

**Shad in the Classroom
Program Report
(2009-2019)**

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By
Danielle Pender
Shad in the Classroom Program Specialist

Melissa Dowland
Coordinator of Teacher Education

and

Megan Davis
Teacher Education Specialist

North Carolina Museum of Natural Sciences



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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 NC Museum of Natural Sciences (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). For the 2019 program, we received \$10,900 in grant funding and also program specialist position funding from APNEP. We received \$7,000 in grant funding from the USFWS. We also leveraged over \$34,000 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 247 classrooms from 2009 to 2019 (Appendix A, Table 6) and many thousands of students. Between 2013–2019, approximately 16,145 students were reached (prior to 2013, the numbers of students were not tracked). Thirty-two classrooms participated in 2019 (Table 1) with 9 of those being new to the program this year. Over 2,000 (2,381) students participated in the program this year and 1,596 participated in river releases.

Table 1. 2019 Schools Participating in the North Carolina Shad in the Classroom Program

School	County	Numbers of Classes	Numbers of Students
Abbotts Creek Elementary School	Wake	1	130
Ballentine Elementary School	Wake	1	24
Bertie Early College High School	Bertie	1	21
Brogden Middle School	Durham	1	25
Central Park School for Children Elementary School	Durham	1	16
Chaloner Middle School	Halifax	1	82
Clarkton School of Discovery Middle School (CFRW)	Bladen	1	80
Daniels IBMYP Magnet Middle School	Wake	1	132
E.B. Frink Middle School	Lenoir	1	89
East Garner Magnet Middle School	Wake	2	259
Emereau Bladen Middle School (CFRW)	Bladen	1	80
Exploris Elementary School	Wake	2	74
Fuquay Varina Middle School	Wake	2	253
Horton Middle School	Chatham	1	105
Longleaf School of the Arts High School	Wake	1	130
Millbrook Environmental Connections Magnet Elementary	Wake	1	98
Moss Hill Elementary	Lenoir	1	21
Northeast Academy for Aerospace & Advanced Technologies High School	Pasquotank	1	40
Perquimans County Middle School	Perquimans	1	110

Table 1. 2019 Schools Participating in the North Carolina Shad in the Classroom Program
Continued

School	County	Numbers of Classes	Numbers of Students
Petree Elementary	Forsyth	1	65
Pine Hollow Middle School	Wake	1	82
Sherwood Githens Middle	Durham	2	124
Smithfield-Selma Senior High School	Johnston	1	90
The Expedition School	Orange	1	20
Tiller Elementary School	Carteret	1	31
W.G. Enloe High School	Wake	1	100
West Johnston High School	Johnston	1	60
Woods Charter Middle School	Chatham	1	40
Total Number of Schools		28	
Total Number of Classrooms		32	
Total Number of Students			2381

Current new tank construction of the red tub style tanks cost approximately \$385 per tank system. The plexiglass tank systems cost approximately \$587 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, and part-time staff.

In the years from 2013–2019, each school received approximately 1,000 eggs from the NCWRC. Beginning in 2011, shad embryos were received from the Neuse River and the Roanoke River and were released in the river basin of their parentage. Starting with the 2019 season, stocking is not part of the NCWRC’s American Shad Management Plan at this time. The Shad in the Classroom Program is only working with Neuse River American Shad and schools in this program are the only ones releasing American Shad in North Carolina, which are all released in the Neuse River Basin.

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
- East Carolina University
- 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 2019 are listed below.

Workshop Electrofishing Demonstration

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

Courtney Buckley courtney.buckley@ncwildlife.org – (NCWRC, District Assistant Biologist)

Additional Education

Fish Anatomy-Dissection Lecture

Ann May – ann.may@ncwildlife.org (NCWRC, Education Center Director)

April Lamb adlamb@ncsu.edu – (NCSU, Grad Student and helped coordinate with the graduate students)

Erika Desiderio – desideriosegoviae16@students.ecu.edu (ECU, Grad Student)

Dr. Gus Engman acengman@ncsu.edu – (NCSU, Post-Doctorate Fellow)

Haley Gambill – mggambill@ncsu.edu (NCSU, Student)

Javan Bailey – baileyja18@ecu.edu (ECU, Grad Student)

Jennifer Archambault – jmarcham@ncsu.edu (NCSU, Grad Student and helped coordinate with the graduate students)

Jon Sherman – shermanj13@students.ecu.edu (ECU, Grad Student)

Julianne Pomnitz – (contact Ann May) (NCWRC, Undergraduate Intern)

Kelsey Lincoln – kelsey.lincoln@ncwildlife.org (NCWRC, District Biologist)

Kris Smith – kris.smith@ncwildlife.org (NCWRC, Division Chief, Wildlife Education)

Sabrina Inthisarath – sinthis@ncsu.edu (NCSU, Student)

Seth Mycko – seth.mycko@ncwildlife.org (NCWRC, District Assistant Biologist)

Steve Meyer – meyerst18@students.ecu.edu (ECU, Grad Student and helped coordinate with the graduate students)

Egg Delivery and Larvae Release Assistance

Heather Jennings Heather.B.Jennings@ncdenr.gov – (APNEP, Program Manager)

Jimmy Johnson jimmy.johnson@ncdenr.gov – (APNEP, Coastal Habitats Coordinator)

Karen Polk karenwpolk@gmail.com – (Museum Contractor)

Kelsey Ellis kelsey.ellis@apnep.org – (APNEP, Communication and Outreach Specialist)

Mike Wicker mike_wicker@fws.gov – (USFWS, Fish and Wildlife Biologist)

Stacey Feken stacey.feken@apnep.org – (APNEP, Policy and Engagement Manager)

Dr. Tim Ellis tim.ellis@ncdenr.gov – (APNEP, Ecosystem Analyst)

Dr. Wilson Laney wilson_laney@fws.gov – (Retired USFWS, Fishery Biologist)

Student Education Analytics

Danielle Lawson dafrank2@ncsu.edu – (NCSU, Grad Student)

Dr. Kathryn Stevenson kathryn_stevenson@ncsu.edu – (NCSU, Associate Professor)

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

In addition, we are very appreciative of the fish donations for the 2019 dissection lectures from Dr. Rich Noble, Dr. Phil Doerr, and fellow anglers, and David Deaton and the NCWRC's Armstrong Hatchery staff. Also, Jennifer Archambault and April Lamb helped coordinate with the NCSU graduate students, Stephen Parker (NCSU) collected fish specimens, and Steve Meyer helped coordinate with the ECU graduate students for the anatomy-dissection lectures. We greatly appreciate Ben Ricks and Courtney Buckley coordinating shad weeks with us, and for their, and additional NCWRC coastal regional staff, collection of American Shad broodstock. American Shad embryos were generously provided by Jeff Evans and the staff at the Watha State Fish Hatchery.

Report cover photos: Top left – Longleaf School of the Arts High School release at Lassiter Mill; bottom left – Central Park School for Children dissection; bottom middle – Tiller School release at Cahooque Creek Recreational Site in Havelock; right – teachers participating in the electrofishing demonstration at the workshop.

Shad in the Classroom Program 2019 Report

This report summarizes the activities accomplished for the 2019 Shad in the Classroom Program. Thirty-two classes at 28 different schools participated in the program: 10 elementary, 16 middle, and 6 high school classes.

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 by NCWRC beginning the week of April 1st. 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 and ECU graduate students and NCSU post doctorates and NCWRC staff or a shad printing (Gyotaku) activity and supplies that we made available.



Photo 3. Jeff Evans giving a tour at the Watha State Fish Hatchery

Nine teachers and staff attended a tour at the Watha State Fish Hatchery, the Cape Fear River Lock and Dam #1, and Cape Fear River Watch classroom facilities.



Photo 1. Teachers participating in the shad life history exercise (Brad the Shad)

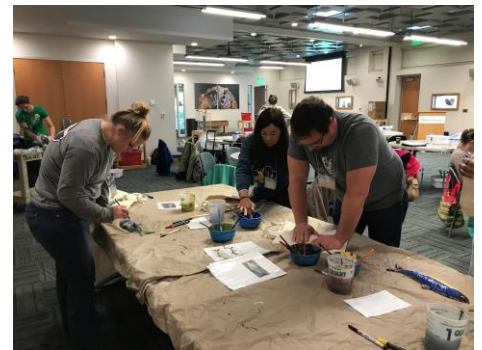
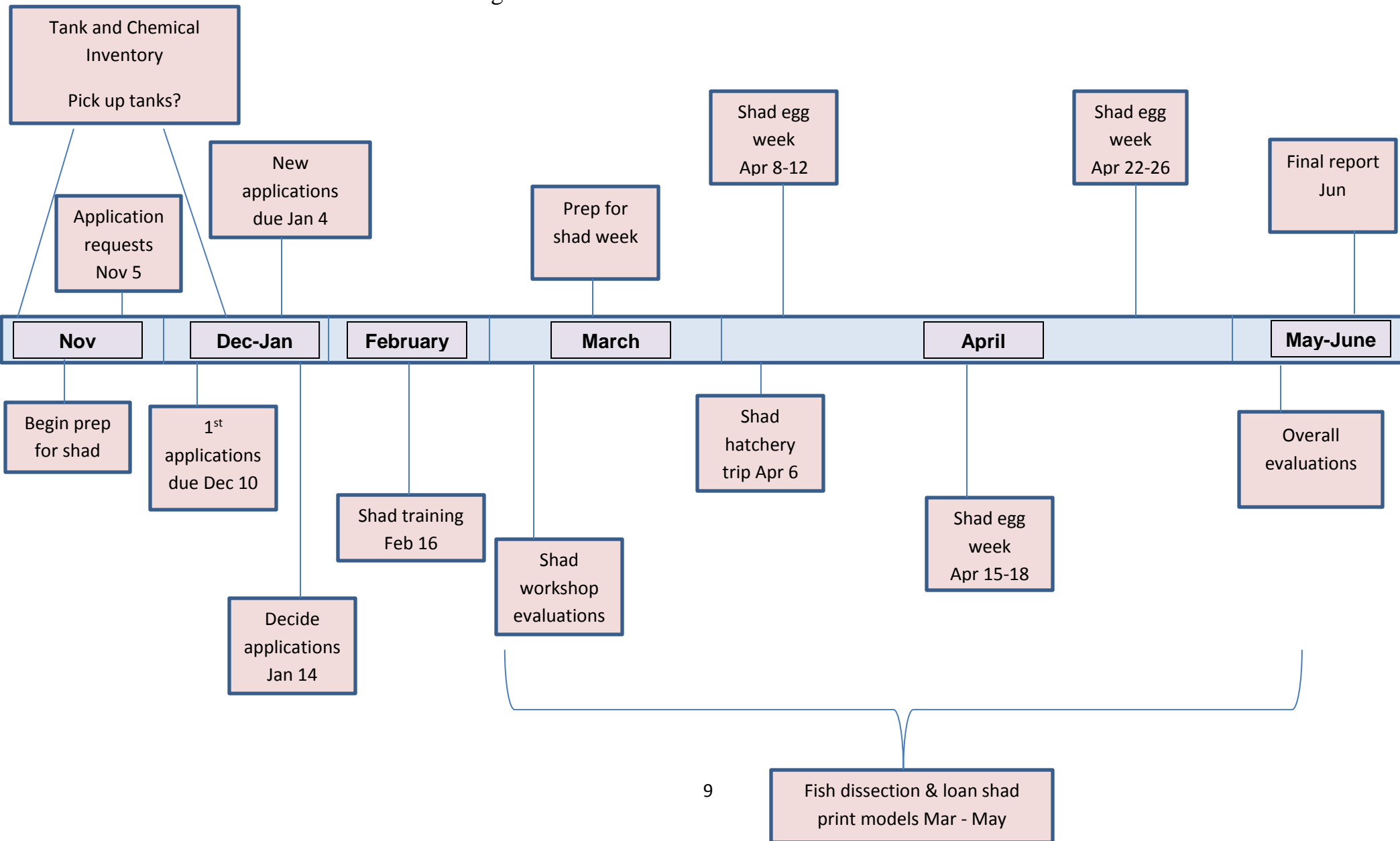


Photo 2. Teachers trying their hand at shad printing (Gyotaku)



Photo 4. Madison Polera giving a tour at the Cape Fear River Watch facilities

Figure 1. Shad in the Classroom 2019 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. Existing tanks were refurbished, as needed, with the assistance of Museum exhibits staff. Museum exhibits staff were able to construct two new tank plexiglass tank systems with the money donated to the program by The NC Chapter of the American Fisheries Society awarded in 2018. An updated inventory list is on file.

Teacher Orientation and Training

A teacher orientation and training session was conducted on February 16, 2019. Danielle Pender and Melissa Dowland co-led the session. 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 life cycle activity (Brad the Shad), water quality testing, egg sorting, “fry” removal, fish printing (Gyotaku), and building tanks.

This year we also took teachers to the Neuse River at Lake Raleigh to observe and participate in an boat electrofishing demonstration and to sample for aquatic macroinvertebrates. Ben Ricks and Courtney Buckley, NCWRC, conducted the electrofishing demonstration. 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-five teachers attended the 2019 workshop. Of those, 21 responded to the 9-question survey regarding the workshop. Most teachers reported that they were very to extremely satisfied with the workshop, that the concepts were explained very to extremely well, and that the activities were useful (Table 2).



Photo 5. Practicing tank building at teacher orientation



Photo 6. Ben Ricks and Courtney Buckley conducting the boat electrofishing demonstration

Table 2. Workshop Survey Results

Question	Response variable			
How confident do you feel in building the shad tank system on your own?	76% (16) extremely confident; 14% (3) very confident; 10% (2) moderately confident			
How comfortable do you feel in contacting the other teachers that you met at the workshop with questions?	71% (15) extremely comfortable; 24% (5) very comfortable; 5% (1) slightly comfortable			
How sufficient was the information you learned to incorporate shad into your curriculum?	81% (17) extremely sufficient; 19% (4) very sufficient			
How well did the workshop explain the importance of the shad restoration and management program?	85% (17) extremely well; 15% (3) very well			
How well did the workshop explain the life history of shad?	85% (17) extremely well; 15% (3) very well			
How well did the workshop explain the proper components to raising shad eggs to the larval stage?	85% (17) extremely well; 15% (3) very well			
What aspects of the workshop were useful? Please choose all that apply.	Lifecycle 89% (17)	Water testing 89% (17)	Egg chamber 84% (16)	Egg sort 89% (17)
What aspects of the workshop were useful? Please choose all that apply.	Fry removal 74% (14)	Tank building 74% (14)	Sharing experience 85% (17)	Site visit 90% (19)
Overall, how satisfied are you with the workshop?	85% (17) extremely satisfied; 10% (2) very satisfied; 5% (1) 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 April 1st. 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 8, Group 2 received them on Monday, April 15, and Group 3 received their eggs on Monday, April 22. The hatchery requested that we have most groups located in the first week. In Group 1 there were 25 classes. There were originally 26 classes, however, one group (a group managed by the CFRW) cancelled receiving their eggs and were not included in the program. CFRW continued to raise those embryos to the larval stage. Of those 26, 12 classes released larval fish on Thursday, April 11 and 14 released on Friday, April 12 (CFRW allowed another school to also release their larval fish (Table 3, Figure 2). Group 2 consisted of 4 classes, and all of those classes released on Thursday, April 18th (April 19th was a state holiday). Two classes remained for Group 3. Originally three classes were scheduled for Group 3, however, one class cancelled receiving eggs due to logistic difficulties,



Photo 7. Tiller School reception for shad embryos



Photo 8. Woods Charter release and invertebrate sampling at West Point on the Eno River

but remained in the program performing other aspects. Both of the remaining classes released on Friday, April 25. Classes received approximately 1,000 eggs from the Watha State Fish Hatchery. However, many of the teachers reported receiving more or less eggs (Table 4). Teachers brought 1,596 students to the Neuse River for release. For many of these students this is rare, or even a first-time opportunity to visit a river.

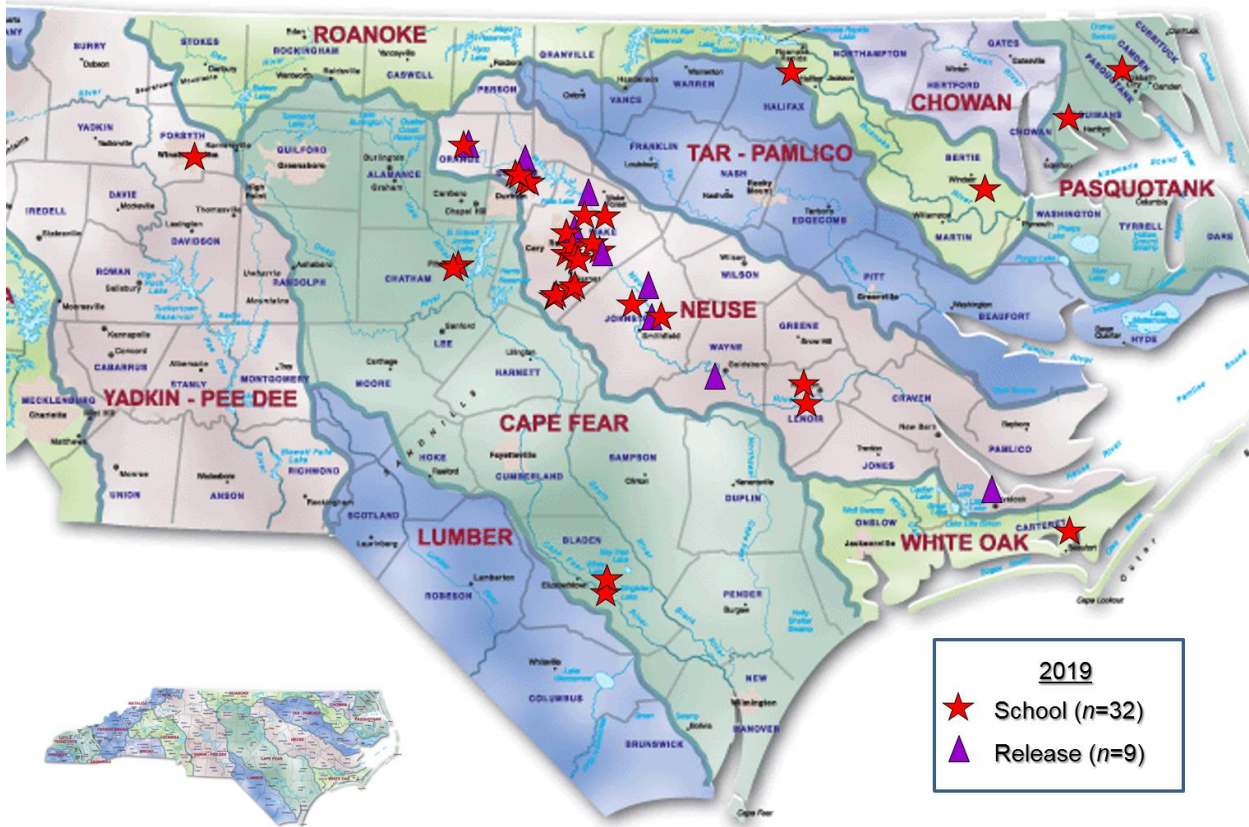
Table 3. Egg and Larval Release Timing and Release Site Information

Educator	School	Received Eggs	Released Eggs/Larva	Neuse River Release Site
Group 1				
Allison Ketcham	Tiller ES	4-8-2019	4-12-201	Cahooque Creek Recreational Site in Havelock
Annah Riedel/Robert Tant	Exploris ES	4-8-2019	4-11-2019	Former Milburnie Dam
Beth Selig	Fuquay Varina MS	4-8-2019	4-11-2019	Smithfield
Branson Phillips	Sherwood Githens MS	4-8-2019	4-11-2019	Smithfield
Brian Reynolds	Bertie Early College HS	4-8-2019	4-11-2019	Falls Dam
Brian Wood	W.G. Enloe HS	4-8-2019	4-11-2019	Former Milburnie Dam
Caroline Smith	Fuquay Varina MS	4-8-2019	4-11-2019	Smithfield
Christina Livingstone	Brogden MS	4-8-2019	4-12-201	West Point, Eno River
Courtney Sykes	Pine Hollow MS	4-8-2019	4-12-201	Falls Dam
Harlyn Strongoli	Sherwood Githens MS	4-8-2019	4-11-2019	Smithfield
Judy Compton	Central Park School for Children ES	4-8-2019	4-11-2019	Cliffs of the Neuse State Park
Kaley Kiffner	Perquimans County MS	4-8-2019	4-12-2019	Falls Dam
Karel Klepacki	Smithfield-Selma Senior HS	4-8-2019	4-12-2019	Smithfield
Kathy Wall	Ballentine ES	4-8-2019	4-12-2019	Former Milburnie Dam
Katrina Herrera	East Garner MS	4-8-2019	4-11-2019	Smithfield
Kristen Davenport	E.B. Frink MS	4-8-2019	4-12-2019	Cliffs of the Neuse State Park
Kristina Jones	Moss Hill ES	4-8-2019	4-12-2019	Cliffs of the Neuse State Park
Leah Ruto/Tom Simmons	Exploris ES	4-8-2019	4-11-2019	Former Milburnie Dam
Madison Polera	CFRW	4-8-2019	4-12-2019	Cliffs of the Neuse State Park

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

Educator	School	Received Eggs	Released Eggs/Larva	Neuse River Release Site
Matthew Lanner	East Garner MS	4-8-2019	4-11-2019	Smithfield
Michelle Malach	Longleaf School of the Arts HS	4-8-2019	4-11-2019	Lassiter Mill Dam, Crabtree Creek
Richard Kowaleski	Daniels IBMYP Magnet MS	4-8-2019	4-11-2019	Lassiter Mill Dam, Crabtree Creek
Rose Syroid	Horton MS	4-8-2019	4-11-2019	Smithfield
Sean Russell	Millbrook Magnet ES	4-8-2019	4-12-2019	Neuse River, Falls Dam
Group 2				
Janice West	Clayton HS	4-15-2018	4-18-2018	Neuse River bridge on 42
Kim Collier	Chaloner MS	4-15-2018	4-18-2018	Cliffs of the Neuse State Park
Madison Polera	CFRW (Clarkton School of Discovery MS)	4-15-2018	4-18-2018	Cliffs of the Neuse State Park
Sonja Younger	Woods Charter MS	4-15-2018	4-18-2018	West Point, Eno River
Group 3				
Krista Brinchek	Abbotts Creek ES	4-15-2018	4-18-2018	Neuse River, Falls Dam
Madison Polera	CFRW (Emereau Bladen MS)	4-15-2018	4-18-2018	Cliffs of the Neuse State Park

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



Overall, the shad rearing and release was successful for most schools, but with a few issues for some (mostly related to age of the embryo and temperature). Each class was to receive approximately 1,000 embryos; however, counts may differ as to what the school actually reported receiving. This year we were asked to have most of the teachers receive their embryos in the first week (26 classes). The first batch of embryos were from a Friday night/Saturday morning spawn. Due to the embryos being at a later stage in development, some hatched that first day (Monday). Due to the early development, some of the schools moved their release up a day (from the Friday to the Thursday of that week) and some had a difficult time with their fry surviving up to the release date. Of those that turned in their water quality information, many that had lower survivability also reported water quality issues. Two reported higher temperature ranges, one reported low alkalinity, and one reported a problem with dust. There was also quite high survivability this week with 42% reporting at $\geq 70\%$ survivability. For the next two weeks survivability was mixed. In the second week, two reported survivability under 20%, one reported it at 67%, and the fourth at 95%. As for the third week, one reported survivability at 40% and the other at 67%. For both of these weeks, I did not

receive water quality data from the teachers with the lower reported survivability and so was unable to determine if water quality may have played a role in the outcome.

Overall, the percent survival ranged from a low of 0% to a high of 96% and averaged 53% (Table 4). Sixteen classes averaged $\leq 50\%$, 17 averaged $> 50\%$, and 11 averaged $\geq 75\%$ survival to release. There were 4 classes that averaged 10% survivability or below, and average survivability was reported at 53%, which was higher than 2018 (41%) and equal to 2017 (53%). The percent of classes that were in the $\geq 75\%$ (34%) category were higher than 2018 (24%) and 2017 (31%) shad seasons.

Table 4. Egg and Larval Survival and Release Numbers

Educator	School	No. Eggs Received	No. Eggs/Larva Survived to Release	Percent Survival (%)
Group 1				
Allison Ketcham	Tiller ES	1000	857	86
Annah Riedel/Robert Tant	Exploris ES	780	700	90
Beth Selig	Fuquay Varina MS	809	381	47
Branson Phillips	Sherwood Githens MS	1000	500	50
Brian Reynolds	Bertie Early College HS	3000	2800	93
Brian Wood	W.G. Enloe HS	850	800	94
Caroline Smith	Fuquay Varina MS	700	100	14
Christina Livingstone	Brogden MS	1000	960	96
Courtney Sykes	Pine Hollow MS	1000	50	5
Harlyn Strongoli	Sherwood Githens MS	1000	850	85
Judy Compton	Central Park School for Children ES	1000	200	20
Kaley Kiffner	Perquimans County MS	1100	550	50
Karel Klepacki	Smithfield-Selma Senior HS	741	124	17
Kathy Wall	Ballentine ES	1000	200	20
Katrina Herrera	East Garner MS	700	450	64
Kristen Davenport	E.B. Frink MS	1000	15	2
Kristina Jones	Moss Hill ES	1000	450	45
Leah Ruto/Tom Simmons	Exploris ES	900	750	83
Madison Polera	CFRW	1000	670	67
Mark Miller	Northeast Academy for Aerospace & Advanced Technologies HS	1000	0	0
Matthew Lanner	East Garner MS	750		91
Michelle Malach	Longleaf School of the Arts HS	1000		75
Richard Kowaleski	Daniels IBMYP Magnet MS	700	600	86
Rose Syroid	Horton MS	1000	500	50
Sean Russell	Millbrook Magnet ES	1000	700	70
Sue Willis	The Expedition School	1000	0	0
Average survival percent				54

Table 4. Egg and Larval Survival and Release Numbers Continued

Educator	School	No. Eggs Received	No. Eggs/Larva Survived to Release	Percent Survival (%)
Group 2				
Janice West	Clayton HS	1500	250	17
Kim Collier	Chaloner MS	800	100	13
Madison Polera	CFRW (Clarkton School of Discovery MS)	1000	670	67
Sonja Younger	Woods Charter MS	1000	950	95
Average survival percent				48
Group 3				
Krista Brinchek	Abbotts Creek ES	500	200	40
Madison Polera	CFRW (Emereau Bladen MS)	1000	670	67
Average survival percent				53
Total Average survival percent				53

Teachers reported that the program is very motivating and provides their students with an authentic experience. Many reported that the students learn more and are more engaged. The Shad Program increases the students interest and confidence in science. We have received great feedback on the program from the teachers throughout the 2019 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).

“It’s a great opportunity to develop cross-curricula ties between science, ELA, social studies and math.”

“It was exciting to participate in something that can directly help a local species.”

“It’s wonderful!!! The students learn about embryology, water quality, river basins and the endangered species act. This program provides opportunity for a truly holistic approach to learning about the natural world and their place within it..”

American Shad Molds – Fish Printing

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

“We really enjoyed the break from science class to make the prints.”

Fish Dissection

We coordinated with the NC State University (NCSU) Student Fisheries Subunit, the East Carolina University (ECU) Student Fisheries subunit, and the NCWRC Division of Inland Fisheries and



Photo 9. Exploris ES Dissection

“Our dissection was amazing, and Sabrina did a great job. The kids absolutely loved the experience and really enjoyed the expertise Sabrina brought to our class. I’m pretty sure we have a few fish biologists or biologists in the making.” (teacher quote)

“I learned a lot about fish that I would have never known. When we learned anatomical terms and directions in class, I got use to using them, but when we did it on the fish yesterday, I got a better understanding. Ms. Gambill was very helpful yesterday because she allowed us to ask her questions during the process. I had a better understanding of different fish and how they adapt to living. I would have never thought that I would be able to see the eggs in a fish, but I did yesterday.” (student quote)

Division of Wildlife Education to conduct fish anatomy/morphology and dissection lessons. Fourteen student, post-doc, researchers, and educators from NCSU, ECU, and the NCWRC volunteered (listed in acknowledgments) to conduct these lessons. Because of these volunteers and the generosity of fish donations (>300 fish), we were able to facilitate the dissection lecture for 19 classrooms (1362 students).

This year we were able to accommodate all teachers that requested a dissection lecture at their school. We are very grateful to NCSU, ECU, 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.

Curriculum Activities and Videos

We continually add or update supplementary materials for the teachers to use to augment the learning process in the classroom and

at the release. Last year we added American Shad Lifecycle Activity. This activity assists students in understanding the lifecycle of American Shad in a visual and physical manner (20 teachers reported that the activity enhanced the program). Activities and exercises have all been uploaded to a shared dropbox site with the teachers. Besides the lifecycle activity, materials include, but are not limited to, a Shad Scent exercise, Shad pipette art, a guide for stream sampling, a watershed GIS exercise, a genetic exercise, and materials provided by the teachers.



Photo 10. Tiller School conducting the Shad Scent exercise

The genetic based exercise, “Who’s your Shaddy”, (developed in 2013 and updated in 2014) was continued. Four teachers (2 high schools, 1 middle school, and one elementary school) reported this exercise was “just right” as far as understandability and complexity for their students. Additional on-line (Museum website) curriculum activities are available for the teachers to use including Food Web Activities (19 reported as useful), GIS Watershed Activity (7 reported as useful), Wishes of Fishes Activity (6 reported as useful), and a Non-Fiction Reading Activity (9 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?	16% (5) greatly enhanced; 10% (3) enhanced; 19% (6) somewhat; 55% (17) did not use
Shad Pipette Art?	10% (3) greatly enhanced; 13% (4) enhanced; 6% (2) somewhat enhanced; 71% (22) did not use
Shad Lifecycle Activity?	32% (10) greatly enhanced; 32% (10) enhanced; 36% (11) did not use
Shad Scents – enhance learning?	19% (6) greatly enhanced; 13% (4) enhanced; 3% (1) did not enhance; 65% (20) did not use
Fish Dissection – enhance learning?	55% (17) greatly enhanced; 6% (2) enhanced; 39% (12) did not use
Genetic Exercise – complexity or understanding?	13% (4) just right; 87% (27) did not use
Food Web Activities – usefulness?	35% (11) very useful; 26% (8) useful; 39% (12) did not use
GIS Watershed Activity – usefulness?	10% (3) very useful; 10% (3) useful; 3% (1) somewhat; 77% (24) did not use
Wishes of Fishes Activity – usefulness?	13% (4) very useful; 6% (2) useful; 81% (25) did not use
Non-Fiction Reading Activity – usefulness?	26% (8) very useful; 6% (2) useful; 68% (21) did not use
Video -Add the eggs – usefulness?	45% (14) very useful; 26% (8) useful; 3% (1) somewhat; 26% (8) did not use

Table 5. Additional Education and Video Use Survey Results Continued

Question	Response variable
Video –Build the Tank – usefulness?	16% (5) very useful; 26% (8) useful; 58% (18) did not use
Video – Fish Passage – usefulness?	48% (15) very useful; 26% (8) useful; 6% (2) somewhat; 19% (6) did not use
Video – History – usefulness?	71% (22) very useful; 19% (6) useful; 10% (3) did not use
Video – It is Time usefulness?	35% (11) very useful; 26% (8) useful; 13% (4) somewhat; 26% (8) did not use
Video - Lifecycle – usefulness?	55% (17) very useful; 29% (9) useful; 16% (5) not use
Video – Overview – usefulness?	45% (14) very useful; 19% (6) useful; 7% (2) somewhat useful; 29% (9) did not use

We are the River Curriculum Development

We are in the process of coordinating with two educators to write a curriculum to supplement the We are the River video, which highlights the natural and cultural resources, history and conservation of the Roanoke River. The curriculum work is slated to be completed by the end of August, at which point it will be posted on the Museum website, along with the video, to be used by educators across the state. Once complete, we will share this resource through our Museum educator email list, as well as other educational listservs.

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 2,381 students directly involved with the Shad in the Classroom Program this year and more that experienced it indirectly.

Student Analytics 2016-2018

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 students Kalysha Clark, Danielle Lawson, and Rachel Szczytko 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 in 2016, 18 teachers in 2017, 16 teachers in 2018) provided the pre- and post-tests to their students (n=505 for 2016, n=835 for 2017, n=591). In addition, there were two “control” classrooms that completed both the pre- and post-tests in 2017 and in 2018. Analysis of the 2017 data showed that participation in the program created large improvements in American Shad knowledge between pre- and post-tests (\bar{x} =0.67, SD=1.22, $p < 0.001$). All students gained knowledge, but African American ($p < 0.001$) and students identifying as “other” race/ethnicity ($p = 0.003$) fell behind their peers.

These results point to the need for improvement in reaching these race/ethnic groups. However, the human dimensions researchers concluded that increased exposure to nature, such as working with hands-on programs like Shad in the Classroom, may be the most consistent pathway to making students comfortable with learning in natural environments. We will continue to monitor student knowledge.

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). In addition to the students and teachers reached with the Shad in the Classroom Program:

- The “We are the River Film” won the Gold Telly award in the nature category in 2018.
- This year information on the Shad in the Classroom Program was presented at the APNEP Engagement and Stewardship Meeting, October 23, 2018.
- An article on the Shad in the Classroom Program was published in the North Carolina American Fisheries Society Fall Newsletter in 2018.

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 2019. Also, a paper on the student analytics was submitted to the journal Fisheries and is undergoing peer review.

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 plan to purchase additional plexiglass tanks and eventually phase out the older tanks as the teachers report that these tanks enhance the experience since they can more readily see the tiny fry. 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. Seventy-seven percent of teachers reported that they were extremely satisfied and 23% reported they were very satisfied with the Shad in the Classroom experience. Teachers and students provided positive feedback on all aspects of the program including the workshop, activities, and the overall program. Twenty-nine of the 31 teachers participating in the Shad in the Classroom Program reported that they would like to continue with the program next year. One of the teachers has a conflict with scheduling and the other is changing schools. At present, we have seven new teachers on the waiting list for the program in 2020. 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.

“We had fry swimming vigorously in every square inch of water. It was quite impressive to look into the tank and see hundreds and hundreds of little fish swimming around. When administrators visited our class, they were impressed with the fish.”

“This was an excellent opportunity for students who struggle with focus and off-task behaviors. These particular students were extremely invested in our survival rate and took on leadership roles within the class. They enjoyed having a role in the water quality testing and ensuring the environment was stable to support our eggs and fry.”

“Some of the students are still talking about how fun the experience of releasing the shad was.”

Appendix A

Table 6. Schools Participating in the North Carolina Shad in the Classroom Program (2009–2018)

Release Basin School	Nos. of Classes	Years
Cape Fear River Basin		
Harnett Central Middle School (NCWRC)	2	2009-2010
Lake Rim Elementary (NCWRC)	2	2009-2010
Overhills Elementary (NCWRC)	1	2010
Neuse River Basin		
Abbotts Creek Elementary School	4	2016-2019
Angier Elementary	2	2013-2014
Ballentine Elementary	3	2017-2019
Bertie Early College High School	1	2019
Brogden Middle School	5	2015-2019
Broughton High School	3	2014-2015
Bunn High School	6	2012-2015
Cedar Creek Middle School	1	2015
Centennial Campus Magnet Middle School	2	2009-2010
Central Park School for Children	9	2013-2019
Chaloner Middle School	1	2019
Chatham Central High School	1	2012
Chestnut Grove Middle School	1	2012
Clarkton School of Discovery (CFRW)	1	2019
Clayton High School	3	2016-2018
Cleveland High School	3	2016-2018
Cook Literacy Model School	2	2017-2018
Daniels IBMYP Magnet Middle School	14	2010-2019
Dillard Middle School	1	2017
Don D. Steed Elementary	1	2012
East Garner Middle School	3	2018-2019
East Wake Middle School	11	2010-2015, 2017
East Wake School of Integrated Technology	1	2014
E.B. Frink Middle School	1	2019
Emereau Bladen (CFRW)	1	2019
The Expedition School	8	2015-2019
Exploris Elementary School	6	2017-2019
Exploris Middle School	7	2010-2016
Forest Pines Dr Elementary	1	2013
Fuquay Varina Middle School	11	2014-2019
Grady A. Brown Elementary	1	2018
Hall Woodward Elementary	2	2012-2013
Horton Middle School	3	2017-2019
Lakewood Montessori Middle School	10	2013-2017
Lead Mine Elementary	3	2009-2011

Table 6. Schools Participating in the North Carolina Shad in the Classroom Program (2009–2018)
continued

Release Basin School	Nos. of Classes	Years
Neuse River Basin		
Lillington Shawtown Elementary	2	2011-2012
Longleaf School of the Arts	1	2019
McLauchlin Elementary	1	2012
Midway Middle School	1	2012
Millbrook Environmental Connections Magnet Elementary	2	2018-2019
Mills Park Middle School	1	2017
Mineral Springs Middle School	1	2014
Moss Hill Elementary	3	2017-2019
North Duplin JR/SR High School	2	2015-2016
Northeast Academy for Aerospace & Advanced Technologies	1	2019
Perquimans County Middle School	1	2019
Petree Elementary	1	2019
Pine Hollow Middle School	2	2018-2019
Rolesville Middle School	1	2017
Sandy Grove Middle School	2	2012-2013
Sherwood Githens Middle	2	2019
Smithfield-Selma Senior High School	2	2018-2019
South Asheboro Middle School	1	2012
South Iredell High School	6	2013-2018
South View High School	1	2012
Southern Vance High School	4	2012-2015
Speas Elementary	1	2012
Tar Heel Middle School	1	2016
The Oakwood School	1	2012
Tiller Elementary School (Carteret County Charter School)	7	2013-2019
Upchurch Elementary	7	2012-2018
Uwharrie Charter Academy	1	2016
Wake Forest Middle School	2	2015-2016
Walkertown Middle School	1	2016
West Hoke Elementary	1	2012
West Johnston High School	1	2019
W.G. Enloe High School	3	2017-2019
Woods Charter Middle School	7	2012-2017, 2019
Roanoke River Basin		
Bartlet Yancey High School	1	2010
Bertie Early College High School	4	2015-2018
Cedar Creek Middle School	1	2016

Table 6. Schools Participating in the North Carolina Shad in the Classroom Program (2009–2018)
continued

Release Basin School	Nos. of Classes	Years
Roanoke River Basin		
Chaloner Middle School	1	2018
Chestnut Grove Middle School	3	2010-2012
Don D. Steed Elementary	1	2011
Hall Woodward Elementary	1	2011
East Bladen High School (CFRW)	1	2018
Hawk Eye Elementary	1	2011
Hertford County High School	2	2014-2015
McLauchlin Elementary	1	2011
Pasquotank county High School	1	2018
Perquimans County Middle School	2	2017-2018
Red Oak Middle School	2	2013
Rockfish Hoke Elementary	1	2011
Sandy Grove Middle School	1	2011
Scurlock Elementary	1	2011
Southern Vance High School	4	2011-2012, 2017-2018
Speas Elementary	2	2010-2011
The Oakwood School	1	2011
Upchurch Elementary	1	2011
Vance Charter School	1	2016
West Hoke Elementary	1	2011
Windsor Elementary	1	2010
W.L. Manning Elementary School	2	2016-2017
Total Number of Schools	83	2009-2019
Total Number of Classrooms	246	2009-2019

Appendix B

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.

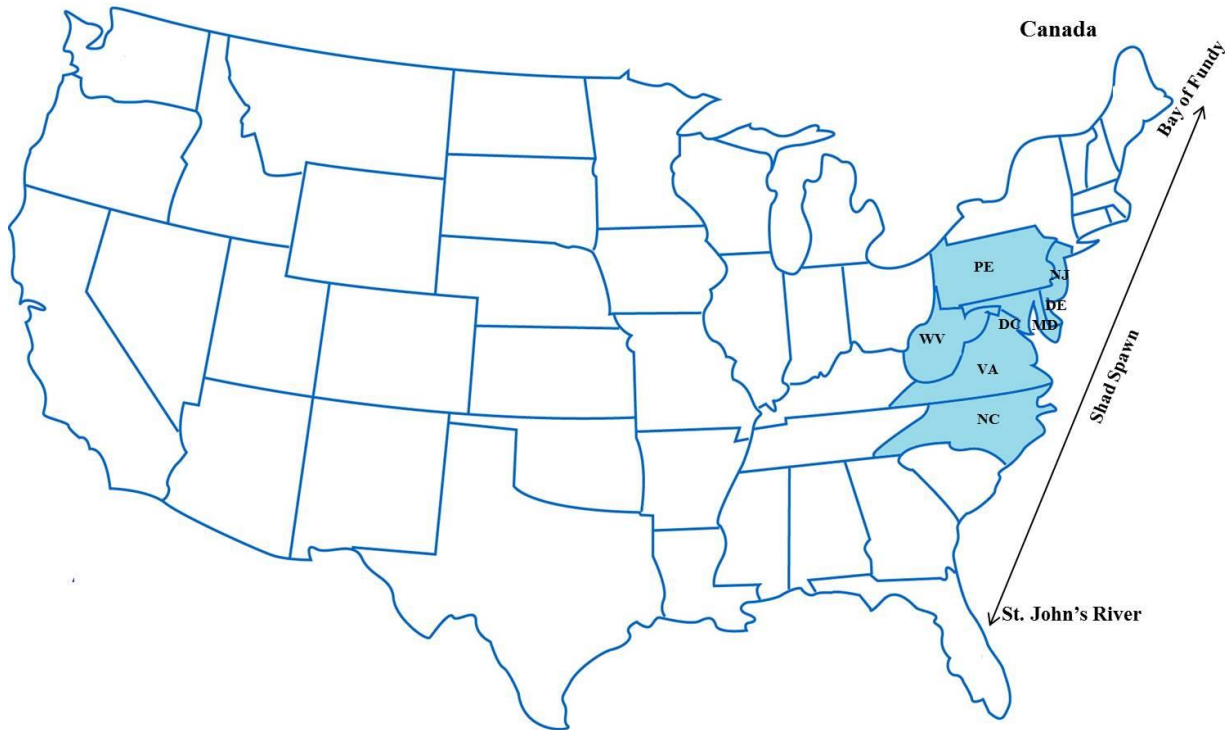


Figure 5. — Map of the states we found to participate in some version of a shad in the classroom program: Delaware, Maryland, New Jersey, North Carolina, Pennsylvania, Virginia, and West Virginia, and the District of Columbia. Arrow depicts American Shad spawning distribution which ranges from the Bay 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, 27 classrooms in the 2015 and 2016 program years, and 33 for the 2017 year. For the 2018 year, 30 classrooms (8 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 – 2018) 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 2018, 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.

