Shad in the Classroom
Program Report
(2009-2020)

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Executive Summary

The Shad in the Classroom Program is the result of many dedicated partners. The program is managed by the NC Museum of Natural Sciences (Museum) and it receives significant logistical and financial support from the Albemarle-Pamlico National Estuary Partnership (APNEP), the North Carolina Wildlife Resources Commission (NCWRC), and the U.S. Fish and Wildlife Service (USFWS). For the 2020 program, we received $9,660 in grant funding and also program specialist position funding from APNEP. We received $7,000 in grant funding from the USFWS. Very important to the program are the many volunteers who generously give their time to enhance the program and the dedicated teachers. The 2020 report will focus on the aspects of the program that were able to be completed before the COVID-19 shutdown and student learning analysis for the years 2016-2019.

Although we were able to begin the 2020 Shad Program season, we were unable to complete it due to the COVID-19 epidemic. We accepted 36 classrooms into the 2020 program. Teacher training took place in February, and schools were just getting geared up for other aspects of the program when schools and the Program had to shut down due to the virus. The Shad in the Classroom Program reached 247 classrooms from 2009 to 2019 (Appendix A, Table 4) and many thousands of students. Between 2013─2019, approximately 16,145 students were reached (prior to 2013, the numbers of students were not tracked).

Table 1. 2020 Schools Accepted to the North Carolina Shad in the Classroom Program

School	County	Numbers of Classes
Abbotts Creek Elementary School	Wake	2
Ballentine Elementary School	Wake	1
Bertie Early College High School	Bertie	1
Brogden Middle School	Durham	1
Central Park School for Children Elementary School	Durham	1
Daniels IBMYP Magnet Middle School	Wake	1
E.B. Frink Middle School	Lenoir	1
East Arcadia Elementary School (CFRW)	Bladen	1
East Garner Magnet Middle School	Wake	2
Emereau Bladen Middle School (CFRW)	Bladen	1
Exploris Elementary School	Wake	2
First Flight Middle School	Dare	1
Fuquay Varina Middle School	Wake	3
Horton Middle School	Chatham	1
Knightdale Elementary School	Wake	1
Lincoln Heights Environmental Connections Magnet Elementary School	Wake	1
Long Mill Elementary School	Franklin	1
Longview School	Wake	1
Northeast Academy for Aerospace & Advanced Technologies High School	Pasquotank	1
Perquimans County Middle School	Perquimans	1

Table 1. 2020 Schools Accepted to the North Carolina Shad in the Classroom Program Continued

School	County	Numbers of Classes
Petree Elementary School	Forsyth	1
Pine Hollow Middle School	Wake	1
Roanoke Rapids High School	Halifax	1
Sherwood Githens Middle School	Durham	2
Smithfield-Selma Senior High School	Johnston	1
Tiller Elementary School	Carteret	1
W.G. Enloe High School	Wake	1
W.J. Gurganus Elementary School	Craven	1
West Johnston High School	Johnston	1
Woods Charter Middle School	Chatham	1
Total Number of Schools		**30**
Total Number of Classrooms		**36**

Current new tank construction of the red tub style tanks cost approximately $385 per tank system. The plexiglass tank systems cost approximately $587 per tank system. Other substantial expenses include tank refurbishment, chemical resupply, teacher training workshop, teacher professional development trek, school field trips to release sites, travel for egg delivery, and part-time staff.

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

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

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

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

ACKNOWLEDGEMENTS

We would like to acknowledge all of the teachers and volunteers who help implement the Shad in the Classroom Program each year. The teachers and volunteers are dedicated to making the program a success and are invaluable. Specific individuals who assisted with various aspects of the program that could occur for 2020 are listed below.

Falls Lake Dam Tour

David Schwartz David.A.Schwartz@usace.army.mil – (USACOE Falls Lake, Natural Resources Specialist)

DEQ Students@Work Program

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

2017 Student Education Analytics

Danielle Lawson dafrank2@ncsu.edu – (NCSU, Grad Student)
Kalysha Clark – (former NCSU, Grad Student)
Dr. Kathryn Stevenson kathryn_stevenson@ncsu.edu – (NCSU, Associate Professor)
Dr. Nils Peterson nils_peterson@ncsu.edu – (NCSU, Associate Professor)
Rachel Szczytko – (Pisces Foundation)

Thank you to Dr. James Peterson, USGS Oregon Cooperative Fish and Wildlife Research Unit, for assistance with 2016-2019 student education analyses. In addition, we are very appreciative of the fish donations for the 2020 dissection lectures from Dr. Rich Noble, Dr. Phil Doerr, Dr. Jim Rice, and fellow anglers, and David Deaton and the NCWRC's Armstrong Hatchery staff. We plan to save donated frozen fish for the 2021 season. Also, Linnea Anderson helped coordinate with the NCSU graduate students and Jon Sherman helped coordinate with the ECU graduate students for the planning of the anatomy-dissection lectures.

Report cover photos: Top and bottom left – teachers participating in the workshop; Center – Exploris Elementary School and teachers participating in a shad zoom session; Top and bottom right – teachers participating in the Falls Lake Dam and tailwater tour at the workshop.

Shad in the Classroom Program 2020 Report

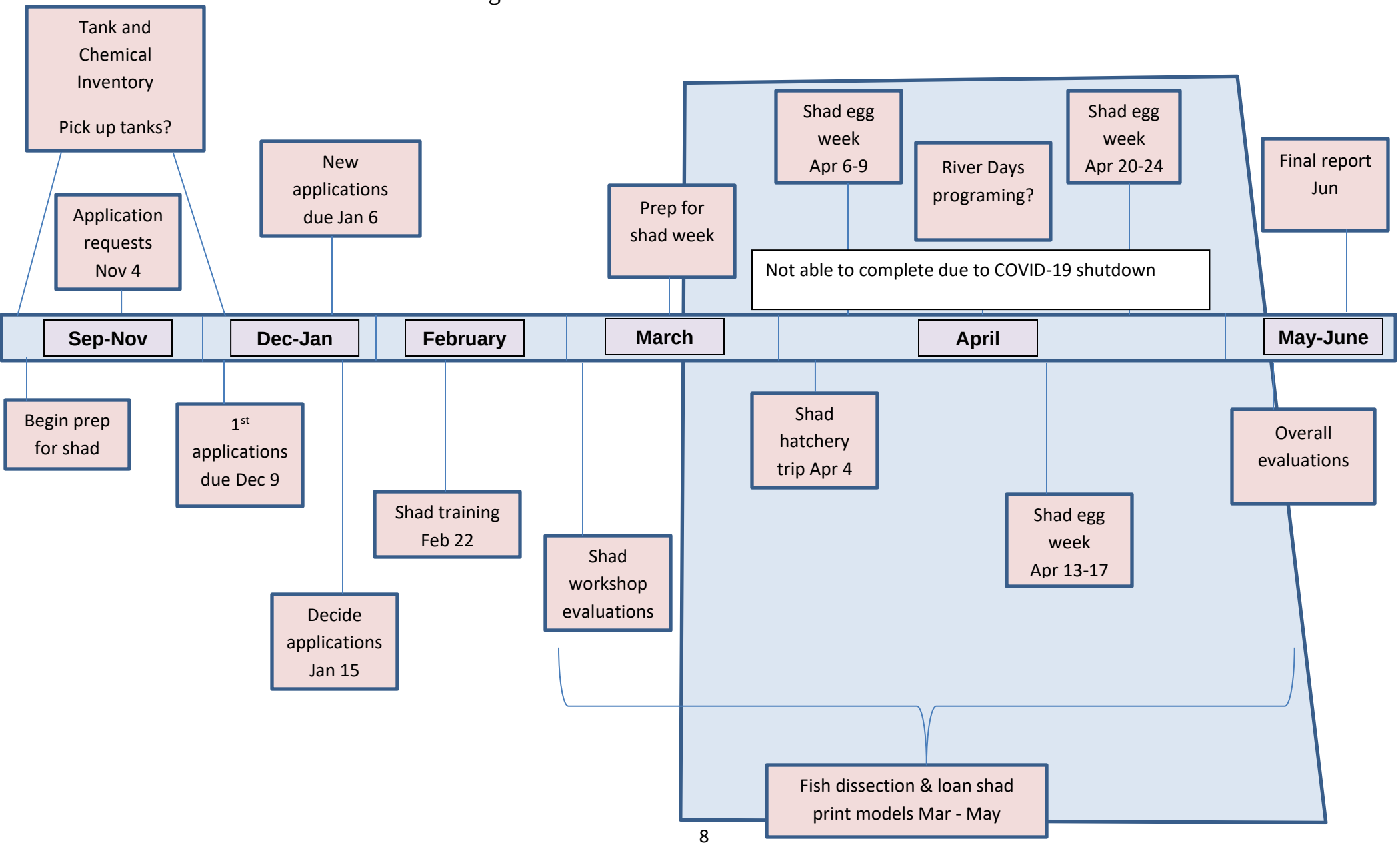
This report summarizes the activities for the 2020 Shad in the Classroom Program completed prior to the COVID-19 shutdown and student learning analysis for the years 2016-2019. Thirty-six classes at 31 different schools were accepted into the 2020 program: 14 elementary, 15 middle, and 7 high school classes. One teacher signed up for two classes at one elementary school, and two of the schools (one high school and one middle school) were accepted under Cape Fear River Watch.

Photo 1. Teachers learning about tank dynamics

Yearly program planning began with forming a timeline (Figure 1), reviewing applications, and conducting a tank and parts inventory. All new teachers and several returning teachers attended an orientation and training session in February.

Returning to their schools, teachers typically began preparing their classrooms for the arrival of the Shad eggs 2–4 weeks prior to receiving the eggs in April. Teachers and classes began this preparation, but then the COVID-19 shutdown occurred, closing schools and the museum along with much of the State of North Carolina. American Shad broodstock were not collected in 2020. One school was able to complete the shad printing (Gyotaku) activity. Although we were gearing up for the fish dissections by obtaining a list of volunteers and receiving fish for dissections, this aspect of the program was not started with the schools.

Figure 1. Shad in the Classroom 2020 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 six 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 22, 2020. Two guests (one from Trout Unlimited, Matt O'Bryant and one from Triangle Fly Fishers, Jennifer Alphin) also attended the training. Danielle Pender, Melissa Dowland, and Amanda Bowers co-led the session. Teachers were provided information about American Shad life history, restoration, and management. They received equipment and instructions for raising shad and learned ways to incorporate shad and aquatic ecology into their curriculum. Teachers participated in shad life cycle activity (Brad the Shad), water quality testing, egg sorting, "fry" removal, fish printing (Gyotaku), and building tanks.

Photo 2. Practicing tank building at teacher orientation

> "Everything was amazing, and this was the first workshop/training that was very detailed & engaging the entire time."

Photo 3. David Schwartz conducting Falls Lake Dam Tour

Photo 4. Krista Brinchek, Abbotts Creek ES Teacher sharing her experience

This year we also took teachers on a tour of Falls Lake Dam and tailwater. David Schwartz, U.S Army Corps of Engineers conducted the tour. In addition, one of the returning teachers very familiar with using the tailwater as a release site shared her experiences. Meeting in a central location with researchers, collaborating partners, and museum program staff facilitated networking among all teachers and schools involved in the project. Twenty-six teachers attended the 2020 workshop. Of those, 22 responded to the

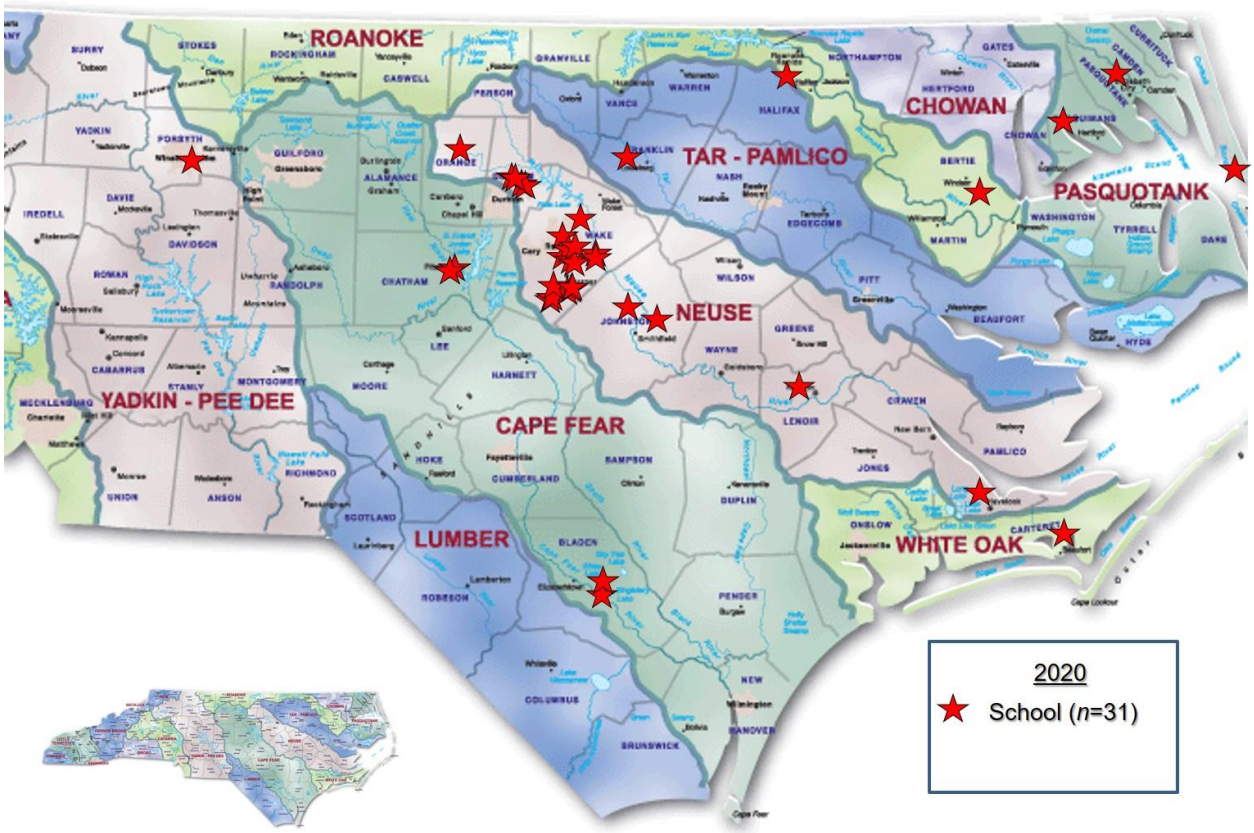
9-question survey regarding the workshop (although not all surveys were complete). Most teachers reported that they were very to extremely satisfied with the workshop, that the concepts were explained very to extremely well, and that the activities were useful (Table 2).

Table 2. Workshop Survey Results

Question	Response variable			
How confident do you feel in building the shad tank system on your own?	67% (16) extremely confident; 13 (3) very confident; 17% (4) moderately confident; slightly confident 4% (1)			
How comfortable do you feel in contacting the other teachers that you met at the workshop with questions?	71% (17) extremely comfortable; 21% (5) very comfortable; 8% (2) moderately comfortable			
How sufficient was the information you learned to incorporate shad into your curriculum?	83% (20) extremely sufficient; 13% (3) very sufficient; 4% (1) no response			
How well did the workshop explain the importance of the shad restoration and management program?	58% (14) extremely well; 4% (1) very well; 8% (2) moderately well; 29% (7) no response			
How well did the workshop explain the life history of shad?	67% (16) extremely well; 4% (1) very well; 29% (7) no response			
How well did the workshop explain the proper components to raising shad eggs to the larval stage?	63% (15) extremely well; 8% (2) very well; 29% (7) no response			
What aspects of the workshop were useful? Please choose all that apply.	Lifecycle 67% (16)	Water testing 67% (16)	Egg chamber 71% (17)	Egg sort 71% (17)
What aspects of the workshop were useful? Please choose all that apply.	Fry removal 67% (16)	Tank building 67% (16)	Sharing experience 71% (17)	Site visit 63% (15)
Overall, how satisfied are you with the workshop?	71% (17) extremely satisfied; 4% (1) very satisfied; 25% (6) no response			

Egg Delivery and Larval Fish Release – Program ended prior to the start of this portion of program

Figure 2. ─ School locations (approximate)



Additional Education

Only one class was able to complete the fish printing exercise, and none had the opportunity to implement the fish dissections this year. We were able to begin obtaining donated fish and names of volunteers for the fish dissections before the shutdown. We plan to save frozen fish already donated for the 2021 shad season. One class at Exploris Elementary School conducted a modified version of Shad Week by

Photo 6. Melissa sharing her shad and ecology knowledge while on the Roanoke River for Exploris ES

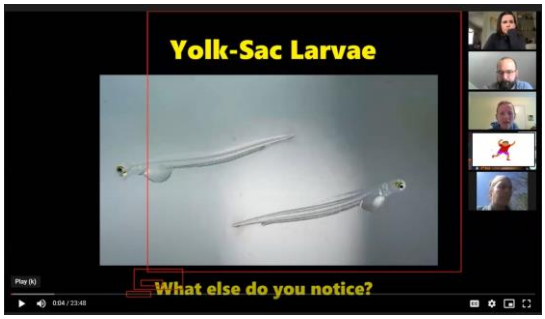


Photo 5. Danielle conducting a shad lesson for Exploris ES.

Zoom video conferencing. They invited the museum to participate in one of their shad sessions. Danielle joined in from home and Melissa from the Roanoke River.

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. Activities and exercises have all been uploaded to a shared Dropbox site with the teachers. Materials include, but are not limited to, a lifecycle activity, a Shad Scent exercise, Shad pipette art, a guide for stream sampling, a watershed GIS exercise, a genetic exercise, and materials provided by the teachers.

Student survey results from 2016-2019 revealed a difference in learning between students self-identified as white and students self-identified as other races, particularly those that self-identified as Black or African American and Hispanic or Latino (see Student Analytics 2016-2019). In an attempt to address this situation, we wanted to ensure that students had the opportunity to see a fisheries professional that looked like them or had a similar life story. Thus, during the shutdown, we decided to produce a series of short videos focusing on the diversity of North Carolina fish/aquatic biologists. We used Zoom video conferencing to interview and record five different scientists answering questions about their career path and their current research. Our plan is to make these videos available to students in the program so that they can see and listen to different perspectives from the field. We also plan to create a lesson plan around these videos

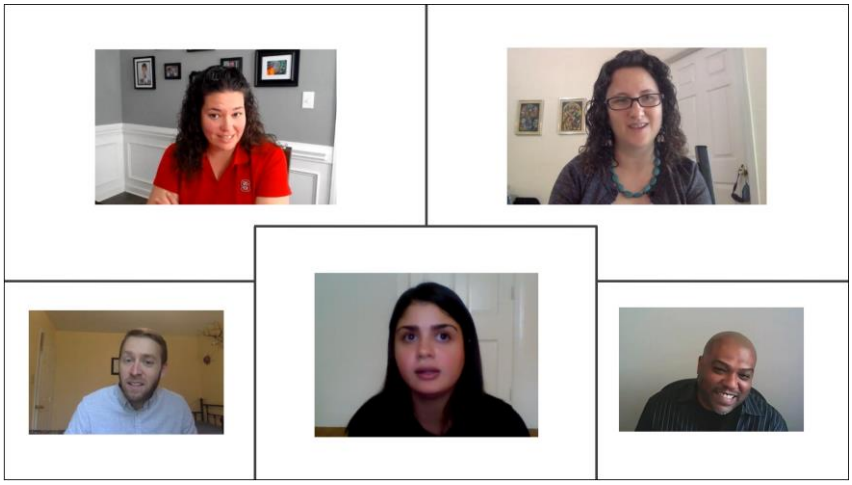


Photo 7. Biologist zoom interviews

We are the River Curriculum Development

We are in the process of writing curriculum to supplement the We are the River video, which highlights the natural and cultural resources, history and conservation of the Roanoke River. The curriculum work is slated to be completed by the end of August, at which point it will be posted on the Museum website, along with the video, to be used by educators across the state. Once complete,

we will share this resource through our Museum educator email list, as well as other education listservs.

Program Outcomes

Student Impact

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

1. History, cultural and biological importance, and life cycle of the American Shad
2. The shad's ecological connections to other species
3. The significance of genetic integrity to population studies
4. Scientific procedures for measuring, testing, collecting, and organizing data
5. Mathematics to estimate, calculate, and predict results
6. Charts, maps, and graphs to aid in using information
7. Information exchange among other classes in the school and to parents and adults
8. The delicate balance of nature and work toward conserving or improving natural resources
9. American Shad restoration in rivers
10. Reporting and presentation techniques, both oral and written

This program provides a valuable experiential learning opportunity for students in the classroom that houses the tank (direct involvement) and those indirectly involved (e.g. collecting and recording water quality during their science period).

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) 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 3). 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 4).

Figure 3. ─ Change in student knowledge by race (2016-2019)

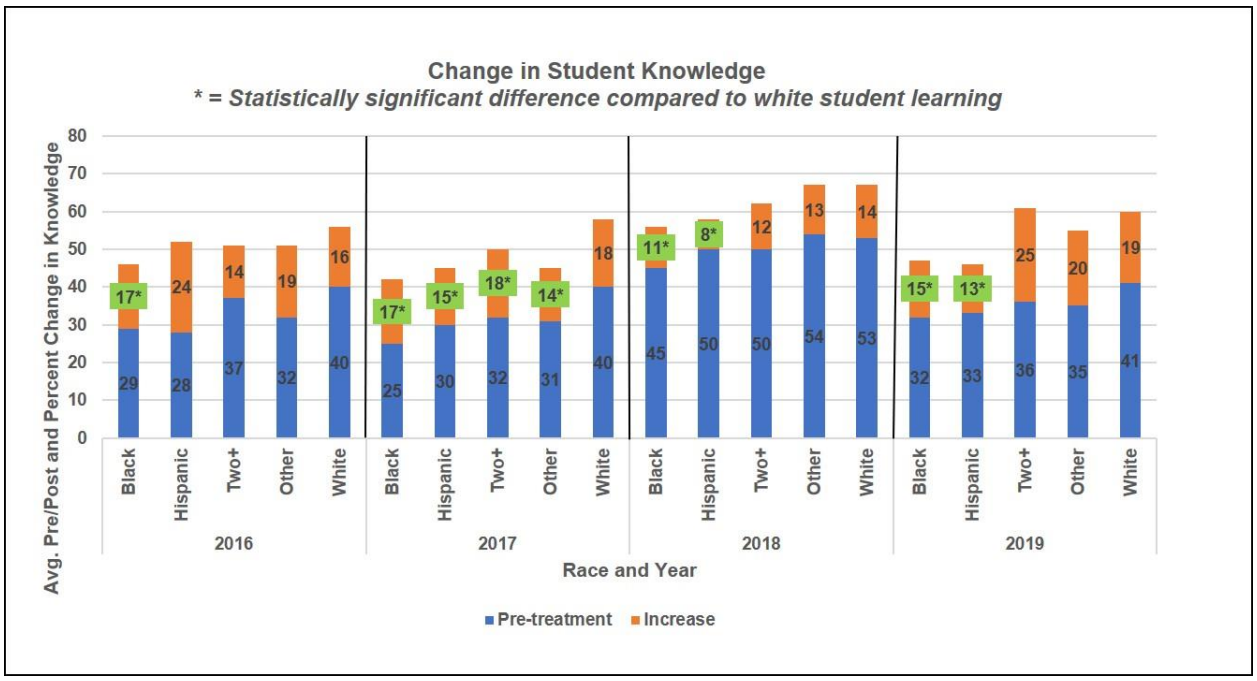
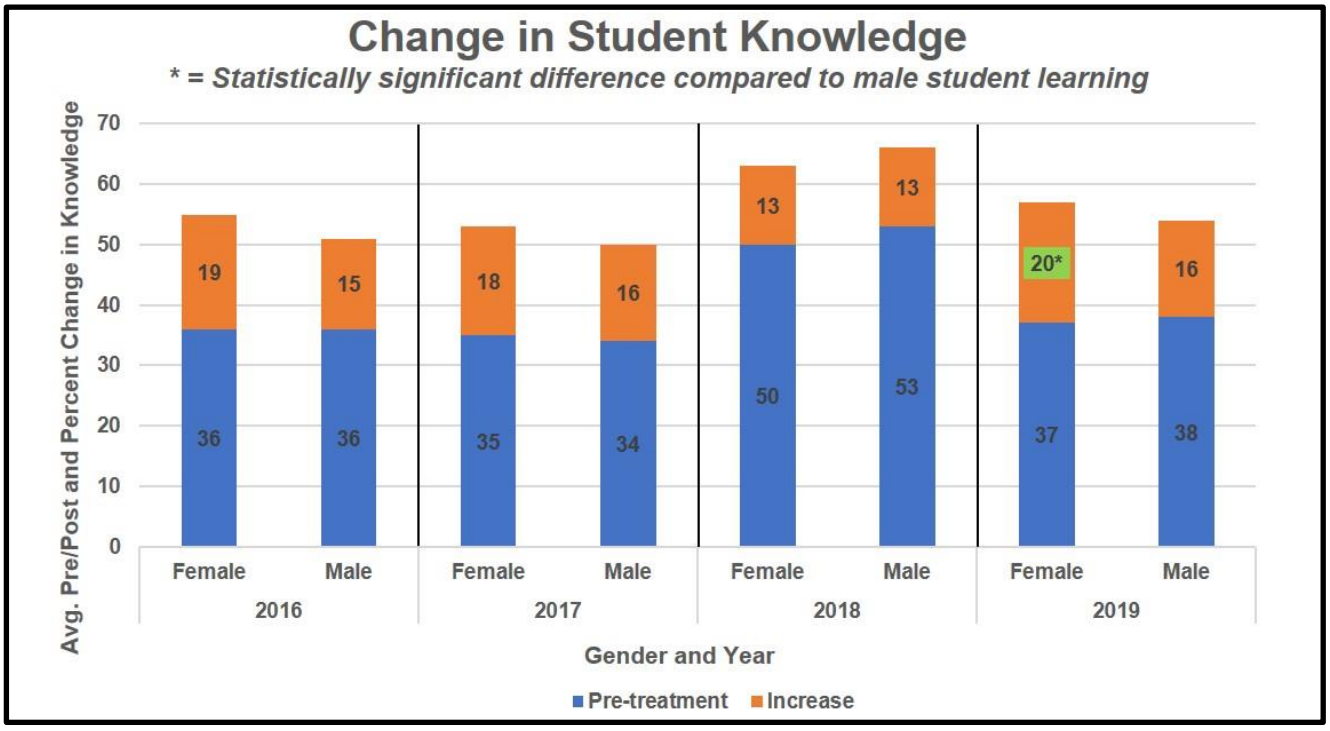


Figure 4. ─ Change in student knowledge by gender (2016-2019)



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 3 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 that 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 3. 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.

Public Outreach

Information on the Shad in the Classroom Program is available on the Museum's website. The program also receives a lot of publicity by word-of-mouth from those who have participated in the program previously (including teachers, students, and volunteers). In addition to the students and teachers reached with the Shad in the Classroom Program:

- The "We are the River Film" won the Gold Telly award in the nature category in 2018.
- This year information on the Shad in the Classroom Program was presented at the fall National Estuary Program meeting by APNEP personnel, October 1, 2019.
- An article on the Shad in the Classroom Program was published in the North Carolina American Fisheries Society Fall Newsletter in 2019.
- The 2017 student analysis was published in Fisheries. Reaching Underserved Populations Through a Fisheries Education Program (Fisheries | Vol. 45 • No. 3 • March 2020).
- We (along with Kelsey Ellis, APNEP) conducted discussions and hands-on activities sessions on the life history and migration of American Shad in North Carolina for the DEQ Students@Work Program, March 2, 2020.

An update on the Shad in the Classroom Program will be published in the North Carolina Chapter American Fisheries Society Fall Newsletter in 2020.

Future Planning

We plan to continue to purchase additional plexiglass tanks as we phase out the older tanks as the teachers report that these tanks enhance the experience since they can more readily see the tiny fry. We will also continue to make additional curriculum activities available for in-classroom and at-release use.

The Shad in the Classroom Program was cut short this year due to the COVID-19 shutdown. We were able to conduct a successful teacher workshop, complete the student survey data analysis for the years 2016-2019, and to conduct, record, and begin editing into videos interviews with fishery and aquatic biologists by Zoom video conference. We are closely following decisions made by the state in regard to opening schools during the 2020-21 school year, and we will adapt the Shad in the Classroom program as necessary to allow teachers and students to participate as much as possible.

"Leadership team is very professional and knowledgeable. I love how they are so compassionate about the shad program."

Appendix A

Table 4. Schools Participating in the North Carolina Shad in the Classroom Program (2009─2019)

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

Table 4. Schools Participating in the North Carolina Shad in the Classroom Program (2009─2019) continued

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

Table 4. Schools Participating in the North Carolina Shad in the Classroom Program (2009─2019) continued

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

Appendix B

Shad in the Classroom Background (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 3). 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.

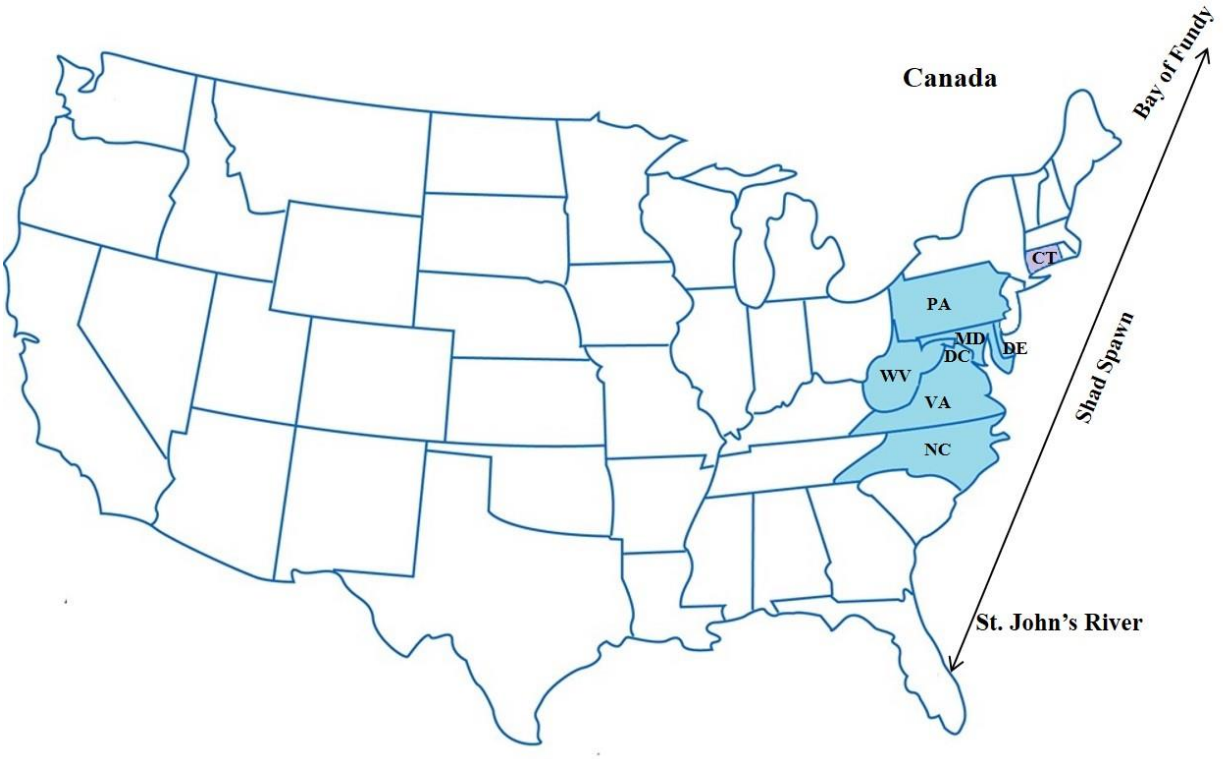


Figure 5. ─ Map of the states we found to participate in some version of a shad in the classroom program: Delaware, Maryland, North Carolina, Pennsylvania, Virginia, and West Virginia, and the District of Columbia (a program in Connecticut in proposed). Arrow depicts American Shad spawning distribution 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 – 2019) is included in Table 4. 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.