

**Shad in the Classroom
Program Report
(2009-2017)**

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Executive Summary

The Shad in the Classroom Program is the result of many dedicated partners. The program is managed by the Museum and it receives significant logistical and financial support from the Albemarle-Pamlico National Estuary Partnership (APNEP), the North Carolina Wildlife Resources Commission (NCWRC), and the U.S. Fish and Wildlife Service (USFWS). We received \$24,000 in grant funding from APNEP and \$7,000 in grant funding from the USFWS for the 2017 Shad season, and we leveraged over \$40,700 of in-kind support. Very important to the program are the many volunteers who generously give their time to enhance the program and the dedicated teachers.

The Shad in the Classroom Program has reached 186 classrooms from 2009 to 2017 (Table 1) and many thousands of students. Between 2013–2017, approximately 11,713 students were reached (prior to 2013, the numbers of students were not tracked). Thirty-three classrooms participated in 2017 with 12 of those being new to the program this year. Four of the schools released larval fish and eggs in the Roanoke River basin and the other 29 schools released in the Neuse River basin. Over 2,100 students participated in the program this year and over 1,300 participated in river releases.

Table 1. Schools Participating in the North Carolina Shad in the Classroom Program (2009–2017)

Release Basin/School	Number of Classrooms by year									
	2009	2010	2011	2012	2013	2014	2015	2016	2017	
Cape Fear River Basin										
Harnett Central Middle School (NCWRC)	1	1								
Lake Rim Elementary (NCWRC)	1	1								
Overhills Elementary (NCWRC)		1								
Neuse River Basin										
Abbotts Creek Elementary School								1	1	
Angier Elementary					1	1				
Ballentine Elementary										1
Brogden Middle School							1	1	1	
Broughton High School						2	1			
Bunn High School				1	2	2	1			
Cedar Creek Middle School							1			
Centennial Campus Magnet Middle School	1	1								
Central Park School for Children					1	1	1	2	2	
Chatham Central High School						1				
Chestnut Grove Middle School				1						
Clayton High School								1	1	
Cleveland High School								1	1	
Cook Literacy Model School										1
Daniels IBMYP Magnet Middle School		1	1	1	1	2	3	1	2	
Dillard Middle School										1
Don D. Steed Elementary				1						
The Expedition School							2	2	2	
Exploris Elementary School										2

Table 1. Schools Participating in the North Carolina Shad in the Classroom Program (2009–2017)
Continued

Release Basin/School	Number of Classrooms by year									
	2009	2010	2011	2012	2013	2014	2015	2016	2017	
Neuse River Basin										
Exploris Middle School		1	1	1	1	1	1	1		
East Wake Middle School		1	2	2	2	2	1			1
East Wake School of Integrated Technology						1				
Forest Pines Dr Elementary					1					
Fuquay Varina Middle School						1	2	2		2
Hall Woodward Elementary				1	1					
Horton Middle School										1
Lakewood Montessori Middle School					2	2	2	2		2
Lead Mine Elementary	1	1	1							
Lillington Shawtown Elementary			1	1						
McLauchlin Elementary				1						
Midway Middle School							1			
Mills Park Middle School										1
Mineral Springs Middle School						1				
Moss Hill Elementary										1
North Duplin JR/SR High School							1	1		
Rolesville Middle School										1
Sandy Grove Middle School				1	1					
South Asheboro Middle School				1						
South Iredell High School					1	1	1	1		1
South View High School				1						
Southern Vance High School				1	1	1	1			
Speas Elementary				1						
Tar Heel Middle School								1		
The Oakwood School				1						
Tiller School Elementary (Carteret County Charter School)					1	1	1	1		1
Upchurch Elementary				1	1	1	1	1		1
Uwharrie Charter Academy								1		
West Hoke Elementary				1						
Wake Forest Middle School							1	1		
Walkertown Middle School								1		
W.G. Enloe HS										1
Woods Charter Middle School				1	1	1	1	1		1
Roanoke River Basin										
Bartlet Yancey High School		1								
Bertie Early College High School							1	1		1
Cedar Creek Middle School								1		
Chestnut Grove Middle School		1	1	1						
Don D. Steed Elementary			1							

Table 1. Schools Participating in the North Carolina Shad in the Classroom Program (2009–2017)
Continued

Release Basin/School	Number of Classrooms by year									
	2009	2010	2011	2012	2013	2014	2015	2016	2017	
Roanoke River Basin										
Hall Woodward Elementary			1							
Hawk Eye Elementary			1							
Hertford County High School						1	1			
McLauchlin Elementary			1							
Perquimans County Middle School										1
Red Oak Middle School					2					
Rockfish Hoke Elementary			1							
Sandy Grove Middle School			1							
Scurlock Elementary			1							
Southern Vance High School		1	1							1
Speas Elementary		1	1							
The Oakwood School			1							
Upchurch Elementary			1							
Vance Charter School									1	
West Hoke Elementary			1							
Windsor Elementary		1								
W.L. Manning Elementary School									1	1
Total Number of Schools	4	13	18	19	16	17	22	23	27	
Total Number of Classrooms	4	13	19	20	20	23	27	27	33	

This year the NCWRC donated 4 plexiglass hexagon tank systems (approximately \$540 each). We also received 4 of these tanks from East Wake Middle School previously. Current new tank construction of the red tub style tanks cost approximately \$385 per tank system. The plexiglass tank systems cost approximately \$585 per tank system. Other substantial expenses include tank refurbishment, chemical resupply, teacher training workshop, teacher professional development trek, school field trips to release sites, travel for egg delivery, part-time staff, and River Days supplies and contractors.

In the years from 2013–2017 each school received approximately 1,000 eggs from the NCWRC. Both the Neuse River broodstock fish and the Roanoke River broodstock fish are brought to the Edenton National Fish Hatchery. Originally, American Shad fry were released in the river basin closest or most convenient to the school. However, this was not in-line with the NCWRC’s American Shad management goals of keeping Shad in their specific watershed. Therefore, since 2011, fry are only released in the river basin of their parentage, and since 2013, Roanoke basin fish are specifically only released at the NCWRC boat ramp at Weldon on the Roanoke River.

In summary, the Shad in the Classroom program has been led and administered by the Museum since 2011. Over the years, state and federal agencies and NCSU have played significant roles in the implementation of the program, including:

- Abermarle-Pamlico National Estuary Partnership
- Dominion Power
- National Fish and Wildlife Foundation
- North Carolina Chapter of the American Fisheries Society
- North Carolina State University
- North Carolina Wildlife Resources Commission
- United States Fish and Wildlife Service

American Shad have ecological, economic, and historical importance to North Carolina and much of the eastern coast of the U.S. Through the Shad in the Classroom program, students get a hands-on and real-life connection with learning about their environment while addressing the importance of American Shad restoration and water quality. Teachers report a great enthusiasm for themselves and their students through the program.

ACKNOWLEDGEMENTS

We would like to acknowledge all of the teachers and volunteers who help implement the Shad in the Classroom Program each year. The teachers and volunteers are dedicated to making the program a success and are invaluable. Specific individuals who assisted with various aspects of the program for 2017 are listed below.

Workshop Speaker

Ben Ricks ben.ricks@ncwildlife.org – (NCWRC District Biologist)

Additional Education

Fish Anatomy-Dissection Lecture

Ani Popp apopp@ncsu.edu – (NCSU Grad Student)

Bobby Cope wrcpe@ncsu.edu – (NCSU Grad Student and helped coordinate with the graduate students)

Casey Williams casey.williams@ncwildlife.org – (NCWRC Education Specialist)

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Egg Delivery and Larvae Release Assistance

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Dr. Nils Peterson nils_peterson@ncsu.edu – (NCSU Associate Professor)

In addition, we are very appreciative of the fish donations for the 2017 dissection lectures from Rich Noble, Phil Doerr, Jim Rice and fellow anglers, First Fruits Farm, and the NCWRC's Armstrong Hatchery. Also, Emilee Wooster and Bobby Cope helped coordinate with the NCSU graduate students for the anatomy-dissection lectures. American Shad eggs were generously provided by Stephen Jackson, Sam Pollock, and the staff at the Edenton National Fish Hatchery.

Report cover photos: Top left – Moss Hill Elementary students' release at Cliffs of the Neuse State Park; top right - Cook Literacy Model School students' fish dissection; bottom – Southern Vance High School students' and teachers' release at the Roanoke River at Weldon.

Shad in the Classroom Program 2017 Report

This report summarizes the activities accomplished for the 2017 Shad in the Classroom Program. Thirty-three classes at 27 different schools participated in the program: 13 elementary, 14 middle, and 6 high school classes. We increased the program by six classes from last year. We originally accepted 34 classes; however, one teacher withdrew from the program as she left her position with the school.

Yearly program planning began with forming a timeline (Figure 1), reviewing applications, and conducting a tank and parts inventory. All new teachers and several returning teachers attended an orientation and training session in February. Returning to their schools, teachers typically began preparing their classrooms for the arrival of the Shad eggs 2–4 weeks prior to receiving the eggs in April. American Shad broodstock were collected beginning the week of March 27. Classes released the Shad larvae on the Thursday or Friday of the week that they received them. Many of the teachers took advantage of either (or both) a fish dissection lecture that we coordinated with NCSU graduate students and post doctorates or a Shad printing (Gyotaku) activity and supplies that we made available. Five teachers were also able to take advantage of an invertebrate lecture. Two in class, 3 at the riverside during release, and one that had an in-class lecture also had a separate riverside lecture (not associated with the release).

Unfortunately, we had to cancel our planned Edenton National Fish Hatchery Tour due to low participation. A 4-day Roanoke River Trek was provided for students in the Museum’s Junior Curator Program. We continued the ‘River Days’ program to reach students and communities along the Roanoke River in 2017. We used the Museum’s inflatable immersion theater, the Geodome, to show a video production entitled ‘We are the River’ documenting the cultural and natural history, conservation, and connection of local communities to the Roanoke River. Contract staff presented supplemental activities to build on the video content.

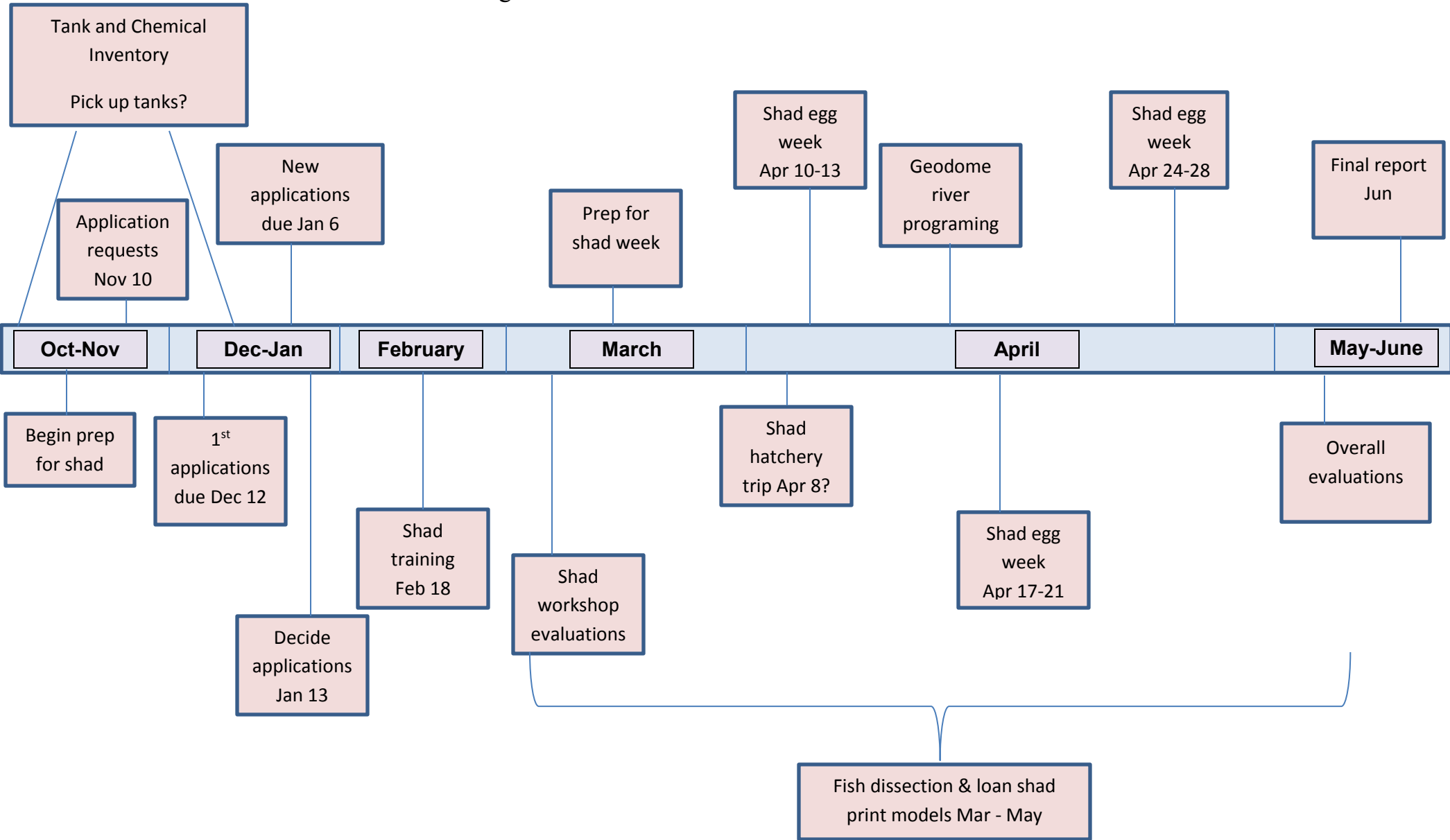


Photo 1. Ballentine Elementary building their tank.



Photo 2. Mills Park MS, Eno River

Figure 1 — Shad in the Classroom 2017 Timeline



Tank Inventory

At the start of the program, tank parts and chemicals were inventoried and items purchased as needed. Tanks were retrieved from schools no longer participating in the program. New tanks were constructed and old tanks refurbished, as needed, with the assistance of Museum exhibits staff. This year the NCWRC donated 4 plexiglass hexagon tank systems. An updated inventory list is on file.

Teacher Orientation and Training

A teacher orientation and training session was conducted on February 18, 2017. Danielle Pender and Melissa Dowland co-lead the session. Ben Ricks (NCWRC) was a guest lecturer. Teachers were provided information about American Shad life history, restoration, and management. They received equipment and instructions for raising shad and learned ways to incorporate shad and aquatic ecology into their curriculum. Teachers participated in shad printing (Gyotaku), shad pipette art, and aquatic macro-invertebrate exercises. Meeting in a central location with researchers, collaborating partners, and museum program staff facilitated networking among all teachers and schools involved in the project. Twenty-four teachers attended the 2017 workshop. Of those, 10 responded to the 9-question survey regarding the workshop. Most teachers reported that they were very to extremely satisfied with the workshop and they learned the concepts very to extremely well (Table 2).



Photo 3. 2017 Teacher orientation

Table 2. Workshop Survey Results

Question	Response variable												
How well did the workshop explain the importance of the shad restoration and management program?	60% (6) extremely well; 40% (4) very well												
How well did the workshop explain the life history of shad?	60% (6) extremely well; 40% (4) very well												
How well did the workshop explain the proper components to raising shad eggs to the larval stage?	80% (8) extremely well; 20% (2) very well												
How confident do you feel in building the shad tank system on your own?	60% (6) extremely confident; 40% (4) very confident												
How resourceful was the leadership team in helping you with your questions about the program?	90% (9) extremely resourceful; 10% (1) very resourceful												
How comfortable do you feel in contacting the other teachers that you met at the workshop with questions?	30% (3) extremely comfortable; 50% (5) very comfortable; 20% (2) moderately comfortable												
How sufficient was the information you learned to incorporate shad into your curriculum?	60% (6) extremely sufficient; 30% (3) very sufficient; 10% (1) moderately sufficient												
What aspects of the workshop were useful? Please choose all that apply.	<table border="1"> <thead> <tr> <th>Life History</th> <th>Shad Restoration</th> <th>Pipette Art</th> <th>Invertebrate exercise</th> <th>Tank Building</th> <th>Sharing Experience</th> </tr> </thead> <tbody> <tr> <td>80% (8)</td> <td>70% (7)</td> <td>40% (4)</td> <td>80% (8)</td> <td>70% (7)</td> <td>100% (10)</td> </tr> </tbody> </table>	Life History	Shad Restoration	Pipette Art	Invertebrate exercise	Tank Building	Sharing Experience	80% (8)	70% (7)	40% (4)	80% (8)	70% (7)	100% (10)
Life History	Shad Restoration	Pipette Art	Invertebrate exercise	Tank Building	Sharing Experience								
80% (8)	70% (7)	40% (4)	80% (8)	70% (7)	100% (10)								
Overall, how satisfied are you with the workshop?	90% (9) extremely satisfied; 10% (1) very satisfied												

Egg Delivery and Larval Fish Release

We coordinated the arrival of the eggs and the release of the larval fish with the schools, hatchery, drivers, and fisheries biologists. This involved foremost the timing of the spawning of the American Shad, but also took into account school schedules. American Shad broodstock were collected the week of March 27 from the Neuse and the week of April 3 from the Roanoke. Many people assisted with the delivery of the eggs and with the release of the larval fish and are mentioned in the acknowledgments.

Classes were divided into three groups. Group 1 received their eggs Monday, April 10, Group 2 received them on Monday, April 17, and Group 3 received their eggs on Monday, April 24. In Group 1 there were 4 classes. Of those, 2 classes released larval fish in the Neuse and 1 in the Roanoke River at Weldon on Thursday, April 13, 2017 and 1 class released into the Neuse on Friday, April 21, 2017 (Table 3, Figure 2). Group 2 consisted of 6 classes. All six classes of this group released on Friday, April 22, 2017 in the Neuse River. The remaining teachers, 23 classes, were all in Group 3. Nine of these classes released on Thursday,



Photo 4. Tiller School receiving shad eggs.



Photo 5. Cook Literacy Model School release on the Eno River.

April 27, 2017 and the rest (14) released larval fish on Friday, April 28, 2017. Thursday's release was all in the Neuse River Basin. For Friday, 3 released in the Roanoke River Basin and 11 in the Neuse River Basin. Two classes chose to raise their shad in Neuse River water (as opposed to municipal water) this year and one class used a mixture of Neuse River water and tap water. Classes releasing in the Neuse River Basin received approximately 21,000 eggs (~1,000 to each class in Group 1 and 2 and ~700 to each class in Group 3) and classes releasing into the Roanoke River Basin received approximately 4,000 eggs (1,000 to each class) from the Edenton National Fish Hatchery. However, many of the teachers from the Neuse Group 3 reported receiving much less than 700 eggs (Table 4). Teachers brought 1,337 students to the Neuse and Roanoke Rivers for release. For many of these students this is rare, or even a first-time opportunity to visit a river.

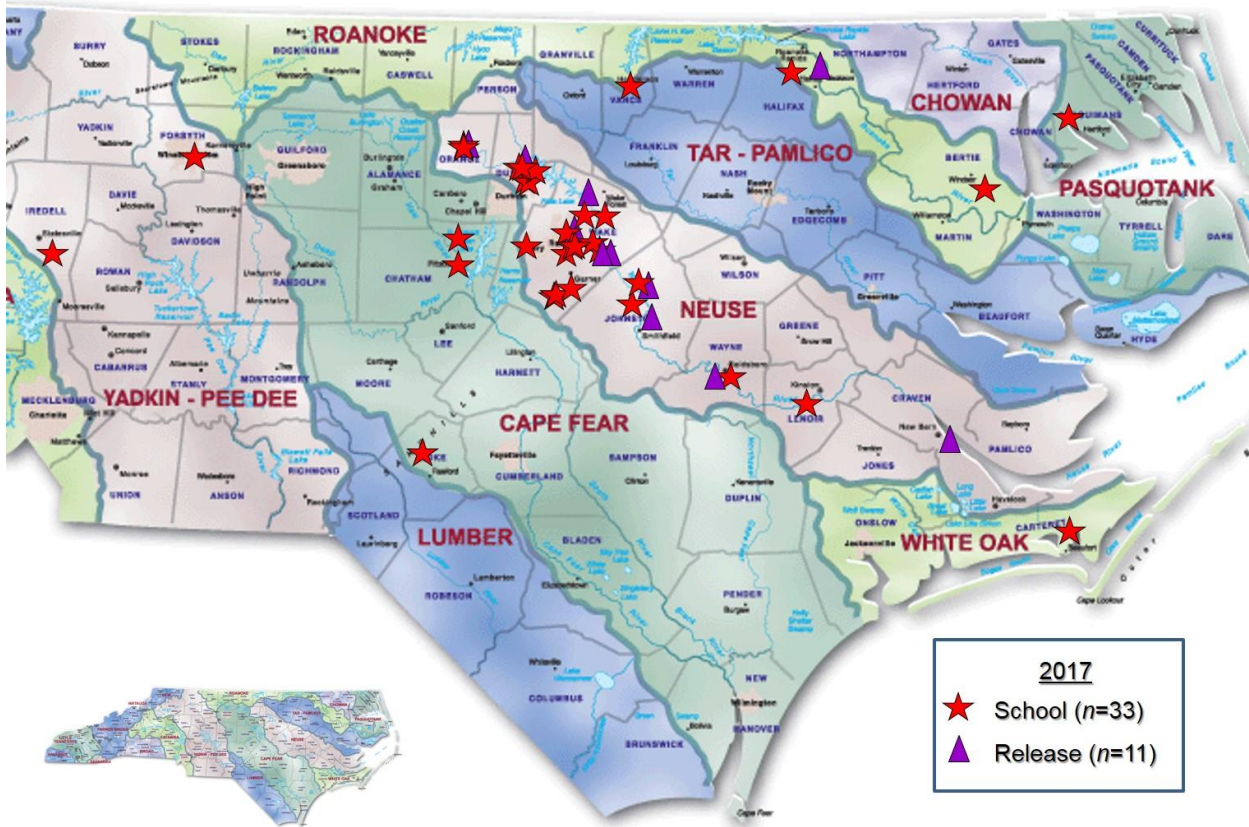
Table 3. Egg and Larval Release Timing and Release Site Information

Educator	School	Received Eggs	Released Eggs/Larva	Release Site
Group 1				
Cheryl Henry	Rolesville MS	4-10-2017	4-13-2017	Neuse River, Falls Dam
Kathy Wall	Ballentine Elementary	4-10-2017	4-13-2017	Neuse River, Anderson Point
Kimberly Stedner-Clayton	Dillard MS	4-10-2017	4-14-2017	Neuse River, Cliffs of the Neuse State Park
Rachel Eure	W.L. Manning Elementary School	4-10-2017	4-13-2017	Roanoke River at Weldon
Group 2				
Brian Wood	W.G. Enloe HS	4-17-2017	4-21-2017	Neuse River, Milburnie Dam
Christina Livingstone	Brogden MS	4-17-2017	4-21-2017	Neuse, West Point, Eno River
Erin McInerney	The Expedition School	4-17-2017	4-21-2017	Neuse, Gold Park, Eno River
Judy Compton	Central Park School for Children	4-17-2017	4-21-2017	Neuse River, Cliffs of the Neuse State Park
Meg Millard	Central Park School for Children	4-17-2017	4-21-2017	Neuse River, Cliffs of the Neuse State Park
Sue Willis	The Expedition School	4-17-2017	4-21-2017	Neuse, Gold Park, Eno River
Group 3				
Beth Selig	Fuquay Varina MS	4-24-2017	4-27-2017	Neuse River, Smithfield
Brad Rhew	Cook Literacy Model School	4-24-2017	4-28-2017	Neuse, West Point, Eno River
Brian Reynolds	Bertie Early College HS	4-24-2017	4-28-2017	Roanoke River at Weldon
Chaundrea M. Mason	Southern Vance HS	4-24-2017	4-28-2017	Roanoke River at Weldon

Table 3. Egg and Larval Release Timing and Release Site Information - Continued

Educator	School	Received Eggs	Released Eggs/Larva	Release Site
Christina Edmiston	Upchurch ES	4-24-2017	4-27-2017	Neuse River, Anderson Point
Courtney Sykes	East Wake MS	4-24-2017	4-28-2017	Neuse River, Milburnie Dam
Gail Clougherty	Cleveland HS	4-24-2017	4-27-2017	Neuse River, Smithfield
Janice West	Clayton HS	4-24-2017	4-27-2017	Neuse River bridge on 42
Kaley Kiffner	Perquimans County MS	4-24-2017	4-28-2017	Roanoke River at Weldon
Kelly Riley	Tiller ES	4-24-2017	4-28-2017	Neuse River, Flanners Beach
Krista Brinckek	Abbotts Creek ES	4-24-2017	4-28-2017	Neuse River, Falls Dam
Kristen Bright	South Iredell HS	4-24-2017	4-28-2017	Neuse, West Point, Eno River
Kristina Jones	Moss Hill Elementary	4-24-2017	4-28-2017	Neuse River, Cliffs of the Neuse State Park
Laine Staton	Lakewood Montessori MS	4-24-2017	4-28-2017	Neuse, West Point, Eno River
Laura Cochrane	Mills Park MS	4-24-2017	4-28-2017	Neuse, West Point, Eno River
Leah Ruto/Ann M Taranto	Exploris Elementary	4-24-2017	4-28-2017	Neuse River, Milburnie Dam
Lucy Eaton	Lakewood Montessori MS	4-24-2017	4-28-2017	Neuse, West Point, Eno River
Matthew Lanner	Fuquay Varina MS	4-24-2017	4-27-2017	Neuse River, Smithfield
Richard Kowaleski	Daniels IBMYP Magnet MS	4-24-2017	4-27-2017	Neuse, Lassiter Mill Dam, Crabtree Creek
Rose Syroid	Horton MS	4-24-2017	4-27-2017	Neuse, West Point, Eno River
Sarah Lancaster	Daniels IBMYP Magnet MS	4-24-2017	4-27-2017	Neuse, Lassiter Mill Dam, Crabtree Creek
Sonja McKay/Annah Riedel	Exploris Elementary	4-24-2017	4-28-2017	Neuse River, Milburnie Dam
Sonja Younger	Woods Charter MS	4-24-2017	4-27-2017	Neuse, West Point, Eno River

Figure 2. — School and release site locations (approximate)



Overall, the shad rearing and release was successful for most schools, but with a number of issues for some. Each class was to receive approximately 700 – 1,000 eggs; however, counts may differ as to what the school actually reported receiving. Significant rains which led to flooding contributed to a complicated release on the third week. This year quite a few schools reported issues with temperature regulation and with fungus. The temperature issues were reported by schools in Group 3 (6 total - 3 Neuse, 3 Roanoke). This was generally a warmer week and many of the schools reported that their schools turn off the air conditioning at night. This resulted in wide fluctuations in temperature with some tanks getting up into the high 70’s and even 80 degrees Fahrenheit at night; to then be cooled down in the morning to about 64 degrees with the addition of ice.

Six Neuse schools (3 from group 2 and 3 from group 3) reported having fungus issues with the eggs, which resulted in some mortality. One tank reported having a type of worm in their tank system and one reported low pH issues. However, most were able to control the low alkalinity and pH issues with a baking soda treatment, which is something we recommended for all schools. One school lost all of their eggs when their power went out overnight and the eggs were sucked down through the

pump to the bottom tank. Group 3 also received eggs in advanced development as that last week the Neuse fish at the hatchery did not want to spawn in significant numbers after the preceding Friday. Some teachers reported that there may have been mortality due to the earlier development of the larvae and subsequent absorption of the yolk sac prior to release.

One tank had complete failure due to the power outage. Percent survival for remaining schools ranged from a low of 1.6% to a high of 96.9% and averaged 48.3% (Table 4). Sixteen classes averaged $\leq 50\%$, 16 averaged $> 50\%$, and 10 averaged $\geq 75\%$ survival to release. Although there were 7 classes that averaged 10% survivability or below, average survivability was slightly higher than last year at 53% of the classes for 2017 vs 42% of the classes for 2016. There was also a higher percentage of classes for the $\geq 75\%$ in 2017 (31% 2017 vs 15% 2016).

Table 4. Egg and Larval Survival and Release Numbers

Educator	School	No. Eggs Received	No. Eggs/Larva Survived to Release	Percent Survival (%)
Group 1				
Cheryl Henry	Rolesville MS	500	200	40
Kathy Wall	Ballentine Elementary	1000	960	96
Kimberly Stedner-Clayton	Dillard MS	1000	800	80
Rachel Eure	W.L. Manning Elementary	1000	750	75
Average survival percent				72.8
Group 2				
Brian Wood	W.G. Enloe HS	1000	800	80
Christina Livingstone	Brogden MS	1500	800	53
Erin McInerney	The Expedition School	1000	100	10
Judy Compton	Central Park School for Children	1300	900	69
Meg Millard	Central Park School for Children	1000	800	80
Sue Willis	The Expedition School	500	50	10
Average survival percent				50.4
Group 3				
Brad Rhew	Cook Literacy Model School	700	678	97
Brian Reynolds	Bertie Early College HS	1400	1100	79
Chaundra M. Mason	Southern Vance HS	1400	1200	86
Christina Edmiston	Upchurch Elementary	700	641	91
Courtney Sykes	East Wake MS	600	75	13
Gail Clougherty	Cleveland HS	346	187	54
Janice West	Clayton HS	415	80	19
Kaley Kiffner	Perquimans County MS	750	12	2
Kelly Riley	Tiller School	700	19	3
Beth Selig	Fuquay Varina MS	269	105	39
Krista Brinckek	Abbotts Creek Elementary	350	20	6
Kristen Bright	South Iredell HS	580	400	69
Kristina Jones	Moss Hill Elementary	700	400	57
Laine Staton	Lakewood Montessori MS	700	450	64
Laura Cochrane	Mills Park MS	700	0	0

Table 4. Egg and Larval Survival and Release Numbers - Continued

Educator	School	No. Eggs Received	No. Eggs/Larva Survived to Release	Percent Survival (%)
Group 3				
Leah Ruto/Ann M Taranto	Exploris ES (both classes)	700	200	29
Sonja McKay/Annah Riedel				
Lucy Eaton	Lakewood Montessori MS	700	50	7
Matthew Lanner	Fuquay Varina MS	290	67	23
Richard Kowaleski	Daniels IBMYP Magnet MS	700	300	43
Rose Syroid	Horton MS	700	300	43
Sarah Lancaster	Daniels IBMYP Magnet MS	250	125	50
Sonja Younger	Woods Charter MS	700	550	79
			Average survival percent	43.2
			Total Average survival percent	48.3

An overall theme reported this year from the teachers is that the students have established a real-world connection and that they are more excited to know about the environment around them. The Shad Program increases the students interest in science. We have received such great feedback on the program from the teachers throughout the 2017 program year.

Additional Education

In addition to learning concepts related to the shad survival, cultural and biological importance of the species, its ecological connections to community assemblages and habitat, and the significance of genetic integrity, we have made available additional educational activities to enhance the program. All teachers responded to the program evaluation survey (Table 5).

“My students have become more aware on their impact on our ecosystems. My students have become more excited about how they can protect the environment and have gained a greater interest on wanting to know more about shad and aquatic species.”

“Students gained a better understanding of stewardship in the community and the impact people are having on the environment around us.”

“I have had students go from failing to an ‘A’ just to participate in the release of the shad.”



Photo 6. Tiffany Penland lecture at Central Park School for Children

This year Tiffany Penland, NCSU graduate student, conducted an aquatic macro-invertebrate lesson for Central Park School for Children and Ballentine Elementary at their schools and on location at the Roanoke River for Bertie Early College High School, Perquimans County Middle School, and Southern Vance High School. Casey Williams, NCWRC, conducted an aquatic macro-invertebrate lesson on the Eno River for Central Park School for Children. We continued with the shad mold loaning program and the fish dissection program, both described in more detail below.



Photo 7. Students holding aquatic macroinvertebrates at Ballentine Elementary

American Shad Molds – Fish Printing

This year we continued to make available two travel kits (4 American Shad molds each) of fish printing (Gyotaku) supplies for the teachers to borrow and use in their classrooms. Thirteen teachers took advantage of these available resources, and reported that the exercise enhanced the learning experience for their students.

Fish Dissection

We coordinated with the NC Chapter of the American Fisheries Society Student subunit (Chapter) at NCSU and the NCWRC Education Section to conduct fish anatomy/morphology and dissection lessons. Eleven student, post-doc, researchers, and educators from the Chapter and NCWRC volunteered (listed in acknowledgments) to conduct these lessons. Because of these volunteers and the generosity of fish donations (320 fish), we were able to facilitate the dissection lecture for 16 classes (1098 students).



Photo 8. Gus Engman fish dissection and anatomy lesson at Brogden Middle School.

This year we were unable to accommodate all teachers (25) that requested a dissection lecture at their school. This was due to having more classes in the program, resulting in more requests, but also having fewer volunteer lecturers available. However, although a few less classrooms (3) were accommodated than last year, there were actually 547 more students participating in dissections (almost double). This was likely due to the fact that some teachers requested up to four lectures to cover all of their classrooms, and more of these “multiple” classes were accommodated this year. One teacher conducted her own dissections with the donated fish. We are very grateful to the Chapter and the NCWRC educators and for the fish donations, which led to the great success of this activity. All teachers that were able to participate in this class reported that the activity enhanced the learning experience for their students. The fish dissection continues to be a highly appreciated component that we have added to the program.

“Dissection - Absolutely one of the student’s favorite activities. Due to many budget cuts over the years they usually do not have this type of opportunity.”

“The dissection activity is something my students talk about for a long time. We have a wall of photographs in our classroom, and I see students looking at photos of previous dissections again and again. I don’t think that students get opportunities to dissect anything in their science classes anymore, so this is a very valuable piece of the program.”

Curriculum Activities and Videos

We continually add and update supplementary materials for the teachers to use to augment the learning process in the classroom and at the release. This year we added Shad Pipette Art. In the Shad in the Classroom, students use plastic squeeze transfer pipettes to suck up American Shad eggs and transfer them between sectioned petri dishes when they examine the eggs for viability. This project will assist students in improving their skills using a plastic squeeze transfer pipette in a fun and artistic manner (7 reported as useful). This and other exercises have all been uploaded to a shared dropbox site with the teachers. In addition to Shad Pipette Art, materials include, but are not limited to, a Shad Scent exercise, a guide for stream sampling, a watershed GIS exercise, a genetic exercise, and materials provided by the teachers.

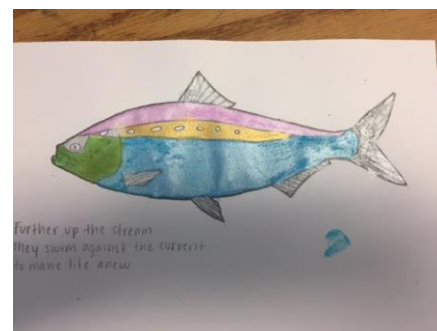


Photo 9. Shad Pipette Art by student at Daniels IBMYP Magnet MS

The genetic based exercise, “Who’s your Shaddy”, (developed in 2013 and updated in 2014) was continued. Three teachers (2 high schools and 1 middle school) reported using this exercise. One of the high schools and the middle school reported that it was “just right” as far as understandability and complexity for their students, and one high school reported that it was “too easy” for their students. Additional on-line (Museum website) curriculum activities are available for the teachers to use including Food Web Activities (14 reported as useful), GIS Watershed Activity (3 reported as useful), Wishes of Fishes Activity (6 reported as useful), and a Non-Fiction Reading Activity (14 reported as useful). Seven

videos were created for the program previously, most teachers reported using at least some videos, and many reported that they were very useful.

Table 5. Additional Education and Video Use Survey Results

Question	Response variable
Fish Printing – enhance learning?	25% (8) greatly enhanced; 13% (4) enhanced; 13% (4) somewhat; 49% (16) did not use
Fish Dissection – enhance learning?	44% (14) greatly enhanced; 6% (2) enhanced; 50% (16) did not use
Shad Scents – enhance learning?	10% (3) greatly enhanced; 6% (2) enhanced; 3% (1) somewhat; 81% (26) did not use
Genetic Exercise – complexity or understanding?	6% (2) just right; 3% (1) too easy; 91% (29) did not use
Shad Pipette Art?	6% (2) greatly enhanced; 3% (1) enhanced; 13% (4) somewhat; 78% (25) did not use
Food Web Activities – usefulness?	31% (10) very useful; 13% (4) useful; 56% (18) did not use
GIS Watershed Activity – usefulness?	6% (2) very useful; 3% (1) somewhat; 91% (29) did not use
Wishes of Fishes Activity – usefulness?	12% (4) very useful; 7% (2) useful; 81% (25) did not use
Non-Fiction Reading Activity – usefulness?	31% (10) very useful; 13% (4) useful; 56% (18) did not use
Video -Add the eggs – usefulness?	50% (16) very useful; 25% (8) useful; 25% (8) did not use
Video –Build the Tank – usefulness?	47% (15) very useful; 16% (5) useful; 6% (2) somewhat; 31% (10) did not use
Video – Fish Passage – usefulness?	53% (17) very useful; 19% (6) useful; 28% (9) did not use
Video – History – usefulness?	65% (21) very useful; 16% (5) useful; 19% (6) did not use
Video – It is Time usefulness?	53% (17) very useful; 28% (9) useful; 19% (6) did not use
Video - Lifecycle – usefulness?	62% (20) very useful; 13% (4) useful; 25% (8) not use
Video – Overview – usefulness?	62% (20) very useful; 16% (5) useful; 22% (7) did not use

Roanoke River Trek

This year, the Museum provided a 4-day 3-night canoe-camping experience on the Roanoke River for 8 high school students involved in our Junior Curator program. This trip helped forge a connection for those students with the Roanoke River basin through an immersive, impactful experience that highlighted the ecological importance of the bottomland hardwood forest. For a summary of the experience in the words of one of the students that participated, please visit: <https://naturalscienceseducation.wordpress.com/2017/05/02/secrets-of-the-swamp-junior-curator-trip/>

River Days – Geodome

The “River Days” component of the Shad in the Classroom program that began in 2014 continued this year, and was primarily based around the Museum’s travelling, inflatable immersion theater, the Geodome. In an effort to reinforce the Shad in the Classroom goals, instead of doing The Incredible Journey from Project WET as an indoor rainy day alternative, the team developed a card game about the life cycle of the anadromous fish, called Survivor! A Fish’s Tale. Over the course of the “River Days” week, the Geodome visited 5 schools (all public, Title 1 schools). The program served grades 4, 5, and 8 (totaling 401 people). Each class rotated through the following activities.

1. *We Are the River* video in the Geodome with accompanying riverbank development activity
2. *Survivor! A Fish’s Tale* –anadromous fish card game

Teachers were uniformly enthusiastic about the program and the staff. Seven teachers asked to be added to the email list for teacher education opportunities from the Museum. All teachers recommended the program to other schools.



Photo 10. W.L. Manning Elementary Students at geodome

“Students had a powerful experience when they were able to see the river days program and were very passionately connected to how important our local estuaries are.”

Program Outcomes

Student Impact

The Shad in the Classroom Program exposes students to important science and math concepts including those listed below.

1. History, cultural and biological importance, and life cycle of the American Shad
2. The shad’s ecological connections to other species
3. The significance of genetic integrity to population studies

4. Scientific procedures for measuring, testing, collecting, and organizing data
5. Mathematics to estimate, calculate, and predict results
6. Charts, maps, and graphs to aid in using information
7. Information exchange among other classes in the school and to parents and adults
8. The delicate balance of nature and work toward conserving or improving natural resources
9. American Shad restoration in rivers
10. Reporting and presentation techniques, both oral and written

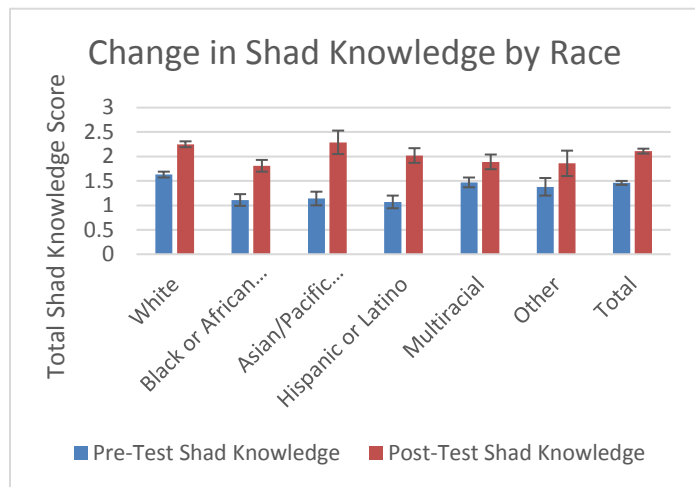
This program provides a valuable experiential learning opportunity for students in the classroom that houses the tank (direct involvement) and those indirectly involved (e.g. collecting and recording water quality during their science period). Some teachers reported that it created an “excitement in the whole school”. There were 2,171 students directly involved with the Shad in the Classroom Program this year and more that experienced it indirectly.

Student Analytics 2016

To better evaluate the Shad in the Classroom Program’s impact on student’s understanding, we partnered with Dr. Nils Peterson, Dr. Kathryn Stevenson, and graduate student Kalysha Clark at the NCSU Human Dimensions of Conservation Biology Lab. We created a questionnaire that used multiple choice questions in order to determine shad knowledge of participants. We also included demographic questions about age, gender, grade level, and whether the participant hunted or fished. Those who agreed to participate (15 teachers) provided the pre- and post-tests to their students (n=505). We additionally conducted the questionnaire for 2017, and those data will be analyzed at a later date.

Preliminary 2016 data analysis shows that the Shad in the Classroom Program improves shad knowledge and it does this for everyone, regardless of race or gender (Figure 3). This is of note, as it is usually found that there are the same gaps in environmental education as is seen in general education (i.e., minority kids fall behind white kids). It also showed that hunting participation predicted a difference in shad knowledge. Specifically, those who hunt entered the program with a higher level of shad knowledge than those who do not hunt, but students exited the program with a similar level of shad knowledge. This suggests that Shad in the Classroom Program may improve knowledge for individuals that may lack significant life experiences, such as spending time outdoors or having adult role models who facilitate outdoor experiences. These preliminary results indicated that the Shad in the Classroom Program could be crucial in increasing environmental literacy in the next generation so that they are equipped to address key issues facing fisheries.

Figure 3. — Change in shad knowledge by race

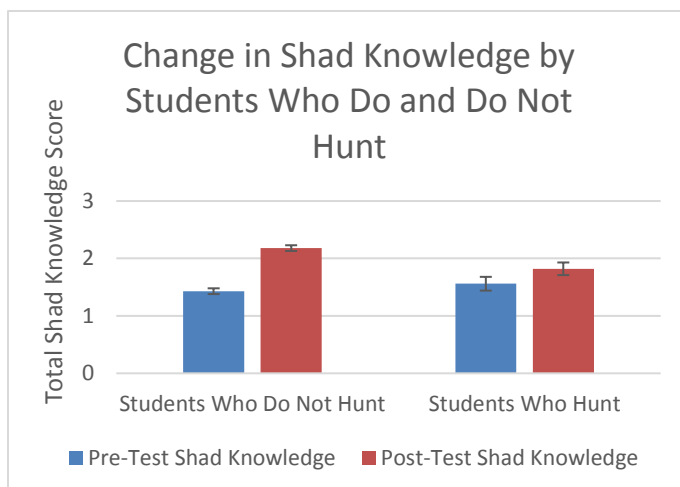


For n=505 students (n=296 White, n=70 Black or African American, n=14 Asian or Pacific Islander, n=56 Hispanic or Latino, n=47 Multiracial, n=21 Other, n=1 did not report), self-reported results.

Possible scores range from 0 to 4.

Note: All figures have error bars incorporated into the graph. When the bars do not overlap, it represents a statistically significant difference.

Figure 4. — Change in shad knowledge by students who do and do not hunt



For n=505 students (n=412 do not hunt, n=88 hunt, n=5 did not report), self-reported results.

Possible scores range from 0 to 4.

Note: All figures have error bars incorporated into the graph. When the bars do not overlap, it represents a statistically significant difference.

Public Outreach

Information on the Shad in the Classroom Program is available on the Museum’s website. The program also receives a lot of publicity by word-of-mouth from those who have participated in the program previously (including teachers, students, and volunteers). The River Days – Geodome component reached 401 people from April 24–28. This year information on the Shad in the Classroom Program was presented at the NC Chapter of the American Fisheries Society Student Subunit (NCSU) Meeting on January 10, 2017.

An update on the Shad in the Classroom Program will be published in the North Carolina Chapter American Fisheries Society Summer or Fall Newsletter in 2017. Also, a paper on the student analytics is proposed to be presented at the 2017 North American Association for Environmental Education Conference and Research Symposium in October.

Future Planning

The shad models for fish printing (Gyotaku) and the fish dissection lectures are greatly valued and we plan to continue them for next year. We will also continue to make additional curriculum activities available for in-classroom and at-release use.

Shad in the Classroom was very successful again this year. Teachers and students provided positive feedback on all aspects of the program including the workshop, activities, the River Days – Geodome, and the overall program. Thirty-one of the 33 teachers participating in the Shad in the Classroom Program reported that they would like to continue with the program next year. Two of the teachers are leaving teaching (one retiring). At present, we have six new teachers on the waiting list for the program in 2018. A few activities were updated and improved this year, which added to the students' overall learning experiences. We received invaluable assistance from partners and volunteers helping with the deliveries of eggs, attendance at releases, and educational lectures. Working with this program is a positive experience for all involved.

“When we visited the river to release the shad, it was a memorable experience for my students in many ways. They saw how they were having a direct impact on increasing the shad population and their impact as a citizen.”

“Students that participate in the program feel like real scientists and most finally believe that they are. I work very hard to make them feel like they are truly using the scientific method and working on projects that make a difference in the world. This one project seems to solidify that for so many of my students each year. “

Appendix 1

Shad in the Classroom Background

The American Shad fishery was once one of the East Coast's most abundant and economically important. However, by the mid-1970s water pollution, over-harvesting and the blocking of spawning habitat by dams led to their decline. Today, American Shad continue to have ecological, economic, and historical importance to North Carolina and much of the eastern seaboard of the U.S.

Many programs across the nation introduce fish and their associated habitats into the classroom to teach students about nature and the environment. These programs go by various names, including Trout in the Classroom, Salmon in the Classroom, and Shad in the Classroom. In North Carolina, Trout in the Classroom began in 2007 and Shad in the Classroom began in 2009. Trout in the Classroom is administered by the North Carolina Trout Unlimited Chapter. The Chapter started with two schools and by 2014 there were 37 schools in North Carolina. Schools receive between 100 and 150 trout eggs (embryos) and they raise them about 7 months to the fingerling stage prior to release. The cost of the trout program is about \$900 per classroom (includes cost of cooling system; 2015 costs). Shad programs from other states have reported the costs for tank construction and running their program ranges from \$550 to \$2,000 per system (with some programs, some of those costs are due to a cooling system).

Shad in the Classroom is led by the North Carolina Museum of Natural Sciences (Museum). Comparable to the Trout in the Classroom, the Shad in the Classroom program provides a hands-on, real-life science learning opportunity. Similar American Shad programs have existed in the Potomac River basin since 1996, setting the groundwork for the Shad in the Classroom program in North Carolina. In addition to North Carolina, several states participate in similar shad in the classroom programs: Delaware, Maryland, New Jersey, Pennsylvania, Virginia, and West Virginia, and the District of Columbia (Figure 3). A number of participating states are part of the Interstate Commission on the Potomac River Basin (ICPRB). The Delaware River Shad Fishermen's Association is another large organization that works with a shad in the classroom program. Some of the names used for these programs include Shad in the Classroom, Schools in Schools, and Shad in Schools. Some of the states also have a Trout in the Classroom program and some even have Perch or American eels in the Classroom Programs.

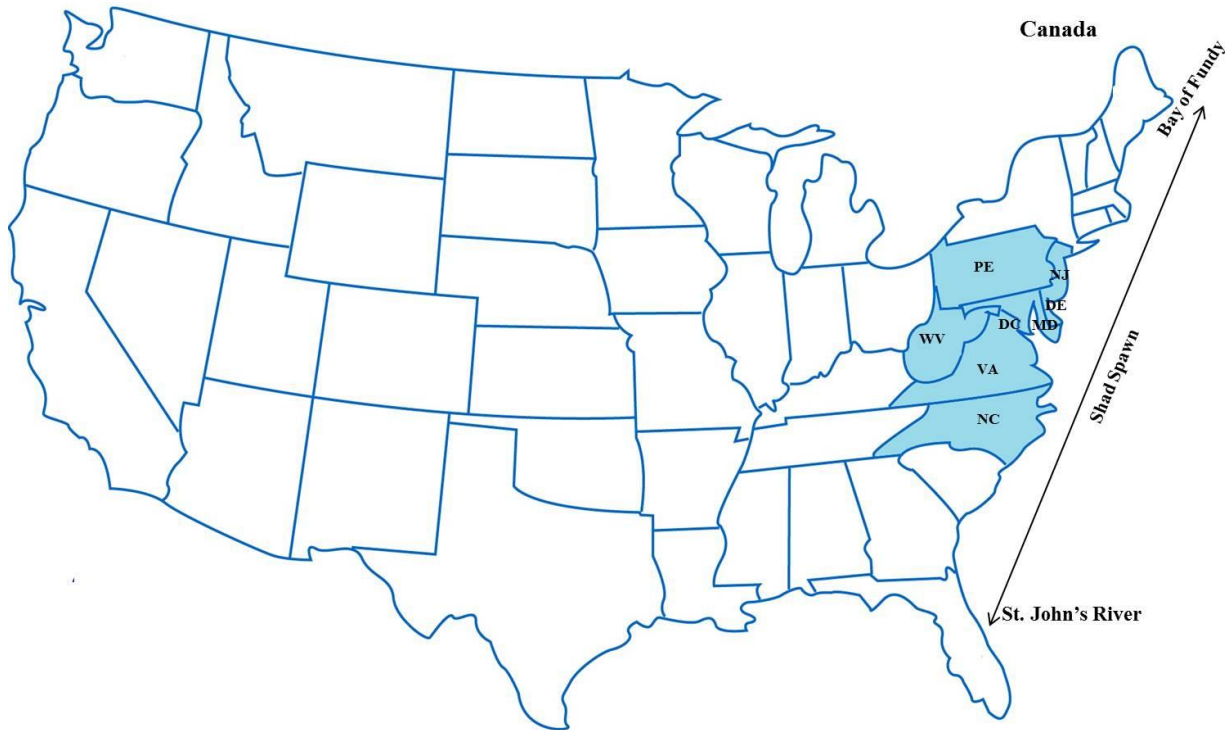


Figure 5. — Map of the states we found to participate in some version of a shad in the classroom program: Delaware, Maryland, New Jersey, North Carolina, Pennsylvania, Virginia, and West Virginia, and the District of Columbia. Arrow depicts American Shad spawning distribution which ranges from the Bay of Fundy in Canada to the Saint John’s River in Florida.

In North Carolina, the United States Fish and Wildlife Service (USFWS) started a pilot American Shad program with four schools in 2009. Two of those school programs were administered by the North Carolina Wildlife Resources Commission (NCWRC), Education Section. The following year (2010) the USFWS partnered with the North Carolina Museum of Natural Sciences (Museum), and the program grew to 13 schools (USFWS funding), three of which were administered by the NCWRC, Education Section. Beginning in 2011, the Museum assumed control of the Shad in the Classroom program and worked with 19 classrooms [with funding provided by the Albemarle-Pamlico National Estuary Partnership (APNEP), Dominion Power, and National Fish and Wildlife Foundation], while the NCWRC, Education Section continued a separate program. Under the Museum’s guidance (and with funding provided solely through APNEP), the Shad in the Classroom program reached 20 classrooms each in 2012 and 2013, 23 classrooms in 2014, and 27 classrooms in the 2015 and 2016 program years. For the 2017 year, 33 classrooms (12 new) were accepted with funding provided through APNEP and the USFWS. Note that these numbers generally reflect the number of tanks that are in a school; some schools had multiple classrooms sharing in the shad rearing or at least observing the program. A comprehensive list of the participating schools (2009 –

2017) is included in Table 1. Students and teachers become involved in the program several weeks prior to receiving American Shad eggs (fertilized embryos) spawned in NCWRC and USFWS hatcheries. For 2017, all shad used for the program were spawned in the USFWS hatchery.

The program timeline begins with the teacher workshop in February and concludes with the release of fry reared by students into native rivers in April to early May. Each February participating teachers attend an all-day workshop and learn how to construct their fish hatcheries, attend expert presentations, participate in hands-on activities, and receive curriculum materials to use in their classrooms. The timing for delivery of eggs to the classrooms is dependent on the natural spawning of the fish. Teachers typically begin setting up their tanks and teaching materials related to the program 2–4 weeks prior to receiving the eggs. Students learn how to set up the tank and pump system, monitor water quality, and tend their shad eggs in special rearing systems prior to the arrival of their eggs. For one week during the spawning period, each classroom receives, monitors, and cares for a batch of shad eggs as part of this hands-on approach to learning about water quality, fisheries science, ecology, and history. Fry hatch within 4–5 days and are then released by the students in their river basin of origin. Lessons and activities related to the American Shad are prime examples of cross curricular connections, integrating history, social studies, ecology, and management. Some teachers elect to have students keep journals throughout the course of the program, further incorporating writing components and practice. Teachers in the program have also participated in an overnight canoe trip along the Roanoke River in late April or early May to explore the river-swamp ecosystem and its resources and to gain valuable insight to take back to their classrooms.

In the wild, or after release for hatchery-reared fish, the fry move downstream, and come together in schools. They will eventually leave the river and move into the sounds and then to the ocean. They will remain in the ocean for 4–6 years and then return to spawn in their native river basin in the spring to complete the life cycle. The NCWRC sample the young shad (collecting genetic material) as they move downstream and prior to moving into the sounds. They use this information to determine the proportion of shad that have been reared in the state and federal hatcheries (including the schools) compared to shad that were spawned directly in the river. These data help the NCWRC determine the management strategies for the American Shad fishery. Having the schools be part of this restoration program is a valuable educational tool.