

Unwelcome Guests: Combating Aquatic Invasive Species through Education, Habitat Conservation and Restoration

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Photo credit: Billy Skaradek

Abstract

Aquatic invasive species are an environmental threat throughout the entire continent, and students in a landlocked, rural South Dakota school district also find themselves at the forefront of the struggle against invasive species. A [NOAA Planet Stewards](#) project in the 2021-22 school year for middle and high school students on aquatic invasive species resulted in a substantial attitudinal change along with increased content understanding. While the issue of aquatic invasive species presented its own logistical problems, these challenges were, for the most part, successfully navigated to meet stewardship goals resulting in a remarkable learning experience for both students and teachers alike.

Introduction

Pole of inaccessibility...no doubt this is an obscurely known reference to most. *Pole of inaccessibility* is an old navigation reference that refers to the farthest point from land in an ocean or on land, the farthest point from the ocean. South Dakota is the pole of inaccessibility for the North American continent. It is more than a geographical oddity; it can also serve conceptually in many minds as a seemingly pervasive sense of isolation, perhaps, even a sense of security from the rest of the world's problems. When it comes to aquatic invasive species, South Dakota was one of the last places in North America that had to deal with the budding issue, but as time has progressed, these threats edged closer and closer to our front door step. Once they became evident in our state, it was apparent that we were no more immune than the rest. Now South Dakota has invasive Asian carp as far up the Missouri River as Gavins Point Dam and the entirety of the James River and most of the Vermillion River. Asian carp, specifically bighead carp, grass carp, and silver carp can starve any trophic level above producers by consuming large quantities of algae each day. The impact can be quite dramatic for a fishery. For example, even though these exotic carp species have only been present in the United States since the 1970s, they are now pound-for-pound the dominant fish species in terms of population density throughout the Mississippi River and its connecting tributaries leading to the decimation of local native fish stocks and having a negative impact on recreational fishing. Asian carp not only harm our aquatic ecosystems, but they can physically harm recreationalists (Atwal 2012). As a cautionary tale to all for introducing a new species to an environment, silver carp have taken on an

unusual characteristic of jumping out of the water when startled. This is a rarely observed characteristic among this same species in its native China, but in America boaters have suffered severe injury due to, up to a 100 lbs., silver carp hitting them in the face making recreation on infested waters dangerous for boaters (Vetter and Mensinger, 2016). Just as we have faced a threat of aquatic invasive species migrating up our rivers through Asian carp, we soon realized the growing frontlines in aquatic invasive species with the presence of zebra mussels in dozens of South Dakota bodies of water. Zebra mussels and their close relative quagga mussels pose an equally devastating ecological problem for our bodies of water. Zebra and quagga mussels can cause great ecological harm to plankton communities, therefore, negatively impacting the entire food chain in a freshwater ecosystem. Zebra and quagga mussels were both likely brought to North America through untreated ballast water dumped into the Great Lakes during the late 1980s. Through untreated ballast water, they were able to make a trip all the way around the world from their native Caspian Sea range to infest the waters of America. Once infesting the Great Lakes, they entered the Mississippi drainage system through the Chicago River. Now recreation boaters are the unwitting spreaders of these mussels to water bodies that are not connected to the Mississippi drainage system (Prather, 2009). While South Dakota awaits its first confirmed quagga infestation, zebra mussels continue to expand their range in South Dakota. With such a daunting set of ecological challenges facing South Dakota concerning aquatic invasive species, we decided to take action through our project made possible by funding from NOAA Planet Stewards.

Racing to Keep Up with the Frontlines of the Invasion

Our project was designed to help combat aquatic invasive organisms by attaining three goals; curriculum development and education, habitat conservation through stewardship, and habitat restoration through stewardship. In order to meet our habitat conservation and habitat restoration stewardship goals, we planned to engage 60 students to complete stewardship activities, inspect and/or clean 500 boats/watercraft, inspect and/or clean 500 bait buckets, inspect and/or clean 500 live wells, inspect 50 aquariums, remove 500 kg of Asian carp, and 10 kg of invasive mussels. During the fall semester of 2021, students were engaged in habitat conservation stewardship by engaging in boat inspections/cleanings, bait



Image 1: Edmunds central students learning about zebra mussel removal while inspecting a boatlift infested with zebra mussels on Pickerel Lake. At the time of our visit, zebra mussels had colonized most hard surfaces in the lake even though the first confirmed zebra mussel in the lake was only discovered 15 months prior to our survey visit. Photo credit: Spencer Cody



Image 2: Edmunds Central students inspecting riprap at Enemy Swim Lake for zebra mussels. Invasive mussels can easily spread from lake to lake as hitchhikers on boats and recreation equipment. Enemy Swim was only a couple of miles from a lake with a known zebra mussel infestation at the time of our survey. While we did not find any zebra mussels on our stop in October of 2021, by July of 2022 zebra mussels were confirmed in the lake. Photo credit: Spencer Cody

bucket inspections/cleanings, live well inspections/cleanings, and aquarium inspections along with site visits to inspect lake accesses for possible infestations for documentation.

Students were also engaged in habitat restoration through stewardship through site visits to known infested waters to work on removing mussels. The inspection and cleaning numbers and restoration removal amounts required students to not just complete these inspections

and removals on their own watercraft and equipment and shorefront but branch out to neighbors, friends, businesses, and other local contacts associated with fishing and watercraft, thoroughly, permeating our local area with our message. While we exceeded our goal in mussel removal due to our fortune of working with a watercraft company in the fall of 2021 for boat lift removal during a fall zebra mussel survey of lakes in Northeastern South Dakota, mussel removal opportunities since that point in time were few and far between.

In South Dakota invasive mussels can be removed, but they cannot be transported. This makes removal very tricky and getting permission trickier. Additionally, known infested waters are not locally close to our school district making these opportunities for removal more difficult for our students to access. The same problem was experienced with the Asian carp removal. They cannot be transported and removal is difficult since flying silver carp are dangerous to boaters

attempting to retrieve them, and infestation locations are not near our school. Not to be deterred, we expanded our removal efforts to include common carp to some degree of success. Our numbers for inspections and cleanings assumed that our arrangements made in the fall for inspection points would be carried out in the spring and summer of 2022. This was not the case. We had been working with a lake association to help staff their zebra mussel check point with our students, but confrontations became so tense that the state took the checkpoint over in the spring of 2022. No one wants zebra mussels in their lake, and no one wants to be caught with them. It seemed as if we were racing to keep up with the frontlines of an ecological invasion. Unfortunately, the lake in question recorded its first zebra mussels in July of 2022; consequently, the inspection point had been completely disbanded shortly after the discovery of the infestation. The battle lines against aquatic invasive species had shifted yet again.

A Thought-Provoking Book Study

The curriculum development portion of our project centered on the reading of *The Death and Life of the Great Lakes*, (Egan, 2018). The student book study worked nicely with our grades 6-12 as students were further engaged in stewardship activities throughout the school year highlighting the different ways in which stewardship can combat invasive species even as the fishing seasons changed. The student book study was paired with a teacher book study and curriculum development workshop that ran through the spring semester. The curriculum development aspect led to a field trip of site visits corresponding to *The Death and Life of the Great Lakes* that was documented from the perspective of South Dakota students/teachers coming face-to-face with zebra/quagga/Asian carp-infested waters on a scale not seen in South Dakota to document and bring back the importance of keeping these invasive organisms out of South Dakota waters.



Image 3: Edmunds Central inspecting docks at Bitter Lake for zebra mussels. Docks are often one of the first places where zebra mussels are noticed frequently when docks are pulled in the fall before ice on.

Photo credit: Spencer Cody

In addition to seeing firsthand what lies in store for South Dakota in terms of the severity of the oncoming invasion, we made site visits referenced in the book looking for potential solutions to what we are facing. The goal was to recruit at least 30 teachers with the requirement that they would implement stewardship activities in their classroom through the reading of the book and going through the South Dakota-focused curriculum that was presented on invasive organisms with the opportunity to interact with site visits discussed in the book virtually during our live virtual teacher field experience of aquatic invasive species. Unfortunately, we fell a little short of this goal at only 26 teachers of which only 22 took the course for credit. However, 17 of these teachers participated in the virtual field trip in July of 2022 with another 7 of them completing it for additional credit.

An Inspiring Field Experience

The July field experience was the culmination of the project. Students and cohort teachers came together in a unique field experience for everyone. We took a bus load of students in grades 6-12 and endeavored to visit as many sites mentioned in the book study that we could during a week-long field experience covering all the Great Lakes. As we traveled from South Dakota up through Minnesota and the UP of Michigan, our students explored Lake Superior posting videos for our cohort teachers to engage virtually with the student field experience. Students posed questions from the book from sites such as the Great Lakes Aquarium and the Duluth harbor for participating teachers to reflect on and discuss topics on native versus introduced species and how shipping has opened the Great Lakes up to aquatic invasive species. The field experience progressed onto Lake Michigan with a stop at Beaver Island in the middle of the lake to learn about the impact of aquatic invasive species on the Great Lakes at Central Michigan University's Biological Station.

After our visit, we headed farther east all the way to the end of Lake Erie and looped back through Chicago to probe the problem of entry points for aquatic invasive species through site visits along the Erie Canal and Niagara Falls and exit points for invasive species through the Chicago River.

Having internet access for a virtual field experience, combined with a student in-person experience, constantly presented logistical issues of having enough time to lead a field trip while uploading and recording enough content for a simultaneous virtual field experience. Overall, both aspects of the field experience proved valuable to teachers and students. The teacher cohort found the student interaction to be engaging in discussion and reflection while the students took their tasks of relaying information and developing thought-provoking questions for the teachers with a heightened sense of duty. Altogether, running a field experience in tandem with its virtual counterpart proved to be logistically challenging, but it produced a more meaningful learning experience for students than those field experiences that we have done that lacked such a virtual component.



Image 4: While piloting Central Michigan University's remote operated vehicle (ROV), students were able to observe invasive quagga mussels along the shores of Beaver Island in Lake Michigan while searching for a sunken car that has been submerged for decades in the harbor.

Photo credit: Spencer Cody



Image 5: Learning about how opening up the Great Lakes via canals helped pave the way for aquatic invasive species as Edmunds Central students ride on a ferry on the Erie Canal in Lockport, New York.

Photo credit: Spencer Cody

If you are interested in recreating this experience in your classroom, you can utilize our teacher-friendly study guide: https://docs.google.com/document/d/1FFuAbVAvJL7jv7JMTZr_eP5uAhYVdPj/edit

This includes slideshows for each chapter in the book including a whole host of interesting discussion questions and media, and as a special treat, we have included original video discussion questions from our students from the Great Lakes field experience. This book study guide paired with *The Death and Life of the Great Lakes* might be woven into lessons that would help students demonstrate understanding from the Next Generation Science Standards (NGSS, 2013). Disciplinary Core Ideas of **LS2.A: Interdependent Relationships in Ecosystems** and **LS2.C: Ecosystem Dynamics, Functioning, and Resilience** are strong in the lessons and are connected to these Performance Expectations:

NGSS Middle School Life Science

- MS-LS2-1: Analyze and interpret data to provide evidence for the effects of resource availability on populations of organism in an ecosystem.
- MS-LS2-2: Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.
- MS-LS2-4: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
- MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment

NGSS High School Life Science

- HS-LS2-6: Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.
- HS-LS2-7: Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
- HS-LS4-5: Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.
- HS-ESS3-3: Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.
- HS-ESS3-6: Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

Conclusion

In total 82 students in grades 6-12 logged 297 stewardship and project involvement hours totaling a wide variety of stewardship activities involving both habitat restoration and conservation. Our habitat conservation activities involving preventative measures to reduce the spread of aquatic invasive species included the following:

- 43 boat inspections
- 22 boat cleanings
- 108 bait bucket inspections and 19 bait bucket cleanings

- 34 live well inspections
- 57 dock inspections
- 72 riprap locations inspected for zebra mussels
- 32 boatlift inspections
- 37 boat trailer inspections
- 12 aquarium inspections

Habitat restoration opportunities were more limited but were also performed: 72 kilograms of zebra mussels were removed, 5 kilograms of quagga mussels removed on Beaver Island, and 42 kilograms of common carp removed. These stewardship activities contributed to marked shifts in student views and understanding as are referenced in Figure 1.

Teacher involvement included 26 teachers in our aquatic invasive book study with 22 teachers completing the course for graduate credit through the University of Sioux Falls. Additionally, 17 of these teachers participated in our summer virtual field experience with another 7 of them taking it for credit. This curriculum development opportunity also led to smaller shifts in teacher perception and understanding as are referenced in Figure 2.

While the issue of aquatic invasive species presented its own logistical problems, these challenges were, for the most part, successfully navigated to meet stewardship goals resulting in a remarkable learning experience for both students and teachers. This NOAA Planet Stewards project produced substantive attitudinal changes paired with documented increases in content understanding proving that South Dakota students on the forefront of our struggle against aquatic invasive species can greatly benefit from project-based, stewardship-centric learning.

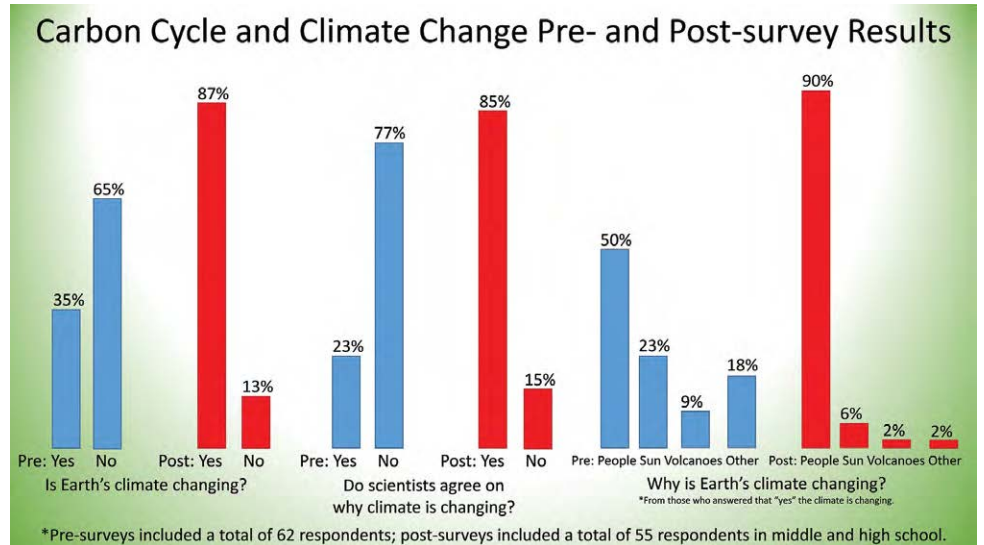


Figure 1: Data collected from pre- and post-surveys from the project's participating students indicate a significant shift in views about the spread of AIS. These shifts were somewhat surprising considering the degree to which aquatic invasive species have been in the local media.

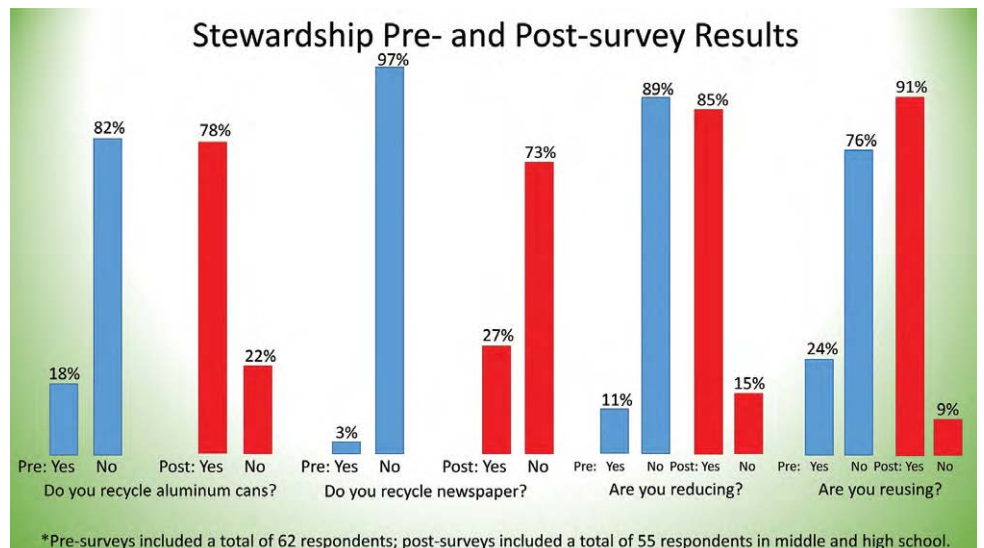


Figure 2: Data collected from pre- and post-surveys from the project's participating teachers indicate a smaller shift in views and understanding on the issue of aquatic invasive species than was exhibited by participating students. Participating teachers had a wide range of backgrounds and, in most cases, did not teach any content concerning aquatic invasive species.

About the Author

Spencer Cody teacher 6-12 Science at Edmunds Central Middle and High School in the Edmunds Central School District in Roscoe, South Dakota. He holds a BA degree in Middle School and Secondary Biology Education from Concordia College in Moorhead, Minnesota, and an MS degree in Chemistry Education from South Dakota State University in Brookings, South Dakota. He has taught for 15 years in the middle and secondary sciences and is the recipient of numerous awards for his teaching including the 2018 Sanford Inspire Teacher of the Year for South Dakota, 2020 North Central Section Outstanding Earth Science Teacher, 2020 EPA Presidential Award for Environmental Education, and 2021 Region Four Teacher of the Year for South Dakota. Spencer can be reached at Spencer.Cody@k12.sd.us.

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