

Restoration Monitoring of American Eel (*Anguilla rostrata*) in Three Southcentral Pennsylvania Streams in the Susquehanna River Basin: 2024 Monitoring Data Summary Update

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INTRODUCTION & BACKGROUND

The Susquehanna River Basin Commission (Commission) has been actively monitoring the restoration of American Eel (*Anguilla rostrata*) in the Susquehanna River Basin since 2015. The American eel is a catadromous fish species previously abundant throughout the basin but was effectively extirpated in the early 20th century with the construction of four river-spanning hydroelectric dams on the Lower Susquehanna River mainstem. In 2005, a basinwide reintroduction effort began with the U.S. Fish and Wildlife Service (USFWS) experimentally trapping American eel elvers at Conowingo Dam and transporting them upstream above the dams.

Through the Federal Energy Regulatory Commission's (FERC's) re-licensing of the Muddy Run Pumped Storage Project, a long-term commitment to trap and transport American eels was developed and implemented. With partial funding support from the U.S. Environmental Protection Agency (USEPA) through a Water Pollution Control (Section 106) grant, the Commission initiated a monitoring project in 2015 to investigate ecological impacts to streams receiving targeted stockings of American eel elvers in the Lower Susquehanna subbasin. The Commission began collecting fish, macroinvertebrate, and water quality data at three study sites prior to elver stocking occurring in 2016 and 2017 and has continued collecting data at these locations annually through 2024. More details regarding the first five years of this study can be found in a larger report published in October 2021 (Henning, 2021). The goal of this technical summary is to provide a summary of the results from the latest year of post-stocking monitoring conducted in 2024. A 10-year report will be written in 2026.

STUDY DESIGN

American eels collected at the Octoraro Creek and Conowingo Dam ramps were stocked at three sites in the Lower Susquehanna Subbasin: North Branch Muddy Creek near Brogue in York County, Conewago Creek near Aberdeen in Lancaster County, and Beaver Creek outside of Hummelstown in Dauphin County (Figure 1).

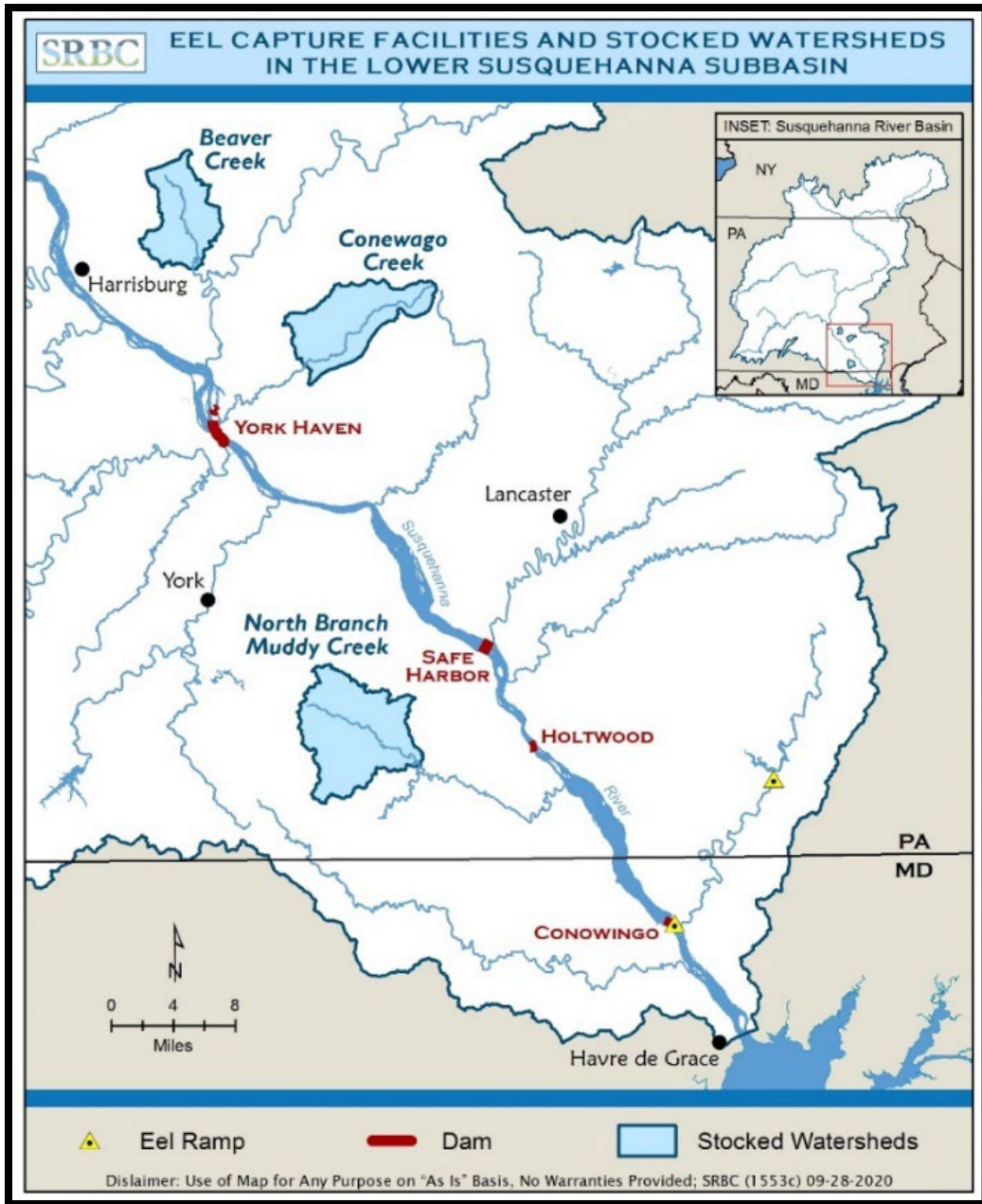


Figure 1. American Eel Stocked Watersheds and Monitoring Locations in the Lower Susquehanna Subbasin

Between May 2016 and June 2017, a total of 48,622 elvers were stocked at these sites (Table 1). Stocking occurred at a single point on each stream which continued to serve as a monitoring location for the extent of this study. Elvers were stocked within one week of capture. Stocked elvers averaged 122mm in length and 2.1g in mass (Normandeau, 2017) and were approximately 1 to 4 years old, with a mean age of 1.65 years (Normandeau, 2021).

Table 1. Cumulative American Eel Stocking by Year at Commission Study Sites

Waterbody	Stocking Goal	Stocked		
		2016	2017	Total
North Branch Muddy Creek	22,000	22,004	0	22,004
Conewago Creek	16,850	1,563	15,317	16,880
Beaver Creek	9,400	0	9,738	9,738
TOTAL	48,250	23,567	25,055	48,622

METHODS

Commission field crews followed the field methods outlined in the USEPA-approved Quality Assurance Work Plan (SRBC, 2021). Sampling occurred annually at each monitoring site and included collection of macroinvertebrates, crayfish, fish, and water samples, as well as assessments of stream characteristics.

Fish community data were collected in the summer (July and August) via electrofishing using a single-unit width based multiple pass protocol (Shank et al., 2016). All captured fish were identified to species and weighed in aggregate to attain a species level biomass value. All captured American eels were weighed and measured individually. Beginning in 2019, all American eels over 200mm were implanted with an 8-mm full duplex Passive Integrated Transponder (PIT) tag. During each subsequent sampling event, individual eels were examined for the presence of a PIT tag by using a handheld PIT tag reader.

Macroinvertebrates were collected in fall using the PA Department of Environmental Protection's (PADEP's) riffle/run freestone macroinvertebrate collection protocol, and small-stream macroinvertebrate Index of Biotic Integrity (IBI) scores were calculated (PADEP, 2013). Separate crayfish samples were collected in summer using a 1-m² quadrat sampler to estimate density (Larson et al., 2008). Crayfish were preserved in ethyl alcohol, identified to species, and weighed to obtain a biomass value for each species at each site.

Water quality samples were collected quarterly at each monitoring location using a handheld depth-integrated water sampler and analyzed by Pace Analytical for aluminum, iron, manganese, phosphorus, nitrate, total organic carbon, sulfate, sodium, and chloride. No storm-impacted samples were collected during water sampling. Water Quality Index (WQI) values were calculated for each sample (Berry et al., 2020).

Physical habitat was rated using the USEPA's rapid bioassessment protocol for riffle/run wadeable streams (Barbour et al., 1999). Representative site photographs were taken at least annually at each monitoring site to document changes in conditions.

RESULTS

Fish

2024 represented the first year in which no American eel were caught at Conewago Creek (Figure 2). Previous years' surveys had documented declining numbers of American eel since achieving a peak in adult captures in 2020. Similarly, electrofishing surveys at North Branch Muddy Creek have had generally declining catch rates since 2020; however, American eels remain present in the fish community. Also consistent with previous results is the absence of American eel at the Beaver Creek monitoring station. While not physically present at the monitoring site during electrofishing, an eDNA survey initiated by SRBC in 2023 revealed American eel DNA existing at eight of nine sites sampled within the Beaver Creek Watershed (Figure 9). At North Branch Muddy and Conewago Creeks, the overall community diversity and total catch-per-unit-effort remained consistent with previous years' surveys (Figures 3 and 4; Tables 2-4). Relative abundance of American eel remained low, only exceeding 1 percent in the two years post-stocking. Both of these streams exhibit a broader species richness and evenness relative to Beaver Creek. Beaver Creek possesses greater overall numbers of fish, but the majority of those individuals are attributed to a single species, typically the Central Stoneroller (*Campostoma anomalum*).

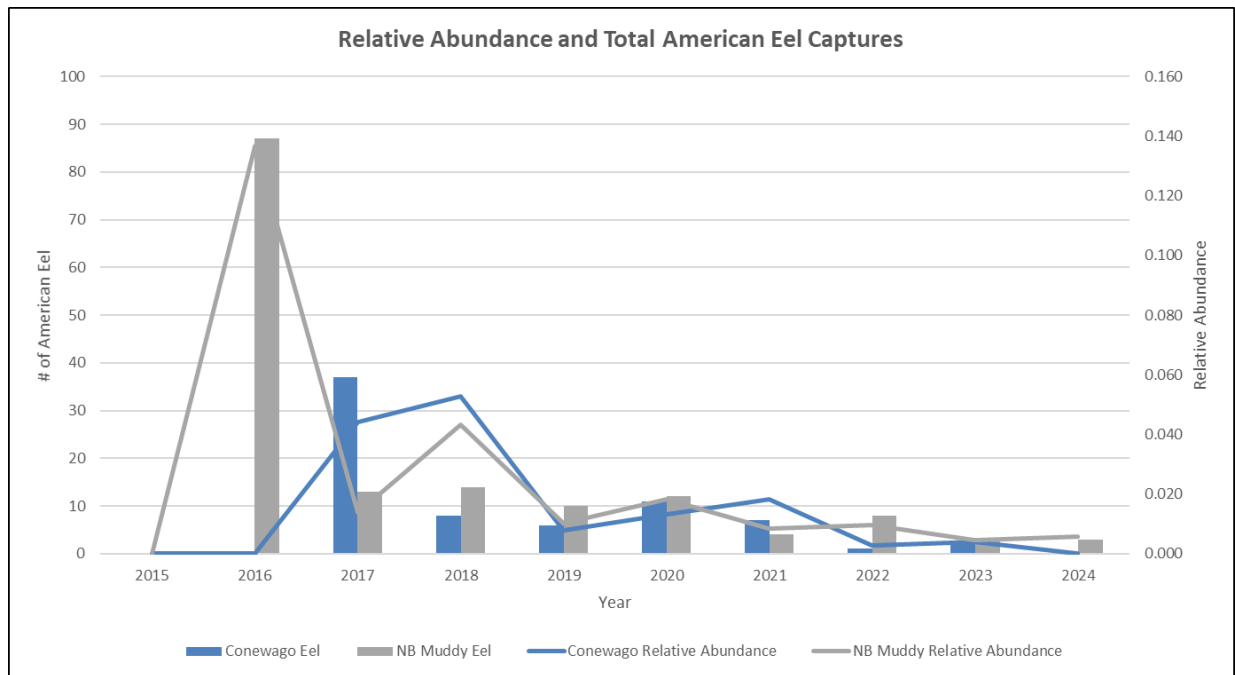


Figure 2. American Eel Captures and Relative Abundance at Conewago and North Branch Muddy Creeks (2015-2024)

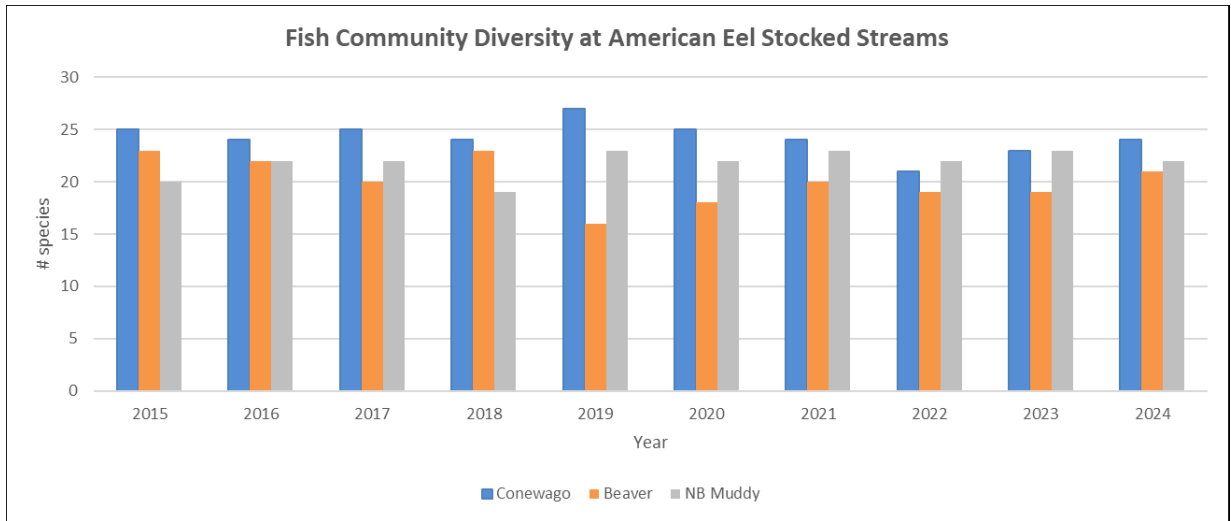


Figure 3. Annual Overall Fish Community Diversity at Eel-stocked Sites (2015-2024)

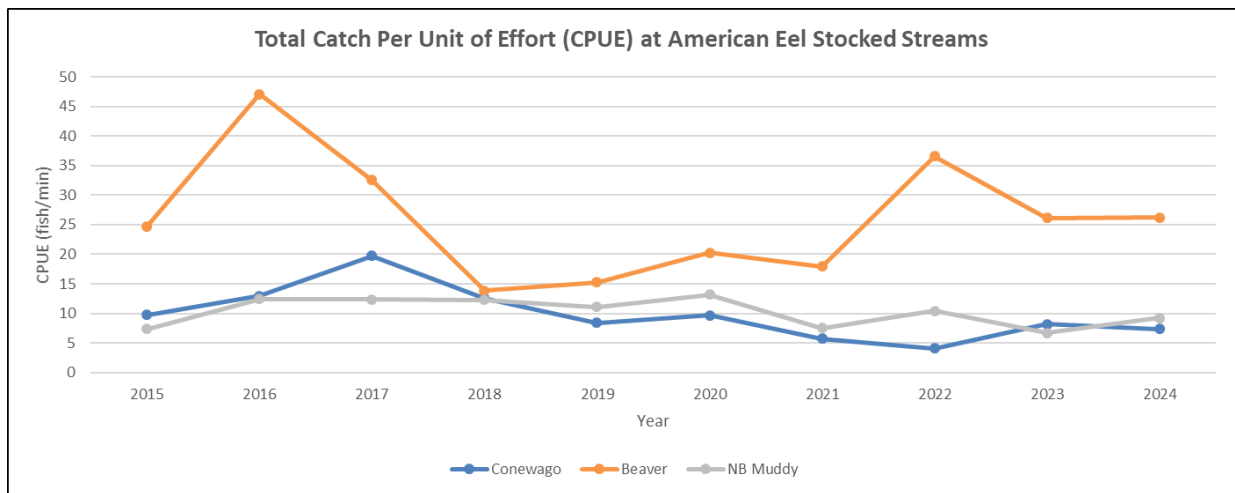


Figure 4. Annual CPUE of All Fish Species at Eel-stocked Streams (2015-2024)

Table 2. Annual American Eel Results at North Branch Muddy Creek

NB Muddy Creek								
Year	n	avg. length (mm)	avg. mass (g)	CPUE (n/min)	Eel biomass (g/min)	Eel relative abundance	Diversity	Overall (CPUE)
2016	87	130	NA	1.7	9.3	0.137	22	12.42
2017	13	205.1	19.3	0.17	3.31	0.014	22	12.37
2018	14	349	85.2	0.21	17.54	0.043	19	12.3
2019	10	384	120.9	0.11	13.59	0.010	23	11.05
2020	12	465.8	244	0.17	42.12	0.018	22	13.17
2021	4	523	293	0.06	18.3	0.008	23	7.51
2022	8	555.5	392	0.09	38.6	0.010	22	10.4
2023	3	535.7	315	0.04	16.7	0.005	23	6.65
2024	3	615	465.7	0.05	24.19	0.006	22	9.25

Table 3. Annual American Eel Results at Conewago Creek

Conewago Creek								
Year	n	avg. length (mm)	avg. mass (g)	CPUE (n/min)	Eel biomass (g/min)	Eel relative abundance	Diversity	Overall (CPUE)
2016	0	NA	NA	NA	NA	0	24	12.94
2017	37	156.8	6.1	0.88	4.8	0.044	25	19.7
2018	8	297.9	52	0.11	5.64	0.0528	24	12.6
2019	6	362.3	72.5	0.07	4.98	0.0079	27	8.42
2020	11	424.9	156.2	0.18	27.4	0.0131	25	9.7
2021	7	459	211	0.11	22.2	0.0183	24	5.7
2022	1	450	175	0.02	2.1	0.0029	21	4.05
2023	2	565.6	367.5	0.04	10.8	0.004	23	8.15
2024	0	NA	NA	NA	NA	0	24	7.36

Table 4. Annual American Eel Results at Beaver Creek

Beaver Creek								
Year	n	avg. length (mm)	avg. mass (g)	CPUE (n/min)	Eel biomass (g/min)	Eel relative abundance	Diversity	Overall (CPUE)
2016	0	NA	NA	NA	NA	0	22	24.7
2017	3	139.6	5	0.03	0.06	0.001	20	47.0
2018	0	NA	NA	0	0	0	23	32.6
2019	0	NA	NA	0	0	0	16	13.8
2020	0	NA	NA	0	0	0	18	15.2
2021	0	NA	NA	0	0	0	20	20.2
2022	0	NA	NA	0	0	0	19	17.9
2023	0	NA	NA	0	0	0	19	36.5
2024	0	NA	NA	0	0	0	21	26.2

Macroinvertebrates

Results from the 2024 macroinvertebrate surveys shows highest or second-highest IBI scores recorded in this project at the three sites (Figure 5). The Beaver Creek sample contained a large relative proportion of Coleopterans, primarily consisting of individuals from *Stenelmis* followed by *Psephenus*. Conewago Creek’s sample yielded greater overall diversity relative to Beaver Creek but contained more pollution-tolerant Chironomids. North Branch Muddy Creek received its highest IBI score in 2024. The sample was dominated by *Ephemerella* followed by *Isonychia* and *Amphinemura*.

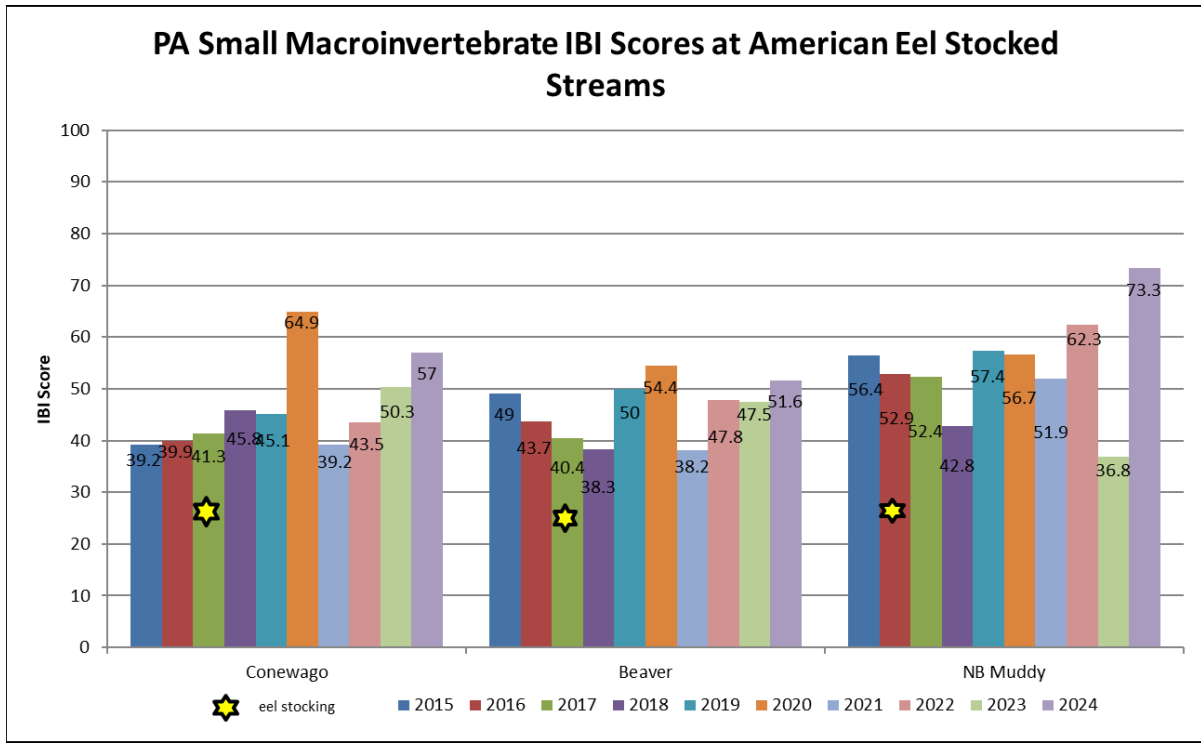


Figure 5. Macroinvertebrate IBI Scores at Eel-stocked Streams (2015-2024)

Crayfish

A targeted crayfish sample was successfully collected at each monitoring location in August 2024. Site-specific species composition remained unchanged with the Beaver Creek sample comprising of entirely non-native rusty crayfish (*Faxonius rusticus*), while North Branch Muddy and Conewago Creek were inhabited by only native Allegheny crayfish (*Faxonius obscurus*) (Figure 6).

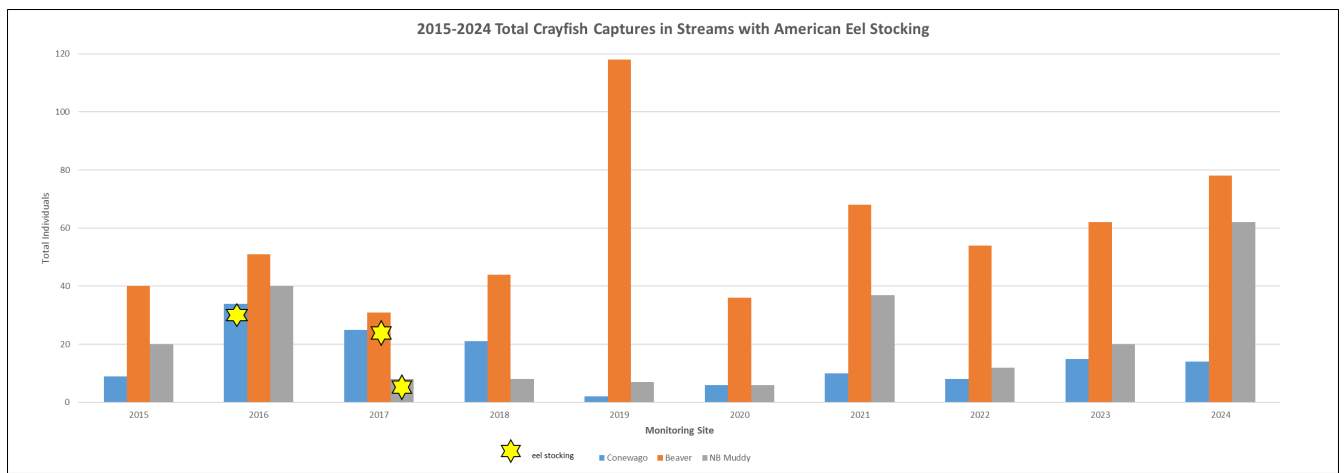


Figure 6. Crayfish Abundance at American Eel-stocked Streams (2015-2024)

Habitat

Habitat assessments were made during the summer months concurrently with the fish community sample. Beaver Creek continued to maintain suboptimal to marginal habitat conditions as reflected in Figure 7. The monitoring site on Beaver Creek suffers from an absence of frequent, well-developed riffles and limited depth and velocity regimes. Beaver Creek also routinely lacks the sufficient fish cover (large woody debris, boulders, undercut banks) to support a broader fish community. The conditions of North Branch Muddy and Conewago Creeks are significantly better ranging on the upper end of suboptimal to optimal. Both North Branch Muddy and Conewago Creeks benefit from persistently abundant fish cover and varied riffle-run-pool sequences.

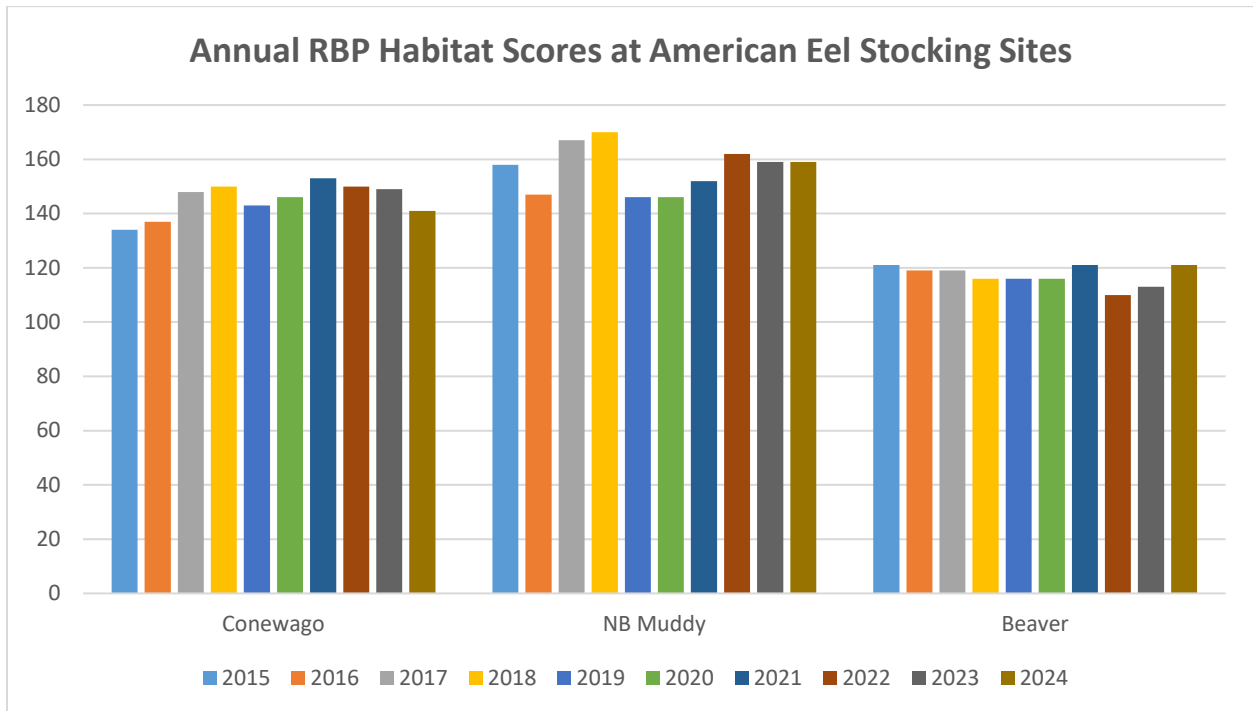


Figure 7. Habitat Scores at American Eel-stocked Streams (2015-2024)

Water Quality

Quarterly water samples were collected and analyzed using the Commission's Water Quality Index. Figure 8 shows that the 2024 results followed the consistent pattern exhibited in previous years' monitoring. Conewago Creek possessed the poorest water quality of all three sites consistently throughout the year while North Branch Muddy Creek rated the highest of the three monitoring sites. A sampling error in summer 2024 at Conewago Creek resulted in an absence of sufficient data to generate a WQI score for this period.

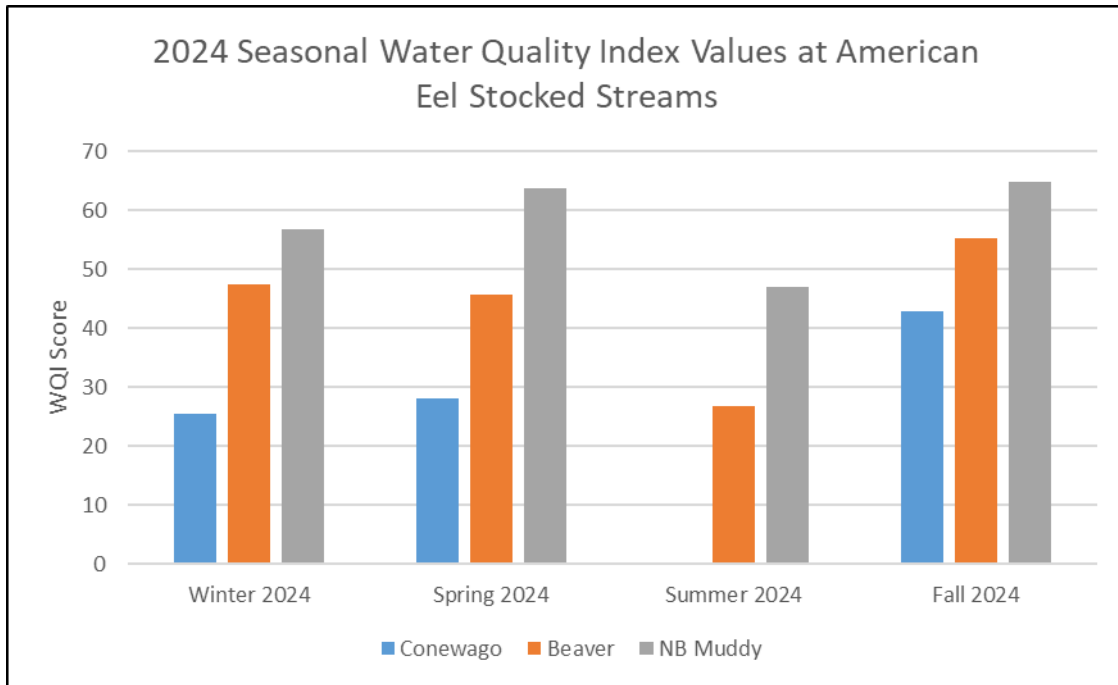


Figure 8. Water Quality Index Scores at American Eel-stocked Streams (2015-2024)

Discussion

American eel have continued to be detected annually in North Branch Muddy Creek since the 2016 stocking effort. Overall eel catch remained consistent with 2023, yielding three mature adult eels in each year. North Branch Muddy Creek also continues to maintain a naturally reproducing brown trout (*Salmo trutta*) population which existed prior to American eel reintroduction. Of the three eels collected at North Branch Muddy Creek, two were previously captured and tagged during prior surveys. Eel No. 6981 was initially tagged in 2022 at a length of 520mm and mass of 217g. When recaptured in 2024, this eel had grown to 630mm and 429g. Eel No. 6967 was also tagged in 2022 at a length of 520mm and mass of 266g. The eel was captured again in 2024 and had achieved an overall length of 560mm and mass of 345g. Over the course of this monitoring effort, 34 unique adults have been documented at North Branch Muddy Creek with six having been recaptured at least once.

No eels were detected at the Conewago Creek monitoring site for the first time since the site was stocked. Historically, 24 unique adult eels have been detected at Conewago Creek with six having been recaptured. Both streams have also maintained their relatively diverse assemblages of fishes, integrating the American eel without losses of previous documented low-abundance species. No juvenile eels (<200mm) have been recorded at any of the monitoring sites since the initial elver stockings in 2016 and 2017, suggesting limited to no migration of translocated elvers into these systems. The continual decline in adult eel captured at these locations suggests the animals are achieving maturation and beginning the outmigration phase of their life cycle.

Basinwide, American eel reintroduction has been successful with nearly 3 million individuals having been translocated since 2005. Expectedly, the general public and anglers particularly have been encountering American eels with increased frequency and curiosity. The Commission has a number of resources available on its website for the public to learn about the American eel as well as a reporting form where encounters can be documented and added to the map shown in Figure 9. The Commission also began collecting eDNA samples aimed specifically at detecting American eel in 2023. This work combined with agency and public reporting provides a useful multi-faceted approach to understating American eel distribution within the Susquehanna River Basin.

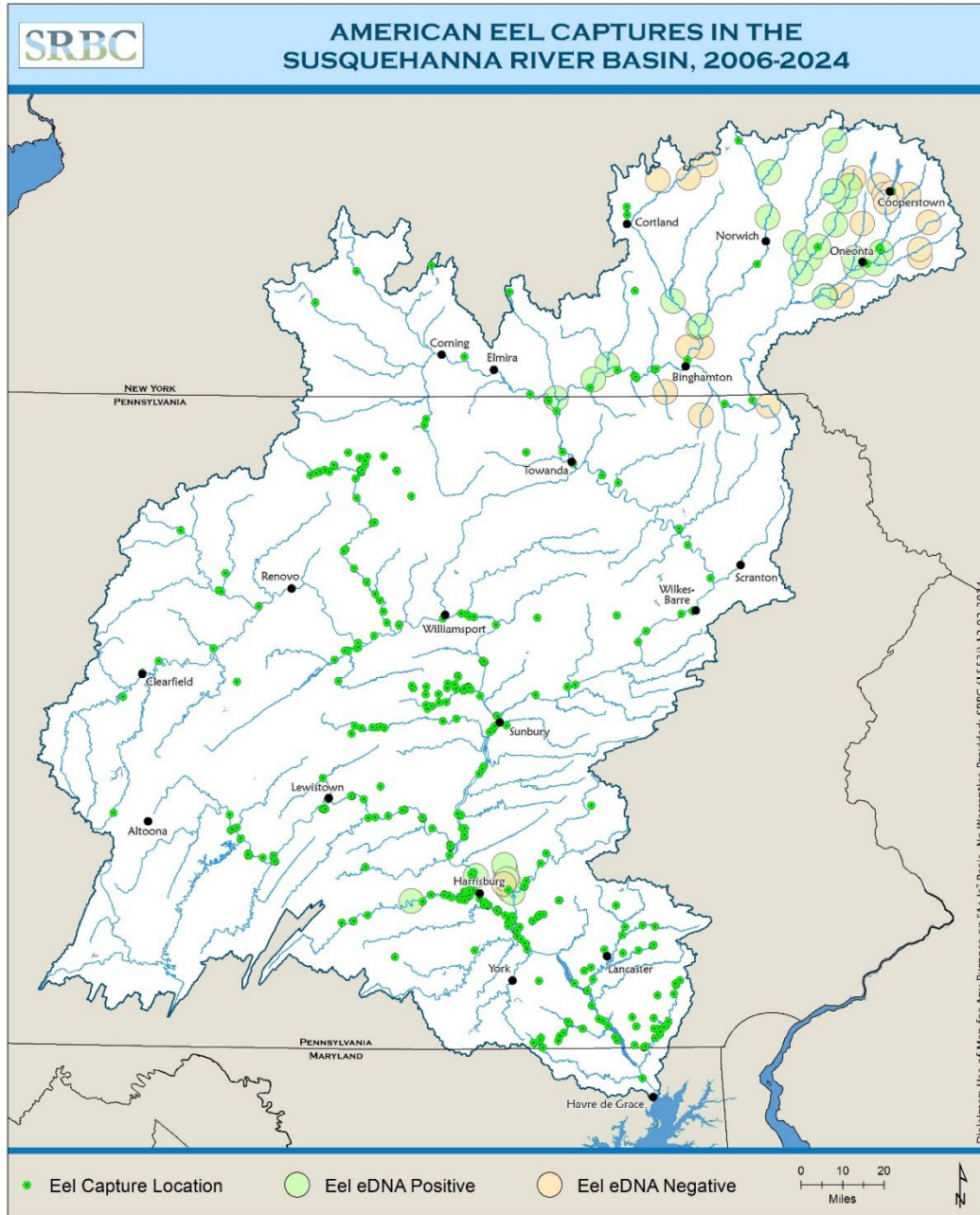


Figure 9. Map of Susquehanna River Basin American Eel Detections 2006-2024

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