

Restoration Monitoring of American Eel (*Anguilla rostrata*) In Three Southcentral Pennsylvania Streams In the Susquehanna River Basin: 2022 Monitoring Data Summary Update

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Aaron Henning
Fisheries Biologist



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 2021. 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 sixth year of post-stocking monitoring conducted in 2022.

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).

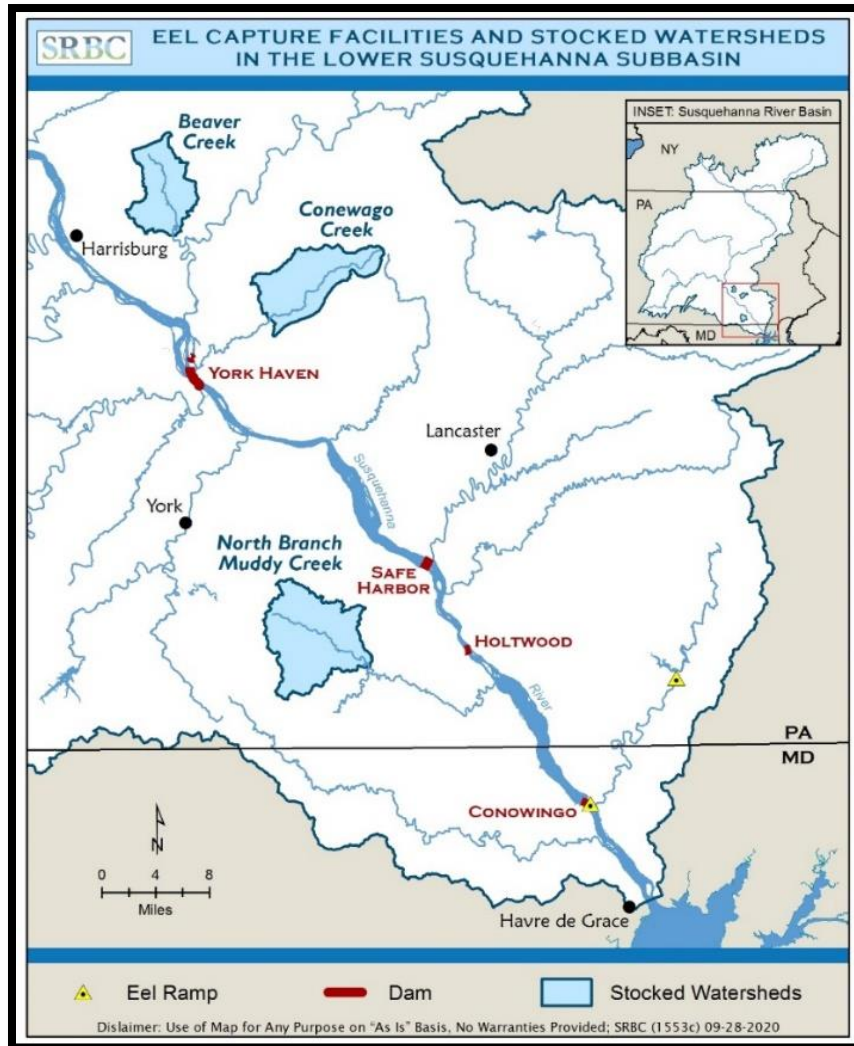


Figure 1. American Eel Stocked Watersheds and Monitoring Locations in the Lower Susquehanna Subbasin

Between May 2016 and June 2017, a total of 48,622 elvers ranging from 1 to 4 years of age 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.

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.

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.

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

American eels continued to be captured at North Branch Muddy Creek and Conewago Creeks. Consistent with previous year's monitoring observations, American eel remain undetected in Beaver Creek.

Overall fish species richness remained unchanged at North Branch Muddy and Beaver Creeks, while Conewago experienced its fourth consecutive year of decreased diversity (Figure 2). In general, the rate of capture also declined slightly at Conewago Creek while increasing at North Branch Muddy and Beaver Creeks (Figure 3).

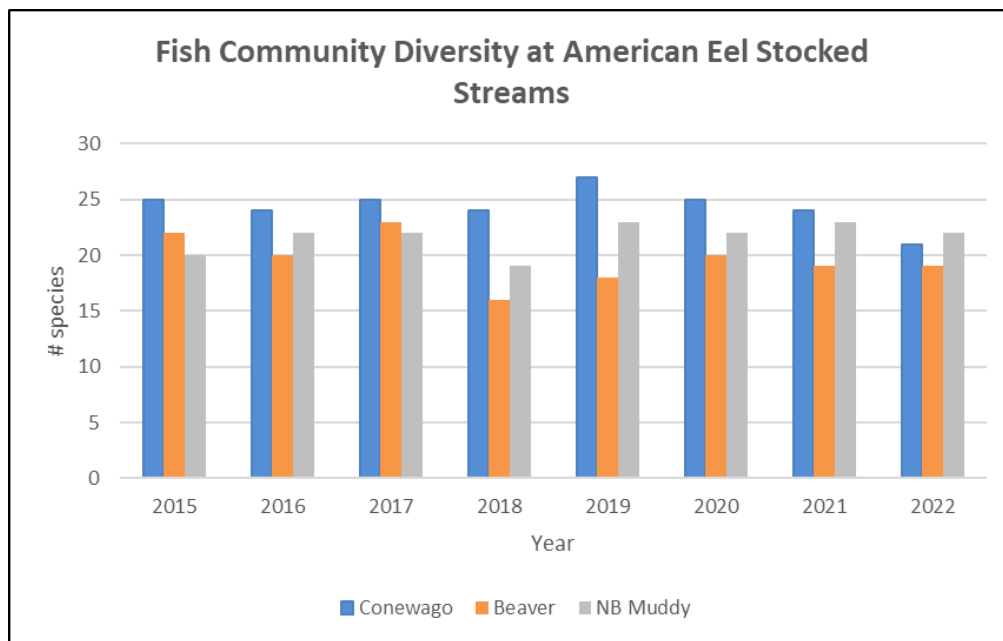


Figure 2. Fish Community Diversity at American Eel-stocked Streams (2015-2022)

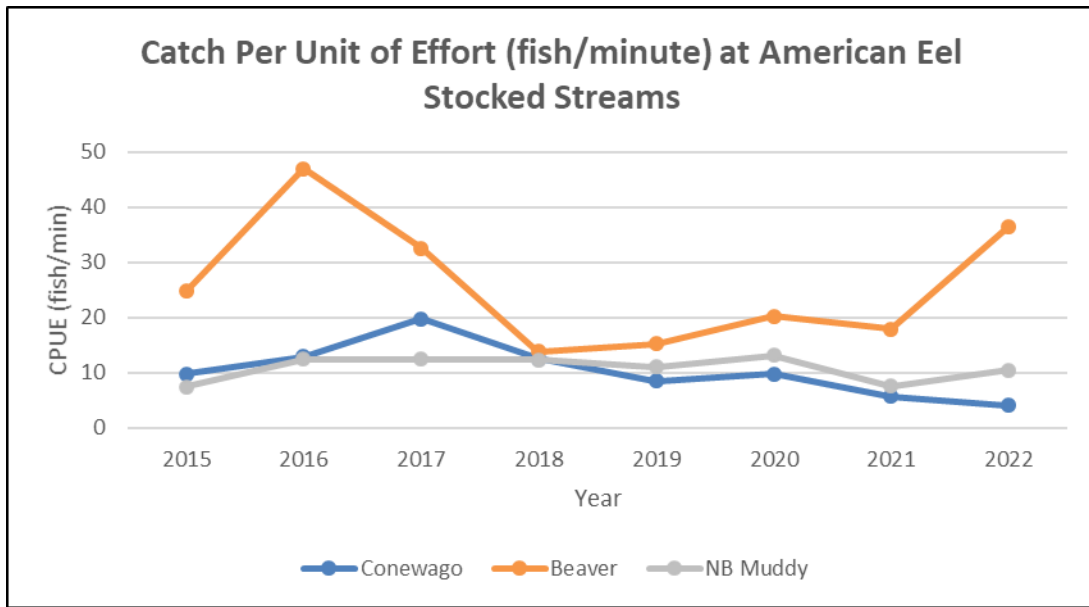


Figure 3. Overall Rate of Capture at American Eel-stocked Streams (2015-2022)

Individual Site Results

North Branch Muddy Creek at Muddy Creek Forks, PA

North Branch Muddy Creek drains 43 square miles of northern and eastern York County (Figure 4). This site is located just upstream of the confluence with South Branch Muddy Creek at Muddy Creek Forks, PA. The watershed’s land use is primarily agricultural crop land (52%), followed by forests and development.

Between May and August of 2016, about 22,000 American eel elvers were stocked at this site. Supported by annual club stockings, North Branch Muddy Creek also supports a naturally reproducing brown trout population. Eight American eels were captured at this site in 2022, including one eel that was tagged in 2019 (Table 2).



Figure 4. View Looking Upstream on North Branch Muddy Creek at Muddy Creek Forks

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)
2016	87	130	NA	1.7	9.3
2017	13	205.1	19.3	0.17	3.31
2018	14	349	85.2	0.21	17.54
2019	10	384	120.9	0.11	13.59
2020	12	465.8	244	0.17	42.12
2021	4	523	293	0.06	18.3
2022	8	212.7	392	0.09	38.6

Beaver Creek at Nyes Road (Harrisburg, PA)

Located in southern Dauphin County, PA, Beaver Creek is an 11-mile long tributary to Swatara Creek. The 27.2-square-mile watershed drains primarily agricultural and increasingly developed lands just east of Harrisburg, PA, before joining the Swatara Creek in Hummelstown, PA.

Just over 9,700 American eel elvers were stocked over the course of two separate events in June 2017. No eels were collected again this year. Beaver Creek is also the only one of the three study sites to have a crayfish community comprised entirely of non-native rusty crayfish (*Faxonius rusticus*). Beaver Creek also possessed the poorest physical habitat of the three sites (Figure 5). A lack of epifaunal substrates and associated fish cover (large woody debris, large boulders) were persistent characteristics of this stream and a presumed contributing factor leading to unsuccessful eel colonization (Table 3).



Figure 5. View Looking Upstream on Beaver Creek at Nyes Road

Table 3. Annual American Eel Results at Beaver Creek

Beaver Creek					
Year	n	avg. length (mm)	avg. mass (g)	CPUE (n/min)	Eel biomass (g/min)
2016	0	NA	NA	NA	NA
2017	3	139.6	5	0.03	0.06
2018	0	NA	NA	0	0
2019	0	NA	NA	0	0
2020	0	NA	NA	0	0
2021	0	NA	NA	0	0
2022	0	NA	NA	0	0

Conewago Creek at Old Hershey Road (Elizabethtown, PA)

Serving as the border between Dauphin and Lancaster Counties, Conewago Creek flows 23 miles from the headwaters in Lebanon County to the mouth at the Susquehanna River in Falmouth, PA (Figure 6). The primary land use in the watershed is agriculture (53%), followed by forest and development. The watershed benefits from the Conewago Creek Initiative, a public-private partnership that has organized restoration efforts to improve water quality through implementation of various best management practices. One eel was captured at this site in 2022 (Table 4).



Figure 6. View Looking Upstream on Conewago Creek at Old Hershey Road

Table 4. Annual American Eel Results at Conewago Creek

Conewago Creek					
Year	n	avg. length (mm)	avg. mass (g)	CPUE (n/min)	Eel biomass (g/min)
2016	0	NA	NA	NA	NA
2017	37	156.8	6.1	0.88	4.8
2018	8	297.9	52	0.11	5.64
2019	6	362.3	72.5	0.07	4.98
2020	11	424.9	156.2	0.18	27.4
2021	7	459	211	0.11	22.2
2022	1	450	175	0.02	2.1

Macroinvertebrate, Crayfish, and Water Quality

Overall biological health of all three stocked streams has slightly improved since the beginning of post-stocking monitoring. Macroinvertebrate IBI scores improved from 2021 to 2022 (Figure 7).

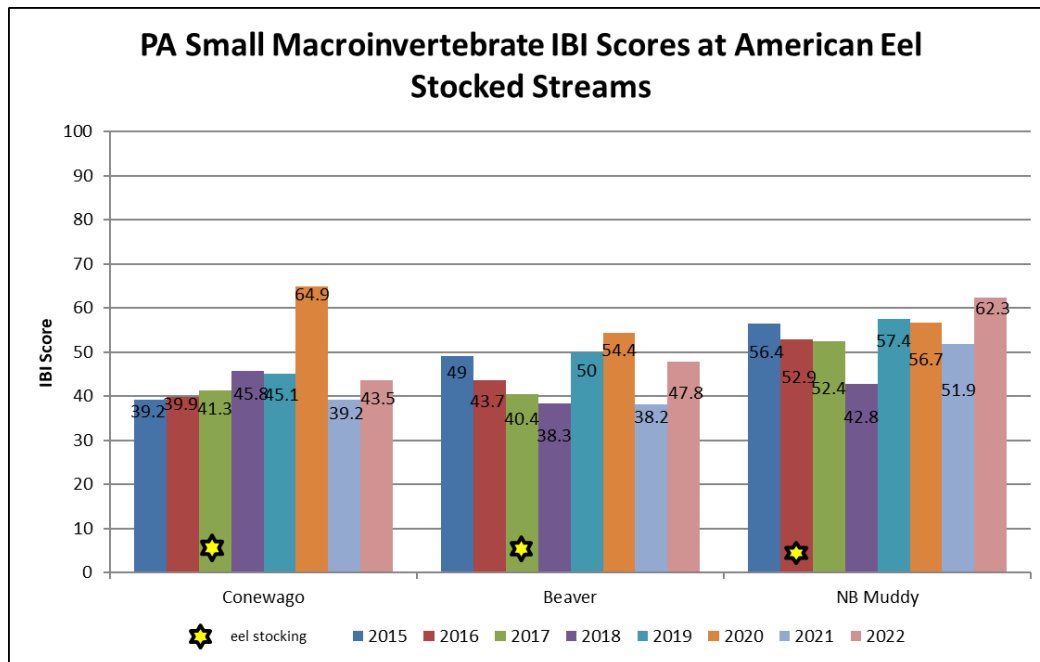


Figure 7. Macroinvertebrate IBI Scores at American Eel-stocked Sites (2015-2022)

Crayfish sampling documented greater overall abundance at Beaver Creek than either Conewago and North Branch Muddy Creeks combined (Figure 8). All crayfish collected at Beaver Creek were invasive Rusty Crayfish (*Faxonius rusticus*), while all other streams were inhabited by the native Allegheny Crayfish (*Faxonius obscurus*).

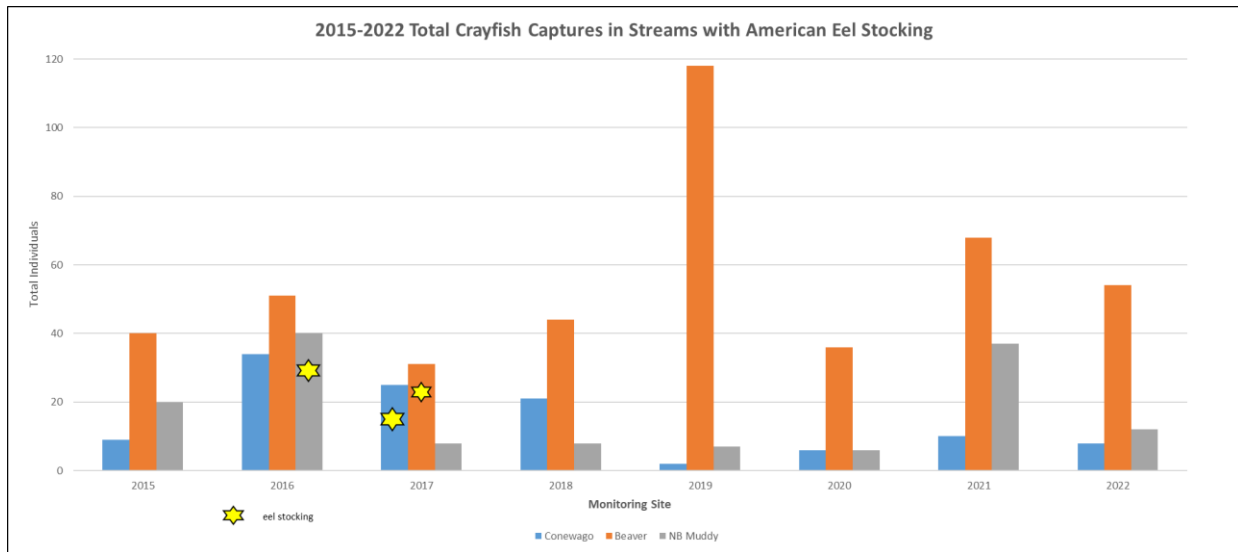


Figure 8. Crayfish Abundance at American Eel-stocked Streams (2015-2022)

Water quality index (WQI) values were compared across sites and seasons in 2022 (Figure 9). North Branch Muddy Creek possessed the best water quality of all three streams followed by Beaver and Conewago Creeks, respectively. These patterns carried across all seasons and is consistent with previous years' monitoring (Henning, 2021).

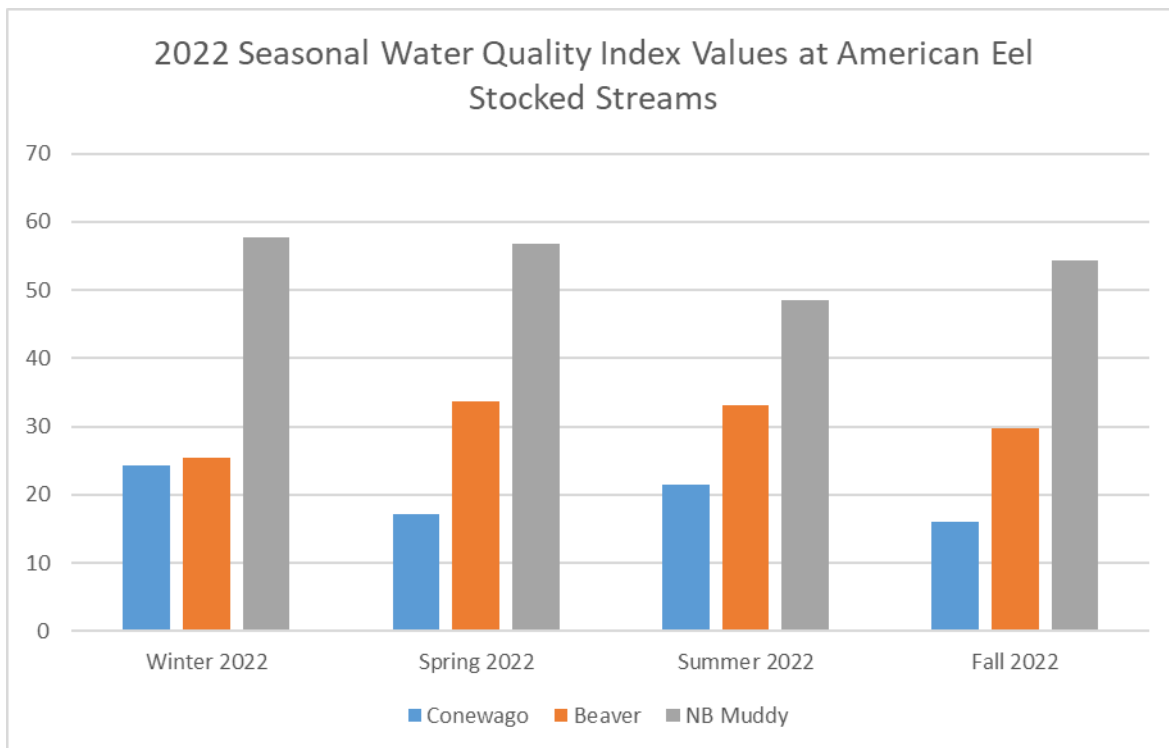


Figure 9. 2022 WQI Values at American Eel-stocked Streams

Overall habitat scores at each site were consistent with scores documented in previous years (Figure 10). Since project inception, North Branch Muddy and Conewago Creeks have shown slight improvements in habitat quality. Beaver Creek trends slightly downward, mainly due to persistently marginal epifaunal substrates and a lack of instream cover. Year-to-year overall site level conditions generally remained static with little to no functionally significant changes since observations began in 2015.

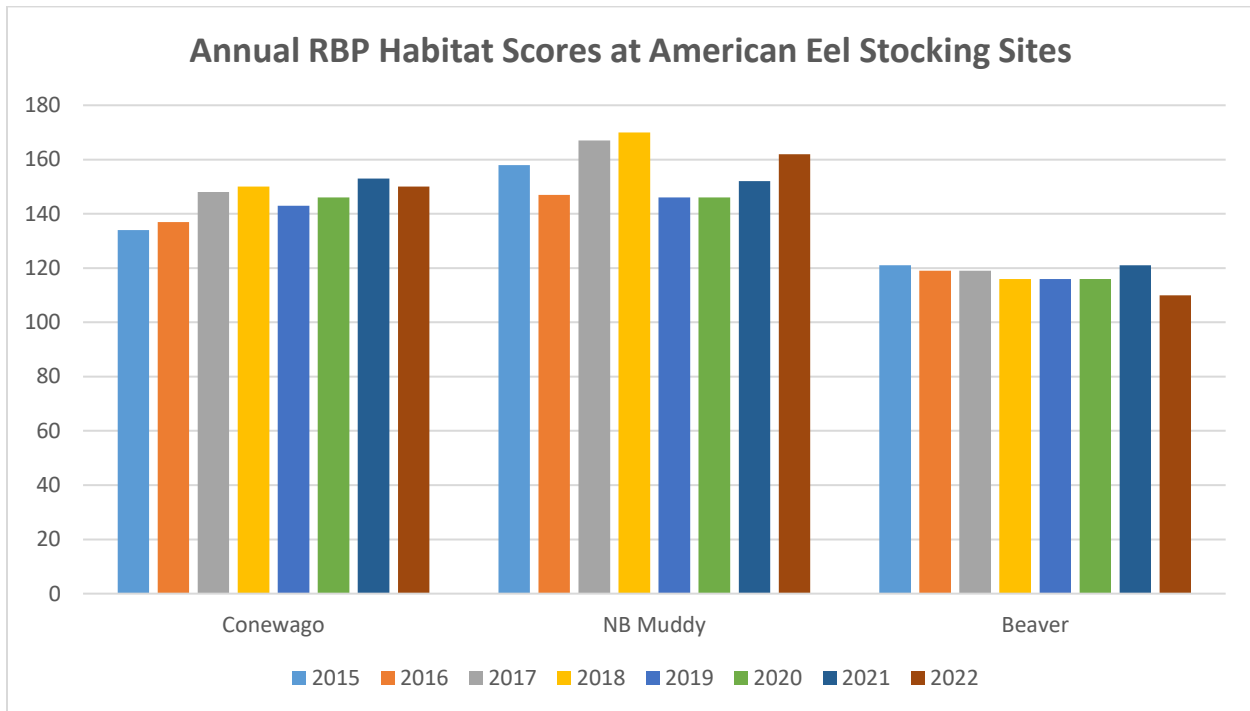


Figure 10. Habitat Scores at American Eel-stocked Streams (2015-2022)

DISCUSSION/CONCLUSIONS

The establishment and occupation of the American eel has been documented at two of the three streams monitored in this study. Both Conewago and North Branch Muddy Creeks have consistently retained and supported eels while Beaver Creek has not. Additional electrofishing surveys within the Beaver Creek Watershed at locations upstream and downstream of the initial stocking location failed to document eels in 2018 and again in 2021 (Normandeau, 2018, 2021). Notably, multiple reports of American eel have originated from points within Swatara Creek, which receives Beaver Creek near Hummelstown, PA (Figure 11).

The failure of Beaver Creek to support eels remains a central issue identified in this monitoring project. While Beaver Creek does have lesser quality habitat sites than the other two sites where eel have successfully established, the differences are not significant enough to fundamentally distinguish Beaver Creek from the others. Relative water quality also does not appear to be a limiting factor in establishment success, as Beaver Creek routinely possesses better water quality conditions than Conewago Creek. Similarly, both Beaver and Conewago Creeks

have depressed macroinvertebrate IBI scores. Additional electrofishing surveys performed at upstream and downstream locations within Conewago Creek have documented eels in 2018, 2020, 2021, and 2022 (SRBC unpublished data).

North Branch Muddy Creek consistently possesses superior water quality, habitat conditions, and a less impaired macroinvertebrate community than either Conewago or Beaver Creeks. In North Branch Muddy Creek and within the greater Muddy Creek Watershed, American eel have been captured at points above and below the initial stocking point near Muddy Creek Forks, PA (Normandeau, 2018, 2021; PFBC personal communication).

The average American eel stocked as part of this experimental study is now over 500 mm long and weighs in excess of 200 g. Ecological impact from the reintroduction of American eel to these streams remains fully undetermined, but this short-term site-level examination suggests little deleterious effects. The pattern of successful upstream and downstream colonization of these watersheds is being mirrored at a larger scale within the greater Susquehanna River Basin. Successful integration into the Conewago and Muddy Creek Watersheds is also consistent with the results of experimental stockings performed by the USFWS in the Pine and Buffalo Creek Watersheds (Minkinen, 2019).

At a basinwide scale, the reintroduction of the American eel to the Susquehanna has been successful. The restoration effort has translocated over two million elvers into the basin with stockings occurring in all three basin states. Eels have been documented throughout the basin, occurring in 59 of the 170 HUC-10 watersheds through 2021 (Figure 11). Eels have been reported from novel, previously unstocked watersheds throughout the basin.

The restoration of American eel is ongoing with annual elver stockings occurring in the mainstem Susquehanna River from May through November. Results of this monitoring work is presented annually to the Susquehanna Anadromous Fish Restoration Cooperative (SRAFRFC) for use in informing the overall stocking strategy. Results from this monitoring project also partially fulfill Objective 3 of the SRAFRFC American Eel Restoration Plan for the Susquehanna River Basin as well as address multiple research priorities outlined within the plan (SRAFRFC, 2013).

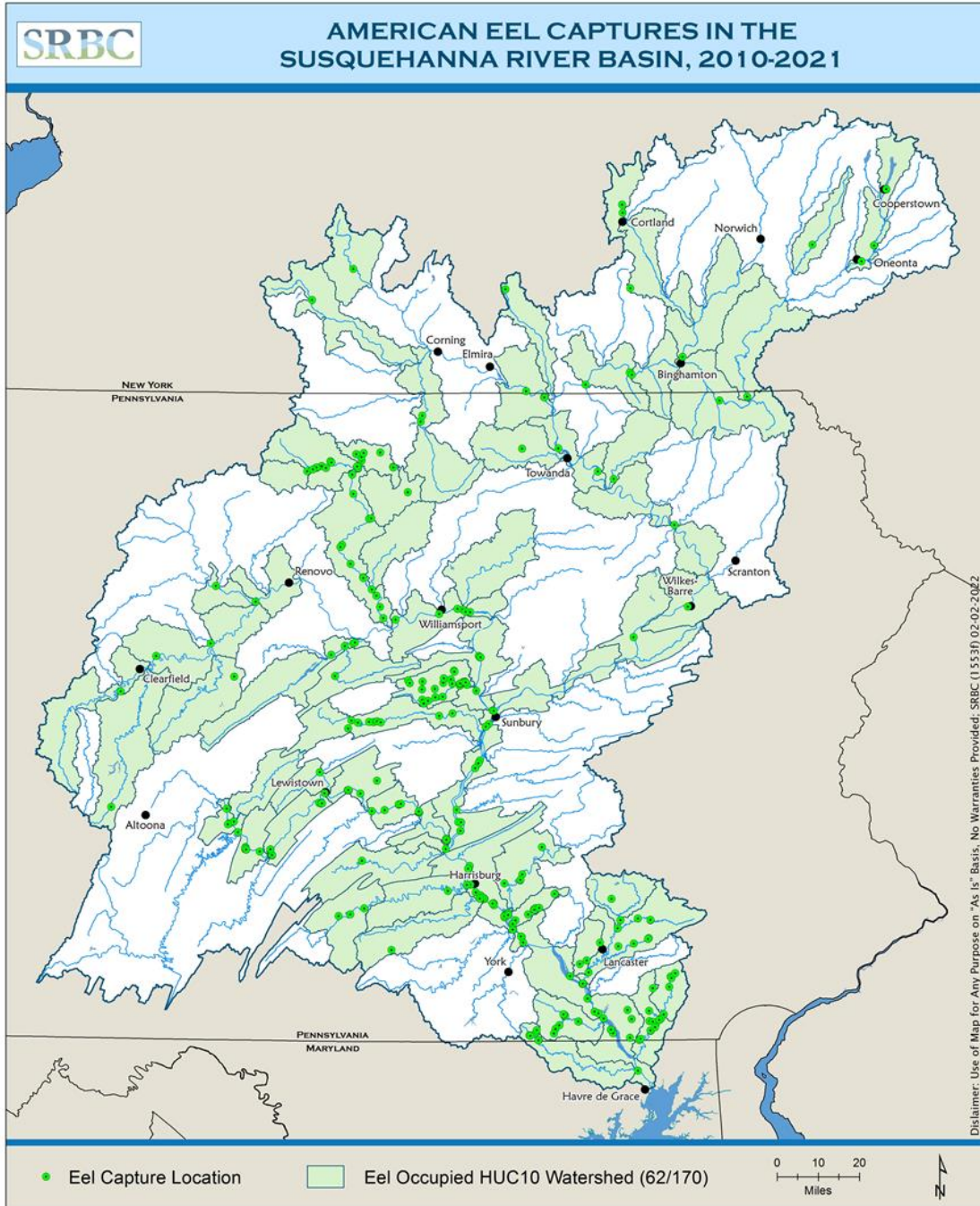


Figure 11. Presence of American Eel in HUC-10s in the Susquehanna River Basin (Henning, unpublished data)

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