>58.1</td>
<td>50.0</td>
<td>59.1</td>
<td>93.3</td>
<td>78.6</td>
<td>49.7</td>
<td>64.8</td>
</tr>
<tr>
<td>Furnace Run</td>
<td>78.8</td>
<td>89.5</td>
<td>76.3</td>
<td>100.0</td>
<td>92.7</td>
<td>98.9</td>
<td>89.4</td>
</tr>
<tr>
<td>Laurel Run</td>
<td>66.7</td>
<td>73.7</td>
<td>50.0</td>
<td>94.1</td>
<td>89.7</td>
<td>93.9</td>
<td>78.0</td>
</tr>
<tr>
<td>Little Poe Creek</td>
<td>90.9</td>
<td>94.7</td>
<td>100</td>
<td>94.0</td>
<td>96.0</td>
<td>78.1</td>
<td>93.2</td>
</tr>
<tr>
<td>Panther Run</td>
<td>33.3</td>
<td>31.6</td>
<td>18.4</td>
<td>92.7</td>
<td>65.0</td>
<td>70.5</td>
<td>51.9</td>
</tr>
<tr>
<td>Pine Creek</td>
<td>87.9</td>
<td>94.7</td>
<td>81.6</td>
<td>95.3</td>
<td>100.0</td>
<td>82.6</td>
<td>90.8</td>
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<td>Poe Creek</td>
<td>45.5</td>
<td>57.9</td>
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<td>96.3</td>
<td>81.1</td>
<td>79.5</td>
<td>70.6</td>
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<tr>
<td>Swift Run</td>
<td>93.9</td>
<td>100.0</td>
<td>100.0</td>
<td>88.0</td>
<td>95.4</td>
<td>65.1</td>
<td>90.8</td>
</tr>
<tr>
<td>Weikert Run</td>
<td>78.8</td>
<td>89.5</td>
<td>92.1</td>
<td>100.0</td>
<td>92.4</td>
<td>100.0</td>
<td>93.6</td>
</tr>
</tbody>
</table>

Table 1. The adjusted standardized metric values for the ten study sites within the middle Penns Creek (PA) watershed, and their combination into a calculated benthic macroinvertebrate IBI for each site. The Elk Creek metrics were calculated with large-stream metric standardization values, all other streams were calculated with small-stream standardization values (PA DEP 2012).
very underdeveloped. Low scores may have been due to site selection, as the site closest the mouth was downstream of a gravel road crossing, possibly having a negative effect on a small location of the creek. According to PA DEP protocols if a sample results in fewer than 160 total organisms in the entire sample, the IBI and assessment procedures may not apply exactly and this could be an improper IBI assessment due to the low total number of organisms (PA DEP 2012).

The overall health of the other headwater streams appears well, as we were able to identify 10 genera in 9 families that had a pollution tolerance value of 0 (Appendix 1). Every stream contained at least one genus with a pollution value of 0, indicating that these streams have the potential to support healthy and diverse benthic macroinvertebrate communities. All genera with a pollution tolerance value of 0 were in the orders Ephemeroptera, Plecoptera, or Trichoptera which are deemed as excellent indicators towards overall stream health. We found both the frequency of genera and individuals had a strong correlation with the calculated benthic macroinvertebrate IBI score and our six metrics (Table 1, Appendix 1).

Our results support the current designated use of many Penns Creek tributaries by PA DEP, but also indicate that certain streams should be proposed for re-designation under a higher classification by PA DEP. Concern for the overall health of the system may be necessary; as some tributaries classified under a higher designated use by PA DEP, failed to meet the minimum scores based on our benthic macroinvertebrate IBI calculations (Table 1). This may be an indicator that these streams are influenced by anthropogenic ecological stressors or possibly other factors such as seasonality or collection method.

### Exceptional Value Waters:

The highest quality streams were Little Poe Creek and Weikert Run. These streams exceeded the minimum benthic macroinvertebrate IBI score of 92 for consideration as EV waters by PA DEP (Table 1). They were of exceptional biological quality, and contained many genera with a pollution tolerance value of 0 (Appendix 1). Other pollution sensitive taxa were also present, and all streams had high species diversity. The high numbers of pollution sensitive taxa and high species diversity were responsible for producing exceptional scores in our six metrics and the overall benthic macroinvertebrate IBI score.

Little Poe Creek and Weikert Run produced IBI scores that exceeded their current HQ designated usage (Table 2). Based on our benthic macroinvertebrate IBI calculations, we propose that they be considered for re-designation to EV. Our data shows that 85 individuals from 9 genera had a pollution tolerance value of 0, which is an excellent indicator of the overall biotic health. These streams also had a benthic macroinvertebrate IBI score exceeding 93, which is exceptionally high for low-order headwater streams (PA DEP 2012).

Pine Creek and Swift Run which are two streams currently designated HQ: had IBI’s >90 which are close to the EV threshold. Pine Creek has sections which are currently both HQ and EV. Our sample site was located in the designated HQ section (Downstream Boundary of Hook Natural Area to Stony Run) between designated EV sections. More benthic macroinvertebrate collection should be conducted on these two to determine if these streams could be considered EV waters.

<table>
<thead>
<tr>
<th>Stream Name</th>
<th>Current DEP Stream Use</th>
<th>Benthic Macroinvertebrate IBI</th>
<th>IBI Calculated DEP Stream Use</th>
<th>Proposed Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cherry Run</td>
<td>EV</td>
<td>81.8</td>
<td>HQ</td>
<td>Evaluate for impairment</td>
</tr>
<tr>
<td>Elk Creek</td>
<td>HQ-CWF</td>
<td>64.8</td>
<td>CWF</td>
<td>Evaluate for impairment</td>
</tr>
<tr>
<td>Furnace Run</td>
<td>CWF</td>
<td>89.4</td>
<td>HQ</td>
<td>Upgrade</td>
</tr>
<tr>
<td>Laurel Run</td>
<td>CWF</td>
<td>78.0</td>
<td>CWF/ possible HQ</td>
<td>Evaluate for upgrade</td>
</tr>
<tr>
<td>Little Poe Creek</td>
<td>HQ-CWF</td>
<td>93.2</td>
<td>Possible EV</td>
<td>Upgrade</td>
</tr>
<tr>
<td>Panther Run</td>
<td>HQ</td>
<td>51.9</td>
<td>Non-attaining</td>
<td>Evaluate for impairment</td>
</tr>
<tr>
<td>Pine Creek</td>
<td>HQ-CWF</td>
<td>90.8</td>
<td>HQ/ possible EV</td>
<td>Evaluate for upgrade</td>
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<tr>
<td>Poe Creek</td>
<td>HQ-CWF</td>
<td>70.6</td>
<td>CWF</td>
<td>Evaluate for impairment</td>
</tr>
<tr>
<td>Swift Run</td>
<td>HQ</td>
<td>90.8</td>
<td>HQ/ possible EV</td>
<td>Evaluate for upgrade</td>
</tr>
<tr>
<td>Weikert Run</td>
<td>HQ-CWF</td>
<td>93.6</td>
<td>Possible EV</td>
<td>Upgrade</td>
</tr>
</tbody>
</table>

Table 2. Current designated stream use by Pennsylvania Department of Environmental Protection (PA DEP), our IBI calculated stream use and proposed action based on calculated benthic macroinvertebrate IBI. Designated stream usage by PA DEP is determined by the calculated benthic macroinvertebrate IBI scores (EV+ HQ: IBI ≥ 80; CWF: IBI ≥ 63). Exceptional Value (EV), High Quality (HQ), and Cold Water Fish (CWF) are the protections awarded by PA DEP.
High Quality Waters:

Pine Creek, Swift Run, Cherry Run and Furnace run exceeded the minimum benthic macroinvertebrate IBI score (>80) for designated use as a HQ water. Pine Creek, Swift Run, Furnace Run are currently under HQ classification, and Cherry Run is under EV. Cherry Run scores were lower than PA DEP classification, but this score was still an excellent indicator of high water quality. The lower than expected benthic macroinvertebrate IBI score (81.8) for Cherry Run may have been due to sampling location, seasonality or processing reasons resulting in an apparent decrease in IBI score. More benthic macroinvertebrate collection should be conducted to determine if the stream no longer meets the minimum requirement for EV waters and to identify possible reasons for decline.

Cold Water Fishes Designation:

Elk Creek contains a Class A Wild Trout population within the sampling location (PA FBC 2013); and therefore, it automatically receives a minimum designation of HQ-CWF. PA DEP also lists this area under the usage of EV. Despite these protections, our benthic macroinvertebrate IBI scores indicate that water quality of Elk Creek may be deteriorating, as scores were far from its designated classification by PA DEP. Our calculated benthic macroinvertebrate IBI score of 64.8, did not meet the EV designation by PA DEP, which is correlated with low scores in our other six metrics (Table 1). Concentrated sampling in upstream sections of Elk Creek may help identify potential sources of non-point or point source pollution that could be responsible for the decline in the benthic macroinvertebrate assemblage. Laurel Run and Poe Creek both had benthic macroinvertebrate IBI scores that were > 63 and < 80, designating their use as CWF. Our determined use for Laurel Run is the same as PA DEP, but with a score of 78.0, future sampling may be conducted to see if its classification should be higher than its current status. The benthic macroinvertebrate IBI score (70.6) for Poe Creek was lower than PA DEP's current classification of HQ-CWF. The Poe Creek sample had less than 160 total organisms and thus the IBI and assessment procedures may not apply and this could be an improper IBI assessment due to the low total number of organisms (PA DEP 2012). Further sampling of this stream may be necessary to determine if there has been a permanent decline in overall water quality.

ACKNOWLEDGEMENTS

This work was supported by the Degenstein Foundation and the Department of Biology at Susquehanna University. We thank B. Thorpe Halloran for his assistance with Figure 1.

LITERATURE CITED

Phylum  Class  Order  Family  Genera  Tolerance Values

Cherry  Elk  Furnace  Laurel  Little  Poe  Panther  Pine  Poe  Swift  Upper  Penns  Weikert

Annelida  Oligochaeta  5  2  2  5  7  3  1  7  1

Arthropoda  Crustacea  Isopoda  Asellidae  Lirceus  8  5

Gammaridae  Gammarus  4  1  4  2

Decapoda  Cambaridae  Orconectes  6  1

Insecta  Ephemeroptera  Leptophlebiidae  Paraleptophlebia  1  3  1  3  13  5  1  1  1  10  10  2  1

Ephemeridae  Ephemera  2  1  1  5

Caenidae  Caenis  7  1

Ephemerellidae  Ephemerella  1  8  49  1  2  22  15  1  17

Eurylophella  4  24  1  11  4  2  1

Serratella  2  4  2

Leptohyphidae  Tricorythodes  4  1

Baetidae  Acentrella  4  12  2

Baetis  6  24  37  3  2  3  2  3

2-Tailed  6  1  10  1

Isonychiidae  Isonychia  3  2  5  1  22

Heptageniidae  Epeorus  0  1  21  14  1  25  2  37

Leucrocuta  1  4  2  3

Maccaffertium  3  28  36  4  9  13  7  10  1  12  2  1

Stenacron  4  5  1

Stenonema  3

Odonata  Aeshnidae  Aeshna  5

Cordulegastridae  Cordulegaster  3

Gomphidae  Gomphus  5

Lanthus  5  1  1  3  1

Plecoptera  Capniidae  Allocapnia  3  5  4  11  2

Paracapnia  1  2  2  4

Leuctridae  Leuctra  0  4  5  1  11  7  2  1  1

Taeniopterygidae  Taenionema  3  17  15  3  11

Taeniopteryx  2  7  20  1

Chloroperlidae  Sweltsa  0  4  7  1  8  1

Peltoperlidae  Tallaperla  0  1  1  5  3  1

Perlidae  Acroneuria  0  10  4  1  2  2

Agnetina  2

Perlodidae  Isoperla  2  1  7  3  6

Malirekus  2  2  3  1  2

Pteronarcyidae  Pteronarcys  0  2  4  3  1

Coleoptera  Psephenidae  Ectopria  5  1  2  1  3

Psephenus  4  1  1

Elmidae  Dubiraphia  6

Macronychus  2

Optioservus  4  24  22  13  3  2  42  52

Oulimnius  5

Promoresia  2  3  1  2  10  1  3

Stenelmis  5

Megaloptera  Corydalidae  Nigronia  2  10  1  1

Trichoptera  Rhyacophilidae  Rhyacophila  1  2  8  16  11  15  1  15  10  3  9

Hydroptilidae  Palaeagapetus  1  4

Glossosomatidae  Agapetus  0

Philopotamidae  Chimarra  4  2  1

Dolophilodes  1  4  2  9  12

Wormaldia  0  2

Polycentropodidae  Cyrnellus  8

Polycentropus  6  4  1  2  1

Cheumatopsyche  6  29  28  6  9  9  20  4

Diplectrona  0  8  50  8  10  15  14

Hydropsyche  5  15  25  4  1  6  8  25  1

Brachycentridae  Micrasema  2  2  2

Lepidostomatidae  Lepidostoma  1  3  2  2  3  1  2

Apataniidae  Apatania  2  2  3

Uenoidae  Neophylax  3  1  1

Diptera  Ceratopogonidae  Bezzia/Probezzia  6  1  1  3

Chironomidae  6  23  14  4  15  29  3  29  13  30  35  14

Simuliidae  Prosimulium  2  16  48  5  7

Simulium  6  1  2

Tipulidae  Antocha  3  1  1  1  1

Dicranota  3  3  1

Hexatoma  2  4  4  1  1

Ormosia  6

Pseudolimnophila  2

Tipula  4

Dolichopodidae  Unknown  4

Appendix 1. Total BMI taxa list present across the 11 study sites in upper Penns Creek watershed samples from Oct. 15-Nov. 22, 2011.
MUSSEL POPULATION AND DISTRIBUTION ON BUFFALO CREEK, AN AMERICAN EEL STOCKED TRIBUTARY TO THE WEST BRANCH SUSQUEHANNA RIVER†

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ABSTRACT

In 2009 the United States Fish and Wildlife Service began stocking young American eel into Buffalo Creek, a small agriculturally impacted stream that feeds into the West Branch of the Susquehanna River. The freshwater mussel *Elliptio complanata* is known to have higher success rates completing its life cycle using American eel as the host fish for its glochidia (Lellis et al. 2013). The objective of this study was to determine if the American eel will affect mussel populations within their first 5 years of reintroduction into Buffalo Creek and hopes to be a baseline study for future research. A total of ten sites were randomly distributed throughout Buffalo Creek with each site consisting of four 5m x 5m quadrants. In the first year of the study (2012) most mussels found were large *E. complanata* adults indicating that they had been present before the eel reintroduction. In 2013 we recorded almost twice as many mussels as last year and four new species (*Strophitus undulates*, *Lampsilis cariosa*, *Alasmidonta marginata*, and *Villosa iris*).

INTRODUCTION

Freshwater mussels are one of the most endangered taxonomic groups in the United States and can filter suspended sediments and particles from the water column and doing so can reduce turbidity and improve water quality (Newell 2004). Although numerous studies of mussel populations have been done in various parts of the country, there is not been extensive research conducted on the mussels of the Susquehanna River. Strayer’s (1999) work on the upper river basin compared presence/absence data from 1955-1965 to his own mussel surveys at the same sites in 1996-1997. His results suggest that there was very little change in mussel communities during the 30 year time span between the two surveys (Strayer and Fetterman 1999). As there are few additional studies available regarding the abundance of mussel communities on the Susquehanna River, it is difficult to make strong conclusions about mussel growth and decline. In an effort to aid these studies and to supplement the data that are present, we conducted a survey in 2009 on the West Branch of the Susquehanna in Milton, Pennsylvania, downstream of Milton State Park and approximately 1.5 miles upstream of where Buffalo Creek enters the West Branch (Figure 1). During that survey 903 mussels were found with a density transformed CPUE of 0.77 mussels/m². Mussel densities by surveyed cell ranged from 0 (a pro-rated bank survey) to 2.37 /m² (a mid-channel cell). Of the 903 mussels found, *Lampsilis cariosa* was the most dominant species averaging 0.59 mussels per m² with a maximum of 1.93 mussels per m² and *E. complanata* averaging 0.089 mussels per m², second most dense mussel. While *E. complanata* is the most widespread freshwater mussel species in the Atlantic drainage, the Susquehanna River watershed contains far fewer *E. complanata* than neighboring watersheds like the Delaware (USFWS and USGS 2010). Looking at size distribution by species, we believe *E. complanata* is suffering from a loss of recruitment. One major factor behind this lack of young *E. complanata* may be the lack of the American eel from the upper Susquehanna River basin due to damming.

_Anguilla rostrata_, or the American eel, comprised roughly twenty-five percent of the total fish biomass in many locations along the Susquehanna River before damming (Minkinnen and Park 2008). American eels are catadromous fish, living in freshwater for most of their lives until sexual maturity and migrating to salt water (Sargasso Sea) to reproduce. Young eels return to freshwater to start the cycle all over again. Although there have been sporadic stockings of eels in the Susquehanna River basin, the population of American eels has been very small upstream of Conowingo Dam since the 1970’s (SRAFRC 2010). In order to improve water quality and strengthen a weak population, juvenile American eels were reintroduced into Buffalo Creek and Pine Creek upstream of all major dams on the West Branch of the Susquehanna River through a joint effort of the U.S. Fish and Wildlife Service and the U. S. Geological Survey.

Freshwater mussels have a unique interaction with fish.
Many use fish as a host for their glochidia or in their larval stage to complete metamorphosis into their juvenile stage. Some mussel species are generalists and can use a variety of fish species as their host while some mussel species are functionally dependent on a specific host fish to complete their life cycles (Haag 2012). Mussels without the specific host fish interaction face complications with reproduction and a diminishing population and eventual extirpation or extinction. American eels are the primary host fish of larval (glochidia) *E. complanata* and improves the success rate of *E. complanata* completing their life cycle when using American eels as their host fish (Lellis et al. 2013).

**MATERIALS AND METHODS**

We chose ten sites to survey in Buffalo Creek in Union County, PA. Five sites were randomly chosen upstream of the eel reintroduction site between Lewisburg and Mazeppa, and five sites were selected at random locations downstream of the introduction site over an area of four river miles (Figure 2). Due to logistics we avoided the approximate 1.3 km stretch of stream that ran through the property of the Lewisburg Federal Penitentiary. At each site, water quality measurements, including pH, dissolved oxygen, and temperature, were taken using a YSI 600 XLM V2 multiparameter water quality sonde. Furthermore, habitat and embeddedness at each site were recorded by the survey team at the time of mussel collection. To standardize our search methods, four 5m x 5m quadrants were made at the center of the creek using a premade dive array which divided the stream into four sections (Figure 3). Using an effective sampling fraction greater than 0.05, we determined an effective search time of five minutes per quadrant (Smith et al. 2001). Each quadrant was surveyed using a random start and timed search. A total of twenty minutes over the entire 10m x 10m site provided a comprehensive mussel density. The species of each individual found was recorded, and each mussel was weighed, measured, and photographed before being returned to the habitat and quadrant in which it was found. A three tiered sieve series ranging from 0.5 inch to 500 micron mesh was used for all excavations. Each quadrant had an excavation performed in a 1 m² area to a depth ≥ 10 cm or to hardpan to search for juvenile mussels. Excavated material was passed through the sieve series, and mussels retained on the different mesh sizes of the sieves were identified and recorded.

**RESULTS AND DISCUSSION**

From June 2009 through August 2012 approximately 88,000 glass eels were introduced into Buffalo Creek in Union County, PA. In July 2012 we began conducting yearly quantitative surveys for freshwater mussels. In 2012 we found 111 mussels with *E. complanata* being the only species found alive. In 2013 we found five species of mussels, *Strophitus undulates*, *Lampsilis cariosa*, *Alasmidonta marginata*, *E. complanata*, and *Lampsilis pungens*.
Villosa iris and Elliptio complanata, which had the highest densities. Of the 198 mussels found in 2013 E. complanata were the most abundant comprising 95% of the mussels found while V. iris was the least abundant at 0.01% (Table 1). We found higher densities of mussels in 2013 and there were signs of increased recruitment in young E. complanata from 2012 to 2013 (Figure 4). In the summer of 2012 we found 9 E. complanata under 60 mm in length compared to 24 E. complanata under 60 mm in length in 2013 (Table 2). The cumulative CPUE for our entire 10 sites in 2013 was 58.8 mussels per hour. Our individual CPUE for each site ranged from 0 in downstream quadrants where substratum was heavily embedded to 204 mussels per hour in one of our upper sites. Higher densities of mussels continued to be more commonly found upstream in areas that had more favorable habitat consisting of mostly cobble/gravel substrate with lower degrees of embeddedness (Figure 5). Embeddedness refers to the extent to which rocks (gravel, cobble, and boulders) are surrounded by, covered or sunken into the silt, sand, or mud of the stream and can hinder a mussel’s ability to burrow. Water quality was recorded at each site with the average water temperature at 22.4 °C in 2013 while 2012 had an average water temperature of 25.6 °C.

**CONCLUSION**

We saw a correlation between embeddedness and number of mussels found suggesting the more impacted the substrate, the lower the population of mussels. The majority of mussels were observed upstream in more favorable, less embedded habitats. While there is not a way to easily and accurately quantify embeddedness, the lower sections of creek were clearly impacted creating unfavorable conditions for populations. Burrowing is a technique that mussels use to provide additional anchorage in streams and rivers to help prevent dislodgement and protection from predation. Some species use burrowing as an adaptation for drought survival and throughout the winter months (Haag 2012). The inability for mussels to burrow due to embeddedness can be a major factor for the absence of mussels in our lower sites.

<table>
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<tr>
<th>Species 2012</th>
<th># alive</th>
<th># dead</th>
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<td>Elliptio complanata</td>
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<td>34</td>
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<table>
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<th>Species 2013</th>
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</thead>
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<tr>
<td>Elliptio complanata</td>
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<td>81</td>
</tr>
<tr>
<td>Strophitus undulates</td>
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<td>3</td>
</tr>
<tr>
<td>Lampsilis cariosa</td>
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<td>4</td>
</tr>
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<td>Alasmidonta marginata</td>
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<td>1</td>
</tr>
<tr>
<td>Villosa iris</td>
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<td>1</td>
</tr>
</tbody>
</table>

Table 1. Total number of live and dead mussels found by species in 2012 and 2013.
We saw an increase in the total number of specimens and species in 2013 from 2012. Factors for the increase of young *E. complanata* in 2013 could be cooler water temperatures, lower seasonal flows and the presence of more American eel available as host fish. Although mussel distribution is directly correlated with the geographical distribution of its host fish, other factors such as habitat can limit distribution and dispersal. Future biennial studies will be structured to assess the impacts of water quality, habitat, and introduction of juvenile eels on mussel population recruitment in Buffalo Creek.

<table>
<thead>
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<th>2012</th>
<th>2013</th>
<th><em>Elliptio complanata</em></th>
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<tbody>
<tr>
<td>Total live mussels found</td>
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<td>188</td>
</tr>
<tr>
<td>Mussels under 50mm</td>
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<td>13</td>
<td>10</td>
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<tr>
<td>Mussels under 60mm</td>
<td>9</td>
<td>25</td>
<td>12</td>
</tr>
</tbody>
</table>

Table 2. Size class comparison 2012 to 2013 (note all live mussels found in 2012 were *E. complanata*).

**LITERATURE CITED**


