

**Shad in the Classroom
Program Report
(2009–2023)**

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Executive Summary

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. 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 their environment while learning about the importance of American Shad restoration and water quality. Teachers report great enthusiasm for the program, both for themselves and their students.

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 2023 Shad season we received grant funding from APNEP, Triangle Fly Fishers, and the USFWS.

The Shad in the Classroom Program has reached 324 classrooms from 2009 to 2023 (Appendix A, Table 8) and many thousands of students. Between 2013–2023, approximately 21,817 students were reached (prior to 2013, the numbers of students were not tracked). Twenty-nine classes in 12 counties (Tier 1 – 3, Tier 2 – 2, Tier 3 – 7) participated in 2023 (Table 1) with 8 classes being new to the program. This year 1,798 students participated with 507 students being in Title 1 schools.

In the years from 2013–2023 (excluding 2020), each school received approximately 600-1,000 eggs from the NCWRC. Presently 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.

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 (APNEP)
- Dominion Power
- East Carolina University (ECU)
- National Fish and Wildlife Foundation
- North Carolina Chapter of the American Fisheries Society
- North Carolina State University (NCSU)
- North Carolina Wildlife Resources Commission (NCWRC)
- Triangle Fly Fishers
- United States Fish and Wildlife Service (USFWS)

ACKNOWLEDGEMENTS

We would like to acknowledge all 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 that could occur for 2023 are listed below.

Workshop Guest Speaker

Todd VanMiddlesworth todd.vanmiddlesworth@ncwildlife.org – (NCWRC, District Fisheries Biologist)

Additional Education

Fish Anatomy-Dissection Lecture

Andrew McCains mcmainsa20@students.ecu.edu – (ECU, Grad Student) – Lecturer

Anne Burroughs amburroughs@ncdot.gov – (NCDOT, Biologist) - Lecturer

Bethany Wager bwager@ncsu.edu – (NCSU, Grad Student) – Lecturer

Caid Menzel menzelca21@students.ecu.edu – (ECU, Grad Student) – Lecturer

Casey G Joubert caseyg8@gmail.com – (NCWRC, District Fisheries Biologist) – Lecturer

Chase Spicer spicerc21@students.ecu.edu – (ECU, Grad Student) – Lecturer

Emma Mitchell ermitch2@ncsu.edu – (NCSU, Grad Student) - Lecturer

Kelsey Roberts kelsey.roberts@ncwildlife.org – (NCWRC, Fisheries Research Coordinator) – Lecturer

Naomi Jainarine jainarinen20@students.ecu.edu – (ECU, Grad Student) – Lecturer

Sean Sullivan spsulliv@ncsu.edu – (NCSU, Student) - Lecturer

Egg Delivery and Larvae Release Assistance

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

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Taylor Prichard taylor.prichard@naturalsciences.org – (Museum, Teacher Education Specialist)

In addition, we are very appreciative of the fish donations from Dr. Jim Rice, Dr. Rich Noble, Dr. Phil Doerr, and fellow anglers, from NCWRC district biologists Seth Mycko and Danci Guiot, and from ECU graduate students, Chase Spicer and Caid Menzel. We greatly appreciate Todd VanMiddlesworth and Nick Shaver for their collection of American Shad broodstock. American Shad embryos were generously provided by Jeff Evans and the staff at the Watha State Fish Hatchery. We also appreciate Bethany Wager, NCSU, and Chase Spicer, ECU for assisting with organizing students for the fish anatomy-dissection lessons.

Report cover photos: Top left – S. Iredell HS release at Gold Park (Eno River); Bottom left – teachers at workshop participating in Migration Madness activity; Middle – Fuquay Varina MS fish anatomy and dissection lesson; Right – developing shad embryo (Margaret B. Pollard MS).

Shad in the Classroom Program 2023 Report

This report summarizes the activities accomplished for the 2023 Shad in the Classroom Program. Twenty-nine classes at 24 different schools (Table 1) were accepted into the 2023 program: 6 elementary, 18 middle, and 5 high school classes. Thirty-two classes were originally accepted, however, 3 had to withdraw due to personal issues. In addition, 4 classes opted to have a hiatus year.

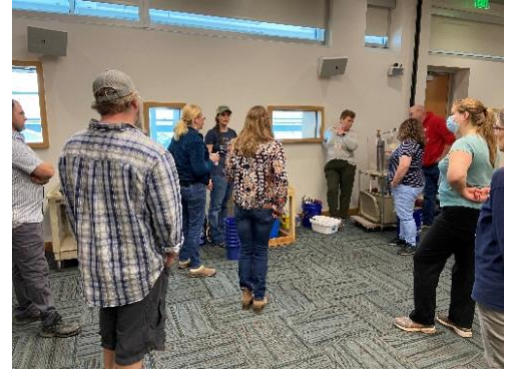


Photo 1. Teachers learning about the tanks systems

Table 1. 2023 Schools Accepted to the North Carolina Shad in the Classroom Program (Title 1 indicated with an *)

School	County	Tier	Numbers of Classes
Abbotts Creek ES	Wake	3	1
Bertie HS	Bertie*	1	1
Brogden MS	Durham*	3	1
Central Park School for Children ES	Durham*	3	1
Chaloner MS	Halifax*	1	2
East Duplin HS	Duplin*	1	1
Exploris ES	Wake	3	2
Falls Lake Academy	Wake	3	1
First Flight MS	Dare	2	2
Fuquay Varina MS	Wake	3	3
George Moses MS	Chatham	3	1
Lakewood Montessori MS	Durham*	3	1
Longview Gardens MS	Wake*	3	1
Margaret B. Pollard MS	Chatham	3	1
Moore Square Magnet MS	Wake	3	1
Oberlin Magnet MS	Wake	3	1
Perquimans County HS	Perquimans*	2	1
Seawell ES	Orange	3	1
Smithfield-Selma Senior HS	Johnston*	3	1
South Iredell HS	Iredell	3	1
Southern Wake Academy	Wake	3	1
Tiller School of Carteret County	Carteret*	3	1
Wake Young Men's Learning Academy	Wake	3	1
Woods Charter HS	Chatham	3	1
Total Number of Schools			24
Total Number of Classrooms			29

In July of 2022 we received a grant award from the USFWS for Project RESTORE (Rescuing Endangered Species through Outreach, Restoration, and Education) for \$165,000 to be utilized up until 9/2027. Project RESTORE employs a multiple species approach focusing on endangered and imperiled species in North Carolina, including American shad, Venus flytrap, Carolina madtom, Neuse River waterdog, and the red wolf.

For the 2023 Shad in the Classroom program, we received \$20,000 in grant funding from APNEP. Triangle Fly Fishers also gifted us with \$500 for the Shad in the Classroom Program. In addition, we leveraged over \$32,934 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.

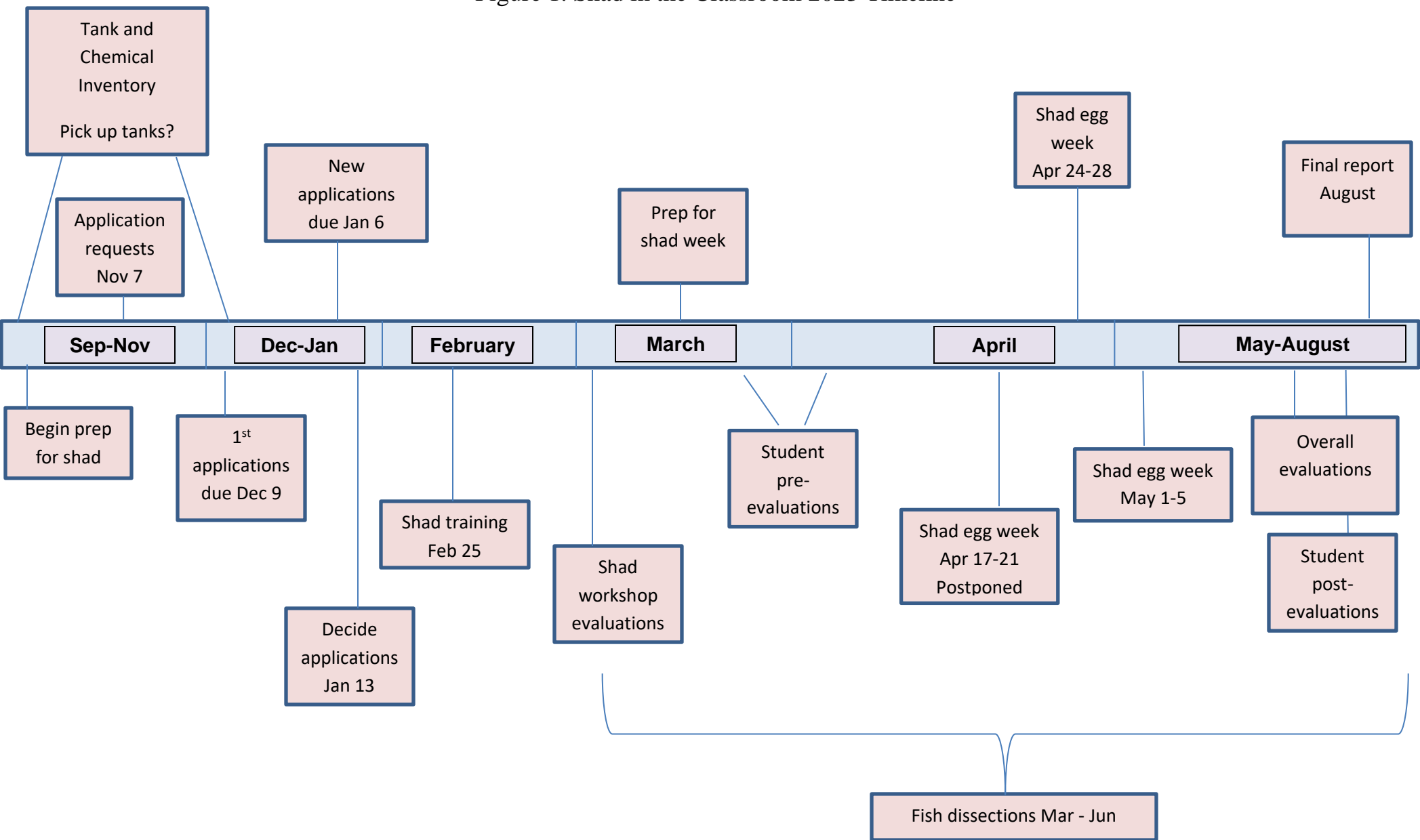
Current new tank construction of the red tub style tanks cost approximately \$406 per tank system. The plexiglass tank systems cost approximately \$606 per tank system. Other substantial expenses include tank refurbishment, chemical resupply, teacher training workshop, school field trips to release sites, travel for egg delivery, and part-time staff.

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. Teachers typically began preparing their classrooms for the arrival of the Shad eggs 2–4 weeks prior to receiving the eggs in April. NCWRC American Shad broodstock collection began the week of April 10th, however collection was unsuccessful, and we extended the season into the first week of May. Classes released the shad larvae primarily on the Thursday or Friday of the week that they received them. Many of the classes took advantage of an in-person fish anatomy and dissection lecture by NCSU and ECU students and by biologist staff at NCWRC and NCDOT.



**Photo 2. Casey Joubert, S. Iredell HS
Fish Anatomy lesson**

Figure 1. Shad in the Classroom 2023 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 five new tank plexiglass tank systems. An updated inventory list is on file.

Teacher Orientation and Training

A teacher orientation and training session was conducted on February 25, 2023. Danielle Pender and Melissa Dowland co-lead the session. NCWRC District Biologist, T.D. VanMiddlesworth guest lectured on American Shad Management via Zoom Conferencing. In addition to being provided information about American Shad life history, restoration, and management, teachers received instructions for raising shad and learned ways to incorporate shad and aquatic ecology into their curriculum. Teachers also participated in a new activity, Migration Madness, which we adapted for the Shad in the Classroom Program from a NCMNS-Whiteville activity.



Photo 3. T.D. VanMiddlesworth Lecture

“Great support in the activities, answering questions, giving, enough breaks through the session.” (Teacher feedback)



Photo 4. Teachers participating in Migration Madness



Photo 5. Teachers participating in Gyotaku – fish painting

Seventeen teachers attended the 2023 workshop (6 were new). New teachers were given a pre- and post-survey to determine their confidence in teaching about shad and their understanding of various concepts important to raising shad, shad issues, and knowledge of shad life history. It was clear by the responses that teachers gained confidence in raising shad and increased their knowledge in most concepts (Table 2). All teachers responded to

the workshop evaluation. Questions that were quantitative are included in Table 3. For the qualitative responses, many reported that they appreciated learning about American Shad history and having the activities available for their classes. Overall, most teachers reported that they were very to extremely satisfied with the workshop and that the concepts were explained very to extremely well (Table 3). One teacher reported having moderate satisfaction with the overall workshop due to them arriving late (acceptable for return teachers) and the workshop ending early.

Table 2. Pre and Post Workshop Survey Results for New Teachers

Question	Response variable
I feel I can teacher students about shad restoration	100% increase in confidence
I feel I can teach students about shad management	83% increase in confidence (one stayed the same at “agree”)
I feel I can teach students about the life history of shad	100% increase in confidence
I feel I can teach students how to raise shad from the egg to the larval stage	100% increase in confidence
Knowledge of shad life stages	67% correct before, 83% correct after
Knowledge of anadromous definition	100% correct before, 100% correct after
Knowledge of factors leading to shad decline	83% correct before, 100% correct after
Knowledge of acceptable pH levels	67% correct before, 100% correct after
Knowledge of shad migration	92% correct before, 100% correct after

Table 3. Workshop Evaluation Results

Question	Response variable
I feel confident in building the shad tank system on my own	76% (13) extremely confident; 24% (4) very confident
I feel comfortable in contacting the other teachers	59% (10) extremely confident; 41% (7) very confident
The information I learned was sufficient to incorporate into my shad curriculum	94% (16) extremely sufficient; 6% (1) very sufficient
This workshop explained the importance of the shad restoration and management program	92% (12) extremely well; 8% (1) very well
This workshop explained the life history of shad	92% (11) extremely well; 8% (1) very well
This workshop explained the proper components to raising shad eggs to the larval stage	100% (12) extremely well
Overall satisfaction with the workshop	85% (11) extremely satisfied; 8% (1) very satisfied; 8% (1) moderately satisfied

We had scheduled a hatchery tour and Neuse River site visit for April 15th; however, it was cancelled due to the lack of broodstock.

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 considered school schedules. Although American Shad collection began the week of April 10, the water was too high due to recent rain to collect the fish. Collection was successful the following weeks and we were able to deliver embryos for the weeks of April 24th and May 1st. Many people assisted with the delivery of the eggs and with the release of the larval fish and are mentioned in the acknowledgments.



Photo 7. Woods Charter HS release Confluence Natural Area, Eno River

Classes were divided into two groups. Classes received their embryos on the Monday of those weeks and released on the Thursday or Friday of the same week. Thirteen classes were scheduled to release on Thursday 4/27, 6 on Friday 4/28, 8 on Thursday 5/4, and 3 on Friday 5/5 (Table 4, Figure 2). Classes received approximately 600-1,000 eggs according to the hatchery; however, some classes reported receiving a different number (Table 5). Most classes had students at the release (866 students

attending). However, three teachers elected to release “virtually” for their students, as there were logistical issues with bus availability. A few classes that had failed tanks (0% survivability) also did not attend a release. One Durham class that had a failed tank on city water the week of 4/24 had a successful tank the following week (5/1) using river water. Of those that were able to attend a release, all teachers reported that it enhanced the learning experience for their students.



Photo 6. Chaloner MS release Glenburnie Park, Neuse River



Photo 8. Woods Charter HS release Confluence Natural Area, Eno River (invert sampling)



Photo 9. Exploris ES release Raleigh Beach, Neuse River (minnow/invert sampling). With Michael Fisk, NCWRC

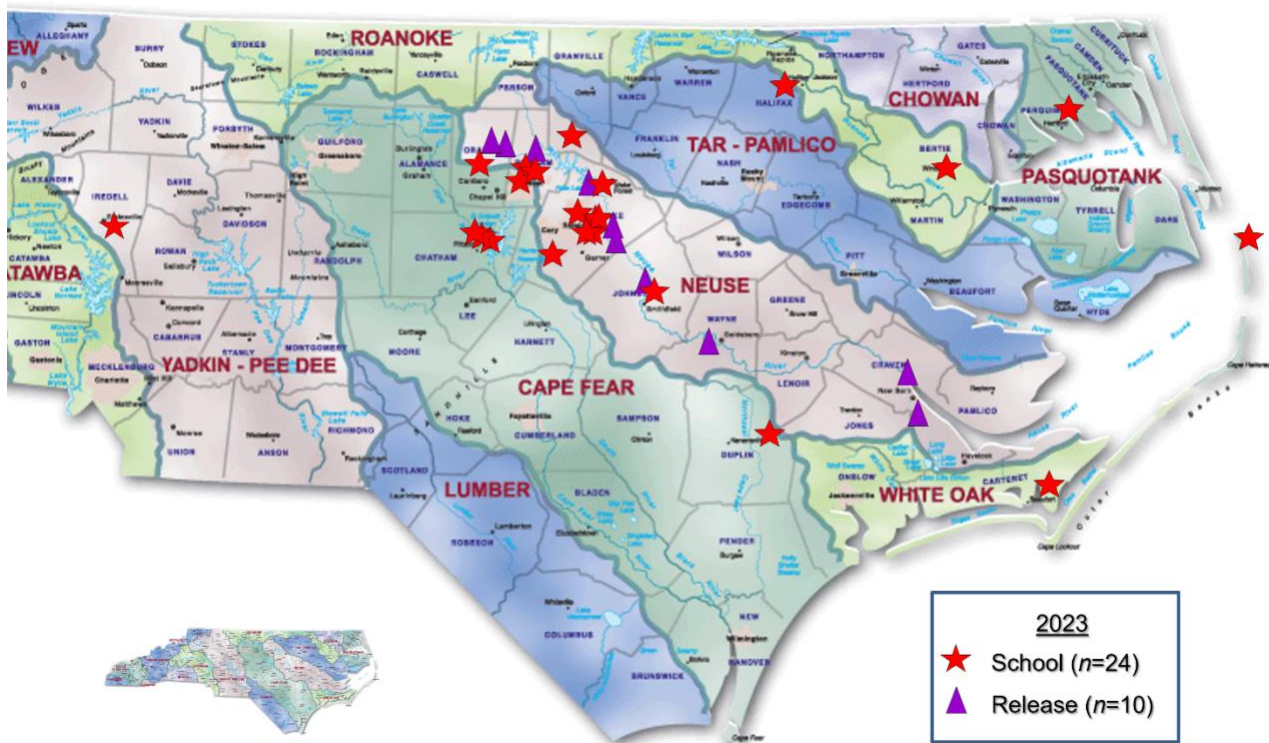
Table 4. Egg and Larval Release Timing and Release Site Information

Educator	School	Received Eggs	Released Eggs/Larva	Neuse River Release Site
Annah Riedel/ Denise Ziemak	Exploris ES	4-24-2023	4-27-2023	Raleigh Beach
Beth Selig	Fuquay Varina MS	5-1-2023	5-4-2023	Smithfield Boat Ramp
Brian Reynolds	Bertie Early College HS	4-24-2023	4-27-2023	Falls Dam
Christina Livingstone	Brogden MS	4-24-2023	4-28-2023	West Point Eno
Corie Hlavaty	Lakewood Montessori MS	4/24 & 5-1-2023	5-4-2023	West Point Eno
Courtney Sykes	Falls Lake Academy	4-24-2023	4-27-2023	Falls Dam
Denise O’Gorman	Woods Charter HS	4-18-2022	4-21-2022	Confluence Natural Area
Douglas Poole	Perquimans County HS	4-24-2023	4-28-2023	Lawson Creek
Edward Tidd	Moore Square Magnet MS	4-24-2023	4-28-2023	Raleigh Beach
Endiga Holdness	Fuquay Varina MS	5-1-2023	5-4-2023	Smithfield Boat Ramp
Gillian Rose	Tiller School of Carteret County	4-24-2023	4-27-2023	Glenburnie Park
Gina Bobbitt	S. Wake Academy	4-24-2023	4-27-2023	Raleigh Beach
Ginny Jones	Seawell ES	5-1-2023	5-5-2023	West Point Eno
J.D. “Tripp” Carter	Longview School	4-24-2023	4-27-2023	Raleigh Beach
Jackie Smith	East Duplin HS	4-24-2023	4-27-2023	Cliffs of the Neuse
Judy Compton	Central Park School for Children ES	5-1-2023	5-4-2023	Cliffs of the Neuse
Kaley Kiffner	First Flight MS	4-25-2021	-	Lawson Creek Park
Karel Klepacki	Smithfield-Selma Senior HS	4-24-2023	4-28-2023	Smithfield
Kim Collier	Chaloner MS	5-1-2023	5-5-2023	Glenburnie Park
Krista Brinckek	Abbotts Creek ES	4-24-2023	4-28-2023	Falls Dam
Leah Purvis	Margaret B. Pollard MS	4-24-2023	4-28-2023	Falls Dam
Leah Ruto/Tom Simmons	Exploris ES	4-24-2023	4-27-2023	Raleigh Beach
Lee Deans	First Flight MS	4-25-2021	-	Lawson Creek Park
Lenae Scafidi	South Iredell HS	5-1-2023	5-4-2023	Gold Park
Matthew Lanner	Fuquay Varina MS	5-1-2023	5-4-2023	Smithfield Boat Ramp

Table 4. Egg and Larval Release Timing and Release Site Information Continued

Richard Kowaleski	Oberlin Magnet MS	4-24-2023	4-27-2023	Lassiter Mill
Rose Syroid	George Moses MS	5-1-2023	5-4-2023	Gold Park
Shannon Hardy	Wake Young Men's Learning Academy	4-24-2023	4-27-2023	Anderson Point Park
Terri Jones	Chaloner MS	5-1-2023	5-5-2023	Glenburnie Park

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



Overall, the shad rearing and release was fairly successful for most schools, but with a few issues for some. Each class was to receive approximately 1,000 embryos (800 expected to be fertilized) the first week and 600 embryos (~200 expected to be fertilized) the second week; however, counts may differ as to what the school reported receiving. Some teachers reported only the viable eggs to start and others reported all that they received. This difference in reporting may affect the percent survivability reported. This year 19 classes received their embryos on, Monday, April 24th and 11 received them on Monday, May 1 (one class received embryos both weeks). Several schools were re-scheduled for their embryo delivery date due to river water levels, correspondingly releases were also rescheduled. Of those that turned in their water quality information (21), many that had lower survivability also reported water quality issues. Three reported higher temperature ranges, one reported low alkalinity values, one reported chlorine above 0, and some had slight ammonia levels

(but below what is listed as tolerable). One class that had a tank fail the first week with Durham city water opted to use river water the following week and had success (83% survival). It is possible that water quality issues contributed to lower than 50% survivability for some schools.

Overall, the percent survival ranged from a low of 0% to a high of 98% and averaged 39% (Table 4). Seventeen classes averaged $\leq 50\%$, 12 averaged $>50\%$, and 7 averaged $\geq 75\%$ survival to release. There were 5 classes that averaged 10% survivability or below. Average survivability was reported at 39%, which was higher than 2021 (35%) but lower than 2022 (41%) and 2019 (53%). The percent of classes that were in the $\geq 75\%$ (23%) category followed similarly with being higher than 2021 (11%) but lower than in 2022 (28%) and 2019 (34%) (no shad were raised in 2020 due to Covid-19).



Photo 10. Brogden MS measuring tank water quality

Table 5. Egg and Larval Survival and Release Numbers

Educator	School	No. Eggs Received	No. Eggs/Larva Survived to Release	Percent Survival (%)
Annah Riedel/ Denise Ziemak	Exploris ES	900	800	89
Beth Selig	Fuquay Varina MS	1117	600	54
Brian Reynolds	Bertie Early College HS	1000	800	80
Christina Livingstone	Brogden MS	1000	57	6
Corie Hlavaty	Lakewood Montessori MS	180	150	83
Courtney Sykes	Falls Lake Academy	1000	200	20
Denise O’Gorman	Woods Charter HS	600	200	33
Douglas Poole	Perquimans County HS	800	108	14
Edward Tidd	Moore Square Magnet MS	800	100	13
Endiga Holdness	Fuquay Varina MS	800	600	75
Gillian Rose	Tiller School of Carteret County	900	350	39
Gina Bobbitt	S. Wake Academy	783	605	77
Ginny Jones	Seawell Elementary School	600	150	25
J.D. “Tripp” Carter	Longview School	800	200	25
Jackie Smith	East Duplin HS	500	245	49
Judy Compton	Central Park School for Children ES	1600	0	0
Kaley Kiffner	First Flight MS	605	0	0
Karel Klepacki	Smithfield-Selma Senior HS	609	500	82
Kim Collier	Chaloner MS	500	260	52
Krista Brinchek	Abbotts Creek ES	700	300	43
Leah Purvis	Margaret B. Pollard MS	1000	650	65
Leah Ruto/Tom Simmons	Exploris ES	1000	350	35
Lee Deans	First Flight MS	1000	0	0
Lenae Scafidi	South Iredell HS	450	440	98

Table 5. Egg and Larval Survival and Release Numbers Continued

Educator	School	No. Eggs Received	No. Eggs/Larva Survived to Release	Percent Survival (%)
Matthew Lanner	Fuquay Varina MS	915	200	22
Richard Kowaleski	Oberlin Magnet MS	850	500	59
Rose Syroid	George Moses MS	400	250	63
Shannon Hardy	Wake Young Men's Learning Academy	684	6	1
Terri Jones	Chaloner MS	632	305	48
Average survival percent				39

“They show empathy that they didn't have before when working with the eggs and the concept of keeping them all alive the best we can.”

“A first and only home run activity for a hardest to reach student! ... some extremely anti-social kids were able to use the water quality test to finally show teamwork.”

Teachers reported that the program creates enthusiasm with their students and increased their involvement in their surrounding environments and local waterways. Many reported that the students learn more and are more engaged. The Shad Program increases students’ interest and confidence in science. We have received great feedback on the program from the teachers throughout the 2023 program year.



Photo 11. Seawell ES release West Point Eno

Additional Student 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).

Gyotaku (fish printing)

All teachers who wish to receive a Gyotaku (fish printing kit) for their class can have one. The kit consists of 4 American Shad casts, supporting instructions, and prints of American Shad photos. Schools provide the paint and materials to print on (e.g., t-shirts, bags, posters). Nine classes reported doing this activity and that it enhanced learning.



Photo 12 Shad gyotaku printed tote bag

Fish Dissection



Photo 13 Caid Menzel (ECU grad student) conducting a fish anatomy lesson at First Flight MS

We coordinated with the NC State University (NCSU) Student Fisheries Subunit, the East Carolina University (ECU) Student Fisheries subunit, the NCWRC Division of Inland Fisheries staff, and an environmental scientist from NC Department of Transportation to conduct fish anatomy/morphology and dissection lessons. Ten students and educators from the above listed agencies and universities (individuals listed in acknowledgments) conducted these lessons. Because of these volunteers and the generosity of fish donations (143 fish), we were able to facilitate the dissection lecture for 10 classrooms (498 students).

Ten teachers (Table 5) reported that these lectures enhanced learning.



Photo 14. Bethany Wager (NCSU grad student) conducting a fish anatomy lesson at Wake Young Men's Learning Academy

“The kids still talk about this almost weekly. This was the best thing that we did all year.”

“Many students shared this was their favorite part of the project.”

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. This year we added an additional activity lesson titled “Migration Madness”, where students “travel” a length of the Cape Fear River while encountering obstacles to experience the migration of the American Shad into this river basin (10 reported it enhanced the learning experience for their students). Migration Madness was modified for the shad program from an activity created by the Whiteville Branch of the NCMNS. We worked with Artworks to create a new tank building video for the clear hexagon tank system and a “Shad Experience” video that follows the experience of students in the Shad Program at Exploris Elementary. These videos were filmed in 2022 and made available for teachers for this shad season. In addition, multiple activities were created for the programs within Project RESTORE and are available to all teachers who participate in any of the programs umbrellaed under Project RESTORE including Shad in the Classroom. (See Table 6 for the analysis of activities and videos)



Photo 15. Teachers participating in the Migration Madness activity at the workshop

Teachers continue to use the short videos we developed focusing on the diversity of North Carolina fish/aquatic biologists and accompanying questions in 2020 (9 teachers reported enhanced learning). These videos were created as an attempt to address the difference in learning revealed in the student surveys from 2016–2019 (and continued in 2021-2023) where students who self-identified as white showed greater increases in learning relative to students who self-identified as other races, particularly those that self-identified as Black or African American and Hispanic or Latino (see Student Analytics 2016–2019 – Appendix B). We hope that having the opportunity to hear from experts from diverse backgrounds will help students of color to picture themselves pursuing careers more readily in science and/or fisheries.

The genetic based exercise, “Who’s your Shaddy”, (developed in 2013 and updated in 2014) was also continued. Four teachers (1 high school, 2 middle schools, and 1 elementary school) reported this exercise was “just right” as far as understandability and complexity for their students. The usefulness of this activity seems mostly related to the class vs the grade as 1 High School, 4 Middle Schools, and 1 elementary school reported it was “too complicated”. Additionally, one middle school reported it was “too easy” (the remaining schools just reported that they did not use the activity). Additional curriculum activities are available for the teachers to use including Food Web Activities (19 teachers reported this as useful), GIS Watershed Activity (7 reported as useful), How Old is your Shad (10 reported as useful), Shad Lifecycle Activity (25 reported as enhanced learning – this is the highest ranked activity besides dissections which are not available to all due to resources), Dichotomous Key Activity (11 reported as enhanced learning), Fintastic Sort (5 reported as enhanced learning), Shad Scents (8 reported as enhanced learning), and a pipette art activity (9 reported as enhanced learning). 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 6. Additional Education and Video Use Survey Results

Question	Response variable
Biologist Interviews – enhance learning?	7% (2) greatly enhanced; 14% (4) enhanced; 10% (3) somewhat; 69% (20) did not use
Dichotomous Key – enhance learning?	7% (2) greatly enhanced; 21% (6) enhanced; 11% (3) somewhat; 61% (17) did not use
Fintastic Sort – enhance learning?	3% (1) greatly enhanced; 3% (1) enhanced; 10% (3) somewhat; 83% (24) did not use
Food Web Activities – usefulness?	34% (10) very useful; 28% (8) useful; 3% (1) somewhat; 34% (10) did not use
Fish Dissection – enhance learning?	28% (8) greatly enhanced; 7% (2) enhanced; 66% (19) did not attend
Genetic Exercise – complexity or understanding?	21% (6) just right; 7% (2) too hard; 72% (21) did not use
GIS Watershed Activity – usefulness?	7% (2) very useful; 14% (4) useful; 3% (1) somewhat; 69% (20) did not use
Gyotaku – enhanced learning?	10% (3) greatly enhanced; 17% (5) enhanced; 17% (5) somewhat; 14% (4) did not use
How Old is Your Shad? – usefulness?	21% (6) useful; 3% (1) somewhat; 76% (22) did not use
Migration Madness – enhanced learning?	10% (3) greatly enhanced; 10% (3) enhanced; 14% (4) somewhat; 66% (19) did not use
Shad Lifecycle Activity – enhance learning?	41% (12) greatly enhanced; 28% (8) enhanced; 17% (5) somewhat; 14% (4) did not use
Shad Pipette Art – enhance learning?	10% (3) greatly enhanced; 3% (1) enhanced; 17% (5) somewhat; 20% (69) did not use
Shad Scents – enhance learning?	7% (2) greatly enhanced; 14% (4) enhanced; 7% (2) somewhat 72% (21) did not use
Wishes of Fishes Activity – usefulness?	10% (3) very useful; 14% (4) useful; 3% (1) somewhat useful; 83% (24) did not use
Video -Add the eggs – usefulness?	34% (10) very useful; 24% (7) useful; 41% (12) did not use
Video –Build the Tank – usefulness?	38% (11) very useful; 21% (6) useful; 41% (12) did not use
Video – Fish Passage – usefulness?	28% (8) very useful; 28% (8) useful; 3% (1) somewhat; 41% (12) did not use
Video – History – usefulness?	52% (15) very useful; 21% (6) useful; 3% (1) somewhat; 24% (7) did not use
Video – It is Time usefulness?	38% (11) very useful; 21% (6) useful; 3% (1) somewhat; 38% (11) did not use
Video - Lifecycle – usefulness?	52% (15) very useful; 28% (8) useful; 21% (6) did not use
Video – Overview – usefulness?	34% (10) very useful; 38% (11) useful; 3% (1) somewhat useful; 24% (7) did not use

Additional Teacher Education Programs

On April 13-14, we conducted a Swamp Treehouse Adventure Educator Trek, a one-night trip to the camping treehouses on the Cashie River in Windsor, NC. Twelve educators participated in this workshop. We paddled on the Cashie River each day of the workshop, exploring different aspects of the bottomland hardwood ecosystem. We conducted activities exploring tree species, lichens, aquatic organisms, and searched for Carolina ghost fireflies. Educators actively participated in activities, including nature journaling, that they could take back to their classrooms. Participants were overwhelmingly satisfied with the experience and rated the workshop as “excellent.”

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).

Student Analytics 2023

We continue our evaluation of the Shad in the Classroom Program's impact on student's understanding and learning with a questionnaire that uses multiple choice questions to determine a participant's knowledge of the American Shad. Demographic questions about age, gender, grade level, and whether the participant hunted or fished are included. Teachers who agreed to participate (15 in 2016, 18 in 2017, 16 in 2018, 18 in 2019, 14 in 2021, 25 in 2022, 18 in 2023) provided the pre- and post-tests to their students (n=505 for 2016, n=835 for 2017, n=591 for 2018, n=672 for 2019, n=393 for 2021, n = 711 for 2022, n = 643 for 2023). See Appendix B for a detailed explanation of the analysis for 2016–2019. For the year 2020, there were no data as most students were unable to participate in the program (one classroom from Exploris ES did a few shad activities). In addition, there were two “control” classrooms in 2017 and 2018, four control classrooms in 2019, two control classrooms in 2021, three control classrooms for 2022, and one control classroom for 2023 that completed both the pre- and post-tests. The control classrooms were non-participating classrooms from the same schools that participate in the Shad in the Classroom program.

Similar to the other years' analysis, although all student groups in the program had a significantly positive increase in learning, students that self-identified as Black or African American showed a significant difference in learning from White students ($p=0.0045$), Hispanic or Latino ($p=.0068$), other ($p=.0003$), and from “two or more” ($p=0.0055$), but there was no significant difference in learning between students Black or African American and “prefer not to answer” (Figure 3). What this means is that although *all* students gained knowledge, students identifying as Black or African American race/ethnicity fell behind their peers. This year

we also saw a small significant difference in learning between those identifying as White and Other, with Other showing a slightly higher increase in learning. There was no significant difference in learning detected among students who identified as males, females, other, or preferred not to say (N/A) (Figure 4). Two classes had students that participated in the previous year. Those students showed a starting level higher in knowledge than the new students and showed a smaller increase in learning than the new students [average increase for all students: repeat students (7%), new students (20%)]. There was no significant difference (no increase in knowledge) for the pre- and post-survey for control students.

Figure 3. — Change in student knowledge by race (2023)

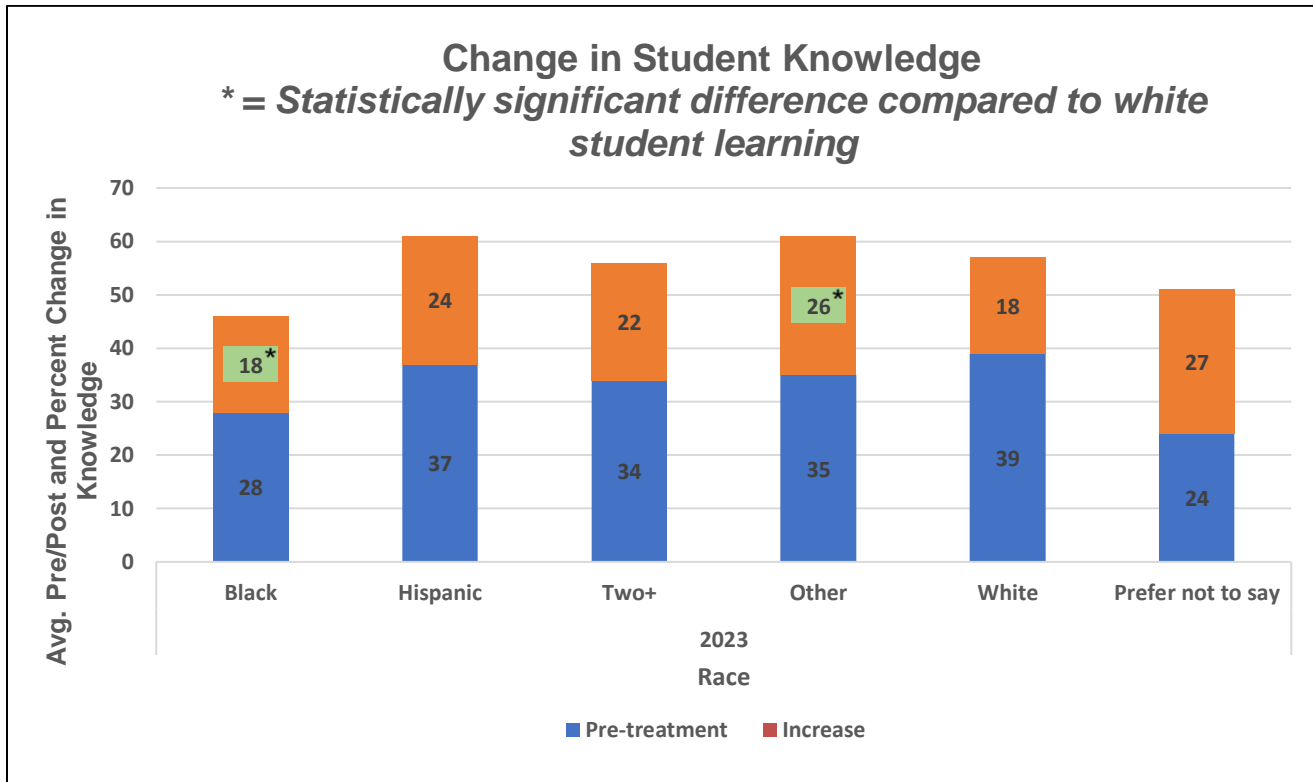
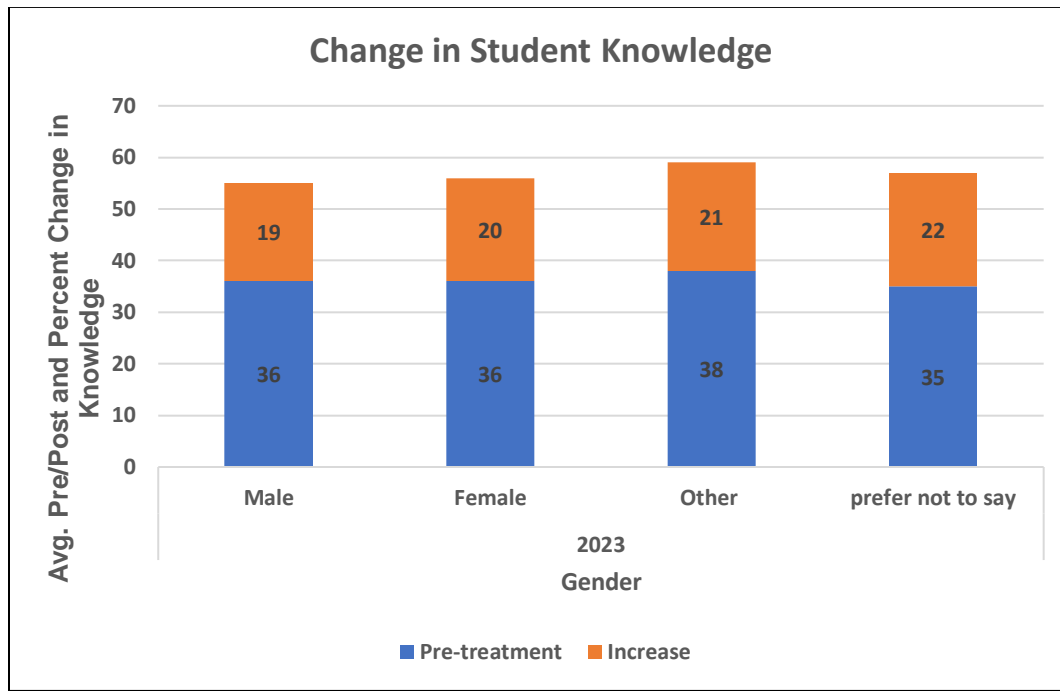


Figure 4. — Change in student knowledge by gender (2023 – note no significant difference)



The student surveys also contained questions to assess environmental attitudes and behaviors of the students. The analysis focused on the following 4 questions:

- 1. I talk to my family or friends outside of school about what I've learned about science**
- 2. I feel I can do something to help my local watershed or river**
- 3. I feel I can do something to help fish like the American Shad**
- 4. I ask others about things I can do about environmental problems**

Table 7 shows pre- and post-program percentages for those that answered “Agree or Strongly Agree” for questions 1-3 or “sometimes, often, or always” for question 4. We looked at all students and groupings by general grade (Elementary Students ES, Middle School Students MS, and High School students HS), gender, and race.

Attitude and behavior changes that reflect an increase of 10% or more from pre- to post-survey are marked with an asterisk in the table. We found no discernable pattern between pre- and post- responses with a few notable exceptions. High school students showed an increase of $\geq 10\%$ or higher for all questions, indicating a positive change in attitude and behavior. For all other student identifying factors, there was variation by race and gender as to whether there was any increase in attitude and behavior for each question.

Table 7. 2022 Analysis of Student Attitude and Behavior (*= notable increase of more than 10%)

Category	Q.1 % Pre	Q.1 % Post	Q.2 % Pre	Q.2 % Post	Q.3 % Pre	Q.3 % Post	Q.4 % Pre	Q.4 % Post
All	37	41	44	47	50	50	45	51
ES	42	47	53	49	66	56	46	46
MS	38	38	46	48	51	49	44	50
HS	31	45*	30	41*	29	45*	48	58*
Female	41	48	47	45	53	47	49	53
Male	32	34	44	48	52	53	41	47
Other	41	38	41	50	34	47*	63	59
Prefer not to answer	48	53	35	45*	35	50*	38	55*
Black	35	31	42	37	50	48	34	53*
Hispanic	22	37*	33	41	31	43*	46	43
Other	41	48	48	62*	59	62	52	66*
Two	39	44	44	47	50	50	45	54
White	38	42	48	49	53	51	48	49
Prefer not to answer	47	50	29	38*	41	41	47	56

Q: Have you seen any changes in the students who participated in this program?

“Yes, the students are so engaged and connected to the real world. They truly feel like they are making a difference.”

“Yes, it greatly motivated students to understand the reason behind what we were doing and how it impacts the environment and ecosystems.”

In summary, it is notable that all student groups in the program had a significantly positive increase in learning for all the years that these parameters have been evaluated (2016–2019, 2021, 2022, 2023). However, students identified as Black or African American were found to fall behind their peers in learning in each year. Other groups showing significantly lower learning levels for some comparisons were those self-identified as Hispanic or Latino (4 of the years) and those self-identified as “Other” (2 of the years). We plan to continue collecting student questionnaires and refine questions as necessary so that we can monitor student learning and attitudes and behavior in all groups between the beginning and end of the Shad program. We will also continue to look for more ways to address any issues identified.

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, the Shad in the Classroom Program was featured through:

- NCMNS Member Night showcase June 2022
- The “We are the River Film” won the Gold Telly award in the nature category in 2018.
- The 2017 student analysis was published in Fisheries. Reaching Underserved Populations Through a Fisheries Education Program (Fisheries | Vol. 45 • No. 3 • March 2020).

An update on the Shad in the Classroom Program will be published in the North Carolina Chapter American Fisheries Society Fall Newsletter in 2023.

Future Planning

We will continue to transition classes to the plexiglass tanks as the teachers report that the new, clear tanks enhance students’ 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, 72% of teachers reported that they were extremely satisfied and 24% reported they were very satisfied with the Shad in the Classroom experience [3% (1) teacher reported being moderately satisfied]. For the teacher with the lower satisfaction level, it seemed to stem from a tank fail, as all other comments were positive. Most teachers and students provided positive feedback on all aspects of the program including the workshop, activities, and the overall program. Twenty-four of the 26 teachers participating in the Shad in the Classroom Program in 2023 reported that they would like to continue with the program next year. Those not returning stated reasons including retirement, changing careers, or lack of school support. It is expected that 4 teachers on “hiatus” for this year plan to return for 2024. At present, we have eight new teachers on the waiting list for the program in 2024. We received invaluable assistance from partners and volunteers helping with the deliveries of eggs and educational lectures. Working with this program is a positive experience for all involved.

“This program gets better each year we participate.”

“(Students) are more excited to visit the Neuse River with their families.”

“Some (students) are considering careers in environmental science, biology etc.”

“I had many parents reach out and tell me that the shad experience was their child's most talked about experience at home! So, I think students, even ones I didn't expect, really enjoyed this program.”

Appendix A

Table 8. Schools Participating in the North Carolina Shad in the Classroom Program (2009–2023)

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	6	2016-2023
Angier Elementary	2	2013-2014
Ballentine Elementary	4	2017-2021
Bertie Early College High School	4	2019-2023
Brogden Middle School	6	2015-2019, 2023
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	12	2013-2023
Chaloner Middle School	3	2019, 2023
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/Oberlin MS	16	2010-2019, 2022-2023
Dillard Middle School	1	2017
Don D. Steed Elementary	1	2012
East Duplin High School	1	2023
East Garner Middle School	4	2018-2021
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	10	2017-2023
Exploris Middle School	7	2010-2016
Falls Lake Academy	2	2023
First Flight Middle School	5	2021-2023
Forest Pines Dr Elementary	1	2013
Fuquay Varina Middle School	20	2014-2023
George Moses Middle School	2	2022-2023
Grady A. Brown Elementary	1	2018
Hall Woodward Elementary	2	2012-2013

Table 8. Schools Participating in the North Carolina Shad in the Classroom Program (2009–2023)
continued

Release Basin School	Nos. of Classes	Years
Neuse River Basin		
Horton Middle School	3	2017-2019
Knightdale Elementary School	1	2022
Lakewood Montessori Middle School	13	2013-2017, 2022-2023
Lincoln Heights Elementary	2	2021-2022
Lead Mine Elementary	3	2009-2011
Lillington Shawtown Elementary	2	2011-2012
Longleaf School of the Arts	2	2019, 2023
Longview Middle School	1	2021
Margaret B. Pollard Middle School	1	2023
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
Moore Square Magnet Middle School	1	2023
Moss Hill Elementary	3	2017-2019
North Duplin JR/SR High School	2	2015-2016
Northeast Academy for Aerospace & Advanced Technologies	2	2021
Perquimans County Middle School	1	2019
Perquimans County High School	4	2021-2023
Petree Elementary	1	2019
Pine Hollow Middle School	2	2018-2019
PreEminent Charter School	1	2022
Roanoke Rapids High School	1	2022
Rolesville Middle School	1	2017
Sandy Grove Middle School	2	2012-2013
Seawell Elementary School	2	2022-2023
Sherwood Githens Middle	4	2019, 2022
Smithfield-Selma Senior High School	6	2018-2023
South Asheboro Middle School	1	2012
South Iredell High School	8	2013-2018, 2022-2023
South View High School	1	2012
Southern Vance High School	4	2012-2015
Southern Wake Academy	1	2023
Speas Elementary	1	2012
Tar Heel Middle School	1	2016
Terrell Lane Middle School	2	2021-2022

Table 8. Schools Participating in the North Carolina Shad in the Classroom Program (2009–2023)
Continued

Release Basin School	Nos. of Classes	Years
Neuse River Basin		
The Oakwood School	1	2012
Tiller Elementary School (Carteret County Charter School)	8	2013-2019, 2023
Upchurch Elementary	7	2012-2018
Uwharrie Charter Academy	1	2016
Wake Forest Middle School	2	2015-2016
Wake Young Men's Learning Academy	1	2023
Wakefield Middle School	2	2022
Walkertown Middle School	1	2016
West Hoke Elementary	1	2012
West Johnston High School	1	2019
W.G. Enloe High School	4	2017-2021
W.J. Gurganus Elementary School	1	2021
Woods Charter Middle School	8	2012-2017, 2019-2022
Woods Charter High School	1	2023
Roanoke River Basin		
Bartlet Yancey High School	1	2010
Bertie Early College High School	4	2015-2018
Cedar Creek Middle School	1	2016
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

Table 8. Schools Participating in the North Carolina Shad in the Classroom Program (2009–2023)
Continued

Release Basin School	Nos. of Classes	Years
Roanoke River Basin		
Windsor Elementary	1	2010
W.L. Manning Elementary School	2	2016-2017
Total Number of Schools	116	2009-2023
Total Number of Classrooms	324	2009-2023

Appendix B

Student Analytics 2016–2019

To better evaluate the Shad in the Classroom Program’s impact on student’s understanding and learning, we created a questionnaire that used multiple choice questions in order to determine a participant's knowledge of the American Shad. We also included demographic questions about age, gender, grade level, and whether the participant hunted or fished. Teachers who agreed to participate (15 in 2016, 18 in 2017, 16 in 2018, 18 in 2019, 14 in 2021) provided the pre- and post-tests to their students (n=505 for 2016, n=835 for 2017, n=591, n=672 for 2019). In addition, there were two “control” classrooms in 2017 and 2018 and four control classrooms in 2019 that completed both the pre- and post-tests. The control classrooms were non-participating classrooms from the same schools and grade level that participate in the Shad in the Classroom program.

We partnered with Dr. Nils Peterson, Dr. Kathryn Stevenson, and graduate students Kalysa Clark, Danielle Lawson, and Rachel Szczytko at the NCSU Human Dimensions of Conservation Biology Lab for the 2017 analysis. The results of the 2017 shad season’s questionnaire analysis were published in Fisheries (Fisheries | Vol. 45 • No. 3 • March 2020). 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.

During the COVID-19 shutdown, we analyzed the larger pool of student knowledge data from 2016-2019 (student surveys began in 2016). In the survey, students self-selected race from the following options: Asian or Pacific Islander, Black or African American, Hispanic or Latino, Native American, White, two or more of the above, or other. Because in each of the years Asian or Pacific Islander and Native American were found to be a low percentage of the student population, these two groups were combined with the “other” category for analysis. Student knowledge data was analyzed by race and gender for pre- and post-knowledge and change in knowledge. Over the four years, we found similar results to those mentioned above for the 2017 analysis

(Figure 5). All races and genders were found to have a significant positive increase in knowledge for all four years ($p < 0.0001$). However, there were statistically significant differences in learning between some race groups, when compared to White students, in each of the four years.

For the 2016 year, students that self-identified as Black or African American showed a significant difference in learning from White students ($p = 0.0188$), but there was no significant difference ($p > 0.05$) in learning for Black or African American students compared to other race categories. For the 2017 year, those analysis were explained in detail above; in summary, all races were significantly different from White students but were not significantly different from each other. For the 2018 year, students that self-identified as Black or African American or Hispanic or Latino showed a significant difference in learning from White students ($p = 0.0002$ and $p = 0.0013$, respectively) and "other" ($p = 0.0125$ and $p = 0.0241$, respectively), but there was no significant difference in learning between each other or from "two or more". Finally, for the 2019-year students, it was found that students that self-identified as Black or African American or Hispanic or Latino showed a significant difference in learning from White students ($p < 0.0001$ for both), "other" ($p = 0.039$ and $p = 0.0155$, respectively), and "two or more" ($p < 0.0001$ for both). There was no significant difference (no increase in knowledge) for the pre- and post-survey for control students for all years tested.

In summary, although all students groups in the program had a significantly positive increase in learning, students identified as Black or African American were found to have a significant difference in learning in every year and those self-identified as Hispanic or Latino had a significant difference in learning in three of the four years from their White peers. Also, for the 2019 year, we found a small significant difference in learning for gender ($p = 0.04$), which was in the positive direction for females, and no significant difference for all other years ($p > 0.05$) (Figure 6).

Figure 5. — Change in student knowledge by race (2016–2019)

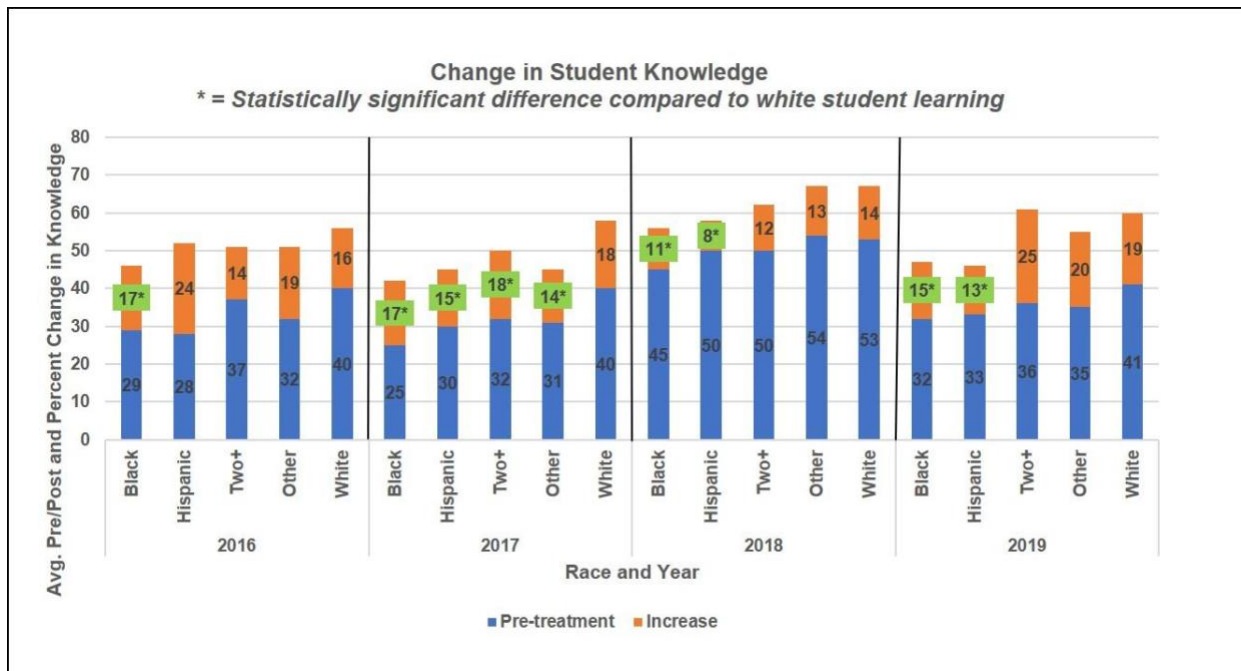
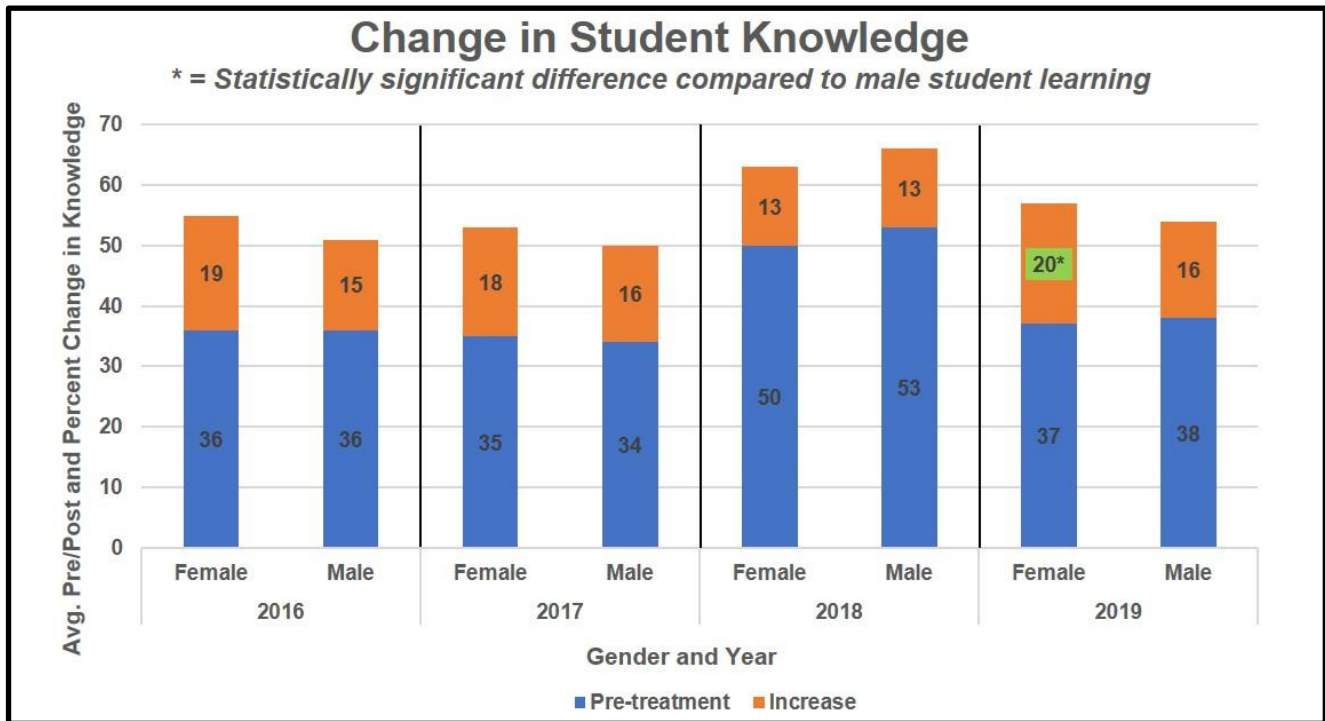


Figure 6. — Change in student knowledge by gender (2016–2019)



One way we are addressing the results of these student surveys is to create a series of video interviews of a diverse group of aquatic or fisheries biologists, as mentioned in the Curriculum Activities and Videos section. These videos will be made available to teachers and students. Our hope is that these videos will help students of color to more easily relate to scientists and begin to envision careers in the aquatic biology field. We continue to look for additional ways to engage these populations and increase their knowledge over the scope of the program.

The student surveys also contained questions to assess environmental attitudes and behaviors of the students. In our 2019 analysis we focused on the following 4 questions (this analysis was done only for 2019 as that is the year these particular questions were given):

1. **I talk to my family or friends outside of school about what I’ve learned about science**
2. **I feel I can do something to help my local watershed or river**
3. **I feel I can do something to help fish like the American Shad**
4. **I ask others about things I can do about environmental problems**

Table 8 shows pre- and post-program percentages for those that answered “Agree or Strongly Agree” for questions 1-3 or “sometimes, often, or always” for question 4. We looked at all students and groupings by general grade (Elementary Students ES, Middle School Students MS, and High School students HS), gender, and race. We found no discernable pattern between pre- and post- responses with a few notable exceptions, in which students had an increase of 10% or more from pre- to post-survey (marked with an asterisk in the table). Both elementary students and those who self-reported their race as "other" (other includes those that chose “other” and also includes Asian and Native American) showed an increase of more than 10% in their answers to Question 3, indicating a positive shift in attitude regarding American Shad restoration. Additionally, high school students showed an 11% increase from pre- to post-survey in their responses to Question 4, indicating a

positive change in behavior. Also notable was those students that self-reported as Black and “other” showed a positive increase in responses to all questions (though only at the 10% level for “other” in Question 3).

Table 9. 2019 Analysis of Student Attitude and Behavior (* = notable increase of more than 10%)

Category	Q.1 % Pre	Q.1 % Post	Q.2 % Pre	Q.2 % Post	Q.3 % Pre	Q.3 % Post	Q.4 % Pre	Q.4 % Post
All	44	43	54	55	61	61	49	53
ES	46	49	71	70	65	77*	57	59
MS	45	42	50	51	59	57	47	41
HS	36	44	53	56	64	59	49	60*
Female	49	46	60	64	64	66	55	59
Male	39	38	48	45	58	56	43	47
Black	36	43	48	53	57	58	35	43
Hispanic	47	39	57	55	63	57	52	52
Other	43	47	45	52	53	70*	57	58
Two	45	43	51	48	56	55	48	51
White	46	43	57	57	64	62	52	56

Additional notable results were females answered 10% or more higher in positive answers (except question 1 post- at 8% higher) compared to males, and elementary students answered 10% or more higher in positive answers for pre- and post- question 2 and post- question 3 compared to middle school and high school. We plan to continue collecting student questionnaires and refine questions as necessary so that we can monitor student learning and attitudes and behavior in all groups between the beginning and end of the Shad program.

Shad in the Classroom Background (Updated 2020)

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, by 2014 there were 37 schools, and by 2020 they increased to 73 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, Pennsylvania, Virginia, and West Virginia, and the District of Columbia (Figure 7). The Connecticut River Museum was looking into starting a Shad in the Classroom Program in their state, but the program got suspended. Previously, a number of participating states were part of the Interstate Commission on the Potomac River Basin (ICPRB). However, as of 2020, Anacostia Watershed Society continues the work and includes schools in Maryland, DC, and Virginia. 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.

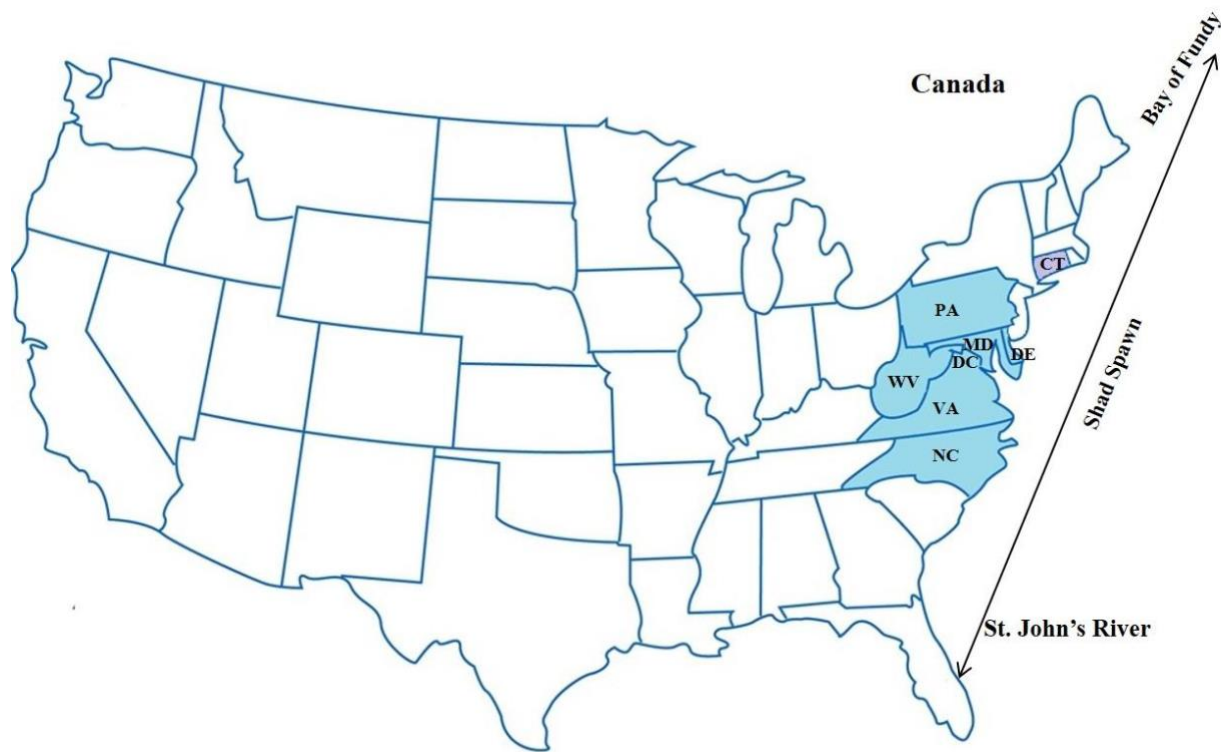


Figure 7. — Map of the states we found to participate in some version of a shad in the classroom program: Delaware, Maryland, North Carolina, Pennsylvania, Virginia, and West Virginia, and the District of Columbia (a program in Connecticut is proposed). Arrow depicts American Shad spawning distribution 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. Funding was provided through APNEP and the USFWS for the years 2017-2019 and 33 classrooms were reached for the 2017 year, 30 for the 2018 year, and 32 for the 2019 year. 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 – 2021) is included in Table 7. 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, and all shad used for the program in 2019 were spawned at the NCWRC Watha State Fish 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. Due to the results of multiple years of study, the NCWRC is presently (as of 2019) not stocking American Shad in NC waters, but are continuing to monitor the populations. American Shad are collected and brought to the Watha State Fish Hatchery solely for the Shad in the Classroom Program. Even though the NCWRC are not collecting broodstock, they continue to monitor the fishery as part of their restoration program. Having the schools be part of this restoration program is a valuable educational tool.