Experimental Stocking of American eels in the Susquehanna River Watershed

2012 Annual Report

Mitigation Project for: **City of Sunbury, Riverbank Stabilization Project**
DA Permit Application Number: NAB 2005-02860-PO5

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INTRODUCTION

American eel populations have been declining along the Atlantic coast. Although the Chesapeake Bay and tributaries support a large portion of the coastal eel population, the Susquehanna River comprises 43% of the Chesapeake Bay watershed and until recently was devoid of eels above Conowingo Dam. Construction of large mainstem dams in the 1900's effectively closed the river to upstream migration of juvenile eels (elvers) (Figure 1). Before dams were constructed, the annual harvest of silver eels in the Susquehanna River was nearly one million pounds. Although eels were stocked in the Susquehanna and its tributaries sporadically from 1938 to 1980, there is currently no commercial harvest or recreational fishery for eels. Dams on the Susquehanna River not only eliminated a once abundant eel fishery, they likely had a profound effect on the way the ecosystem functions. American eels, top predators in many streams, are estimated to have once comprised almost 25% of the fish biomass in Atlantic slope streams and rivers. In addition, eels may be important to freshwater mussel populations in the Susquehanna River.

Research conducted by the U.S. Geological Survey (USGS), Northern Appalachian Research Laboratory (NARL) and the U.S. Fish and Wildlife Service (USFWS), Maryland Fishery Resources Office (MFRO) indicates that American eel is a successful host fish for the freshwater mussel, *Elliptio complanata* (eastern elliptio) in the Susquehanna River (Lellis 2002, USGS NARL, unpublished data 2008). The larvae (glochidia) of freshwater mussels must parasitize a host fish to complete metamorphosis to the independent juvenile life stage. Glochidia from eastern elliptio collected in the Susquehanna River have higher metamorphosis success rates on American eels (≥ 90% success) than on other fish species found in the Susquehanna River (White et al. in review). While eastern elliptio is the most abundant and

widespread freshwater mussel species in the northeastern United States, there are fewer eastern elliptio in the Susquehanna River watershed than nearby watersheds. In some streams and rivers, they comprise the most abundant biomass of any fauna in a watershed and can provide great filtration capacity. For example, the estimated 280 million eastern elliptio in the Delaware River have the potential to filter between 2 billion and 6 billion gallons of water and remove 78 tons of sediment from the water column each day (Spooner and Lellis 2010). If eels are important to reproducing eastern elliptio populations in the Susquehanna River, restoring eels could also restore mussels, which could result in improved water quality in the system.

After the 1928 construction of Conowingo Dam near the mouth of the Susquehanna River, access for eels to 400 miles of the Susquehanna River watershed drastically declined. Mainstem Susquehanna River fish passage facilities (lifts and ladder) were designed and sized to pass adult shad and herring and are not effective (due to attraction flow velocities and operating schedules) in passing elvers upriver. A specialized passage system designed to accommodate eels is needed to allow them access to the Susquehanna River watershed above the mainstem dams. Low recruitment of eastern elliptio could be linked to the lack of eel passage over dams in the mainstem Susquehanna River. In order to test this hypothesis and as mitigation for the City of Sunbury, Riverbank Stabilization Project, the objectives of this project are to:

1. Stock juvenile American eels (elvers) in upstream tributaries to the Susquehanna River with existing eastern elliptio populations (Buffalo Creek, Union County, PA, and Pine Creek, Tioga County, PA).
2. Encourage larval eastern elliptio attachment on a subset of reintroduced eels through tank culture techniques.
3. Monitor eel presence/absence at 2 sites in each tributary during each of the three years of stocking (2010, 2011, and 2012) and 5 years (2014) and 10 years (2019) after the first eel introduction.
4. Survey freshwater mussel populations in each tributary to collect baseline mussel population data and to assess recruitment to the mussel populations 5 years (2014) and 10 years (2019) after the first eel reintroduction.

METHODS

Eastern Elliptio Glochidia Transformation

In April and May of 2012, we attempted to encourage larval eastern elliptio attachment on a subset of reintroduced eels through tank culture techniques at the USFWS MFRO laboratory in Annapolis, MD. Eastern elliptio were collected from Buffalo Creek on April 17 (water temperature 17.8°C) and May 1 (water temperature 15.9°C) and from Pine Creek on April 22. Eels were collected from the eel ladder operated by the USFWS at Conowingo Dam (Susquehanna River, Cecil County, MD). We attempted to induce release of eastern elliptio larvae (glochidia) by increasing water temperatures to 18°C.

To assess natural attachment of glochidia, 6 eels were collected from Buffalo Creek using a backpack electrofishing unit on May 24, 2012. Captured eels were transported live to the USFWS MFRO Laboratory for analysis. Four eels were sacrificed and gills removed for examination under the dissecting microscope. Two eels were placed in 1 liter plastic aquaria (Aquatic Habitats ® (AHAB)) where they were monitored for the duration of the experiment (30 days). Aquaria were siphoned approximately three times each week until one week after the last juvenile mussel was found to ensure no glochidia or juveniles went undetected. After siphoning, collected material from each aquarium was transferred to a Petri dish, and contents were observed under a dissecting scope. Juvenile mussels were identified by their opaque shells and presence of a foot. The number of glochidia or transformed juvenile mussels was recorded.

Eel Stocking

Based on eel data (number of eels per km) collected in tributaries to the Susquehanna River and Chesapeake Bay below Conowingo Dam, a rough estimate of capacity for eels in upstream tributaries was calculated. An average density of eels was estimated at 529 eels/km

using data collected by Maryland Department of Natural Resource (MD DNR), Maryland Biological Stream Survey (MBSS), in four tributaries downstream of Conowingo Dam: Big Elk Creek (Cecil County, MD), Furnace Bay (Cecil County, MD), Little Elk Creek (Cecil County, MD), and Northeast River (Cecil County, MD). The number of eels needed to achieve a similar density of 529 eels/km at stocking sites was calculated by multiplying the number of mainstem stream kilometers above the stocking site by the average density. Based on these calculations and the projected feasibility of capturing eels for stocking, we proposed to relocate up to 60,000 eels to each of Buffalo Creek and Pine Creek over a three year period (2010 through 2012).

The MD DNR is required by the Atlantic States Marine Fisheries Commission (ASMFC) to conduct Young-of-Year (YOY) eel monitoring. Their sampling devices are located at a bridge culvert in Turville Creek (Ocean City, MD) and at the Bishopville Dam on Bishopville Prong (Bishopville, MD). In April of 2012, MD DNR personnel collected glass eels at these locations which were then transported by the USFWS and the Tiadaghton Audubon Society to the USGS NARL in Wellsboro. Glass eels were held in captivity at the lab, then OTC marked before being released on May 24, 2012. The eels (55-94 mm) were then stocked at 2 locations (Table 1).

American eel elvers (90-150 mm) were collected by the USFWS using a collection device located immediately downstream of Conowingo Dam. An eel ramp consisting of cable tray, covered and lined with Enkamat, was deployed at the base of Conowingo Dam. Water from the Susquehanna River was pumped to the top of the cable tray ramps where it flowed down the Enkamat to attract elvers. Elvers crawled up the ramps and were swept by sprayed water into collection tanks. Aerated water was circulated through the collection tanks to keep elvers in good health. Captured elvers were sedated, measured, and counted. Large numbers of eels were

estimated volumetrically. Transported eels were marked using buffered oxytetracycline (OTC) at a concentration of 550 ppm for 5 hours prior to release.

From 2010 through 2012, captured eels were stocked in two tributaries to the Susquehanna River in the vicinity of eastern elliptio beds to encourage additional association between eastern elliptio glochidia and eels (Figure 2). While both Buffalo Creek and Pine Creek have relatively high densities of eastern elliptio, very few young mussels have been found in these creeks. The mouth of Buffalo Creek, near Lewisburg, PA is approximately 9 miles north of Sunbury, PA on the West Branch of the Susquehanna River. Eels were stocked near high densities of eastern elliptio in 2 locations, Strawbridge Rd. Bridge (40.9856 N, 76.93237 W) and the footbridge on Rt. 1003 (40.98105 N, 76.95134 W). A second tributary, Pine Creek, located north of Jersey Shore, PA on the West Branch of the Susquehanna River, has the highest density of eastern elliptio found in our surveys in the Susquehanna River watershed. Eels were stocked near high densities of eastern elliptio in 4 locations, Owassee Rapids (41.71568 N, 77.45543 W), Darling Run Access (41.74368 N, 77.43394 W), Marsh Creek Boat Ramp (41.74466 N, 77.42775 W), and Ansonia Bridge (41.73671 N, 77.43036 W). Stockings conducted in 2012 (Table 1) were documented and reported to the Pennsylvania Fish and Boat Commission as part of the requirements of the Scientific Collecting Permit Number 354, Type 2.

Fish survey

To evaluate eel stocking success, including survival, growth and habitat use, as well as to document the fish community, we conducted electrofishing surveys using 3 backpack and 1 barge electrofishing units in July and August 2012. The barge electrofisher provided electricity to three attached anodes. Methods used by the MD DNR MBSS (2007) were used to quantify the catch per unit effort (CPUE), abundance, and biomass of eels. Two sites, near the eel release

sites, in each stream were surveyed. At each site, 75 meters of stream was blocked off using ¼" mesh block net. In order to get a complete picture of the fish community in each stream, 2 passes with the electrofishing units were conducted and all fish collected were enumerated. Captured eels were measured to assess growth and a subsample of collected eels was brought back to the lab to assess stomach contents, sex, and otoliths. Mass (kg) of the total catch and of eels captured was measured to assess changes in biomass of eels over time. Abundance estimates for eels in the surveyed area were calculated using the methods of Seber and LeCren (1967). Differences in eel lengths between years were determined using a two sample t- test in program PAST (Hammer et al. 2001). Subsamples of eels from Buffalo and Pine Creeks were returned to the lab to assess stomach contents, presence of the swim bladder parasite *Anguillicola crassus*, and remove otoliths for aging and verification of OTC marks.

In addition to the electrofishing surveys at the stocking locations in Buffalo Creek and Pine Creek, we conducted an electrofishing survey upstream and downstream of the Buffalo Creek stocking locations in September of 2012. We used two backpack electrofishing units to capture American eels at several locations ranging from 2.4 kilometers upstream to 2 kilometers downstream of stocking locations. Captured eels were sedated with MS-222 and measured. Eels with lengths over 200 mm were tagged by inserting PIT (Passive Integrated Transponder) tags into the dorsal musculature. Captured eels were then released near their capture location.

Mussel survey

No mussel surveys were conducted in 2012 as part of this project. Baseline mussel data were collected during mussel surveys conducted in Buffalo Creek in July of 2010. Data collected during mussel surveys conducted by USGS NARL in 2008 in Pine Creek as part of

another project, using identical methods, were used as baseline data for this project. Mussel surveys will next be conducted in 2014.

RESULTS

Eastern Elliptio Glochidia Transformation

In 2012, no elvers were infected with eastern elliptio in laboratory trials. Previous studies in both the USGS NARL laboratory and the USFWS MFRO laboratory indicated that eastern elliptio release glochidia at around 18 °C. While eastern elliptio were collected from Buffalo Creek and Pine Creek at similar water temperatures and time of year in 2012 as collections in previous years, mussels collected from both creeks, at multiple sampling events, either did not release glochidia or released glochidia at much lower temperatures before eels were available. We suspect that unusual temperature fluctuations in March and April affected the mussels' ability to brood glochidia until the typical release temperature of 18 °C. There was a 4.2 °C increase in the average daily maximum water temperature in the Susquehanna River (Danville Guaging station) from 7.6°C in 2011 to 11.8°C in 2012 over a 4 month period from February 1 to May 31 (Figure 3). The abnormally high temperatures in 2012 may have caused the mussels to spawn earlier, start their brooding period earlier and thus release glochidia either earlier or at lower temperatures. Because eastern elliptio only brood glochidia once a year in the springtime, we were not able to inoculate a subset of American eels with eastern elliptio glochidia in 2012.

During a spring electrofishing survey conducted in Buffalo Creek near Strawbridge Rd. Bridge, six eels were recaptured and returned to the MFRO laboratory to determine if they were inoculated with eastern elliptio glochidia. Four of the recaptured eels were dissected to inspect the gills for encysted glochidia. Each of the dissected eels had at least 1 glochidium attached to the gills. The largest eel (304 mm in length) had 12 glochidia attached to its gills. No

untransformed glochidia or transformed juvenile mussels were detected in the tanks of the 2 remaining eels that were held in aquaria for more than 30 days.

Eel Stocking

Of the approximately 30,000 glass eels collected near Ocean City, MD and held in captivity at NARL, an estimated 23,500 survived until they became pigmented (average length 67.4 mm), were OTC marked and stocked in Pine Creek and Buffalo Creek (Table 1). All glass eels were certified disease free by USFWS Lamar Fish Health Center (Lamar, PA) prior to release. In Pine Creek, 15,237 glass eels were released at Darling Run Access site. In Buffalo Creek, 8,526 glass eels were released at the Strawbridge Rd. Bridge site.

During June, July, and August of 2012, an estimated 135,748 elvers (average length 121 mm) were captured in the Susquehanna River below Conowingo Dam. A sample of captured elvers was certified disease-free by the USFWS Lamar Fish Health Center. An estimated 36,023 elvers captured below the dam were marked with OTC and stocked in Buffalo and Pine Creeks (Table 1). Additional elvers captured at Conowingo Dam were stocked in Deer and Broad Creeks in MD and in the Susquehanna River, near Etters, PA.

Fish Survey

During electrofishing surveys in July and August of 2012, 164 eels were recaptured in Buffalo Creek and 235 eels were recaptured in Pine Creek (Table 2). The Pine Creek sites (Darling Run Access and Ansonia Bridge) were sampled in July and the Buffalo Creek sites (Strawbridge Rd Bridge and Footbridge on Rt 1003) were sampled in August.

The lengths of the recaptured eels in Buffalo Creek were significantly larger ($p < 0.0001$) in 2012 (mean: 196 mm S.D: ± 68 mm) than 2011 (mean: 137 mm S.D. ± 24 mm) (Figure 4). The longest eel captured in Buffalo Creek during this survey was 371 mm. In Pine Creek, the

average length of recaptured eels was 128 mm (S.D. ± 31) and the longest recaptured eel was 292 mm, which was not significantly different from average length of eels collected in 2011 (Figure 5). The 163 recaptured eels in Buffalo Creek had a total mass of 2.9 kg resulting in an average of 17.8 g per eel and comprised 7.1% of the total biomass of captured fish. The 232 recaptured eels in Pine Creek had a total mass of 1.1 kg resulting in an average of 4.5 g per eel and comprised 3.9% of the total biomass of captured fish. Density (eels per m^2), estimated abundance and % biomass increased from 2011 to 2012 at all sites but the Strawbridge Rd. Bridge site in Buffalo Creek (Table 3).

Stomach contents of the subsample of eels returned for lab dissection from Buffalo Creek (n = 30) and Pine Creek (n=10) were comprised of crayfish, water pennies, damselfly nymphs, caddisfly larvae, and other unidentifiable macroinvertebrates. Six of those eels returned to the lab for dissection had lengths greater than 270 mm (ranging from 299 mm to 334 mm) and sex could be determined visually by examining the gonads. All 6 eels (captured in Buffalo Creek) were identified as males and none were identified as females. Ten percent of eels captured in Buffalo Creek and 30% of eels captured in Pine Creek were infected with a swim bladder parasite (*Anguillicola crassus*).

In Buffalo Creek, 3,348 individuals of 33 fish species were collected. In Pine Creek, 4,717 individuals of 24 fish species were collected (Table 2). Relative abundance by family indicates that eels make up a greater proportion of the population at Pine Creek sampling sites in comparison with Buffalo Creek sampling sites in 2012 (Figure 6). From 2010 to 2011 relative abundance of eels decreased in Buffalo Creek from 5.6% to 4.9% but increased in Pine Creek from 0.6% to 5.0%.

During September electrofishing surveys, a total of 210 eels were recaptured upstream and downstream of the stocking locations in Buffalo Creek. The upstream CPUE was 38.2 eels per hour, and the downstream CPUE was 26.7 eels per hour. The total length of recaptured eels ranged from 138 mm to 551 mm (Figure 7). We inserted PIT tags into the dorsal musculature of 174 eels that measured greater than 200 mm. All eels, except 3 that were returned to the lab for dissection, were returned to Buffalo Creek near their capture locations.

DISCUSSION

During the third year of this project, we continued to exceed our 3 year stocking goals of 60,000 in both Buffalo Creek and Pine Creek. In Buffalo Creek, an additional 16,716 eels were stocked in 2012, bringing the number of eels stocked over three years to 88,128. In Pine Creek 43,070 eels were stocked, bringing the number of eels stocked over three years to 122,049. The number of eels stocked in Pine Creek is more than double the original stocking goal. We also completed electrofishing surveys in both Pine Creek and Buffalo Creek. Our success in recapturing over 163 eels in Buffalo Creek and 232 eels in Pine Creek indicates that the stocked elvers and glass eels are surviving and growing well near the stocking sites.

Due to abnormally high temperatures during the winter and spring of 2012, we were not able to complete objective 2 in 2012. None of the eastern elliptio collected in Buffalo or Pine Creek released glochidia when eels were available to be inoculated. The Corps of Engineers agreed to remove Objective 2, stocking inoculated eels, from the Department of Army permit conditions in November 2012 because it is believed, based on data collected during 2011 and 2012 field sampling, that there is natural occurrence of glochidial infestation of the eels. As an alternative to objective 2, we will continue our efforts in 2013 to confirm that stocked eels are becoming inoculated in the wild with eastern elliptio glochidia.

The relative abundance of eels decreased from 2011 to 2012 at the sampling location near the Strawbridge Rd. Bridge stocking site in Buffalo Creek. This is likely because fewer eels were stocked in Buffalo Creek in 2012 than in 2011 and previously stocked eels may have moved upstream and into tributaries. At the same time, relative abundance of eels increased at sampling locations near stocking sites in Pine Creek. This is likely due to the large number of eels stocked in the fall of 2011 and the spring of 2012 in Pine Creek. As eels spread out throughout the watershed, we may see fewer eels at sampling locations near stocking sites while more eels may be detected at other locations throughout the watershed.

During fish surveys conducted by other agencies in 2012, eels that have migrated away from the stocking locations were captured. Biologists from the Pennsylvania Fish and Boat Commission collected two eels in Rapid Run (a tributary to Buffalo Creek). The eel's lengths were estimated to be 280-330 mm and were found approximately 19 kilometers upstream from the stocking locations (Jason Detar, personal communication). Biologists from the Susquehanna River Basin Commission captured several eels upriver and downriver from our stocking location in Pine Creek. The eel found furthest upriver was approximately 19 kilometers upstream from the stocking locations, and the eel found furthest downriver was about 82 kilometers downstream of the stocking locations (Matthew Shank, personal communication). Recaptured eels in Pine Creek ranged from 130 mm to 500 mm. Eels could be in other locations in the basin and additional sampling will likely provide more information about their dispersal throughout the watershed.

The average length and weight of eels in Buffalo Creek increased from 2011 to 2012. The largest eel captured during the summer electrofishing surveys near stocking locations was 371 mm in length. However, during fall electrofishing surveys upstream and downstream of

stocking locations, an eel, 551 mm in length, was captured in Buffalo Creek. This eel grew approximately 400 mm in length from the summer of 2010 to 2012, possibly exceeding an annual growth rate of 200 mm per year. This far exceeds growth rates cited in studies conducted in South Carolina which found a max growth rate of 69 mm per year (Hansen and Eversole 2011) and in Maine which found an average growth rate of 30 mm per year (Oliveira and McCleave 2002). Abundant food resources are likely driving the high growth rates in Buffalo Creek.

Similar to previous studies (Ogden 1970, Lookabaugh and Angermeier 1992), stomach contents of eels, ranging in length from 144 mm to 334 mm, consisted of aquatic insects, crayfish, and other macroinvertebrates. One eel returned to the lab for dissection from the September electrofishing survey, measured > 400mm in length, and contained a crayfish greater than 65 mm in length.

The eels identified as males in our monitoring surveys measured less than 410 mm, while 3 eels captured in September of 2012, were identified as females and exceeded 410 mm. Although it is common for eels identified as females to range from 263 mm to 1000mm, males rarely exceed 400 mm (Oliveira and McCleave 2000, and Hansen and Eversole 2011). We will continue to assess the sex of stocked eels recaptured during surveys.

In 2013, we plan to collect eels near stocking sites in the spring after *Elliptio complanata* have released their glochidia. We plan to also hold some eels in tanks in our laboratory to assess whether juvenile mussels transform and fall off of eels inoculated in the wild. Monitoring of fish and mussel populations will resume in 2014.

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Table 1. Eels stocked in Buffalo Creek (Union County, PA), Pine Creek (Tioga County, PA) and Conowingo Creek (Lancaster County, PA) in 2010, 2011, and 2012.

Date	# Stocked	Location	Mean Length (mm)	Origin
		Pine Creek		
June 9, 2010	3,000	Darling Run Access	56.3*	Turville Creek
June 9, 2010	3,000	Ansonia Bridge	56.3*	Turville Creek
June 9, 2010	3,000	Owassee Rapids	56.3*	Turville Creek
June 21, 2011	10,666	Darling Run Access	80.1 ± 16.0	Turville Creek
June 21, 2011	10,666	Ansonia Bridge	80.1 ± 16.0	Turville Creek
June 21, 2011	10,668	Owassee Rapids	80.1 ± 16.0	Turville Creek
June 30, 2011	7,222	Marsh Creek Boat Ramp	127 ± 16.9	Conowingo Dam
August 22, 2011	1,528	Ansonia Bridge	127 ± 16.9	Conowingo Dam
August 31, 2011	8,940	Ansonia Bridge	127 ± 16.9	Conowingo Dam
September 2, 2011	8,084	Ansonia Bridge	127 ± 16.9	Conowingo Dam
September 7, 2011	12,205	Ansonia Bridge	127 ± 16.9	Conowingo Dam
May 24, 2012	15,237	Darling Run Access	67.4 ± 10.0	Bishopville Prong
June 6, 2012	16,241	Ansonia Bridge	121.0 ±16.5	Conowingo Dam
June 20, 2012	11,592	Ansonia Bridge	121.0 ±16.5	Conowingo Dam
Total	**122,049**			
		Buffalo Creek		
June 10, 2010	8,084	Strawbridge Rd. Bridge	127.7	Conowingo Dam
June 10, 2010	4,500	Strawbridge Rd. Bridge	56.3*	Turville Creek
June 10, 2010	4,500	Footbridge on Rt. 1003	56.3*	Turville Creek
June 21, 2010	7,790	Strawbridge Rd. Bridge	127.7	Conowingo Dam
June 21, 2011	16,219	Strawbridge Rd. Bridge	80.1 ± 16.0	Turville Creek
June 21, 2011	16,000	Footbridge on Rt. 1003	80.1 ± 16.0	Turville Creek
July 14, 2011	6,326	Strawbridge Rd. Bridge	127 ± 16.9	Conowingo Dam
July 18, 2011	4,390	Strawbridge Rd. Bridge	127 ± 16.9	Conowingo Dam
July 28, 2011	3,603	Strawbridge Rd. Bridge	127 ± 16.9	Conowingo Dam
May 24, 2012	8,526	Strawbridge Rd. Bridge	67.4 ± 10.0	Bishopville Prong
May 31, 2012	7,122	Strawbridge Rd. Bridge	121.0 ±16.5	Conowingo Dam
August 7, 2012	1,068	Strawbridge Rd. Bridge	121.0 ±16.5	Conowingo Dam
Total	**88,128**			

* length (mm) of glass eels was estimated using regression

Table 2. Number and catch per unit effort (CPUE, #/hour) of fish species captured in Buffalo Creek and Pine Creek during electrofishing surveys conducted in August and September of 2012.

	Buffalo Creek				**Pine Creek**			
	Strawbridge Rd Bridge		Footbridge on Rt 1003		Darling Run Access		Ansonia Bridge	
Shock time (hours)	7.0		5.9		4.7		5.5	
Common name	#	CPUE	#	CPUE	#	CPUE	#	CPUE
American eel	64	14.7	100	19.3	21	4.5	214	30.7
Northern hogsucker	22	5.0	30	5.8	55	11.8	27	3.9
Shorthead redhorse	0	0.0	1	0.2	0	0.0	0	0.0
White sucker	71	16.3	107	20.6	71	15.2	121	17.3
Rockbass	22	5.0	40	7.7	32	6.8	2	0.3
Redbreast sunfish	14	3.2	35	6.7	10	2.1	8	1.1
Green sunfish	11	2.5	2	0.4	1	0.2	0	0.0
Pumpkin seed	1	0.2	7	1.3	0	0.0	0	0.0
Bluegill	0	0.0	8	1.5	1	0.2	0	0.0
Smallmouth bass	25	5.7	56	10.8	19	4.1	25	3.6
Central stoneroller	2	0.5	1	0.2	37	7.9	83	11.9
Spotfin shiner	12	2.7	26	5.0	0	0.0	0	0.0
Common carp	0	0.0	4	0.8	0	0.0	0	0.0
Cutlips minnow	37	8.5	29	5.6	145	31.0	189	27.1
Common shiner	1	0.2	0	0.0	2	0.4	69	9.9
River chub	1	0.2	0	0.0	41	8.8	134	19.2
Spottail shiner	7	1.6	4	0.8	17	3.6	7	1.0
Rosyface shiner	89	20.4	25	4.8	191	40.8	157	22.5
Mimic shiner	790	181.0	488	94.0	324	69.3	342	49.0
Bluntnose minnow	28	6.4	8	1.5	123	26.3	18	2.6
Blacknose dace	1	0.2	1	0.2	2	0.4	0	0.0
Longnose dace	82	18.8	17	3.3	1	0.2	51	7.3
Creek chub	1	0.2	0	0.0	0	0.0	0	0.0
Fallfish	93	21.3	63	12.1	96	20.5	114	16.3
Yellow bullhead	1	0.2	5	1.0	0	0.0	0	0.0
Margined madtom	105	24.1	20	3.9	59	12.6	336	48.1
Greenside darter	137	31.4	50	9.6	112	23.9	169	24.2
Fantail darter	12	2.7	1	0.2	0	0.0	0	0.0
Tessellated darter	154	35.3	75	14.4	372	79.5	216	30.9
Banded darter	149	34.1	60	11.6	91	19.5	439	62.9
Shield darter	55	12.6	96	18.5	50	10.7	123	17.6

Table 3. Density (# eels / m^2) of eels, estimated abundance (Seber and Le Cren 1967) (± S.E.) of eels in a 75 meter length of stream, average length (± S.D.) and % biomass of captured fish were eels during 2011 and 2012 electrofishing surveys in Buffalo Creek and Pine Creek.

2011

	Buffalo Creek		**Pine Creek**	
	Strawbridge Rd Bridge	Footbridge on Rt 1003	Darling Run Access	Ansonia Bridge
Density (# eels/m^2)	0.17	n/a	0.004	0.003
Abundance	480.3 (± 14)	n/a	12.5 (± 1)	n/a
Ave. Length (mm)	137 (± 24)	193 (± 21)	161 (± 37)	118 (± 28)
% Biomass	10.1	6.1	1.2	0.6

2012

	Buffalo Creek		**Pine Creek**	
	Strawbridge Rd Bridge	Footbridge on Rt 1003	Darling Run Access	Ansonia Bridge
Density (# eels/m^2)	0.03	0.04	0.008	0.07
Abundance	72 (± 6)	160 (± 41)	28 (± 9)	302 (± 37)
Ave. Length (mm)	154 (± 41)	223 (± 68)	167 (± 46)	124 (± 26)
% Biomass	3.8	9	2.7	4.8

Figure 1. Susquehanna River watershed with the locations of the 4 hydroelectric dams, York Have, Safe Harbor, Holtwood Dam, and Conowingo Dam denoted by straight lines across the mainstem Susquehanna River.

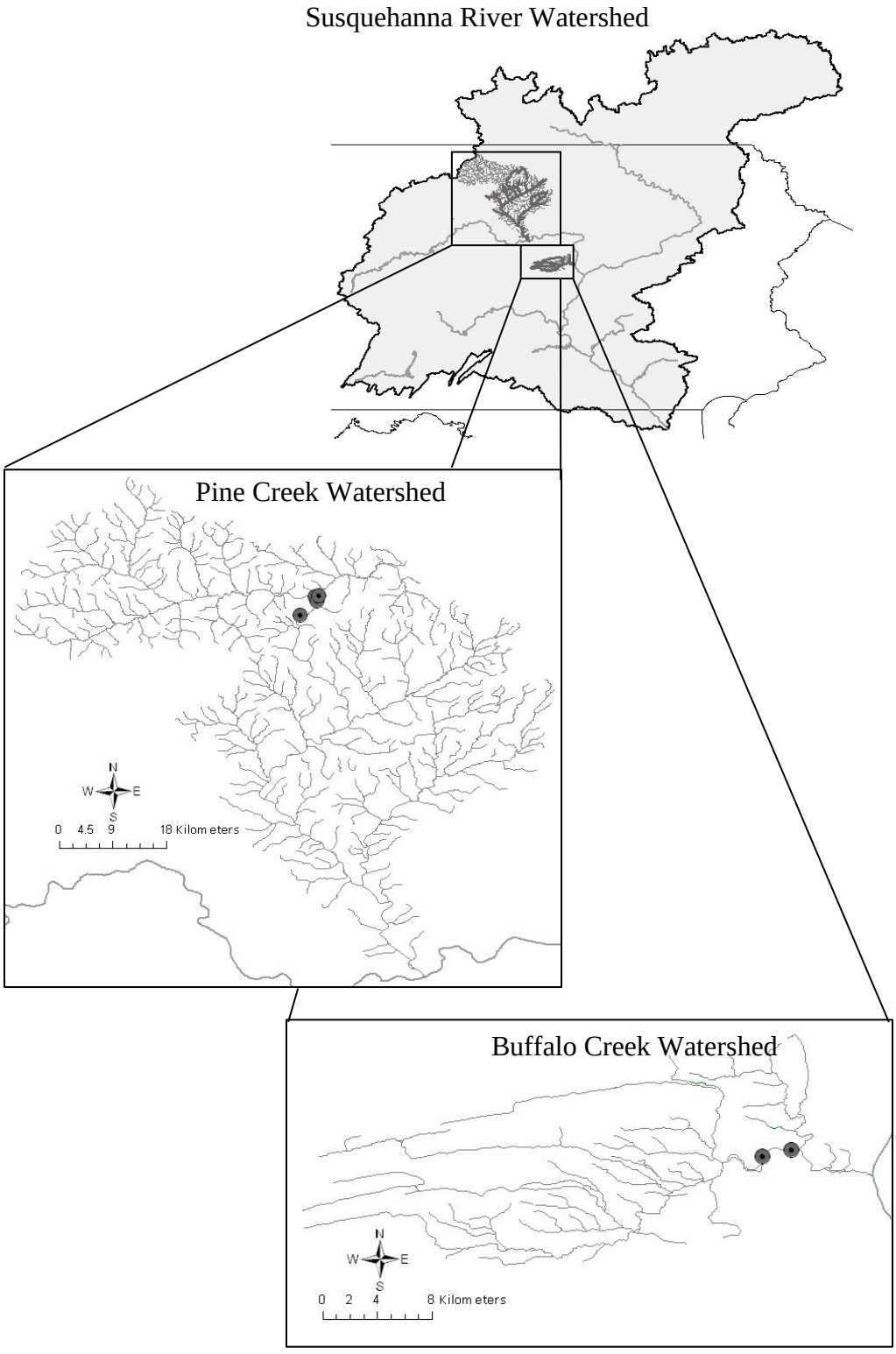

Figure 2. Eel stocking sites (indicated by dots) at Owassee Rapids, Darling Run Access, Marsh Creek, and Ansonia Bridge in Pine Creek (Tioga County, PA) and Strawbridge Rd. bridge and the footbridge at Rt. 1003 in Buffalo Creek (Union County, PA) in the Susquehanna River drainage.

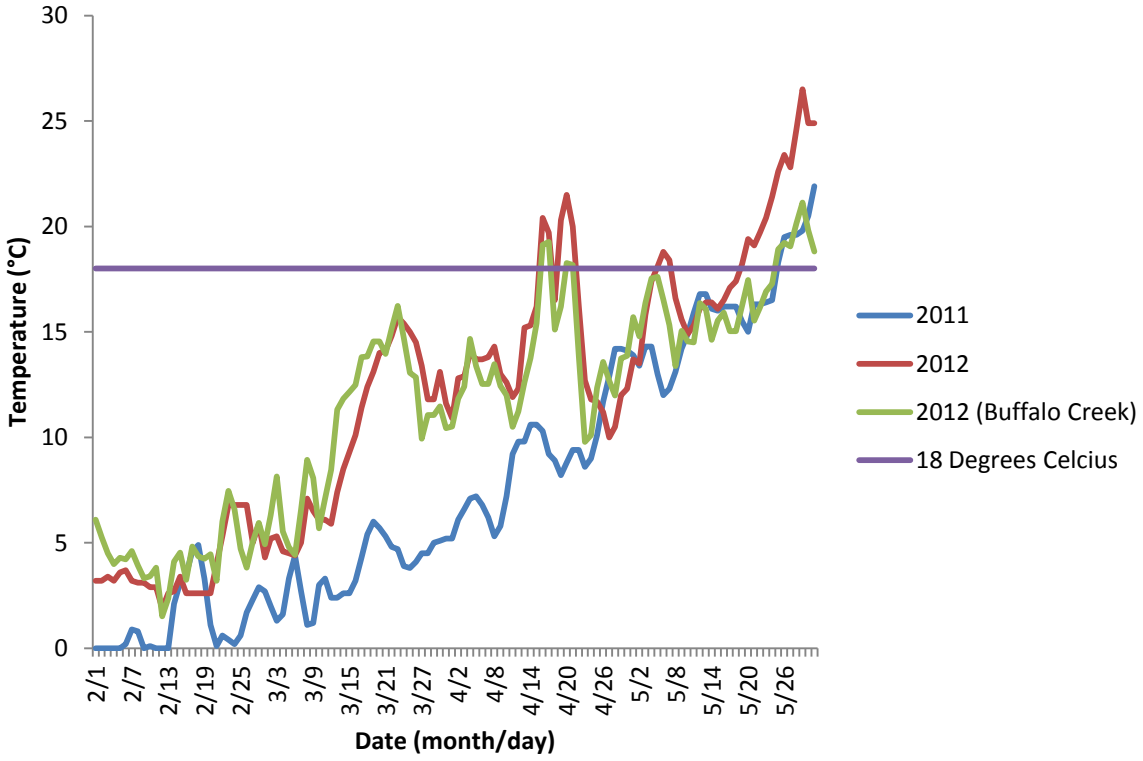

Figure 3. Water temperature at the USGS gauging station in the Susquehanna River near Danville, PA from February to May of 2011 (blue) and 2012 (red). Represented in green is water temperature recorded by a Hobo Data logger at Strawbridge Rd in Buffalo Creek from February to May of 2012 and in purple, the typical temperature at which glochidia are released from brooding female eastern elliptio.

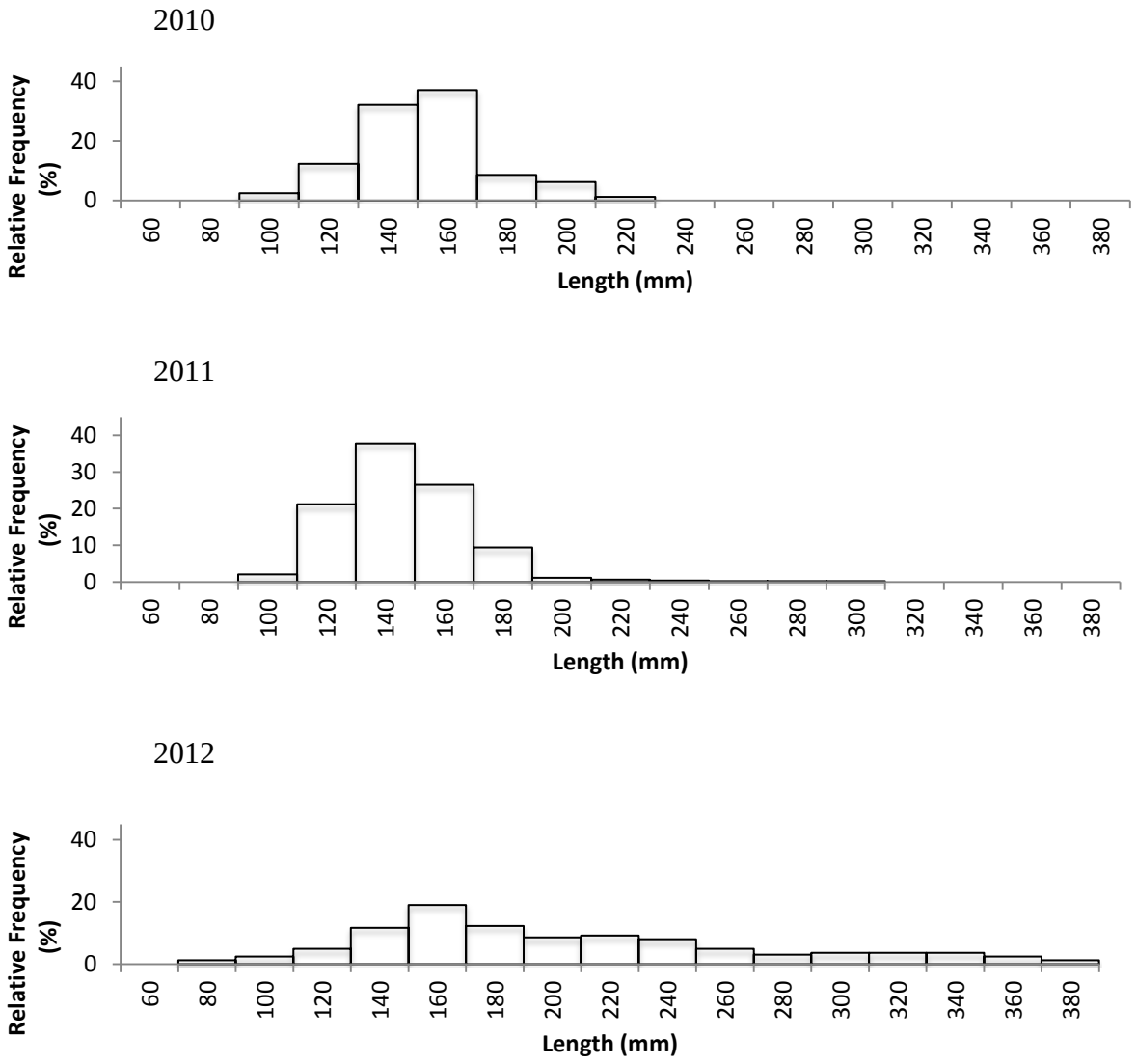

Figure 4. Relative length frequency (expressed as percentage) of eels captured during monitoring surveys in Buffalo Creek in 2010 (n = 81), 2011 (n = 434), 2012 (n = 163).

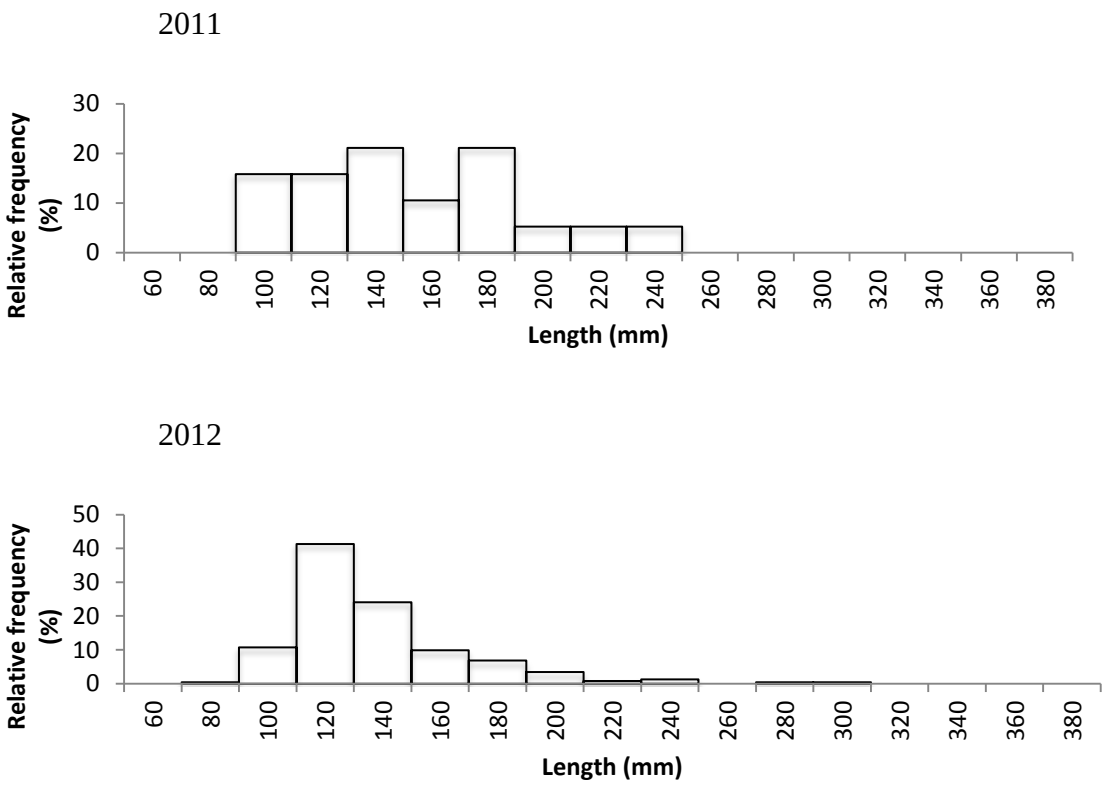

Figure 5. Relative length frequency (expressed as percentage) of eels captured during monitoring surveys in Pine Creek in 2011(n = 20), 2012 (n = 232).

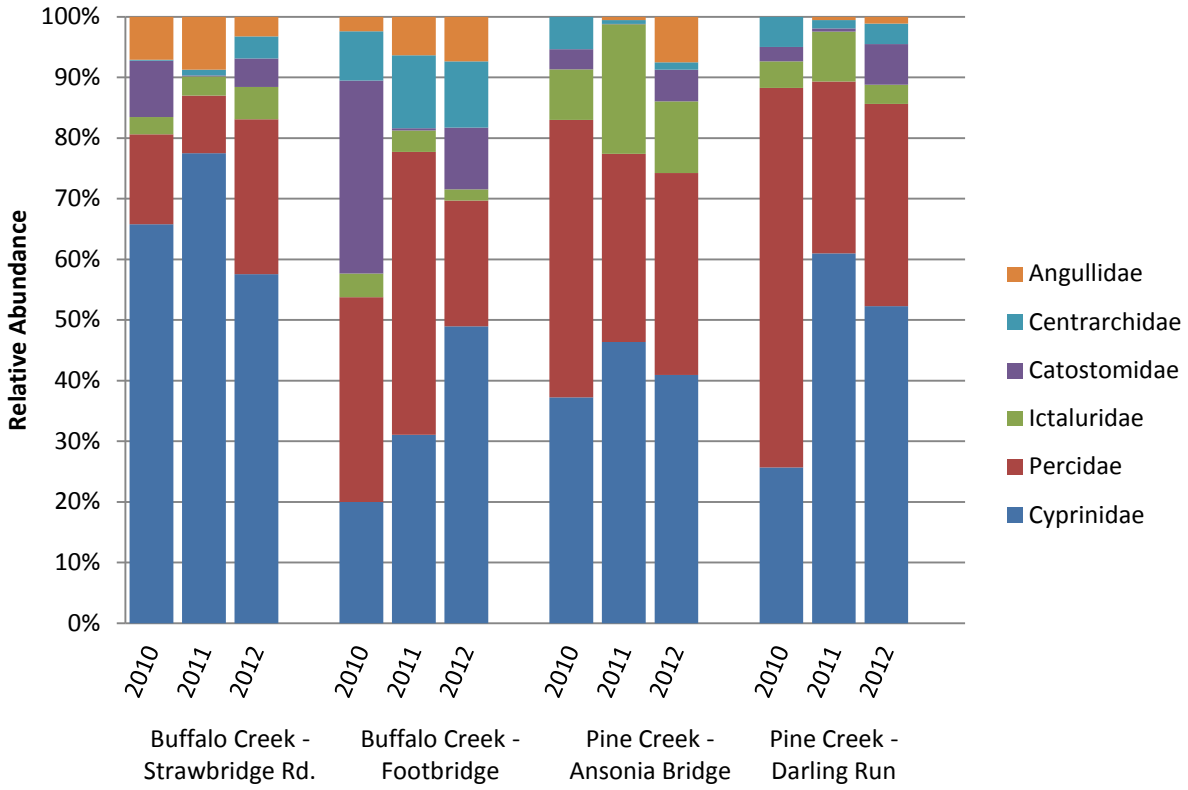

Figure 6. Relative abundance expressed as a percentage of 6 families of fish, Anguillidae (eels), Centrarchidae (sunfish and bass), Catastomidae (suckers), Ictaluridae (catfish and madtoms), Percidae (perch and darters), and Cyprinidae (minnows and shiners), caught in Buffalo and Pine Creeks during backpack electrofishing in July and August, 2012.

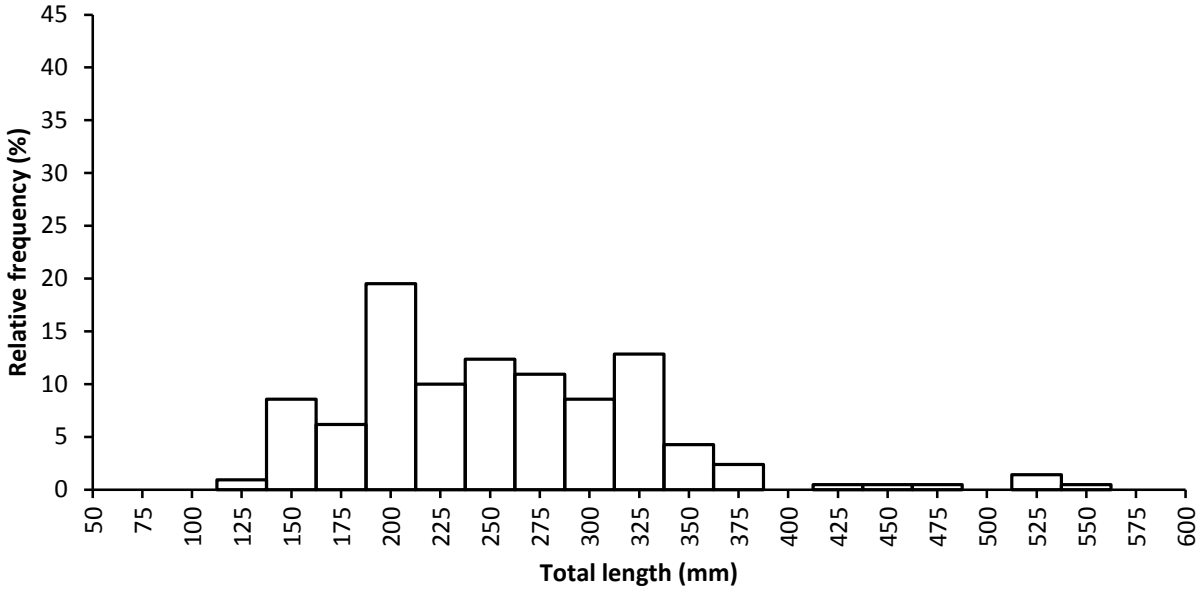

Figure 7. Relative length frequency (%) of eels captured in Buffalo Creek during September, 2012 electrofishing surveys (n = 210).

Appendix 1. CPUE (# / hour) of fish species captured in Buffalo Creek and Pine Creek during electrofishing surveys conducted in 2010, 2011 and 2012.

	Buffalo Creek						Pine Creek					
	Strawbridge Rd Bridge			Foot bridge on Rt 1003			Darling Run Access			Ansonia Bridge		
	2010	2011	**2012**	2010	2011	**2012**	2010	2011	**2012**	2010	2011	**2012**
American eel	33	73	**15**	8	10	**19**	0	2	**4**	0	2	**31**
Banded darter	9	26	**34**	13	9	**12**	29	27	**19**	44	39	**63**
Blacknose dace	1	2	**0.2**	0	0	**0.2**	11	12	**0.4**	10	2	**0**
Bluegill	0	0	**0**	7	2	**1.5**	2	0	**0.2**	3	0.2	**0**
Bluntnose minnow	0	92	**6.4**	0.8	7	**1.5**	0	14	**26**	0	10	**3**
Central Stoneroller	4	10	**0.5**	0	0	**0.2**	2	0	**8**	4	0.7	**12**
Chain Pickerel	0	0	**0**	0	0	**0**	0	0.4	**0**	0	0	**0**
Common carp	0	0	**0**	0	1	**0.8**	0	0	**0**	0	0	**0**
Common Shiner	0	6	**0.2**	0.8	0	**0**	0	3	**10**	0	4	**10**
Creek chub	0	0	**0.2**	0	0	**0**	0	0	**0**	4	0	**0**
Creek chubsucker	0	0	**0**	2.3	0	**0**	0	0	**0**	0	0	**0**
Cutlips Minnow	1	10	**8**	11	16	**6**	15	33	**31**	2	18	**27**
Fallfish	8	9	**21**	6	9	**12**	5	23	**21**	19	59	**16**
Fantail darter	0	0	**3**	0	0	**0.2**	0	0	**0**	0	0	**0**
Green sunfish	0	0	**3**	0	0	**0.4**	0	0	**0.2**	0	0	**0**
Greenside darter	18	7	**31**	8	8	**10**	33	22	**24**	12	15	**24**
Longnose dace	9	8	**19**	0	1	**3**	0.4	6	**0.2**	15	2	**7**
Margined madtom	13	26	**24**	11	3	**4**	9	38	**13**	19	68	**48**
Mimic shiner	0	25	**181**	0	9	**94**	0	3	**69**	0	0	**49**
Northern hogsucker	14	24	**5**	0	22	**6**	3	7	**12**	5	4	**4**
Pearl dace	0	0.1	**0**	0	0	**0**	0	0	**0**	0	0	**0**
Pumpkinseed	0	4	**0.2**	2	8	**1**	0.4	0	**0**	0	0	**0**
Redbreast sunfish	0	0.5	**3.2**	0	0	**7**	0	0	**2**	0	0	**1**
River chub	0	0	**0**	0	0	**0**	0	0.2	**0**	0	0	**0**
Rockbass	0	1.3	**5**	15	7	**8**	8	0.4	**7**	9	0.4	**0.3**
Rosyface shiner	0.5	18	**20**	0	0	**5**	14	176	**41**	8	50	**22**
Rosyside dace	0	0	**0**	0	2	**0**	0	0	**0**	0	0	**0**
Shield darter	6	10	**13**	23	27	**18**	22	23	**11**	17	13	**18**
Shiner sp.	0	463	**0**	48	0	**0**	0	2	**0**	22	0.2	**0**
Shorthead redhorse	0	0.2	**0**	0	0	**0**	0	0	**0**	0	0	**0**
Smallmouth bass	0.9	2	**6**	5	11	**11**	0	6	**4**	0.4	1	**4**
Spotfin Shiner	0	0.7	**3**	0	5	**5**	0	0	**0**	0	0.4	**0**
Spottail shiner	11	0	**2**	14	1	**0.7**	2	7	**4**	0	2	**1**
Tessellated darter	36	36	**35**	74	14	**14**	44	58	**80**	30	32	**31**
White sucker	29	8	**16**	108	20	**21**	2	0.6	**15**	3	0.2	**17**
Yellow bullhead	0	0	**0.2**	2	1	**1**	0	0	**0**	0	0	0