

**Shad in the Classroom
Program Report
(2009–2024)**

September 26, 2024

By
Danielle Pender
Project RESTORE Program Specialist

Melissa Dowland
Manager of Teacher Education

and

Megan Davis
Coordinator of Teacher Education

North Carolina Museum of Natural Sciences



Table of Contents

Executive Summary	3
Acknowledgments	4
Program Report 2024	5
2024 Program Timeline (Figure 1)	8
Tank Inventory	9
Teacher Orientation and Training	9
Egg Delivery and Larval Release	11
Additional Education	17
Gyotaku (fish printing)	17
Fish Dissections	18
Curriculum Activities	18
Program Outcomes	21
Student Impact	21
Student Analytics 2024	21
Public Outreach	24
Future Planning	25
Appendix A – Table 8. Schools Participating in the North Carolina Shad in the Classroom Program (2009–2024)	26
Appendix B – Student Analytics 2016–2019	32
Appendix C – Shad in the Classroom Background (2020 update)	36

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 2024 Shad season we received grant funding from the UFWS and Triangle Fly Fishers.

The Shad in the Classroom Program has reached 355 classrooms from 2009 to 2024 (Appendix A, Table 8) and many thousands of students. Between 2013–2024, approximately 24,320 students were reached (prior to 2013, the numbers of students were not tracked). Thirty-one classes in 15 counties (Tier 1 – 4, Tier 2 – 5, Tier 3 – 6) participated in 2024 (Table 1) with 8 classes being new to the program. This year 2,553 students participated with 1011 students being in Title 1 schools.

In the years from 2013–2024 (excluding 2020), each school received approximately 600-2,000 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 2024 are listed below.

Additional Education

Fish Anatomy-Dissection Lecture

Aly Lynch aclynch2@ncsu.edu – (NCSU, Grad Student) - Lecturer

Ambar Torres Molinari ambar.t@catawbariverkeeper.org – (Catawba River Keeper) – Lecturer

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

Cami Miller millerca23@students.ecu.edu – (ECU, Grad Student) - Lecturer

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

Devin Raburn dmraburn@ncsu.edu – (NCSU, Grad Student) - Lecturer

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

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

Egg Delivery and Larvae Release Assistance

Beth Cranford beth.cranford@naturalsciences.org – (NCMNS, Coordinator, Elementary Education)

Christy Flint christy.flint@naturalsciences.org – (NCMNS, Director of Education)

Heather Jennings Heather.jennings@apnep.org – (APNEP, Program Manager)

Jerry Reynolds jerry.reynolds@naturalsciences.org – (NCMNS, Head of Outreach)

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

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

Steve Anderson steve.anderson@deq.nc.gov – (APNEP, Partnership Coordinator)

Tim Ellis tim.ellis@apnep.org – (APNEP, Quantitative Ecologist)

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 David Hart, and from ECU graduate students, Chase Spicer and Andrew McCains. We greatly appreciate Todd VanMiddlesworth, Josh Cooper, and Barry Midgett, 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 Devin Raburn and Tyler Muller, NCSU, and Chase Spicer, ECU for assisting with organizing students for the fish anatomy-dissection lessons.

Report cover photos: Top left – Hub Farm (Durham Public Schools) release at West Point Eno River; Bottom left – teachers at workshop participating in Big Canoe activity; Top right – Lakewood Montessori MS release at West Point Eno River; Bottom right – Lakewood Montessori MS students viewing shad fry in their tank.

Shad in the Classroom Program 2024 Report



Photo 1. Teachers practicing water quality testing

This report summarizes the activities accomplished for the 2024 Shad in the Classroom Program. Thirty-one classes at 26 different schools (Table 1) were accepted into the 2024 program: 7 elementary, 17 middle, and 7 high school classes. This year The Hub Farm – Durham Public Schools became part of the program. Although they are listed as one school, they had students from 8 schools participate from Durham that included high school interns that assisted throughout the week and schools that helped with maintaining the tank and water quality, learned about shad, and attended the field trip to release the shad.

Table 1. 2024 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
Brinson Memorial ES	Craven*	2	1
Chaloner MS	Halifax*	1	2
Cumberland Polytechnic HS	Cumberland*	1	1
Durham Public Schools – The HUB	Durham	3	1
East Duplin HS	Duplin*	1	1
Falls Lake Academy	Wake	3	1
First Flight MS	Dare	2	2
Fuller GT/AIG Basics Magnet ES	Wake	3	1
Fuquay Varina MS	Wake	3	3
George Moses MS	Chatham	3	1
Glenwood ES	Orange	3	1
Lakewood ES	Durham*	3	1
Lakewood Montessori MS	Durham	3	2

Table 1. 2024 Schools Accepted to the North Carolina Shad in the Classroom Program – cont'd
(Title 1 indicated with an *)

Moore Square Magnet MS	Wake	3	1
Oberlin Magnet MS	Wake	3	1
Perquimans County HS	Perquimans*	2	1
Seawell ES	Orange	3	1
Sherwood Githens MS	Durham*	3	1
South Iredell HS	Iredell	3	1
Southern Wake Academy	Wake	3	1
Terrell Lane MS	Franklin*	2	1
Wake Young Men's Learning Academy	Wake	3	1
West Johnston HS	Johnston	3	1
Woods Charter HS	Chatham	3	1
Total Number of Schools			26
Total Number of Classrooms			31

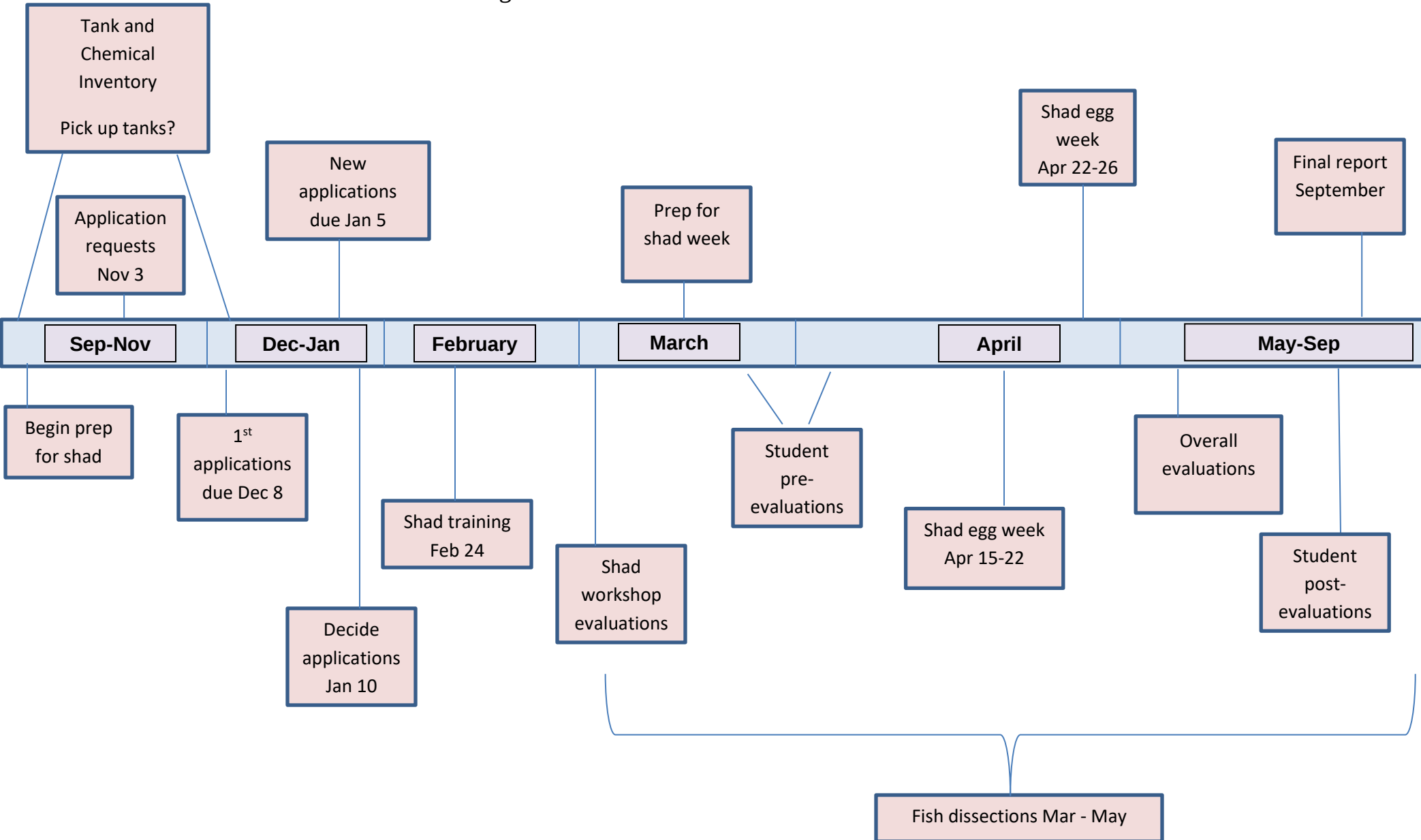
In July of 2022 we received a grant award from the USFWS for Project RESTORE (Rescuing Endangered Species through Outreach, Restoration, and Education) for \$165,000 to be utilized up until 9/2027. Project RESTORE employs a multiple species approach focusing on endangered and imperiled species in North Carolina, including American shad, Venus flytrap, Carolina madtom, Neuse River waterdog, and the red wolf. For the 2024 Shad in the Classroom program, we primarily operated on our budget from the USFWS. Triangle Fly Fishers also gifted us with \$500 for the Shad in the Classroom Program. In addition, we leveraged over \$30,700 of in-kind support. Very important to the program are the many volunteers, who generously give their time to enhance the program, and the dedicated teachers.

Current new tank construction of the red tub style tanks cost approximately \$406 per tank system. The plexiglass tank systems cost approximately \$605 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 8th, and only one collection was necessary this year. 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 the Catawba River Keeper.



**Photo 2. Ambar Torres Molinari, S.
Iredell HS Fish Anatomy lesson**

Figure 1. Shad in the Classroom 2024 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



Photo 3. Teachers learning about tank setup

A teacher orientation and training session was conducted on February 24, 2024. Danielle Pender and Melissa Dowland co-led the session. 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 Big Canoe activity sponsored by NC State Parks at Falls Lake. Due to this introduction, a number of teachers took advantage of the opportunity to take their students on a Big Canoe experience.

“I came a little frustrated to be working the weekend - and leaving with my new connections and an overflowing excitement for this project. Thank you for all of your hard work to make this amazing!.”
(Teacher feedback)



Photo 4. Teachers receiving a lesson for canoe paddling from Sean Higgins and Alex Lemon, NC Parks

Fifteen teachers attended the 2024 workshop (8 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 felt the information was explained clearly and appreciate having the

activities available for their classes. Teachers reported that they were very to extremely satisfied with the workshop and that the concepts were explained very to extremely well (Table 3).

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

Question	Response variable
I feel I can teacher students about shad restoration	89% increase in confidence (one stayed the same at “agree”)
I feel I can teach students about shad management	89% increase in confidence (one stayed the same at “agree”)
I feel I can teach students about the life history of shad	78% increase in confidence (two stayed the same at “agree”)
I feel I can teach students how to raise shad from the egg to the larval stage	89% increase in confidence (one stayed the same at “agree”)
Knowledge of shad life stages	56% correct before, 78% correct after
Knowledge of anadromous definition	78% correct before, 100% correct after
Knowledge of factors leading to shad decline	78% correct before, 100% correct after
Knowledge of acceptable pH levels	56% correct before, 89% correct after
Knowledge of shad migration	78% 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	68% (13) extremely confident; 32% (6) very confident
I feel comfortable in contacting the other teachers	63% (12) extremely confident; 37% (7) very confident
The information I learned was sufficient to incorporate into my shad curriculum	89% (17) extremely sufficient; 11% (2) very sufficient
This workshop explained the importance of the shad restoration and management program	82% (14) extremely well; 18% (3) very well
This workshop explained the life history of shad	82% (14) extremely well; 18% (3) very well
This workshop explained the proper components to raising shad eggs to the larval stage	82% (14) extremely well; 18% (3) very well
Overall satisfaction with the workshop	88% (15) extremely satisfied; 12% (2) very satisfied

Egg Delivery and Larval Fish Release

We coordinated the arrival of the eggs and the release of the larval fish with the schools, hatchery, drivers, and fisheries biologists. This involved foremost the timing of the spawning of the American Shad, but also considered school schedules. American Shad collection was successful the week of April 8th and we were able to deliver embryos for the weeks of April 15th and 22nd. Many people assisted with the delivery of the eggs and with the release of the larval fish and are mentioned in the acknowledgments. In addition, Danielle and retired professor Dr. Rich Noble assisted T.D.

VanMiddlesworth with Neuse River American Shad and Striped Bass population monitoring on April 17th for NCWRC.



Photo 5. Jeff Evans, Landon Beaver, and Barry Midgette, packaging American Shad embryo for schools.



Photo 6. Danielle and Dr. Rich Noble assisting with electrofishing sampling on the Neuse 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 4/18, 8 on Friday 4/19, 4 on Thursday 4/25, and 6 on Friday 4/26 (Table 4, Figure 2). Classes received approximately 1,000-2,000 eggs according to the hatchery; however, some classes reported receiving a different number (Table 5). Most classes had students at the release (970 students attending). A few classes that had failed tanks (0% survivability) also did not attend a release. Of those that were able to attend a release, all teachers reported that it enhanced the learning experience for their students.



Photo 7. Abbotts Creek ES release below Falls Dam, Neuse River



Photo 8. Lakewood Montessori MS release West Point Eno (using view scopes & invert sampling)

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

Educator	School	Received Eggs	Released Eggs/Larva	Neuse River Release Site
Beth Selig	Fuquay-Varina MS	4/15/2024	4/18/2024	Smithfield Boat Ramp
Brian Reynolds	Bertie HS	4/15/2024	4/18/2024	Falls Dam
Ginny Jones/Christina Davidson	Seawell ES	4/15/2024	4/19/2024	West Point on the Eno
Corie Hlavaty	Lakewood Montessori MS	4/15/2024	4/18/2024	West Point on the Eno
Courtney Sykes	Falls Lake Academy	4/15/2024	4/19/2024	Falls Dam
Denise O’Gorman	Woods Charter	4/15/2024	4/18/2024	Confluence of the Eno
Douglas Poole	Perquimans County HS	4/15/2024	4/19/2024	Anderson Point
Edward Tidd	Moore Square MS	4/22/2024	4/25/2024	Raleigh Beach
Endiga Holdness	Fuquay Varina MS	4/15/2024	4/18/2024	Smithfield Boat Ramp
Fred Pfeiffer	Lakewood Montessori MS	4/15/2024	4/18/2024	West Point on the Eno
Gina Bobbitt	Southern Wake Academy	4/22/2024	4/26/2024	Raleigh Beach
Jackie Smith	East Duplin HS	4/15/2024	4/18/2024	Cliffs of the Neuse
Janice West	West Johnston HS	4/22/2024	4/26/2024	Smithfield Boat Ramp
Katie Dorn	Cumberland Polytechnic HS	4/15/2024	4/19/2024	Smithfield Boat Ramp
Kaley Kiffner	First Flight MS	4/15/2024	—	Lawson Creek
Kim Collier	Chaloner MS	4/15/2024	4/18/2024	Anderson Point
Krista Brinchek	Abbotts creek ES	4/15/2024	4/19/2024	Falls Dam

Table 4. Egg and Larval Release Timing and Release Site Information – Cont'd

Lamonica Williams	Wake Young Men's Leadership Academy	4/22/2024	4/26/2024	Walnut Creek Wetland Center
Lee Deans	First Flight MS	4/15/2024	—	Lawson Creek
Lenae Scafidi	South Iredell HS	4/15/2024	4/19/2024	Gold Park
Matthew Lanner	Fuquay Varina MS	4/15/2024	4/18/2024	Smithfield Boat Ramp
Branson Phillips	Githens MS	4/22/2024	4/26/2024	West Point on the Eno
Rae Cohn	DPS Hub Farm	4/15/2024	4/18/2024	West Point on the Eno
Richard Kowaleski	Oberlin Magnet MS	4/15/2024	4/18/2024	Lassiter Mill
Sarah King	Chaloner MS	4/15/2024	4/19/2024	Anderson Point
Shannon Lee	Brinson Memorial ES	4/22/2024	4/26/2024	Behind school (319 Neuse Forrest Ave, Ampitheater)
Sheryl Kirkey-Dean	Glenwood ES	4/15/2024	4/18/2024	Falls Dam
Sophie Hatcher Peters	Lakewood ES	4/15/2024	4/18/2024	Falls Dam
Susette McConnell	Terrell Lane MS	4/15/2024	4/19/2024	Falls Dam
Rose Syroid	George Moses Horton MS	4/15/2024	—	Gold Park
Wayne Shore	Fuller ES	4/22/2024	4/26/2024	Walnut Creek Wetland Center

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

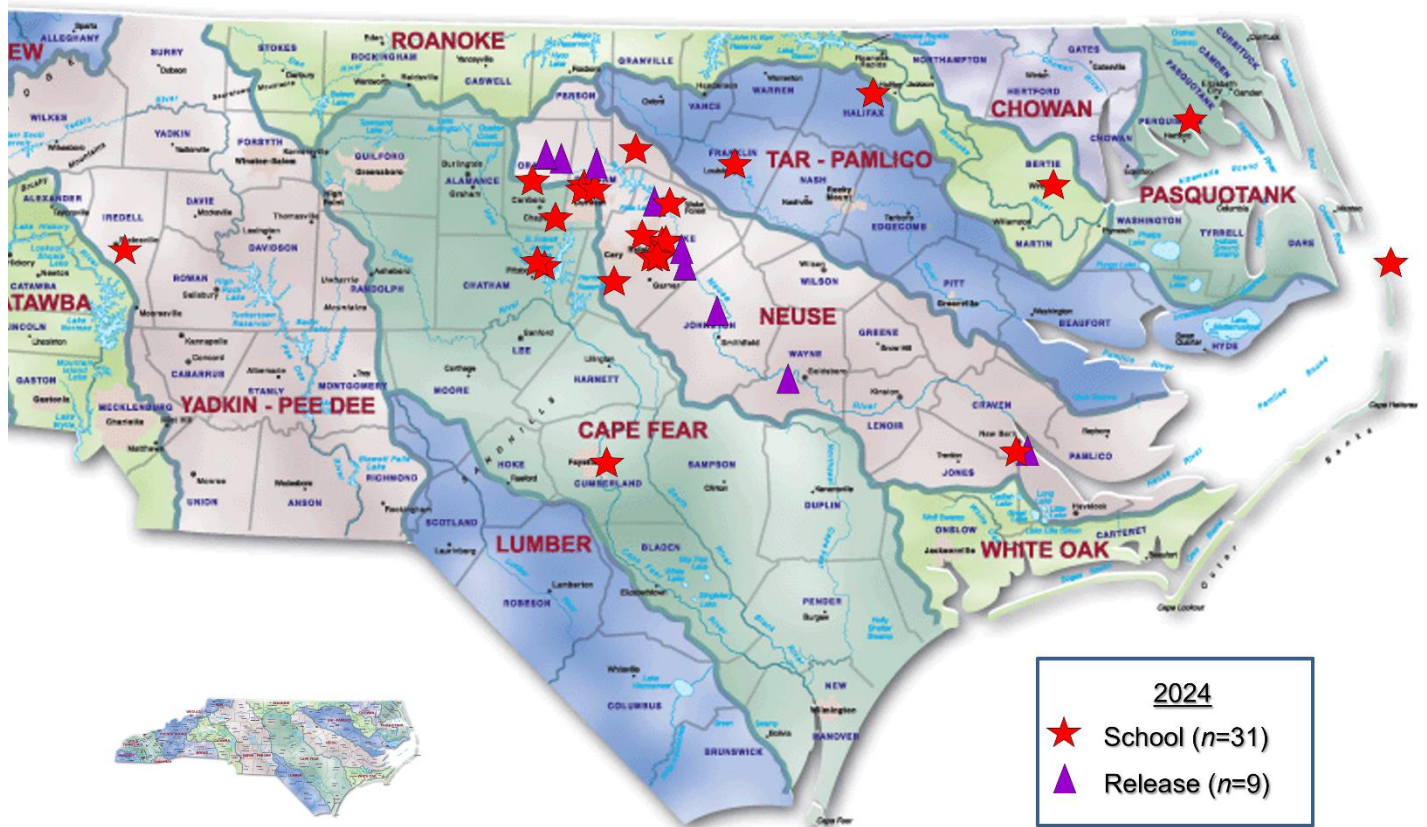


Photo 9. Glenwood ES measuring tank water quality

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 – 2,000 embryos; 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 21 classes received their embryos on, Monday, April 15th and 10 received them on Monday, April 22nd. Of those that turned in their water quality information (29), many that had lower survivability also reported water quality issues. Eight reported higher temperature ranges, four reported ammonia issues, and one reported nitrate issues. A few classes reported tank and pump issues. Two that had tank or pump issues had 0 and 3% survivability. Eight classes used river water rather than tap. Although “river water” teachers reported water quality issues and had similar survivability averages to those that used tap, there were no complete tank failures (2 reported having less than 10% survivability). 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 97% and averaged 35% (Table 4). Twenty-two classes averaged $\leq 50\%$, 9 averaged $>50\%$, and 4 averaged $\geq 75\%$ survival to release. There were 8 classes that averaged 10% survivability or below. Average survivability was reported equal to 2021 (also 35%), but

lower than 2022 (39%), 2022 (41%), and 2019 (53%). The percent of classes that were in the $\geq 75\%$ (13%) was higher than 2021, (11%) but lower than in 2023 (24%), 2022 (28%), and 2019 (34%) (no shad were raised in 2020 due to Covid-19).

Table 5. Egg and Larval Survival and Release Numbers

Educator	School	No. Eggs Received	No. Eggs/Larva Survived to Release	Percent Survival (%)
Beth Selig	Fuquay-Varina MS	1691	300	18
Brian K Reynolds	Bertie HS	1500	50	3
Ginny Jones/Christina Davidson	Seawell ES	1000	600	60
Corie Hlavaty	Lakewood Montessori MS	2000	1500	75
Courtney Sykes	Falls Lake Academy	1000	250	25
Denise O’Gorman	Woods Charter	1000	800	80
Douglas Poole	Perquimans County HS	1000	20	2
Edward Tidd	Moore Square MS	2000	900	45
Endiga Holdness	Fuquay Varina MS	2000	700	35
Fred Pfeiffer	Lakewood Montessori MS	2500	1800	72
Gina Bobbitt	Southern Wake Academy	787	530	67
Jackie Smith	East Duplin HS	1650	850	52
Janice West	West Johnston HS	2000	250	13
Katie Dorn	Cumberland Polytechnic HS	1500	0	0
Kaley Kiffner	First Flight MS	1500	0	0
Kim Collier	Chaloner MS	1500	425	28
Krista Brinchek	Abbotts creek ES	1200	300	25
Lamonica Williams	Wake Young Men's Leadership Academy	2000	300	15
Lee Deans	First Flight MS	1000	0	0

Table 5. Egg and Larval Survival and Release Numbers Continued

Educator	School	No. Eggs	No. Eggs/Larva	Percent
		Received	Survived to Release	Survival (%)
Lenae Scafidi	South Iredell HS	1600	1555	97
Matthew Lanner	Fuquay Varina MS	1400	0	0
Branson Phillips	Sherwood Githens MS	2000	150	8
Rae Cohn	DPS Hub Farm	2000	500	25
Richard Kowaleski	Oberlin Magnet MS	1500	1000	67
Sarah King	Chaloner MS	800	250	31
Shannon Lee	Brinson Memorial ES	996	802	81
Sheryl Kirkey-Dean	Glenwood ES	1,500	650	43
Sophie Hatcher Peters	Lakewood ES	3,000	800	27
Susette McConnell	Terrell Lane MS	1000	0	0
Rose Syroid	George Moses Horton MS	1000	500	50
Wayne Shore	Fuller ES	1020	500	49
Average survival percent				35

“I really enjoyed this experience. I definitely stepped outside my comfort zone. However, it was great and it tied in with 2 of my ELA units. The students enjoyed the excitement of raising fish from eggs to fry and then releasing them.”

“If there was a selection that indicated something like "really super greatly enhanced," I would've checked that. This was an extraordinary experience, capped off by the field trip finale, which was outstanding.”

Teachers reported that the program helps increase a positive human interaction with nature and were more connected to their environment. Many reported that the students have more motivation to learn in school. The Shad Program increases students’ interest and confidence in science. We have received great feedback on the program from the teachers throughout the 2024 program year.



Photo 10. Cumberland Polytechnic HS release Smithfield Boat Ramp



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 Seawell ES Shad gyotaku printing

Fish Dissection



Photo 13 Seawell ES fish anatomy lesson

“This was absolutely amazing! Students were fully engaged and even our students who are frequent fishermen and know how to filet a fish, talked about how cool of an experience it was to actually learn about the organs and structures of the fish. Many parents also emailed me about how much their child enjoyed the experience (although smelly) and how appreciative they were for this experience being offered to our students.

We coordinated with the NC State University (NCSU) Student Fisheries Subunit, the East Carolina University (ECU) Student Fisheries subunit, the Catawba River Keeper to conduct fish anatomy/morphology and dissection lessons. Eight 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 (142 fish from friends and NCWRC staff, 82 collected by ECU), we were able to facilitate the dissection lecture for 11 classrooms (818 students). Eleven teachers (Table 5) reported that these lectures enhanced learning.



Photo 14 Andrew McCains (ECU grad student) conducting a fish anatomy lesson at First Flight MS

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 “Catch you later!”, where students learn about various fish sampling gear and in what scenarios they are used. Students will estimate the size of an American Shad population (simulated) in the Neuse River using the mark-recapture technique. (7 reported it enhanced the learning experience for their students). In addition, additional 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)

Teachers continue to use the short videos we developed focusing on the diversity of North Carolina fish/aquatic biologists and accompanying



Photo 15. Glenwood ES doing a fish population lesson as part of the Catch You Later! activity.

questions in 2020 (13 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 2021-2024) 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 and 3 middle schools) 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, 3 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 (22 teachers reported this as useful), GIS Watershed Activity (11 reported as useful), How Old is your Shad (8 reported as useful), Shad Lifecycle Activity (22 reported as enhanced learning), Dichotomous Key Activity (12 reported as enhanced learning), Fintastic Sort (8 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?	32% (10) greatly enhanced; 3% (1) enhanced; 65% (20) did not use
Catch you later! – enhanced learning?	16% (5) greatly enhanced; 3% (1) enhanced; 3% (1) somewhat; 77% (24) did not use
Dichotomous Key – enhance learning?	19% (6) greatly enhanced; 16% (4) enhanced; 3% (1) somewhat; 58% (18) did not use
Fintastic Sort – enhance learning?	6% (2) greatly enhanced; 6% (2) enhanced; 13% (4) somewhat; 74% (23) did not use
Food Web Activities – usefulness?	29% (9) very useful; 35% (11) useful; 6% (2) somewhat; 29% (9) did not use
Fish Dissection – enhance learning?	32% (10) greatly enhanced; 3% (1) enhanced; 65% (20) did not attend
Genetic Exercise – complexity or understanding?	16% (5) just right; 19% (6) too hard; 65% (20) did not use

Table 6. Additional Education and Video Use Survey Results – Cont'd

GIS Watershed Activity – usefulness?	13% (4) very useful; 19% (6) useful; 3% (1) somewhat; 65% (20) did not use
Gyotaku – enhanced learning?	10% (3) greatly enhanced; 10% (3) enhanced; 10% (3) somewhat; 68% (21) did not use
How Old is Your Shad? – usefulness?	23% (7) useful; 3% (1) somewhat; 74% (23) did not use
Migration Madness – enhanced learning?	10% (3) greatly enhanced; 16% (5) enhanced; 6% (2) somewhat; 68% (21) did not use
Shad Lifecycle Activity – enhance learning?	45% (14) greatly enhanced; 13% (4) enhanced; 13% (4) somewhat; 26% (8) did not use
Shad Pipette Art – enhance learning?	6% (2) greatly enhanced; 16% (5) enhanced; 6% (2) somewhat; 71% (22) did not use
Shad Scents – enhance learning?	3% (1) greatly enhanced; 23% (7) enhanced; 74% (23) did not use
Wishes of Fishes Activity – usefulness?	6% (2) very useful; 19% (6) useful; 3% (1) somewhat useful; 71% (22) did not use
Video -Add the eggs – usefulness?	39% (12) very useful; 29% (9) useful; 3% (1) somewhat useful; 29% (9) did not use
Video –Build the Tank – usefulness?	45% (14) very useful; 29% (9) useful; 29% (9) did not use
Video – Fish Passage – usefulness?	52% (16) very useful; 26% (8) useful; 23% (7) did not use
Video – History – usefulness?	68% (21) very useful; 23% (7) useful; 10% (3) did not use
Video – It is Time usefulness?	45% (14) very useful; 13% (4) useful; 42% (13) did not use
Video - Lifecycle – usefulness?	55% (17) very useful; 23% (7) useful; 23% (7) did not use
Video – Overview – usefulness?	52% (16) very useful; 19% (6) useful; 3% (1) somewhat useful; 26% (8) did not use

Additional Teacher Education Programs

On April 5-7, we conducted a Swamp Treehouse Adventure Educator Trek, a two-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 2024

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, 20 in 2024) 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, $n=651$ for 2024). 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 and 2024 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 ($p=0.0048$) and other ($p=.0058$), but there was no significant difference in

learning between students Black or African American and Hispanic and “two or more” (Figure 3). This year we also saw a significant difference in learning among those identifying as Hispanic to White ($p = .0006$), Other ($p = .001$), and “two or more” ($p = .0383$). What this means is that although *all* students gained knowledge, students identifying as Black or African American and Hispanic race/ethnicities fell behind their peers. We also found a significant difference in learning in gender this year (Figure 4). Students that answered “preferred not to say” showed a significant difference in learning to those self-identified as Male ($p = .0126$), and “Other” ($p = .0037$). There was also a small significant difference in learning between Female and “Other” ($p = .0423$). One class had students that participated in the previous year. Those students showed a starting level higher in knowledge then the new students with a similar increase in learning (both averaged 20%), resulting in a higher ending level as well. 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 (2024)

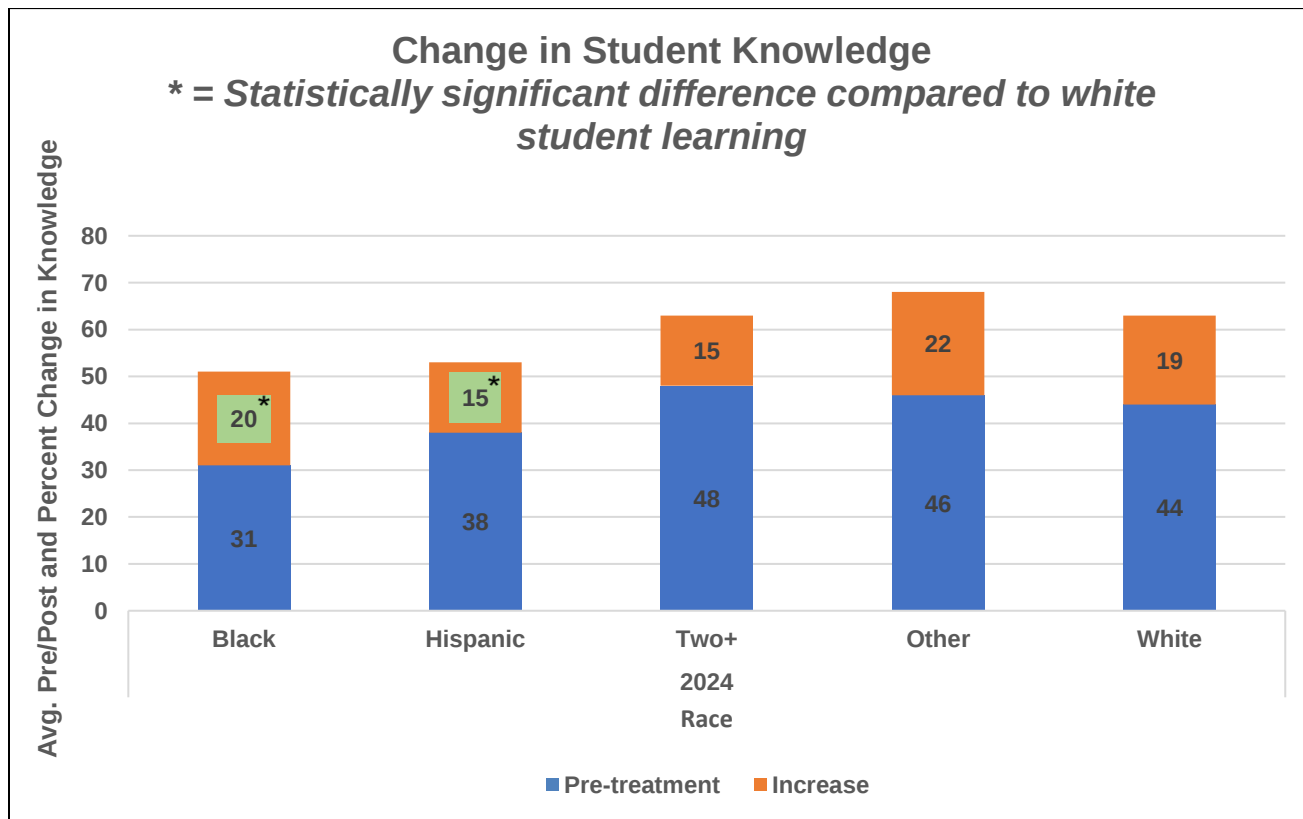
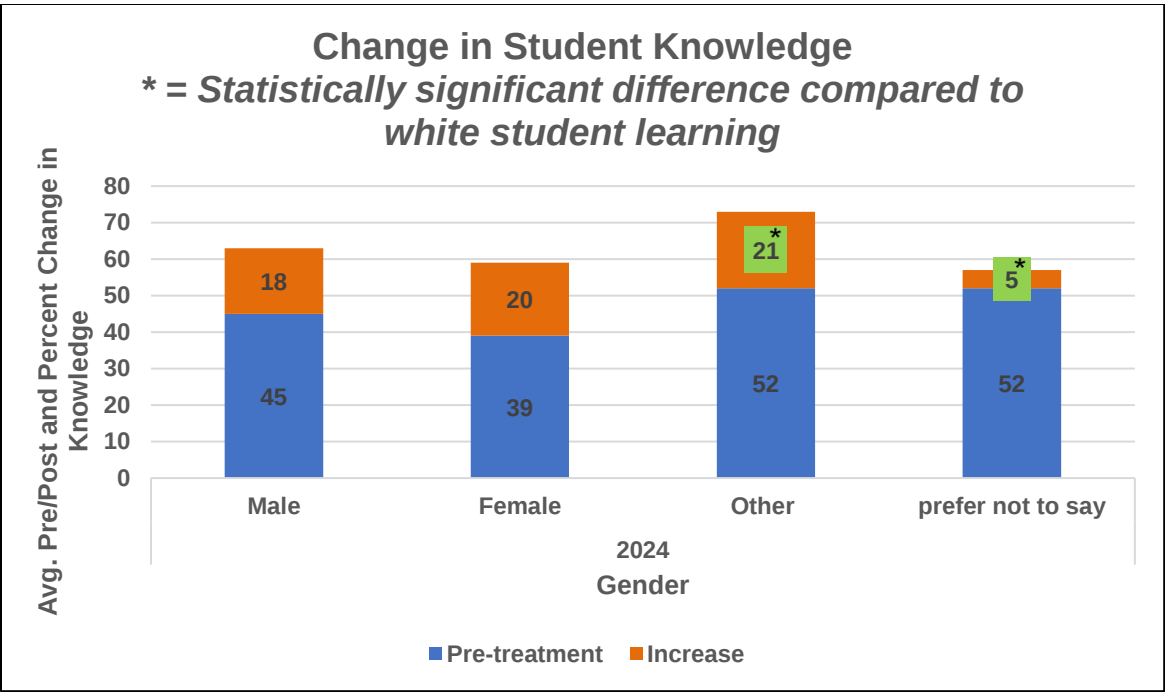


Figure 4. — Change in student knowledge by gender (2024)



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. Positive changes in attitude and behavior were found in all school levels; however, high and middle students showed an increase of $\geq 10\%$ or higher for questions 3 and 4. Elementary students showed a much smaller

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

“Engagement and enthusiasm in science. Students willing to get into the river who wouldn't have before. Pride and excitement over our successful shad-rearing.”

“The students all reflected on the experience and all of them talked about how they learned that they can be focused, and that they like to get messy, they are now more interested in the restoration process. They also explained how they learned that there are a lot more people involved in this process than they thought, and that they are going to share about what they learned to help educate their community.”

change; however, they also had higher pre- and post-values than the upper grades. 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, with the greatest increases in positive changes seen for questions 3 and 4 for most groups.

Table 7. 2024 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	41	43	52	59	53	63	38	47
ES	64	65	67	71	74	77	58	59
MS	35	42	43	61	53	64*	35	47*
HS	42	36	40	48	41	51*	33	43*
Female	46	46	53	61	57	64	39	50*
Male	32	38	50	59	49	61*	36	44
Other	50	61	67	44	50	61*	22	33*
Prefer not to answer	72	67	50	67*	50	67*	56	72*
Black	33	41*	48	52	50	56	40	41
Hispanic	37	40	40	54*	43	52	29	46*
Other	54	59	63	59	63	68	46	57*
Two	41	47	57	60	47	68*	33	48*
White	41	42	52	62	55	64*	38	48*

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, 2024). 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 (5 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:

- 2024 International Fly Fishing Film Festival April 2024
- 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 2024.

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, 74% of teachers reported that they were extremely satisfied and 19% reported they were very satisfied with the Shad in the Classroom experience [6% (2) teacher reported being moderately satisfied]. For both teachers 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. Thirty of the 31 teachers participating in the Shad in the Classroom Program in 2024 reported that they would like to continue with the program next year (one teacher is retiring). It is expected that 4-5 teachers on "hiatus" for this year plan to return for 2025. At present, we have eight new teachers on the waiting list for the program in 2025. 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.

“Each year, the Shad in the Classroom gets even better. Students learned a great deal and took a lot of pride in taking care of their shaddies before the release.”

“I feel very proud of the field trip experience I facilitated for the kids! I took out a whole grade level and involved several different community and professional partners to create different stations for my kids to rotate through. Having the hands-on experience of releasing the fish was crucial for creating a meaningful experience for students.

“Students who said they couldn't do science or didn't like science were fully engaged and were doing science. It boosts their self-confidence and enjoyment in the subject.

Appendix A

Table 8. Schools Participating in the North Carolina Shad in the Classroom Program (2009–2024)

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	7	2016-2024
Angier Elementary	2	2013-2014
Ballentine Elementary	4	2017-2021
Bertie Early College High School	3	2019-2021
Bertie High School	3	2022-2024
Brinson Memorial Elementary School	1	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	5	2019, 2023-2024
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

Table 8. Schools Participating in the North Carolina Shad in the Classroom Program (2009–2024)
continued

Release Basin School	Nos. of Classes	Years
Neuse River Basin		
Cleveland High School	3	2016-2018
Cook Literacy Model School	2	2017-2018
Cumberland Polytechnic High School	1	2023
Daniels IBMYP Magnet Middle School/Oberlin MS	16	2010-2019, 2022-2023
Dillard Middle School	1	2017
Don D. Steed Elementary	1	2012
Durham Public Schools Hub Farm	1	2023
East Duplin High School	2	2023-2024
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	2023-2024
First Flight Middle School	7	2021-2024
Forest Pines Dr Elementary	1	2013
Fuller GT/AIG Basics Magnet Elementary School	1	2023
Fuquay Varina Middle School	23	2014-2024
George Moses Middle School	3	2022-2024

Table 8. Schools Participating in the North Carolina Shad in the Classroom Program (2009–2024)
continued

Release Basin School	Nos. of Classes	Years
Neuse River Basin		
Glenwood Elementary School	1	2023
Grady A. Brown Elementary	1	2018
Hall Woodward Elementary	2	2012-2013
Horton Middle School	3	2017-2019
Knightdale Elementary School	1	2022
Lakewood Elementary School	1	2023
Lakewood Montessori Middle School	15	2013-2017, 2022-2024
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	2	2023-2024
Moss Hill Elementary	3	2017-2019

Table 8. Schools Participating in the North Carolina Shad in the Classroom Program (2009–2024)
Continued

Release Basin School	Nos. of Classes	Years
Neuse River Basin		
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	5	2021-2024
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	3	2022-2024
Sherwood Githens Middle	5	2019, 2022, 2024
Smithfield-Selma Senior High School	6	2018-2023
South Asheboro Middle School	1	2012
South Iredell High School	9	2013-2018, 2022-2024
South View High School	1	2012
Southern Vance High School	4	2012-2015
Southern Wake Academy	2	2024
Speas Elementary	1	2012
Tar Heel Middle School	1	2016
Terrell Lane Middle School	3	2021-2022,2023

Table 8. Schools Participating in the North Carolina Shad in the Classroom Program (2009–2024)
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	2	2023-2024
Wakefield Middle School	2	2022
Walkertown Middle School	1	2016
West Hoke Elementary	1	2012
West Johnston High School	2	2019, 2024
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	2	2023-2024
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

Table 8. Schools Participating in the North Carolina Shad in the Classroom Program (2009–2024)
continued

Release Basin School	Nos. of Classes	Years
Roanoke River Basin		
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	119	2009-2024
Total Number of Classrooms	355	2009-2024

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 Kalysha 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)

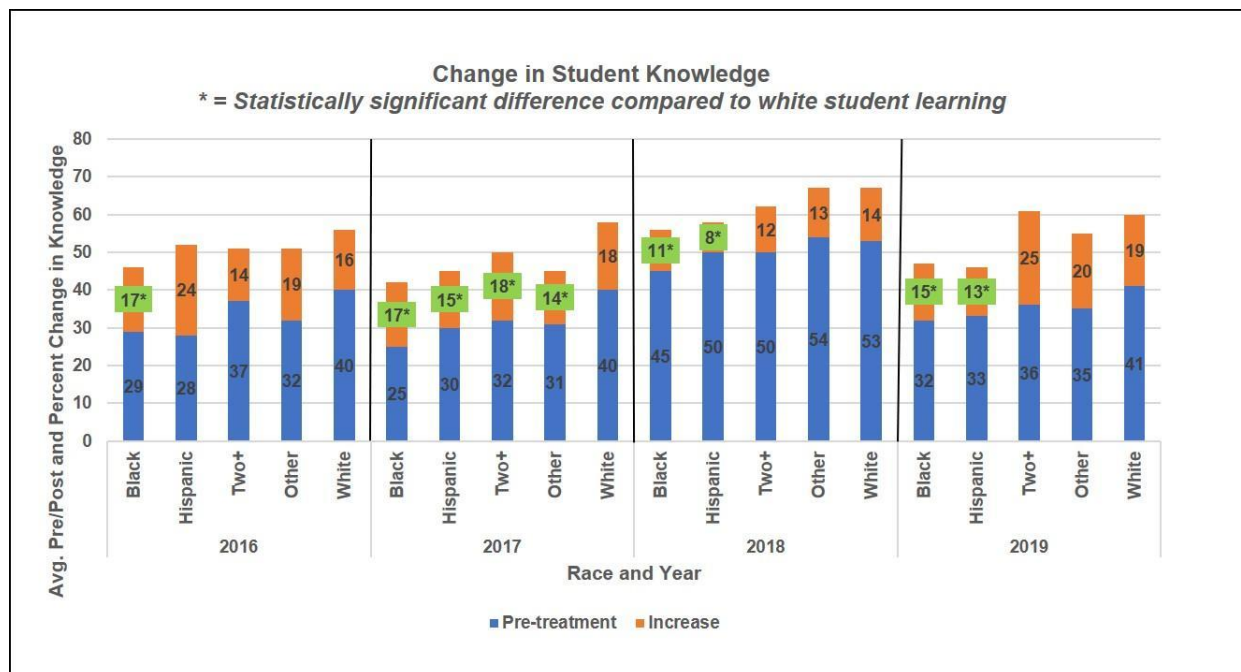
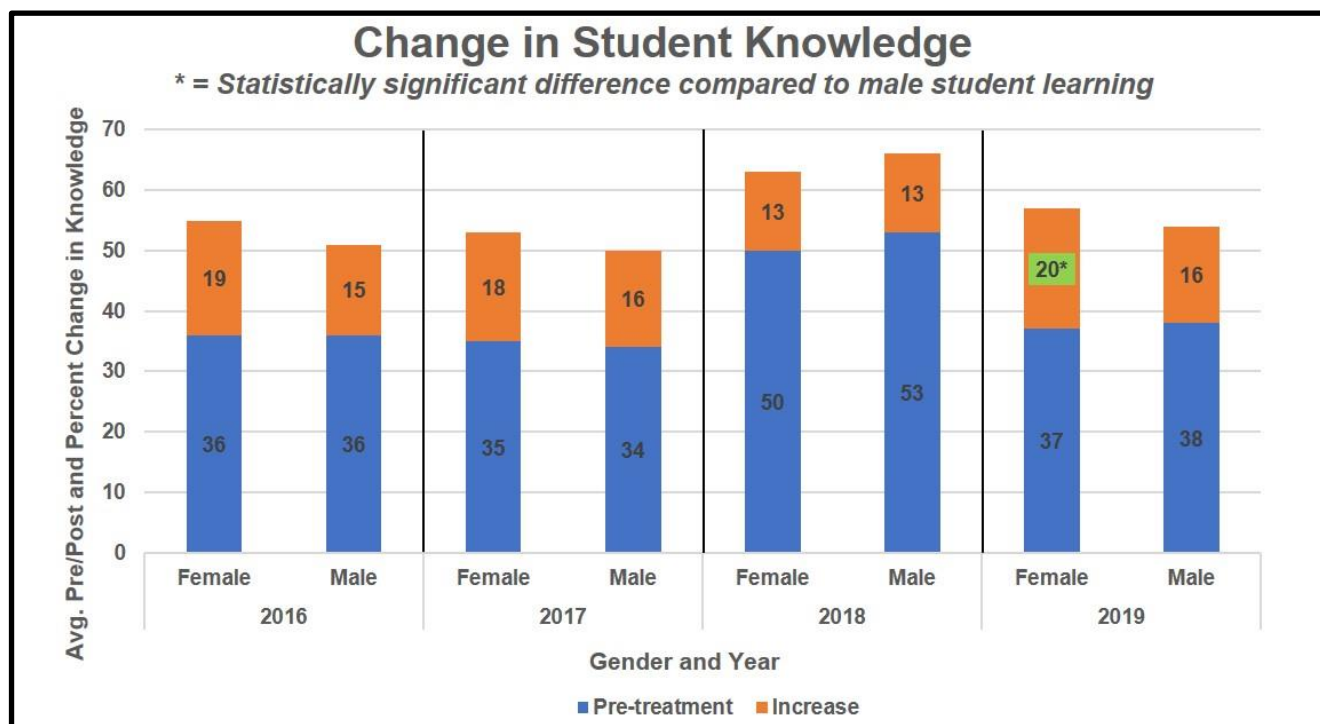


Figure 6. — Change in student knowledge by gender (2016–2019)



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.

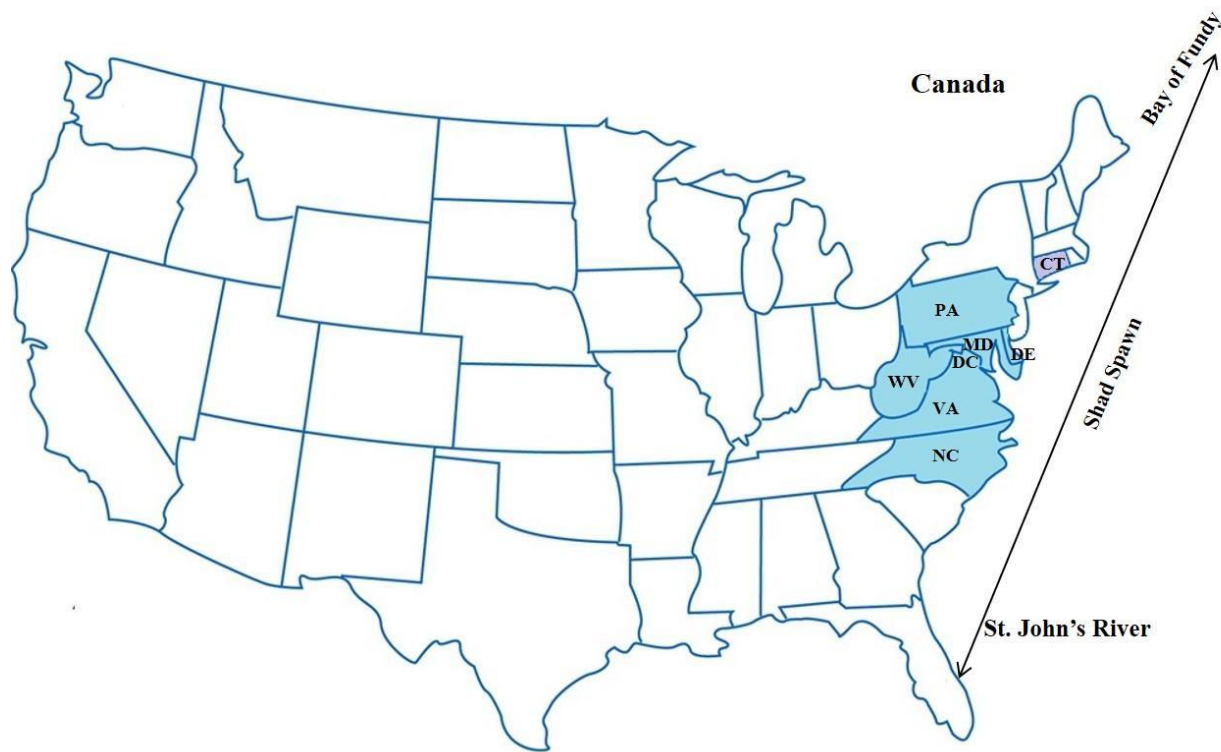


Figure 7. — Map of the states we found to participate in some version of a shad in the classroom program: Delaware, Maryland, North Carolina, Pennsylvania, Virginia, and West Virginia, and the District of Columbia (a program in Connecticut is proposed). Arrow depicts American Shad spawning distribution 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.