

Restoration Monitoring of American Eel (*Anguilla rostrata*) In Three Southcentral Pennsylvania Streams In the Susquehanna River Basin: 2021 Monitoring Data Summary Update

Publication No. 327

November 2022

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 basin-wide 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 US 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 sampling conducted in 2021.

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).

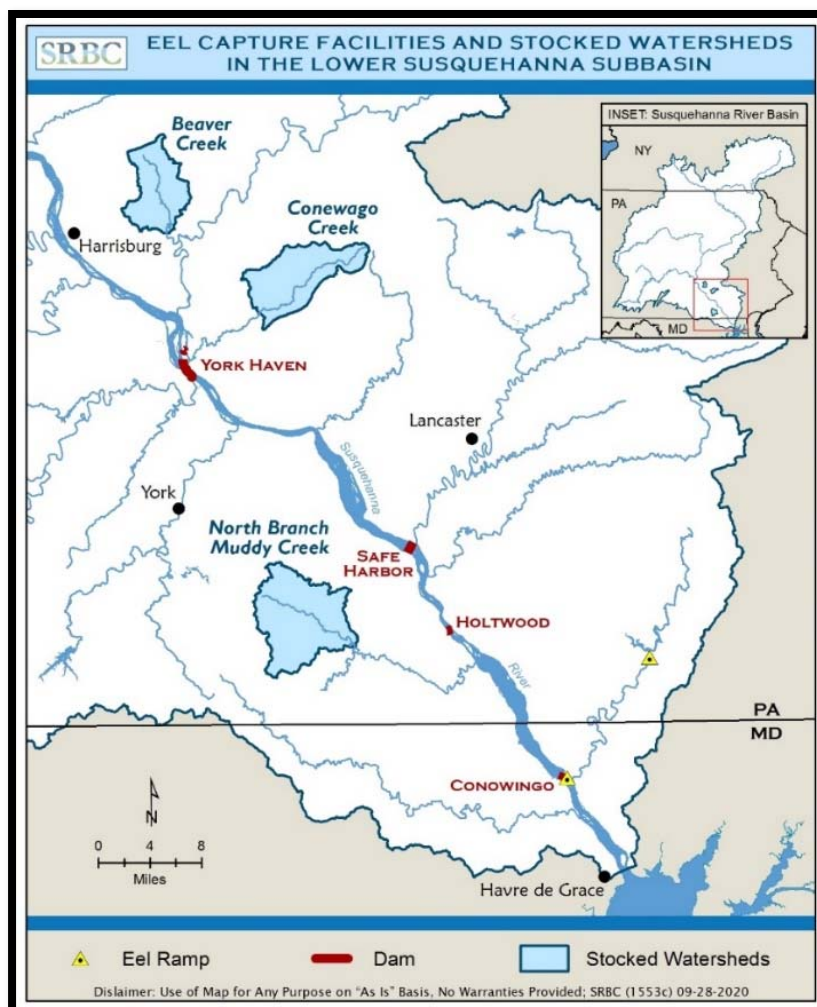


Figure 1. American Eel Stocked Watersheds and Monitoring Locations in the Lower Susquehanna Subbasin

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).

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 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, and estimates of density were calculated. Crayfish were then identified to species and weighed to obtain a biomass value for each species at each site.

Fish community data were collected in the summer via electrofishing. 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 and lab-analyzed 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

Eels

North Branch Muddy Creek at Muddy Creek Forks, PA

North Branch Muddy Creek drains 43 square miles of northern and eastern York County. 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. Four American eels were captured in 2021, including two carrying PIT tags implanted the previous summer (Table 2).



Figure 2. View Looking Upstream on North Branch Muddy Creek at Muddy Creek Forks

Table 2. Average Annual American Eel Length and Mass At North Branch Muddy Creek

NB Muddy Creek			
Year	n	avg. length (mm)	avg. mass (g)
2016	87	130	NA
2017	13	205.1	19.3
2018	14	349	85.2
2019	10	384	120.9
2020	12	465.8	244
2021	4	523	293

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. Notably, no eels have been detected within the Beaver Creek Watershed since three were captured in 2017. 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 3). 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 4).



Figure 3. View Looking Upstream on Beaver Creek at Nyes Road

Table 5. Average Annual American Eel Length and Mass At Beaver Creek

Year	n	avg. length (mm)	avg. mass (g)
2016	0	NA	NA
2017	3	139.6	5
2018	0	NA	NA
2019	0	NA	NA
2020	0	NA	NA
2021	0	NA	NA

Conewago Creek at Old Hershey Rd (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 4). 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.

Seven eels were captured at the site in 2021 (Table 4). Of those seven, three were previously tagged individuals, two from 2020, and one tagged in 2019.



Figure 4. View Looking Upstream on Conewago Creek at Old Hershey Road

Table 4. Average Annual American Eel Length and Mass at Conewago Creek

Year	n	avg. length (mm)	avg. mass (g)
2016	0	NA	NA
2017	37	156.8	6.1
2018	8	297.9	52
2019	6	362.3	72.5
2020	11	424.9	156.2
2021	7	459	211

Site Comparisons of Other Data

Overall habitat scores at each site were consistent with scores documented in previous years (Figure 5). Habitat scores at Beaver Creek are lower than scores at Conewago and North Branch Muddy Creeks, mainly due to persistently marginal epifaunal substrates and a lack of instream cover.

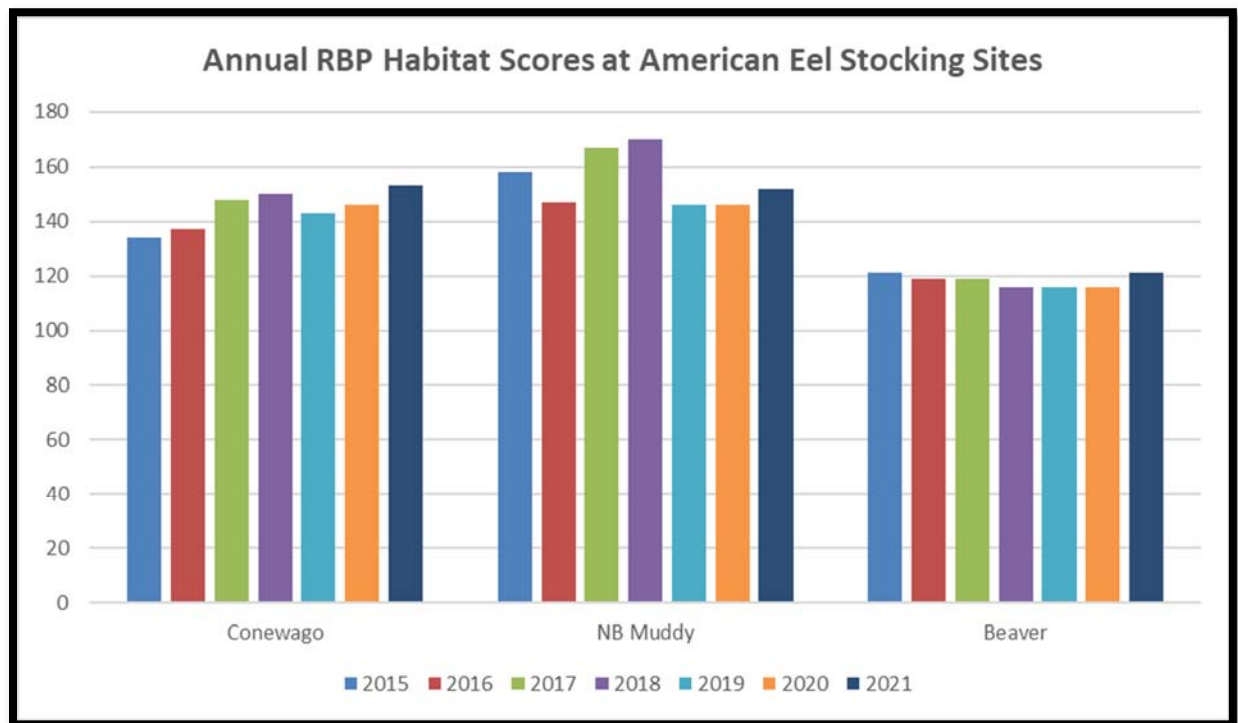


Figure 5. Annual Rapid Bioassessment Protocol Scores At Sites Receiving American Eels

WQI scores at Conewago and Beaver Creeks were lower in Summer 2021 compared to Spring 2021. This pattern existed in Summer and Spring 2020 as well. The lesser water quality at these sites is attributed mainly to the ongoing nutrient enrichment and developmental pressures

within both watersheds. Despite having a higher percentage of agricultural land use in the watershed than the other two sites, nutrient-related water quality impacts are lesser at North Branch Muddy Creek. North Branch Muddy Creek also maintains a persistently higher overall WQI score attributed to lower developmental pressures than the other two sites.

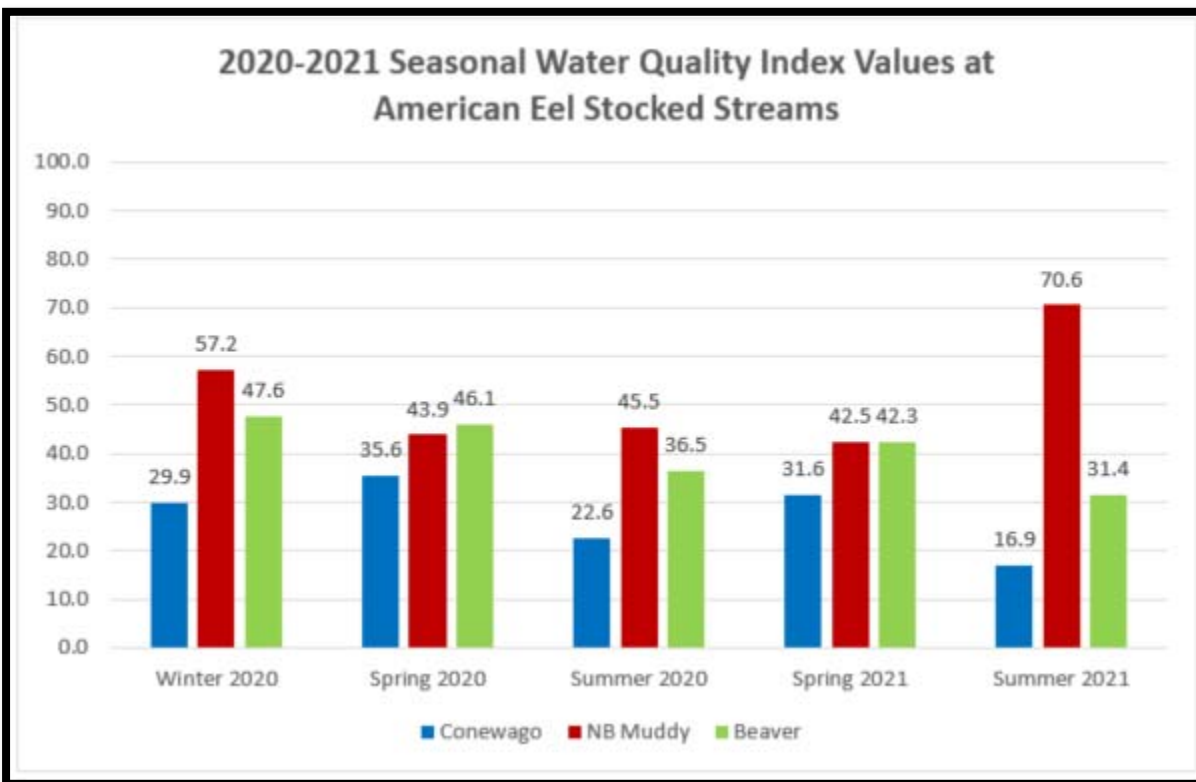


Figure 6. 2020-2021 Seasonal Water Quality Index Values

Macroinvertebrate IBI scores in 2021 were consistent with scores observed since 2015 but were lower than scores seen in 2020 (Figure 7).

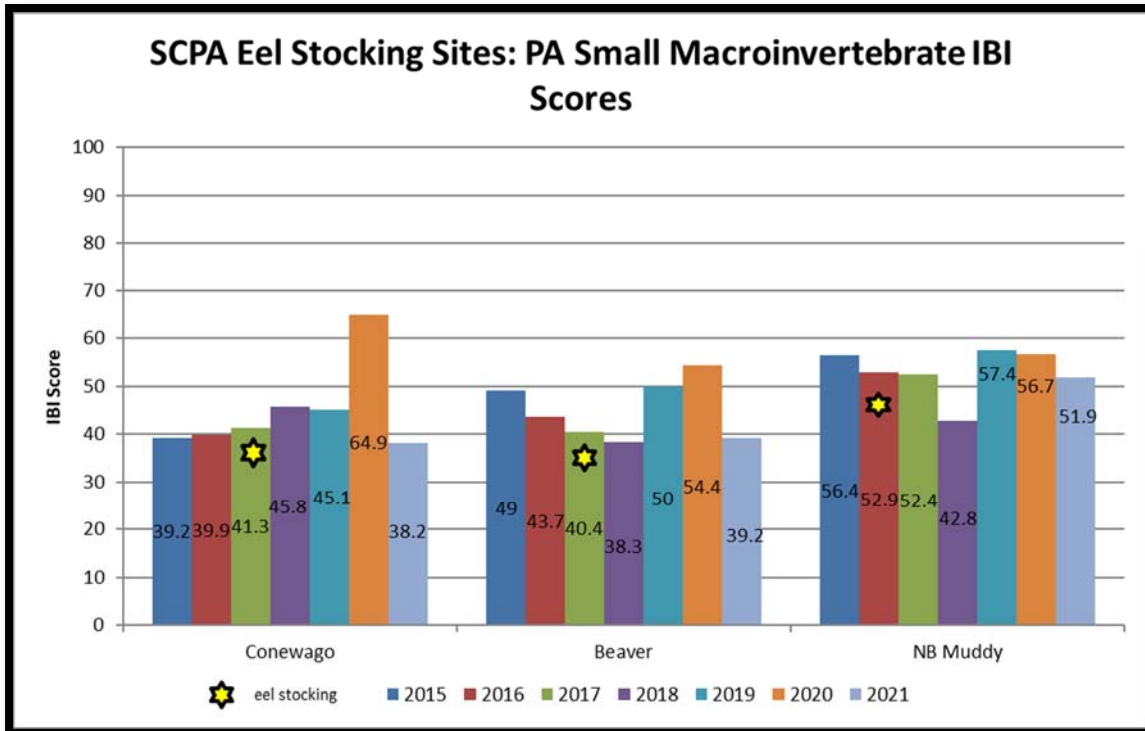


Figure 7. Macroinvertebrate Index of Biological Integrity (IBI) Scores at American Eel Stocking Sites 2015-2021

The number of crayfish collected at sites in 2021 were higher than in 2020 (Figure 8). The greatest number of crayfish were again captured in Beaver Creek, which is dominated by rusty crayfish. No rusty crayfish were observed at the other two sites. Other data regarding biomass and density can be found in Appendix A.

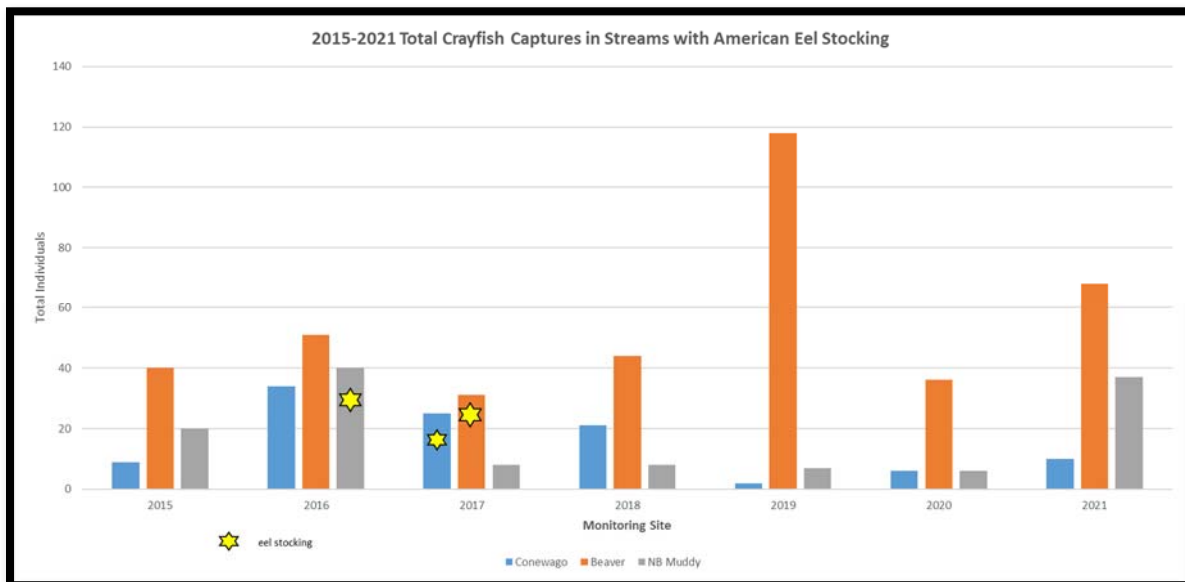


Figure 8. Total Annual Crayfish Captures At American Eel Stocked Streams 2015-2021

DISCUSSION/CONCLUSIONS

The 2021 monitoring year represented the seventh consecutive year of biomonitoring at sites where American eel have been reintroduced. As observed in prior years, American eels have successfully established themselves at North Branch Muddy and Conewago Creeks, accounting for less than two percent of the overall population but contributing over 14 percent of the fish community biomass (Table 5). The size of a typical American eel encountered continues to increase, currently to an average of 482 mm and 240 grams. While eels at these sites had fewer individuals than the previous monitoring year, the relative abundance stayed consistent with 2020 observations. Proportional biomass contributions also declined in 2021 but still exceed 10 percent of the community total. Consistent with previous years, American eel were still not collected at Beaver Creek. Conversely, eels have been captured from North Branch Muddy and Conewago Creeks every year since their reintroduction.

Table 5. Annual American Eel Relative Abundance And Proportional Biomass At Successful Stocking Sites

Year	Conewago		North Branch Muddy	
	Abundance %	Biomass %	Abundance %	Biomass %
2015	0.0	0.0	0.0	0.0
2016	0.0	0.0	13.8	8.3
2017	4.4	2.8	1.4	2.8
2018	2.3	6.6	4.3	22.9
2019	<1.0	4.2	1.0	13.5
2020	1.8	20.2	1.3	40.0
2021	1.3	14.8	1.8	14.0

Habitat conditions within a receiving watershed appear to be one of the plausible limiting variables to successful eel establishment. Future stockings of eels should be targeted towards watersheds containing suitable instream conditions to promote retention of stocked individuals.

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 (Figure 5). Relative water quality also does not appear to be a limiting factor in establishment success, as Beaver Creek routinely possesses higher water quality conditions than Conewago Creek (Figure 6). Similarly, Figure 7 shows depressed macroinvertebrate scores at both Beaver and Conewago Creeks. North Branch Muddy Creek consistently possess superior water quality, habitat conditions and less impaired macroinvertebrate community than either Conewago or Beaver Creeks.

At a basin-wide scale, the reintroduction of the American eel to the Susquehanna has been successful. The restoration effort has translocated over two million elvers into the watershed with stockings occurring in all three basin states. Eels have been documented throughout the watershed, occurring in 59 of the 170 HUC-10 watersheds in the basin (Henning, unpublished data).

Upstream and downstream movement has been demonstrated in North Branch Muddy and Conewago Creeks (Normandeau, 2018). Similarly 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).

REFERENCES

- Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency, Office of Water; Washington, D.C.
- Berry, J., L. Steffy, and M. Shank. 2020. Development of a Water Quality Index (WQI) For the Susquehanna River Basin. Susquehanna River Basin Commission Publication No. 322. Harrisburg, Pennsylvania.
- Henning, A.H. 2021. Restoration Monitoring of American Eel (*Anguilla rostrata*) in Three Southcentral Pennsylvania Streams In The Susquehanna River Basin (2015-2020). Publication No. 326. Susquehanna River Basin Commission. Harrisburg, Pennsylvania.
- Normandeau Associates, Inc. 2018. Muddy Run Pumped Storage Project Periodic Evaluation of Upstream Stream Segments, 2018. FERC Project No. 2355. Prepared for Exelon.
- PADEP. 2013. A Benthic Macroinvertebrate Index of Biological Integrity for Wadeable Freestone Riffle-Run Streams in Pennsylvania. Pennsylvania Department of Environmental Protection. Division of Water Quality Standards.
- Susquehanna River Basin Commission (Commission). 2021. Quality Assurance Work Plan, American Eel Ecological Monitoring, CY 2021. Document Control Number SRBC-QA076. Harrisburg, Pennsylvania.
- Susquehanna River Anadromous Fish Restoration Cooperative. 2013. American Eel Restoration Plan for the Susquehanna River Basin – Addendum to the Susquehanna River Anadromous Fish Restoration Cooperative (SRAFRFC) 2010 Migratory Fish Management and Restoration Plan for the Susquehanna River Basin.

APPENDIX A **Annual Crayfish Data Summary Of American Eel Stocked Streams 2015-2021**

	Group	Site	Total Individuals	Total Biomass (g)	Search Time (s)	CPUE (indv/min)	Density (indv/m ³)	Biomass (g/min)	Biomass (g/m ³)	% Rusty crayfish
2015	SCPA	Cornwago	9	89.2	1050	0.5	0.9	5.10	8.92	0.0
	SCPA	Beaver	40	104.4	738	3.3	4	8.49	10.44	98.0
	SCPA	NB Muddy	20	82.1	892	1.3	2	5.52	8.21	0.0
2016	SCPA	Cornwago	34	46.8	950	2.1	3.4	2.96	4.68	0.0
	SCPA	Beaver	51	220.5	840	3.6	5.1	15.75	22.05	84.0
	SCPA	NB Muddy	40	113.5	1020	2.4	4	6.68	11.35	0.0
2017	SCPA	Cornwago	25	129.5	672	2.2	2.5	11.56	12.95	0.0
	SCPA	Beaver	31	33.1	844	2.2	3.1	2.35	3.31	100.0
	SCPA	NB Muddy	8	55.6	717	0.7	0.8	4.65	5.56	0.0
2018	SCPA	Cornwago	21	43.2	1206	1.0	2.1	2.15	4.32	0.0
	SCPA	Beaver	44	85.1	710	3.7	4.4	7.19	8.51	100.0
	SCPA	NB Muddy	8	20.7	1273	0.4	0.8	0.98	2.07	0.0
2019	SCPA	Cornwago	2	1.5	768	0.2	0.2	0.12	0.15	0.0
	SCPA	Beaver	118	312.1	778	9.1	11.8	24.84	32.21	100.0
	SCPA	NB Muddy	7	8.7	884	0.5	0.7	0.59	0.87	0.0
2020	SCPA	Cornwago	6	2.4	892	0.4	0.6	0.16	0.24	0.0
	SCPA	Beaver	33	145.6	628	3.2	3.3	13.91	14.56	100.0
	SCPA	NB Muddy	6	10.0	803	0.4	0.6	0.75	1.00	0.0
2021	SCPA	Cornwago	10	4.3	739	0.8	1	0.35	0.43	0.0
	SCPA	Beaver	68	68.6	696	5.9	6.8	5.91	6.86	100.0
	SCPA	NB Muddy	37	25.0	608	3.7	3.7	2.46	2.50	0.0