American Eel sampling at Conowingo Dam 2008

Steve Minkkinen, Ian Park, Maryland Fishery Resources Office, 12/10/2008

Background

American eel occupy a significant and unique niche in the estuarine and freshwater habitats of the Atlantic coast. Eels are a catadromous species that ascend freshwater environments as juveniles. These fish reside in riverine habitats until reaching maturity at which time they migrate to the Sargasso Sea where they spawn once and die. Larval eels are transported by ocean currents to rivers along the eastern seaboard of the continent. Unlike anadromous shad and herring, they have no particular homing instinct. Historically, American eels were very abundant in East Coast streams, comprising more than 25 percent of the total fish biomass in many locations. This abundance has declined from historic levels but remained relatively stable until the 1970s. More recently, fishermen, resource managers, and scientists have noticed a further decline in abundance from harvest and assessment data.

Although the Chesapeake Bay and tributaries support a large portion of the coastal eel population, eels have been essentially extirpated from the largest Chesapeake tributary, the Susquehanna River. The Susquehanna River basin comprises 43% of the Chesapeake Bay watershed. Construction of Conowingo Dam in 1928 effectively closed the river to upstream migration of elvers at river mile 10. Before mainstem dams were constructed, the annual harvest of silver eels in the Susquehanna River was nearly one million pounds. There is currently no commercial harvest (closed fishery in Pennsylvania) and very few fish (resulting from Pennsylvania Fish & Boat Commission stockings in the early 1980s) are taken by anglers above the dam. The Maryland Biological Stream Survey (MBSS) collects data in freshwater drainages of Maryland. Eel captures in this survey were collected for the Susquehanna River and tributaries in the vicinity of Conowingo Dam (Figure 1). This data reflects the fact that the dam blocks the upstream migration of eels. By extrapolating densities of eels captured in Maryland the MBSS survey estimated that there would be over 11 million eels in the Susquehanna watershed if their migration was not blocked by dams.

Mainstem Susquehanna 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 juvenile eels (elvers) upriver. Specialized passages designed to accommodate eels are needed to allow them access to the watershed above dams.

Survey methods and Equipment Placement

To determine the best method to reintroduce eels into the Susquehanna River above the Conowingo dam, we have collected baseline information on eel abundance, migration timing, catchability, and attraction parameters at the base of the Conowingo Dam since the spring of 2005. Information from the study will assist in determining the potential for reintroducing eels into the Susquehanna watershed above Conowingo Dam.

In contrast to previous years sampling took place on the east side of the dam in addition to the west side of the dam. This sampling served as an attempt to survey the population of juvenile eels at the base of Conowingo Dam. In 2008 we constructed elver traps from industrial cable tray with landscape fabric attached to the bottom, which provided a substrate for the elvers to climb (Figure 2). The top of the cable trays emptied into a fine meshed collection bag placed in collection tanks (Figure 3). Aerated water was supplied to the collection tanks to keep the elvers alive. On the east side of the dam the elver trap was run from the shoreline into the river and we created attraction flow by pumping river water to the base of the elver trap as well as down the trap.

On the west side of the dam we placed our eel trap on the shore adjacent to the West Fish Lift. In 2007, elvers were observed climbing up the rip rap where water was spilling over from pumps operated to supply water for the West fish Lift operations (Figure 4). In 2008 we used this excess water as attraction flow for our elver trap. Elvers that found this attraction flow would crawl up the rip rap to the trap and then climb it into the collection bag.

Elvers were sedated, measured, counted, and in the occurrence of large numbers, eels were counted volumetrically. Captured elvers were originally being transported to Deer Creek and released above Wilson Mill dam so that we were not recapturing the same individuals. The collection of substantial numbers of eels allowed for the experimental stocking of elvers into Conestoga Creek. All of the elvers stocked into Conestoga Creek were marked with a 6 hour immersion in buffered oxytetracycline (OTC) at a concentration of 550 ppm prior to release. Yellow eels captured in eel pots were sedated, measured, fin clipped, and had PIT tag inserted in the dorsal musculature and released.

As in previous years eel pots with a 6 mm square mesh were set around the base of the West Fish Lift to catch larger eels. This year the goal was to tag new eels and recapture yellow eels that had previously been tagged with Passive Integrated Transponder (PIT) tags during 2007.

Results

Eels were sampled between 13 May and 4 August 2008 (Table 1). Elvers were collected from May 30th – Aug 4th. A total of 44,000 elvers were collected during 2008 (Table1). Numerous GFI outages, along with pump obstructions interrupted the operation of the elver traps which reduced our potential catch. Juvenile eel length frequencies ranged from 90 to 176 mm TL (Figure 5). A total of three releases in Conestoga Creek were conducted, with an estimated total of 17500 elvers being stocked (Table 2, Figure 7).

The length frequency of yellow eels collected in eel pots varied from 321 to 770 mm TL (Figure 6). A total of 38 yellow eels were captured, with 25 recaptures and 13 new captures. Of those eels recaptured, 12 were tagged in 2008 and the other 13 eels were originally tagged in 2007. The annual growth of the recaptured eels from 2007 ranged from 11 mm to 129 mm, with average growth of 47mm. (Table 3)

Discussion

We compared elver captures to water temperature, stream flow, lunar phase and date. It appears that elvers reach the dam first week of May through the end of June. In 2008 peak captures occurred during periods of a waning moon (decreasing lunar fraction)(Figure 8).

The east side elver trap was not as effective at capturing elvers as the west side trap (Table 2) We believe this is due to our limited ability to create sufficient attraction flow at the base of the elver trap and competition with the spill leaking from flood gates on the east side of the dam. Conversely, attraction flow trickling down the west side along the rip rap enters the river, in an eddy along the shoreline just below the base of the dam. This is attracts elvers moving upstream along the shoreline.

We encountered problems ensuring a constant supply of water to the collection devices. We had numerous GFI outages, and pump failures that interrupted the water flow that was supplying water to operate the elver traps. Several outages occurred during the peaks in elver migration which reduced our potential catch. Next year we plan on using water that is gravity fed from the pool above the dam to operate our collection devices. This will eliminate the need for electronic pumps and the associated malfunctions. We also plan on increasing the sampling effort by installing two elver traps on the west side of the dam, and increasing the size of the holding tanks. We will be operating one elver trap in the spill on the rip rap where we sampled in 2008. The other elver trap will also be located on the west side of the dam and will run over the rip rap down to the waters edge. The purpose of the second elver trap will be to try and directly attract elvers into the trap instead of collecting the elvers after they have climbed over 60 feet up rip rap before entering the tray. Our proposed goal for 2009 is to collect 100,000 elvers and release them in Conowingo creek and a tributary in Pennsylvania. Elvers will be marked with OTC before being released. The Maryland Biological Stream Survey plans on conducting surveys in Conowingo Creek to evaluate the stocking effort. The MFRO will survey elvers released in the Pennsylvania tributary using electrofishing gear.

In addition to the American eel trap and transport research being conducted by the U.S. Fish and Wildlife Service at Conowingo Dam, the U.S. Fish and Wildlife Service collaborated with U.S. Geological Society, Northern Appalachian Research Lab to assess the importance of eels to freshwater mussels in the Susquehanna River (Appendix 1).

Figure 1. Map of the Maryland Biological Stream Survey (MBSS) sampling sites of tributaries to the Susquehanna River in Maryland. The numbers in boxes indicates eel counts at each sampling site. Note the difference in densities of eels in tributaries below Conowingo Dam compared to above the Dam.

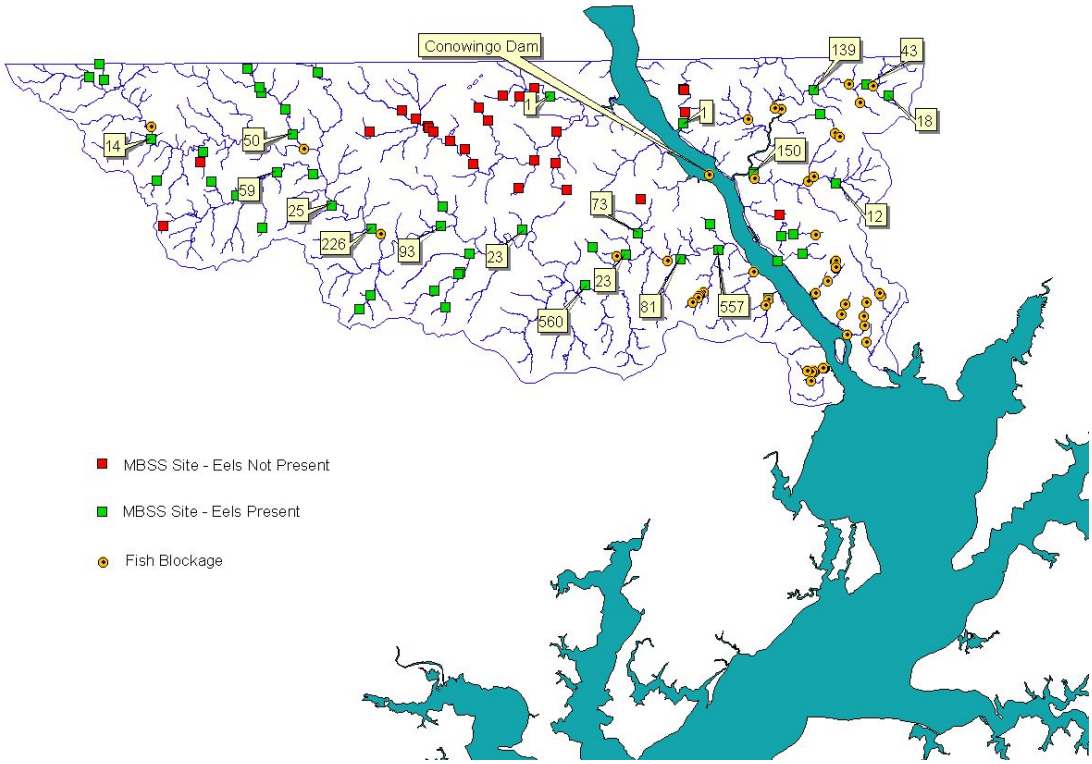

Figure 2. Eel trap constructed of industrial cable tray and landscape fabric.

Figure 3. Cable tray emptying into a spat bag in the collection tank.

Figure 4. Elvers climbing up rip rap in overflow from west fish lift pumps.

Figure 5. Length frequencies of elvers captured at the base of Conowingo Dam during 2008.

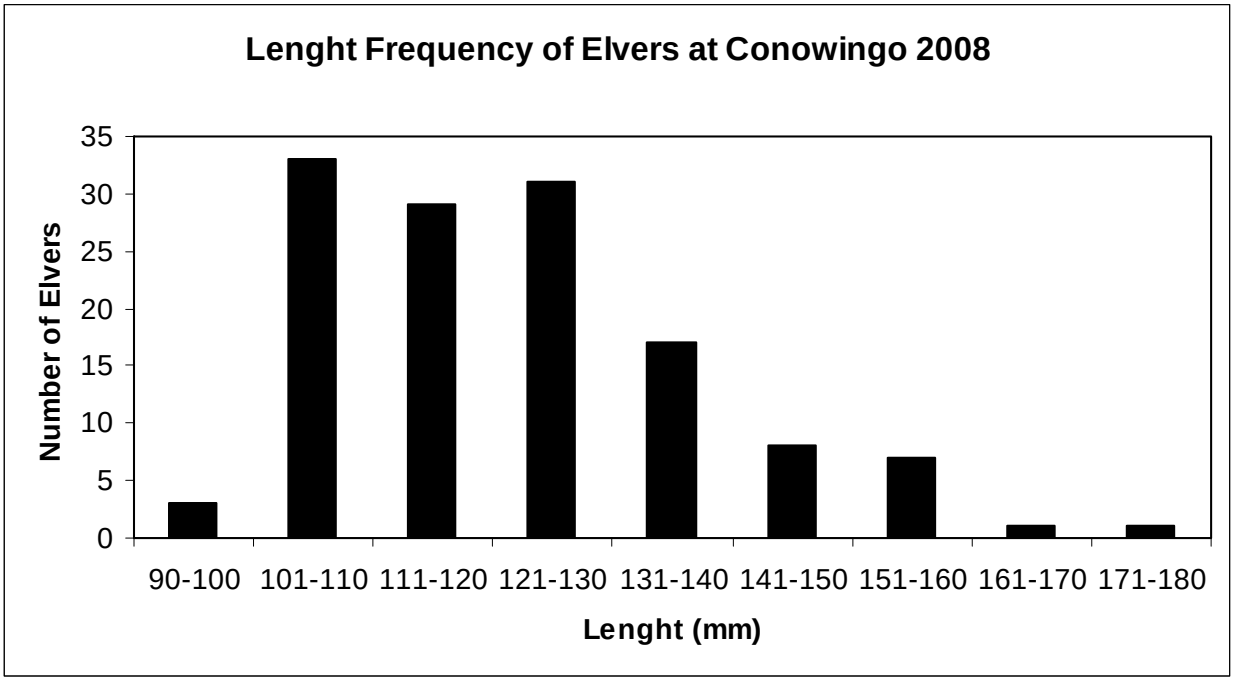

Figure 6. Length frequency of yellow eels captured at Conowingo Dam, 2008.

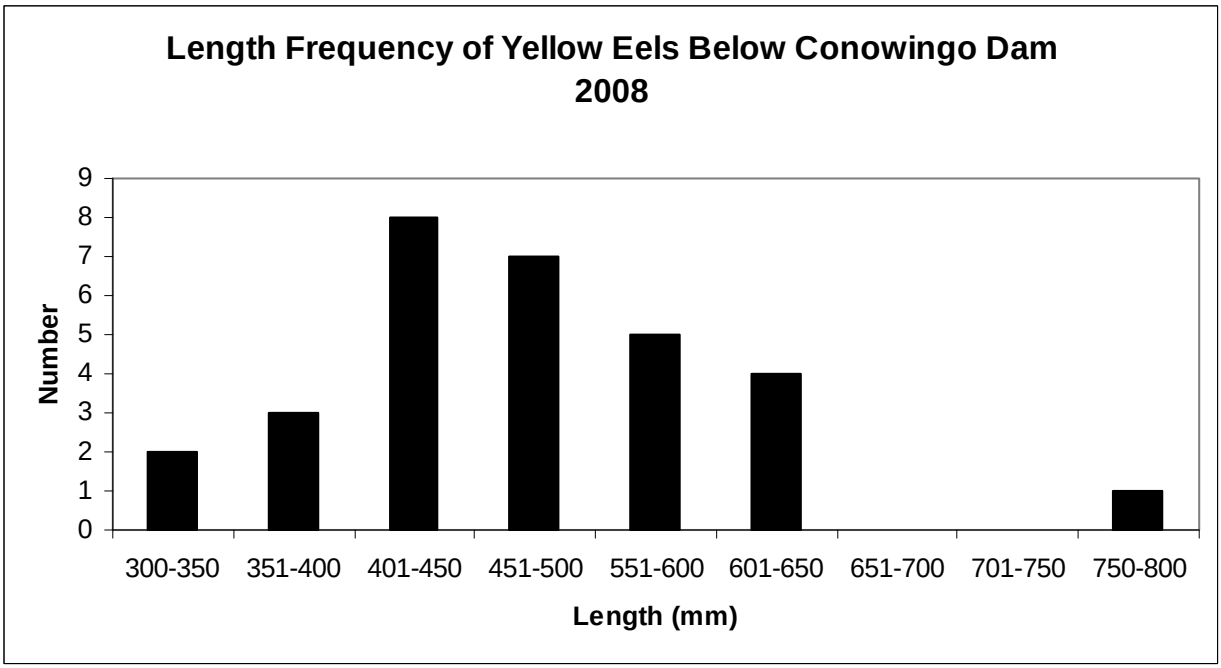

Figure 7. Elvers in Conestoga creek after being released.

Figure 8 Elver capture in relation to Lunar Fraction

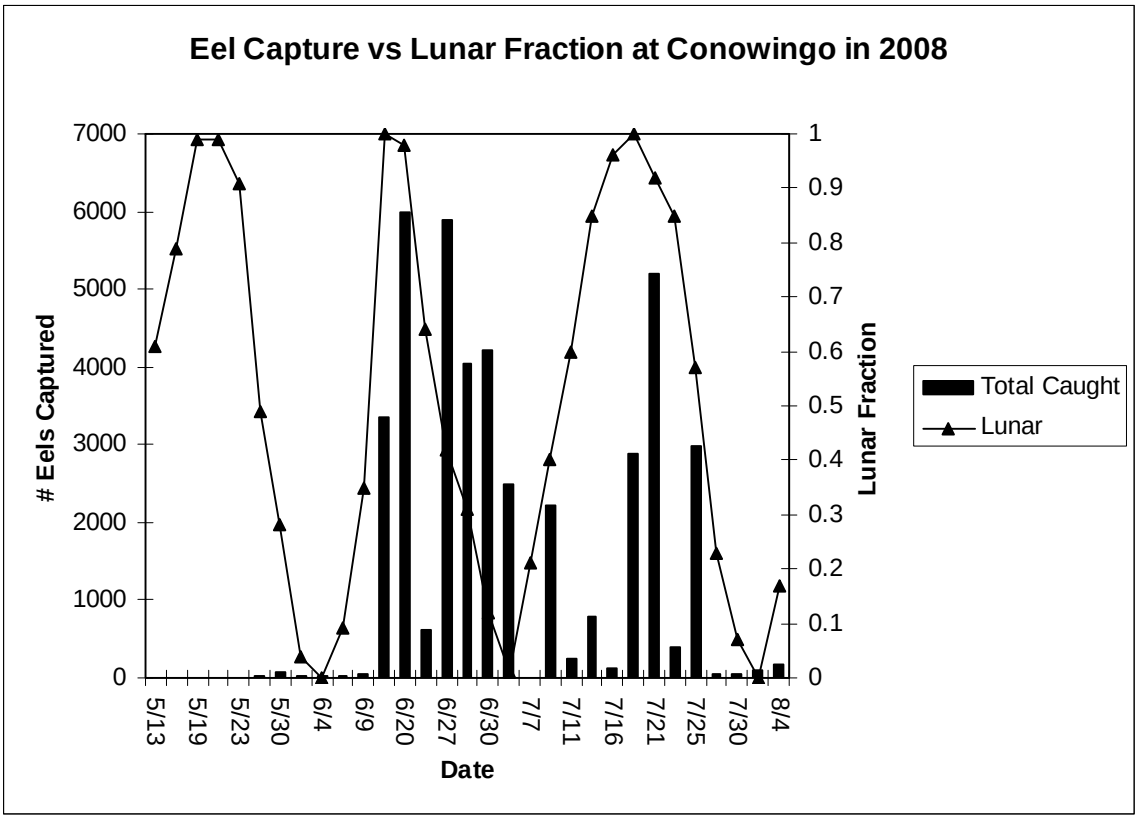

Table 1. Number of eels caught at the base of Conowingo Dam on the Susquehanna River by eel passages on the West and East side of the dam during 2008.

Date	Lunar Fraction	West	East	Total
13-May	0.61	0	0	0
15-May	0.79	0	0	0
19-May	0.99	0	0	0
21-May	0.99	0	0	0
23-May	0.91	0	0	0
28-May	0.49	0	0	0
30-May	0.28	13	0	13
2-Jun	0.04	76	0	76
4-Jun	0	20	0	20
6-Jun	0.09	17	7	24
9-Jun	0.35	25	0	25
11-Jun	0.56	61	0	61
13-Jun	0.75	0	0	0
16-Jun	0.94	614	0	614
17-Jun	0.98	526	0	526
18-Jun	1	3350	0	3350
20-Jun	0.98	6000	0	6000
25-Jun	0.64	621	106	727
27-Jun	0.42	5900	0	5900
28-Jun	0.31	4050	92	4142
30-Jun	0.12	4212	26	4238
2-Jul	0.01	2500	0	2500
7-Jul	0.21	7	62	69
9-Jul	0.4	2210	0	2210
11-Jul	0.6	236	0	236
14-Jul	0.85	780	78	858
16-Jul	0.96	130	100	230
18-Jul	1	2873	145	3018
21-Jul	0.92	5200	0	5200
22-Jul	0.85	390	208	598
25-Jul	0.57	2990	0	2990
28-Jul	0.23	61	0	61
30-Jul	0.07	50	0	50
1-Aug	0	108	0	108
4-Aug	0.17	162	0	162
Total		43182	824	44006

Table 2. Date, Location, and number of elvers stocked

Date	# Stocked	Creek	Latitude	Longitude
30-Jun	7600	Conestoga	39`56'27"	76`23'26
16-Jul	1088	Conestoga	39`56'47"	76`22'05
22-Jul	8816	Conestoga	39`56'47"	76`22'05

Table 3. Yellow eel recaptures and growth increase

ID	2007 Length (mm)	2008 Length (mm)	Annual Growth (mm)
257C63E092	594	617	23
257C6534CA	733	770	37
257C6526C0	463	474	11
257C65EB48	404	510	106
257C655F24	426	445	19
257C65F2F2	338	390	52
257C63E581	551	589	38
257C65F8B0	475	511	36
257C65E87B	405	471	66
257C65FBAB	377	405	28
257C652B3A	466	490	24
257C63C580	391	520	129
257C660193	386	428	42

APPENDIX 1

Work completed in 2008 by USGS, Northern Appalachian Research Lab, Wellsboro, PA and USFWS, Maryland Fishery Resources Office, Annapolis, MD to assess the importance of American eels to freshwater mussels in the Susquehanna River

Submitted by Julie L. Devers as an Appendix to "American Eel sampling at Conowingo Dam 2008"

Introduction

Research conducted by the USGS, Northern Appalachian Research Laboratory indicates that American eel *(Anguilla rostrata)* is the primary fish host for the freshwater mussel, eastern elliptio (*Elliptio complanata*) in the Susquehanna River (Lellis et al. 2001). The larvae (glochidia) of freshwater mussels must parasitize a host fish to complete metamorphosis to the independent juvenile life stage. Some mussel species are generalists and can use multiple fish species as hosts while others are specialists that rely heavily on one or two host fish species. Eastern elliptio glochidia collected from Pine Creek (a tributary to the Susquehanna River) metamorphose on American eels at a higher rate than other fish species found in the river (Lellis et al. 2001).

Eastern elliptio is abundant throughout most of its range which spans the entire east coast. However, in comparison with other rivers such as the Delaware River where the eastern elliptio population is estimated to be in the millions (Lellis 2001), biologists have noticed a distinct absence of eastern elliptio and lack of recent recruitment to the Susquehanna River (personal communication, William Lellis, USGS, Wellsboro, PA). Low recruitment of eastern elliptio could be linked to the lack of eel passage over the 4 mainstem dams in the Susquehanna River.

If eels are essential to the reproduction of eastern elliptio or other freshwater mussel species, the implications of providing eel passage to freshwater mussel populations and in turn, ecosystem function could be significant. Similar to oysters in the Chesapeake Bay, freshwater mussels provide the service of natural filtration to the rivers and streams where they live. A healthy reproducing population of eastern elliptio could remove algae, sediment, and micronutrients from billions of gallons of Susquehanna River water each day. Restoring the upstream distribution of American eels and eastern elliptio could improve water quality of the Susquehanna River and subsequently the Chesapeake Bay. A research project to further evaluate the relationship between eastern elliptio and American eel was funded by the USFWS, Region 5, Science Support Program and was conducted during 2008.

Methods

The U.S. Fish and Wildlife Service collaborated with the U.S. Geological Survey, Northern Appalachian Research Lab (NARL) in Wellsboro, PA to conduct host fish studies and conduct field surveys of eastern elliptio sites. Five fish species (alewife, blue herring, American shad, hickory shad, and American eel) were tested for suitability as hosts for eastern elliptio at the Manning State Fish Hatchery, Brandywine, MD. Twelve additional species were tested at NARL

(American eel, banded killifish, brook trout, river chub, banded darter, green sunfish, redbreast sunfish, pumpkinseed, white suckers, spottail shiners, rosyface shiner, and striped bass). To assess age and recruitment at each location, mussel surveys were conducted in previously surveyed Susquehanna River tributaries with the highest densities of eastern elliptio.

Host fish studies were conducted by allowing eastern elliptio glochidia to infect potential fish hosts and collecting samples to determine if metamorphosis has occurred. To induce natural release of eastern elliptio glochidia, water temperature in each aquarium was increased gradually to 18C prior to conducting infections. Viability of glochidia was tested by exposing a subsample to salt (Zale and Neves 1982). All test fish, separated into groups of 5-10 individuals per species, were introduced to a bath of glochidia at 18C in 1-liter beakers (for small fish), 5-gallon buckets (for larger fish), and tanks (drained to <200 gallons) for shad and herring. Fish were then transferred to 10-gallon glass aquaria (or 8 foot circular tanks filled to ~ 1000 gallons for shad and herring) where they were monitored to determine if glochidia successfully metamorphosed into juvenile mussels. Aquaria and tanks were siphoned at least three times each week until one week after the last juvenile mussel was found, to ensure no juveniles went undetected. At each siphoning, collected material from each aquarium was transferred to a Petri dish, and contents were observed under a dissecting scope using a polarized lens. Juvenile mussels were identified by the presence of a foot.

Both qualitative and quantitative mussel surveys were conducted upstream and downstream of Conowingo Dam in the Susquehanna River and its tributaries. Surveys were conducted at 13 sites in the Susquehanna River watershed. Sites with at least 30 eastern elliptio individuals detected in one hour in previous surveys were chosen to ensure sufficient numbers of eastern elliptio to assess age and recruitment. Study sites were located below the Conowingo Dam in Deer Creek and Little Deer Creek, and above the dam, in Conewago Creek, Conodoguinet Creek, Middle Creek, Bald Eagle Creek, Buffalo Creek, Pine Creek, Aughwick Creek, Mud Creek, Chenango River, Charlotte Creek, and Tuscarora Creek. One additional site in Quantico Creek was surveyed to further assess age and recruitment of eastern elliptio where eels occur in the Chesapeake Bay watershed.

At each site, we conducted qualitative searches in 2 mile stream reaches using snorkel and plexiglass-bottom buckets to determine the 200 meter stretch with the highest density of mussels. Quantitative surveys were then conducted at the highest density stream reach. All quantitative survey sites were sampled using $0.25m^2$ 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. Mussel diversity, counts of each species, as well as morphology measurements were collected for all mussels. Mussel densities and length frequency were compared between sites at which eels were present below Conowingo Dam and locations with suitable mussel habitat above the dam. Quantitative and qualitative survey methods followed accepted protocol developed by Strayer and Smith (2003). In addition, electrofishing surveys were conducted at a number of sites to ensure that no potential host fish were missed.

Results

Results of host fish trials indicate that American eel was the only suitable host fish species included in the study. Of the fish tested at Manning Hatchery, juvenile eastern elliptio were only found in the American eel tank. Similarly, no metamorphosed juveniles were detected in any aquaria at NARL except those with infected American eel.

A sufficient number of eastern elliptio to justify 200 meter quantitative surveys were found at 11 of the 14 two mile qualitative survey sites. Length frequency analysis was conducted at quantitative sites where more than 50 individuals were found (Figure 1). Lengths of eels at sites at which eels are present (Deer Creek and South Quantico Creek) are different ($p<0.05$) from all but two sites above Conowingo Dam (Augwhick Creek and Middle Creek). Additional analyses to be conducted in 2009 include analyzing age of mussels at various lengths for each study site, population estimates for each study site. Results of these analyses will provide insight into whether there has been any recent recruitment of young mussels in streams above Conowingo Dam. In addition, species and number of fish collected during electrofishing surveys will be compared between sites.

References

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Strayer, D.L., and D.R. Smith. 2003. A Guide to Sampling Freshwater Mussel Populations. American Fisheries Society Monograph 8, Bethesda, MD. 103 pp.

Zale, A. V. and R. J. Neves. 1982. Identification of a host fish for *Alasmidonta minor* (Mollusca: Unionidae). American Midland Naturalist 107: 386-388.

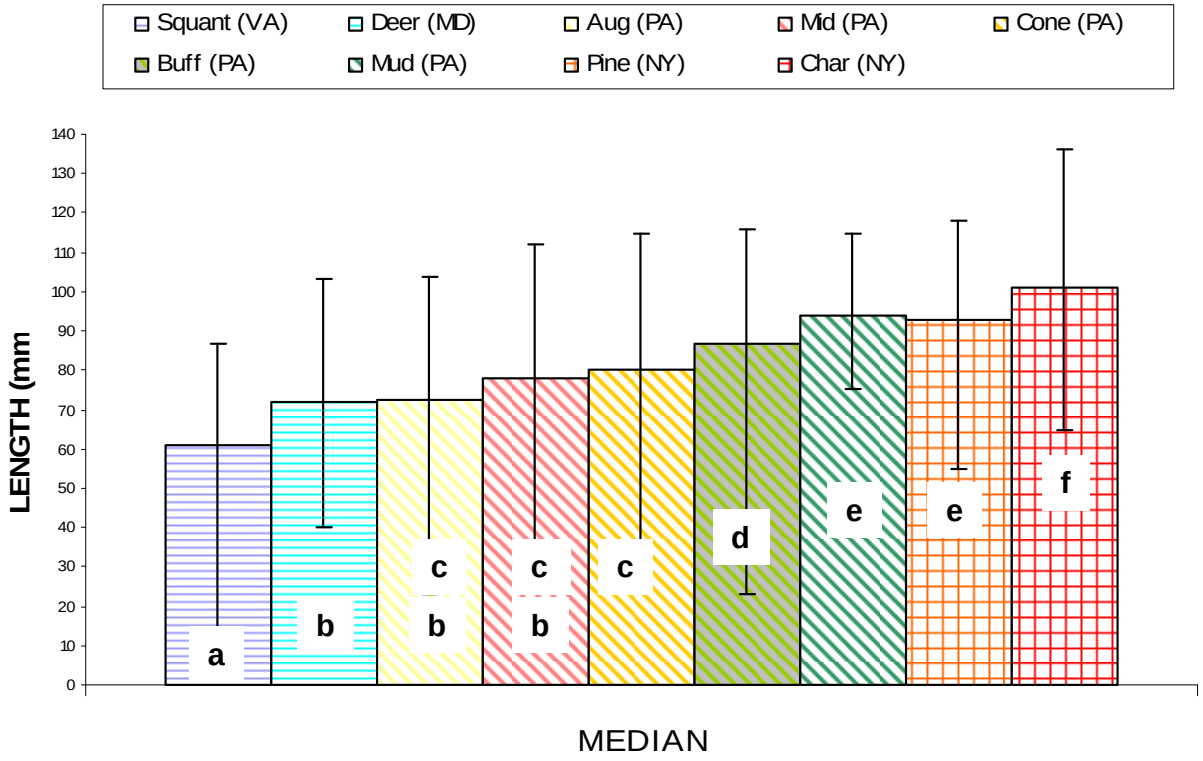

Figure 1. Median length of eastern elliptio found in quadrats during quantitative surveys at South Quantico Creek (Squant), Deer Creek (Deer), Augwhick Creek (Aug), Middle Creek (Mid), Conewago Creek (Cone), Buffalo Creek (Buff), Mud Creek (Mud), Pine Creek (Pine), and Charlotte Creek (Char). Letters indicate significant difference according to Tukey-Kramer HSD ($p < 0.05$). Error bars indicate maximum and minimum lengths found at each site.