

Final Performance Report

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Project Title: Anadromous Species Investigations, Study 2: Shad and Herring Research, Activity 4: Adult alosine abundance, juvenile alosine abundance and American Shad nursery habitat evaluation in the Christina system

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ABSTRACT

Similar to many east coast states, Delaware closed its river herring fishery in 2008 due to ASMFC Fishery Management Plan mandates. The current status of the Delaware River watershed alosine populations, including those on the White Clay Creek, Christina River, and Brandywine Creek is relatively unknown. Five sampling locations in the Christina River and one location in Brandywine Creek, both tributaries of the Delaware River, were sampled biweekly from July through October with a 45.7-m long x 3.0-m deep haul seine consisting of 6.35-mm nylon netting. The four species targeted during these efforts included: American Shad (*Alosa sapidissima*), Hickory Shad (*Alosa mediocris*), Alewife (*Alosa pseudoharengus*), and Blueback Herring (*Alosa aestivalis*). During the course of this activity all of the target species were captured, except for Hickory Shad and for the first time in survey history Alewife were absent from the survey. Determining a juvenile index for shad and river herring in the Christina River watershed will support American Shad and river herring restoration efforts as will increasing the access to historically used habitat as a result of the removal of any of the 17 dams in the watershed.

INTRODUCTION

The Delaware River Basin Fish and Wildlife Cooperative (DRBFWC) identified the Delaware shad stock as stable, but at low levels in their sustainable fishing plan for American Shad (DRBFWC 2017). The only drainage in Delaware, where adult and juvenile alosine populations have historically been monitored, occurred as part of an ongoing restoration project within the Nanticoke River watershed (Moore 2016). The current status of the Delaware River watershed alosine populations, including those on the White Clay Creek, Christina River, and Brandywine Creek was relatively unknown. The objective of this activity is to support alosine restoration efforts by determining a juvenile abundance index (JAI) to assess the annual and long term trend in reproduction and recruitment for these species in the Christina River. The four species targeted during this effort included: American Shad (*Alosa sapidissima*), Hickory Shad (*Alosa mediocris*), Alewife (*Alosa pseudoharengus*), and Blueback Herring (*Alosa aestivalis*).

The American Shad population in the Christina system (i.e. Brandywine Creek, White Clay Creek, and Christina River) received considerable attention from the 1950's into the early

1970's. Bi-state efforts were made to restore the population on Brandywine Creek with the Delaware Department of Natural Resources and Environmental Control (DNREC) providing fish passage at dams 1, 2 and 4 (3 is breached). The Pennsylvania Fish and Boat Commission stocked fry well upriver in the Pennsylvania portion of Brandywine Creek. However, diminishing numbers of returning adult shad resulted in the discontinuation of active restoration efforts. Eventually the fishways were removed or closed due to being an unmaintained safety hazard in an urban area and vandalism of the fishways was also an issue. Despite the discontinuation of restoration efforts at that time, a limited recreational fishery on Brandywine Creek below Dam 2 in Wilmington remained.

In 2005 the Brandywine Conservancy (BC) completed an American Shad restoration feasibility study for the Delaware portion of Brandywine Creek (BC 2005) and developed partnerships to remove Dams 1 (owned by the City of Wilmington) and 4 (owned in part by DNREC). The project was delayed after funding delays and key staff from the BC and DNREC resigned or retired. As part of a Natural Resources Damage Assessment consent order with DNREC (effective November 2015), the removal of Dam 1 was funded by the City of Wilmington and was completed in 2019. Pre-dam removal fish sampling began in 2016 directly above and below Dam 1. Post-dam removal sampling will be conducted as needed to evaluate the effectiveness of the removal on fish movement and migration. Dam 1 was removed by the City in 2019 with coordination from the Fisheries Section to assure passage of the different anadromous species upstream to Dam 2. A small number of adult American Shad (n=9) were caught upstream of Dam 1 in 1998 as part of the Smallmouth Bass Assessment on Brandywine Creek (Michael Stangl, DE F&W, personal communication), and as part of pre-dam removal sampling (n=6 in 2016; n=9 in 2017) (Johnny Moore, DE F&W, personal communication). Before removal, passage was possible for a limited number of shad to pass by the low-head dam during high flow events. Post-removal reports from anglers in 2020 noted sizeable numbers of migrating hickory and American shad just downstream of Dam 2. The University of Delaware Water Resource Agency (UDWRA), and the Brandywine Shad 2020 committee (<http://www.wrc.udel.edu/public-service/brandywine-shad-2020/> are currently addressing passage at the remaining dams <https://www.facebook.com/Brandywine-Shad-2020-328130287817797/>).

METHODS

Juvenile abundance

Potential seining locations were identified in 2013 and selected based on the availability of open shoreline, proximity to snags, and bathymetry. Sampling was fully implemented in 2014. In 2015, adjustments were made to the sampling locations based on the previous years sampling results and the lack of target species captured at the lower sampling locations. One downstream site was removed from the sampling scheme, and two upriver sample locations were added. In 2017, a location in the Brandywine Creek was sampled in addition to the five sampling locations on the Christina River, and these sites remained unchanged since 2018 (Table 1; Figure 1). Sites were sampled biweekly from July through the second week of October with a 45.7-m long x 3.0-m deep haul seine consisting of 6.35-mm nylon netting. One end of the net was anchored to the shoreline while the remainder of the net was set in a semicircle pattern off the bow of a Carolina Skiff, and then hauled to shore. Haul seining was conducted during ebb or slack tides. All captured fish were identified to species and enumerated.

The JAI was determined by calculating the geometric mean number taken per haul of age-0 fish for each target species. The method for calculating the JAI involved logarithmic transformation of the arithmetic mean as described in Sokal and Rohlf (1995), ASMFC (1992), and Crecco (1992). Typically, a few large catches of alosine species can occur and bias CPUE estimates within the sampling period, thus a geometric mean is used to smooth out the bias associated with single large catches of schooling species. Catch per unit effort (CPUE), recorded as fish caught per haul, was calculated for each of the four species.

RESULTS AND DISCUSSION

Juvenile abundance

The Christina drainage is comprised of four dammed tributaries in descending order of mean annual discharge: Brandywine Creek, Christina River, White Clay Creek and Red Clay Creek. Of these, only the Christina River is currently sampled downstream of the dam that occurs at Smalleys Pond (<https://www.google.com/maps/place/Smalleys+Pond>). In 2016, the Division attempted to sample in Brandywine Creek and only one suitable haul seine location was found, but the area had a large snag in the prospective area and was not able to be sampled. In

2017, another location in Brandywine Creek was located and was sampled successfully on multiple occasions.

Haul seine sampling in 2020 produced 265 American Shad and 645 Blueback Herring (Table 2). No Alewife or Hickory Shad were caught. A majority of the Blueback Herring (64%) were collected at the Brandywine Creek sampling location in 2020, however the most productive location for capturing American Shad was site 2 (Table 3). During the 2020 haul seining efforts only two of the four targeted alosine species were captured, and an additional 33 species were captured, a slight increase from 31 other species collected in 2020.

The JAI increased substantially in 2020 for American Shad and Blueback Herring was the second highest of the survey history, however the index of abundance for Alewife was the lowest in the time series (Table 4). The increase in the geometric mean number taken per haul (GM) in 2015 when compared to 2014 was attributed to the new sampling locations. Those same locations were sampled again in 2016 and the GM dropped to levels closer to 2014 levels. Those locations were sampled again in 2017, and when only compared with the Christina River haul seine locations (BC excluded), the GM increased. In 2018 the same stations were sampled as in 2017, and again the GM showed an increase in abundance for all three species in the Christina River, and Brandywine Creek when compared to the 2017 survey. In 2020 the same sites were sampled as in 2017 to 2018, and an increase in GM was observed for American Shad and Blueback Herring throughout the watershed. Haul seine sampling in 2020 produced 65 American Shad and 415 Blueback Herring from Brandywine Creek. In comparison, Hale (2020) caught 160 juvenile American shad (159 in one sample) and no river herring or Hickory Shad with a haul seine over four sampling events (2 samples/day). That sample site is below dam 2 on Brandywine Creek and is 1.6 miles upstream of our location. The GM of Blueback Herring caught in Brandywine Creek increased in 2020 while the GM of American Shad only increased slightly but still below what was observed in 2017 and 2018 (Table 5). This demonstrates that there is strong variability in juvenile alosine production and survival in the Christina River watershed.

The highest single-day CPUE (58.7 fish/haul) was on July 9th with 290 Blueback Herring and 62 American Shad captured (Table 6). Blueback Herring exhibited the highest total CPUE (13.7 fish/haul), followed by American Shad (5.6 fish/haul). Catch per unit effort for Blueback

Herring and American Shad increased, and Alewife decreased in 2020 when compared to the total CPUE in 2019 (1.2, 0.4 and 0.3 fish/haul respectively). Alewife total CPUE remained below 0.7 fish/haul since 2016, a sharp contrast to the 7.8 fish/haul observed in 2015 (Park 2016). Catch amongst sampling sites in the past has varied greatly but in 2020 the Brandywine Creek site was the most productive and accounted for slightly more than half of the total captures (Table 3). In 2015, 2016, 2018 and 2019, site 2 produced the most alosines, however in 2017, and again in 2020, the Brandywine Creek site produced the greatest number of young of the year alosines. Sites 4 and 5 are closer to the mouth of the Christina River and typically exhibit a higher salinity value than the other 3 locations (Figure 1) and generally produce lower catches. Differences in water quality may spatially affect species abundance, and below average precipitation in 2020 is most likely responsible for lower catches at these downstream sites.

The absence of Hickory Shad in any collection may be a function of gear avoidance and habitat preference. Juvenile Hickory Shad are seldomly taken consistently, even in systems which have significant adult spawning runs (Richardson et al. 2009). Similar observations were made by Mansueti (1962) who reported a scarcity of Hickory Shad fingerlings in fish samples from the Chesapeake Bay tributaries.

Dam Surveys

Brandywine Creek - Sampling below Dam 1 in the tidal portion of Brandywine Creek did not occur in 2019 as a result of the process of removing Dam 1. No sampling was performed in 2020 due to Covid-19. This area has been sampled multiple times in the past and has documented that American Shad were able to pass Dam 1, albeit in low numbers. In 2020, anglers reported catching a variety of alosines below Dam 2, indicating that fish were able to migrate past the Dam 1 removal location and continue their migration upstream. The University of Delaware along with Brandywine Shad 2020 obtained a Delaware River Restoration grant in 2018 to address other blockages on Brandywine Creek.

White Clay Creek - Sampling in White Clay Creek was not conducted in 2019 or 2020 due to the lack of captures in the first two years of sampling. The section of White Clay Creek just below where Dam 1 originally existed appeared to be very shallow and sediment may be blocking fish passage, especially for larger fish during low flows. The access point to sample the

Dam 1 location is through a golf course owned by a private country club which made access difficult. Staff will sample below Dam 2 again in subsequent years to evaluate if alosines are able to reach Dam 2 as proposals to remove other dams in White Clay Creek have been suggested. In 2019 the University of Delaware obtained a Delaware River Restoration grant to address other blockages on White Clay Creek.

Survey Validation

The 2014 through 2019 American Shad geometric mean evaluated from the Christina sampling was comparable to the geometric mean number taken per haul of age-0 fish for American Shad in the New Jersey Department of Environmental Protection (NJDEP) juvenile Striped Bass seine survey. While the haul seine used in the NJDEP survey is only 30.5-m long x 1.8-m deep, the survey is also completed from July through November and is performed twice a month. Data from two of the NJDEP seine sites which are within two miles of the mouth of the Christina River were calculated for comparison. The comparison between the two surveys demonstrates a similar trend in abundance from 2014 to 2019 (Figure 2). Unfortunately, data from 2020 was unable to be compared because the NJDEP juvenile striped bass survey was not completed.

Recommendations

1. Continue to conduct a survey of juvenile alosines in the Christina River and calculate a JAI to assess trends in population abundance.
2. Continue to monitor presence and absence of alosines in relation to dam removals.
3. Continue to validate survey using the NJDEP Striped Bass haul seine survey.

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Table 1. The haul seine sites in tidal waters of the Christina River that were used to develop the juvenile index of abundance in 2020.

Site #	Site Name	y	x	Description	Rkm
1	Churchmans Rd	39.6876	-75.6257	Two bends east of Churchmans Rd ramp	15.3
2	White Clay	39.6971	-75.6217	Across from White Clay Creek	13.9
3	Newport Utility	39.7109	-75.6037	South bank at underground utility crossing	11.6
4	Rt. 95	39.7191	-75.5811	West of Rt. 95 overpass on the North bank	9.3
5	Nature Center	39.7269	-75.5616	DuPont Environmental Education Center	6.5
BR	Brandywine Creek	39.7404	-75.5371	Upstream of railroad crossing	2.0

Table 2. Species and the number observed during Christina River haul seine in 2020.

Family	Scientific Name	Common Name	Number Captured
Achiridae	<i>Trinectes maculatus</i>	Hogchoker	19
Anguillidae	<i>Anguilla rostrata</i>	American Eel	0
Atherinopsidae	<i>Menidia beryllina</i>	Inland Silverside	5
Catostomidae	<i>Catostomus commersonii</i>	White Sucker	3
Centrarchidae	<i>Lepomis cyanellus</i>	Green Sunfish	0
	<i>Lepomis gibbosus</i>	Pumpkinseed	1
	<i>Lepomis machrochirus</i>	Bluegill	49
	<i>Micropterus salmoides</i>	Largemouth Bass	7
	<i>Micropterus dolomieu</i>	Smallmouth Bass	11
Channidae	<i>Channa argus</i>	Northern Snakehead	1
Clupeidae	<i>Alosa aestivalis</i>	Blueback Herring	645
	<i>Alosa pseudoharengus</i>	Alewife	0
	<i>Alosa sapidissima</i>	American Shad	265
	<i>Brevoortia tyrannus</i>	Atlantic Menhaden	0
	<i>Dorosoma cepedianum</i>	Gizzard Shad	12
Cyprinidae	<i>Cyprinella analostana</i>	Satinfin Shiner	4
	<i>Cyprinus carpio</i>	Common Carp	7
	<i>Hybognathus regius</i>	Eastern Silvery Minnow	268
	<i>Notropis hudsonius</i>	Spottail Shiner	244
	<i>Notemigonus crysoleucas</i>	Golden Shiner	0
	<i>Semotilus corporalis</i>	Fallfish	0
Engraulidae	<i>Anchoa mitchilli</i>	Bay Anchovy	178
Fundulidae	<i>Fundulus diaphanus</i>	Banded Killifish	40
	<i>Fundulus heteroclitus</i>	Mummichog	7
Ictaluridae	<i>Ictalurus punctatus</i>	Channel Catfish	13
	<i>Ictalurus furcatus</i>	Blue Catfish	2
Moronidae	<i>Morone americana</i>	White Perch	285
	<i>Morone saxatilis</i>	Striped Bass	25
Percidae	<i>Etheostoma olmstedii</i>	Tessellated Darter	19
	<i>Perca flavescens</i>	Yellow Perch	38
Perciformes	<i>Pomoxis nigromaculatus</i>	Black Crappie	1
Poeciliidae	<i>Gambusia affinis</i>	Mosquito Fish	3
Portunidae	<i>Callinectes sapidus</i>	Blue Crab	2
Sciaenidae	<i>Leiostomus xanthurus</i>	Spot	2
	<i>Micropogonias undulates</i>	Atlantic Croaker	3

Table 3. Daily catch of alosine species from the 2020 Christina River and Brandywine Creek haul seine.

Date	Site	Blueback Herring	American Shad	Alewife	Date	Site	Blueback Herring	American Shad	Alewife
7/9/2020	1	0	0	0	9/9/2020	1	0	1	0
	2	2	9	0		2	1	27	0
	3	0	5	0		3	1	27	0
	4	0	1	0		4	0	2	0
	5	1	0	0		5	0	5	0
	Brandywine	287	47	0		Brandywine	47	2	0
7/23/2020	1	0	0	0	9/23/2020	1	0	0	0
	2	168	14	0		2	7	33	0
	4	0	0	0		3	0	1	0
	5	0	0	0		4	0	0	0
	Brandywine	0	2	0		5	1	0	0
	Brandywine	0	0	0		Brandywine	0	0	0
8/10/2020	1	3	0	0	10/12/2020	1	0	0	0
	2	8	4	0		2	0	7	0
	3	1	5	0		3	0	0	0
	4	0	0	0		4	2	14	0
	5	4	0	0		5	3	3	0
	Brandywine	0	4	0		Brandywine	68	3	0
8/24/2020	1	0	0	0	10/26/2020	1	1	2	0
	2	0	6	0		2	21	4	0
	3	0	2	0		3	1	4	0
	4	4	1	0		4	0	19	0
	5	0	0	0		5	1	4	0
	Brandywine	0	1	0		Brandywine	13	6	0

Table 4. The geometric mean number taken per haul of alosine species in the Christina River and Brandywine Creek.

	Alewife	American Shad	Blueback Herring
2014	0.02	0.45	0.61
2015	2.11	2.58	1.34
2016	0.15	0.2	0.58
2017	0.14	4.74	1.24
2018	0.27	6.67	1.49
2019	0.13	0.18	0.4
2020	0	2.2	1.43

Table 5. The geometric mean number taken per haul of alosine species in Brandywine Creek.

	Alewife	American Shad	Blueback Herring
2017	0	10.06	13.90
2018	0	7.85	0.76
2019	0	0	0
2020	0	3.32	6.78

Table 6. Daily catch per unit effort (CPUE: fish/haul) of alosine fish species collected in the Christina River during the juvenile abundance estimate in 2020 using haul seine gear.

Date	Species	Catch Frequency	CPUE (fish/haul)	Average Total Length(range, mm)
7/9/2020	American Shad	62	10.3	54 (35-68)
7/23/2020	American Shad	16	3.2	54 (40-74)
8/10/2020	American Shad	13	2.2	68 (58-78)
8/24/2020	American Shad	10	1.7	68 (56-75)
9/9/2020	American Shad	64	10.7	72 (56-86)
9/23/2020	American Shad	34	5.7	78 (66-87)
10/12/2020	American Shad	27	4.5	82 (73-96)
10/26/2020	American Shad	39	6.5	82 (72-94)
2020 Total	American Shad	265	44.2	
7/9/2020	Blueback Herring	290	48.3	39 (32-48)
7/23/2020	Blueback Herring	168	33.6	36 (24-55)
8/10/2020	Blueback Herring	16	2.7	51 (36-61)
8/24/2020	Blueback Herring	4	0.7	55 (54-56)
9/9/2020	Blueback Herring	49	8.2	62 (57-69)
9/23/2020	Blueback Herring	8	1.3	66 (52-71)
10/12/2020	Blueback Herring	73	12.2	67 (62-75)
10/26/2020	Blueback Herring	37	6.2	65 (52-75)
2020 Total	Blueback Herring	645	107.5	

Figure 1. Christina River haul seine site locations



Figure 2. The geometric mean number taken per haul of American Shad in the Christina River and Brandywine Creek and the geometric mean number taken per haul of American Shad in the NJDEP Striped Bass survey.

