American Eel sampling at Conowingo Dam

2014

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Background

Eels are a catadromous species that ascend freshwater environments as juveniles then reside in estuarine and 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 abundant in East Coast streams, comprising more than 25 percent of the total fish biomass in many locations. However, Atlantic coast commercial landings have been declining since the 1970's.

The Atlantic States Marine Fisheries Commission Fishery Management Plan for American Eel lists access to freshwater habitat as a priority for protecting the population. 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 encompasses 43% of the Chesapeake Bay watershed. Construction of Conowingo Dam in 1928 effectively closed the river to upstream migration of elvers at river mile ten (Figure 1).

Mainstem Susquehanna fish passage facilities (lifts and ladders) were designed 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 passage devices designed to accommodate elvers 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 Conowingo Dam, we have collected baseline information on eel abundance, migration timing, catch efficiency, and attraction parameters at the base of the Conowingo Dam since the spring of 2005. Information from the study will assist in directing restoration efforts in the Susquehanna watershed above Conowingo Dam.

The 2014 American eel sampling below Conowingo took place on the west side of the dam adjacent to the West Fish Lift. During 2005 and 2006 exploratory efforts were conducted to determine the best placement and design of a temporary trapping facility. 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. From 2008 through 2014 we used this excess water as attraction flow for our elver trap, constructed from industrial cable tray with landscape fabric

attached to the bottom (Figure 2). Elvers that found this attraction flow would crawl up the rip rap to the trap and then climb into the trap. The top of the cable tray emptied into a covered collection tanks (Figure 3). Aerated water was supplied to the collection and holding tank using a 1/8 HP Sweetwater™ Blower. This year an additional blower, Medo Linear Piston Air Pump SL44B, was added in an attempt to create more oxygen turnover in the tanks. In 2009 and 2010 we made an attempt to attract elvers directly from the Susquehanna River at the base of the riprap as well. In 2011 we discontinued the experimental trap going down to the river's edge. In 2013 we increased the number of holding tanks, and increased the water supply and drain pipe sizes.

All collected elvers were sedated with, Finquel Tricane Methanesulfonate (MS-222), individually counted and a subsample were measured for total length (TL). Large numbers of eels were counted volumetrically. The collection of substantial numbers of eels allowed for the continued stocking of elvers into Susquehanna River mainstem (Table 1).

Subsamples of elvers were sent to the Lamar Fish Health Center (Lamar, PA) for disease testing before any stocking occurred.

In 2014, our yellow eel collection continued using a double throated rectangular trap with a 25 mm by 13 mm mesh that is consistent with local commercial gear. Yellow eels captured in eel pots were sedated with a concentrated solution of MS-222 (450g/L), measured, and examined for a passive integrated transponder (PIT). No new PIT tags were applied during the 2014 sampling.

Results

The upstream collection device was operated between 29 May and 5 September 2014 and elvers were collected throughout the entire sampling period (Table 2). A total of 185,628 elvers were collected during 2014 with the majority collected in one peak migration event. However there did appear to be 3 smaller migration events. The first small peak occurred at the beginning of June followed by another larger peak in the third week of July and two smaller peaks at the end of the sampling period. The seasonal pattern of migration in 2014 was similar to that observed in previous years with a majority of the eels collected from mid-June through mid-August. In 2008, 2010-2013 we saw multiple peaks in elver migration during our sampling efforts; whereas in 2009 there did not appear to be peaks in collections, but a more steady level of migration throughout the sampling period. In 2011 we saw a large peak in elver collection at the end of August through the beginning of September during high flows associated with hurricane Irene and tropical storm Lee (Figure 4). Peaks in the 2014 collection were not associated with a distinct weather event, but did coincide with the lunar phase for the first two peak events (Figure 5).

Juvenile eel lengths ranged from 78 to 212 mm TL (Figure 6), with an average length of 115 mm, which is 7 mm smaller than the average size eel collected since 2008. However as in past years over 95% of the eels measured were between 80 and 150 mm. Yellow and silver eel collections in eel pots have taken place from 2007 through 2014. In 2014, we captured 36 yellow

and silver eels that ranged from 327 to 476 mm TL. Of the 36 captures, 4 were recaptures from tagging done in 2013 or in previous years. In 2014 we had more captures but the same number of recaptures compared to 2013 (29 captures and 4 recaptures). We have recorded annual growth rates of the 42 PIT tagged eels that have been recaptured after at least one year after tagging (Table 3). These eels have an average growth of 44 mm a year with a maximum of 123 mm and a minimum of 11 mm.

Fourteen stockings events of elvers captured at Conowingo Dam were completed, with an estimated total of 168,000 elvers being stocked in Susquehanna Watershed (Table 1).

To evaluate stocking success at Buffalo and Pine Creek, we conducted electrofishing surveys using 3 backpack electrofishers and a barge electrofisher in July 2014. We duplicated methods used by the Maryland Biological Stream Survey (2007) to quantify the catch per unit effort (CPUE) and the biomass of eels. Two sites, bracketing the eel stocking sites, in each creek were surveyed. At each site, 75 meters of stream were blocked off using ¼" mesh block net. In order to quantify the fauna in the stream, two passes with the electrofishing units were conducted and all species of fish collected were enumerated. Captured eels were measured to assess growth and a subsample of the eels collected was brought back to confirm previous marking of otoliths by OTC and to evaluate the sex ratio of stocked eels. In July of 2014, 161 elvers were recaptured in Buffalo Creek. We recaptured 53 elvers at the Strawbridge Rd site and 108 at the foot bridge on Rte. 1003. Sampling in Pine Creek in 2014 provided 60 recaptured elvers, 25 of which were recaptured at the Darling Run site and 35 at the Ansonia Bridge site. The average TL of stocked elvers from Conowingo was 125 mm, and the average TL of glass eels stocked was 76 mm, while the average TL of recaptured eels in Buffalo Creek was 229 mm. The average TL of recaptured eels in Pine Creek was 266 mm.

Discussion

Surveys conducted by other agencies have documented 44 independent occurrences of eels that emigrated from the release locations (Figure 7). Biologists from the Pennsylvania Fish and Boat Commission (J. Buzzar, J. Detar, D. Kristine, K. Kuhn, G. Smith, personal communication), biologists from the Susquehanna River Basin Commission (A. Henning, M. Shank, personal communication), and biologists from the New York State Department of Environmental Conservation have all reported recapture events. The furthest documented migration from a stocking location was observed in Hornell, NY about 85 river miles from the release location approximately 12 months prior. Eels released above the four mainstem blockages should continue to disperse and colonize upstream habitat in the watershed. Additional sampling efforts will likely provide more information about their dispersal. Dispersal of eels in the watershed indicates that trap and transport is not disrupting their upstream migration.

Sampling upstream and downstream of the release site in Buffalo Creek has shown that some transplanted eels are growing faster than the eels that we have caught below the Conowingo dam. Yellow eels captured below the dam had an average growth rate of 43 mm per year with a standard deviation of 25 mm. The maximum growth in one year for a yellow eel captured below Conowingo dam was 129 mm per year and the minimum growth was 14 mm per year. Four eels

in Buffalo Creek were over 525 mm (assuming they were stocked in 2010 and averaged 125 mm TL at the time of stocking) suggesting an annual growth rate on average of 200 mm per year. Eels stocked in Conestoga Creek averaged 122 mm at release and were recaptured five years after their release and grew over 530 mm.

It is unknown when American eels sex is determined, and the factors associated with what controls sex determination are poorly understood. Some published literature suggests that density is a key factor in sex determination, where high densities favor males and low densities favor females (Roncarti et al., 1997; Zeng et al., 2002). However several documented stocking programs have manipulated the sex ratios of eel populations and have resulted in an increase in percentage of male eels (Tesch, 2003). Sampling in Buffalo Creek suggests that a majority of the eels in Buffalo Creek are becoming male. It is generally believed that male eels in the northeast do not reach lengths of over 400 mm (ASMFC 2001). Sampling in 2012 and 2013 indicates that the eel population above and below the release location do not appear to be getting larger than 400mm. Sampling in 2014 produced 30 eels from Buffalo Creek that we were able to identify sex organs. Of those 30 eels, 25 were males (83%). In 2012 sampling data indicate 96.6% of the eels recaptured were less than 400 mm. In 2013 one would have expected the length frequency to shift upward in size; instead 98.5% of the eels recaptured were still less than 400 mm. We believe that the eels stocked in Buffalo Creek are becoming males due to high densities from stocking.

Yellow eels with a length over 270mm should have developed sex organs that should be visible to the naked eye. Sampling in 2014 produced 30 eels from Buffalo Creek that we were able to identify sex organs, of those 30 eels, 25 were males (83%). We were able to identify sex organs in 17 eels from Pine Creek, only 5 of those eels were males (29%).

We attempted to evaluate the relationship between elver migrations in relation to environmental cues. The factors we considered were lunar fraction, river flow, barometric pressure, air temperature, daily precipitation levels, and the average daily values of dissolved oxygen, salinity, water temperature, pH, turbidity, and chlorophyll. In years past we have not been able to determine what environmental factors control the timing of the elver migration below Conowingo Dam. Typically elvers reach the dam between the first week of May through the end of June and peak captures usually occur in June and July. In 2011 using Pearson correlation it appeared that turbidity, river flow and precipitation have the largest correlation and these three variables are directly related to one another. However in 2012 we did not see a correlation between environmental factors and elver collection. In 2013 we evaluated river flow from several nights prior in our correlation analysis and it appears that flow 3 nights prior to elver collection and turbidity had the strongest positive correlation, there was also a negative correlation to a full moon. Similar to sampling in 2012, this year we did not see a correlation between environmental conditions or flow.

Future Plans

In 2015 we will release a majority of the elvers captured at Conowingo Dam into the Susquehanna River above the York Haven dam to allow them to continue their upstream

migration. The Maryland Fishery Resources Office will survey Buffalo Creek for PIT tagged eels in an attempt to continue growth analysis of stocked eels.

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.

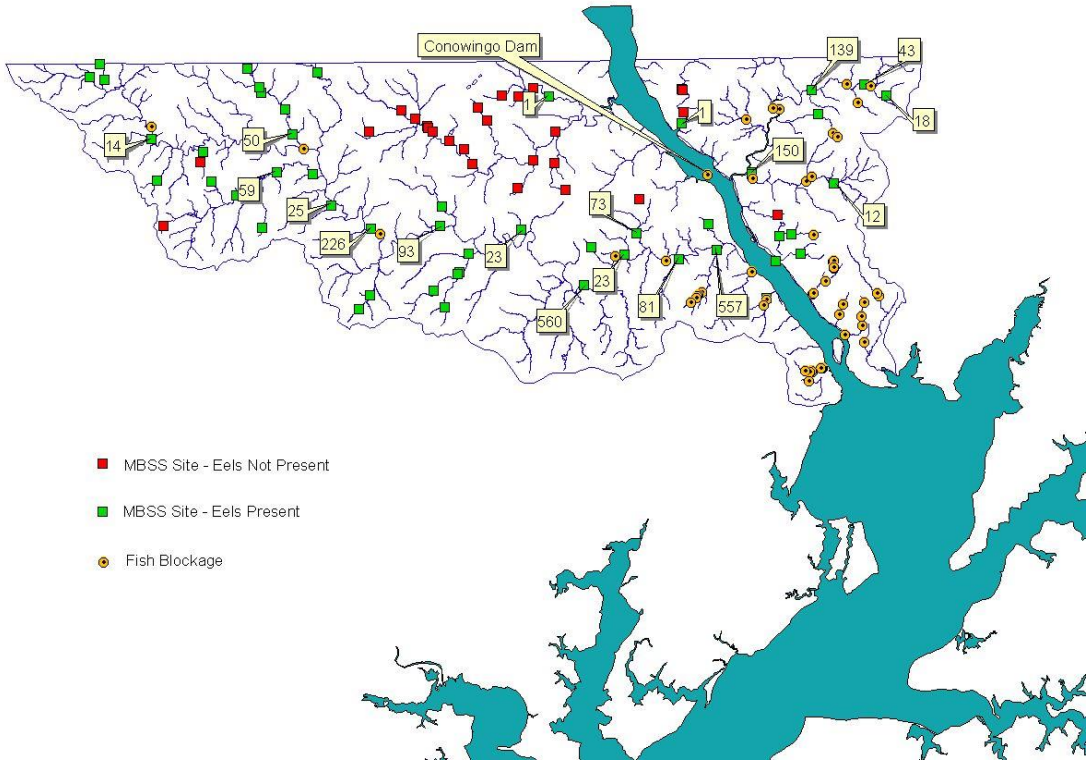

Figure 2. Eel trap constructed of industrial cable tray and landscape fabric.

Figure 3. The cable tray emptying into a collection tank. N = 43,784 eels

Figure 4. Weekly elver captures at Conowingo Dam, 2008 – 2014.

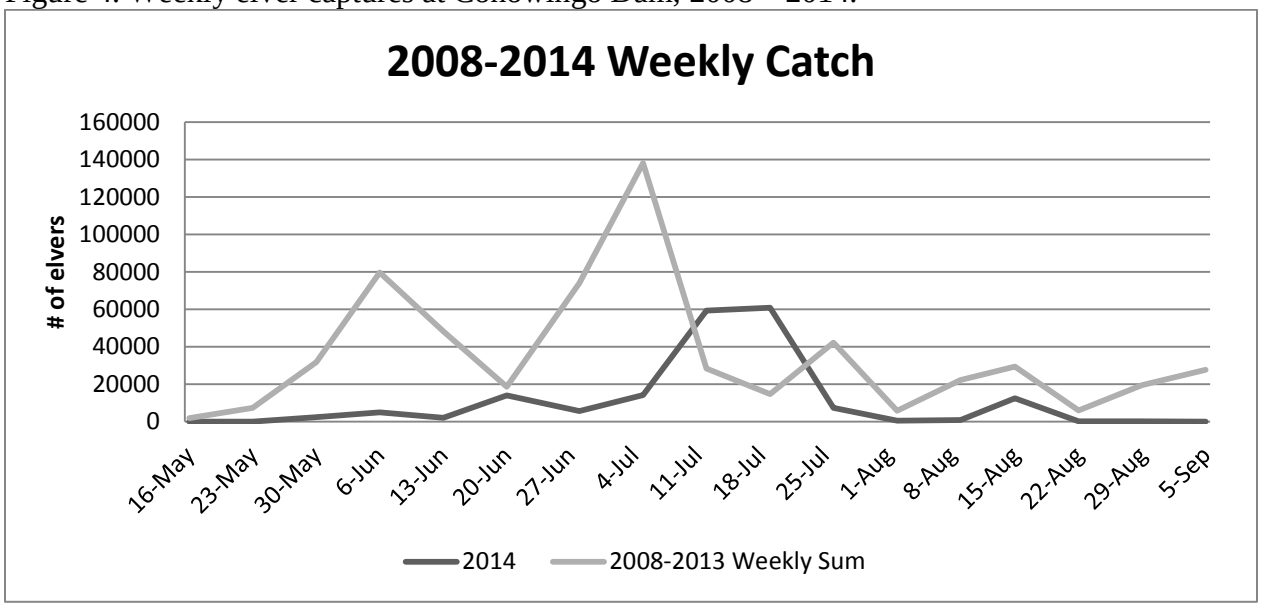

Figure 5. Elver capture in relation to lunar fraction in 2014 at Conowingo Dam.

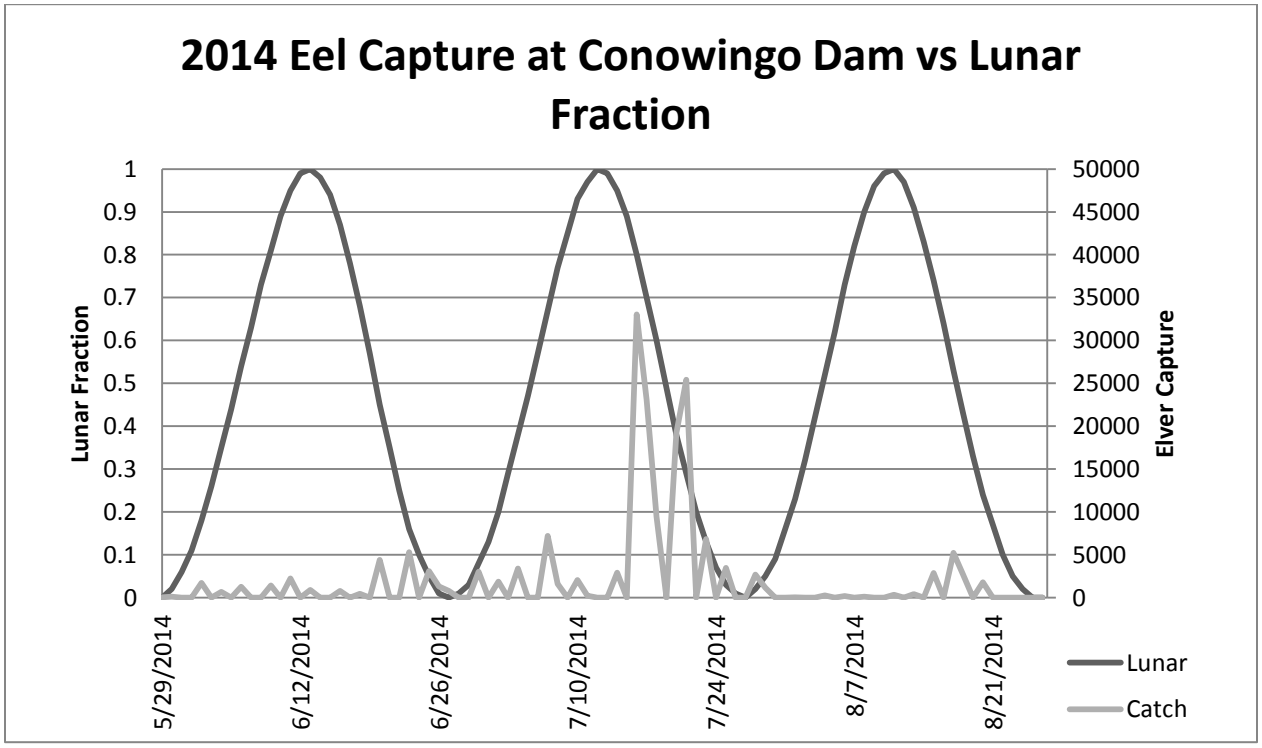

Figure 6. Length frequency of elvers captured below Conowingo Dam, 2005-2014.

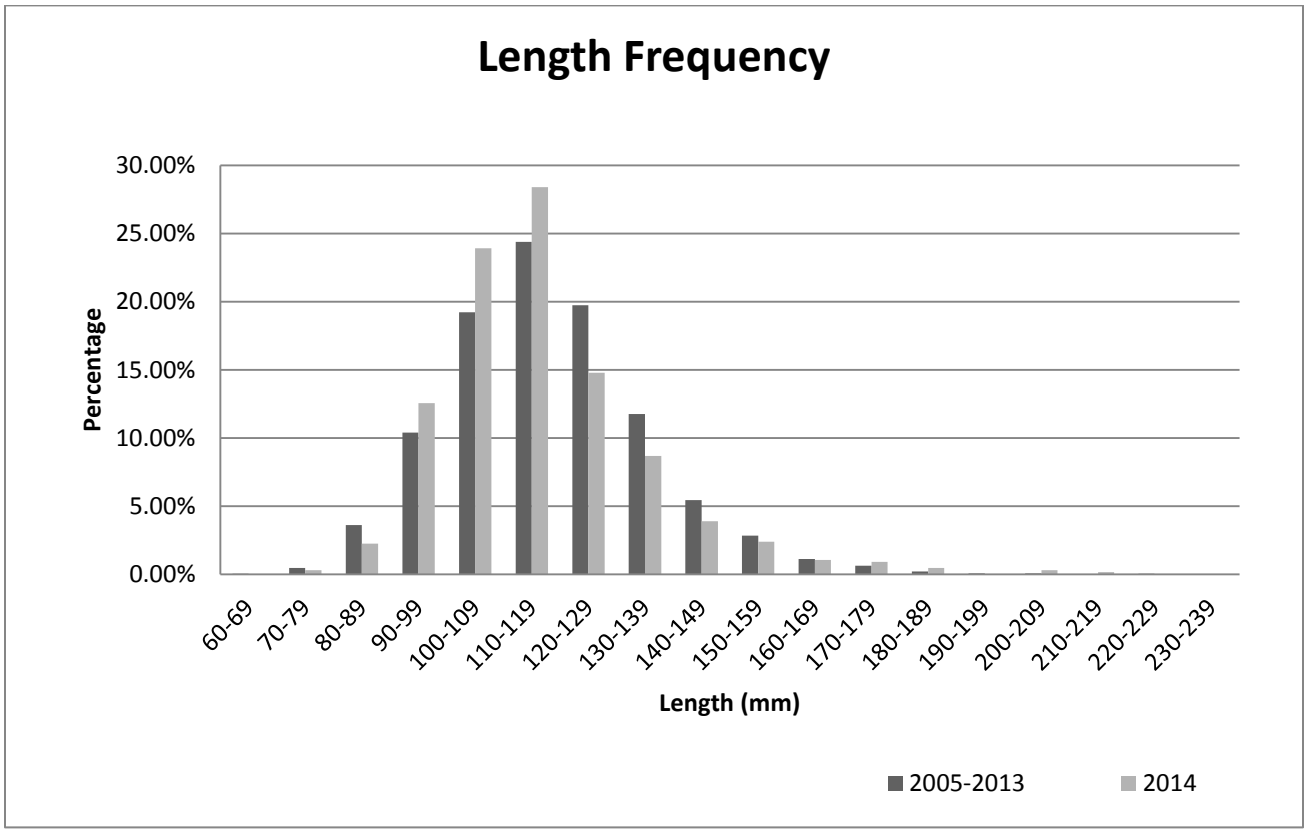

Figure 7. Elver stocking and eel recapture locations.

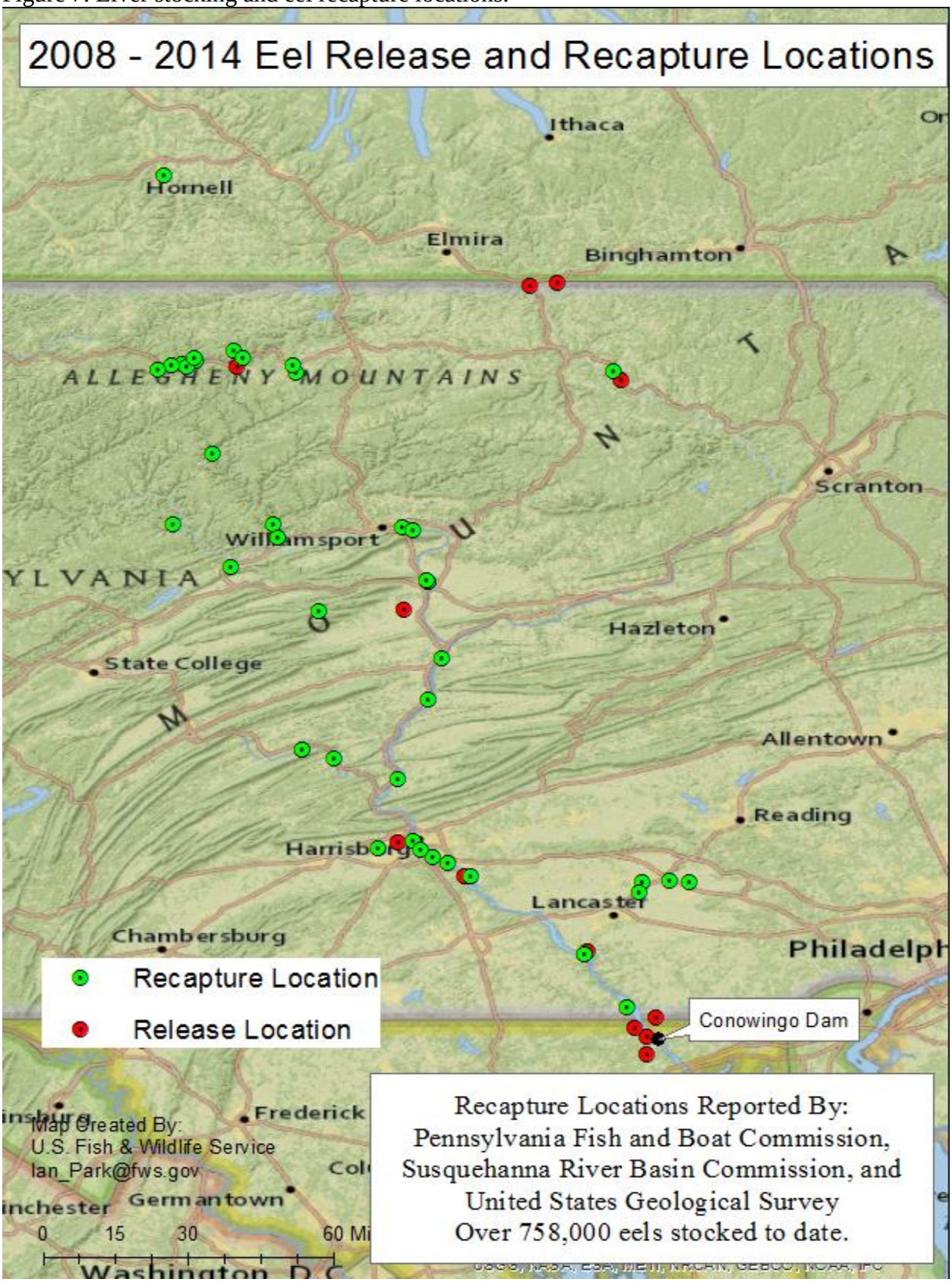

Table 1. Date, location, and number of elvers stocked in 2014

Date	# Stocked	Latitude	Longitude	Site
6/11/2014	1,343	39 25.321' N	76 42.615' W	North Branch Before Fork, Jones Falls MD
6/11/2014	108	39 23.687' N	76 40.114' W	Morres Run, Jones Falls MD
6/11/2014	461	39 23.684' N	76 38.827' W	Roland Run, Jones Falls MD
6/11/2014	1,319	39 22.010' N	76 39.680' W	Western Run, Jones Falls MD
6/18/2014	1,994	40 52 550' N	76 59 241' W	Penns Creek, PA
6/26/2014	17,806	40 09.900' N	76 44.850' W	Goldsboro Boat Ramp, Susquehanna River
7/10/2014	18,875	41 41.666' N	76 16.889' W	TerryTown Boat Ramp, Susquehanna River
7/16/2014	8,400	39 40.288' N	76 12.170' W	Glen Cove Marina, Conowingo Pool
7/17/2014	46,352	40 09.900' N	76 44.850' W	Goldsboro Boat Ramp, Susquehanna River
7/21/2014	52,196	40 09.900' N	76 44.850' W	Goldsboro Boat Ramp, Susquehanna River
7/29/2014	6,032	40 09.900' N	76 44.850' W	Goldsboro Boat Ramp, Susquehanna River
8/11/2014	792	39 40.288' N	76 12.170' W	Glen Cove Marina, Conowingo Pool
8/20/2014	12,098	40 09.900' N	76 44.850' W	Goldsboro Boat Ramp, Susquehanna River
8/28/2014	491	39 40.288' N	76 12.170' W	Glen Cove Marina, Conowingo Pool

Table 2. Number of elvers caught at the base of Conowingo Dam on the West side of the dam during 2014.

Date	Catch		Date	Catch		Date	Catch
5/29/2014	30		7/1/2014			8/3/2014	
5/30/2014	108		7/2/2014	1879		8/4/2014	270
5/31/2014			7/3/2014			8/5/2014	
6/1/2014			7/4/2014	3384		8/6/2014	201
6/2/2014	1721		7/5/2014			8/7/2014	
6/3/2014			7/6/2014			8/8/2014	128
6/4/2014	662		7/7/2014	7196		8/9/2014	
6/5/2014			7/8/2014	1616		8/10/2014	
6/6/2014	1277		7/9/2014			8/11/2014	337
6/7/2014			7/10/2014	2065		8/12/2014	
6/8/2014			7/11/2014	214		8/13/2014	399
6/9/2014	1437		7/12/2014			8/14/2014	
6/10/2014			7/13/2014			8/15/2014	2881
6/11/2014	2250		7/14/2014	2916		8/16/2014	
6/12/2014			7/15/2014			8/17/2014	5208
6/13/2014	904		7/16/2014	33036		8/18/2014	2689
6/14/2014			7/17/2014	23100		8/19/2014	
6/15/2014			7/18/2014	9430		8/20/2014	1786
6/16/2014	790		7/19/2014			8/21/2014	
6/17/2014			7/20/2014	19200		8/22/2014	107
6/18/2014	465		7/21/2014	25440		8/23/2014	
6/19/2014			7/22/2014			8/24/2014	
6/20/2014	4409		7/23/2014	6823		8/25/2014	196
6/21/2014			7/24/2014			8/26/2014	
6/22/2014			7/25/2014	3483		8/27/2014	
6/23/2014	5291		7/26/2014			8/28/2014	188
6/24/2014			7/27/2014			8/29/2014	
6/25/2014	3112		7/28/2014	2697		8/30/2014	
6/26/2014	1323		7/29/2014	1152		8/31/2014	
6/27/2014	782		7/30/2014			9/1/2014	
6/28/2014			7/31/2014			9/2/2014	
6/29/2014			8/1/2014	29		9/3/2014	
6/30/2014	3006		8/2/2014			9/4/2014	
						9/5/2014	11

Table 3. Growth of yellow eels caught and recaptured in pots at the base of Conowingo dam by year.

	Average Length (mm)								*Average Annual Growth Increase (mm)*
ID	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	
1	594	617	*	*	*	*	*	*	23.0
2	733	770	*	*	*	*	*	*	37.0
3	463	474	*	*	*	*	*	*	11.0
4	404	510	521	*	*	*	*	*	58.5
5	426	445	*	*	*	*	*	*	19.0
6	338	390	505	*	*	*	*	*	83.5
7	551	589	*	*	*	*	*	*	38.0
8	475	511	*	*	*	*	*	*	36.0
9	405	471	510	*	*	*	*	*	55.0
10	377	405	440	*	*	*	*	*	31.5
11	466	490	*	*	*	*	*	*	24.0
12	391	520	*	557	*	*	*	*	55.3
13	386	428	*	*	*	*	*	*	21.0
14	458	*	565	*	*	*	*	*	53.5
15	484	*	624	*	*	*	*	*	70.0
16	457	*	590	*	*	*	*	*	66.5
17	386	*	478	*	*	*	*	*	46.0
18	447	*	580	*	*	*	*	*	66.5
19	*	419	433	*	*	*	*	*	14.0
20	*	364	383	395	449	*	*	*	28.3
21	*	393	516	*	*	*	*	*	123.0
22	*	479	543	*	*	*	*	*	64.0
23	*	497	575	*	*	*	*	*	78.0
24	*	454	*	550	*	*	*	*	48.0
25	*	*	612	626	*	*	*	*	14.0
26	*	*	495	578	*	*	*	*	83.0
27	*	*	432	462	470	*	*	*	19.0
28	*	335	*	*	446	*	*	*	37.0
29	*	321	*	*	377	*	*	*	18.6
30	*	*	476	*	508	*	*	*	16.0
31	*	*	368	*	465	*	*	*	48.5
32	*	*	*	*	446	482	*	*	36.0
33	*	*	*	*	390	422	*	*	32.0
34	*	*	405	*	*	465	*	*	20.0
35	*	*	*	*	418	458	*	*	40.0
36	*	*	*	*	464	513	*	*	49.0
37	*	*	*	*	*	388	410	*	17.5
38	*	*	*	*	*	422	468	*	46.0
39	*	*	*	*	*	*	412	465	53.0
40	*	*	*	*	*	*	436	476	40.0
41	*	*	*	*	*	*	400	453	53.0
42	*	*	*	*	390	*	*	446	18.6

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