U.S. Fish & Wildlife Service Susquehanna River American Shad (*Alosa sapidissima*) Restoration: Potomac River Egg Collection, 2017

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Abstract

During April and May 2017, monofilament gill nets were used to collect spawning ready American shad (*Alosa sapidissima*) from the Potomac River, Maryland. Mature adults were strip-spawned on the river and fertilized eggs were provided to Pennsylvania's Van Dyke American shad hatchery in support of Susquehanna River American shad restoration. Sampling consisted of 22 days, during which 4,819 adult American shad were collected, with 2,412 of those adults used for spawning. A total of 330.9 L of American shad eggs (~14.42 million) with a 29.6% fertilization rate resulted in approximately 4.26 million viable eggs that were used for stocking into the Susquehanna River.

Introduction

American shad (*Alosa sapidissima*) are an anadromous, pelagic fish species that range along the Atlantic coast from Labrador, Canada to Florida, United States of America (U.S. Fish and Wildlife Service 2006). American shad are the largest of the clupeids native to North America (Stier and Crance 1985) and an important planktivore and prey species for Bluefish (*Pomatomus saltatrix*) and Striped bass (*Morone saxatilis*; U.S. Fish and Wildlife Service 2006). American shad return to their natal river to spawn after four to six years maturing at sea. Spawning movements follow a latitudinal cline and, although variable, generally peak at water temperatures of 14 to 21 ^{o}C (Stier and Crance 1985). Generally, April is the peak spawning month for American shad in the Potomac River, Maryland.

Shad were once a valuable resource for Native Americans and have been economically important since European colonization of North America. In Pennsylvania, American shad are said to have once ruled the waters of the Susquehanna River and its tributaries (The Native Fish Conservancy 2005). However, over the past century, American shad populations have declined for a number of reasons. Initial population declines resulted from increased commercial harvest coinciding with increases in human population and gear efficiency. Habitat loss (impoundments) and degradation (pollution) followed and remain today as significant challenges to restoration. Attempts to mitigate impoundment effects on American shad and other Susquehanna River species began in 1866. In that year Pennsylvania enacted the Act of March 30, 1866, which formed what is today the Pennsylvania Fish and Boat Commission (PFBC), and began over a century of fish passage efforts on the Susquehanna River (The Native Fish Conservancy 2005).

The U.S. Fish and Wildlife Service (Service) is partnered with state, Federal, and hydro-power companies, through the Susquehanna River Anadromous Fish Restoration Cooperative to restore American shad to the Susquehanna River watershed. The Service's current Potomac River egg harvest operation is part of this forty-five year, multi-agency restoration effort. The Service's Maryland Fish and Wildlife Conservation Office's (MDFWCO) role is to deliver viable American shad eggs to the Van Dyke American shad hatchery near Thompsontown, Pennsylvania. There, the eggs are incubated until hatching and fry are grown and marked before stocking into the Susquehanna River drainage.

Study Area

The Potomac River is approximately 1.5 km wide at Marshall Hall, Maryland (rkm 150), where American shad gill netting occurs. The collection site is bounded by Dogue Creek (North) and Gunston Cove (South) and has long been linked to shad harvest and culture. The river is tidal within this area, but remains fresh throughout the spring. Bottom habitat is characterized by an abrupt transition from the deep channel (≈ 18.3 m) area to relatively shallow depths (≤ 3.5 m). Channel substrate consists of firm, sandy, mud with intermittent shell. Sand increases in the shoal area forming a comparatively harder substrate.

Materials and Methods

Two boats with a crew of three to four each fished for American shad nightly. Four different sized, monofilament, floating gill nets were used in 2017. A 14.0 cm (5.5 in) stretch mesh net was used to target ripe females and was 6.1 m deep by 91.4 m long (female net). The net used to target males was 11.7 cm (4.6 in) stretch mesh and 5.2 m deep by 91.4 m long (male net). A third type of net was used to target males and smaller females. This net had 12.7 cm (5.0 in) stretch mesh and was 5.8 m deep by 91.4 m long (unisex net). A fourth net type was added in 2017 for targeting American shad in shallow water. It had 12.7 cm (5.0 in) stretch mesh and was 2.4 m deep by 91.44 m long (shallow net). Each boat set up to five nets, with at least one net of each type per boat. Nets were joined in series and drifted parallel to shore in water depths ranging from approximately 3.0 to 12.2 m. Fishing began nightly approximately 1 hour before evening slack tide. Multiple sets were made nightly with each set consisting of one to three net quantities/mesh size. Each net set was fished for 10-20 minutes, emptied, and reset. Net sets per night ranged from two to seven, with an average of four. Strip spawning was typically conducted between net set retrievals.

Tidal condition (transitioning high or low) was noted and surface temperature (^{o}C), dissolved oxygen (mg/L), and salinity (ppt) were recorded (Yellow Springs Instruments Model Pro 2030) each night (Figure 1). The numbers of running, green, or spent female American shad, ripe male American shad, and all bycatch (by species) were recorded (Table 2). Gill net effort (minutes fished) was recorded but varied since the goal was to maximize catch during each sampling event. American shad catch per unit effort (CPUE) was calculated by sex (male, ripe female, green female) and net type fished (male, female, unisex, shallow unisex) per total net square footage and time fished (CPUE= [n/hr/m^2]). For ease of interpretation, all CPUE values were multiplied by a scalar of 1,000. A sub-sample of American shad (*n*=100, 4.2% of fish kept for spawning) were measured for total length (nearest mm) and weight (nearest 0.01 kg), and otoliths were extracted for aging, as a permit requirement of the Potomac River Fisheries Commission (PRFC). In addition, we stocked 12.8% (48.7 L) of all eggs stripped from American shad back into the Potomac River, as another permit requirement by PRFC.

Results

During spring 2017, the Potomac River was sampled a total of 22 days from 3 April through 4 May. Water temperature remained below 15°C from 3 April to 11 April, then stayed between 15-20°C from 12 April to 27 April, followed by an increase to 23°C on 30 April when it then stayed between 21-23°C for the remainder of sampling period. (Figure 1). Surface water temperatures ranged from 13.3 to 23 ^{o}C ($\bar{x}$ = 17.8 ^{o}C) while dissolved oxygen ranged from 5.5 to 12.9 mg/L ($\bar{x}$ = 8.5 mg/L; Figure 1).

Throughout the sampling period, we made 19 egg shipments between 4 April and 4 May (86% of fishing nights). A total of 330.9 L (range = 3.9–40.1 L, $\bar{x}$ = 17.4 L/shipment) of eggs were shipped from the Potomac River (J. Tryninewski, PFBC, personal communication). The overall egg viability was 29.6%, although daily shipments had a range of 6.8–67.4%. This resulted in the production of 4.26 million larvae for stocking into selected tributaries (Table 1) of the Susquehanna River (J. Tryninewski, PFBC, personal communication).

Gill netting captured 8,066 fish from the Potomac River, representing twelve fish species (Table 2). American shad comprised 59.7% of all fish caught, with gizzard shad the next largest portion of the catch (37.9%). Green female American shad were more common than ripe females with a ratio of 1.6:1, but ripe females were more common than males with a ratio of 1.4:1 (Table 2, Figure 3).

Catch per-unit-effort (Table 4) was highest for male American shad in our male nets (11.7 cm stretch). Highest CPUE for ripe females was from our shallow unisex nets

(12.7 cm stretch mesh). Female nets (14.0 cm stretch mesh) produced the lowest CPUE values for both sexes and spawning conditions of American shad.

Discussion

American shad collection numbers were sufficient to yield eggs shipments for 19 out of 22 fishing nights (86%). In regards to all years of egg collection efforts, 2017 produced the second highest volume of overall eggs collected and fourth highest overall volume of viable eggs. It is likely that variability in availability of male shad inhibited egg shipment viabilities. A weak, albeit positive correlation was observed between the ratio of male shad to ripe shad and the viabilities of egg shipments (Figure 5). Male shad were caught in relatively high numbers during the beginning of the fishing season, but then declined during the time period when ripe females were most abundant. (Figure 1).

Shallow unisex nets were used for the first time in 2017 as a novel method for targeting shad in shallower water. While the shallow nets did occasionally catch high numbers of target fish, there was high variability in catches. The shallow nets also produced the highest CPUE's for gizzard shad over the season compared to all other net types, therefore crews had a tendency to avoid their use.

Bycatch abundances were low enough as to not hinder successful egg collection as it has in other years. In 2016 crews had difficulties with both high abundances of gizzard shad, as well as issues with commercial gear entanglement on the fishing grounds, neither of which caused notable problems for crews in 2017.

Water temperatures (Figure 1) remained within the ideal range for successful American shad spawning for the majority of the fishing season, likely leading to relatively successful egg shipment volumes (Table 3).

Conclusion

The Service provided Pennsylvania with 330.9 L of eggs, with an overall viability of 29.6% (~4.26 million viable eggs; see Project Summary results below from previous years). The 2017 overall viability was below the ten year average (36%) and was the fifth lowest viability in the history of the program; 2013 was the lowest at 21%.

Project Summary

Over the past eleven years the USFWS has provided Pennsylvania with ~2,482 liters of eggs with an average viability of 36%, resulting in the production of over 41 million viable shad eggs.

Acknowledgements

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Table 1. Annual egg volumes, viable counts, and viabilities.

Year	Volume (L)	Viable Eggs (N)	Viability (%)
2017	330.9	4,264,317	30%
2016	165.6	2,138,510	26%
2015	170.6	2,044,013	23%
2014	316.7	5,671,992	39%
2013	118.1	1,603,498	21%
2012	258	5,664,920	51%
2011	137.4	2,714,435	44%
2010	375	6,874,712	39%
2009	132.2	1,885,500	30%
2008	194.4	3,491,069	41%
2007	183.9	2,875,455	42%
2006	99.3	2,003,222	44%

Table 2. List of species and number sampled (count) in gill nets from the Potomac River, MD during spring 2017.

Common Name	**Scientific Name**	**Count**
American shad	*Alosa sapidissima*	4819
Atlantic menhaden	*Brevoortia tyrannus*	2
Blue catfish	*Ictalurus furcatus*	52
Brown bullhead	*Ameiurus nebulosus*	1
Channel catfish	*Ictalurus punctatus*	3
Common carp	*Cyprinus carpio*	7
Gizzard shad	*Dorosoma cepedianum*	3061
Largemouth bass	*Micropterus salmoides*	1
Longnose gar	*Lepisosteus osseus*	13
Quillback	*Carpoides cyprinus*	1
Sea lamprey	*Petromyzon marinus*	4
Striped bass	*Morone saxatilis*	102

Table 3. Daily American shad (*Alosa sapidissima*) catch totals, with number of liters stocked/shipped to Van Dyke Hatchery and the associated viability of the shipment for spring 2017 (Note: Viability is only for eggs shipped to hatchery, for eggs stocked the viability is unknown).

Date	Males	Ripe Females	Green Females	Liters Stocked	Liters Shipped	Viability (%)
4/3/2017	165	10	22	1.2	-	-
4/4/2017	73	15	22	3	3.9	43.6
4/5/2017	21	46	53	-	14.7	67.4
4/6/2017	27	45	49	-	18.0	35.9
4/9/2017	71	33	14	-	8.1	45.0
4/10/2017	23	21	24	-	6.2	42.6
4/11/2017	53	30	26	-	7.5	27.0
4/12/2017	52	97	267	-	30.5	52.7
4/13/2017	101	99	332	-	26.0	22.9
4/16/2017	37	171	259	2.4	34.0	6.8
4/17/2017	63	67	74	-	31.2	43.3
4/18/2017	15	89	153	4.5	26.9	45.6
4/19/2017	32	120	94	-	40.1	15.7
4/23/2017	22	64	94	11	8.3	17.0
4/25/2017	40	105	62	13.75	9.7	45.3
4/26/2017	26	68	110	-	13.6	52.1
4/27/2017	80	67	36	-	12.0	20.6
4/30/2017	18	33	142	-	10.4	23.6
5/1/2017	1	31	43	-	-	-
5/2/2017	1	22	111	-	-	-
5/3/2017	58	96	173	12.85	18.0	13.9
5/4/2017	21	83	120	-	11.8	9.7
Totals	**1000**	**1412**	**2280**	**48.7**	**330.9**	

Table 4. Average daily catch per unit effort (CPUE; fish/hour/m^2) for spawning condition American shad caught during Potomac River, MD gillnetting in spring 2017. Note: all values were multiplied by a scalar of 1,000.

CPUE		
Males	Sh. Unisex Net	20.87
	Male Net	39.39
	Unisex Net	19.06
	Female Net	1.44
Ripe Females	Sh. Unisex Net	60.84
	Male Net	39.23
	Unisex Net	24.77
	Female Net	8.33
Green Females	Sh. Unisex Net	48.90
	Male Net	95.16
	Unisex Net	31.48
	Female Net	12.88

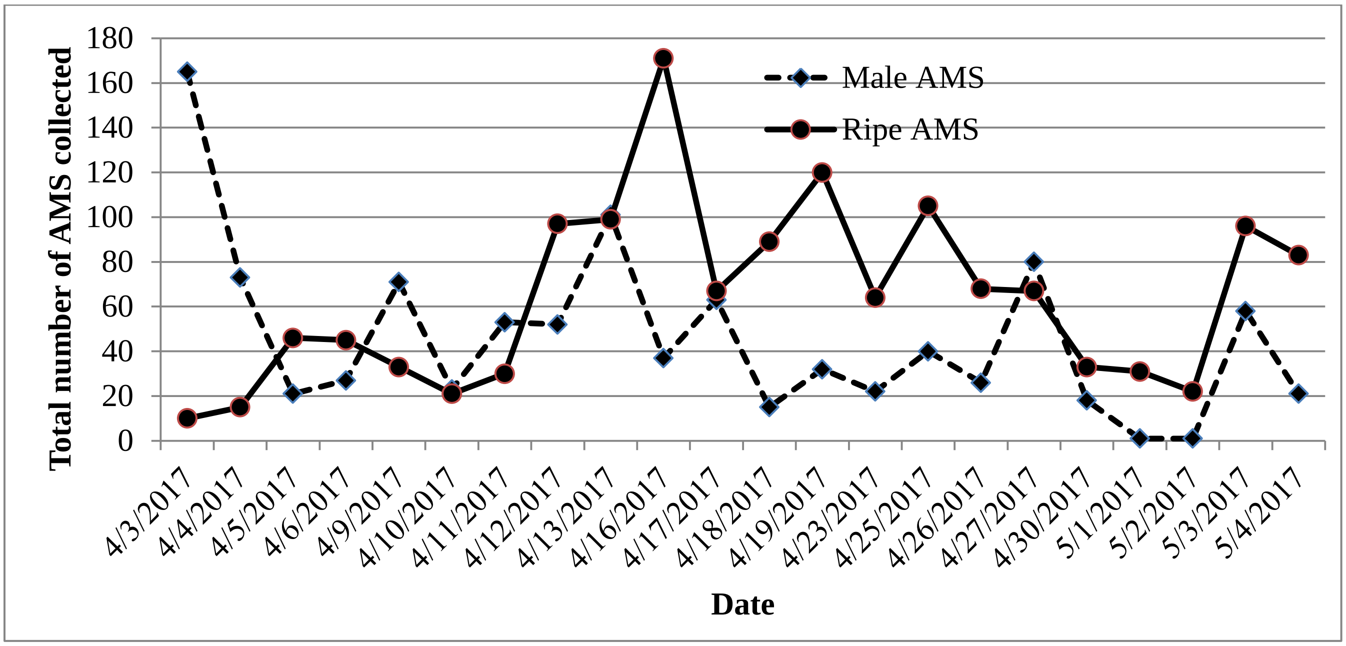

Figure 1. Total nightly catches of male and ripe AMS during fishing season.

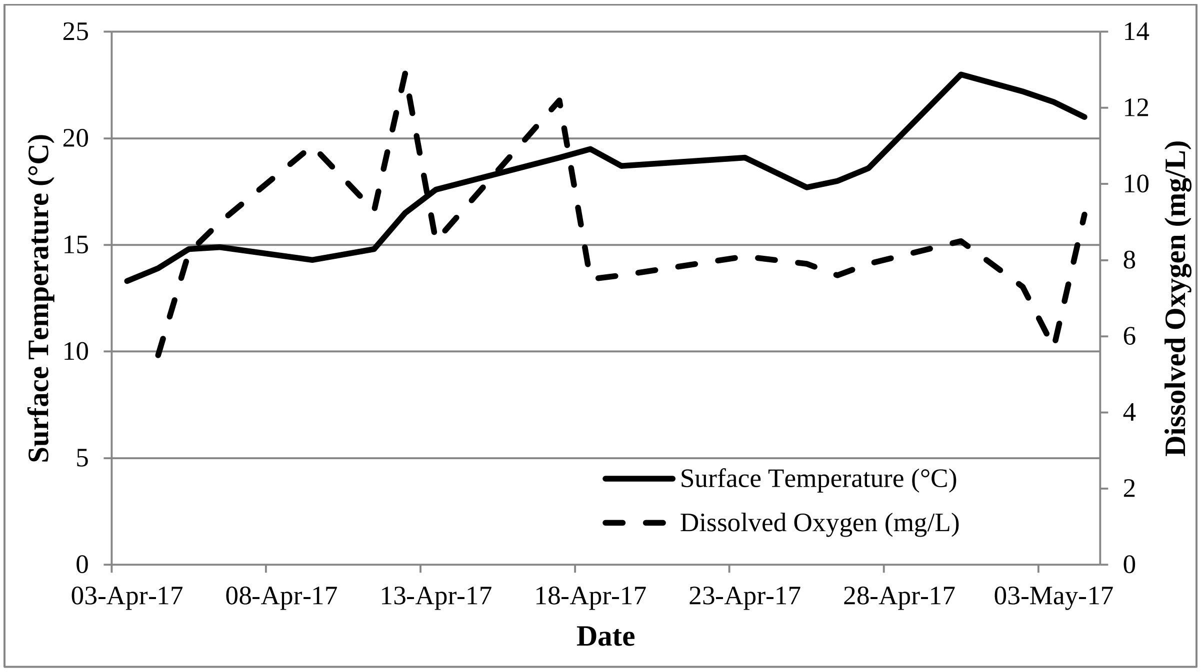

Figure 2. Spring 2017 Potomac River, Maryland surface water temperature (^{o}C) and dissolved oxygen (mg/L) measurements taken during American shad (*Alosa sapidissima*) gill netting.

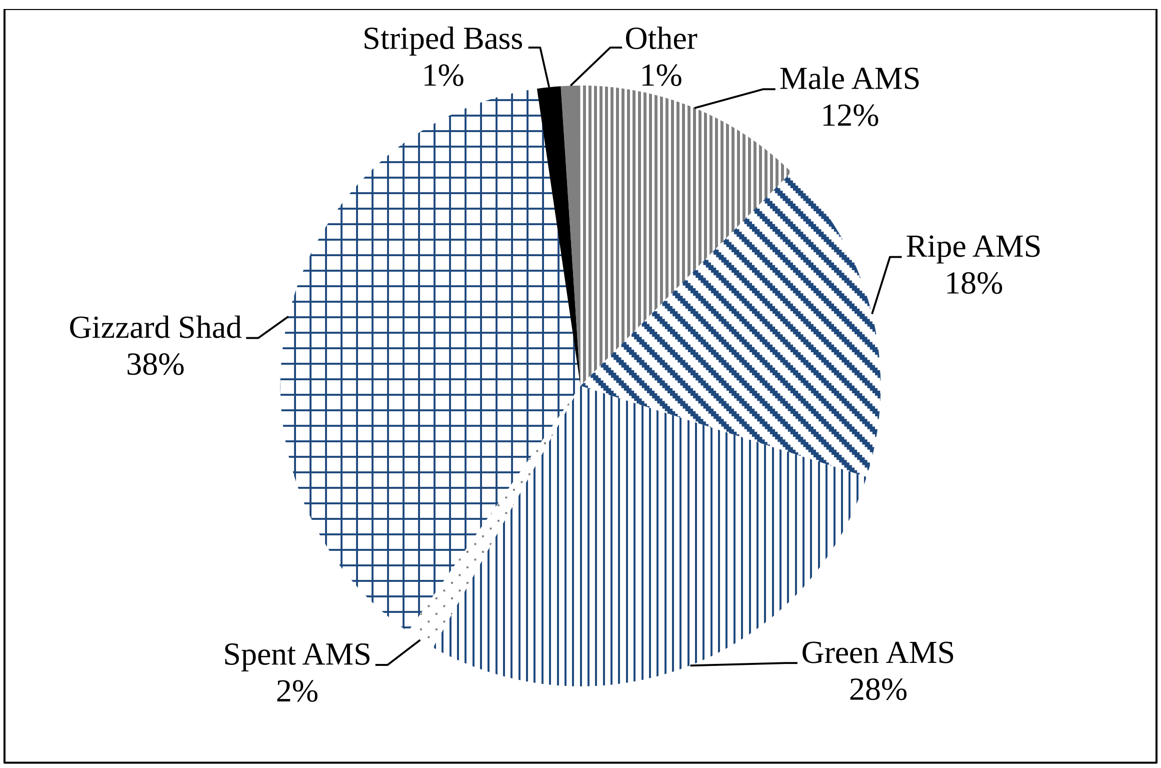

Figure 3. Spring 2017 species composition from Potomac River, MD gill net sampling. Other species, scientific names, and counts are listed in Table 1.

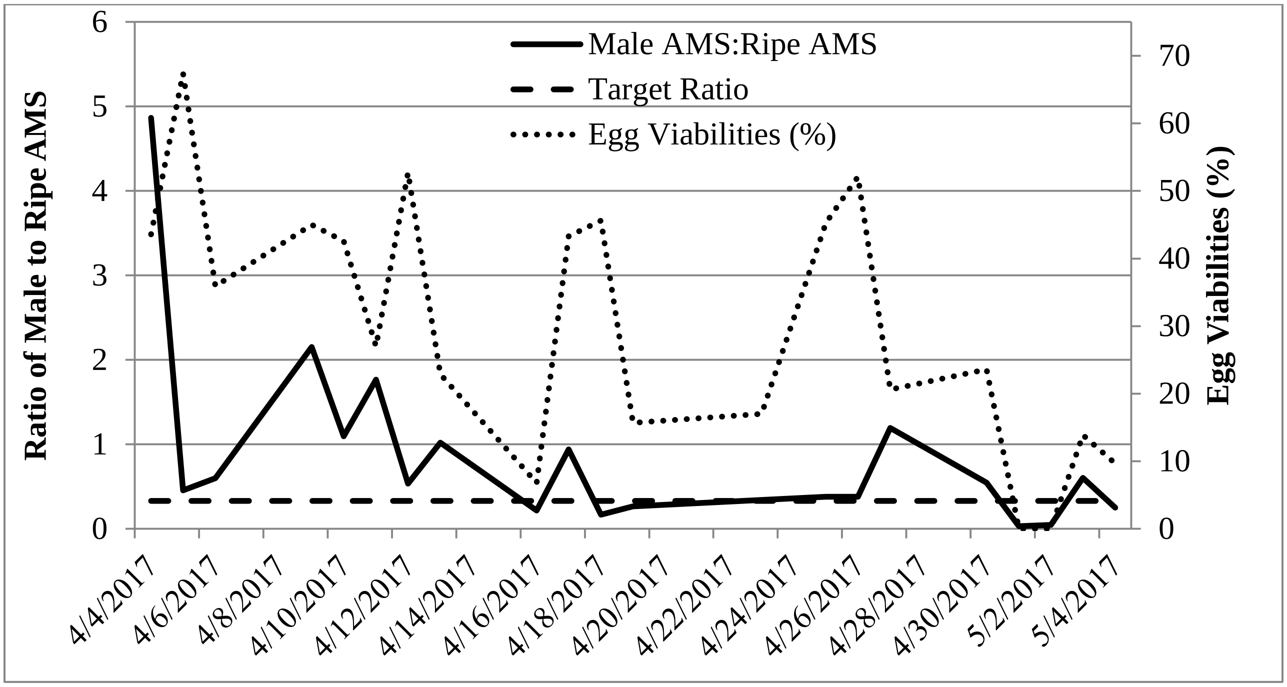

Figure 4. 2017 American shad male to female ratios and egg shipment viabilities. Note: 4/3 not depicted (ratio M:F=16.5, no egg shipment)

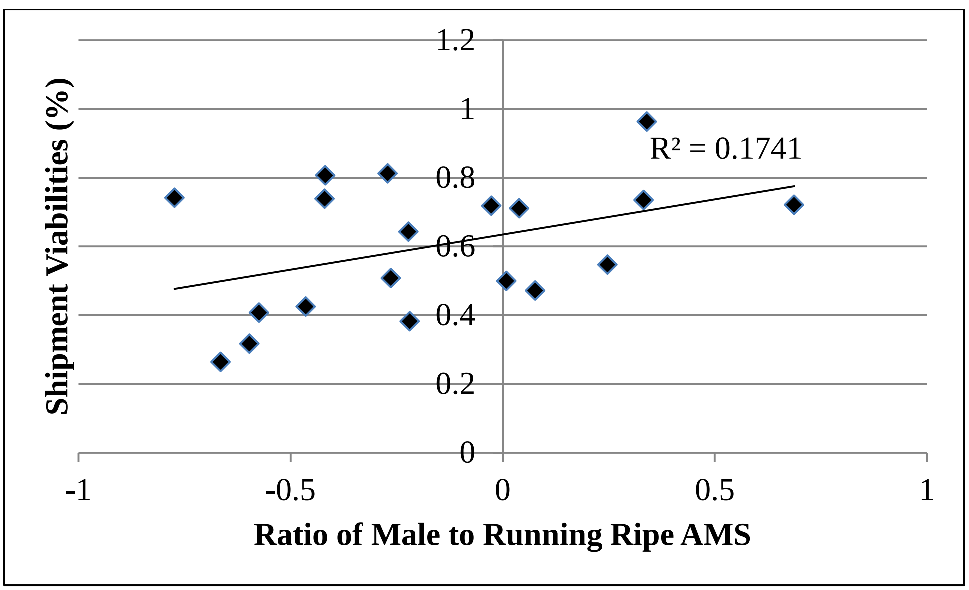

Figure 5. Scatterplot depicting weak positive correlation between ratio of male to ripe female AMS and egg shipment viabilities. Note: Shipment viability values were transformed using arcsine square root, and ratios of male to ripe females were transformed using $\log_{10}$.

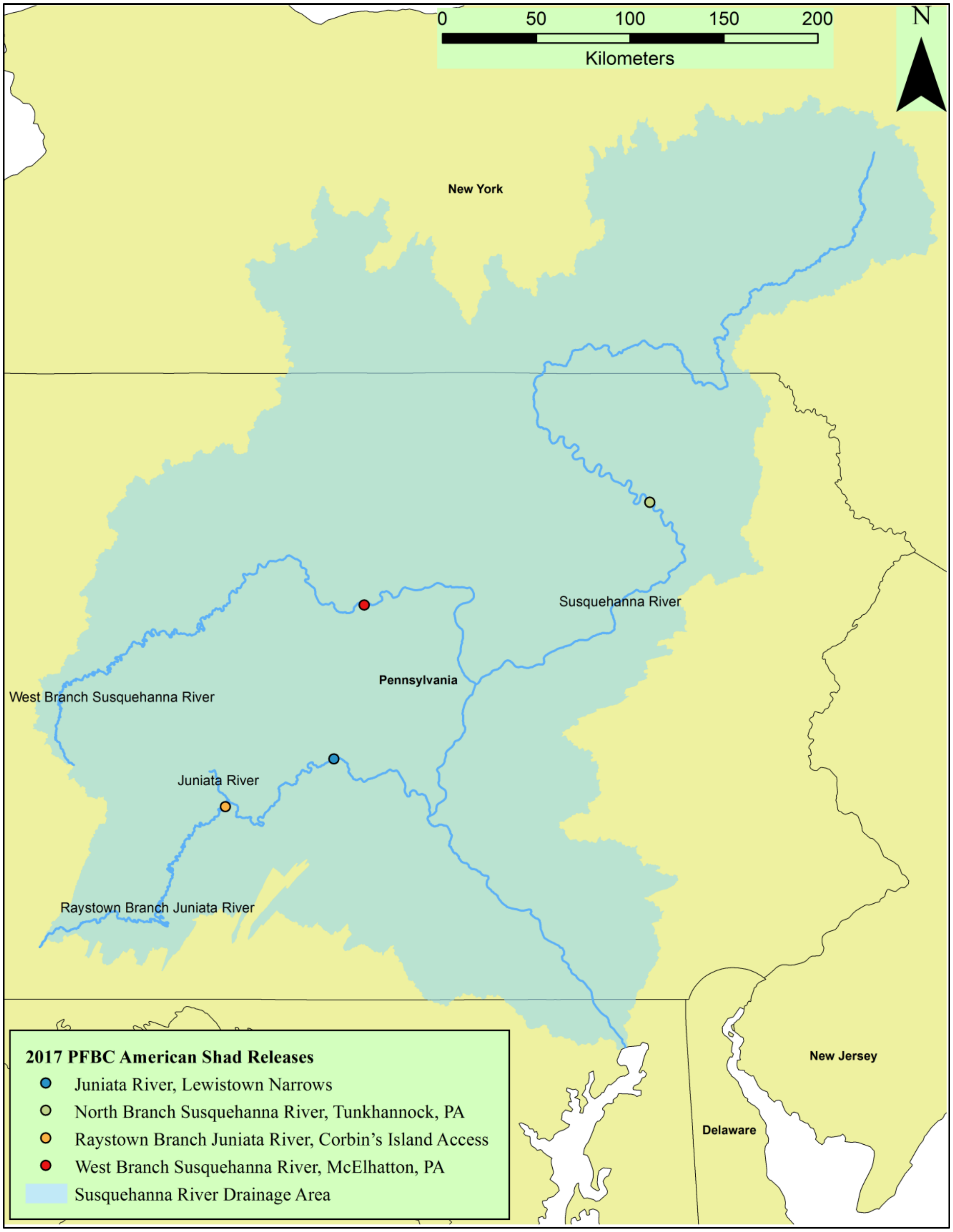

Figure 6. Map depicting 2017 Susquehanna River and tributaries stocking locations.