American Eel: Collection and Relocation
Conowingo Dam, Susquehanna River, Maryland
2016

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BACKGROUND

The American Eel (*Anguilla rostrata*) is the only species of freshwater eel in North America and originates from the Sargasso Sea in the North Atlantic Ocean (USFWS 2011). The eels are catadromous, hatching in saltwater and maturing in freshwater before returning to their natal waters to spawn. Larval eels (referred to as leptocephalus larvae) are transported throughout the eastern seaboard via ocean currents where their range extends from Brazil to Greenland. By the time the year-long journey to the coast is over, they have matured into the "glass eel" phase and have developed fins and taken on the overall shape of the adults (Hedgepath 1983). After swimming upstream into continental waters, the 5-8 cm glass eels mature into "elvers" at which time they take on a green-brown to gray pigmentation and grow beyond 10 cm in length (Haro and Krueger 1988). Elvers migrate upstream into estuarine and riverine environments where they will remain as they change into sexually immature "yellow eels". Yellow eels have a yellow-green to olive coloration and will typically remain in this stage for three to 20 years before reaching the final stage of maturity. The eels may begin reaching sexual maturity when they reach at least 25 cm in length and are called "silver eels". Silver eels become darker on the dorsal side and silvery or white on the ventral side and continue to grow as they complete their sexual maturation. By the time they are ready to return to their spawning grounds, males can reach 40 cm and females 150 cm in length. A variety of factors may contribute to the sexual determination of the eels, including growth rate, water salinity, and population density (Krueger and Oliviera 1999).

The American Eel population has been steadily declining throughout its range according to evidence reported from various resource agencies (Beak 2001). Prior to the decline, eels comprised more than 25 percent of the total fish biomass in streams of the Mid-Atlantic region (Smith and Saunders 1955; Ogden 1970). Factors that may have contributed to the decline include: overharvest of each life stage, poor water quality, habitat loss/fragmentation from blockages preventing upstream migration, and turbine mortality in hydroelectric power stations during downstream migration (ASMFC 2000).

Access to upstream habitat has been drastically reduced to historic habitat reaches due to dams and other barriers. This has resulted in fragmented habitat and disjointed migration corridors (ASMFC 2012). Eels are capable of passing over or through some dams and obstructions during up or downstream migration. However, mortality occurring as they pass through hydroelectric plant turbines during downstream migration has contributed to the decline as well (Hadderingh 1990).

The Atlantic States Marine Fisheries Commission Fishery Management Plan for American Eel lists protecting access to freshwater habitat as a priority for sustaining American Eel populations. The Chesapeake Bay and its tributaries (Figure 1) support a large portion of the coastal eel population. The Susquehanna River basin comprises 43% of the Chesapeake Bay watershed (Figure 2; Minkkinen and Park 2008); however four dams constructed in the early 1900s on the mainstem Susquehanna River have blocked upstream eel migration (Figure 3). These dams on the lower Susquehanna River are: York Haven Dam at river mile 65, Safe Harbor Dam at river mile 33, Holtwood Dam (originally named McCall's Ferry Dam) at river mile 25, and Conowingo Dam at river mile 10.

Annual harvest of American eels was notably higher prior to the installation of the dams on the Susquehanna River (ASMFC 2000). The fishery is now closed in Pennsylvania and only limited entry for commercial licenses is available in Maryland (ASMFC 2000). The Maryland Biological Stream Survey (MBSS) of the Maryland Department of Natural Resources (MDNR) surveys and collects data in freshwater drainages throughout the state. Using eel capture data from this project below Conowingo Dam (Figure 4), MBSS extrapolated densities of eels throughout the watershed in the absence of blockages to upstream migration. Without the upstream blockages, there would be over 11 million eels in the Susquehanna watershed (Minkkinen and Park 2007).

Fish passage facilities on the mainstem Susquehanna River were engineered to pass migratory fish species (Normandeau 2011). Lifts and/or ladders enable species such as American Shad (*Alosa sapidissima*), Hickory Shad (*Alosa mediocris*), Blueback Herring (*Alosa aestivalis*), Alewife (*Alosa pseudoharengus*), Striped Bass (*Morone saxatilis*), and White Perch (*Morone americana*) to pass over the dams. However, these structures have not proven effective at passing juvenile American Eels upriver (Sheldon 1974).

Upstream passage for the American Eel may be beneficial to the recruitment of the native freshwater mussel *Elliptio complanata* (Eastern Elliptio). Mussel larvae called glochidia are parasitic and must attach to the gills of a host species before metamorphosing into the subsequent juvenile life stage. Eastern Elliptio may rely on eels as their primary host species (Lellis 2013). While Eastern Elliptio is abundant throughout its range, lack of passage for eels may be linked to reduced recruitment of juveniles of this species in the Susquehanna River. Increasing or improving passage for eels could increase recruitment of Eastern Elliptio which could lead to improvements in water quality and ecosystem function (Vaughn et al. 2008). Since 2010, The US Fish and Wildlife Service (USFWS) and the US Geological Survey (USGS) have been monitoring the recruitment of Eastern Elliptio juveniles following the experimental stocking of eels in two tributaries upstream of the mainstem dams in the Susquehanna River watershed.

This report describes the work completed by the US FWS in 2016 to pass American Eel elvers past Conowingo Dam. Work was completed in conjunction with Exelon Corporation and Normandeau Associates, Inc.

METHODS: Surveys, Sampling, and Equipment

American Eel abundance, migration timing, and attraction parameter data have been collected at the base of Conowingo Dam since spring of 2005. The purpose of this work is to reintroduce eels into the Susquehanna River basin above the dam. The resulting information gathered in this ongoing study assists Susquehanna watershed restoration efforts. Reports from each year may be obtained through the USFWS.

The 2016 American Eel collection site was located on the western shore of the Susquehanna River immediately below Conowingo Dam and adjacent to the west fish lift device (Figure 5). The location was determined based on exploratory studies in the vicinity of the dam from 2005-2007. Elvers were observed attempting to climb the rip-rap and concrete wall below the west fish lift where they were attracted to overflowing water from a holding tank. In 2008 an eighteen foot eel ladder was placed near the west fish lift and has been set up each year in this manner through 2016. The ladder was constructed using an enclosed industrial cable tray lined with landscape cloth (Enka Mat 7220) and positioned on the rip-rap where the elvers were observed (Figure 6). Water flowed from a spray bar at the top of the ladder, down through the landscape cloth and over the rip-rap to the river. Elvers were able to detect the flowing water and follow it from the river up to the top of the ladder. At the top of the ladder eels dropped into a collection tank (Figure 7).

Collection days occurred an average of three times per week from May 13, 2016 to September 14, 2016. Elvers were removed from the collection tank, enumerated, and then transferred to large, circular holding tanks equipped with air stones and fresh water circulation (environmental data for the holding and collection tanks is in Appendix A). If there was less than 200 mL of elvers in the collection tank, all elvers were sedated and counted. If there was more than 200 mL of elvers in the collection tank, then 200 mL were sedated and individually counted, while the remaining elvers were enumerated volumetrically in liters. From the 200 mL subsample of sedated elvers, 25 individuals were randomly selected and measured for total length. If there were less than 25 elvers in the collection tank on that day all elvers were measured. In past years, the USFWS was responsible for transporting and stocking eels above dams. Normandeau Inc. was responsible for transport and stocking efforts for the 2016 collection season. Effort to recapture PIT tagged yellow eels was discontinued for the 2016 season.

The use of the sedative Aqui-S20E continued through the 2016 collection season. Aqui-S20E is effective at low concentrations, has a wide margin of safety, and exhibits quick recovery times (Aquatactics 2015). This drug was obtained by applying for inclusion in the USFWS's Investigational New Animal Drug (INAD #: 11-741-16-149F) Program which is designed to collect the scientific data necessary to establish the safety and effectiveness of this sedative. In field use, fish treated with Aqui-S20E may be returned immediately to the water with no hold-over time or withdrawal period (Bowker et al. 2014).

Elver collection data were compared to environmental variables to determine if any associations were present. Lunar fraction, dissolved oxygen, river water temperature, and river discharge were all examined. Discharge data were obtained from the USGS stream gauge Conowingo location, and river water temperature was obtained from the National Oceanic and Atmospheric Administration's (NOAA) Chesapeake Bay Interpretive Buoy System (CBIBS) Susquehanna buoy at Havre De Grace, MD. Dissolved oxygen data was taken from the collection tank because the water was pumped from the river in close proximity to where the juvenile eels were staging for their upstream migration. The USGS stream gauge at the mouth of the Susquehanna no longer provides water temperature or dissolved oxygen data. Elver catch was transformed into Log_{10} values and compared to the percentage of average discharge (through September) occurring during the collection period using Pearson's correlation coefficient.

Normandeau Associates, Inc. operated a smaller eel ladder immediately downstream of a low head dam in Octoraro Creek at Octoraro Lake Dam (Figure 8). Octoraro Creek is located 1.6 km downstream of Conowingo Dam and the ladder was located 33.7 km upstream of its confluence with the Susquehanna River. Normandeau recorded daily catch, water temperature, dissolved oxygen, and subsampled elvers for total lengths. Eels collected from Octoraro Creek were transported to our holding tanks at the dam and held up to a week before stocking. Eels were then transported to Octoraro Lake, Conewago Creek, and Muddy Creek in Pennsylvania (Appendix B). Contact Normandeau Associates, Inc. for specific information regarding the Octoraro Creek collection effort.

RESULTS

The Conowingo eel ladder was installed on May 9, 2016. Attractant flow started on May 11, 2016, and the collection period started on May 13, 2016 and continued through September 14 2016. In previous years, elvers could be observed within the rip-rap and on the concrete embankments attempting to follow the overflow from the fish lift holding tanks prior to installation. No elvers were observed prior to the start of the collection period, and eels were not collected until May 25, 2016. Total eel catch for the 2016 collection period was 2,684. Previous years frequently required volumetric measurement of eel catch to determine daily totals; however, due to the relatively low catch this year volumetric measurement was only used once (Table 1). Weekly totals greater than 200 eels occurred in five out of 19 collection weeks and 82% of the yearly total was captured from June 24, 2016 to July 22, 2016. Mortality was 2% of the total catch for the 2016 season with no mortality being attributed to the use of Aqui-S20E.

Discharge in the Susquehanna River was lower in 2016 than any other year since the current eel ladder was installed in 2008 (Table 2). Discharge fell below 15,000 ft^3/sec after June 15, 2016 with flows exceeding that mark only twice for the remainder of the season. On July 7, 2016, the mean daily discharge reached 17,300 ft^3/sec and was followed on July 11th by the largest daily total recorded for the season: 786 eels, or 29% of the season total (Figure 9). River discharge rose to 20,200 ft^3/sec on August 11, 2016 and was followed on August 12th with a daily total of 42 eels. August 12th is the only day after July 20, 2016 that more than 20 eels were collected for the remainder of the season. Historically, annual eel catch is greater in years when the mean discharge rates are above 20,000 ft^3/sec during the collection period (Figure 10). This could account for the increased daily catch following the spikes in discharge on July 7th and August 11th in 2016. Comparison of the 2016 elver catch to the percent discharge occurring during the collection period showed a positive correlation (Pearson's $r = 0.496$).

Mid-points of lunar fraction have been associated with peaks in eel catch in previous years but there does not appear to be an association in this year's data (Figure 11). The largest daily total of 786 elvers on July 11th coincides with the midpoint of the associated date's rising lunar fraction of 0.42. The August 12th catch of 42 eels is also associated with a rising lunar fraction of 0.64. However, the remaining peaks in daily elver catch do not appear to follow this pattern.

River water temperatures began to increase rapidly after installation of the eel ladder, rising from 16.5 ºC on May 13, 2016 to 24.9 ºC on June 10th (Figure 12). Temperatures increased at a lower rate after this point, stabilizing in early July. Water temperatures then remained above 29 ºC for 24 consecutive days and did not drop below 27 ºC before the end of the collection period. Compared to 2015, there was more than twice the number of collection days when river temperatures were above 29 ºC.

Dissolved Oxygen (DO) levels in the collection tank began at 8.7 mg/L on May 13, 2016 and dropped gradually until the midpoint of the collection period (Figure 13). DO levels stabilized after June 24, 2016 and averaged 5.9 mg/L until the last day of collection. DO in the tank was likely very close to levels in the river due to the increased flow of river water being pumped into the collection tank directly from the river below. Flow rates were doubled this year from around 30 cfs to 60 cfs. While the largest single daily catch of eels occurred shortly after dissolved oxygen levels stabilized, there are no other associations this year between weekly catch rates and dissolved oxygen levels. In prior years, DO was not monitored as closely as in 2016, so comparisons cannot be made.

The number of elvers collected per week in 2016 was compared to the 2008-2015 average weekly catch (Figure 14). Weekly totals for the 2016 season were the lowest since the current model of the eel ladder was introduced in 2008 with 2,684 elvers collected. The majority of elvers were caught later this year than in previous years, with the first pulse of elvers occurring two weeks later than initial captures in 2008-2015. The largest peak in 2016 occurred one week later than the midsummer peak in the 2008-2015 weekly average data. Weekly catch decreased significantly in late July, mirroring the trend from previous years. The relatively large late-season pulse in the 2008-2015 data may be linked to a hurricane and tropical storm that occurred toward the end of the collection period in 2011 as catch has been observed to increase following storm events (Minkkinen and Park 2013).

This year, 636 elvers (24% of the total catch) were measured for total length (Figure 15). Lengths ranged from 82 to 186 mm with an average of 118 mm, nearly identical to the annual average length since 2008 of 120 mm. In 2016, there was a higher proportion of eels within one standard deviation (SD = ±13 mm) from the mean than in 2015 with 77% of elvers between 105 and 131 mm in length compared to 63%. However, the distribution of total lengths resembles previous years' data above one standard deviation.

DISCUSSION

The total catch for the 2016 season was considerably lower than previous seasons in which the current eel ladder design has been in use (Table 3). The total catch of 2,684 elvers is just 15% of the next lowest year's total of 17,437 elvers in 2009. Elvers were observed climbing the wall below the lower platform as they attempted to follow the overflow from the American Shad holding tank during installation each year prior to the 2016 season. This year no elvers were observed on the wall, and elvers were not collected until May 25, 2016, 14 days after attractant flow was started on the ladder. While the presence of eels has not necessarily guaranteed immediate collection of the eels in past seasons, it was at least obvious that there were eels staging below the dam as they attempted to continue their migration. This year there was no indication that the eels were staging when the eel ladder was installed.

The total yearly catch of elvers collected at Conowingo Dam has ranged from 2,684 to 293,141 eels over an eight year period (Table 3). Average annual catch prior to 2016 was 104,067 eels. The annual average including 2016 is 92,802 eels. Eel catch rose from 2009 to 2013, and has decreased each subsequent year. Given the relatively short timeframe of eel collection, it is not possible to determine whether this is the result of environmental factors or long term trends in the eel population. The annual Maryland DNR glass eel index had been predictive of an increase in collection totals of elvers at Conowingo following an increase in glass eel abundance from 2008 to 2014, but the trend has not continued for the past two seasons (Figure 16).

Lunar fraction, river temperature, and dissolved oxygen showed either a weak potential association or no association at all when compared to daily totals for the season. Daily totals showed two pulses in eel catch that coincided with the midpoint of lunar fraction over the course of the season. However, the total number of eels for each pulse was still extremely small compared to catches from previous seasons. Remaining pulses in daily total catch did not appear to follow the pattern. Additionally, there did not appear to be a strong correlation between dissolved oxygen or river temperature despite 2016 exhibiting a greater number of collection days above 29 ºC than the previous season. The majority of eels were collected before the temperature stabilized for the season as seen in previous years (Figure 12). Dissolved oxygen levels were relatively stable while the majority of eels were captured (Figure 13).

Low discharge was a suspected factor in the reduced catch for the 2016 season. Total catch has historically been lower when the average discharge during the collection period is below 20,000 cfs. The positive correlation (Pearson's $r = 0.496$) between elver catch and average discharge from 2008 through 2016 suggests that total catch is related to discharge. Fewer eels are caught when the average discharge during the collection period (mid-May through mid-September) is less than 50% of the annual discharge from January through September (Figure 17). This has only occurred in three collection periods from 2008 to 2016, and it does coincide with two of the three lowest yearly totals in eel catch (Figure 10). The positive relationship between eels and river discharge is supported further by observed increases in catch following events of heavy precipitation.

Elver holding mortality in 2016 was 2%. Transport mortality is unknown for elvers collected by the USFWS at Conowingo Dam in 2016 as they were transported with eels from Normandeau Associates, Inc. Historically, reported mortality rates include mortality occurring during transport and so 2016 cannot be compared to previous mortality data. Transport mortality estimates are reported in the Normandeau report on Octoraro collections. Escape of collected elvers from collection and holding tanks occurred this season, and has been noted in previous years. It was suspected that eels were able to exit the tanks through holes in the screening on the standpipes and/or when clogged screens raised water levels high enough for elvers to exit through the inflow pipes. When this occurred, eels could have been flushed to the bottom of the cable tray where it is assumed they would follow the attractant flow back into the collection tank.

The goal of the Conowingo Dam eel collection project was to reintroduce eels into the Susquehanna watershed. Over 800,000 eels were released at more than 40 stocking sites (Figure 18) throughout the Susquehanna River watershed from 2008 through 2016 (Table 4). Elvers released above Conowingo Dam could remain in the watershed for the next 20 years. Exelon and Normandeau Associates, Inc. have entered into agreement to continue the collection and transport of eels into the Susquehanna watershed at locations determined by the Eel Passage Advisory Group (EPAG). Research and monitoring by the USFWS and USGS will continue to evaluate the effect that the eels' reintroduction could have on the watershed.

FUTURE PLANS

This is the last year the USFWS will operate the eel ladder at Conowingo Dam. In accordance with the Federal Energy Regulatory Commission (FERC) license issued for the Muddy Run Pump Station, Exelon will be responsible for the collection and transport of American Eels from the base of Conowingo Dam and from Octoraro Creek.

The US FWS will continue to monitor the eel collection and upstream stocking conducted by Exelon and contractors (currently Normandeau Associates, Inc.). Other American Eel related projects throughout the Susquehanna Watershed will continue. Sampling for the presence of eels and monitoring growth rates of PIT tagged eels in Buffalo and Pine creeks will continue until 2019. Monitoring and sampling for freshwater mussels in Buffalo Creek, Pine Creek, and Penns Creek will continue until 2020.

Acknowledgments

We thank the many personnel who assisted in any or all phases of this project. Their time and effort has been greatly appreciated. We also thank the staff of the US FWS-Maryland Fishery Resources Office, the staff of Normandeau Associates, Inc., and the employees of Exelon Corporation stationed at Conowingo Dam. Without the continued cooperation of these agencies and companies, the collection and relocation of the American Eel on the Susquehanna River would not have been a success.

We also appreciate the peer revision of this report by the following professionals:

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Table 1. Number of elvers collected by date at Conowingo Dam, Maryland, during the 2016 sampling season. The elver ladder was operational from May 13 through September 14, 2016.

Date	Daily Total		Date	Daily Total
5/13/2016	0		7/20/2016	147
5/20/2016	0		7/22/2016	13
5/25/2016	2		7/25/2016	20
5/27/2016	3		7/27/2016	5
5/31/2016	33		7/29/2016	1
6/3/2016	62		8/1/2016	4
6/6/2016	83		8/3/2016	7
6/8/2016	14		8/5/2016	14
6/10/2016	3		8/8/2016	1
6/13/2016	32		8/10/2016	5
6/15/2016	36		8/12/2016	47
6/17/2016	45		8/15/2016	8
6/20/2016	99		8/17/2016	5
6/22/2016	97		8/19/2016	1
6/24/2016	157		8/22/2016	4
6/27/2016	116		8/24/2016	12
6/29/2016	37		8/26/2016	15
7/1/2016	99		8/29/2016	8
7/5/2016	97		8/31/2016	10
7/8/2016	150		9/2/2016	2
7/11/2016	786		9/6/2016	6
7/13/2016	169		9/9/2016	0
7/15/2016	106		9/12/2016	3
7/18/2016	120		9/14/2016	0

Table 2. Total river discharge per year for the collection period (May through September) and from January through September.

Year	Collection Period Discharge (cfs)	Discharge through September (cfs)	Δ
2008	18,465	44,166	25,701
2009	26,132	32,662	6,530
2010	15,077	32,438	17,361
2011	62,332	72,888	10,556
2012	23,198	31,261	8,063
2013	24,796	35,541	10,745
2014	29,967	39,483	9,516
2015	24,814	33,141	8,327
2016	14,979	30,184	15,205

Table 3. Total yearly elver catch at Conowingo Dam from 2005 through 2016. The current eel ladder design has been in since 2008.

Year	Total Elvers Caught
2005	42
2006	19
2007	3,837
2008	42,058
2009	17,437
2010	23,856
2011	84,961
2012	127,013
2013	293,141
2014	185,628
2015	58,444
2016	2,684
Project Total	839,120

Table 4. Total elvers stocked in the Susquehanna River and tributaries. Most tributaries contain multiple stocking sites.

Elvers Stocked	Watershed
41,997	Conodoguinet Creek, PA
378	Conewago Creek, PA
20,228	Broad Creek, MD
5,000	Deer Creek , MD
22,004	Muddy Creek, PA
3,231	Jones Falls, MD
505	Octoraro Lake, PA
9,763	Chemung River, NY
2,250	Penns Creek, PA
118,642	Buffalo Creek, PA
17,504	Conestoga River, PA
42,208	Conowingo Creek, PA
32,579	Conowingo Pool, MD/PA
122,047	Pine Creek, PA
401,771	Susquehanna River, PA

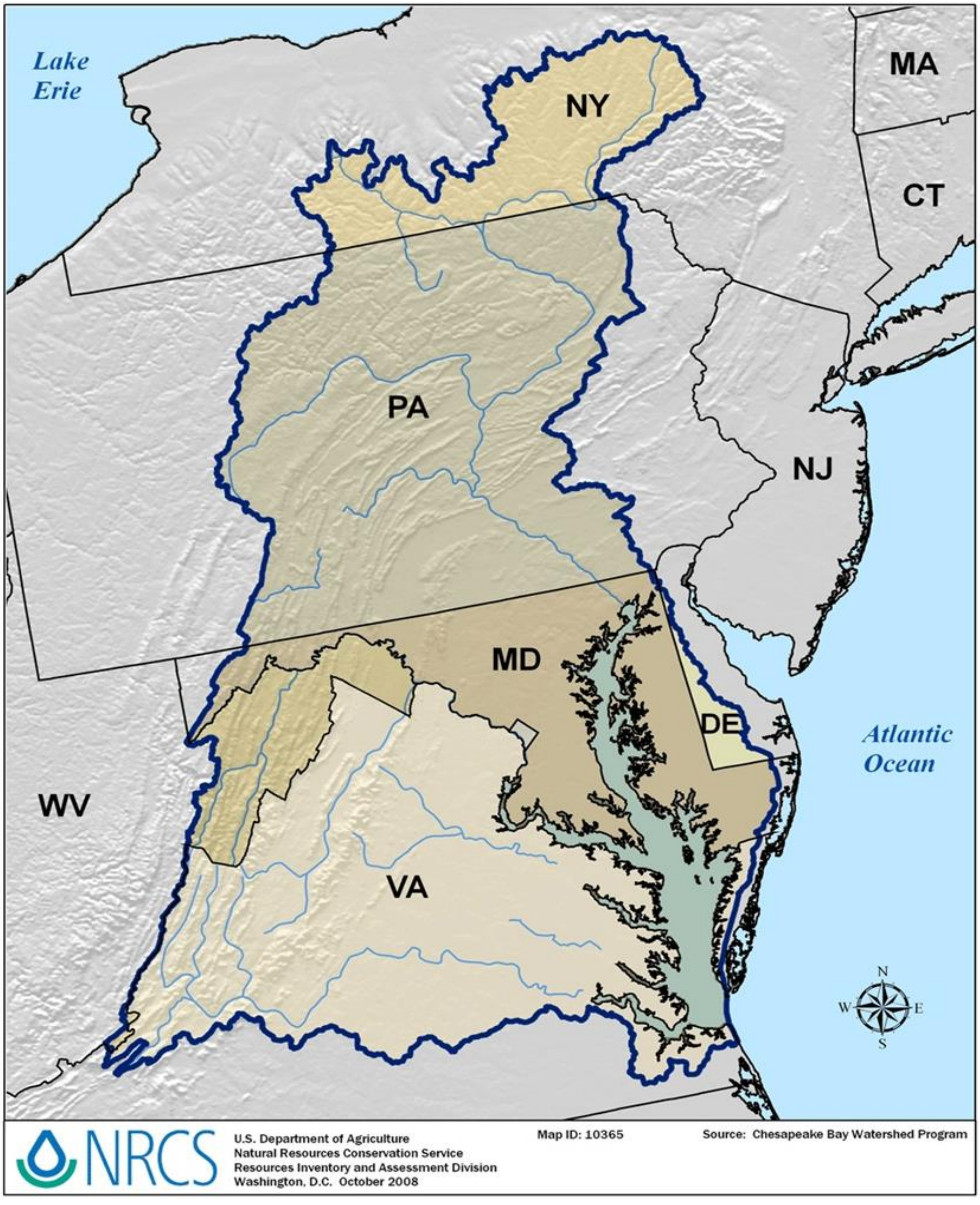

Figure 1. Chesapeake Bay Watershed, north-eastern United States. Credit: USDA-Natural Resources Conservation Service.

Figure 2. Susquehanna River basin and sub-basins, north-eastern United States. Credit: Susquehanna River Basin Commission.

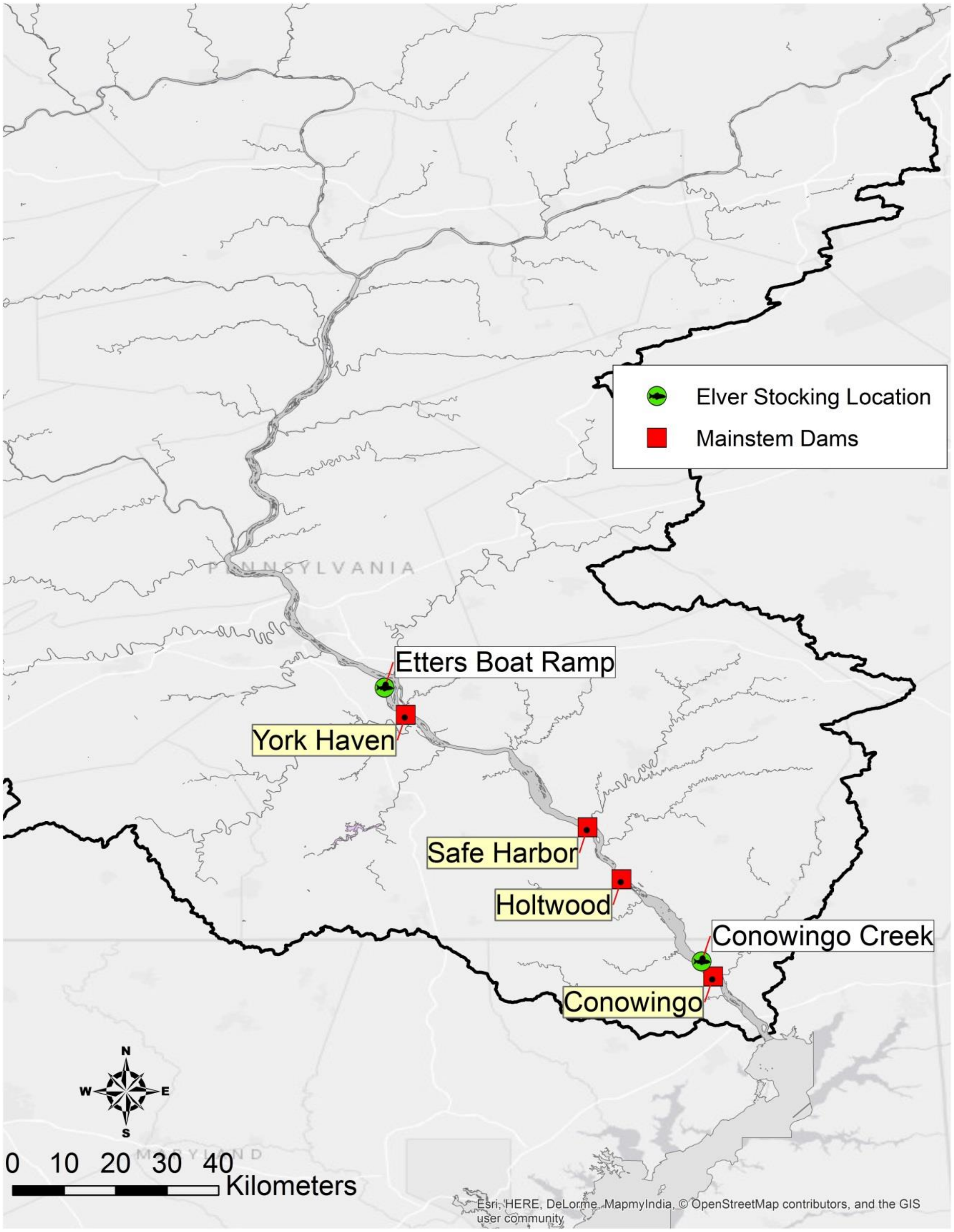

Figure 3. Locations of the four mainstem dams on the Lower Susquehanna River, including Conowingo Dam at river mile 10, Holtwood Dam at river mile 25, Safe Harbor Dam at river mile 33, and York Haven Dam at river mile 65. Also shown are the two locations at which elvers were stocked in 2015. Credit: USFWS/MDFWCO/JNewhard.

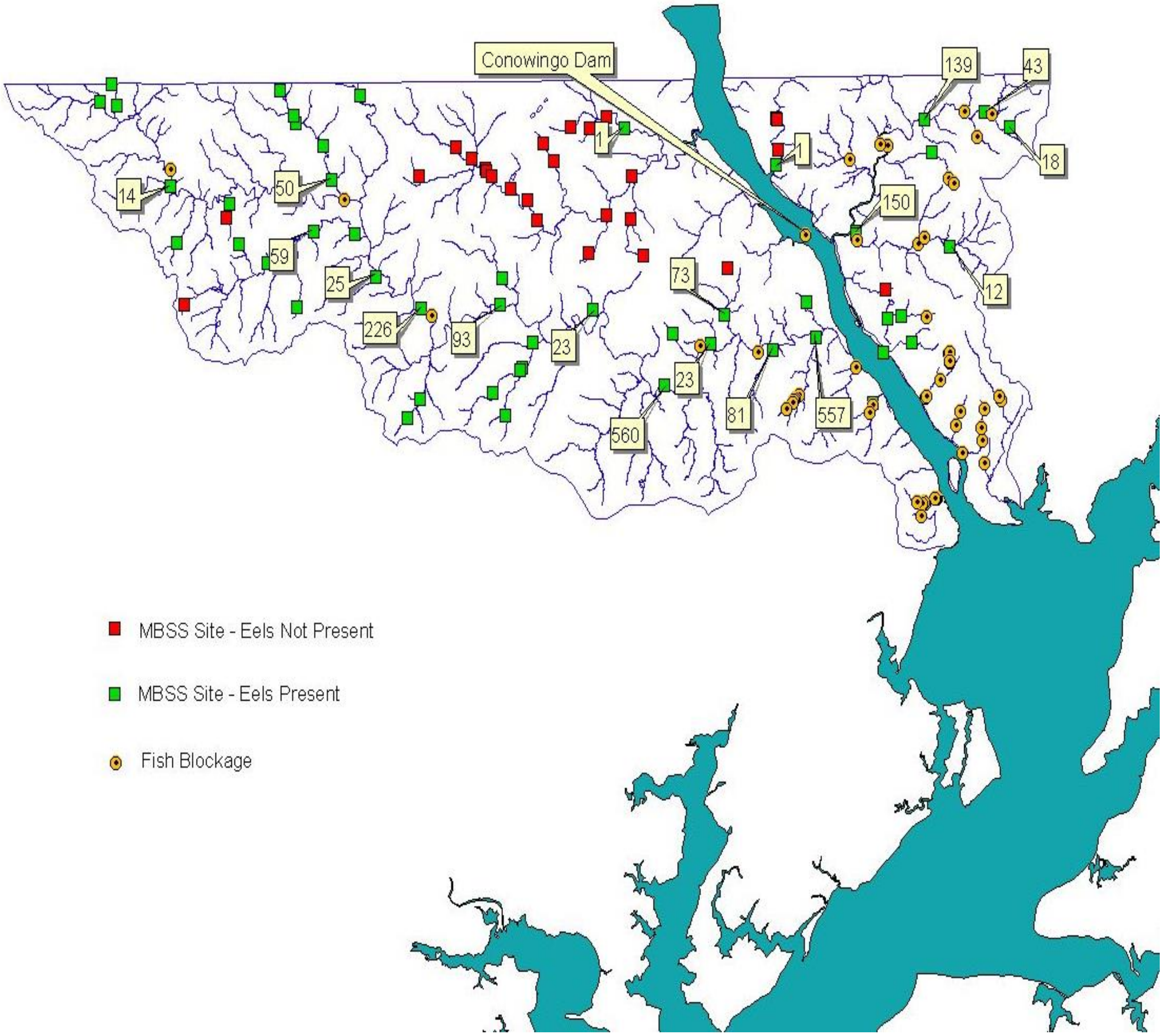

Figure 4. Map of Maryland Biological Stream Survey (MBSS) sampling sites on tributaries of the Susquehanna River. The numbers of eels sampled at each site are indicated in boxes on the map. Note the difference in densities of eels found in tributaries below Conowingo Dam versus above the Dam. Credit: Maryland Department of Natural Resources-Maryland Biological Stream Survey.

Figure 5. Collection location for American Eels at the base of Conowingo Dam, Darlington, Maryland. Credit: USFWS/MDFWCO/JMalavasi.

Figure 6. Elver ladder at base of Conowingo Dam, Maryland. Credit: USFWS/MDFWCO/JMalavasi.

Figure 7. Collection tank and holding tanks located on the lower platform, at the top of the elver ladder, Conowingo Dam, Maryland. Credit: USFWS/MDFWCO/JMalavasi.

Figure 8. American Eel collection site on Octoraro Creek, Oxford, Pennsylvania; operated by Normandeau Associates, Inc. Credit: USFWS/MDFWCO/JNewhard.

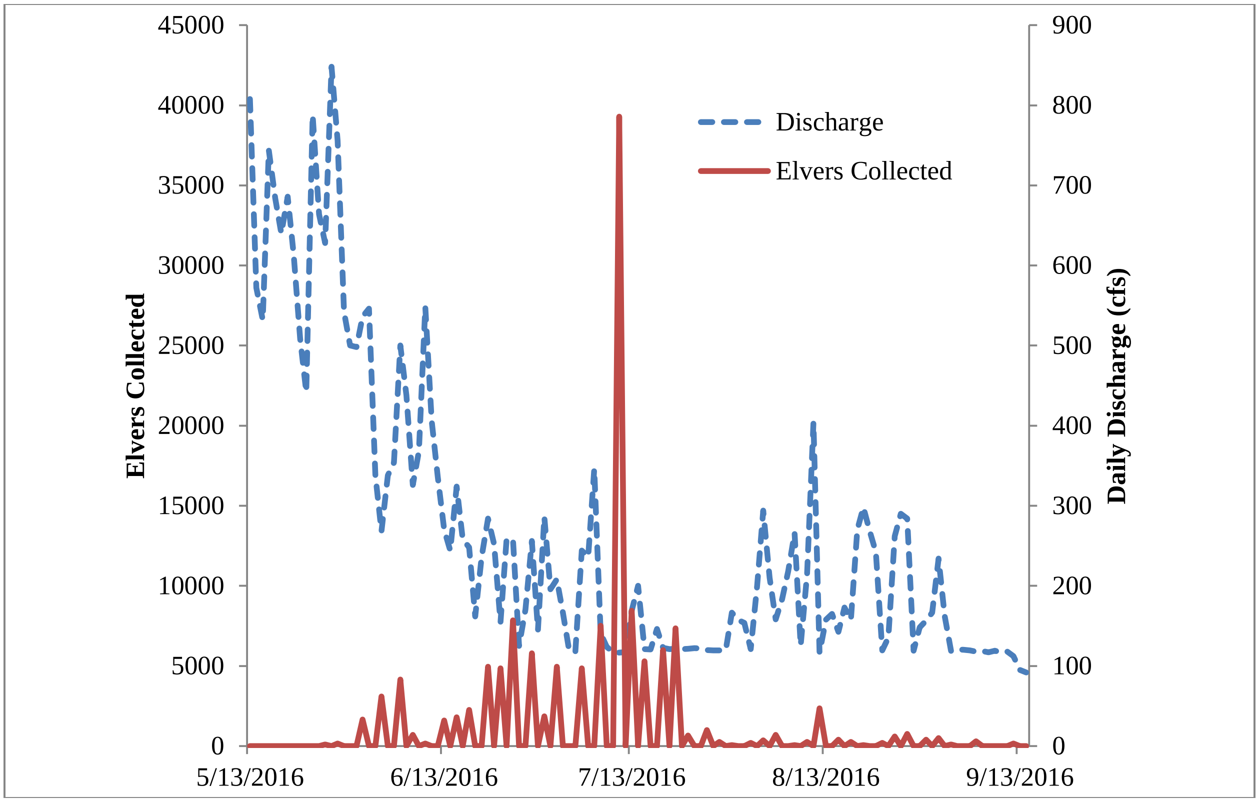

Figure 9. Number of elvers collected by date at Conowingo Dam, Maryland, during the 2016 sampling season. Daily discharge levels shown on the secondary axis.

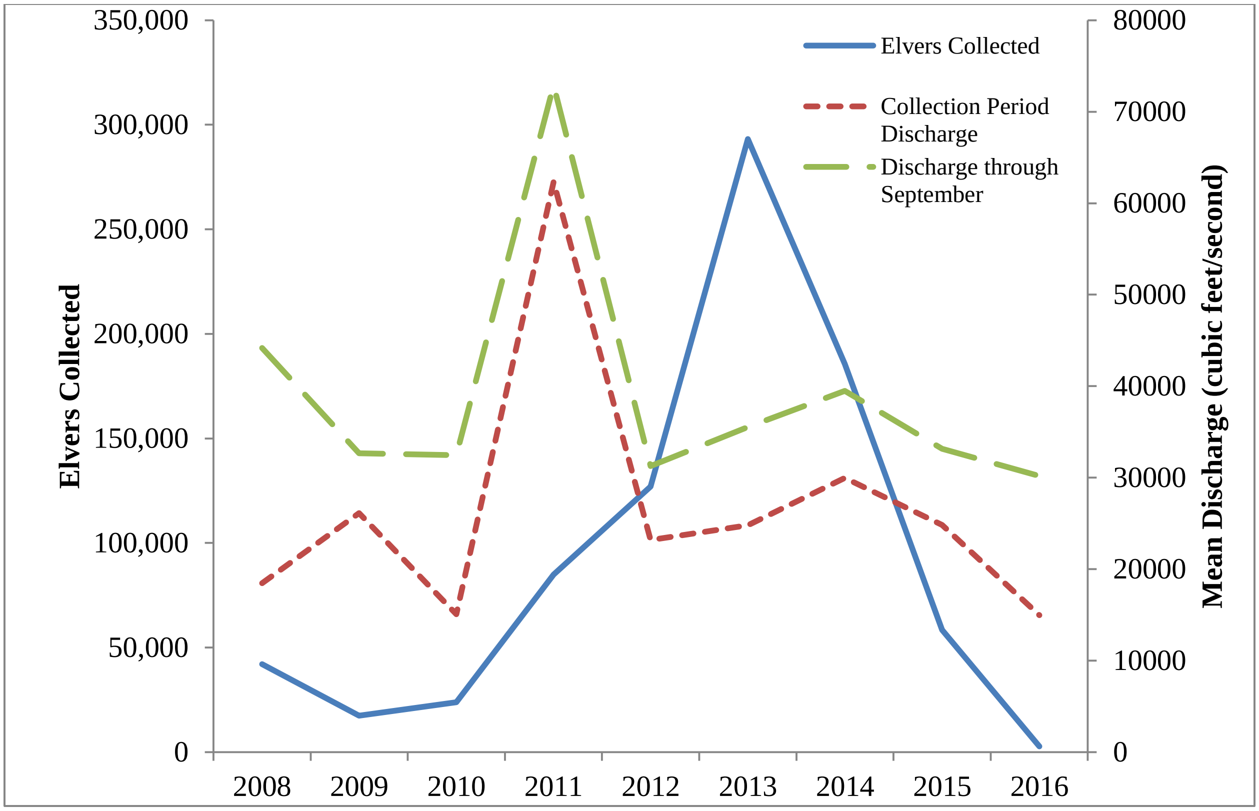

Figure 10. Number of elvers collected by year at Conowingo Dam, Maryland, from 2008 to 2016. Annual discharge during collection period and discharge from January 1 through September 30 for 2008 through 2016 are shown on the secondary axis.

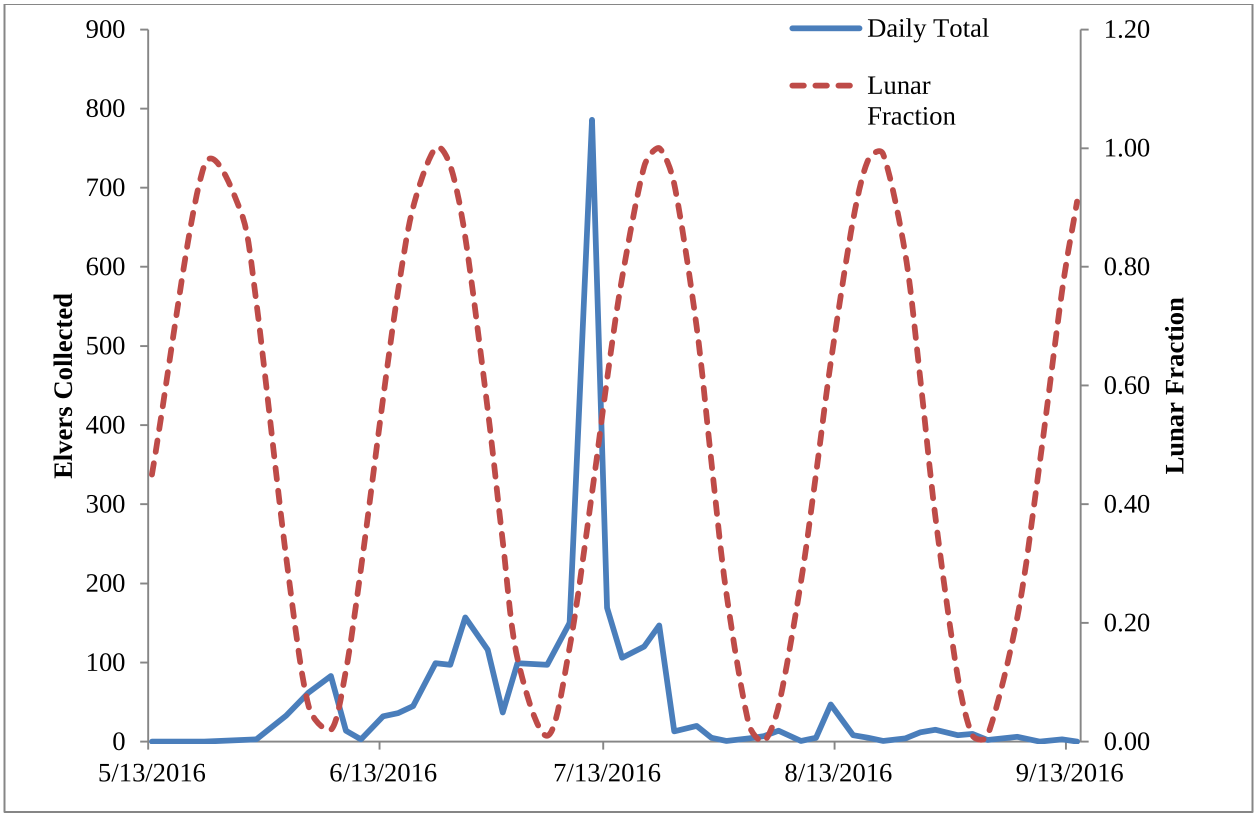

Figure 11. Number of elvers collected by date at Conowingo Dam, Maryland, during the 2016 sampling season. Lunar Fraction is shown on the secondary axis.

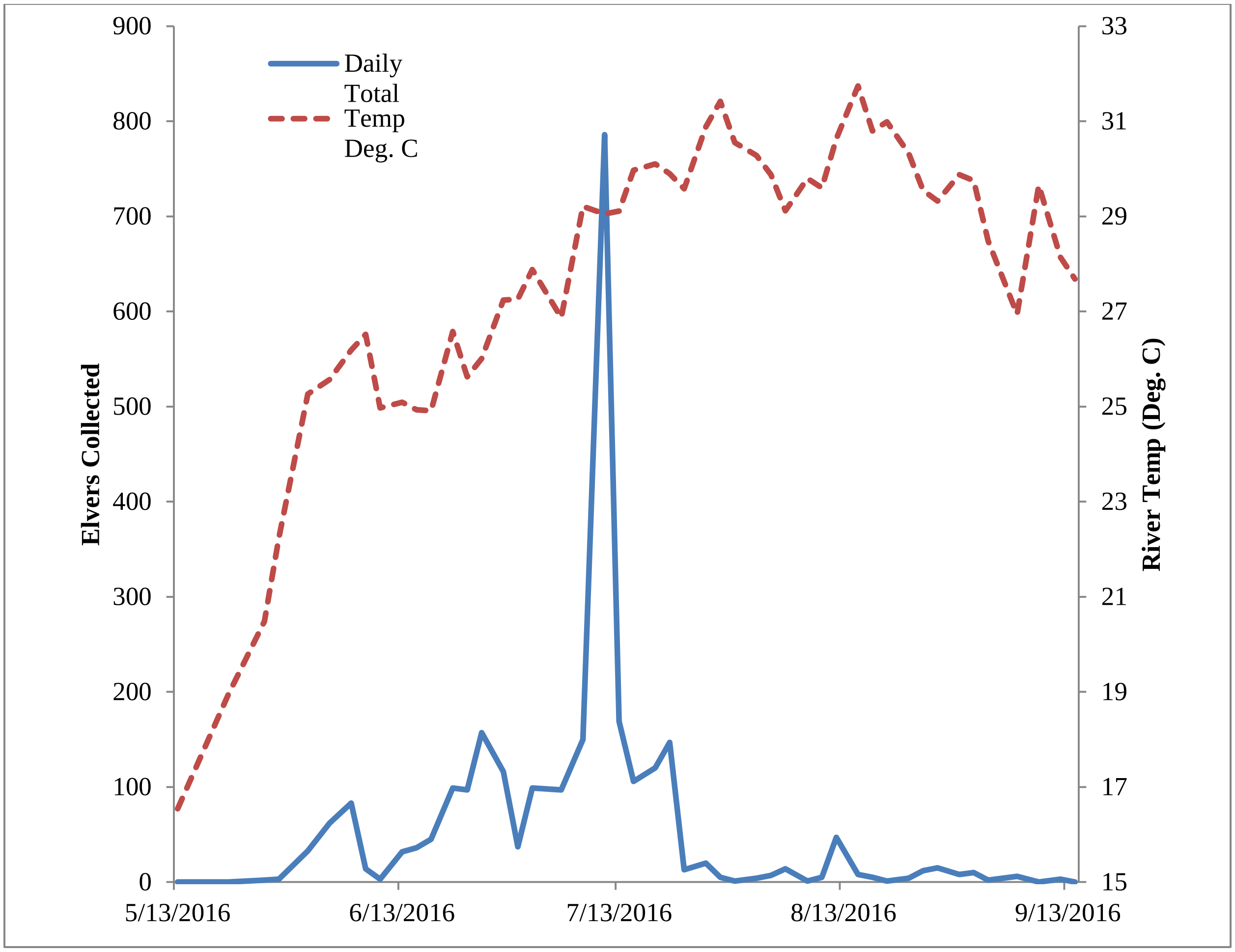

Figure 12. Number of elvers collected by date at Conowingo Dam, Maryland, during the 2016 sampling season. River Temperature is shown on the secondary axis.

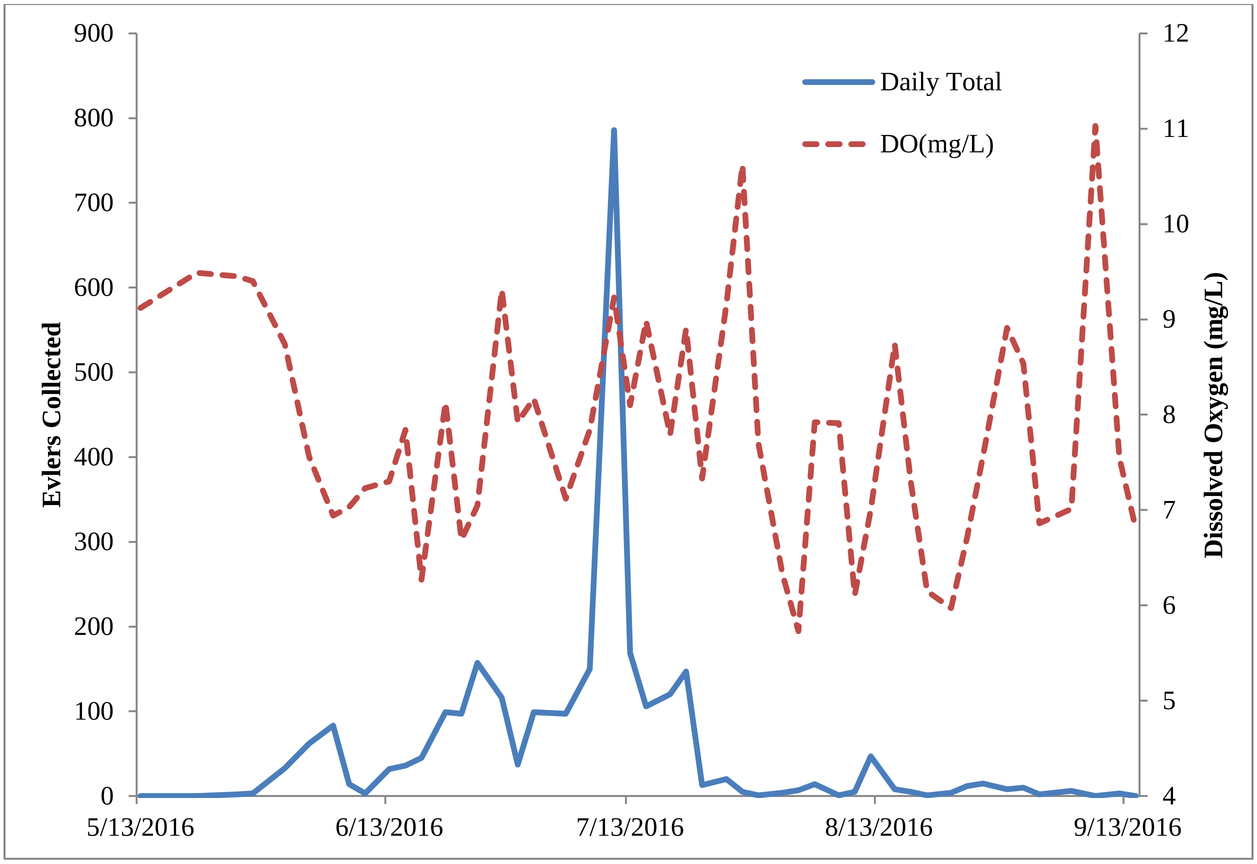

Figure 13. Number of elvers collected by date at Conowingo Dam, Maryland, during the 2016 sampling season. Dissolved Oxygen levels are shown on the secondary axis.

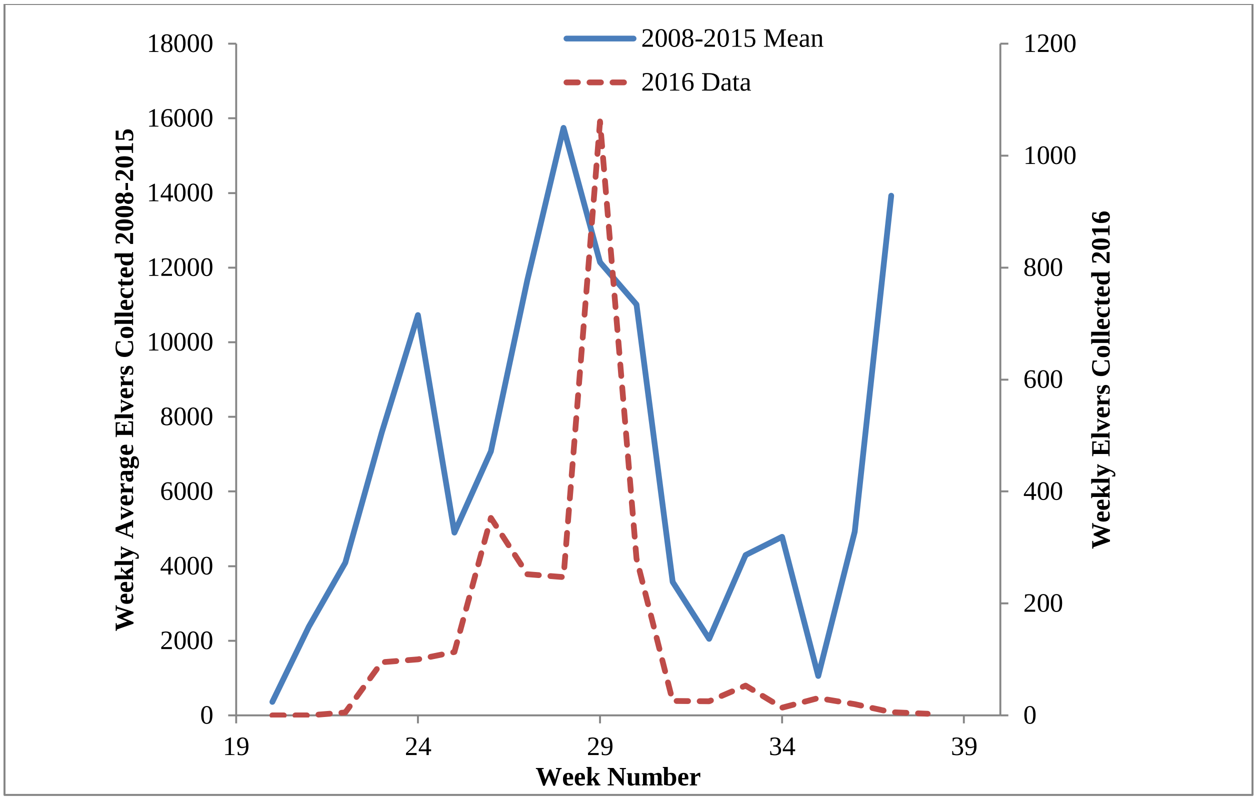

Figure 14. Weekly average catch for the 2016 sampling season. Historic average weekly catch is shown on the primary y-axis axis and weekly data for 2016 is on the secondary y-axis.

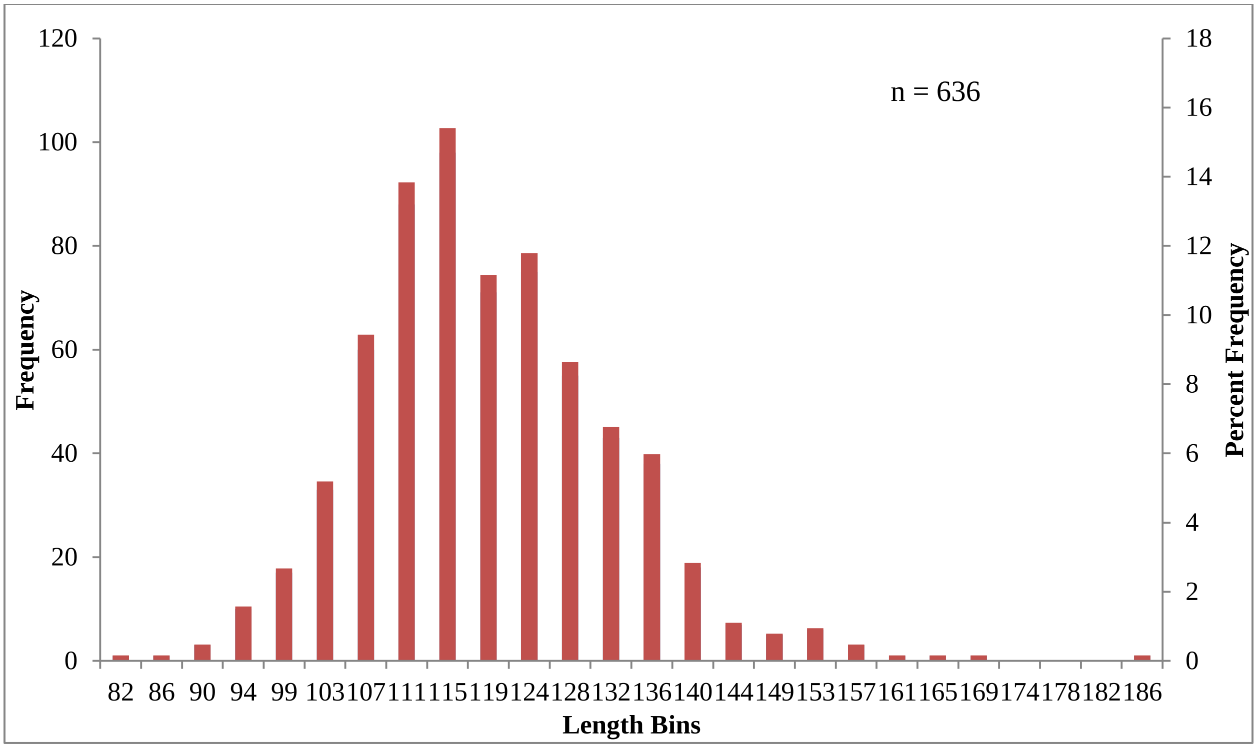

Figure 15. Length-frequency histogram of all elvers measured at Conowingo Dam, Maryland, during the 2016 sampling.

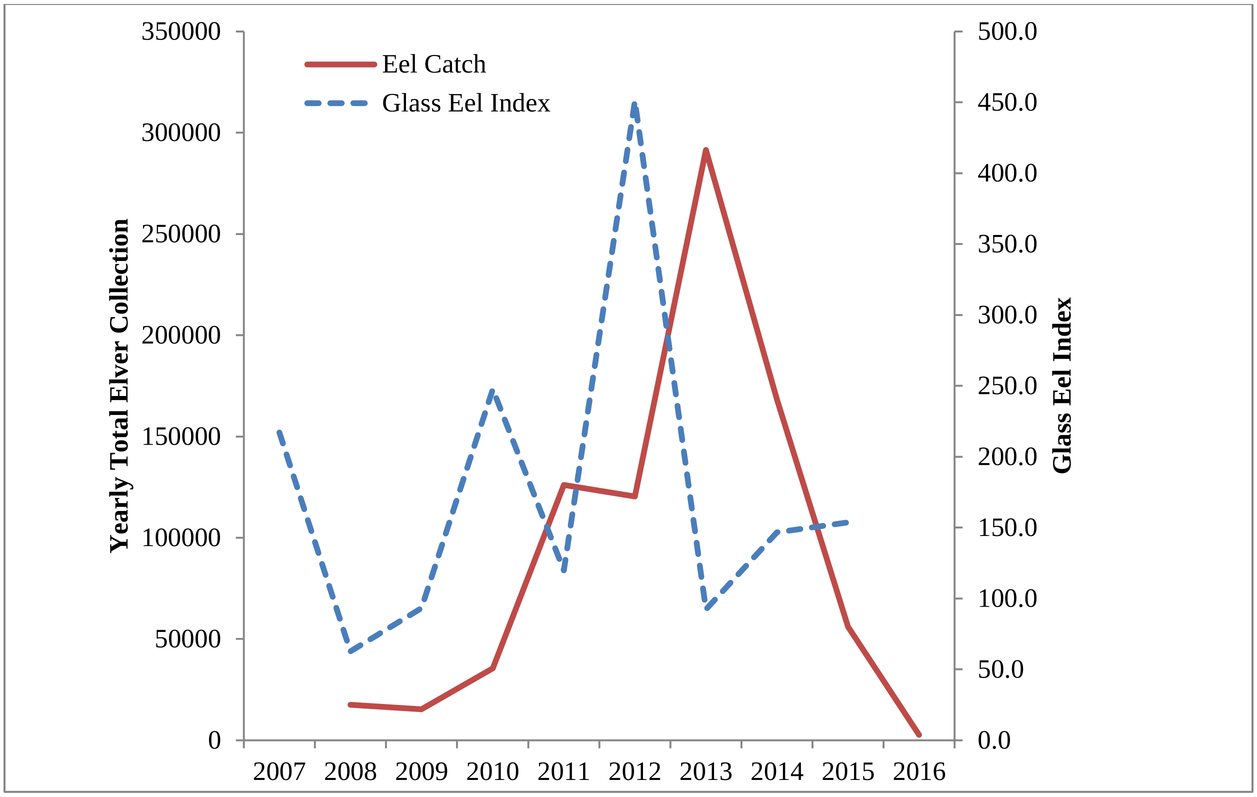

Figure 16. Annual total elver catch collected from Conowingo Dam from 2008 through 2015. Maryland Department of Natural Resources annual Glass Eel survey results from 2007 through 2015 is shown on the secondary axis. Annual index numbers are compared to subsequent years' elver catch due to year-long migration of eels from the Glass Eel Index survey site to Conowingo Dam.

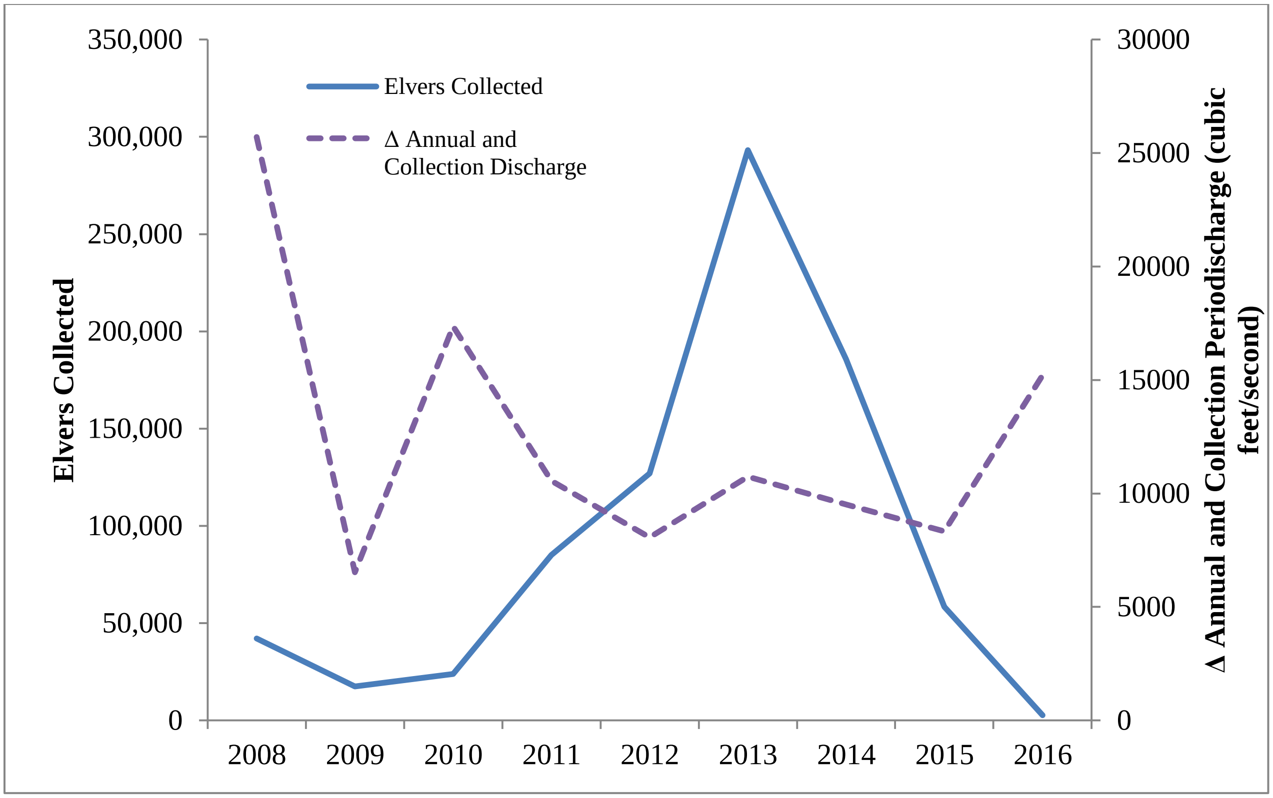

Figure 17. Annual total elver catch collected from Conowingo Dam from 2008 through 2016. The Δ of annual discharge through September and discharge during the collection period is shown on the secondary axis.

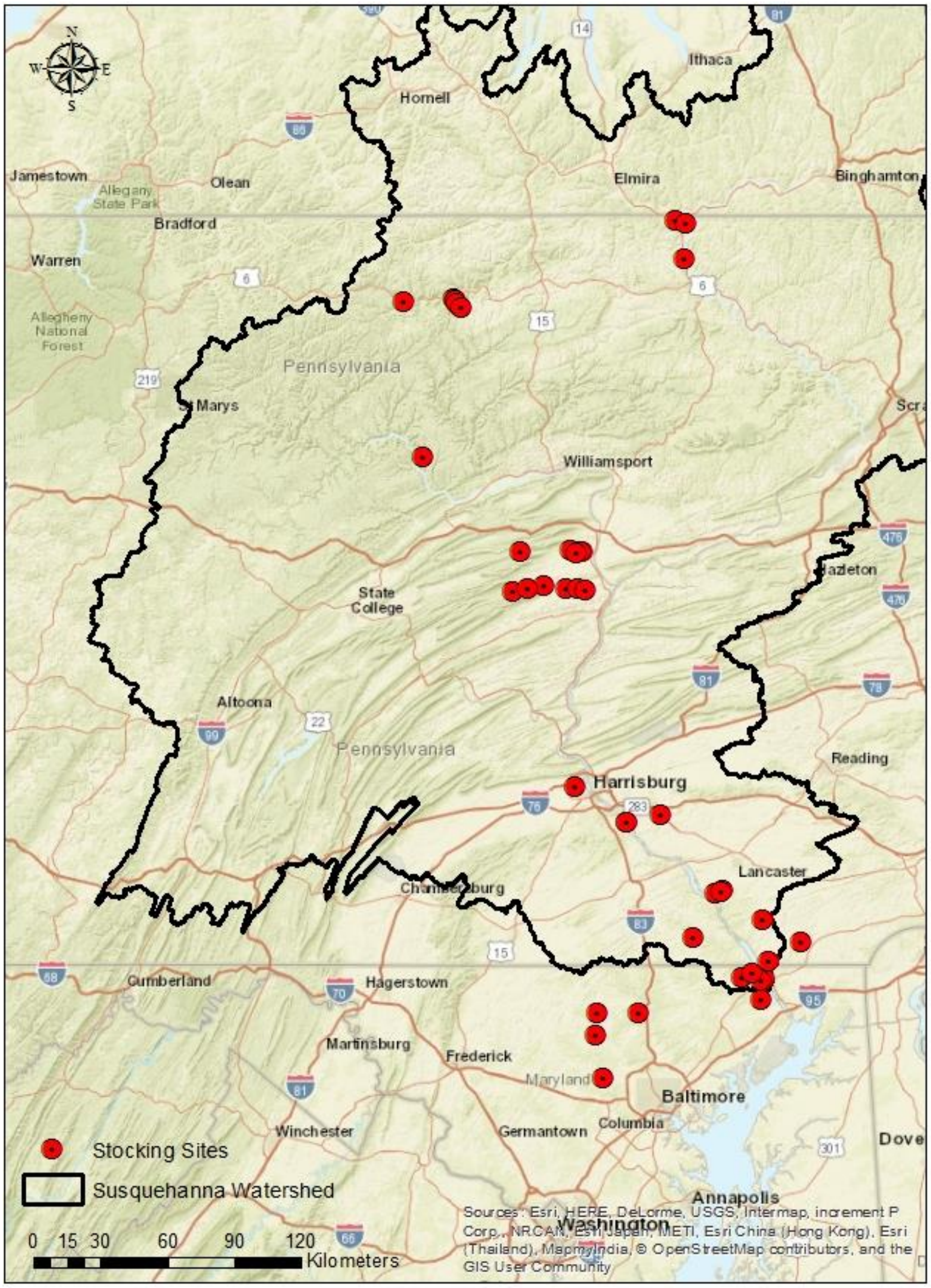

Figure 18. Elver stocking locations throughout the Susquehanna River from 2008 through 2016. Credit: USFWS/MDFWCO/CReily

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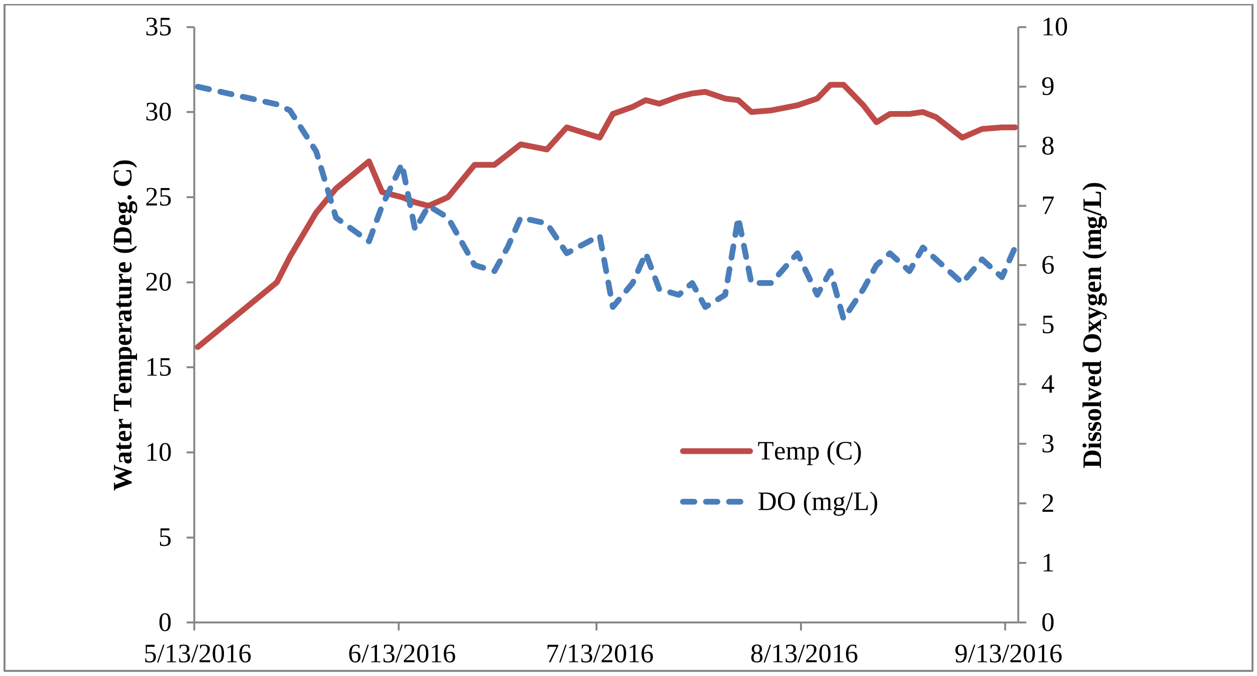
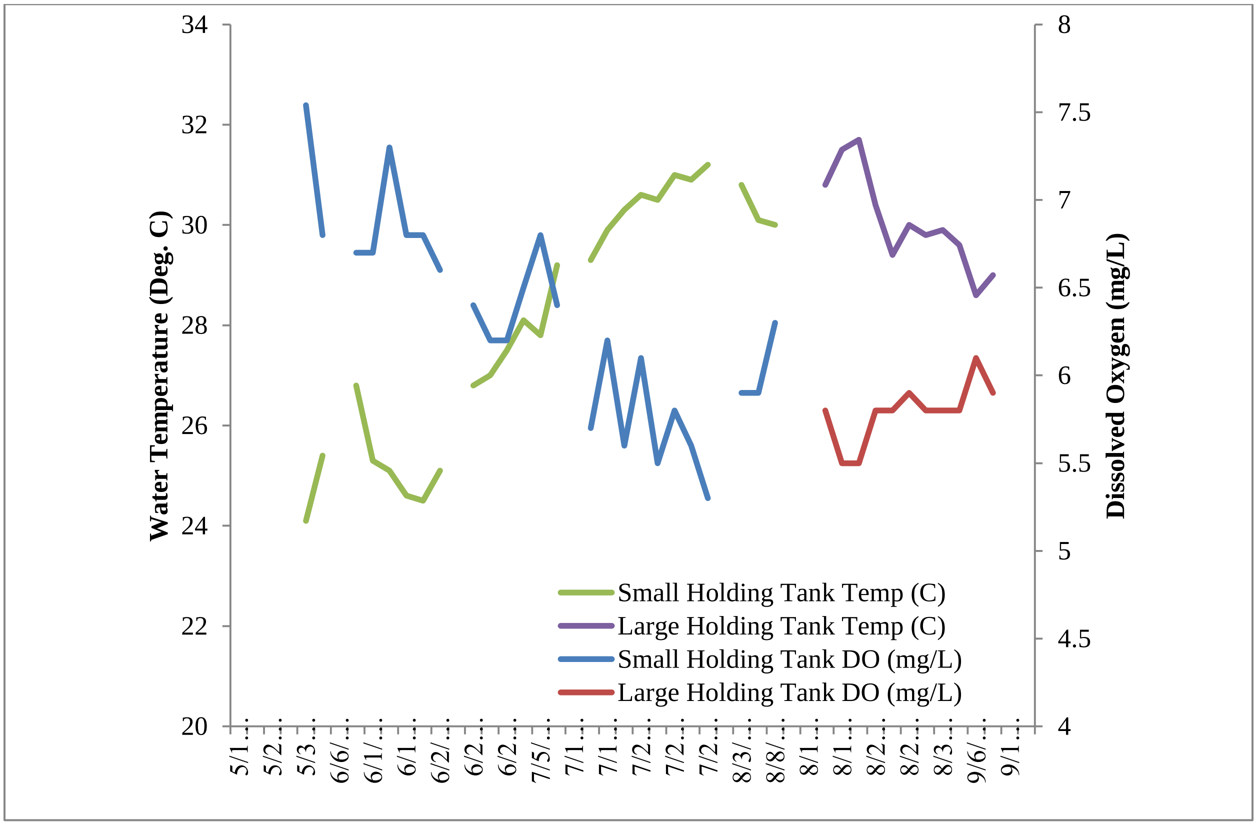
Appendix A. Water quality parameters in the elver collection tank (above) and large and small holding tanks (below), Conowingo Dam, Maryland, during the 2016 sampling season.





Appendix B. Number of eels stocked, per site, by Normandeau Associates, Inc. during the 2016 eel collection season. Eels collected by the USFWS are included in these figures.

Site	Eels Stocked
Octoraro Lake	215
Muddy Creek Forks (Site A)	22,004
Conewago Creek (Site B)	378
Total Stocked	22,597