American Eel sampling at Conowingo Dam

2013

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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 2013 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 2013 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. 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 experimental stocking of elvers into several tributaries to the Susquehanna River as well as the Susquehanna River mainstem (Table 1). Stockings in Buffalo Creek and Pine Creek are part of compensatory mitigation for the Sunbury Riverfront Stabilization Project for the City of Sunbury (DA Permit Application Number: NAB 2005-02860-PO5).

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

In 2013, 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 had a passive integrated transponder (PIT) tag inserted in the dorsal musculature before being released.

Results

The upstream collection device was operated continuously between 28 May and 26 August 2013 and elvers were collected throughout the entire sampling period (Table 2). A total of 293,141 elvers were collected during 2013 with the majority collected in four peak migration events. The first peak occurred at the beginning of June followed by another peak in the first week of July and two smaller peaks at the end of the sampling period. The seasonal pattern of migration in 2013 was similar to that observed in previous years with a majority of the eels collected from mid-June through mid-August. In 2008, 2010, 2011 and 2012 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 2013 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 63 to 207 mm TL (Figure 6), with an average length of 113 mm, which is 10 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 2013. In 2013, we captured 29 yellow and silver eels that ranged from 365 to 480 mm TL. Of the 29 captures,

25 eels had new PIT tags inserted, 4 were recaptures from tagging done in 2012 or in previous years. In 2013 we had fewer captures and recaptures compared to 2012 (187 captures and 22 recaptures, Table 3). The addition of the 25 PIT-tagged eels this year brings the total number of PIT-tagged yellow eels in the study to 384. We have recorded annual growth rates of the 36 PIT tagged eels that have been recaptured after at least one year after tagging (Table 4). These eels have an average growth of 44 mm a year with a maximum of 123 mm and a minimum of 11 mm.

Sixteen stockings events of elvers captured at Conowingo Dam were completed, with an estimated total of 275,000 elvers being stocked in Susquehanna Watershed (Table 1).

To evaluate stocking success at Buffalo Creek, we conducted electrofishing surveys using two backpack shockers and sampled the creek 2.4 kilometers upstream and 2 kilometers downstream from the stocking locations in 2012 and again in 2013. In 2013 we collected a total of 282 eels, an increase from 210 in 2012. This year both locations also had an increase in CPUE of roughly 10 eels per hour, the upstream CPUE was 38.2 eels per hour, and the downstream CPUE was 26.7 eels per hour. The recaptured eels were sedated with MS-222 and measured, total length ranged from 138 mm to 551 mm (Figure 7). We inserted 168 PIT tags into the dorsal musculature of eels that were over 200 mm TL. In 2013, 11 eels were recaptured that were tagged in 2012. The eels had an average growth of 60 mm a year with a maximum of 110 mm and a minimum of 33 mm.

Discussion

Surveys conducted by other agencies have recaptured eels that emigrated from the release locations (Figure 8). Biologists from the Pennsylvania Fish and Boat Commission collected two eels in Rapid Run (a tributary to Buffalo Creek). These eels were approximately 19 kilometers upstream from the release locations. Pennsylvania biologists also collected four eels in the Conestoga watershed that were approximately 70 kilometers upstream of a release site. Pennsylvania biologists also recaptured 3 elvers in the Susquehanna River upstream of our release location at the Goldsboro boat ramp in Etters, PA (J. Buzzar, J. Detar, D. Kristine, K. Kuhn, G. Smith, personal communication). Biologists from the Susquehanna River Basin Commission have found several eels upriver and downriver from our release locations in Pine Creek. The most upriver eel found was approximately 19 kilometers from the release site, and the most downriver location was about 82 kilometers downstream (A. Henning, M. Shank, personal communication). 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 44 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. 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.

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 (Table 5).

Future Plans

In 2014 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. A portion of the collected eels will also be released above the inflatable dam at Sunbury and the Terrytown boat ramp. A smaller quantity of elvers will also be released into a smaller tributary to further evaluate the effects of stocking densities on sex ratios in future years. The Maryland Fishery Resources Office will survey Buffalo Creek for PIT tagged eels in an attempt to continue growth analysis of stocked eels. We will also survey Buffalo and Pine Creek as part of our mitigation project (Sunbury, Riverbank Stabilization Project DA Permit Application Number: NAB2005-02860-POS) on the impacts of reintroducing eel on fish and mussel populations.

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.

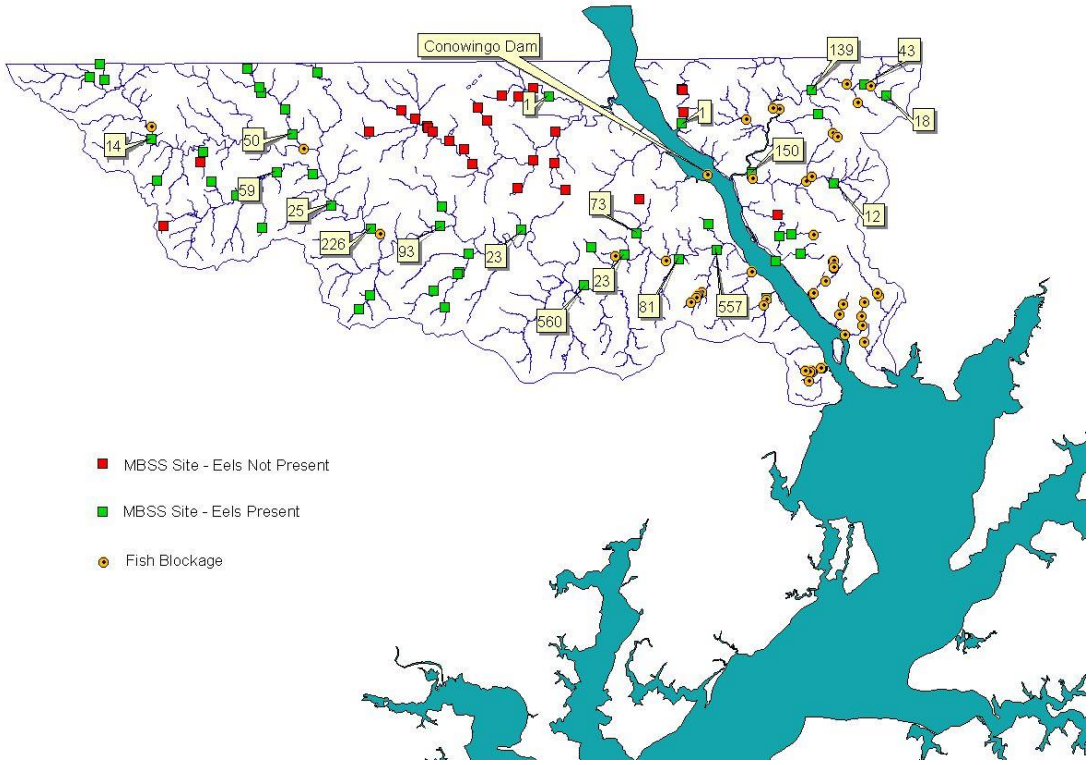

Figure 2. Eel trap constructed of industrial cable tray and landscape fabric.

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

Figure 4. Weekly elver captures at Conowingo Dam, 2008 – 2012.

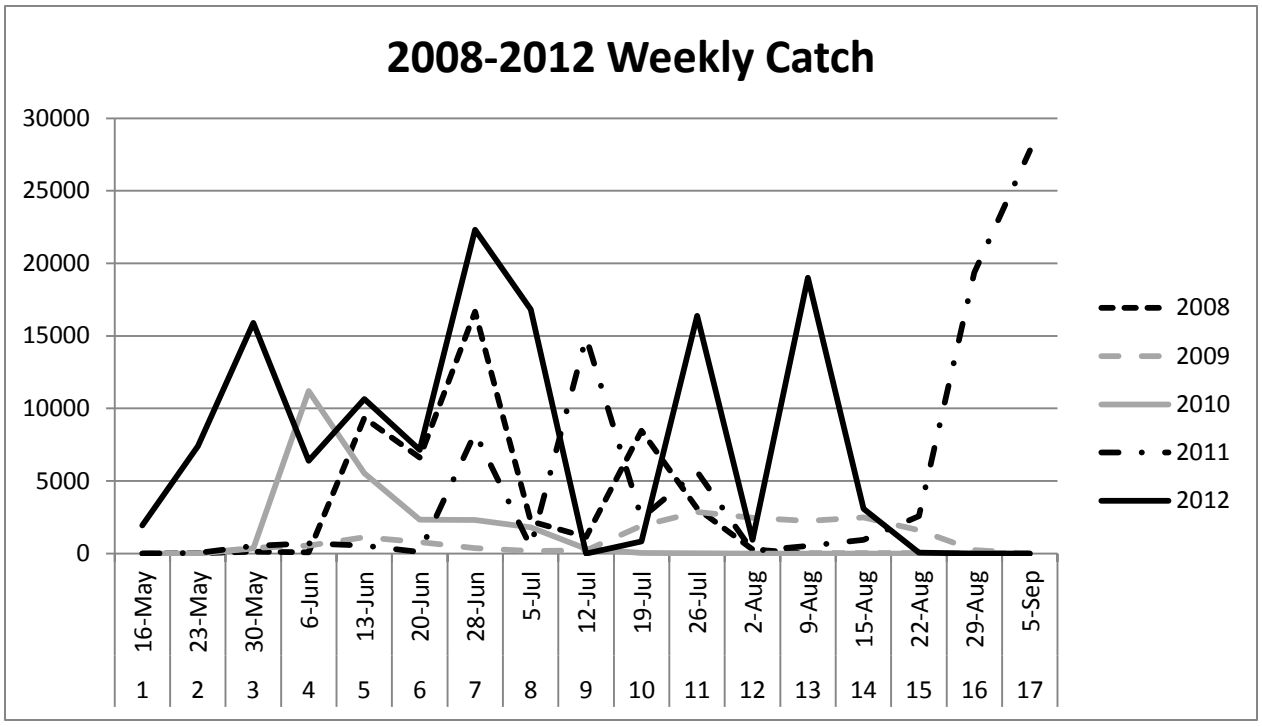

Figure 5. Elver capture in relation to lunar fraction in 2013 at Conowingo Dam.

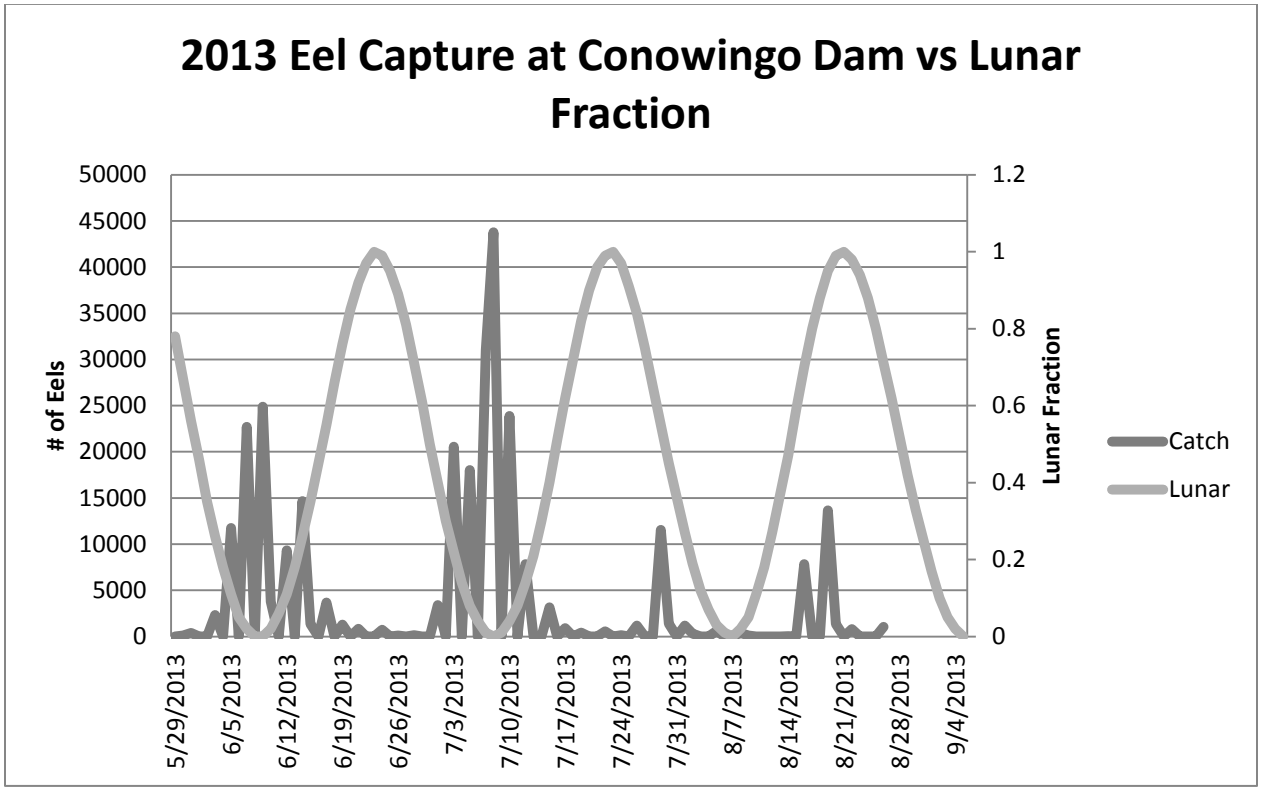

Figure 6. Length frequency of elvers captured below Conowingo Dam, 2005-2013.

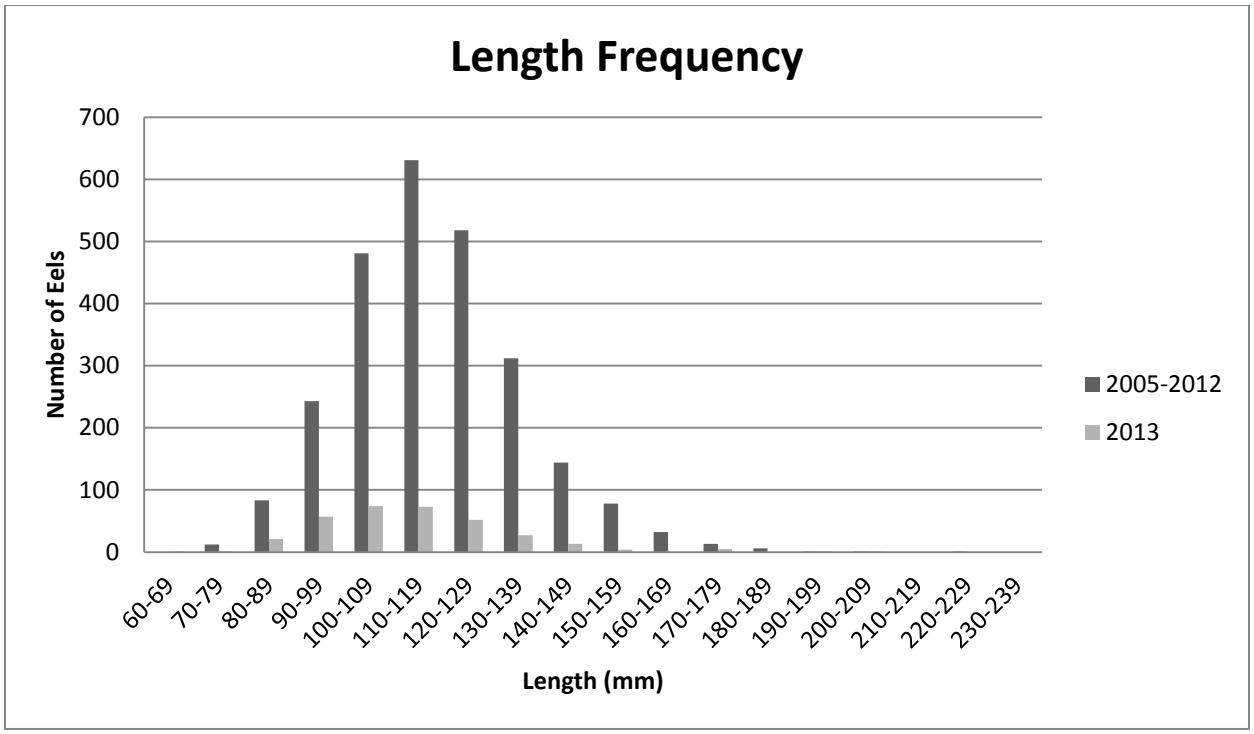

Figure 7. Length frequency of yellow eels captured in Buffalo Creek. 2012-2013.

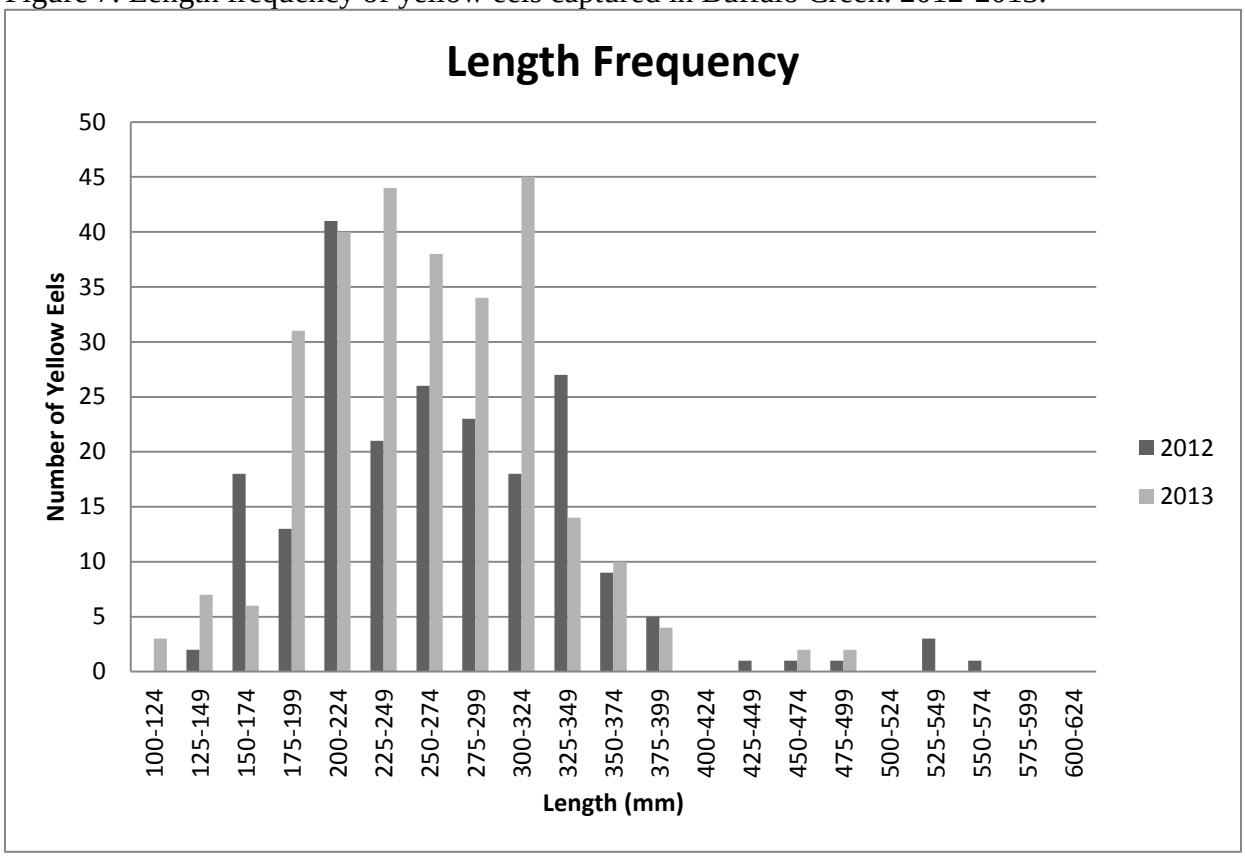

Figure 8. Elver stocking and eel recapture locations.

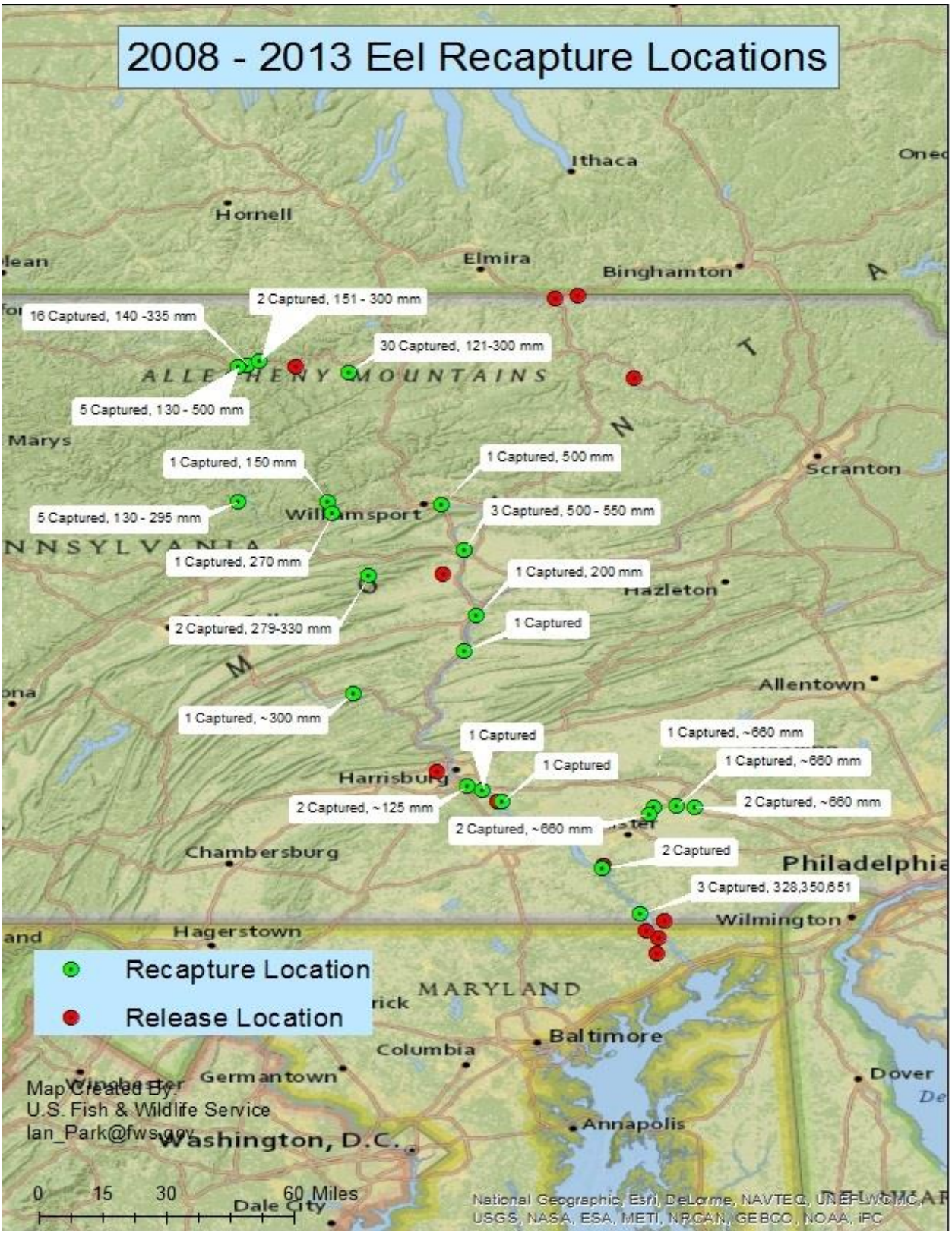

Table 1. Date, location, and number of elvers stocked in 2013

Date	# Stocked	Latitude	Longitude	Site
6/7/2013	6000	39 40.288' N	76 12.170' W	Glen Cove Marina, Conowingo Pool
6/7/2013	11159	40 09.900' N	76 44.850' W	Etters Boat Ramp, Susquehanna River
6/9/2013	15600	39 43.852' N	76 10.701' W	Conowingo Creek
6/10/2013	4090	41 41.666' N	76 16.889' W	Terrytown Boat Ramp, Susquehanna River
6/10/2013	9763	41 59.132' N	76 33.200' W	Tozers Landing Boat Ramp, Chemung River
6/10/2013	9763	41 59.756' N	46 28.406' W	Sayre Boat Launch Riverside Road, Susquehanna River
6/14/2013	23027	40 09.900' N	76 44.850' W	Etters Boat Ramp, Susquehanna River
6/26/2013	7908	40 59.139' N	76. 55.930'W	Strawbridge Rd, Buffalo Creek
7/5/2013	41997	40 16.251'N	76. 57.096'W	Acri Meadow Rd Boat Ramp, Conodoguinet Creek
7/7/2013	4770	39 40.288' N	76 12.170' W	Glen Cove Marina, Conowingo Pool
7/8/2013	70019	40 09.900' N	76 44.850' W	Etters Boat Ramp, Susquehanna River
7/12/2013	30781	40 09.900' N	76 44.850' W	Etters Boat Ramp, Susquehanna River
7/19/2013	2461	39 40.288' N	76 12.170' W	Glen Cove Marina, Conowingo Pool
8/1/2013	14250	40 09.900' N	76 44.850' W	Etters Boat Ramp, Susquehanna River
8/8/2013	1185	39 40.288' N	76 12.170' W	Glen Cove Marina, Conowingo Pool
8/22/2013	22706	40 58.239' N	76 55.239' W	US Penitentiary Lewisburg, Buffalo Creek

Table 2. Number of elvers caught at the base of Conowingo Dam on the West side of the dam during 2013.

Date	Catch		Date	Catch		Date	Catch
5/29/2013	6		6/28/2013	136		7/28/2013	
5/30/2013	104		6/29/2013			7/29/2013	11560
5/31/2013	380		6/30/2013			7/30/2013	1400
6/1/2013			7/1/2013	3412		7/31/2013	
6/2/2013			7/2/2013			8/1/2013	1174
6/3/2013	2329		7/3/2013	20567		8/2/2013	318
6/4/2013			7/4/2013			8/3/2013	
6/5/2013	11751		7/5/2013	18032		8/4/2013	
6/6/2013			7/6/2013			8/5/2013	581
6/7/2013	22703		7/7/2013	31005		8/6/2013	
6/8/2013			7/8/2013	43784		8/7/2013	
6/9/2013	24885		7/9/2013			8/8/2013	379
6/10/2013	3769		7/10/2013	23865		8/9/2013	107
6/11/2013			7/11/2013			8/10/2013	
6/12/2013	9323		7/12/2013	7826		8/11/2013	
6/13/2013			7/13/2013			8/12/2013	
6/14/2013	14664		7/14/2013			8/13/2013	
6/15/2013	1346		7/15/2013	3168		8/14/2013	23
6/16/2013			7/16/2013			8/15/2013	
6/17/2013	3691		7/17/2013	900		8/16/2013	7832
6/18/2013			7/18/2013			8/17/2013	
6/19/2013	1282		7/19/2013	418		8/18/2013	
6/20/2013			7/20/2013			8/19/2013	13651
6/21/2013	846		7/21/2013			8/20/2013	1351
6/22/2013			7/22/2013	563		8/21/2013	
6/23/2013			7/23/2013			8/22/2013	816
6/24/2013	732		7/24/2013	126		8/23/2013	
6/25/2013			7/25/2013			8/24/2013	
6/26/2013	94		7/26/2013	1198		8/25/2013	
6/27/2013			7/27/2013			8/26/2013	1044

Table 3. Number of Passive Integrated Transponder Tags (PIT) applied to yellow eels below Conowingo Dam by year.

Year	# of Tags Applied
2007	51
2008	32
2009	68
2010	11
2011	127
2012	66
2013	25

Table 4. Growth of yellow eels caught and recaptured in pots at the base of Conowingo dam by year.

Eel ID	*Average Length (mm)*							*Average Annual Growth Increase (mm)*
	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	
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	*	30.0
35	*	*	*	*	418	458	*	40.0
36	*	*	*	*	464	513	*	49.0
37	*	*	*	*	*	388	410	17.5
38	*	*	*	*	*	422	468	46.0

Table 5. Results of Pearsons Correlation

	Eel Catch
2013	
Eel Catch	1
Precip (in)Sum	-0.00883
Pressure	0.051171
Flow	0.307866
Flow Evening Before	0.333282
Flow 2 Night Prior	0.342245
Flow 3 Night Prior	0.547927
Flow 4 Night Prior	0.454541
Flow 5 Night Prior	0.49853
Average of DO (conc.)	-0.14803
Average of Salinity (ppt)	-0.27877
Average of Temp (°C)	-0.05635
Average of pH	-0.32268
Average of Turbidity (NTU)	0.452648
Average of Chlorophyll a (µg/l)	-0.1393
SPCOND	-0.27151
Lunar	-0.35108

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