Experimental Stocking of American eels in the Susquehanna River Watershed

2010 Annual Report

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

Project Officer:
Steven P. Minkkinen, Project Leader, Maryland Fishery Resources Office (MFRO), USFWS
U.S. Fish and Wildlife Service, 177 Admiral Cochrane Dr., Annapolis, MD 21401
phone: 410-573-4506, fax: 410-263-2608, e-mail: steve_minkkinen@fws.gov

Alternate contact:
Julie L. Devers, Fishery Biologist, MFRO, USFWS
phone: 410-573-4508, e-mail: julie_devers@fws.gov

Cooperators:
William A. Lellis, PhD, Branch Chief, Leetown Science Center, Northern Appalachian Research Laboratory (NARL), USGS, 176 Straight Run Road, Wellsboro, PA 16901
phone: 570-724-3322 x 222, fax: 570-724-2525, e-mail: wlellis@usgs.gov

Heather S. Galbraith, PhD, Research Fish Biologist, NARL, USGS
phone: 570-724-3322 x 230, fax: 570-724-2525, e-mail: hgalbraith@usgs.gov

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 is devoid of eels. 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 most Atlantic slope streams and rivers. In addition, eels may be an important link to freshwater mussel populations.

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 the primary host fish for the freshwater mussel, eastern elliptio (*Elliptio complanata*) in the Susquehanna River (Lellis 2002, USGS NARL, unpublished data 2008).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 collected in the Susquehanna River have higher metamorphosis success rates on American eels (55-98% success) than on other fish species found in the Susquehanna River. While eastern elliptio is the most abundant and widespread freshwater mussel species in northeastern America, there are far 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 2 billion to 6 billion gallons of water and remove 78 tons of sediment from the water column each day (Spooner and Lellis 2010). If eels are the missing link to abundant freshwater mussel populations in the Susquehanna River, restoring eels could also restore this fauna, 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 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. Specialized passages designed to accommodate eels are needed to allow them access to the watershed above 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 (approximately 45,000 in Buffalo Creek, Union County, PA, and 55,000 in 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 over the three year stocking period and after 5 years and 10 years.
4. Survey freshwater mussel populations in each tributary to collect baseline mussel population data and to assess recruitment to the mussel populations 5 years and 10 years after the first eel reintroduction.

METHODS

Eastern Elliptio Glochidia Transformation

In April and May of 2010, methods for transforming eastern elliptio glochidia to juveniles through attachment to elver gills were tested at the USFWS MFRO laboratory in Annapolis, MD. Eastern elliptio were collected from Andover Branch (tributary to the Chester River, Queen Anne's County) and Deer Creek (tributary to the Susquehanna River, Harford County, MD). Eels were collected using a backpack electrofishing unit in Octoraro Creek (tributary to the Susquehanna River, Cecil County, MD).

In the laboratory, we induced release of glochidia in *E. complanata* by increasing water temperatures to 18°C. Viability of glochidia was tested by exposing a subsample of glochidia to salt; those that snapped shut in response were considered viable (Zale and Neves 1982). In order to infest fish, we introduced eels to water baths (17.0-18.5°C) containing glochidia. After approximately one hour, fish were transferred to a second water bath (without glochidia) for 50-70 more minutes, where glochidia that were not fully attached after the initial exposure fell off. Fish were then transferred to 1 liter plastic aquaria where they were monitored for the remainder of the experiment (30-40 days). Aquaria were siphoned at least 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. Numbers of glochidia or transformed juvenile mussels were recorded. Juvenile mussels were identified by their opaque shells and presence of a foot. Results will aid in the estimation of the number of mussels capable of being transformed from glochidia to juveniles on the gills of elvers.

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 carrying capacity for eels in upstream tributaries was calculated. Eel data collected by Maryland Department of

Natural Resource (MDDNR), 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)), an average density of 529 eels/km was calculated. The carrying capacities for eels in Buffalo Creek and Pine Creek upstream of the stocking sites are estimated to be 45,000 and 55,000 respectively. Over a three year period (2010 through 2012), we plan to relocate up to 60,000 eels to each of Buffalo Creek and Pine Creek.

The MDDNR is required by the Atlantic States Marine Fisheries Commission (ASMFC) to conduct Young-of-Year (YOY) eel monitoring. Their sampling device is located at a bridge culvert in Turville Creek (Ocean City, MD). In April of 2010, MDDNR personnel collected glass eels which were then transported by the USFWS and the Audubon Society of Wellsboro, PA to the USGS Northern Appalachian Research Laboratory in Wellsboro. Glass eels were held in captivity at the lab until June of 2010. Eels were then stocked at 5 locations (Table 1).

For the collection of American eel elvers (90-150 mm), two eel ramps consisting of cable tray, covered and lined with Enkamat, were deployed at the base of Conowingo Dam. Water from the Susquehanna River was pumped to the top of the cable tray ramps where it trickled down the Enkamat to attract elvers. Elvers crawled up the ramps and were swept into fine meshed collection bags inside 80 gallon cattle 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.

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. One tributary, Buffalo Creek, has a relatively high density of eastern elliptio. The mouth of Buffalo Creek, near Lewisburg, PA is approximately 9 miles north of Sunbury, PA on the West Branch of the Susquehanna River. The length of this creek is relatively short which makes achieving a carrying capacity of eels attainable. A second tributary, Pine Creek, has the highest density of eastern elliptio found to date in the Susquehanna River watershed. However, almost all of the eastern elliptio found in Pine Creek are older adults. Conowingo Creek (Cecil County, MD) just above Conowingo Dam serves as a backup stocking location. Elvers collected in batches too small for transport to Buffalo or Pine Creek were stocked in Conowingo Creek. Stockings conducted in 2010 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 stocking success, including survival, growth and habitat use, we conducted electrofishing surveys using 3 backpack electrofishing units in September of 2010. Methods used by the MDDNR MBSS (2007) were used to quantify the catch per unit effort (CPUE) and the biomass of eels. Two sites, bracketing the eel release sites, in each stream were surveyed (Table 1). At each site, 75 meters of stream was blocked off using ¼" block net. In order to get a complete snapshot of the fauna in the 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 the eels collected was brought back to the lab to assess otoliths to verify that eels were marked with OTC.

Mussel survey

Baseline mussel data were collected during mussel surveys conducted in Buffalo Creek in July of 2010. Qualitative searches were conducted in a 2 mile stream reach of Buffalo Creek

using snorkel and plexiglass-bottom buckets. The number of mussels and the search time were recorded after each 200 meter section to determine a CPUE. Within the surveyed area, we identified a 200 meter section of stream, approximately 1500-3000 m^2 in area, with a relatively high mussel density. We conducted quantitative surveys in this area to estimate mussel abundance and assess presence of juvenile mussels. The quantitative survey site was sampled using 0.25 m^2 quadrats in a systematic random design with multiple random starts (Strayer and Smith 2003). All quadrats were excavated to 10 cm or to hardpan and sifted through a 3 mm^2 mesh screen in order to detect juvenile mussels. Counts of each species and length measurements were collected for all mussels. Quantitative and qualitative survey methods followed accepted protocol developed by Strayer and Smith (2003). Results of the quantitative mussel survey were analyzed using the Mussel Estimation Program (Version 1.1.4) developed by David R. Smith (USGS, Leetown Science Center, Leetown, WV).

Data collected during mussel surveys conducted by USGS NARL in 2008 in Pine Creek as part of another project, using identical methods to those used in Buffalo Creek, were used as baseline data for this project.

RESULTS

Eastern Elliptio Glochidia Transformation

A total of 50 elvers were infested with eastern elliptio glochidia in the laboratory. Over 230 eastern elliptio were transformed from glochidia to juveniles on 16 elvers during the experiment. However, water quality in the recirculating aquaria affected the survival of elvers in captivity and only 3 infested elvers survived the duration of the experiment. From the tanks housing elvers that survived the duration of the experiment (over 40 days), 41, 44, and 69 juvenile mussels were recovered, resulting in an average of 51 glochidia transformed to juveniles

on each surviving eel. The 13 eels that survived long enough to produce juveniles but not to the end of the experiment had similar daily results until they perished. Following the study, a new water treatment system was implemented to avoid future water quality problems.

Eel Stocking

Of the 30,000 glass eels collected and held in captivity, approximately 18,000 survived to the elver stage, were OTC marked, and stocked at 5 locations 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, 3000 glass eels were released at each of 3 sites spanning 2 miles of stream length (Figure 2). In Buffalo Creek, 4500 glass eels were released at each of two sites approximately 1 mile apart.

During May, June and July of 2010, approximately 17,500 elvers (average length 124 mm) were captured in the Susquehanna River below Conowingo Dam. A sample of elvers was certified disease-free by the USFWS Lamar Fish Health Center. Nearly 16,000 of the elvers captured below the dam were marked with OTC and stocked in Buffalo Creek (Table 1). In addition, 1651 elvers were stocked in Conowingo Creek.

Fish Survey

During electrofishing surveys in September of 2010, 81 eels were recaptured in Buffalo Creek. Of the eels captured, 70 were found at the Strawbridge Rd. bridge site where over 20,000 elvers and glass eels were stocked and 11 were found at the foot bridge on Rt 1003 where 4500 glass eels were stocked. The lengths of the recaptured eels suggest that a large majority were elvers from below Conowingo Dam (Figure 3). Two of the recaptured eels measured less than 100 mm in length suggesting that they may have been stocked glass eels since most elvers were longer than that at stocking. The average length of stocked elvers from Conowingo was 124.73

mm while the average length of recaptured eels was 143.46 mm. The 81 recaptured eels had a total weight of 830 g which results in an average of 10.2 g per eel. At the time this report was submitted, otoliths had not yet been extracted from these eels to verify the presence of the OTC tag administered at the time of stocking.

Only 1 eel was recaptured in Pine Creek during electrofishing surveys. The captured eel was an older yellow eel (approximately 500 mm in length) likely released in 2009 by the USGS. Although the eel lacked an external tag, there was a scar in the location at which tags were placed.

In addition to eels, 1447 individuals of 26 fish species were collected in Buffalo Creek and 1060 individuals of 20 fish species were collected in Pine Creek during electrofishing surveys (Table 2).

Mussel Survey

Buffalo Creek

In 21.2 qualitative survey hours, 2739 eastern elliptio, 66 creeper (*Strophitus undulatus)*, and 5 yellow lampmussel (*Lampsilis cariosa*) were detected in 2 miles. Of the mussels found during the survey, 97.5% were eastern elliptio. The cumulative CPUE for eastern elliptio was 129.4 mussels per hour. CPUE for individual 200 meter sections sampled ranged from 11.2 eastern elliptio per hour to 538.2 eastern elliptio per hour. The 200 meter section with the highest eastern elliptio CPUE (538 mussels/hour) was chosen for the quantitative mussel survey.

During the quantitative mussel survey, 61.3 m^2 (245 quadrats) of the 5292 m^2 area was excavated. Two species, eastern elliptio (354 found) and creeper (19 found) were detected during this survey. The estimated abundance of eastern elliptio in the survey area was 27,249

(SE = ± 1831) mussels and the estimated density was 5.2 mussels/m^2 (SE = ± 0.35). The average length of eastern elliptio found in quadrats was 82.1 mm (SD = ± 14.9) (Figure 4).

Pine Creek

In the summer of 2008, qualitative surveys were conducted in 17 miles of Pine Creek. However, mussels were found in only 3 miles of the surveyed area. In the 74 survey hours spent in this 3 mile section, 4956 individuals of 7 species, (4459 eastern elliptio, 240 creeper, 208 brook floater (*Alasmidonta varicosa*), 35 green floater (*Lasmigona subviridis*), 10 elktoe (*Alasmidonta marginata*), 2 yellow lampmussel, and 2 triangle floater (*Alasmidonta undulata*)), were detected. Of the mussels found during the survey, 90% were eastern elliptio. The cumulative CPUE for eastern elliptio in the 3 mile section with mussels was 20.2 mussels per hour. The 200 meter section with the highest eastern elliptio CPUE (307 mussels/hour) was chosen for the quantitative survey.

An area of 10,200 m^2 was quantitatively surveyed in Pine Creek. In the quadrats excavated for the survey, totaling 75 m^2 (300 quadrats), 452 eastern elliptio were detected. The estimated density for eastern elliptio was 5.9 mussels/m^2 (SE = ± 0.64) and abundance for the surveyed area was 60,615 (SE = ± 6578). The average length of eastern elliptio found on the surface and in excavated quadrats was 93.1 mm (SD = ± 8.2) (Figure 5).

DISCUSSION

In the first year of this project we achieved 41% of our 3 year stocking goal of 60,000 eels in Buffalo Creek and 15% of our 3 year stocking goal of 60,000 eels in Pine Creek. We also completed electrofishing surveys in both Pine Creek and Buffalo Creek and qualitative and quantitative mussel surveys in Buffalo Creek. Our success in capturing 81 presumably stocked eels in Buffalo Creek 3 months after stocking indicates that the stocked elvers and glass eels

remained near the stocking sites for at least 3 months. Freshwater mussel beds were also documented near these stocking locations. The baseline data collected for both fish and mussels will help us detect changes in fish species composition and recruitment of freshwater mussels over the duration of the project.

Eastern elliptio density at the quantitative survey sites in Buffalo Creek (5.2mussels/m^2) and Pine Creek (5.9 mussels/m^2) are the highest that we have found thus far in the Susquehanna River watershed. Catch rates in these 200 meter sections (538 mussels/hour and 307 mussels/hour respectively) were also among the three highest catch rates found in the Susquehanna River watershed in recent surveys. Similarly, catch rates of over 200 eastern elliptio per hour were found in only 1% of survey sites (8 of 325 sections surveyed in 2008 and 2010 by USFWS and USGS and 1 of 583 sites previously surveyed (unpublished data, PA Fish and Boat Commission)) in the Susquehanna River. In comparison, catch rates of over 200 eastern elliptio per hour were found at 20% of survey sites (106 of 535 sections surveyed by USGS) in the Delaware River (Lellis 2002)

The age structure, if not the actual ages, of eastern elliptio populations can be inferred from the length data (Kesler and Downing 1997). In comparison to the length frequency curve for eastern elliptio in the Delaware River, which resembles the expected bell curve, the length frequency curves for eastern elliptio in both Buffalo Creek and Pine Creek are skewed toward a higher frequency of large mussels (Figure 6). The high frequency of larger mussels and lack of small mussels indicates that there is very little recruitment of juvenile mussels occurring in these streams. The exception was in Buffalo Creek where 37 of the 354 eastern elliptio found during the 2010 quantitative survey measured less than 60 mm and one individual was only 12 mm in length indicating that there has been some recent recruitment of juveniles into the Buffalo Creek

population. While most fish species found at the Buffalo Creek site have been tested by the USGS Northern Appalachian Research Laboratory (unpublished data) to determine whether they are suitable hosts for eastern elliptio transformation of glochidia to juveniles, there were 4 species (chain pickerel, northern hogsucker, satinfin shiner, and swallowtail shiner) found in electrofishing surveys that have not been tested. It is possible that one of these four species or one of the species (pumpkinseed or bluegill) identified as a host by Watters et al. (2005) are acting as hosts for the transformation of a small number of juvenile eastern elliptio. Other host fish possibilities are mottled and slimy sculpin. While they were not found during electrofishing surveys in Buffalo Creek, they are two species that were found to be successful hosts for eastern elliptio in laboratory studies (USGS NARL, unpublished data) and if present could be serving as a host fish to transform a small number of juveniles each year.

In host fish trials conducted by USGS NARL, the average transformation rate of eastern elliptio on larger yellow eels was 81 mussels per eel while the transformation rate on glass eels was 0.9 mussels per eel (unpublished data). In comparison, the trials conducted in the MFRO yielded an average of 51 mussels per eel for elvers. In areas where mussel density is high and elvers are present, we would expect a similar rate of transformation.

In 2011, we again expect to stock equal numbers of eels collected as glass eels from Ocean City in each of Buffalo Creek and Pine Creek. Because stocking eels collected as glass eels was successful in 2010, we hope to increase the number of glass eels transported to and held at the USGS NARL and in turn increase our stocking numbers in Buffalo and Pine Creeks.

There appears to be a relationship between the three years of elver capture data below Conowingo Dam and the glass eel (Young-of Year) index conducted on Turville Creek in Ocean City, MD (Figure 7). Catch rates for elvers at Conowingo Dam reflect predicted recruitment of

glass eels one year earlier at Turville Creek. If this relationship holds true, we should expect a more abundant year class of elvers available for capture below Conowingo Dam in 2011. In the coming year, we plan to maximize our stocking effort in Pine Creek by stocking it with elvers captured at Conowingo Dam during the first part of the summer and stocking Buffalo Creek with elvers caught later in the summer.

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Table 1. Eels stocked in Buffalo Creek (Union County, PA) and Pine Creek (Tioga County, PA) during the summer of 2010.

Water Body	Release Date	# Eels released	Mean length (mm)	Release Location	GPS coordinates		Origin
Buffalo Creek							
	6/10/2010	8,084	124.7	Strawbridge Rd Bridge	40.98560	-76.93237	Conowingo Dam
	6/10/2010	4,500	56.3*	Strawbridge Rd Bridge	40.98560	-76.93237	Turville Creek
	6/10/2010	4500	56.3*	Foot bridge on Rt. 1003	40.98105	-76.95134	Turville Creek
	6/21/2010	7,790	124.7	Strawbridge Rd Bridge	40.98560	-76.93237	Conowingo Dam
	Total	**24,874**					
Pine Creek							
	6/9/2010	3000	56.3*	Ansonia Bridge	41.74368	-77.43394	Turville Creek
	6/9/2010	3000	56.3*	Darling Run Access	41.73671	-77.43036	Turville Creek
	6/9/2010	3000	56.3*	Owassee Rapids	41.72098	-77.41300	Turville Creek
	Total	**9000**					
	Grand Total	**33,874**					

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

Table 2. Presence of fish species captured in Buffalo Creek and Pine Creek during electrofishing surveys conducted in September of 2010.

	Buffalo Creek		Pine Creek	
	Strawbridge Rd Bridge	Foot bridge on Rt 1003	Darling Run Access	Ansonia Bridge
American eel	+	+		+
Banded darter	+	+	+	+
Blacknose dace	+		+	+
Bluegill		+	+	+
Bluntnose minnow		+		
Creek chub				+
Creek chubsucker		+		
Cutlips minnow	+	+	+	+
Chain pickerel		+		
Common shiner		+		
Central stoneroller	+	+	+	+
Fallfish	+	+	+	+
Green sunfish				
Greenside darter	+	+	+	+
Longnose dace	+	+	+	+
Margined madtom	+	+	+	+
Northern hogsucker	+		+	+
Pearl dace			+	
Pumpkinseed		+		
Rock bass		+	+	+
Rosyface shiner	+		+	+
Satinfin shiner		+		
Shield darter	+	+	+	+
Smallmouth bass	+	+		+
Spottail shiner	+	+	+	+
Swallowtail shiner	+	+	+	+
Tessellated darter	+	+	+	+
White sucker	+	+	+	+
Yellow bullhead		+		

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.

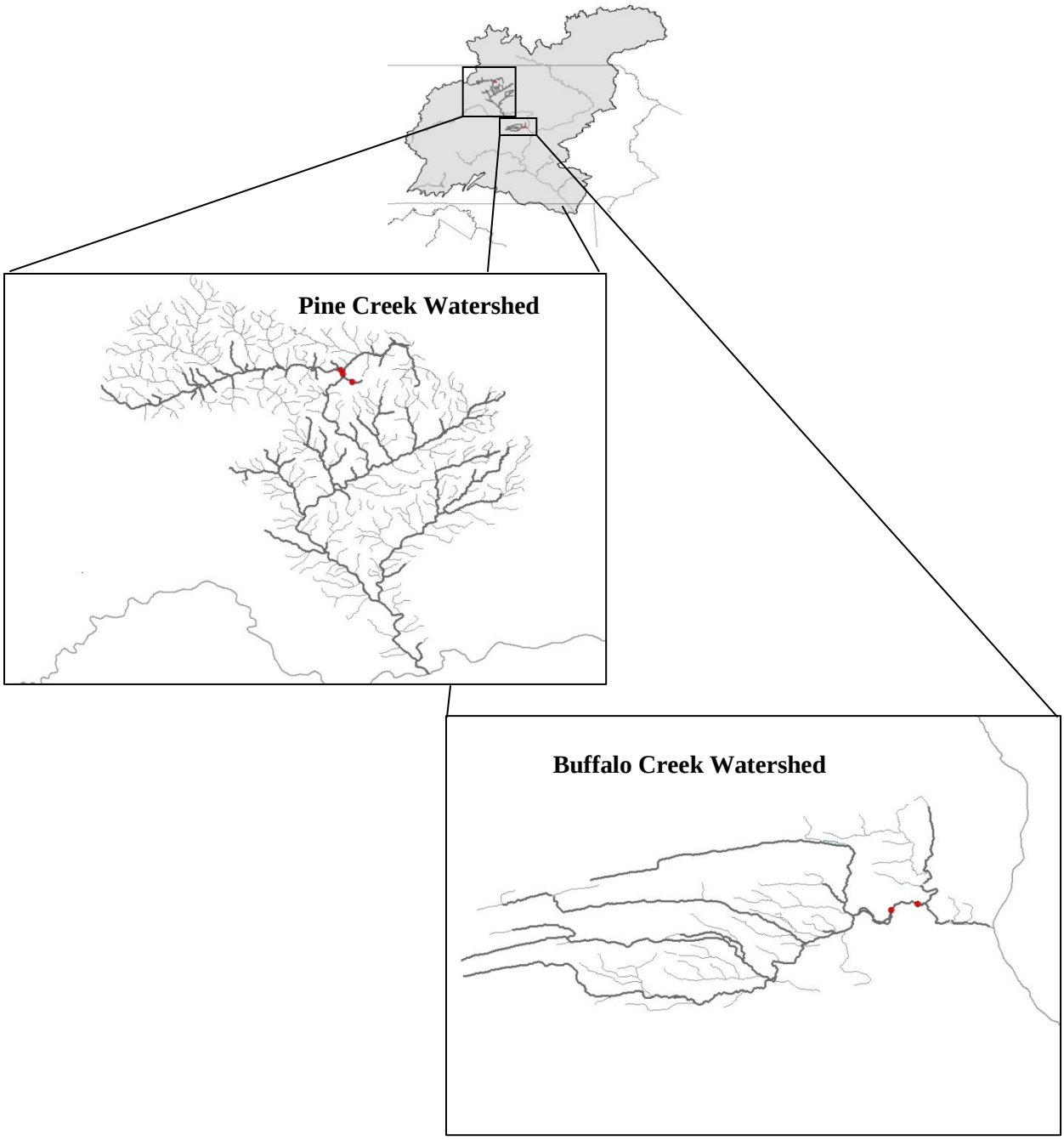

Figure 2. Eel stocking sites (indicated by red dots) in the Pine Creek (Tioga County, PA) and Buffalo Creek (Union County, PA) watersheds in the Susquehanna River drainage.

Figure 3. Length frequency of eels captured during monitoring surveys in Buffalo Creek in September of 2010. Average length of elvers at stocking (June 2010) and average length of recaptured eels at monitoring (September 2010) denoted by vertical black lines.

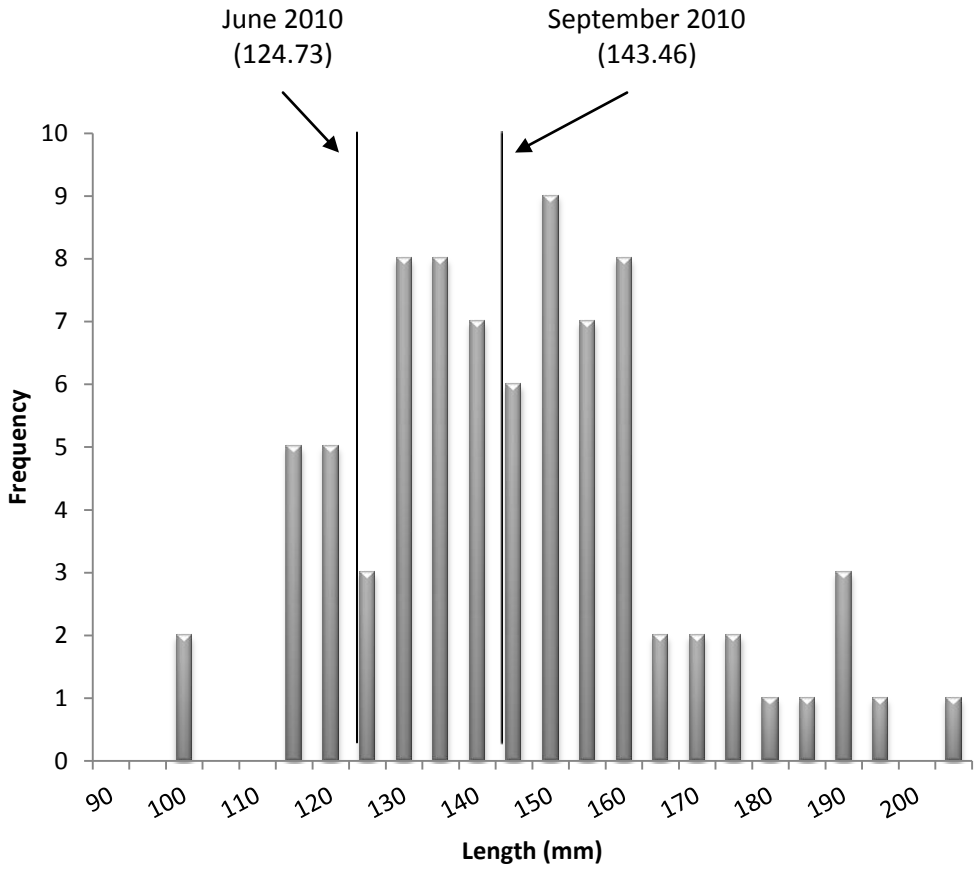

Figure 4. Length frequency of eastern elliptio (*Elliptio complanata*) found in a 200 meter section of Buffalo Creek during a quantitative survey conducted in July 2010.

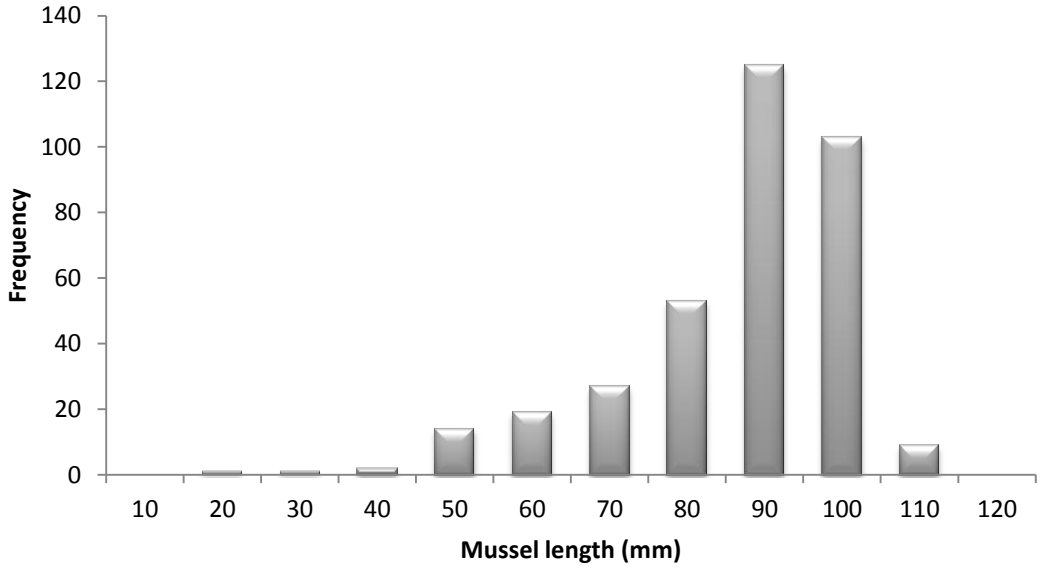

Figure 5. Length frequency of eastern elliptio (*Elliptio complanata*) found in a 200 meter section of Pine Creek during a quantitative survey conducted in July 2008.

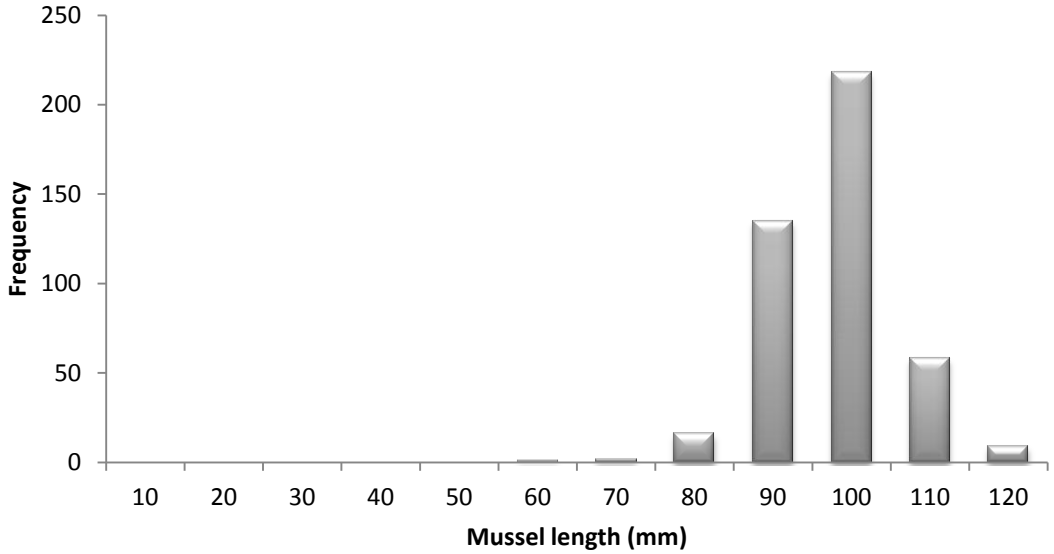

Figure 6. Length frequency of eastern elliptio (*Elliptio complanata*) found in quantitative surveys conducted in two tributaries to the Susquehanna River, Pine Creek and Buffalo Creek and in the mainstem Delaware River.

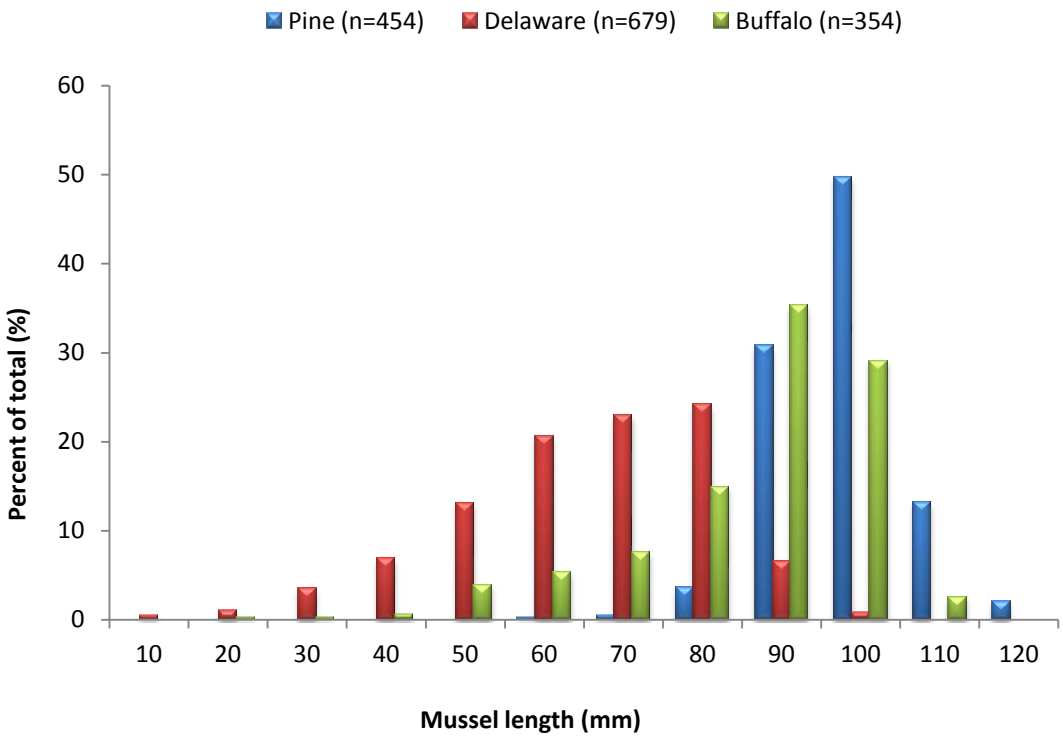

Figure 7. Glass eel (Young of Year (YOY)) catch per hour at the permanent sampling location in Turville Creek (Ocean City, MD) and the total number of elvers captured at the sampling location below Conowingo Dam on the Susquehanna River (Darlington, MD).