Shad in the Classroom
Program Report
(2009-2016)

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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 Program (APNEP), the NCWRC, and the USFWS. 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 153 classrooms from 2009 to 2016 (Table 1) and many thousands of students. Between 2013─2016, approximately 9,542 students were reached (prior to 2013, the numbers of students were not tracked). Twenty-seven classrooms participated in 2016 with 8 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 23 schools released in the Neuse River basin.

Table 1. Schools Participating in the North Carolina Shad in the Classroom Program (2009─2016)

	Number of Classrooms by year							
Release Basin/School	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
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
Angier Elementary					1	1		
Brogden Middle School							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
Chatham Central High School						1		
Chestnut Grove Middle School				1				
Clayton High School								1
Cleveland High School								1
Daniels IBMYP Magnet Middle School		1	1	1	1	2	3	1
Clayton High School							1	
Don D. Steed Elementary				1				
The Expedition School							2	2
Exploris Middle School		1	1	1	1	1	1	1
East Wake Middle School		1	2	2	2	2	1	
East Wake School of Integrated Technology						1		
Forest Pines Dr Elementary					1			
Fuquay Varina Middle School						1	2	2
Hall Woodward Elementary				1	1			
Lakewood Montessori Middle School					2	2	2	2

Table 1. Schools Participating in the North Carolina Shad in the Classroom Program (2009–2016) Continued

Release Basin/School	Number of Classrooms by year							
	2009	2010	2011	2012	2013	2014	2015	2016
Neuse River Basin								
Lead Mine Elementary	1	1	1					
Lillington Shawtown Elementary			1	1				
McLauchlin Elementary				1				
Midway Middle School							1	
Mineral Springs Middle School						1		
North Duplin JR/SR High School							1	1
Sandy Grove Middle School				1	1			
South Asheboro Middle School				1				
South Iredell High School					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
Upchurch Elementary				1	1	1	1	1
Uwharrie Charter Academy								1
West Hoke Elementary				1				
Wake Forest Middle School							1	1
Walkertown Middle School								1
Woods Charter Middle School				1	1	1	1	1
Roanoke River Basin								
Bartlet Yancey High School		1						
Bertie Early College High School							1	1
Cedar Creek Middle School								1
Chestnut Grove Middle School		1	1	1				
Don D. Steed Elementary			1					
Hall Woodward Elementary			1					
Hawk Eye Elementary			1					
Hertford County High School						1	1	
McLauchlin Elementary			1					
Red Oak Middle School					2			
Rockfish Hoke Elementary			1					
Sandy Grove Middle School			1					
Scurlock Elementary			1					
Southern Vance High School		1	1					
Speas Elementary		1	1					
The Oakwood School			1					
Upchurch Elementary			1					

Table 1. Schools Participating in the North Carolina Shad in the Classroom Program (2009–2016) Continued

Release Basin/School	Number of Classrooms by year							
	2009	2010	2011	2012	2013	2014	2015	2016
Roanoke River Basin								
Vance Charter School								1
West Hoke Elementary			1					
Windsor Elementary		1						
W.L. Manning Elementary School								1
Total Number of Schools	**4**	**13**	**18**	**19**	**16**	**17**	**22**	**23**
Total Number of Classrooms	**4**	**13**	**19**	**20**	**20**	**23**	**27**	**27**

Current new tank construction costs approximately $300 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 eggs and delivery, presentations and conferences, part-time staff, Geodome supplies and contractors, and museum overhead.

In the years from 2013–2016 each school received about 1,000 eggs from the NCWRC. The Neuse River broodstock fish are brought to the Edenton National Fish Hatchery and the Roanoke River broodstock fish are brought to the Watha State Fish Hatchery; however, this year both Roanoke and Neuse eggs that were used by the shad program were spawned by broodstock at 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 by themselves and their students for 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 2016 are listed below.

Workshop Speakers

Ben Ricks ben.ricks@ncwildlife.org – (NCWRC District Biologist)
Dr. Heather Evans heather.evans@naturalsciences.org – (Museum Research Adjunct, Genomics & Microbiology Research Lab)

Additional Education

Electrofishing Demonstration
Ben Ricks ben.ricks@ncwildlife.org – (NCWRC District Biologist)
Kayla Herrera kayla.herrera@ncwildlife.org – (NCWRC Technician)

Fish Anatomy-Dissection Lecture
Ani Popp apopp@ncsu.edu – (NCSU Grad Student and helped coordinate with the graduate students)
Casey Grieshaber cagriesh@ncsu.edu – (NCSU Grad Student)
Casey Williams casey.williams@ncwildlife.org – (NCWRC Education Specialist)
Stephanie Buhler sbuhler@ncsu.edu – (NCSU Grad Student)
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Tiffany Penland tnpenlan@ncsu.edu – (NCSU Grad Student and helped coordinate with the graduate students)
Tomas Ivasauskas tjivasau@ncsu.edu – (NCSU Grad Student)

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Invertebrate Lesson
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Emily Jernigan emily_jernigan@fws.gov – (USFWS Biologist)
Dr. Heather Evans heather.evans@naturalsciences.org – (Museum Research Adjunct, Genomics & Microbiology Research Lab)
Jerry Reynolds jerry.reynolds@naturalsciences.org – (Museum Senior Manager of Outreach)
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Stacey Feken stacey.feken@apnep.org – (APNEP Policy and Engagement Manager)
Dr. Wilson Laney wilson_laney@fws.gov – (USFWS Fishery Biologist and NCSU Adjunct Faculty)

River Days – Geodome

Karen Polk – karen.polk@naturalsciences.org – (Museum River Days Specialist)
Katia Griffin-Jakymec katia.griffin-jakymec@ncdenr.gov– (APNEP Education and Outreach Assistant)
Jess Beasley – jess.beasley@gmail.com– (Museum River Days Contractor)

In addition, we are very appreciative of the fish donations for the 2016 dissection lectures from Rich Noble, Phil Doerr, Jim Rice and fellow anglers, Tiffany Penland, Ani Popp, and Spencer Gardner from NCSU, and the NCWRC's Armstrong Hatchery. Also, Tiffany Penland and Ani Popp helped coordinate with the NCSU graduate students for the anatomy-dissection lectures. American shad eggs were generously provided by Stephen Jackson and the staff at the Edenton National Fish Hatchery.

Shad in the Classroom Program 2016 Report

This report summarizes the activities accomplished for the 2016 Shad in the Classroom Program. Twenty-seven classes at 23 different schools participated in the program: 8 elementary, 13 middle, and 6 high school classes. We increased the program by four classes from 2014–2015 and maintained that number (27) for 2016.

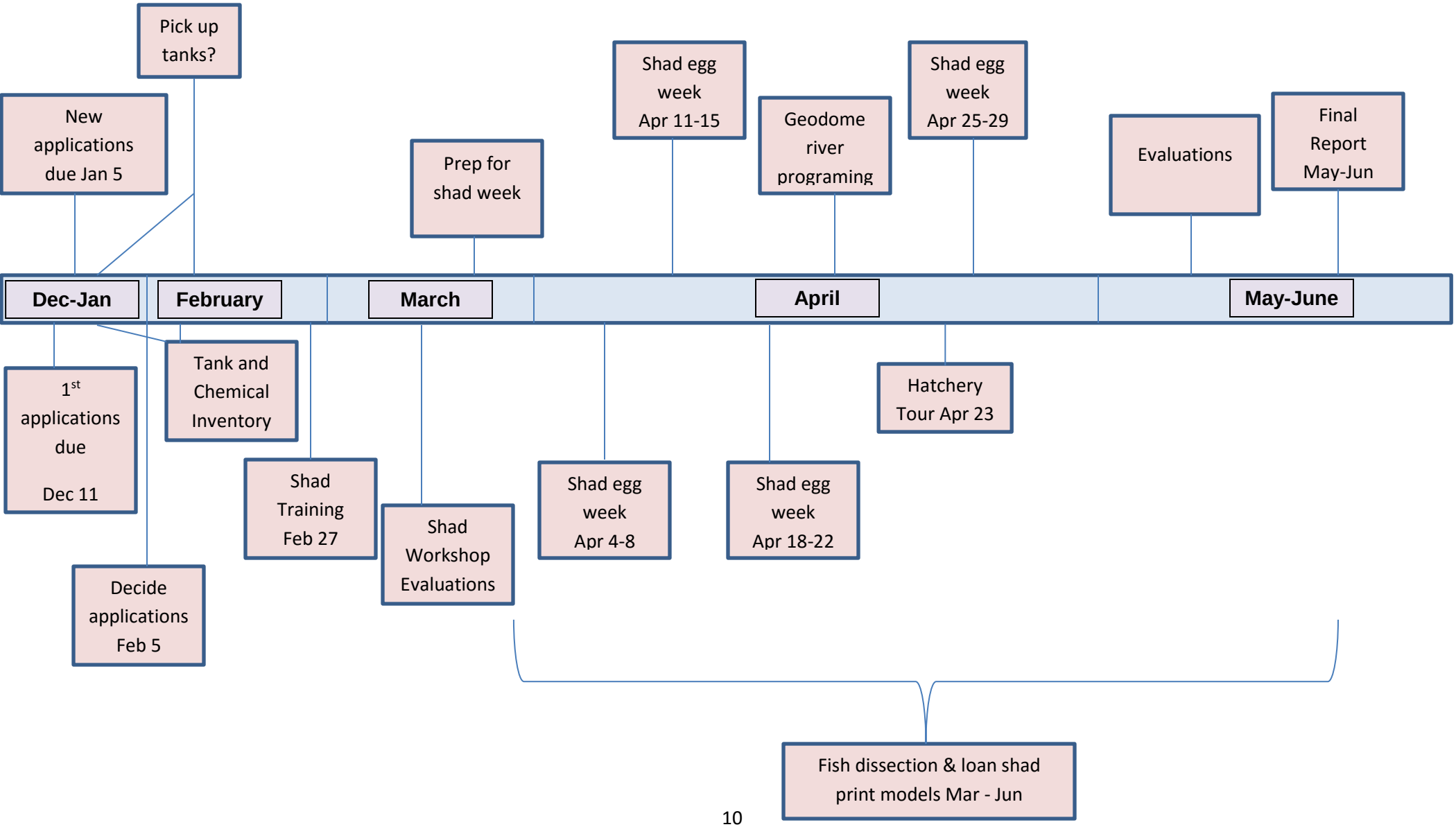
Yearly program planning began with forming a timeline (Figure 1), reviewing applications, and conducting a tank and parts inventory. All new teachers and several returning teachers attended an orientation and training session in February. Returning to their schools, they typically began preparing their 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 28. 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. One teacher was also able to take advantage of an invertebrate lecture.

Photo 1. Ben Ricks and Kayla Herrera demonstrating boat electrofishing at Smithfield boat ramp (along with: Stacey Feken, APNEP)

We continued the 'River Days' program to reach students and communities along the Roanoke River in 2016. 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 and APNEP staff presented supplemental activities to build on the video content.

Photo 2. Woods Charter Middle School aquatic macro-invertebrate sampling on the Eno River

Figure 1. –Shad in the Classroom 2016 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. An updated inventory list is on file.

Teacher Orientation and Training

A teacher orientation and training session was conducted on February 27, 2016. Danielle Pender and Melissa Dowland co-led the session. Ben Ricks (NCWRC) and Dr. Heather Evans were guest lecturers. Teachers were provided information about American shad life history, restoration, management, and genetics. 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) and Shad genetic and watershed 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. Seventeen teachers attended the 2016 workshop. Of those, 12 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. Teachers shad printing

Table 2. Workshop Survey Results

Question	Response variable
How well did the workshop explain the importance of the shad restoration and management program?	42% (5) extremely well; 42% (5) very well; 16% (2) moderately well
How well did the workshop explain the life history of shad?	42% (5) extremely well; 42% (5) very well; 16% (2) moderately well
How well did the workshop explain the proper components to raising shad eggs to the larval stage?	42% (5) extremely well; 58% (7) very well
How confident do you feel in building the shad tank system on your own?	67% (8) extremely confident; 16% (2) very confident; 16% (2) moderately confident
How resourceful was the leadership team in helping you with your questions about the program?	63% (7) extremely resourceful; 37% (4) very resourceful
How comfortable do you feel in contacting the other teachers that you met at the workshop with questions?	50% (6) extremely comfortable; 25% (3) very comfortable; 25% (3) moderately comfortable
How sufficient was the information you learned to incorporate shad into your curriculum?	50% (6) extremely sufficient; 42% (5) very sufficient; 8% (1) moderately sufficient
What aspects of the workshop were useful? Please choose all that apply.	Life History: 83% (10); Shad Restoration: 75% (9); Genetics presentation: 50% (6); Genetics exercise: 50% (6); Tank Building: 67% (8); GIS exercise: 42% (5); Sharing Experience: 92% (11)
Overall, how satisfied are you with the workshop?	58% (7) extremely satisfied; 25% (3) very satisfied; 17% (2) moderately 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 28 from the Neuse and the week of April 4 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 11, Group 2 received them on Monday, April 18, and Group 3 received their eggs on Monday, April 25. In Group 1 there were 8 classes. Of those, 3 classes released larval fish in the Neuse on Thursday, April 14, 2016 and 5 classes released on Friday, April 15, 2016; 2 in the Neuse and 3 in the Roanoke River Basin at Weldon (Table 3, Figure 2). Thirteen classes (Group 2) received eggs on Monday, April 28, 2016. Of those, 6 classes released larval fish on Thursday, April 21, 2016 and 7 released on Friday, April 22, 2016. All of Group 2 released in the

Photo 4. Vance Charter School release at the Roanoke River

Photo 5. Ben Ricks boat electrofishing demonstration for Tar Heel Middle School at Smithfield boat ramp on the Neuse River

Neuse River Basin. The remaining six classes (Group 3) received their eggs on Monday, April 25, 2015. One of these classes released on Thursday, April 28, 2016 and the rest released larval fish on Friday, April 29, 2016; 4 in the Neuse and 1 in the Roanoke River Basin. Three classes chose to raise their shad in Neuse River water (as opposed to municipal water) this year. One class from Group 1 raised two tanks of fish comparing the water quality and survival results of raising shad in municipal water vs Neuse River water. Classes releasing in to the Neuse River Basin received approximately 24,000 eggs (1,000 to each class, with the exception of one classroom which has two tanks and received 2,000 eggs) and classes releasing into the Roanoke River Basin received approximately 4,000 eggs (1,000 to each class) from the Edenton National Fish Hatchery.

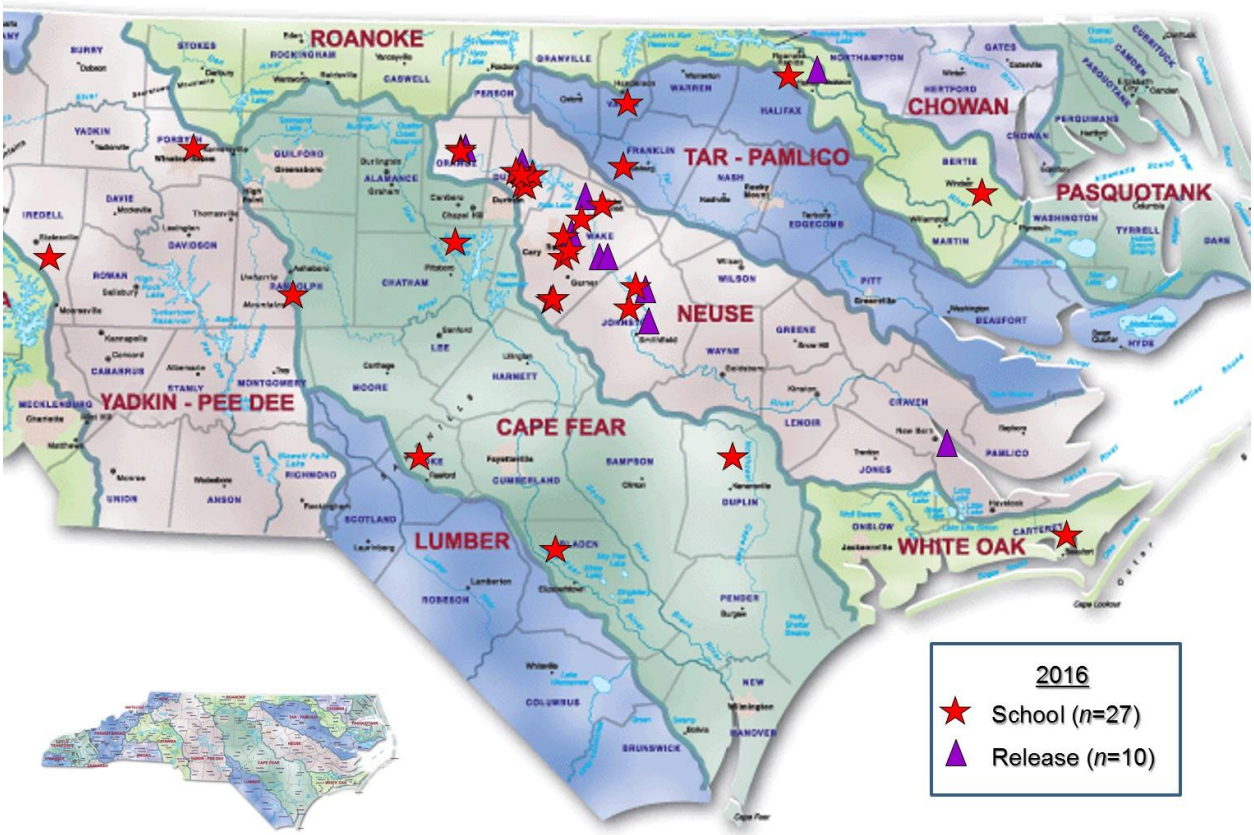
Table 3. Egg and Larval Release Timing and Release Site Information

Educator	School	Received Eggs	Released Eggs/Larva	Release Site
Beth Selig	Fuquay Varina MS	4-11-2015	4-15-2015	Neuse River (Smithfield)
Brian Reynolds	Bertie Early College HS	4-11-2015	4-15-2015	Roanoke River at Weldon
Jody Smith	Uwharrie Charter Academy	4-11-2015	4-14-2015	Neuse (West Point, Eno River)
Matthew Lanner	Fuquay Varina MS	4-11-2015	4-15-2015	Neuse River (Smithfield)
Melissa Oakley	Vance Charter School	4-11-2015	4-15-2015	Roanoke River at Weldon
Rachel Eure	W.L. Manning Elementary School	4-11-2015	4-15-2015	Roanoke River at Weldon
Richard Kowaleski	Daniels IBMYP Magnet MS	4-11-2015	4-14-2015	Neuse (Lassiter Mill Dam, Crabtree Creek)
Shannon Hardy	Exploris MS	4-11-2015	4-14-2015	Neuse River (Milburnie Dam)
Angie Archbold	The Expedition School	4-18-2015	4-21-2015	Neuse (Gold Park, Eno River)
Christina Edmiston	Upchurch ES	4-18-2015	4-21-2015	Neuse (Anderson Point, Crabtree Creek)
Christina Livingstone	Brogden MS	4-18-2015	4-22-2015	Neuse (West Point, Eno River)
Christopher Wagoner	Tar Heel Middle School	4-18-2015	4-21-2015	Neuse River (Smithfield)
Daniel Cates	North Duplin JR/SR HS	4-18-2015	4-21-2015	Neuse River (Cliffs of the Neuse State Park)
Gail Clougherty	Cleveland High School	4-18-2015	4-22-2015	Neuse River (Smithfield)
Janice West	Clayton High School	4-18-2015	4-21-2015	Neuse River bridge on 42
Judy Compton	Central Park School for Children	4-18-2015	4-22-2015	Neuse River (Cliffs of the Neuse State Park)
Kelly Riley	Tiller ES	4-18-2015	4-22-2015	Neuse River (Flanners Beach)
Laine Staton	Lakewood Montessori MS	4-18-2015	4-22-2015	Neuse (West Point, Eno River)

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

Educator	School	Received Eggs	Released Eggs/Larva	Release Site
Meg Millard	Central Park School for Children	4-18-2015	4-22-2015	Neuse River (Cliffs of the Neuse State Park)
Michelle Amato	Wake Forest MS	4-18-2015	4-22-2015	Neuse River (Milburnie Dam)
Sue Willis	The Expedition School	4-18-2015	4-21-2015	Neuse (Gold Park, Eno River)
Brad Rhew	Walkertown Middle School	4-25-2015	4-29-2015	Neuse (West Point, Eno River)
Cheryl Henry	Cedar Creek MS	4-25-2015	4-29-2015	Roanoke River at Weldon
Courtney Millis	Lakewood Montessori MS	4-25-2015	4-29-2015	Neuse River, Falls Dam
Krista Brinchek	Abbotts Creek Elementary School	4-25-2015	4-29-2015	Neuse River, Falls Dam
Kristen Bright	South Iredell HS	4-25-2015	4-29-2015	Neuse (West Point, Eno River)
Sonja Younger	Woods Charter MS	4-25-2015	4-28-2015	Neuse (West Point, Eno River)

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



Overall, the shad rearing and release was successful for most schools. Each class was to receive approximately 1,000 eggs; however, counts may differ as to what the school actually reported receiving. A few schools reported receiving eggs in advanced development––having some develop the first day. Some of the schools had problems with the early development, which may have caused higher mortalities; however, others reported it to be their best year ever due to the earlier development, since they were able to release more larval fish rather than only developing eggs. Schools only reported minor water quality issues this year, and they continued with a baking soda treatment for low alkalinity and low pH issues. Percent survival for each tank ranged from as low as 10% up to 85% and averaged 48% (Table 4). Fifteen classes averaged ≤ 50%, 11 averaged ≥ 51%, and 4 averaged ≥75% survival to release.

Table 4. Egg and Larval Survival and Release Numbers

Educator	School	No. Eggs Received	No. Eggs/Larva Survived to Release	Percent Survival (%)
Angie Archbold	The Expedition School	1000	500	50
Beth Selig	Fuquay Varina Middle School	2400	1550	65
Brad Rhew	Walkertown Middle School	1000	250	25
Brian Reynolds	Bertie Early College High School	1000	100	10
Cheryl Henry	Cedar Creek Middle School	1000	unknown	unknown
Christina Edmiston	Upchurch Elem	1000	700	70
Christina Livingstone	Brogden Middle School	1000	250	25
Christopher Wagoner	Tar Heel Middle School	1000	400	40
Courtney Millis	Lakewood Montessori Middle School	1000	200	20
Daniel Cates	North Duplin JR/SR High School	1000	400	40
Gail Clougherty	Cleveland High School	750	350	47
Janice West	Clayton High School	1500	500	33
Jody Smith	Uwharrie Charter Academy	800	575	72
Judy Compton	Central Park School for Children	700	250	36
Kelly Riley	Tiller School (Carteret County Charter School)	1000	111	11
Krista Brinchek	Abbotts Creek Elementary School	500	425	85
Kristen Bright	South Iredell High School	1000	187	19
Laine Staton	Lakewood Montessori Middle School	1000	800	80
Matthew Lanner	Fuquay Varina Middle School	2499	1681	67
Meg Millard	Central Park School for Children	1000	400	40
Melissa Oakley	Vance Charter School	1800	1350	75
Michelle Amato	Wake Forest Middle School	1000	850	85
Rachel Eure	W.L. Manning Elementary School	1000	700	70
Richard Kowaleski	Daniels IBMYP Magnet MS	1000	250	25
Shannon Hardy	Exploris MS	4683	3556	76
Sonja Younger	Woods Charter MS School	1000	700	70
Sue Willis	The Expedition School	1000	150	15

An overall theme reported this year from the teachers is that the students are much more aware of the organisms, the rivers, and the watersheds around them and the impacts that humans have on these resources. The Shad Program increases the students interest in science. We have received such great feedback on the program from the teachers throughout the 2016 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). This year Ben Ricks conducted an electrofishing demonstration for Tar Heel Middle School at Smithfield boat ramp on the Neuse River, CC King conducted an aquatic macro-invertebrate lesson for Central Park School for Children on the Eno River, and we assisted a number of schools with basic aquatic invertebrate sampling during their release. This year we continued with the shad mold loaning program and expanded the fish dissection program, both described in more detail below.

"A young man that NEVER participated got involved & became an active talker. The student gamed esteem from classmates for this. It was an awesome moment."

"Helps overall grade not just information on Shad. Real life experience in the classroom creates stewards of our students that will carry on for years to come. Every student that has participated in the program that I talk to remembers each aspect of it."

"I think the students gain a much better understanding of their watershed and things that affect the watershed by having this hands-on experience. I think they also gain a better understanding of what it might be like to be a fisheries or wildlife biologist from meeting people involved in those fields such as Casey (NCSU), our fish dissection helper, and CC King from the NCWRC, and the rangers at the Eno and Neuse Rivers."

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. An additional teacher had models created for their own continued use.

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. Thirteen 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 (over 250 fish), we were able to facilitate the dissection lecture for 19 classes (551 students). We were fortunate that all teachers that requested a dissection lecture at their school were accommodated. 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.

Photo 6. Kevin Hining fish dissection and anatomy lesson at Walkertown Middle School

The fish dissection is a highly appreciated component that we have added to the program. One of the high schools (South Iredell High School) started an Ichthyology club because of this program and the fish dissection.

Curriculum Activities and Videos

This year we updated the GIS Watershed Activity for the Neuse and Roanoke Rivers. Teachers participated in the exercise at the workshop. One teacher reported that the exercise was very useful for their students and others reported that they are hoping to add some of the additional activities as time permits. In addition, we continually add and update supplementary materials for the teachers to use to augment the learning process in the classroom and at the release. These have all been uploaded to a shared dropbox site with the teachers. Materials include, but are not limited to, the Shad Scent exercise, a guide for stream sampling, the genetic exercise, and materials provided by the teachers.

"Dissection is an experience that the students would never have."

"The dissection really adds to the experience because kids get to see parts of the fish that they never really think about. Like the swim bladder – they never before wondered how a fish can go up and down and stay upright in the water. If they ever noticed that fish have different shapes of fins, they certainly never wondered why."

"It was an amazing experience. Gave the students an opportunity to understand the anatomy of fish and how their body parts/adaptations help them with survival."

The genetic based exercise, "Who's your Shaddy", (developed in 2013 and updated in 2014) was continued. Four teachers (3 high schools and 1 middle school) reported using this exercise. Two 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 "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 (1 reported as useful), Wishes of Fishes Activity (5 reported as useful), Non-Fiction Reading Activity (16 reported as useful), and Hands-on Activities for Students (16 reported as useful). Seven videos were created for the program previously, all teachers reported using at least some videos, and many reported that they were very useful.

Table 5. Additional Education Survey Results

Question	Response variable
Fish Printing – enhance learning?	11% (3) greatly enhanced; 22% (6) enhanced; 11% (3) somewhat; 8% (2) not yet done; 48% (13) did not use
Fish Dissection – enhance learning?	59% (16) greatly enhanced; 11% (3) enhanced; 30% (8) did not use
Shad Scents – enhance learning?	11% (3) greatly enhanced; 4% (1) enhanced; 85% (23) did not use
Genetic Exercise – complexity or understanding?	11% (3) just right; 4% (1) too easy; 85% (23) did not use
Food Web Activities – usefulness?	37% (10) very useful; 15% (4) useful; 48% (13) did not use
GIS Watershed Activity – usefulness?	4% (1) very useful; 96% (26) did not use
Wishes of Fishes Activity – usefulness?	11% (3) very useful; 7% (2) useful; 81% (22) did not use
Non-Fiction Reading Activity – usefulness?	33% (9) very useful; 26% (7) useful; 41% (11) did not use
Hands-on Activities – usefulness?	41% (11) very useful; 19% (5) useful; 41% (11) did not use
Video -Add the eggs – usefulness?	46% (12) very useful; 15% (4) useful; 38% (10) did not use
Video –Build the Tank – usefulness?	35% (9) very useful; 23% (6) useful; 42% (11) did not use
Video – Fish Passage – usefulness?	56% (14) very useful; 20% (5) useful; 24% (6) did not use
Video – History – usefulness?	64% (16) very useful; 12% (3) useful; 8% (2) somewhat useful; 16% (4) did not use
Video – It is Time usefulness?	56% (14) very useful; 16% (4) useful; 8% (2) somewhat useful 20% (5) did not use
Video - Lifecycle – usefulness?	76% (19) very useful; 16% (4) useful; 8% (2) not use
Video – Overview – usefulness?	68% (17) very useful; 24% (6) useful; 8% (2) did not use

Edenton National Fish Hatchery Tour and Cashie River visit

Four teachers, one APNEP personnel, and two museum staff attended the Edenton National Fish Hatchery Tour on Saturday, April 23, 2016. Originally, ten teachers were to attend the tour; however, for various reasons they were unable to be present. Sam Pollock conducted the tour. Following the tour, the group picnicked at the Hatchery's boardwalk overlooking Pembroke Creek. The group then attended the Lost Colony Festival in Windsor, NC and had pontoon boat tour of the Cashie River. The teachers highly valued the hatchery tour and enjoyed the pontoon boat tour of the Cashie River along with the festival.

Photo 6. Sam Pollock conducting the tour at the Edenton National Fish Hatchery

Photo 7. Pontoon Boat tour Cashie River

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. Over the course of the "River Days" week, the Geodome visited 4 schools (all public, eligible Title 1 schools). The program served grades 4 and 5 (totaling 435 people). Each class rotated through the following activities.

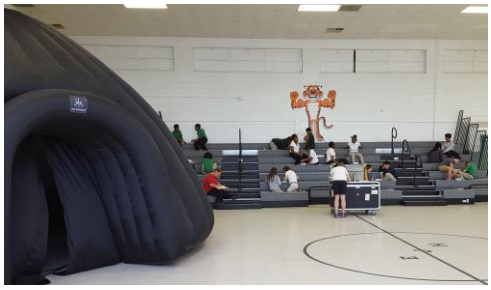


Photo 8. Students at geodome

1. ***We Are the River*** video in the Geodome with accompanying riverbank development activity
2. ***Hooks and Ladders***--fish migration enactment/game

As in previous years, all the teachers found the activities to be meaningful and engaging and would have us back as well as recommend the program to other schools.

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 1,808 students directly involved with the Shad in the Classroom Program this year and more that experienced it indirectly.

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 435 people from April 18–22. Information on the Shad in the Classroom Program was presented at the Southeastern Association of Fish and Wildlife Agencies (SEAFWA) Meeting on November 3, 2015 and the Environmental Educators of North Carolina Annual Conference in September, 2015.

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 2016.

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, hatchery tour, River Days – Geodome, and the overall program. All teachers participating in the Shad in the Classroom Program reported that they would like to continue with the program next year. At present, we have four new teachers on the waiting list for the program in 2017. 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.

Quote from a student's journal: "I loved releasing the shad into the river. I know that I helped make a difference in their population and I am happy for them!"

"It is a great way for students to learn---to really learn and remember---all kinds of things from NC geography and the water connections we all share to how to read a thermometer. It's fun."

"Because when we teach kids about their small part in the bigger world, they become better people. And when we trust them to take care of tiny live things, they become better people. And better people take care of our environment because they realize that their actions affect more than just what's right in front of them. Thank you for providing such a great experience for my students! I have many who would never engage in real-world, hands-on science without opportunities such as these."

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). 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.

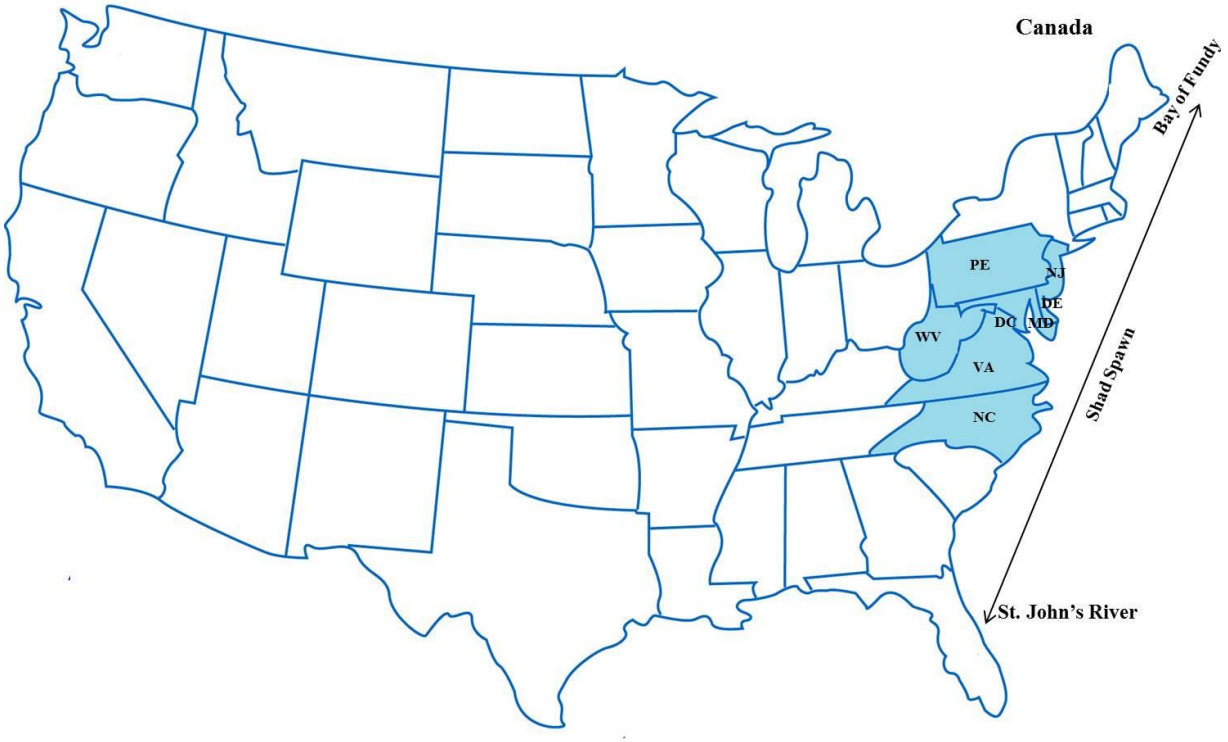


Figure 3. ─ Map of the states we found to participate in some version of a shad in the classroom program: Delaware, Maryland, New Jersey, North Carolina, Pennsylvania, Virginia, and West Virginia, and the District of Columbia. Arrow depicts American shad spawning distribution which ranges from the Bay 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 program year. For the 2016 year there were again 27 classrooms (8 new) with funding provided through APNEP. 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 – 2016) 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 2016, 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.