THE EARTH SCIENTIST

NATIONAL EARTH SCIENCE TEACHERS ASSOCIATION

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Tijuana River National Estuarine Reserve.
Photo Credit: NOAA, Department of Commerce

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NESTA'S MISSION

To facilitate and advance excellence in Earth and Space Science education.

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NESTA Address:
PO Box 271654
Fort Collins, CO 80527

Visit the NESTA website at
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From the President

As seasons change, so do our methods of teaching. Sometimes we share the latest and greatest resource with our colleagues, while other times we are reminded of the excellent resources we have used in the past. I have a special education Environmental systems teacher on my team who has been asking me for advice on various resources to support not only the content but the varying abilities in her classroom. As a special education science teacher plus general education teacher myself who has taught most sciences from 6th through 12th grade and community college, as well, I have quite an array from which to select. I found myself referring her to the great rock cycle and carbon cycle games from my past middle school experiences vetted from PolarTrec and UCAR , along with the engaging and interactive EarthLabs series from TERC (serc.carleton.edu/eslabs/index.html) that I once piloted in my classes.

There are many credible, aligned resources available to us as Earth science educators, in addition to the wide array of professional development opportunities that bring us in contact with our colleagues and foster that sharing and collaborative resource network. Among these opportunities are workshops at conferences such as the Geological Society of America (GSA), the National Science Teachers Association (NSTA), and the American Geophysical Union (AGU) Annual Meetings. NESTA provides K-12 teachers an opportunity to learn from both a scientist and fellow educator through multiple offerings at the Geophysical Information for Teachers (GIFT) workshop held at AGU each year. This collaboration with AGU gives teachers valuable hands-on experience in addition to robust content knowledge with no costs other than travel expenses to participate. In addition to GIFT, NESTA works with the National Association for Geoscience Teachers (NAGT) to produce the Earth Educators' Rendezvous each summer. This three, four, or five-day experience provides a more intimate setting to collaborate and learn with Earth science educators and is another opportunity to share that highly effective lab investigation or field technique with others. Learn more about the Rendezvous in Nashville, Tennessee this summer (https://serc.carleton.edu/earth_rendezvous/2019/index.html).

Whether in another state or your own backyard, I encourage you to be open to new ideas and methods for teaching the concepts we teach year after year. Be the teacher with the open door to new instructional colleagues and keep the collaboration fresh as we strive to provide the next generation of geoscientists with a rich and relevant Earth science experience.

Cheers,

Belinda Jacobs
NESTA President 2018-2020

From the Executive Director

We are very excited for the National Oceanic and Atmospheric Administration's (NOAA's) National Ocean Service (NOS) to sponsor this issue of *The Earth Scientist!*

This issue features articles covering a wide range of topics including watersheds, recycling, marine debris, and citizen science among others. Some of the authors of articles in this issue are former NOAA Climate Stewards. In late 2017 the NOAA Climate Stewards Education Project changed its title to the NOAA Planet Stewards Education Project. This change reflects an expansion of the program's scope allowing it to better serve educators looking to engage their students in science and stewardship relating to the broad range of NOAA's mission programs concerned with understanding and protecting our environment. NOAA Planet Stewards continues its programmatic emphasis on climate as a primary driver of environmental impacts to human communities and natural ecosystems.

NOAA provides many education programs, products, and professional development opportunities for K-12 educators. The NOAA Planet Stewards Education Project (oceanservice.noaa.gov/education/planet-stewards/welcome.html) offers webinars, a book club, and a variety of face-to-face workshops. NOAA's Data in the Classroom project (datainteclassroom.noaa.gov/) provides five freely-available modules in which students use real-time ocean data to explore pressing environmental issues and develop problem-solving skills used by scientists. Oysters in the Chesapeake Bay (oceanservice.noaa.gov/education/oysters-in-the-chesapeake-bay/welcome.html) is a free K-12 curriculum aligned with the three dimensions of the Next Generation Science Standards. It contains six elementary lessons, two middle school modules, and four high school modules in a coordinated learning sequence at each level. Ocean Today (oceantoday.noaa.gov/) is another free resource containing over 300 videos in six categories 1) Fix the Ocean, 2) Marine Life, 3) Exploration, 4) Research, 5) Go Fish, and 6) Danger Zone. These videos are displayed at various kiosks in aquariums, museums, and learning centers. All the videos, complete with transcripts, are available on the website and can easily be downloaded and shown to the students you teach. Overall, NOAA's National Ocean Service (oceanservice.noaa.gov/) provides a wide variety of information, resources, and data that you also might find useful for your teaching. In particular, check out the education resources oceanservice.noaa.gov/education/ and multimedia resources oceanservice.noaa.gov/multimedia/ from NOAA NOS.

If you are planning to attend the National Science Teachers Association National Conference on Science Education this spring in St. Louis, then be sure to come by the Annex room of the America's Center Convention Complex on Friday, April 12 and Saturday, April 13 where NESTA has a number of co-sponsored sessions with NOAA and other partners.

The AGU-NESTA featured speaker is Dr. Theresa Damiani from NOAA's National Geodetic Survey. Dr. Damiani's talk, Finding Our Way: The Science Behind Today's GPS Revolution, explores the science of GPS and mapping, how it allows us to quickly and easily find our way through the world, and the sometimes, unexpected ways in which it is revolutionizing our society. The talk is from 2:00 – 3:00 PM on Friday, April 12 at the Ferrara Theatre, America's Center Convention Complex.

Last, we hope to see you Saturday evening from 6:30 – 8:00 PM at our Friends of Earth Science Reception in the Cystal Ballroom of the Marriot St. Louis Grand where we will recognize many stellar Earth science educators!

Dr. Carla McAuliffe
Executive Director, NESTA

NESTA Contacts

REGIONAL DIRECTORS

Region I - ME, MA, NH, RI, VT
Susan Meabh Kelly
susan.meabh.kelly@ttu.edu

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mr.boydearthscience@gmail.com

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sinclair.jay@sbcglobal.net

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earladurf@gmail.com

Region VIII - AK, CA, HI, WA, OR
John-Henry Cottrell
jcottrell@murrieta.k12.ca.us

DIRECTORS AT LARGE

Elaine Bohls-Graham
LanieB123@gmail.com

Dr. Doug Lombardi
lombardi.doug@gmail.com

Pradip Misra
pradicm@yahoo.com

Parker Pennington, IV
p.o.pennington@gmail.com

APPOINTED DIRECTORS

Ardis Herrold – amacio@comcast.net
Joe Monaco – monacoj@aol.com
David Thesenga – dthesenga@gmail.com
Deborah Ezell – deborah.ezell@spartanburg2.k12.sc.us
Tina Harte – tina.r.harte@nasa.gov
Tom Ervin – tombervin@gmail.com

NESTA Coordinators

Conference Logistics Coordinator
Howard Dimmick
dimmick@esteacher.org

Merchandise Coordinator
Howard Dimmick
dimmick@esteacher.org

Procedures Manual Coordinator
Parker Pennington IV
p.o.pennington@gmail.com

Rock Raffle Coordinators
Parker Pennington IV
p.o.pennington@gmail.com

Share-a-thon Coordinator
Dr. Carla McAuliffe
Carla_McAuliffe@terc.edu

Volunteer Coordinator
Joe Monaco
MonacoJ@aol.com

Webpage Coordinator
Jack Hentz
hentz@aaps.k12.mi.us

E-News Editor
Tina Harte
tina.r.harte@nasa.gov

Guest Editor's Corner

For what or for whom do you care for? Your children, a pet, a favorite plant? No matter who you are and where you live, you care for someone or something – probably many someones and somethings. The Merriam-Webster dictionary says, "The careful and responsible management of something entrusted to one's care," is stewardship. The articles in this edition of *The Earth Scientist* focus on efforts made by Kindergarten through twelfth-grade students to learn about and care for the Earth and its ocean by monitoring and analyzing changes, changing behaviors, and sharing their knowledge to increase science understanding both inside and outside of school. Participation in stewardship activities helps students gain a deeper appreciate for science, and increase their interest, confidence, and performance in school science.

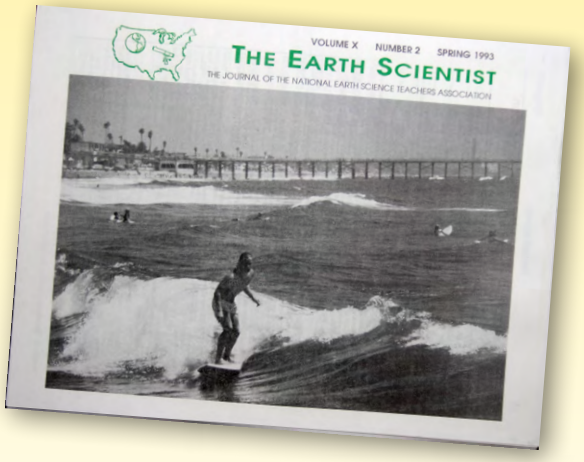
Part of the mission of the National Oceanic and Atmospheric Administration (NOAA) is "to conserve and manage coastal and marine ecosystems and resources," and this is partly accomplished through stewardship. By monitoring and collecting essential data about the earth, providing scientific knowledge and education resources, and making connections, NOAA helps educators and their students become active stewards of their local environment. Much of this is done through hands-on activities and place- based science education in cooperation with NOAA programs such as NOAA's Office of National Marine Sanctuaries, the NOAA Marine Debris Program, and the NOAA Planet Stewards Education Project.

In this special issue of The Earth Scientist, you will read about how schools are taking up the call to be "Ocean Guardians" to help their students explore their natural surroundings and form a personal connection with the ocean or their local watersheds. Individual teachers are using hands-on activities with their students to develop a lifelong stewardship ethic. Through the design and implementation of recycling programs, raising and releasing sea urchins, and reducing energy consumption and trash production, students are transforming science knowledge into action. Indigenous students along the Pacific Rim are strengthening their understanding of global marine issues through sharing information with "pen pals" about their local environment and cultural communities. After school, science, stewardship actions, and digital cameras are merged to help mitigate climate change. In addition, there are high-quality resources in this issue for teaching about marine debris and incorporating citizen science into the classroom.

NOAA is proud to work with these educators and students who are using science and action to care for the ocean, the atmosphere, and their fellow citizens. We hope their work inspires you to undertake stewardship activities with your audiences. To learn more about NOAA's education programs, products, and professional development opportunities, visit (noaa.gov/education).

Guest Writers of this Editor's Message
Molly Harrison & Bruce Moravchik
Coordinators, NOAA Planet Stewards Education Project
oceanservice.noaa.gov/education/planet-stewards/welcome.html

25 Years Ago in TES



A little over twenty-five years ago, in 1993, TES was in its tenth year of publication. The focus of this issue was "The Ocean", and fittingly, the cover of the issue featured a photo of a surfer enjoying a ride on the Pacific waves along Oceanside Beach in California. This issue led off with an in depth article detailing the latest information about the Mid Oceanic Ridge. The next article dealt with Marine Chemistry, calling the oceans a "complex chemical soup". This was followed by an article dealing with El Nino. Finally, there was an article detailing the educational programs available at the Monterey Bay Aquarium.

By Tom Ervin

oceanservice.noaa.gov/education/planet-stewards/

The Earth Scientist

PUBLICATIONS COMMITTEE
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Kottie Christie-Blick, Nicole Harris, Richard M. Jones, Jessica Lura, Karen Matsumoto, John McLaughlin, Seaberry Nachbar, Brandon Schroeder, Peg Steffen, Krista Stegemann, June Teisan, Carlie D. Trott, Sarah Waters

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To get more information about NESTA or advertising in our publications, contact, Carla_McAuliffe@terc.edu.

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Patty Schuster, Page Designs

The NOAA Planet Stewards Book Club

Discussing *Please Don't Paint Our Planet Pink*

Peg Steffen, NGSS Curriculum Writer for the Illinois Mathematics and Science Academy

Are you part of a book club? Usually defined as periodic meetings to discuss books that are read ahead of time, book clubs are a way to meet new people and share insights about important literature. Book clubs, even virtual ones, are also an important professional development tool for educators. NOAA Planet Stewards sponsors virtual book discussions each year, raising awareness of books useful for classroom use or for educators' better science understanding.

The book club recently discussed "Please Don't Paint Our Planet Pink" written by Gregg Kleiner and illustrated by Laurel Thompson. It is appropriate for elementary through adult ages and discusses the problem of carbon dioxide in global warming.

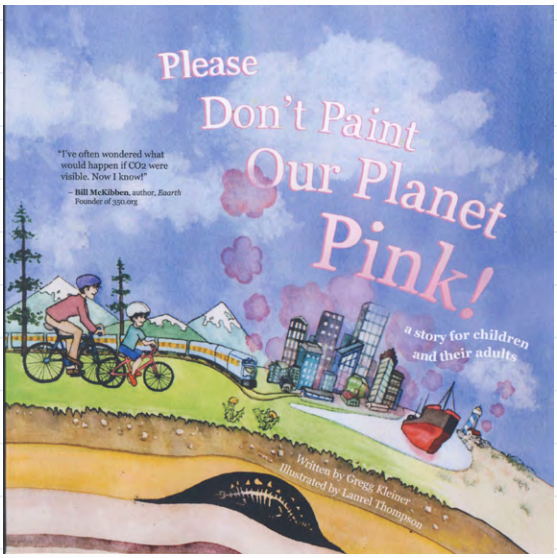

Figure 1. *Please Don't Paint Our Planet Pink* is a book about climate change that imagines it is possible to actually see CO2 in the atmosphere.

Gregg was part of the book club that night and he explained, "As a father of two children, I often lie awake nights tossing and twisting with worry about the climate crisis and how it will impact the lives of my children, their children, and children all over the world. I knew a major problem with inspiring action to slow climate change is that we can't really see what's causing it. We can't touch or smell or taste CO2 or other greenhouse gasses, either. But what if we COULD see carbon dioxide? Puffing from smoke stacks and tail pipes and the rear of cows? What if CO2 were, say, pink? And the world was getting pinker? What if every kid came home from school with a deep understanding of climate change and took action? My hope is that my book will help in some small way. Years from now, when my kids ask me, "What were you doing, Dad, back when you all knew climate change was coming on fast?," I can tell them I was writing through my own fears, in hopes the power of a simple story might inspire a few kids – and their adults, and their teachers – to start seeing the invisible, imagining the impossible. I can tell them I was writing for our kids, and the kids of future generations. I can tell them I was writing to help school teachers help the kids in their classrooms tap their amazing imaginations, and then take action. My fight against climate change continues, but these days, at night I sleep a little better now." Find out more about the book at cloudburstcreative.com/pink.

Some of the questions that were used to guide the book club discussion are below:

1. Wilbur is a 10-year-old boy and is a typical upper elementary school student. What audiences do you think would be engaged with this story and be able to understand the science behind it?
2. Many students have a hard time understanding that gases are present all around them in the atmosphere. The goggles with no lenses are an interesting way for Wilbur to "see" carbon dioxide. How might this strategy be used for other purposes?
3. On page 18, the author talks about activities that students love (like campfires) but that contribute small amounts of carbon dioxide. In the grand scheme of things, some of these might not be big contributors in the United States. However, the use of fossil fuels and vegetation for cooking and heating is used in other countries because of the lack of other types of energy. About three billion people cook their food over open fires or inside structures in which the smoke can easily escape. This results in a good deal of black carbon pollution both indoors and outdoors. How can we help students understand that living conditions (and energy sources and use) are vastly different in other countries?
4. The author provides an explanation of how trees "suck" carbon dioxide out of the air and put it into wood and leaves. Photosynthesis is a tough concept. Does this analogy help you? Would it help your students?
5. The carbon cycle is an unspoken concept of the book. What activities have you tried in class or other learning situations that help to explain the cyclic nature of carbon?
6. The book offers several things that we can do to reduce the amount of "pink" in the atmosphere. It might be helpful to start with the knowledge of our ecological footprint. EPA calculator at www3.epa.gov/carbon-footprint-calculator/. For students, try one of these: web.stanford.edu/group/inquiry2insight/cgi-bin/i2sea-r3b/i2s.php?page=calculate. How do you think you stack up in terms of energy use? Are you planning ways to reduce your carbon footprint?
7. What are some ways we can get students to think "pink"?

The NOAA Planet Stewards book club has an extensive list that focuses on diverse topics: decreasing the impacts of marine debris, climate change, conserving and restoring natural resources, and understanding and responding to severe weather events. Usually scheduled on the last Monday of a given month, meetings begin at 8:00 pm Eastern Time. You can find a list of books that have been discussed along with the guiding questions at oceanservice.noaa.gov/education/planet-stewards/book-club.html. Consider using these books in your classroom or for your own science content update. Sign up to our email list and receive invitations to future events and book club discussions.

About The Author

Peg Steffen is an NGSS Curriculum Writer for the Illinois Mathematics and Science Academy. For more than a decade, she was the education coordinator for the Communications and Education Division of NOAA's National Ocean Service where she led a development team that provided web-based products, professional learning, and educational games in ocean, coastal and climate science. Her 26 years of classroom teaching included biology, physics, and astronomy/geology at the high school and university levels. She received a National Board for Professional Teaching Standards Certificate for Adolescent and Young Adult Science and many teaching awards in her 40 years of work to bring science education to teachers in the United States, Mexico, Europe and Asia.

Peg can be reached at peg.steffen@gmail.com

TODAY'S TECHNOLOGY

Become a Citizen Scientist and join NOAA's Research on Earth's Geomagnetic Field using the CrowdMag app

The geomagnetism group of NOAA's National Centers for Environmental Information (NCEI) conducts original research on the magnetic field of Earth. Their primary goal is to create and update models of the geomagnetic field to keep pace with Earth's constantly changing magnetic field. The magnetic models are integrated into millions of smartphones, car and aircraft navigation systems and GPS so that users know which way is north.

Earth's magnetic field (geomagnetic field) provides us an all-weather referencing system. Earth acts like a great spherical magnet and its magnetic field resembles, in general, the field generated by a dipole magnet (i.e., a straight magnet with a north and south pole) located at the center of Earth. The geomagnetic field has been observed and used for navigation since ancient times. Today, magnetic navigation is implemented on most planes, ships and even on your smartphone for safe and reliable navigation.

As the geomagnetic field changes with time and space, it is important to monitor its changes. Scientists use observatories, satellites and ship/airborne surveys to keep track of the change. Due to gaps in coverage – both in time and space – scientists are always looking for alternative ways to obtain geomagnetic data.

What is CrowdMag app?

CrowdMag is a smartphone app that enables phones all around the world to send magnetometer data to the National Centers for Environmental Information (NCEI). For a given phone, the app sends the time of the measurement, its location, location accuracy, magnetic data from the phone's magnetic sensor, and the phone's model because there are different sensors inside different models. When NCEI receives the data, it checks the quality of the magnetic data and then makes the data available to the public as aggregate maps and charts. CrowdMag app can potentially improve magnetic field models and magnetic navigation by filling data gaps with existing technologies that capitalize on citizen science. By downloading CrowdMag app, you and your students can contribute to this important citizen science effort.

Download the CrowdMag smartphone app today and turn your phone into a magnetic sensor!
ngdc.noaa.gov/geomag/crowdmag.shtml#apps

CrowdMag

NOAA's Ocean Guardian School Program: Protecting Our Ocean One School at a Time

Seaberry Nachbar, Ocean Guardian School Program Director, NOAA Office of National Marine Sanctuaries

Abstract

NOAA's Office of National Marine Sanctuaries works to bring the ocean and these special ocean parks called national marine sanctuaries to youth around the country. One way they do this is through the Ocean Guardian School program, which encourages students to explore their natural surroundings to form a personal connection to the ocean or watersheds where they live. Ocean Guardian Schools work within their communities to protect and conserve local watersheds, the ocean, and special ocean areas like national marine sanctuaries. Through evaluation the program has shown students 1) become active stewards of their environment by directly reducing threats to the natural resources, and 2) students are more inclined to talk to others about the environment.

Introduction

Does your school have what it takes to help protect the ocean for the future? You can work locally within your school and community to promote the protection of the ocean globally by becoming an Ocean Guardian School. All K-12 schools around the country are invited to apply. Schools in particular counties in California, Oregon, Washington, Maryland, Florida, Texas and North Carolina are eligible to receive Ocean Guardian grants to help support their stewardship project. More information about the program can be found at this website: sanctuaries.noaa.gov/education/ocean_guardian/.

An Ocean Guardian School makes a commitment to the protection and conservation of its local watersheds, the world's ocean, and special ocean areas, like national marine sanctuaries. The school makes this commitment by proposing and then implementing a school- or community-based conservation project.

An Ocean Guardian School:

- provides project(s) for students related to the conservation of local watersheds, the world's ocean, and/or special ocean areas, like national marine sanctuaries.
- provides opportunities for students, teachers, parents and friends to participate in a range of environmental and sustainable activities.

- provides learning programs and opportunities that reflect environmentally sustainable practices that enable all students to be environmentally active and committed "Ocean Guardians."
- provides ways for classrooms to promote best environmental practices within local communities, while at the same time projecting a positive image of the school itself.

Program Development and Implementation

The Ocean Guardian School program was designed to further the educational and resource protection goals of national marine sanctuaries by supporting hands-on ocean stewardship projects in K-12 public, private, and charter schools. The Ocean Guardian School program works with schools and school communities to raise awareness of the land-ocean connection as well as the environmental issues affecting the health of the ocean's watershed. The program strives to inspire changes in environmental stewardship behavior by encouraging projects that take active steps in creating solutions to environmental issues while at the same time becoming an integral part of the school culture (Figure 1).

Figure 1. Students engaged in ocean conservation at an Ocean Guardian School.

The first step in becoming an Ocean Guardian School is to develop a plan of action that outlines your school or community-based project. Currently only certain regions of the country are eligible to receive funding through the Ocean Guardian School program, but applications will be accepted from any school across the country if the school is applying without requesting funds. Ocean Guardian School grant applications for 2018-2019 are no longer being accepted. The new application form for 2019-2020 will be available on the website by April 1, 2019. The application and requirements can be found at this website: sanctuaries.noaa.gov/education/ocean_guardian/application.html

Schools must designate one of five ocean and climate literacy "project pathways" that connect to their Ocean Guardian School project:

1. **Restoration** – watershed/wetland restoration, fish habitat creation, shoreline/bank stabilization;
2. **Rethink/Refuse/Reduce/Reuse/Recycle/Rot** – school-wide recycling/composting programs, redesign and implementation of school-based water system, school-wide green purchasing program, zero waste lunch program;
3. **Marine Debris** – reducing single-use plastics in school, promoting reusable bags in local community/stores;
4. **Schoolyard Habitats/Gardens** – creating or improving school gardens/schoolyard habitats with an emphasis on the native plants, low water use, rain catchment systems, etc. while clearly connecting these activities to the health and preservation of the local watershed and/or ocean;
5. **Energy and Ocean Health** – school energy audits/carbon footprint calculations resulting in energy saving plans (i.e., "power down" campaign, bike to school days, light bulb/computer energy saving plans, etc.), clean energy alternatives such as wind/solar project, water saving projects, tree planting projects.

Program requirements help to guide schools during their project year as they work to encourage students to understand the connection between their stewardship actions and the health of the ocean. Program requirements include school and community outreach activities, collection of measurable project data as well as student presentations at the start and end of the year. A summary

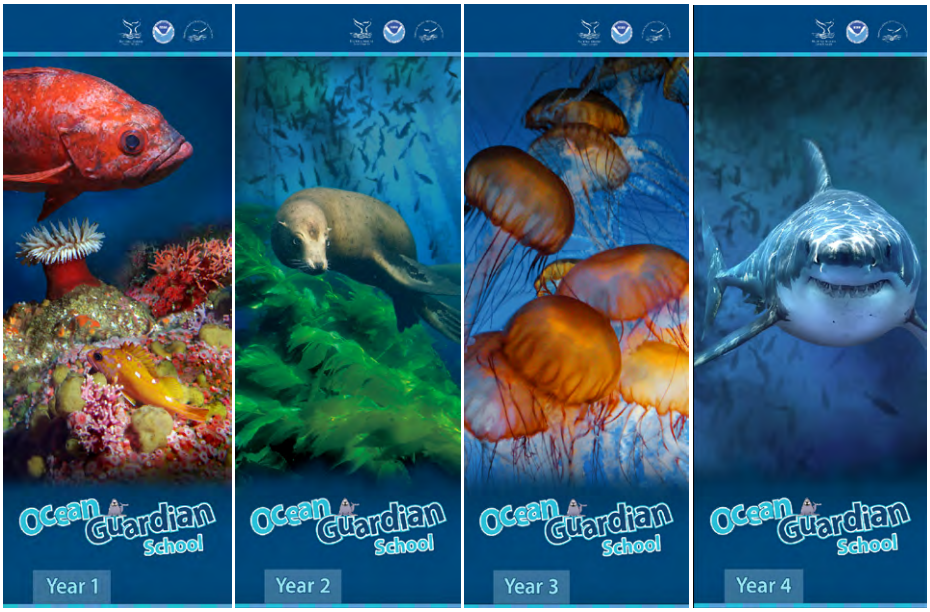

Figure 2(a-d). Ocean Guardian school banners, years 1-4.

of the program requirements can be found at the following website: nmssanctuaries.blob.core.windows.net/sanctuaries-prod/media/docs/2019-2020-ogs-program-guidelines.pdf

During the project year, students collect specific, measurable data that will help quantify the environmental impacts that result from their watershed/ocean stewardship projects (see Evaluation section below). These activities and the results are then communicated to others in the community through various outreach activities.

At the end of the project year, schools are evaluated through a formal evaluation rubric and a comprehensive final report survey used to determine the final Ocean Guardian School recognition. Upon Ocean Guardian School recognition, a school receives an Ocean Guardian School banner. A different banner is awarded for each year of recognition (Figure 2). Well-documented environmental and behavioral change has been seen from Ocean Guardian Schools. This can be attributed to the rigorous evaluation process consisting of measurable data and the program requirements. The structure of this program sets it apart from other similar school grant programs creating a level of accountability among the participating schools resulting in real environmental and behavior change.

In addition to the Ocean Guardian School public website with various dedicated program resources (sanctuaries.noaa.gov/education/ocean_guardian/resources.html), participating schools have access to a special private resources webpage with a library of activities, lesson plans, curricula, and videos.

In addition, the program has produced five videos for the Ocean Guardian School program. A 2-minute promotional video was also created and posted on the Ocean Guardian School webpage and the Office of National Marine Sanctuaries You Tube channel, youtube.com/watch?v=MxmTNHPdCG0&feature=youtu.be. Most recently, a 12-minute video was produced for participating schools to use at the onset of their project year to introduce some basic concepts to their school communities including information about the National Marine Sanctuary System, ocean and climate literacy, and the land-ocean connection (i.e., watersheds): youtu.be/hByglw4Grkc.

Evaluation

The Ocean Guardian School program sets itself apart from other stewardship programs due to the extensive and systematic evaluation that takes place at the program level and with each of the individual school projects. Over the course of the program's life, a number of assessments have been conducted to collect both outcomes and outputs. In addition, we continue to collect success stories and highlights from each of the schools that provide qualitative information about the program success.

Starting in 2010, the Ocean Guardian School program has required that each school collect measurable data during the project pertaining to the stewardship activities they are conducting (Table 1). Over 50,000 students have participated in the program. Students at the schools have had major impacts. 497, 788 single use water bottles are no longer being used, having been replaced

by reusable bottles at water filtration stations. Students have removed 145, 548.04 kilograms of trash/debris. Over 52,000 liters of water have been reclaimed from water catchment systems. This data then shows the large impacts that "guard" our ocean, protect our resources, and change student behaviors.

Although the results of the program can be measured using a variety of data, its accomplishments are often most reflected by the successes of its participants. A school's ability to go above and beyond their initial project plans is a direct result of the consistent communication and personal outreach with these participants. Some highlights of these successes include qualitative results.

Table 1: Ocean Guardian School Measurable Data 2010-2018

Number of recycle bins installed	954
Number of compost bins installed	473
Kilograms of compost made from school food/garden waste	857.75
Kilograms of recycled e-waste	2,322.85
Kilograms of reused oyster and clam shells	2,721.55
Kilograms of trash/debris removed from campus and/or from out in the community	145,548.04
Number of reusable bags (grocery bags, snack bags, etc.) distributed	10,614
Number of reusable bottles distributed	17,679
Number of single use plastic bottles NOT used due to use of reusable bottles at filtration station	497,788
Number of rain barrels installed	81
Liters of water reclaimed from use of water catchment system	52,078.13
Number of native trees planted	4061
Number of native perennials/grasses/annuals planted	34,696
Square meters of native plants planted	47,945.89
Square meters of non-native invasive plants removed	33,948.21
Square meters of turf removed	3,517.42
Linear meters of bank stabilization	1,178.94
Number of wildlife habitat structures installed	173
Number of LED or energy saving bulbs installed	44
Number of bike-to-school days	145
Number of stenciled storm drains	63

In the spring of 2016, Dr. Danielle Schwarzmann, an economist on staff at NOAA's Office of National Marine Sanctuaries, conducted a formal study of the economic benefits of this program. During the study, roughly 50% of Ocean Guardian Schools participated in a survey to estimate both the monetary and non-monetary benefits of the program to children. Ocean Guardian School teachers contacted parents of Ocean Guardian School students, asking them to complete a survey about their perceptions and values towards their child's participation in the program. All surveyed schools were in California.

Nearly 90 percent of parents support their child's participation in the program. Nearly 80 percent of parents support outdoor education and 85.3 percent support environmental education. Roughly 80 percent of parents thought the Ocean Guardian School program positively influenced their child's perceptions of watersheds, ocean ecosystems, and our natural world. In addition, about two-thirds of parents thought their own perception of watersheds, ocean ecosystems, and our natural world was positively influenced through their child's participation in the program.

Nearly 10 percent reported they would like to see the program "available to more students, schools, and teachers" with several noting that federal funding is important because it provides opportunities for low-income families to participate.

One parent said of Ocean Guardian Schools (OGS), *"They knew nothing about it [the OGS] until it happened. It was refreshing that something happened without having to push for it. (We have a relatively poor school district and have to constantly battle the finances)."*

Although many parents reported both themselves and their children were already recycling, minimizing water use, and single-use plastics, there were slight improvements to these behaviors.

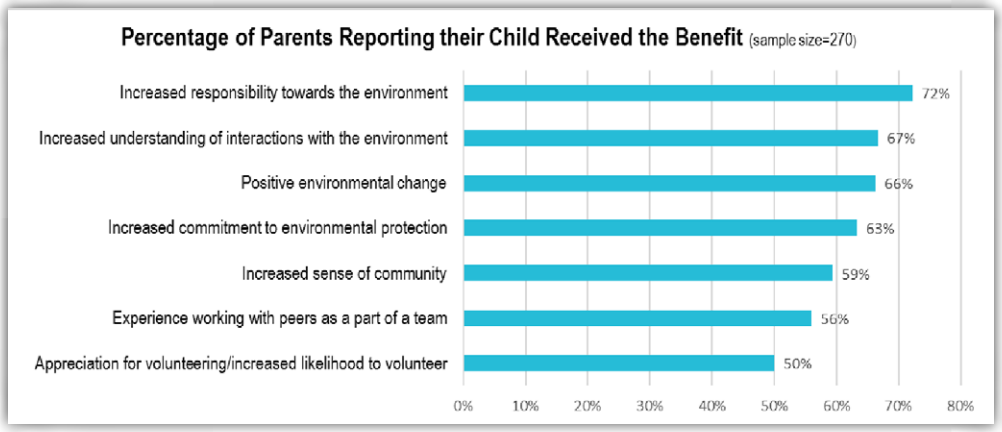

Figure 3. Percentage of parents reporting their child received a given benefit from the program.

The greatest change to behavior reported was that students are now talking to others (family and friends) about the actions others can take to improve the environment. Two-thirds of the children are having conversations with others and 22 percent of students are encouraging others to make more eco-friendly decisions.

Figure 3 shows the benefits that parents reported their child received because of participating in the Ocean Guardian School program. The top two benefits parents reported were: 1) an increased responsibility towards the environment and 2) the increased understanding of how people interact with the environment. Forty percent of parents reported their child received five or more benefits.

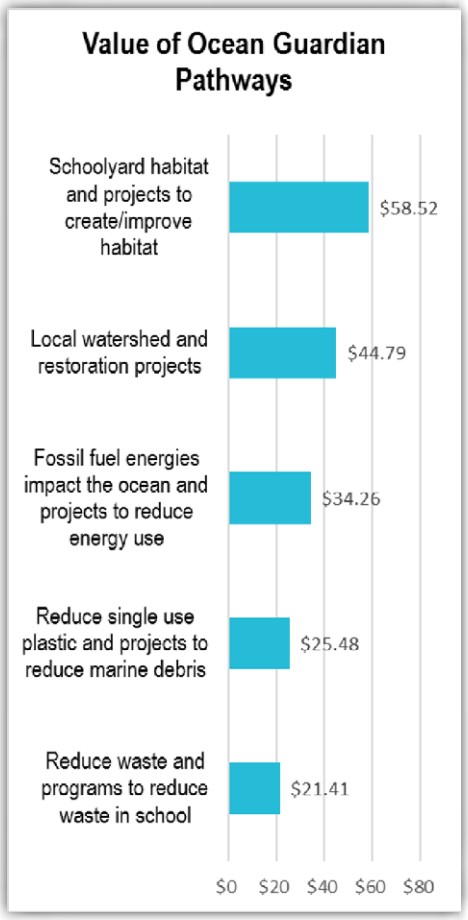

Figure 4. What parents think Ocean Guardian Pathways are worth spending on per student annually.

Parents were asked to indicate how much they were willing to pay per student annually to participate in each of the different Ocean Guardian School pathways. The highest valued pathway is schoolyard habitat and gardens (Figure 4). Parents are willing to pay nearly $60 through increased school costs and/or field trip costs for their child to receive this education. Watershed restoration has a value of roughly $45 per year annually to parents.

When considering the grant amount awarded to the school and the number of students participating, on average $14 -$53 of a school's grant is spent per student. This means that if a student participates in a habitat project, the benefit to that student ($59) exceeds the maximum amount spent on the student ($53). Another example of where benefits exceed costs is if a student learns about both marine debris and fossil fuel energies or learns about both recycling and fossil fuel energies.

Conclusion

As the Ocean Guardian School's tagline reveals, the small investment of "protecting the ocean one school at a time" brings about large impacts that help to guard our watersheds and one ocean while empowering students to be effective agents of change. We invite you and your students to join us as an Ocean Guardian School by visiting (sanctuaries.noaa.gov/education/ocean_guardian/).

About the Author

Seaberry Nachbar is an Education Coordinator with the NOAA Office of National Marine Sanctuaries. She has worked for NOAA for the last eighteen years, developing education programs and implementing them across the country. Currently, she is the Program Director for the NOAA Ocean Guardian School Program. Seaberry can be reached at Seaberry.nachbar@noaa.gov.

Student Leadership and Climate Literacy

Jessica Lura
Bullis Charter School, California

Abstract

In order to be an active citizen of today's world, children and adults need to be climate-literate. This article describes a NOAA Climate Stewards year-long project that provided opportunities for student leadership, student choice, and learning how to be a climate-literate person. The schoolwide stewardship program in California involved students at all grade levels. Sixth, seventh, and eighth graders established overall goals for students to reduce energy usage and waste consumption. Fourth and fifth grade students created an *Eco Super Hero* program for grades K-5 and a *Turtle Camp* specifically for kindergarten and 1st grade students. Grade 4 through grade 8 students in the program were able to explain climate science, understood its connections to human activity, and felt like they had the tools to continue to make a difference in mitigating future impact.

In late 2017 the NOAA Climate Stewards Education Project changed its title to the NOAA Planet Stewards Education Project.

Introduction

Research shows a significant increase in the concentration of heat-trapping gases (so-called greenhouse gases), especially carbon dioxide (CO2), in the Earth's atmosphere. In addition, a rise in global temperatures relates to the rise in carbon dioxide. A large percentage of the rise in carbon dioxide can be traced to human activity including the use of electricity.

For this reason, in order to be an active citizen of today's world, children and adults need to be climate-literate. According to *Climate Literacy: The Essential Principles of Climate Science*, a climate-literate person "is able to make informed and responsible decisions with regards to actions that may affect climate" (USGCRP, 2009). Climate change has been identified by many scientists to be one of the 'grand challenges' facing society with implications for many facets of life. Therefore, it is imperative that citizens gain an understanding of the climate system and the impacts that changes to the system will have in their daily lives.

As an educator, I have the responsibility to teach students to be climate literate and to provide opportunities for stewardship. Luckily, an understanding of the interconnectedness of communities and their environments and the responsibility to be agents of change is part of the mission statement of Bullis Charter School, the K-8 school I work at. In addition, I was fortunate to have been accepted into the NOAA Climate Steward Education Project —a program that focuses on

supporting formal and informal educators in teaching about climate science as well as assisting in developing and implementing stewardship projects.

After 16 years in the classroom, it was going to be my first year as a teacher on special assignment, and so I decided that for my stewardship project I wanted to focus on providing meaningful opportunities for students—opportunities that allowed for student leadership, choice, and learning. I decided to test the hypothesis: *If students analyze energy consumption at school and devise and implement a plan to reduce it, then energy consumption will decrease, and student habits and understanding will change.*

Eco-Workshop for Middle School Students

I kicked the project off with an optional two-day Eco-Workshop for middle school students (sixth, seventh, and eighth graders) where the students were tasked with analyzing the school and its impact on the greater environment and then using that information to create a yearlong action plan to implement solutions to the issues identified.

Twenty-seven students answered the call and gave up two days of their summer vacation to attend the workshop. To get baseline data of how our school is functioning, the students completed the National Wildlife Federation's Environmental Audit (nwf.org/~/media/PDFs/Eco-schools/Eco-SchoolsUSA%20EnviroReview12-7-15EditsUPDATED.pdf). The Environmental Review Checklist asks students to collect data on energy usage, water usage, climate change, global dimensions, transportation, school grounds, consumption and waste, healthy living, sustainable food, biodiversity, and healthy school. Students worked in small groups to survey classrooms, observing energy use and using tools such as Kill O Watt Monitors to collect data on energy consumption. They interviewed students and teachers about different habits with questions such as, "At what temperature do you keep your thermostat?" and "Do you use a reusable water bottle?" In addition, students learned about energy and saving energy from the National Energy Education Development Project (NEED) resources (need.org/content.asp?contentid=197). I used pre and post surveys to determine growth in climate literacy, student agency, and collaboration and communication skills.

Based on issues identified through their research, students created problem statements, brainstormed solutions, quickly prototyped solutions, and received feedback on the solutions from their peers. Examples of solutions included paper towel dispenser reminder stickers and videos to remind students to not waste paper towels. Reminders (such as door magnets to draw attention to turning lights off when leaving the room and closing the door when the heat or AC was on) were popular solutions. Check out the Eco Workshop slide deck (bit.ly/eco_slide) for the process used.

Students Identified the Challenges

After discussing the problem statements and solutions, students at the Eco Workshop picked three main areas the school should focus on for the school year—energy, waste reduction, and ocean literacy—creating two design challenges: *1) How might we reduce energy consumption at BCS so that BCS lessens its carbon footprint?* and *2) How might we reduce waste production so that BCS lessens its impact on the local natural environment and the ocean (and its animals)?* They created an action plan that included educating other students about the importance of energy reduction and its tie to climate change. Since Bullis is a K-8 school, students focused on activities that would be appropriate for all ages, adhering to the idea of "no gloom and doom before 4th grade." With this in mind, they decided that the school should create an *Eco Super Hero* program celebrating energy and waste reduction habits and a *Turtle Camp* to teach K-1 students about recycling, waste, and the ocean.

Student-created action plan in hand, I offered an elective class for 4th and 5th graders focused on creating solutions to the two questions from the Eco Workshop. To measure the effectiveness of

my stewardship project, students in the elective class, called Blue Crew, participated in pre and post surveys about their knowledge of climate change and marine debris and changes in behavior.

Because of the interconnectedness of the environment, many of the topics tackled by students in this class included activities that were also part of other grant initiatives such as National Marine Sanctuaries Ocean Guardians program and a Monterey Bay Aquarium Ocean Plastic Pollution Action Plan Proposal (marine debris and single-use plastic reduction) and Green Up Our Schools (recycling efforts).

Table 1. Performance Expectations addressed by the Stewardship Project

Connections to the Next Generation Science Standards (NGSS Lead States, 2013):
Grade K-2: K-ESS3-3 Earth and Human Activity Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment.
Grade 4: 4-ESS3-1 Earth and Human Activity Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.
Grade 5: 5-ESS3-1 Earth and Human Activity Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

Before designing and implementing ideas from the Eco summit, Blue Crew students learned about energy, marine debris, and human impact through activities from *Talking Trash and Taking Action* (Ocean Conservancy & NOAA Marine Debris) and NEED's (National Energy Education Development Project) *All about Trash*, *Using and Saving Energy*, and *Primary Energy Info Book* (resources shared as part of the NOAA Climate Steward Education Project). Once students had a basic understanding of climate science and ocean literacy, they selected topics to work on including recycling, reduction of energy use, no waste lunches, elimination of single-use plastic (especially single-use water bottles), reduction of marine debris, and creating *Eco Super Hero* cards. Each group created an action plan to implement their topic, taking notes on shared Google docs. Check out the Eco Super Hero doc for an example of the student action plans and directions.

The *Eco Super Hero* group created three K-2 super heroes and three super heroes for students in grades 3-5. Each super hero had specific "green" traits (such as focusing on recycling) and students who could verbally identify behaviors they shared were given the trading card of that super hero. See Figure 1 for a poster with all the *Eco Super Heroes*. To encourage students to exhibit these behaviors, the group created competitions between the classes to see which class received the most trading cards (and thus had the most eco-friendly students). I was lucky enough to receive funds for the trading cards and prizes the NOAA Climate Stewards Education Project.

Figure 1. Poster showing the six Eco Super Heros that students created to encourage the reduction of waste, the reduction of energy usage, and saving of water.

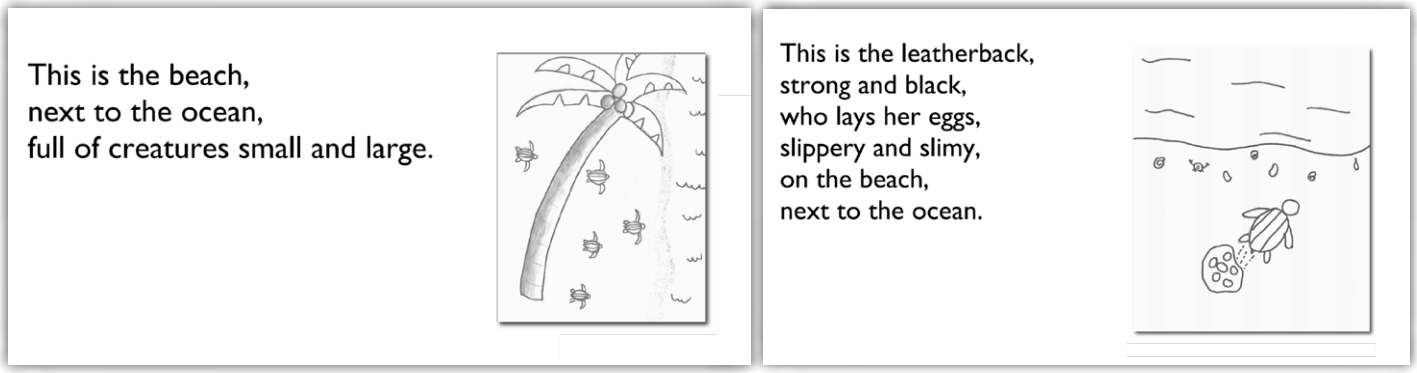

Figure 2a/b. The first two pages of "A Leatherback Turtle Story" written by first graders.

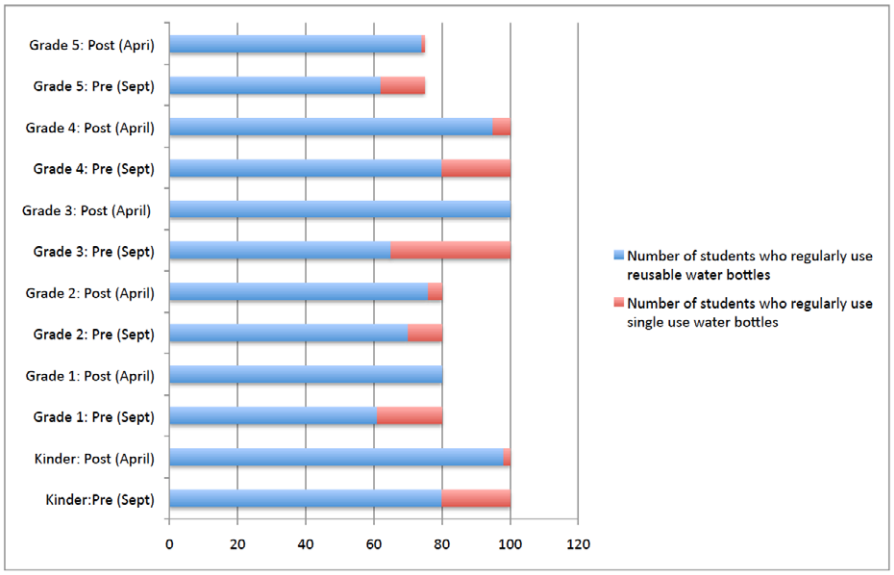

Figure 3. The number of students using water bottles in September compared to April across grades kindergarten through five.

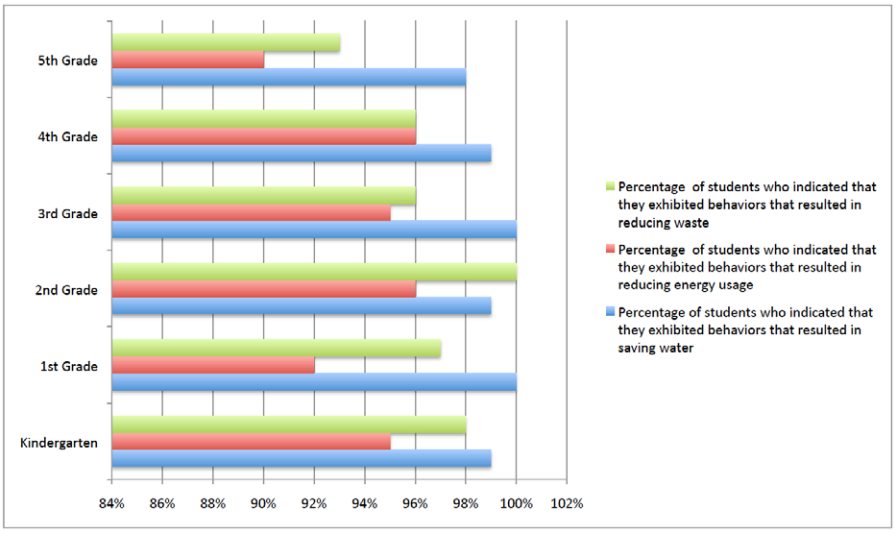

Figure 4. Percentage of students by grade level who indicated they reduced waste, reduced energy usage, and saved water.

To check out some of the items created by the *Eco Super Hero* group, click on the following: Eco Super Hero Kinder Presentation (intended to be shown by a kindergarten teacher who would record the number of students who raised their hands), Eco Super Hero iBook link, and Eco Super Hero Ads.

In addition, the Blue Crew students designed a turtle camp for all kindergarten and 1st grade students focusing on teaching the younger students about marine debris, reducing plastic usage, and leatherback sea turtles through a Turtle Camp Coloring Book (A Turtle Story) and Turtle Camp Rotations.

Evaluation

All of the activities implemented showed positive impact on student behavior and choice. For example, the usage of single-use water bottles declined in all grade levels between September, when the pre-project data was collected, and April, after the project was completed (Figure 3).

The biggest impact of implementation was on students saving water (Figure 4). The next greatest impact was on reducing waste and the least impact was on reducing energy use.

Conclusion

My goal of creating a stewardship project that provided opportunities for student leadership, student choice, and learning how to be a climate literate person was realized during this NOAA Climate Stewards year-long project. Students who attended the Eco Workshop or who part of the Blue Crew class were able to articulate what climate science was as well as the connections between human activity and the climate and felt like they had the tools to continue to make a difference in mitigating future impact.

References

NGSS Lead States. (2013). *Next Generation Science Standards: For states, by states*. Washington, DC: The National Academies Press.

(2009). *Climate literacy: the essential principles of climate sciences: a guide for individuals and communities*. Washington, DC: U.S. Global Change Research Program/Climate Change Science Program.

About the Author

Jessica Lura works at Bullis Charter School, a K-8 public charter school in California. A National Board Teacher and Google Certified Innovator, she has taught both elementary and middle school including first, second, third, and eighth grade. She can be reached at msjlura@gmail.com.

Photovoice for Children's Climate Change Engagement: *Using Digital Photography to Bridge Knowledge and Action*

Carlie D. Trott, Assistant Professor, Social and Community Psychology, University of Cincinnati

Abstract

A priority for climate change educators is to present evidence-based information while promoting students' positive engagement. A crucial avenue towards achieving these goals is to combine classroom activities with opportunities for students' active engagement with sustainable solutions through individual and collaborative action projects. The present article describes *Science, Camera, Action!* (SCA), a fifteen-week after-school program carried out with fourth- to seventh-graders. SCA's *Science* component used interactive activities to demonstrate the interrelationships between Earth's changing climate, ecosystems, and sustainable actions within communities. Photovoice, SCA's *Camera* component, involved the use of digital photography to explore youths' climate change perspectives and to identify opportunities for their active engagement. Finally, SCA's *Action* component aimed to cultivate youth potential as agents of change in their families and communities through the development and implementation of youth-led action projects. Action projects included local policy advocacy, a tree-planting campaign, a photo gallery opening, development of a website, and the establishment of a Boys and Girls Club community garden. Following the program, participants demonstrated increased climate change knowledge, improved pro-environmental attitudes and behaviors, and an enhanced sense of agency to positively impact the environment. They also gained a deeper appreciation for science (e.g., in school, careers, and society) and reported increased interest, confidence, and performance in school science.

Introduction

In the U.S., there is widespread public support for educating young people about climate change. A recent nationally representative study found that a large majority (78%) of U.S. adults believe that the causes, consequences, and potential solutions to global warming should be taught to children in schools (Leiserowitz, Maibach, Roser-Renouf, Rosenthal, & Cutler, 2017). So far, eighteen states—representing more than 35% of U.S. students—require climate change to be taught in the classroom through adoption of the Next Generation Science Standards for K-12 STEM (science, technology, engineering, and mathematics) education (National Science Teachers Association, 2017). Moreover, nearly 75% of public school science teachers report devoting classroom time to climate change,

indicating that most students are likely to encounter climate change at some point in their education (Plutzer et al., 2016).

A concern among teachers is the "doom and gloom" nature of the problem, and the need for activities that inspire and empower students (Plutzer et al., 2016). An important avenue for cultivating students' sense of agency is to offer opportunities for their active engagement. Social science research has consistently found that knowledge alone does not motivate action (Chawla, 2009), but that action is indeed a powerful antidote to negative emotions (Spence & Pidgeon, 2009). In the context of climate change, strengthening students' action competence involves presenting sustainable solutions at both personal and societal levels (Jensen & Schnack, 2006), and ideally, offering opportunities for individual and collaborative action. This article describes a novel after-school program, conducted as part of the National Oceanic and Atmospheric Administration's (NOAA) Climate Stewards Education Project, that used digital photography to bridge children's climate change knowledge with youth-led action projects for environmental sustainability.

In late 2017 the NOAA Climate Stewards Education Project changed its title to the NOAA Planet Stewards Education Project.

Science, Camera, Action!: Program Components and Implementation

Science, Camera, Action! (SCA) was a fifteen-week after-school program that combined interactive climate change education with digital photography to empower youth to act as agents of sustainable change within their families and communities. SCA was carried out with 55 fourth- to seventh-graders across three Boys and Girls Clubs in Northern Colorado. Program content was framed by the 'Head, Hands, and Heart' model for sustainability education (Sipos, Battisti, & Grimm, 2008), and its process was guided by photovoice methodology for purposes of science learning, placed-based inquiry and connection, and youth-led participatory action (Cook, 2015).

Science: Making the Invisible Visible through Hands-on Activities

SCA's Science component consisted of six, hour-long, hands-on activities to demonstrate the interrelationships between Earth's changing climate, ecosystems, and sustainable actions within communities (see Table 1). Educational program content explored the scientific and social dimensions of climate change under the theme "Making the Invisible Visible," while providing a platform

Table 1. Science, Camera, Action! (SCA) Program Overview

Week	Component	Topic	Activity
1	N/A	Introduction	Gallery Walk
2	S	Ecosystems	Weaving the Web
3	S	Climate vs. Weather	Climate and Weather with Skittles
4	C	Photovoice #1	Photo-printing and Discussion - Topics 1-2
5	S	The Greenhouse Effect	Greenhouse Gas Tag
6	S	Climate Change & Ecosystems	Oh Deer! & Glaciers: Then & Now
7	C	Photovoice #2	Photo-printing and Discussion - Topics 3-4
8	S	Sustainable Solutions #1: Energy & Waste	Energy Bingo & Carbon Footprint Contest
9	S	Sustainable Solutions #2: Teamwork & Leadership	Young Voices for the Planet Videos
10	C	Photovoice #3	Photo-printing and Discussion - Topics 5-6
11-15	A	Action Projects	Various

Note. S = Science: Educational activity; C = Camera: Photovoice process; A = Action: Collaborative action project. Each science activity was paired with a photovoice prompt. For example, following "Weaving the Web," participants were asked to find evidence of ecosystems in their own lives; "This week, we thought about how people, plants, and animals depend on one another for survival. In your own life, what examples of this can you find? What does this make you think about? How does it make you feel? Take a few photos of these ideas." Photovoice sessions followed each pair of SCA activities.

Figure 1. Students' brainstorm their ideas about climate change using the Gallery Walk method.

Figure 2. Participants' take photographs to connect climate change topics to real-world experiences.

for youth to take informed action on learned concepts (see Figure 1). Descriptions of each activity are available online (Trott, 2017).[1] In the framework of 'Head, Hands, and Heart,' the science component of SCA emphasized critical and systems thinking ("Head") through interactive activities to enhance climate change knowledge. SCA's Science component also introduced participants to various STEM disciplines (e.g., ecology, climatology), with particular emphasis on how STEM careers can make a difference in people's lives.

Camera: Bringing it Down to Earth through Photovoice Process

Following each science activity, participants used digital cameras in a process called "photovoice" (Hergenrather, Rhodes, Cowan, Bardhoshi, & Pula, 2009). Specifically, participants were asked to photograph images conveying their thoughts and feelings about program topics (see Figure 2). Subsequently, participants engaged in group discussions about the content and meaning of their photographs. During each of three photovoice sessions, participants were encouraged to narrate their photos and reflect on what they learned, while also making connections between their own and others' photographs and experiences. The final step in photovoice involved identifying common themes discussed during photovoice sessions and translating themes into action plans (Trott, 2017).

The main goals of photovoice methodology are to enable participants to record and reflect community strengths and concerns, to promote critical and reflexive group dialogue on important issues using photographs, and to promote social change (Wang et al., 2004). Although photovoice has traditionally been used as a participatory action research method, it has also been developed as a pedagogical technique, connecting students to science and empowering them to make improvements to the environmental conditions of their communities (e.g., Schell, Ferguson, Hamoline, Shea, & Thomas-Maclean, 2009). According to Cook and Quigley (2013):

> Applied as a pedagogical tool in science education, photovoice puts cameras into the hands of students in order to document and address scientific issues from their position and point-of-view. This technique offers students new and reflective ways to perceive their own world and the science around them, as well as the potential to generate change in their own community. (p. 340)

In the framework of 'Head, Hands, and Heart,' the photovoice method encouraged participants to experience connection ("Heart") to their surroundings through greater awareness of the interconnectedness of the natural world. Moreover, photovoice was intended to facilitate youths' ability to make connections between their own lives and SCA's science content, simultaneously making abstract science concepts more concrete as well as personally relevant.

1 Additional information about program content is available online at sciencecameraaction.com. For additional materials or questions about implementation, please contact the author directly.

Action: Putting Ideas into Motion through Individual and Collaborative Action Projects

In the final phase of SCA, participants contributed to sustainable change in their families and communities by: (1) Developing family action plans to promote engagement in small-scale, everyday sustainable solutions, and (2) Designing and carrying out a larger collaborative action project. In the latter, youth were supported in realizing their visions for a community-focused sustainability initiative. Both action projects were aimed to advance youth potential as agents of change. In the framework of 'Head, Hands, and Heart,' they each promoted youths' active engagement ("Hands") with learned concepts through everyday practices and innovative projects.

Family Action Plans. Halfway through the program, participants estimated their carbon footprints by filling out a 20-item survey (Trott, 2017). Items focused on youths' environmentally-significant behaviors and were summed into a total number of pounds of carbon dioxide emissions per year associated with their daily routines. Carbon dioxide-equivalent (CO2e) "scores" were then handed back, providing participants with individual-level recommendations for lowering their carbon footprint. Participants then developed and implemented family action plans to reduce their environmental impact. In the process, they were encouraged to take on a leadership role within their families, sharing knowledge and promoting sustainable actions in the areas of household energy use and waste.

Figure 3. Participants' reflect on digital photography to generate plans for action.

Collaborative Action Projects. In the final five weeks of SCA, participants translated their knowledge into collaborative action projects. After reflecting on themes derived from all photovoice sessions, participants engaged in a brainstorming and consensus process to formulate plans that were specific to their shared interests and goals (see Figure 3). The process of deciding on youth-led projects was open-ended, but bounded in terms of focus (i.e., climate change), time (i.e., five weeks), and funds (i.e., $500 or less). Action projects included local policy advocacy (i.e., a City Council presentation), a tree-planting campaign (see Figure 4), a "photovoice" gallery opening and program website to generate community interest and engagement with climate change solutions, and a community garden to provide local food to the Boys and Girls Club community (see Figure 5).

Figure 4. Following their speech to City Council emphasizing the importance of local leadership to address climate change, these participants were granted permission to plant trees in public parks.

Figure 5. After clearing an overgrown lot on the property of their Boys and Girls Club, these participants planted more than one hundred fruit and vegetable plants and formed a "Garden Club" for summertime garden maintenance.

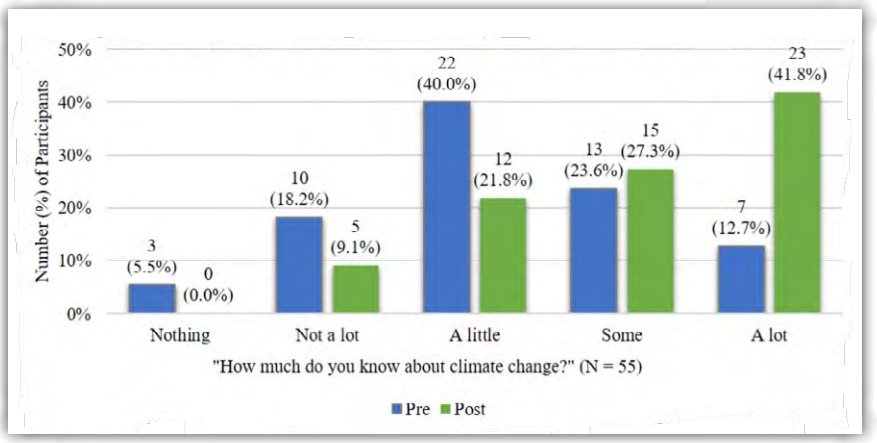

Figure 6. Pre-post program differences in self-estimated climate change knowledge.

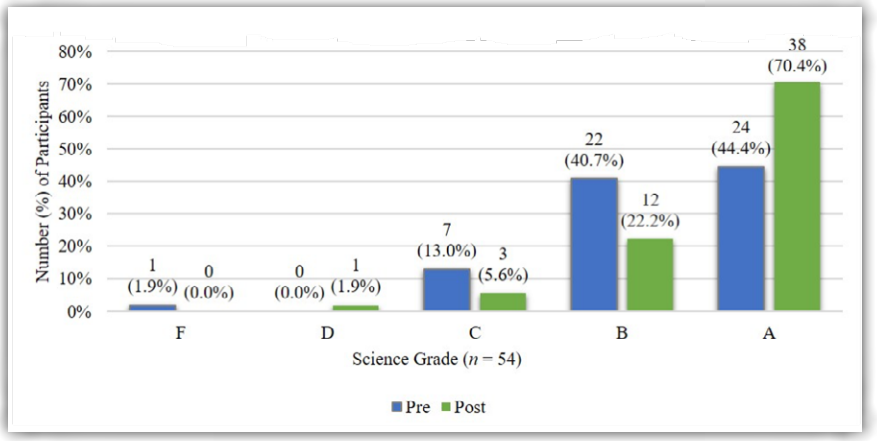

Figure 7. Pre-post program differences in self-reported science grades.

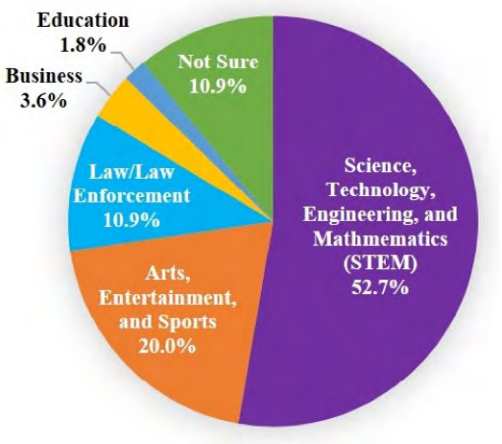

Figure 8. Post-program career aspirations by major career category.

Summary of Program Impacts

The SCA program was evaluated using a mix of pre-post survey and post-program focus group methods. Selected program impacts are presented below.

Climate Change Knowledge, Attitudes, and Behavior. Following the program, participants demonstrated increased knowledge of the scientific and social dimensions of the causes and consequences of climate change, as well as its solutions through human action. They also felt more informed on the issue, estimating their own knowledge to be greater following the program (see Figure 6). Participants left the program with an increased sense of respect for nature, an enhanced sense of environmental responsibility, and a greater sense of urgency towards the need for climate change action. Finally, participants reported increased engagement in personal pro-environmental behaviors.

Sense of Agency. As participants reflected on the impact of SCA during focus groups, it was clear that the program strengthened their self-confidence in their abilities. Many left the program feeling informed, capable, and inspired to continue making a difference for the environment. Participants commonly described undergoing a perspective-shift that allowed them to view themselves, and young people in general, as competent and effective change agents in their families and communities. Their improved self-confidence went beyond environmental problems to overcoming personal challenges. As one twelve-year-old put it, *"When I want to do something that is really hard for me to do, this [program] made me feel like I can be more confident in myself and have a better chance at actually being able to succeed."*

Science Engagement. Through SCA, participants gained a deeper appreciation for science (e.g., in school, careers, and society) and reported increased interest, participation, confidence, and performance in school science. Although most participants were already performing well in science class, many reported improved class grades (see Figure 7), and more than half aspired to a science career (see Figure 8). Several participants said that learning about climate change made science more interesting. As one eleven-year-old described, *"I didn't really like [science] before, and I wasn't interested in it. But now I know that you really need to know about it and you can't just ignore the changes happening in the world."*

Conclusion

The immensity of the challenges to social systems and lifestyles that climate change presents is palpable in urgent calls for global transformation towards sustainability. Climate change education in both formal and informal contexts is a promising avenue for strengthening children's role as knowledge-bearers and change agents for a sustainable future. Through SCA, youth participants demonstrated diverse psychosocial and educational gains, while simultaneously playing an active role in the sustainable transformation of their families and communities.

References

Chawla, L. (2009). Growing up green: Becoming an agent of care for the natural world. *The Journal of Developmental Processes*, 4(1), 6-23.

Cook, K. (2015). Grappling with wicked problems: Exploring photovoice as a decolonizing methodology in science education. *Cultural Studies of Science Education*, 10(3), 581-592.

Cook, K., & Quigley, C. F. (2013). Connecting to our community: Utilizing photovoice as a pedagogical tool to connect college students to science. *International Journal of Environmental and Science Education*, 8(2), 339-357.

Hergenrather, K. C., Rhodes, S. D., Cowan, C. A., Bardhoshi, G., & Pula, S. (2009). Photovoice as community-based participatory research: A qualitative review. *American Journal of Health Behavior*, 33(6), 686-698.

Jensen, B. B., & Schnack, K. (2006). The action competence approach in environmental education: Reprinted from *Environmental Education Research* (1997) 3(2), pp. 163–178. *Environmental Education Research*, 12(3-4), 471-486.

Plutzer, E., Hannah, A. L., Rosenau, J., McCaffrey, M. S., Berbeco, M., & Reid, A. H. (2016). *Mixed messages: How climate is taught in America's schools*. Oakland, CA: National Center for Science Education. Retrieved from ncse.com/files/MixedMessages.pdf

National Science Teachers Association (2017). *About the Next Generation Science Standards*. Arlington, VA. Retrieved from ngss.nsta.org/About.aspx

Leiserowitz, A., Maibach, E., Roser-Renouf, C., Rosenthal, S., & Cutler, M. (2017). *Climate change in the American mind: May 2017*. New Haven, CT: Yale Program on Climate Change Communication. Retrieved from climatechangecommunication.org/wp-content/uploads/2017/07/Climate-Change-American-Mind-May-2017.pdf

Schell, K., Ferguson, A., Hamoline, R., Shea, J., & Thomas-Maclean, R. (2009). Photovoice as a teaching tool: Learning by doing with visual methods. *International Journal of Teaching and Learning in Higher Education*, 21(3), 340-352.

Sipos, Y., Battisti, B., & Grimm, K. (2008). Achieving transformative sustainability learning: Engaging head, hands and heart. *International Journal of Sustainability in Higher Education*, 9(1), 68-86.

Spence, A., & Pidgeon, N. (2009). Psychology, climate change & sustainable behaviour. *Environment: Science and Policy for Sustainable Development*, 51(6), 8-18.

Trott, C. D. (2017). *Engaging key stakeholders in climate change: A community-based project for youth-led participatory climate action* (Doctoral dissertation). Available from Colorado State University Libraries. dspace.library.colostate.edu/handle/10217/181349

Wang, C. C., Morrel-Samuels, S., Hutchison, P. M., Bell, L., & Pestronk, R. M. (2004). Flint photovoice: Community building among youths, adults, and policymakers. *American Journal of Public Health*, 94(6), 911-913.

About the Author

Dr. Carlie Trott is an Assistant Professor in the Department of Psychology at the University of Cincinnati. Her research focuses on university-community partnerships for collaborative research and action to advance social justice and environmental sustainability. She received her M.S. and Ph.D. in Applied Social Psychology from Colorado State University (CSU). Previously, Carlie held a postdoctoral research fellowship with CSU's STEM Center. Carlie can be reached at carlie.trott@uc.edu.

Recycling at School: An Action Project

Kottie Christie-Blick, South Orangetown Central School District, New York State

Abstract

While many of us assume that recycling is now entrenched in our 21st century culture, analyzing recycling bins in public places, such as schools, quickly dispels that notion. This article describes an action project completed by 5th grade students in New York State as they focused their attention on their school's recycling bins and worked to increase recycling behavior in their school community. Students first collected photographic evidence of the use of recycling bins in classrooms and then used a variety of methods to educate fellow students on the importance of recycling. Two months later, they collected additional photographic evidence of bin use, and saw an increase in the number of bins used correctly. Students concluded that recycling behavior can be increased through education.

Introduction

In late 2017 the NOAA Climate Stewards Education Project changed its title to the NOAA Planet Stewards Education Project.

To become a NOAA Climate Steward, I was asked to complete an action project that would involve my students taking steps towards mitigating climate change. In return, I would receive free professional development in climate science, funding for school projects and conference attendance, and support from climate experts at NOAA (National Oceanic and Atmospheric Association). Little did I realize at the time of joining that I would continue on with the NOAA Climate Stewards Education Project, becoming a mentor to new members, and a continued presence in this powerful network of formal and informal educators who are working to get climate science into the schools, and engage children in environmental stewardship.

For my action project I focused on recycling in my school. There are recycling bins throughout the building, but as is often the case, they were often not being used correctly. With that in mind, the stage was set for my students to discover the problem, educate themselves about recycling, and take action to affect change. As far as my students were concerned, the goal of our project was to see if our school community was recycling correctly. Once answered, the goal became to determine if it is possible to alter recycling behavior through education. Additionally, my goal was to introduce my students to basic scientific data gathering and methodology, and the art of effective dissemination, while heightening their own awareness of the importance of recycling. This project involved two classes of 5th graders but would have been just as effective in middle school or high school.

As part of our Earth Science Unit (NGSS Earth and Human Activity), my students discussed ways in which humans impact Earth's systems (ESS3.C). They brainstormed ways to reduce air pollution to mitigate climate change. They researched online (see Resources for a link to a list of child-friendly websites). And they visited the local recycling center, learning that it takes less energy to re-make an item out of plastic, glass, metal, or paper than it does to manufacture it from scratch. They concluded that recycling to help the environment was a no-brainer. That led them to wonder: *Is our own school community disposing of trash properly, that is, in an environmentally friendly way? Are the school's recycling bins being used correctly so items can be recycled?*

My students set out to find the answer. Once they determined that the bins were often not used correctly, they worked to alter the community's behavior. The aim was to increase the recycling behavior of the community. They looked at trash in each type of bin (trash bin or recycling bin) as proxy evidence for recycling behavior. They gathered baseline data, worked to educate the school community, and then collected additional data to see if the bins were now being used correctly more often.

Methods

My students collected baseline data by photographing classroom trash bins and recycling bins in random classrooms around the school. This was done once a week, at the end of the school day, for three weeks. I had emailed all the teachers ahead of time, letting them know that my students would be photographing bins as part of a class project. I asked them not to discuss it with their own students yet. If their students asked, they would just tell them it was for a project for one of the other classes. I assured teachers that we were not interested in any individual's results, and that there would be no identifying features in the photographs. We were only interested in the aggregate results. Students took one photo of each bin in each classroom, pointing the camera straight down into the bin (Figure 1). They did not photograph any bins that were empty.

Figure 1. Student gathers photographic evidence to determine if the recycling bin is being used correctly.

My students analyzed this photographic evidence at the end of three weeks. I projected each photograph on the Smartboard. We could distinguish bins by their color. All paper recycling bins in our school are blue; all hard, plastic recycling bins are green; all trash bins are grey or black. The children tallied all bins that had correct items in them: only paper products in the paper bin, only hard, plastic bottles (with no water in them) in the plastic bin, only non-recyclables in the trash bin. If there was even one incorrect item in the container, the tally mark went into the column showing that it was not being used correctly.

We discovered that out of 50 usable photos (some were so blurry that they were unusable), 14 pictures showed the bins had been used correctly (paper in the paper bin, empty plastic bottles in the bottle bin, garbage in the trash bin). That meant that only 28% of the bins were being used correctly on a typical school day. While analyzing the photos, it became clear that even my science students were confused about the correct use of recycling bins. Common misconceptions: it's alright to put partially filled drink containers in the plastic recycling bin if the lids are on; tissues and paper towels go in the paper recycling bin; paper plates with food on them go in the paper recycling bin.

Using this as our baseline data, the students brainstormed ways to increase recycling at school. They hypothesized that if students were taught how to recycle properly, and understood the importance of recycling, they'd dispose of their trash properly (in an environmentally friendly way) at school.

Figure 2. Students created posters to hang in the school hallways to encourage recycling.

Brainstorming and planning during science class, and after school on their own, the children came up with a number of ways to help educate the student community about recycling. They designed posters, which they mounted in the school hallways (Figure 2). They wrote "Public Service Announcements," reminding students to recycle properly. Individuals read these over the intercom to the entire school once a week for two months. They talked to students around the school about the importance of recycling. They created amusing, educational skits about recycling properly, which they performed at a school-wide assembly. They had a family member photograph them at home recycling and performing other actions that would demonstrate environmental stewardship. Parents emailed the photographs to me, and I uploaded them to make Animoto videos, one for each of my two science classes. (See Resources.) The videos were also shown at the assembly. Our goal was to educate the student community about recycling, while also adding a bit of societal pressure, making concern for the environment seem cool, and recycling the right thing to do. Children have the ability to achieve this in a way that is unattainable by adult presenters.

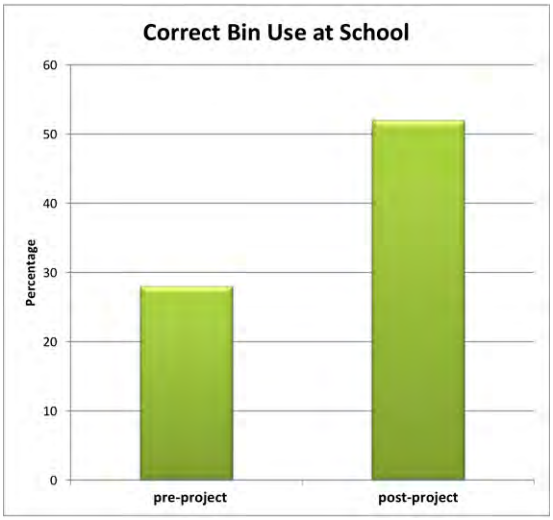

Figure 3: After educating the school community, 52% of the trash and recycling bins were used correctly, compared with only 28% used correctly before the start of our recycling action project.

Results

Two months later, my students again photographed bins around the school for three weeks, accumulating another fifty usable photographs of classroom bins. Did their actions make a difference? Did they affect change in the recycling behavior of our school community? Analyzing the photographs, the students tallied the number of bins that had been used correctly, and those used incorrectly. The criterion was the same: if even one piece of trash in the bin was inappropriate for that bin, the children had to consider the bin used incorrectly. This time, out of 50 photos, 26 showed the bins had been used correctly; 24 incorrectly. That is, 52% of the bins were used correctly, up from 28% before the students' recycling campaign (Figure 3).

Discussion

We celebrated that there had been a marked increase in correct recycling at school. At the outset of this action project, we had hoped that after educating the school community there would be close to 100% of the trash bins and recycling bins used correctly. While we were disappointed that the results indicated only 52% were being used correctly after our education campaign, we concluded that the evidence of change from 28% to 52% of bins used correctly showed that my students' dissemination of information, and their acting as role models of environmental stewardship, had significantly increased the recycling behavior of our school community.

Anecdotal evidence also showed that my own science classes developed an appreciation for the scientific methodology. They were able to explain the need for quantifying information in order to

measure change. They demonstrated an understanding of the importance of recycling. In class, they discussed what they saw in bins around the school, expressed their dismay at egregious offenses against responsible disposal of waste, and excitedly planned creative ways to educate the community. They also, voluntarily, worked on posters, skits, and an Animoto video outside of class time. Additionally, their own heightened awareness of the importance of recycling meant that my own classroom recycling bins were now being used properly by students every day.

Class discussion provided insights into probable reasons why there wasn't higher compliance of correct waste disposal. We concluded that habits are difficult to break, especially one that is as automatic as throwing away a piece of trash. However, measuring positive change in behavior during the limited time of our action project suggests that additional repeated encounters with the recycling message and societal pressure would yield additional increases in recycling behavior. This was a simple action project designed for elementary students in the 5th grade. I would welcome information from middle school and high school teachers who replicate this project with older students in a larger school, and, if possible, over a larger period of time with more recycling education for the students.

Note that we did not count or weigh the recyclables, as has been done in other action projects involving students. That data would be irrelevant to this study. We were not looking to generate more recyclable trash, nor less garbage. Our goal was to have people categorize their waste correctly, no matter how much or how little, so they would become conscientious recyclers at school. People don't like to think of themselves as being hypocritical, so there's reason to think that if they understand the importance of recycling to the degree that they actually recycle correctly at school, they will also recycle at home.

Conclusion

I once attended a presentation by Alan Alda, early in life a famous actor (think M.A.S.H.), and now, later in life, a famous communicator of science to the general public. In his talk, "Getting Beyond a Blind Date with Science," (Columbia University, May 6, 2015), he explained that getting the public to appreciate science is like dating. There are three stages: attraction, infatuation, and then commitment. To get children to appreciate the importance of environmental science and the need for stewardship, first we need to attract them to the topic, next help them become infatuated with the concept of helping the planet, and then, with continued exposure, will come personal responsibility.

Acknowledgements

I'm grateful to NOAA's Climate Stewards program for the professional development they offer, as well as for the opportunities they afford teachers as we work together to get climate science into schools.

Resources

NASA Climate Kids: climatekids.nasa.gov/

NOAA Planet Stewards Education Project: oceanservice.noaa.gov/education/planet-stewards/

National Geographic: natgeokids.com/uk/discover/geography/general-geography/what-is-climate-change/

The Climate Reality Project: climaterealityproject.org/blog/just-kids-what-climate-change-and-what-can-i-do

Kids Against Climate Change: kidsagainstclimatechange.com/

Animoto video: animoto.com/play/jr1fazm1aPgrObEFuMXL1Q

Reference

NGSS Lead States. (2013). *Next Generation Science Standards: For states, by states*. Washington, DC: The National Academies Press.

About the Author

Kottie Christie-Blick is a teacher in the South Orangetown Central School District in New York State. She is also an educational consultant who specializes in teaching educators how to teach about climate change. She is the creator of the children's blog kidsagainstclimatechange.com. She is a NOAA Climate Stewards Educator and a Distinguished Fulbright Teacher. Kottie can be reached at kchristieblick@socsd.org.

Marine Debris Tools for Educators: Making the Connection Between Us and Debris

Krista Stegemann, New York Sea Grant, Ocean & Marine Outreach Coordinator for New York Ocean Action Plan

Abstract

There are many resources available to educators to assist in discussing marine debris with their classes and encouraging students to realize the connection they have with this massive pollution problem. The *Washed Ashore Integrated Arts Marine Debris Curriculum* does this through educating and communicating about marine debris through the arts. The *Marine Debris Monitoring Toolkit for Educators* helps students learn about this topic through marine debris surveys, data collection, analysis, and outreach. Both resources present the marine debris issue to students in a relatable way and assist teachers with tackling this subject in their classrooms.

Introduction

Marine debris is one of the most widespread pollution problems facing our ocean and waterways today (Figure 1). This issue of solid, man-made materials in the ocean or Great Lakes is a global one that leaves no part of the world untouched by debris and its impacts. Any man-made item can become marine debris, from small microplastics all the way to large abandoned and derelict vessels. The negative effects of debris can range from damage to habitats and ingestion by or entanglement of marine animals, to economic losses, threats to navigation safety, and impacts to human health.

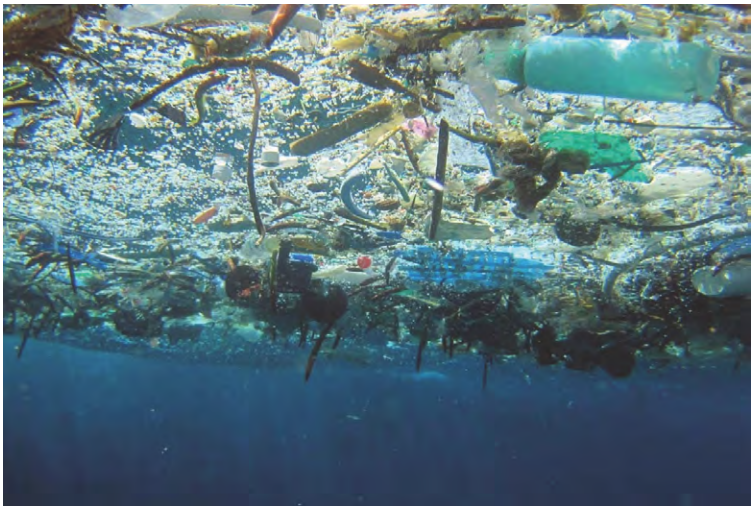

Figure 1. Marine debris is one of the most widespread pollution problems facing our ocean. Photo Credit: NOAA

Marine debris originates from a variety of sources, both from land and sea, but is a completely human-caused problem. Preventing items from becoming debris in the first place is the ultimate solution to this widespread issue and is achieved through marine debris education and outreach. Involving youth in marine debris solutions and encouraging students to form connections to their natural world is an important first step toward addressing the problem and moving toward a debris-free future. Enabling

children to make the connection between their lives and habits and marine debris can help make this issue more relatable and emphasize the importance of every person's efforts.

There are several resources available to educators to achieve this goal of connecting students with environmental issues like marine debris. The *Washed Ashore Integrated Arts Marine Debris Curriculum* and the *Marine Debris Monitoring Toolkit for Educators* are just two examples. These two resources work to foster students' realization of their connection to the marine debris problem through lessons, activities, art, and marine debris surveying.

> Marine debris is legally defined as "any persistent solid material that is manufactured or processed and directly or indirectly, intentionally, or unintentionally, disposed of or abandoned into the marine environment of the Great Lakes."
>
> — Marine Debris Research, Prevention, and Reduction Act (33 U.S.C. 1951-1958 (2006))

Washed Ashore Integrated Arts Marine Debris Curriculum

The *Integrated Arts Marine Debris Curriculum*, developed by the *Washed Ashore Project* and funded by the National Oceanic and Atmospheric Administration (NOAA) Marine Debris Program, is composed of lessons and activities to educate students about marine debris and encourage behavior change as part of the solution. Building off the *Washed Ashore Project*, which raises awareness about marine debris through the creation of large and captivating marine debris sculptures, this curriculum takes the next step to target behavior change in students.

Released in 2017, this curriculum is composed of twelve lessons, each about 45-minutes long, as well as three additional extension lessons. Each lesson focuses on a different topic area related to marine debris, including color and emotion, plastic, how long substances can last in the environment, where trash goes, the connection between people and debris, single-use plastics, packaging, and the use of the arts to communicate about marine debris. Throughout the course of the curriculum, students work to create their own marine debris artwork and participate in activities to help them visualize the connection between themselves, the waste they produce, and marine debris.

As students create their own marine debris art, they are working to demonstrate our throw-away culture and the alternatives to such behavior. By the end of the final lesson, students have created a large plastic mask art piece, representing our throw-away lifestyles and how they have contributed to the marine debris problem we face today, as well as an "eco mask" to represent the alternatives to these habits which can help to prevent debris at its source (Figure 2). To complete the curriculum and the creation of these masks, several supplies are needed, including many plastic single-use items and packaging, other pieces of common household trash, wire, paper clips, glue, caulk, scissors, pliers, and wire cutters. A full supply list can be found along with the curriculum at http://washedashore.org/iamdc

In addition to the creation of art pieces to communicate the marine debris issue, students also partake in several activities specifically designed to foster the realization of our connection to marine debris. One such activity, found within Lesson 7 of the curriculum, focuses on teambuilding and reinforcing the concepts that we are all connected and that there is no "away" when we throw our trash "away." Using a partition between two teams, each with a pile of trash in front of them,

Figure 2. Masks created by a class in Bandon, Oregon, during a pilot of the Integrated Arts Marine Debris Curriculum. Photo Credit: Washed Ashore

students are instructed that the team with the cleanest side will win the game. No other instruction is given. Since this is a teambuilding exercise that is designed for students to come to conclusions on their own, very little instruction is given throughout the course of the activity. Students spend the next few minutes cleaning their side of the partition by tossing trash to the other side. When their time is up, they realize that their area is still just as dirty as it was, since as they were tossing their trash, items were coming at them from the opposite side as well. After a few rounds with time for strategizing in between, students realize that the only way to keep their side clean is by taking responsibility for their trash, picking it up, and holding it in their arms, effectively cleaning the floor on their side of the partition. This leads to a discussion about how we are all connected by the ocean, and how we have to be responsible for our trash, which never goes "away"—realizations that the students have arrived at themselves.

Although this curriculum is designed to be presented in its entirety and is aligned with national standards focused on fourth through sixth grade students, the lessons and activities, such as the example given above, are still able to stand alone and can be modified for any grade level. The curriculum is unique in focusing on communicating about marine debris through the language of the arts and incorporates the subjects of art, science, language arts, and social studies.

Table 1. Grade 5 to 8 Next Generation Science Standards addressed in the *Integrated Arts Marine Debris Curriculum*

Performance Expectations
5-PS1-1. Develop a model to describe that matter is made of particles too small to be seen.
5-LS2-1. Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.
5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.
MS-PS1-3. Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.
MS-LS2-1. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
MS-ESS2-6. Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.
MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
MS-ESS3-4. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

Connections to the Next Generation Science Standards

The *Integrated Arts Marine Debris Curriculum* is informed by the most accurate NOAA science and utilizes the Next Generation Science Standards augmented by the Essential Principles of Ocean Literacy Campaign, Principle 6: The Ocean and Humans are Inextricably Interconnected (Table 1).

Marine Debris Monitoring Toolkit for Educators

Similarly, the *Marine Debris Monitoring Toolkit for Educators* is designed to enable students to see the connection between themselves and marine debris (Figure 3). Created through the collaborative efforts of the NOAA Office of National Sanctuaries and the NOAA Marine Debris Program, this toolkit works to adapt the pre-existing Marine Debris Monitoring and Assessment Project (MDMAP) for use by teachers and students. The MDMAP is a robust citizen science initiative that engages volunteers around the country in surveying for marine debris and recording what they find. Each volunteer selects a local shoreline monitoring site that they return to monthly for this purpose, submitting their results to a national database. Using this *Toolkit*, educators can involve their class in this data collection. This includes submitting their data into the same national database, where they can also have access to others' datasets, including those collected by other classes.

Only recently released for use, the *Toolkit* targets middle to high school students and simplifies the rigorous MDMAP citizen science initiative, including references to all the resources needed to make marine debris monitoring work for a class. It is comprised of four sections—teacher resources, guidelines for data collection, guidelines for data analysis, and community engagement and outreach. These are designed to lead a class through the process of learning about the subject,

collecting marine debris data and analyzing it, and reaching out to the local community to help prevent debris. The *Toolkit* includes a PowerPoint presentation to introduce classes to the subject of marine debris, the necessary datasheets, and a supply list, which lists items such as survey flags, measuring tape, gloves, bags, and other items needed for completing marine debris surveys.

Students are able to connect to the marine debris issue by seeing first-hand the kind of debris that is in their local area. By considering where this debris might come from and analyzing their data, they can strategize about their outreach and messaging approach to target debris most effectively. This not only helps to make the connection between people and debris, but to encourage a sense of empowerment and responsibility within students. For instance, students from the Goleta Family School in Santa Barbara, California, observed plastic wrappers from toothpicks and mints at their local beach over multiple months. After evaluating where this debris was coming from, they were able to approach a local beachfront restaurant owner to ask for individually-wrapped toothpicks and mints to stop being served. With a monitoring program such as that outlined within the *Toolkit*, students are then able to observe any changes to debris as a result of their efforts.

Tools in Use

The *Washed Ashore Integrated Arts Marine Debris Curriculum* and the *Marine Debris Monitoring Toolkit for Educators* have proven to be useful resources for connecting students to the marine debris issue. Responses from students and teachers have been positive to both resources.

The *Washed Ashore Integrated Arts Marine Debris Curriculum*, launched in early 2017, was first piloted in schools in Bandon, Oregon, home to the Washed Ashore Program. Following the successful pilot and launch of the curriculum, NOAA has used portions of the curriculum as stand-alone resources, particularly the tossing trash activity previously described. This activity was used with middle school students on several occasions, with students performing exactly as prescribed and arriving at the intended conclusions. The *Marine Debris Monitoring Toolkit for Educators*, has been reviewed, piloted, revised, and is now in use by many educators.

Both the *Washed Ashore Integrated Arts Marine Debris Curriculum* and the *Marine Debris Monitoring Toolkit for Educators* can be accessed and downloaded free of charge. These resources can be used as a complete program as they were intended or can be broken into smaller segments. The *Washed Ashore Curriculum* is designed for middle school students, although the lessons and activities have been found useful for all ages and can be easily adapted if needed. The *Monitoring Toolkit* is targeted toward middle and high school students but may be adapted and the resources used for younger students as well.

These and other marine debris educational materials can be found at the NOAA Marine Debris Program website: marinedebris.noaa.gov/

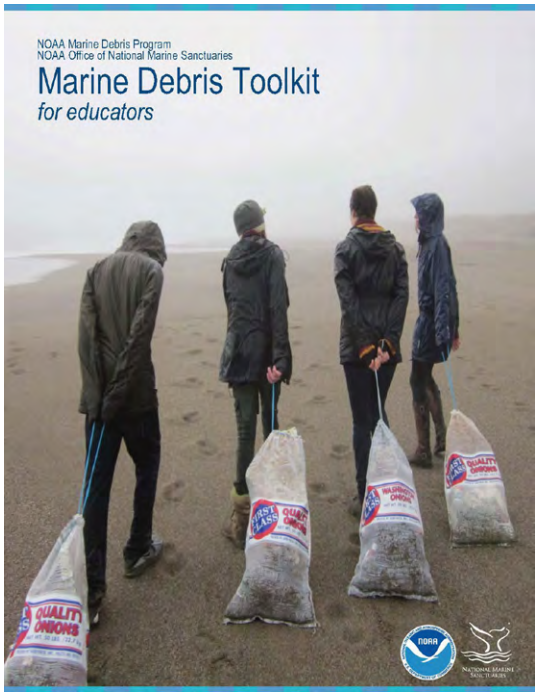

Figure 3. The Monitoring Toolkit for Educators simplifies the robust Marine Debris Monitoring and Assessment Project citizen science initiative and is available free of charge. Photo Credit: NOAA

If you still feel that the *Marine Debris Monitoring Toolkit for Educators* is too much for your class, you can still get involved with monitoring debris and recording your data. Use the Marine Debris Tracker app (marinedebris.engr.uga.edu/) to record what you find and add data to a national database.

Figure 4. Marine Debris Tracker App. Photo Credit: NOAA

About the Author

Krista Stegemann is the Ocean & Marine Outreach Coordinator with New York Sea Grant in Stony Brook, NY. She previously worked as the Education & Communication Specialist with the NOAA Marine Debris Program. Krista has a background in both marine biology and education, with B.S. and M.S. degrees in marine biology from the University of New Hampshire and James Cook University, respectively, as well as previous experience as the founding fifth-grade science teacher at an inner-city charter school in Little Rock, Arkansas. She can be reached at krista.e.stegemann@noaa.gov.

Ecosystem Pen Pals: Connecting Indigenous Fishing Communities through National Marine Sanctuaries

Nicole Harris, NOAA Olympic Coast National Marine Sanctuary, and
Karen Matsumoto, Climate Change and Environmental Science Educator,
Suquamish Tribe

Abstract

The marine environment holds important knowledge through lessons in science, literature, and social studies providing opportunities for place-based observations and investigations exploring natural and cultural connections. *Ecosystem Pen Pals* is a cultural and natural history exchange program that brings together students from different regions in the Pacific Rim – the Hawaiian Islands, American Samoa, and the western coast of Washington State. Through sharing of common ideas among indigenous communities across the Pacific, this project connects students who study and research in parallel about their local natural environment and cultural community. Through this connection across geographic boundaries, students from different cultures can strengthen their understanding of global marine issues, particularly around shared concerns about climate change and ocean acidification, and their impacts on fisheries, economy, and culture.

Figure 1. A sea star on the shore of the Channel Islands National Marine Sanctuary. Credit: Ellie Burck, Ocean for Life, NOAA

Introduction

National marine sanctuaries are a network of underwater parks encompassing more than 600,000 square miles of marine and Great Lakes environments. This network, managed under NOAA's Office of National Marine Sanctuaries and made up of 13 national marine sanctuaries and Papahānaumokuākea and Rose Atoll marine national monuments, works to protect America's most iconic natural and cultural marine resources. Within these waters, whales breed and bear young, corals flourish, and shipwrecks tell stories of our marine history. Sanctuary habitats include beautiful coral reefs, lush kelp forests, intertidal zones teeming with life, spectacular deep-sea canyons, and underwater archaeological sites (Figure 1). Sanctuaries across the nation offer natural outdoor classrooms where students can engage in place-based inquiry driven investigations enhancing their understanding of our changing ocean environment and the potential impacts on local and global marine resources.

Indigenous communities around the Pacific Rim have depended on the marine environment for millennia, utilizing the ocean for food, transportation, and economy. Unfortunately, our changing ocean and climate, disproportionately influences indigenous communities. Their culture and economies are some of the most vulnerable to climate related catastrophes (Grossman and Parker, 2012). Research shows that providing culturally relevant education creates opportunities for indigenous students to use traditional knowledge in combination with Western science to broaden the knowledge base for thinking and acting critically in the world, and in understanding particular environmental problems (Chinn, 2011). Combining indigenous learning systems and Western science give students insights into regional ecology, which supports the link between conservation of biodiversity and conservation of cultural diversity.

Ecosystem Pen Pals is a cultural and natural history exchange program, using pen pal exchange as a learning tool to bring together students from different regions in the Pacific Rim – the Hawaiian Islands, American Samoa, and the western coast of Washington State. Sharing common ideas, values, and traditional ways of knowing, students investigate community and marine health through culturally significant resources and habitats, fostering support for marine conservation while facilitating cultural themed written exchanges between students. The school-year long program encourages cross-cultural understanding and promotes personal relationships between indigenous students facing similar issues in regard to fisheries, food sovereignty, and environmental change due to global climate change and ocean acidification (Figure 2).

Figure 2. Suquamish students engage in service project at the 400-year-old traditional Waikalua Fish Pond to remove invasive algae and learn about traditional Hawaiian fisheries management.

The Lessons

Students are paired up and begin a pen pal correspondence with students at a partner school. Students are required to write a minimum of three letters to their pen pal. As part of the program students study and document their own natural ecosystem, producing a field guide or poster that they share with their pen pal, partner school across the Pacific. Students and their families also put together an "ecosystem suitcase" that they fill with natural and cultural artifacts to gift to their partner school. The program culminates with a teleconferenced and in-person symposium for sharing of challenges and solutions to our changing environment and the effect on indigenous ecosystems, culture, economy, and traditional ways of life life (See Table 1 for a suggested timeline for activities). Project components include:

1. Letter Writing Exchanges

In conjunction with each of the three projects listed below, students write to an assigned pen pal throughout the school year. Each student is given an ecosystem pen pal from the selected sister school to write four letters or postcards while each project component is completed. Letter templates are encouraged for elementary students.

- **Letter writing #1** – Students introduce themselves, tell their pen pal about who they are, where they come from, what activities they like, their favorite thing to do outside, and a bit about their cultural background. Because the majority of students will come from indigenous communities, students can share some stories or information about their Tribe or community.

- **Letter writing #2** – Students write about their local ecosystem and the nearby national marine sanctuary. They also include information about the natural and cultural aspects that make their communities unique. Sanctuary education and outreach staff can provide information about their local sanctuary through internet or local presentations.
- **Letter writing # 3** – Students write about concerns they have regarding the ocean, how they feel about climate change and ocean acidification, how ocean changes may affect their ecosystem, and what steps they are taking to protect the ocean. Students can also focus on the impacts that climate change and ocean acidification may specifically have on their local community. (Example: How ocean acidification may affect shellfish or fin fish harvest in their community.)
- **Letter writing # 4 or video conference sharing** – Students share what they learn about their friends' ecosystem and how it is similar/ different to their own. Students are encouraged to thank their buddy for sharing their knowledge and provide contact information if they would like to continue to stay in touch. This can be shared through the video conference or poster at the culminating symposium as opposed to a fourth letter.

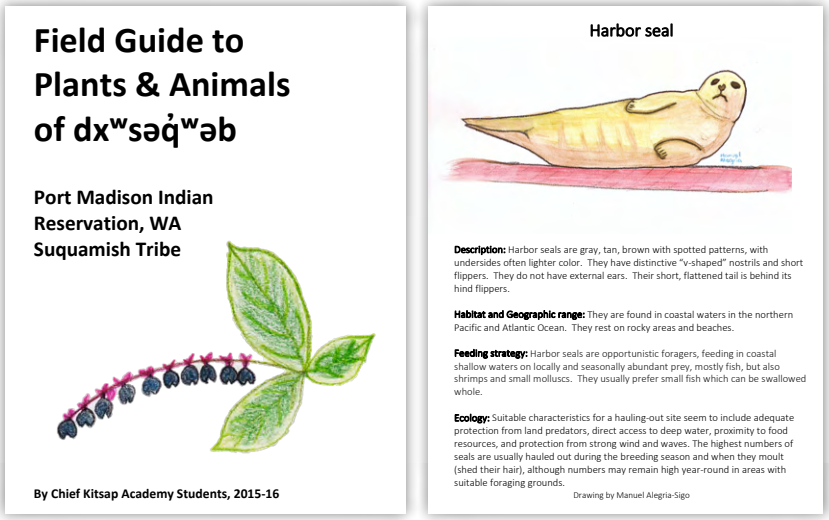

Figure 3. Field Guide cover and sample page created by Suquamish students.

2. Field Guide

Students research, design, and create field guides of their local environment and communities with a focus on understanding natural and cultural systems (Figure 3). Each class conducts research on their local marine environment, with emphasis on their designated national marine sanctuary. Each student selects a species from their local marine environment/nearby national marine sanctuary and completes the field guide template. Students research their selected species and provide a drawing or picture, description of behaviors, adaptations, and threats. A variety of species are selected to represent the ecosystem. As a class, items are assembled to develop a field guide for their national marine sanctuary ecosystem and shared with the sister school classroom.

3. Ecosystem Suitcase

Students create an 'ecosystem suitcase' with objects from the natural environment, as well as cultural pieces selected by the students. Upon completion of the field guide, each class develops an ecosystem suitcase by compiling a box of artifacts that represent their natural marine ecosystem and local culture. Teachers facilitate a discussion with the class about the items to include. Items should represent both natural and cultural aspects of the marine area. Artifact selection needs to consider the potential hazards when transporting, therefore, no live specimens, seeds, or plants can be included; this also provides an excellent opportunity to discuss invasive species. Once a list of items is selected, students break into groups and are tasked with collecting one of the items for the suitcase. Each group writes a paragraph about the object included. Artifacts are gifted to the sister school along with a written packet explaining each item. Some examples of objects that can be included are:

- Animal "replica-skulls" of animals found in their ecosystem

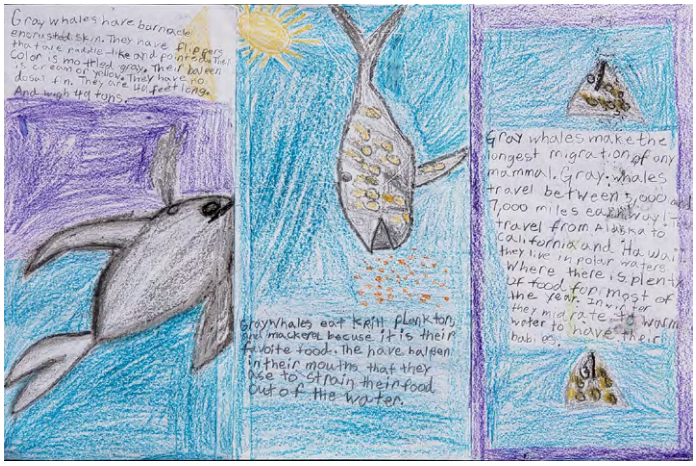

Figure 4. Student drawing and research of a local animal, the gray whale.

Figure 5. Suquamish students at the Ecosystem Pen Pal cultural exchange at Luluku Organic Farm, Oahu learning how to process taro and make poi.

- Fish prints of local native fish (made by students)
- Feathers of common birds, but unique to their ecosystem
- Shells of commonly harvested marine food species
- Local stories or music
- Photographs or drawings of local plants and animals
- Food items, such as smoked salmon or coconut
- Pressed plants
- Cedar woven baskets or carved paddles (Washington Tribes)
- Kukui nut bracelets or woven palm bookmarks (Pacific Islands communities)

Table 1. Ecosystem Pen Pals suggested timeline for school activities

SUGGESTED TIMELINE FOR SCHOOL ACTIVITIES	
Month	**Scheduled activity**
June-September	Selection of schools and locations for exchange
September	Introduction to program, teacher commitment and planning meeting
October	Introduction letter writing # 1
November	Field guide assignment
December	Letter writing # 2, development of ecosystem suitcase
January	Ecosystem suitcase completion
February	Letter writing # 3
March	Development of class ecosystem poster
April	Letter writing # 4, ecosystem poster completion
May	Video web conference

4. Video Conference and Ecosystem Poster

Students communicate through social networking such as Google Hangout for group presentations and Skype or FaceTime (or similar program) for individual correspondence. The entire class can participate during a social media culminating exchange activity at the end of the program.

This last large-scale project involves the design of a classroom poster that represents what the students learned throughout the year. Each student submits a photograph or drawing that represents his or her local culture, natural environment, or sanctuary ecosystem. Pictures are then assembled and printed as one large poster collage for the sister school; each student can also receive a smaller copy of the poster to take home. Video conferencing with the sister school will be held so that the students can explain their posters. Sharing of culturally relevant food at the end of the program is also suggested (Figure 5).

Results

Similarities in culture and indigenous learning systems from diverse regions in the Pacific can connect students despite great distances. By exploring natural and cultural environments and using the marine environment as a context for sharing, students can develop a bioregional understanding,

helping to shape their identities, connect with their surroundings, and foster cultural responsibility and local knowledge. By harnessing the connection to place (Semken, et. al., 2017) that is engrained in indigenous culture, *Ecosystem Pen Pals* encourages understanding the importance of the environment in our daily lives.

The project began in summer of 2015, with teacher recruitment in Hawaii, American Samoa, and Western Washington. The 2015 year focused on middle and high school students, anticipating more in-depth conversations and investigations on ocean health in relation to fisheries, food sovereignty, and environmental change. See Table 2 for outcomes outlined for the 2015/16 *Ecosystem Pen Pals* program.

Table 2. Projected outcome for students, teachers, and the Ecosystem Pen Pals program

	Short term outcomes	Medium term outcomes	Long term outcomes
Student outcomes	Students and local communities learn about ocean acidification. Students gain bioregional understanding of marine ecosystems. Students from indigenous communities connect across Pacific Rim. Students gain experience in expository writing and communication skills.	Students demonstrate increased involvement in traditional practices. Students demonstrate interest and involvement in marine activities. Students develop long-term relationships with other students across Pacific Rim.	Students appreciate and participate in lifelong indigenous culture and traditions. Students adopt a lifelong commitment to marine conservation. Students pursue marine career paths in NOAA mission-critical disciplines.
Teacher and program outcomes	Teachers teach traditional learning systems with Western science.	Teachers demonstrate support for teaching traditional learning systems.	Program provides a lasting model for cultural and ecosystem exchange in indigenous communities.

Evaluation of the program consisted of a post-program survey of students, a brief interview with participating teachers and selected students, and observation of a culminating celebration event. Evaluations of 91 participating students showed that the *Ecosystem Pen Pals* project positively changed students' attitudes about conservation and connecting with long-distance peers, as well as more than two-thirds of the participating students surveyed (68 percent) had a greater appreciation for indigenous and cultural practices. Two-thirds of respondents (64 percent) agreed they "know a lot more about what causes ocean acidification," and more than two-thirds (69 percent) agreed they "know what ocean acidification is doing to the local ecosystem." Slightly more than half (54 percent) were in agreement they "know what to do about ocean acidification (Anderson, 2016)."

Teachers surveyed felt that while there were challenges to the timeliness and flow of the program, and the ability to fit the program within a science class framework at the high school level, they could easily identify benefits to their students including:

- A better understanding of their ecosystem and the science behind it through research,
- Empowering teens to share knowledge with other teens,
- A global perspective on marine issues, especially ocean acidification and warming sea temperatures and the effect on local communities in Washington State and Hawaii, and
- Letter writing skills – some students didn't know their own address or how to address an envelope!

In the 2016/17 school year the *Ecosystem Pen Pals* program moved to elementary classrooms, based on lessons learned from the pilot program conducted in 2012-2013 with fourth and fifth grade students between Neah Bay, Washington and Hawaii (Weiner and Matsumoto, 2014). While the context of changing ocean conditions in relation to cultural resiliency may seem too complex for the elementary grade level, students and teachers have the benefit of conducting investigations or writing letters during science and English subject time. Participating elementary students gained a better understanding of their ecosystem and the science behind it through research, presentations, and hands-on place-based field investigations, and also gained a friend. Pen pal friendships can be effective in encouraging cross-curricular learning through peer support. These exchanges help to create open relationships where the students feel free to engage with others that they have never even met, fostering a broader worldview.

References

Anderson, Andrea. (2016). Pen Pals Report. Soundview Evaluation and Research. Lake Forest Park, WA.

Chinn, P. W. (2011). Developing a sense of place and an environmental ethic: A transformative role for Hawaiian indigenous science in teacher education? In Reyhner, J, Gilbert, W.S, and Lockard, L (Eds). *Honoring Our Heritage: Culturally Appropriate Approaches to Indigenous Education*. Flagstaff, AZ: Northern Arizona University: 75-95.

Grossman, Z and Parker, A (EDs) (2012). *Asserting Native Resilience: Pacific Rim Indigenous Nations Face the Climate Crisis*. Corvallis, OR: OSU Press.

Semken, S., Ward, E. M. G., Moosavi, S., & Chinn, P. W. U. (2017). Place-based education in geoscience: Theory, research, practice, and assessment. *Journal of Geoscience Education, 65*(4), 542-562.

Wiener, Carly and Matsumoto, Karen (2014). Ecosystem Pen Pals: Place-Based Marine Science and Culture. *Journal of Geoscience Education*, 62, 41-48

About the Author

Nicole Harris is an Education Specialist with the National Marine Sanctuary Foundation in support of NOAA's Olympic Coast National Marine Sanctuary, in Port Angeles WA. She has a background in Early Childhood Education and a Bachelors from Western Washington University in Environmental Policy, Planning and Science. Before joining the sanctuary team, Nicole worked as a Nearshore Project Biologist monitoring biological use of nearshore environments and sediment transport. Nicole's experience as a commercial fisherwoman in Alaska in the early 1990's sealed her devotion to the ocean and has since shaped her work and personal interests. Nicole can be reached at Nicole.Harris@noaa.gov.

Karen Matsumoto is an educator and naturalist with over 25 years of experience in environmental education. Karen currently works for the Suquamish Tribe in Washington State as a climate change educator to assist the Tribe in developing a community-driven climate change adaptation plan. Karen was an environmental studies teacher with the Suquamish Tribal School, focusing much of her curriculum on tribal sovereignty and environmental justice issues. Prior to her work with the Tribe, Karen was Marine Science Education Coordinator for Seattle Aquarium, working on ocean science issues with elementary students from coastal Tribal communities on Olympic Peninsula. Karen graduated from the University of California, Berkeley in Conservation of Natural Resources, and has additional degrees in education and instructional design. Her previous work as a National Park Service naturalist in Alaska, environmental consultant, and classroom teacher has enabled her to experience the joy of sharing nature with children. Karen can be reached at kmatsumoto@suquamish.nsn.us.

Ocean/Climate Literacy, and Action at Hale Kula and Beyond

Richard M. Jones, University of Hawai'i at West O'ahu

In late 2017 the NOAA Climate Stewards Education Project changed its title to the NOAA Planet Stewards Education Project.

Abstract

This paper describes the NOAA Climate Stewards project selected by one elementary school on the island of Oʻahu. The project focused on raising and releasing sea urchins to help restore the health of recently remediated reefs adjacent to the Waikīkī Aquarium. In May of 2013, 117 urchins were released giving everyone involved a sense of accomplishment and the knowledge that in their small way they *could* do something to improve overall reef health. Also discussed are the challenges and successes encountered by the participating educators' and students', the logic for selecting the school to participate in this program, and recommendations for similar citizen science stewardship projects.

Introduction

Science in many elementary classrooms is given minimum time and generally is taught out of a textbook (Jones and Swanson, 2009) and according Chamberlain and Crane, (2009) moving beyond the textbook can be a valuable tool when introducing new science concepts to students. The Sea Urchins for Reefs Future (SURF) Project was designed to engage teachers and students in science content and process by linking the content to students' lives through a Citizen Science research experience focused on restoring the health and sustainability of Oahu's reefs.

Figure 1. The invasive species *Dictyosphaeria cavernosa* or "bubble algae". Photo Credit: University of Hawai'I Botany Department.

Why the reef's? In Hawaiʻi, scientists from the Hawaiʻi Institute of Marine Biology, Waikīkī Aquarium, the Hawaiʻi Department of Land and Natural Resources (DLNR) and Hawaiʻi Pacific University's Ocean Institute, have noticed high-diversity coral communities around Oʻahu shifting over the past several decades to algae dominated reefs with greatly reduced species diversity. In most cases these algae are invasive species like *Dictyosphaeria cavernosa* or "bubble algae" (Stimson, Larned, and Conklin, 2001) (Figure 1) and *Gracilaria salicornia* or "gorilla ogo" (Meditz and Jang, 2010). According to Vitousek, D'Antonio, Loope, Rejmanek, and Westbrooks (1997), understanding the impacts of invasive species is crucial to preserving marine biodiversity and biocomplexity because these invaders, not only consume, outcompete, or hybridize with

native species, causing a loss of native biodiversity, they can also alter the ecosystem through uncontrolled growth that potentially smothers corals, altering reefs permanently.

With this research in mind, especially the unchecked growth of algae potentially smothering and killing corals, the initial focus of the SURF project at Hale Kula Elementary was designed to make teachers and their students aware of the impacts of invasive alga-like *bubble algae* and *gorilla ogo* on the reefs of O'ahu. This project, designed by the author, the teachers, and the students focused on teacher participation in professional development as well as Citizen Science research projects designed and developed to be not only place-based but to provide the teachers with a new set of tools and different perspectives on science that in turn helped students connect science content more easily to their everyday lives (Vardell, Hadaway, and Young, 2006; Hadaway, Vardell, and Young, 2002).

As the project developed and matured, the teacher and student teams learned how to reduce the impacts of invasive algae by growing and releasing the common collector urchin, *Tripneustes gratilla,* (Figure 2) which have been found through previous research studies to be promising as a biocontrol agent (Stimson, Larned, and Conklin, 2001; Hunter, 2003; Conklin and Smith, 2005; Meditz and Jang, 2010), acting as common reef grazers, eating alien algae off of reefs where the algae has been mechanically or hand removed previously. Once introduced on these "cleaned" areas of the reef, Hale Kula urchin's are able to control the regrowth of the algae which improves reef health and ultimately community sustainability.

Figure 2. Baby Hawaiian collector sea urchins (*Tripneustes gratilla*).
Photo Credit: NOAA.

The Project

Why Hale Kula Elementary? The teachers in this school, while not unique in their limited understanding of environmental education, climate science, and earth system science as a whole, do work with a unique student population for O'ahu. The majority of their students, on average 22 per classroom, have one or both parents serving in an active duty capacity in the US Army. Due to the transient nature of military family life, these students also have limited experience with the reefs on O'ahu, threats to the reefs, and the importance of protecting these reefs to ensure a sustainable future (ecological and economic) for O'ahu. Another reason for choosing Hale Kula is that the building Principal and the teachers in this school had recently engaged with the author and several other education faculty from the University of Hawai'i - West O'ahu in a Title II STEM Professional Development project and they were eager to apply many of the their newly-learned skills into another project, one that would engage their students directly in "doing science", or what the Next Generation Science Standards call, "developing an understanding of the enterprise of science as a whole (NGSS Lead States, 2013). This initial cohort of six teachers was also selected because they represented grades K through 5 at the school and had the potential to initially reach 110 students through their participation in the NOAA Climate Stewards Education project and the "Citizen Science" Research conducted in conjunctions with these students.

One key component of the Citizen Science Research project is that it provided teachers and their students field-oriented and place-based experiences and curriculum that not only enhanced their understanding of the natural and cultural environment (Cusick, 2012) but also got them actively involved in an ecological restoration project that is locally and globally relevant, improving the sustainability of the reef ecosystem of O'ahu. Engaging in Citizen Science with the goal of

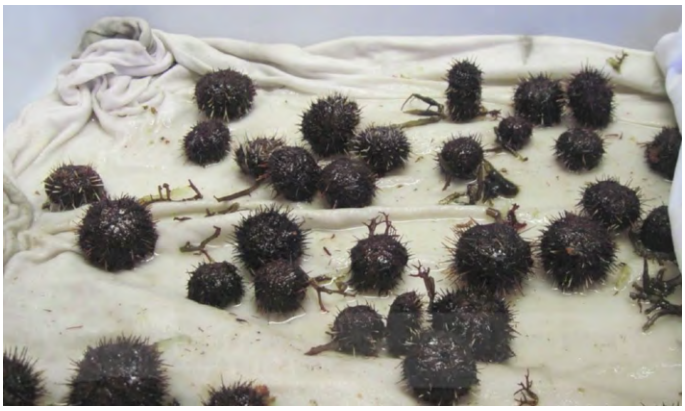

Figure 3. Collector sea urchins after transport from the Sand Island Hatchery and prior to introduction to classroom saltwater tanks.

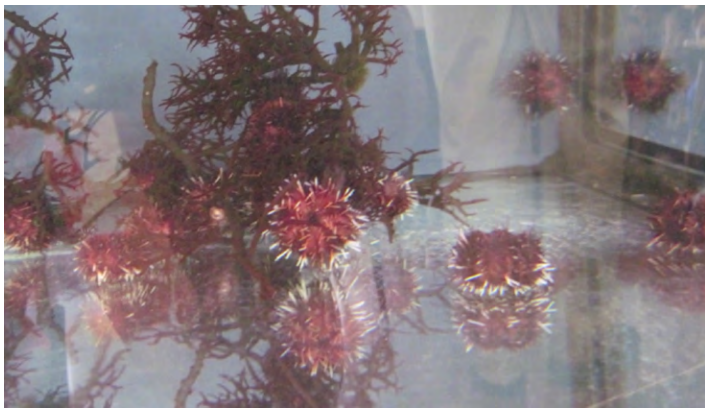

Figure 4. Sea urchins in salt water fish tank.

Figure 5. Students mass and measure the sea urchins to reveal growth patterns.

improving local reefs has been supported during and after the initial project by David Cohen at the Hawai'i Department of Land and Natural Resources (DLNR) Fish Hatchery at Sand Island who provided both essential instruction and focused science content concerning the common collector urchin, *Tripneustes gratilla* as well as larval and juvenile animals for the classroom growth tanks (Figure 3).

The project was initially carried out in the fall of 2012 by students and teachers at the individual classroom level, each with a 29-gallon "BioCube" saltwater fish tank that housed between 15 and 20 two- to five-millimeter urchins (Figure 4). The teachers, in partnership with their students, designed a variety of experiments to maintain and grow the urchins for release on the reefs either in Kāne'ohe Bay or the waters adjacent to the Waikīkī Aquarium adding to current efforts by the Aquarium and the DLNR to mitigate invasive algae (Figure 5).

The first attempt at raising urchins in the classrooms was mixed, and several tanks had catastrophic mortality (100%). Other classrooms were more successful, with mortality ranging from 20% to 75%. Much learning came from this initial semester; participants discovered that several classrooms would get hot over weekends when fans were off and windows were closed, raising the temperature in the tanks to levels fatal to urchins. Other teams realized that they overfed the urchins and the pH and water chemistry drifted beyond optimal levels, and one team found that it was better to measure and mass the urchins weekly rather than handling them on a daily basis. The classroom with the lowest mortality, 16 or 20 survived four months and grew to a size suitable for introduction onto reefs on O'ahu, used fresh seawater, refreshed weekly, and fed them only fresh *limu mane`one`o,* a Native Rhodophyta (UHM, 2015).

The project focused on raising and releasing sea urchins to help restore the health of recently remediated reefs adjacent to the Waikīkī Aquarium and acted as the motivator for one teacher and her students' to create a Public Service Announcement, "The Time We Became Citizen Scientists" (vimeo.com/65187852) that they entered in the 2013 Olelo Youth XChange.

In December the teachers, several parents, and students made the trip to the reef adjacent to the Waikīkī Aquarium, where they released 41 urchins (Figure 6). During the spring of 2013 the teachers and students were ready to "try again" and this time, the experiences they gained during the fall paid off with roughly 25% of the initial starting population of 156 urchins suffering mortality. In May of 2013, 117 urchins were released giving everyone involved a sense of accomplishment and the knowledge that in their small way they ***could*** do something to improve overall reef health. Over the summer the teachers expressed interest in adding tanks in other classrooms at their school and asked to include other schools in their area as well. This development is exactly what NOAA had in mind when it began the Climate Stewards Education Project (United States Global Change Research Program, 2009).

This project turns out to be scalable and had the ability to move beyond the initial 6 classrooms at Hale Kula. The potential for other classrooms and even private citizens to become involved with growing sea urchins for future release on the reefs of Oahu is exceptional and growth of the project beyond the initial cohort will not only provide an opportunity for students and other nonprofessional scientists to participate in scientific research, it will provide needed place-based experiences for students and the community that will enrich learning and help teachers meet the Next Generation Science Standards (NGSS Lead States, 2013) (Table 1). While Hale Kula was the initial target audience for the NOAA Climate Stewards project, and the campus continues to grow urchins, it is hoped that further sources of support will allow second and third iterations that could eventually be included in all public and private regular and special education teachers, island wide.

Figure 6. Hale Kula Elementary teachers release sea urchins into the ocean.

Table 1. Next Generation Science Standards Performance Expectations Addressed by Project

Performance Expectations	
K-ESS3-3.	Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment.
K-LS1-1.	Use observations to describe patterns of what plants and animals (including humans) need to survive.
3-LS4-4.	Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.
5-ESS3-1.	Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

Going Further

By actively participating in the Hale Kula's SURF NOAA Climate Stewards project, teachers and students have studied, cared for, grown, and eventually released urchins to the reefs in the waters adjacent to the Waikīkī Aquarium. This not only has the potential to improve overall reef health, but it has also given the teachers and students an opportunity to provide a service to the community that is directly tied to community resilience through improved reef health. Improving reef health not only provides a more diverse ecosystem, these healthier reefs have the potential to positively impact the local economy in several ways. As corals regain their role in an ecosystem that has been hampered by invasive algae and other stressors, they become a prime destination of Hawaii's tourist industry as well as a renewed source of juvenile fish, growing the availability and diversity of species for both subsistence and sport fishing. Healthy reefs also help buffer O'ahu's fragile beaches from erosion and inundation during storms and from rising sea levels.

Finally, participation in SURF's "Citizen Science" has provided teachers and students with meaningful, first hand experiences engaging in place-based science, thus enabling them to understand that they do have the ability to make a difference for the future of O'ahu Hawai'i and globally. Participation in NOAA's Climate Stewards project has been a very successful program that shows that even a small project, like the project at Hale Kula Elementary has the potential not only to change the teachers and the students directly involved, but countless others beyond the walls of their classroom.

Resources

The Time We Became Citizen Scientists: vimeo.com/65187852

How Tiny Sea Urchins Are Saving Kāne'ohe Bay: fisheries.noaa.gov/feature-story/how-tiny-sea-urchins-are-saving-kaneohe-bay

Sea Urchins Help Combat Invasive Algae on Corals: oceanservice.noaa.gov/news/mar17/sea-urchins-hawaii.html

Sea Urchin Hatchery: dlnr.hawaii.gov/ais/invasivealgae/urchn-hatchery/

References

Chamberlain, K., & Crane, C. (2009). *Reading, writing, & inquiry in the science classroom grades 6-12*. Thousand Oaks, CA: Corwin Press

United States Global Change Research Program (2009). Climate Literacy: The essential principles of climate science. Washington, D.C. downloads.globalchange.gov/Literacy/climate_literacy_highres_english.pdf

Conklin, E., and Smith, J. (2005). Abundance and spread of the invasive red algae, *Kappaphycus* spp., in Kne'ohe Bay, Hawai'i and an experimental assessment of management options. *Biological Invasions* (7). 1029-1039.

Cusick, J. (2012). Teaching Ecotourism in the Backyard of Waikk, Hawai'i. In K. Bartels, & K. Parker (Eds.), *Teaching Sustainability Teaching Sustainably.* pp. 140-148). Sterling, VA: Stylus.

Hadaway, N., Vardell, S, & Young, T. (2002). Linking science and literature for ESL students. *Book Links,12* (2), 31–26.

Hunter, C. (2003). Alien Algae on Hawaii's Reefs: Distributional changes and ecological responses. *Project FINAL REPORT FY 2003.* Grant # NA160A2412, Waikiki Aquarium, University of Hawaii. malamamaunalua.org/wp-content/uploads/Hunter-2003.pdf

Jones, R., & Swanson, E. (2009). "Understanding Elementary Teachers' Use of Science Teaching Time: Lessons from the Big Sky Science Partnership", *Journal of Mathematics and Science: Collaborative Explorations. 11*. Virginia Mathematics and Science Coalition, Richmond, VA.

Meditz, T., and Jang, R. (2010). The Effects of Invasive Species Gorilla Ogo (*Gracilaria salicornia)* in Hawai'is Coral Reef Ecosystem. *Project Proposal University of Southern California*. usc.edu/org/quikscience/Projects/2010/Kamehameha-OgoProposal.pdf

NGSS Lead States. (2013). *Next Generation Science Standards: For States, By States*. Washington, DC: The National Academies Press. nextgenscience.org/next-generation-science-standards

Stimson, J., Larned, S., and Conklin E. (2001). Effects of herbivory, nutrient levels, and introduced algae on the distribution and abundance of the invasive macroalga *Dictyosphaeria cavernosa* in Kne'ohe Bay, Hawai'i. *Coral Reefs* (19) 343-357.

University of Hawaii-Manoa. (2015). Marine Algae of Hawaii Field Guide. University of Hawaii Botany Department. hawaii.edu/reefalgae/natives/sgfieldguide.htm.

Vardell, S., Hadaway, N., & Young, T. (2006). Matching books and readers: Selecting literature for English learners. *The Reading Teacher, 59* (8), 734-741. dmschools.org/wp-content/uploads/2011/10/ELLliterature.pdf

Vitousek, P., D'Antonio, C., Loope, L., Rejmanek, M., and Westbrooks, R. (1997). Introduced Species: A significant component of human-caused global change. *NewZealand Journal of Ecology 21* (1). 1-16. newzealandecology.org/system/files/articles/NZJEcol21_1_1.pdf

About the Author

Rick Jones is an Associate Professor of Science Education and Science at University of Hawai'i at West O'ahu (UHWO). He holds B.S. degrees in Geology and Secondary Science Education and a MS in Natural Science from the University of Wyoming and an Ed. D in Curriculum and Instruction – Science Education from Montana State University. He has over twenty-five years of teaching sciences in public schools in Wyoming, Hawai'i and Montana. Rick was the 2014 University of Hawaii Regents Teaching Excellent Awardee and recently completed his seventh year at UHWO, where he teaches Geology, Meteorology, Oceanography and Science Methods courses. Rick can be reached at rmjones7@hawaii.edu.

The Northeast Michigan Great Lakes Stewardship Initiative (NEMIGLSI)

Sarah Waters, Thunder Bay National Marine Sanctuary and Brandon Schroeder, Michigan Sea Grant

Abstract

Place-based stewardship education (PBSE) is a proven method of bringing students closer to their communities and developing knowledgeable and active stewards of the environment. Headquartered out of the offices of Thunder Bay National Marine Sanctuary in Alpena, Michigan, the Northeast Michigan Great Lakes Stewardship Initiative (NEMIGLSI) sponsors an award-winning suite of programs that promotes PBSE experiences for K-12 students. Alongside Great Lakes scientists and natural resource professionals, youth are helping to conserve Lake Huron's biodiversity, map threatened and endangered species habitat, restore native fisheries, monitor vernal pool wetlands, preserve our maritime heritage, and tackle the ongoing issue of marine debris. This article describes this Michigan Initiative, the benefits to students, teachers, and the community, and shares two cases studies of PBSE in action.

Introduction

The Northeast Michigan Great Lakes Stewardship Initiative (NEMIGLSI) has been growing place-based stewardship education (PBSE) in northeast Michigan since 2009. More than 19,000 students (around 20 percent of the student population annually) have engaged as Great Lakes stewards and valued community leaders through the network. This initiative has supported more than 35 schools and 290 educators from eight counties in professional development opportunities and stewardship project support (Figure 1). The network has also engaged more than 100 community partner organizations, including staff of agencies such as NOAA's Thunder Bay National Marine Sanctuary (TBNMS) and the Michigan Sea Grant, who are key partners in administration and leadership of the network as well as community partners working directly with students.

Figure 1. Students collect aquatic macroinvertebrates with community partner Thunder Bay National Marine Sanctuary to help determine water quality at this Thunder Bay River site that drains to Lake Huron.

Photo Credit: NOAA, Thunder Bay National Marine Sanctuary

The NEMIGLSI is one of nine regional hubs of the Great Lakes Stewardship Initiative (GLSI), a statewide effort to develop knowledgeable, active stewards of the Great Lakes. The NEMIGLSI network's proven educational program strategy is framed in national place-based and community-based literature, research, and best practices (Smith and Sobel 2010, Woodhouse and Knapp 2000, Yoder 2012, Demarest 2015, Semken et. al, 2017). Evaluating our efforts locally, we have contributed scholarship toward a growing statewide Great Lakes Stewardship Initiative network, including contributions to the scholarly, 'Place-Based Stewardship Education Guiding Principles' to support educational best practices (GLSI network 2017).

In the Michigan Sea Grant evaluation report*, Place-Based Education: Engagement from the Student Perspective* (Rote et. al. 2015), we document what students value in PBSE experiences as hands-on and engaging, community connected, career oriented, and fun. In the *Peabody Journal of Education*, our network used an evaluative case study to highlight how PBSE strategies can foster environmental stewardship and civic engagement values among youth (Gallay et. al. 2016). The NEMIGLSI network was recognized with the 2016 UL Innovative Education Award from the North American Association for Environmental Education for excellence in connecting environmental-STEM learning experiences in student-led PBSE efforts. The NEMIGLSI network and partnership efforts are supported by the Great Lakes Fisheries Trust's GLSI and also by NOAA BWET funding.

Why Place-Based Stewardship Education (PBSE)?

As a teaching and learning practice and philosophy that relies on place - including lands and waters, people and organizations, history, and culture - benefits can be categorized in various ways. One way to look at benefits of PBSE is by thinking of them as 1) individual student and teacher benefits, 2) institutional benefits, and 3) area or community benefits. Student benefits may include improved academic scores, critical thinking skills, workplace skills (leadership, persistence, etc.), and increased engagement in school and motivation for achievement. PBSE has also been shown to increase positive youth development, such as a sense of place and community attachment, and increased civic-engagement. In PBSE these positive youth development benefits translate as pro-environmental attitudes and action competence on environmental issues (Figure 2). Individual benefits for teachers may include an opportunity to pursue their interests and advance their values, developing skills so they teach in ways that invigorate their practice and an increase in student interest and enjoyment of learning. School and district benefits may include increased levels of teacher engagement and satisfaction, and stronger connections with community-based partner organizations, as well as parents and other community members. Finally, PBSE benefits community partner organizations by expanding their capacity to address certain issues and opportunities through collaboration that exceeds the partner organization's capacity when it works alone, and to raise awareness of the organization's mission, activities, and employment opportunities (Marckini-Polk et. al. 2016).

Figure 2. Students watch the morning mist rise off the Thunder Bay River in Alpena, Michigan as they prepare to collect water quality data as part of their *Thunder Bay River Watershed* place-based stewardship education project.

Photo Credit: NOAA, Thunder Bay National Marine Sanctuary

Students participating in the NEMIGLSI network are valued community and conservation partners. Numerous NEMIGLSI student projects have directly benefited NOAA, Sea Grant, and other community partner priorities helping to conserve Lake Huron's biodiversity, map threatened and endangered species habitat, restore native fisheries, monitor water quality and vernal pool wetlands,

manage invasive species, enhance understanding of maritime heritage, investigate marine debris, and more. Youth contribute as community development partners today and perhaps even more in their future. The following case studies from northeast Michigan offer examples of how place-based stewardship education (PSBE) can be incorporated into classrooms at all grade levels and with various curricular goals. Additional case study examples can be found at www.nemiglsi.org.

Case study one: *The Thunder Bay River Watershed Project.*

Fifth grade teacher Bob Thomson started using interactive education more than 10 years ago when his students built outdoor shelters based on a popular novel. This led to writing exercises that included nonfiction directions on how to build their student shelters. After a few years of similar projects, Thomson connected with community members and partners who introduced him to robotics. Building and utilizing robots has now become a foundation element of all Thomson's projects and classes. From testing water quality to documenting zebra mussels on shipwrecks, Thomson's elementary students have used their robots to serve the local community. Thomson's curriculum is largely grounded in math and science and English language arts (ELA) connections, but he also infuses hands-on learning in all aspects of his classroom teaching. Although his curriculum incorporates the PBSE concepts of fun, hands-on learning, careers, and community, community is the principle best exemplified by his fifth-grade class' PBSE efforts.

Each year Thomson's students build underwater remotely operated vehicles (ROVs) with support from the staff of TBNMS. This involves both in-class builds and on-site workshops at the sanctuary headquarters in Alpena, Michigan. Instead of just building robots for the sake of building robots, however, Thomson ensures that his students put them to use. His classes often participate in the MATE (Marine Advanced Technology in Education) Great Lakes Regional ROV competition alongside fellow community members, ranging from elementary students to community college students enrolled in a local marine technology program in Alpena, Michigan. Thompson's students commented that they had never been involved in their community "before this kind of project," and that they wanted to be more involved following the experience. These are the long-lasting benefits that place-based education can have on relations between students and their community (Rote et. Al. 2015).

In addition to building underwater robots for the annual competition, students engage in a variety of watershed science and studies that include monitoring water quality over time at specific sites along the Thunder Bay River, tracking populations of invasive species (Figure 3), testing for microplastics in the local watershed (Figure 4), and raising native lake trout and sturgeon in their classroom for release. They incorporate the ROVs into these projects that benefit their community. For example, Thomson's students raised native lake trout in their classroom and released the fry with their ROVs as part

Figure 3. Fifth-grade students collect data on invasive rusty crayfish collected in the Thunder Bay River as part of their *Thunder Bay River Watershed* place-based stewardship education project.

Photo Credit: NOAA, Thunder Bay National Marine Sanctuary

Figure 4. Teacher, Bob Thomson, and his students collect water samples to test for the presence of micro-plastics in the Thunder Bay River as part of their *Thunder Bay River Watershed* place-based stewardship education project.

Photo Credit: NOAA, Thunder Bay National Marine Sanctuary

of a multi-agency project to restore reef habitat in Lake Huron's Thunder Bay. Over the course of the school year, his students repurposed plastic bottles and used a classroom 3-D printer to produce a system that attached to their ROV and released the trout to their underwater reef habitat. In May, with the help of community partners including agency staff and a local boat tour company, students successfully maneuvered their ROV to an artificial reef in Thunder Bay and released all of the lake trout fry directly onto the reef.

Figure 5. Teacher, Bob Thomson, and his students prepare to launch their student-built underwater remotely operated vehicle (ROV) to collect data for their *Thunder Bay River Watershed* place-based stewardship education project. Photo Credit: NOAA, Thunder Bay National Marine Sanctuary

Student-driven interest is key to PBSE and Thomson's students initiate each of their PBSE projects, including one that landed them in the Thunder Bay River turning over rocks and looking for invasive zebra mussels. They counted and measured each mussel to identify age and gain an idea of population, distribution, and reproduction. The following year, the students built on the previous 5th graders mussel database by venturing from the river out into Thunder Bay to study the attachment preference of zebra and invasive quagga mussels on various substrates below the surface (Figure 5). After studying the geological makeup of local shoreline and lake bottom and the presence of hundreds of shipwrecks protected by TBNMS, students constructed an experiment using various substrates to measure mussel growth at a 30-foot depth in Lake Huron's cold, fresh water environment. Near the end of the school year, they took their ROVs equipped with video cameras to observe the mussel growth on their experimental structures. Students translated their findings into public outreach materials, showing how invasive species are not only bad for native ecosystem health, but may impact a community's cultural resources as well.

Quality PBSE involves three components: student engagement, school-community partnerships, and sustained professional development. Student engagement as demonstrated in the first case study example can be accomplished in a number of ways, like getting students outdoors and using nature as the classroom; collecting data and contributing to research with citizen science; and connecting cross curricular subject matters, like history, math, writing, and science for the complete learning experience. Thomson's 5th grade class PBSE projects also showcase the possibilities for school-community partnerships. Our second case study example also highlights both of these PBSE components and shows how PBSE can be a driver for focusing on the future careers. When students work side by side with community partners, they are exposed to potential career pathways they may never have considered.

Figure 6. Students learn about the shipwrecks of Thunder Bay National Marine Sanctuary while cruising in Lake Huron aboard the *Lady Michigan* as part of their place-based stewardship education project.

Photo Credit: NOAA, Thunder Bay National Marine Sanctuary

Case study two: *Shipwreck Alley: Shipwrecks, Science, and the Marine Sanctuary.*

Alpena Public School teacher John Caplis was inspired to create this Earth science elective class after participating in an education working group at TBNMS and also in a hands-on maritime heritage experience sailing aboard a Great Lakes tall ship with fellow teachers (Figure 6). While designing the course Caplis sought content guidance from staff at TBNMS to help launch his vision for the elective class where students would go on to engage in PBSE efforts related to their coursework. Caplis finds,

"that students are most excited about learning when it is interesting, or it matters to them." And he hopes that, "these projects will inspire [his] students to explore careers in science, or some field they haven't considered before."

The first section of the class was offered to students in grades 9 through 12 in 2012, and additional sections have continued to be added by the school administration to meet student demand since. The class is a great example of how humans and history can be woven together through environmental watershed studies. Caplis teaches the students about geology, meteorology, and environmental issues like invasive species. Because it is an elective class the students also study history, economic issues, and maritime archaeology. Caplis notes, "geologic formations like North Point reef [in Lake Huron's Thunder Bay] sink ships, [and] storms like the 'white hurricane' of 1913 sink ships, and so we study the related Earth science content. We try to look at all aspects of marine sanctuary operations, to give the students a sense of what takes place there on a daily basis."

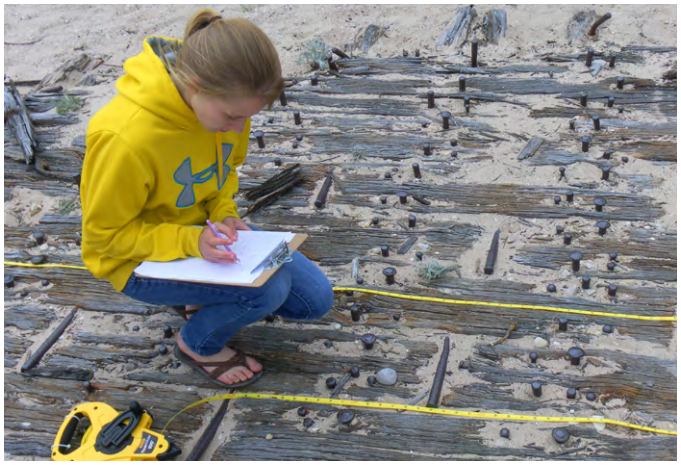

Figure 7. Student maps historic shipwreck remains in Thunder Bay National Marine Sanctuary as part of the high school earth science class: *Shipwreck Alley*. Photo Credit: NOAA, Thunder Bay National Marine Sanctuary

Due to scheduling, getting high school students out of their classroom is often challenging, but Caplis' students have managed to get out and map shoreline shipwrecks protected by TBNMS, and collect oral histories from commercial fishermen who worked on the waters of northern Lake Huron near Alpena (Figure7). The students hope to help preserve these stories as they learn more about the lives of people who worked on the Great Lakes, and also learn about the health and history of the Great Lakes, including the fishery of years past. They plan to use the information to help create an interpretive public exhibit at a local museum that houses a historic commercial fishing vessel. This class reflects a great example of PBSE in practice, where students are contributing to their community by enhancing maritime heritage studies and environmental stewardship of northeast Michigan through their education. The students learn science, history, writing, technology, and more during hands-on, multi-disciplinary, learning experiences. Enthusiastic youth are not only learning in school and contributing to their communities, but also exploring firsthand the wealth of careers (working directly with professionals that are NEMIGLSI community partners, like staff at NOAA's TBNMS and Sea Grant) connected with Great Lakes Science.

Conclusion

Once teachers like Caplis and Thomson are fully engaged in PBSE through the NEMIGLSI network, the collaboration strives to ensure the third component of quality PBSE is achieved, sustained professional development, which is the key to sustaining the network over time. Sustained professional development is accomplished in a number of ways. Schools and educators are supported by the network through sustained professional development reflecting content such as Great Lakes science and Great Lakes Literacy Principles (Fortner and Manzo 2011) training, PBSE best practices and instructional process, and relationships through mentoring and networking opportunities. The NEMIGLSI network also encourages and supports teachers who are actively engaged in PBSE to be mentors to their peers and help take PBSE school-wide with special attention paid to gaining administrative support. And it's working! Since 2009, the network's participation tracking database documents that 199 unique northeast Michigan educators from eight counties have applied PBSE in educational practices, fielding stewardship projects with their students (67 percent adoption rate among the total 290 educators trained or supported through this initiative).

Resources

The Northeast Michigan Great Lakes Stewardship Initiative: nemiglsi.org

Thunder Bay National Marine Sanctuary: thunderbay.noaa.gov

Michigan Sea Grant: miseagrant.umich.edu

Additional place-based stewardship education case studies from urban to rural schools: greatlakesstewardship.org/case-studies/

PBSE and guiding principles document: greatlakesstewardship.org/guiding-principles-of-place-based-stewardship-education/

References

Demarest, A. (2015). *Place-based Curriculum Design: Exceeding Standards through local investigations.* New York, NY: Routledge.

Fortner, R. W. and L. Manzo. (2011). Great Lakes literacy principles. *Eos, Transactions, American Geophysical Union*, *92*(13), 109. doi:10.1029/2011EO130002

Gallay, E., L. Marckini-Polk, B. Schroeder, and C. Flanagan. (2016). *Place-based stewardship education: Nurturing aspirations to protect the rural commons. 2016.* Peabody Journal of Education, special issue on rural schools.

Great Lakes Stewardship Initiative (GLSI) network. (2017). *Guiding Principles for Exemplary Place-Based Stewardship Education.* EPA Environmental Education-supported project, Lansing, MI. Retrieved online: greatstewards.glstewardship.org/

Rote, Z., B. Schroeder, and T. D'Augustino. (2015). *Place-based education: Engagement from the student perspective [poster].* Proceedings, 2014 Great Lakes Place-Based Education Conference, Nov 2014, Grand Rapids, MI. 2015 Michigan Sea Grant Research Report.

Schroeder, B., T. D'Augustino, S. Waters, and M. Gass. (2016). *Northeast Michigan Great Lakes Stewardship Initiative: Place-Based Education meets Great Lakes Literacy and E-STEM Opportunity [Research Poster].* North American Assoc. for Environmental Education Conference, Madison, WI.

Semken, S., Ward, E. M. G., Moosavi, S., & Chinn, P. W. U. (2017). Place-based education in geoscience: Theory, research, practice, and assessment. *Journal of Geoscience Education, 65*(4), 542-562.

Smith, G. A., and D. Sobel. (2010). Place- and community-based education in schools. New York, NY: Routledge.

Woodhouse, J. L., and C.E. Knapp. (2000). Place-based curriculum and instruction: Outdoor and environmental education approaches. Retrieved from ericdigests.org/2001-3/place.htm

Yoder, J. (2012). Connecting classrooms to the community: A guide for a community-based approach to education. Northwest Center for Sustainable Resources, Chemeketa Community College, project supported by National Science Foundation [NSF DUE # 0757239]

About the Authors

Sarah Walters is the current Education and Outreach Coordinator at NOAA's Thunder Bay National Marine Sanctuary in Alpena, Michigan. She contributes to the sanctuary's mission of protecting the Great Lakes and their rich maritime history through research, education, and resource protection, ensuring future generations can enjoy these underwater resources. She has an MA in Maritime Archaeology from East Carolina University. Previously, she's worked as an archaeologist, a museum curator and educator, and taught aboard a tall ship with a semester at sea program. Sarah can be reached at sarah.a.walters@noaa.gov.

Brandon Schroeder is a Sea Grant Educator with the Michigan University Alpena County Extension Office. He works with coastal communities and businesses in northeast Michigan to apply science-based knowledge to address Great Lakes and northern Lake Huron issues. He also focuses on Great Lakes education, offering workshops for the public that include citizen science opportunities. He serves the Cheboygan, Presque Isle, Alpena, Alcona, and Iosco counties. Brandon can be reached at schroe45@msu.edu.

Your Students Can Contribute to Our Understanding of the World

John McLaughlin, NOAA Office of Education and
June Teisan, Former Albert Einstein Distinguished Educator Fellow with NOAA's Office of Education

Abstract

Students can and do successfully serve as citizen scientists. The National Oceanic and Atmospheric Administration (NOAA) offers a wide range of citizen science projects. This article provides a rationale for engaging students in citizen science and shares a number of existing programs and projects.

Introduction

Don't you love when students are actively engaged in exploration and inquiry? Isn't it incredible to witness the energy and enthusiasm of learners digging into authentic investigations? Wouldn't you like to find low/no cost projects that will grab student interest and allow them to contribute to critical challenges in our world today? Citizen science offers a powerful means of engaging students of all ages in authentic scientific inquiry and the National Oceanic and Atmospheric Administration (NOAA) offers a wide range of citizen science projects.

What is Citizen Science?

The Crowdsourcing and Citizen Science Act (congress.gov/bill/114th-congress/senate-bill/3084/text#toc-idc675e4e0-f615-4d4a-8ad5-b9cc94092dde) (Section 402, Act 15 USC 3724), signed into law in January of 2017, defines citizen science as "a form of open collaboration in which individuals or organizations participate voluntarily in the scientific process in various ways, including: (A) enabling the formulation of research questions; (B) creating and refining project design; (C) conducting scientific experiments; (D) collecting and analyzing data; (E) interpreting the results of data; (F) developing technologies and applications; (G) making discoveries; and (H) solving problems". The 2018 Report from the National Academies Press, *Learning Through Citizen Science: Enhancing Opportunities by Design* (nap.edu/catalog/25183/learning-through-citizen-science-enhancing-opportunities-by-design) more broadly described citizen science projects as those that "typically involve nonscientists (i.e., people who are not professionally trained in project-relevant disciplines) in the processes, methods, and standards of research, with the intended goal of advancing scientific knowledge or application." So, with Citizen Science, volunteers do more than

just collect data. Rather, they engage in all aspects of making unique discoveries, highlighting that anyone, anywhere, can participate in meaningful scientific research.

Reasons to Implement Citizen Science

Students can and do successfully serve as citizen scientists. Meaningful hands-on involvement in the scientific process provides students with powerful authentic learning opportunities. Students may be encouraged by the realization that the work they are doing will result in outputs that are valued and used by others, including professional scientists. This can help break down barriers of students feeling science is not accessible to them. For example, LiMPETS (Long-term Monitoring Program and Experiential Training for Students) (limpets.org/), which involves students in monitoring the coastal ecosystems of California's national marine sanctuaries, found that seven months to a year after their citizen science experience the majority of students (53%) felt their participation increased their interest in science. Citizen science ensures students are not learning outdated science, but rather that they are working on emerging discoveries (Figure 1). A 2014 look at the convergence of science with environmental education found the integration of citizen science "may make education more responsive to current global challenges" (Wals et. al, 2014).

Figure 1. LiMPETS students learn the process of science that helps to protect our local marine ecosystems.

Photo Credit: Daniel Dreifuss/Santa Maria Times

The Framework for K-12 Science Education (nap.edu/catalog/13165/a-framework-for-k-12-science-education-practices-crosscutting-concepts) calls for students to engage in Scientific and Engineering Practices. Participation in citizen science is well tailored to provide this type of engagement. A 2015 review of documented outcomes of citizen science found there is "limited but growing evidence that citizen science projects achieve participant gains in knowledge about science knowledge and process" (Bonney et. al., 2015). This potential is not limited to just middle and secondary student learning either. With proper framing, elementary age student can and do successfully undertake citizen science activities. In a report, *Taking Science to School: Learning and Teaching Science in Grades K-8, the National Research Council* states: "In contrast to the commonly held and outmoded view that young children are concrete and simplistic thinkers, the research evidence now shows that their thinking is surprisingly sophisticated. Important building blocks for learning science are in place before they enter school" (National Research Council, 2007).

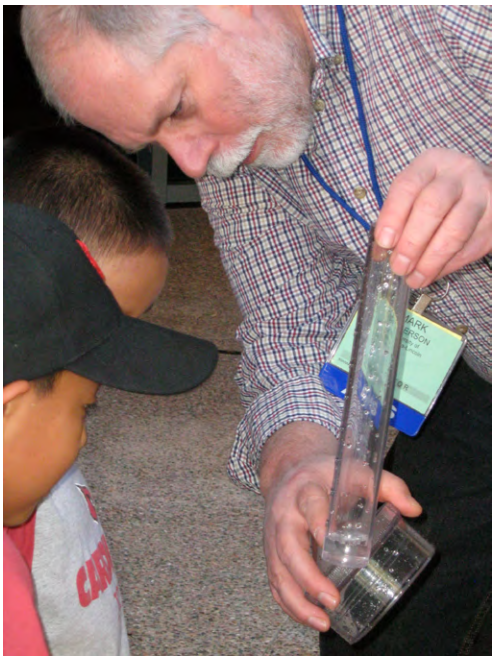

Figure 2. Mark Anderson of Univ. of Nebraska, a CoCoRaHS volunteer, explains how to use a rain gauge.

Photo Credit: Henry Reges/CoCoRaHS

Citizen Science Projects to Explore

There are a diverse and growing set of citizen science projects from NOAA focused on Earth Sciences available for use with students (Table 1). A few of these are highlighted below:

Measuring Precipitation with the Community Collaborative Rain, Hail, and Snow Network

Is it raining today? Snowing? Is there a drought affecting the plants around our school? These are questions that grab student interest. The Community Collaborative Rain, Hail and Snow (CoCoRaHS) Network (cocorahs.org) provides

resources and training to learn about and monitor precipitation. This community-based network of volunteers of all ages and backgrounds work together to measure and map rain, hail and snow using low-cost measurement tools (Figure 2). The main tool is a plastic rain gauge that costs about $35. This network maintains a school network and offers lesson plans and educational materials (cocorahs.org/Content.aspx?page=education).

Interacting with Weather Logs from Historic Vessels

What was it like to sail through the Arctic a century ago? What weather did these ships experience? Would you like to see log books from one of these vessels and help recover valuable data stored in it? If so, consider the Old Weather project (oldweather.org). Volunteers in this project explore, mark, and transcribe historic ships' logs from the 19th and early 20th centuries. This allows scientists to learn about historic climate and gives participants the chance to see and engage in a fascinating part of history. Many of these logs haven't been examined since they were originally filled in by a mariner long ago, so your students might even discover something surprising! This project also provides a great opportunity to expose students to cursive writing in a meaningful way.

Table 1. Examples of Citizen Science Projects at NOAA

Community Collaborative Rain, Hai, and Snow Network (CoCoRaHS) (cocorahs.org) CoCoRaHS is a grassroots volunteer network of backyard weather observers of all ages and backgrounds working together to measure and map precipitation (rain, hail and snow) in their local communities.
Old Weather project (oldweather.org) Volunteers explore, mark, and transcribe historic ship's logs from the 19th and early 20th centuries. They help collect data about past weather and sea-ice conditions which are vital for climate scientists.
Citizen Science Water Level Application (coastalscience.noaa.gov/news/new-citizen-science-water-level-application-available-nationwide/) A citizen science application to report water levels is available online, anyone can submit a water level report from their mobile device. This application collects photographs and associated GPS locations of water levels.
Marine Debris Monitoring Toolbox (marinedebris.noaa.gov/research/monitoring-toolbox) The Marine Debris Monitoring and Assessment Project, or MDMAP, is a citizen science initiative that engages NOAA partners and volunteers across the nation to survey and record the amount and types of marine debris on shorelines.
Elkhorn Slough Research, Volunteer Water Quality Monitoring (elkhornslough.org/research-program/waterquality-weather-monitoring/volunteer-monitoring/) Elkhorn Slough National Estuarine Research Reserve, the Elkhorn Slough Foundation, and the Monterey County Water Resources Agency have supported this volunteer water monitoring program since 1988.
Gulf of the Farallones National Marine Sanctuary Beach Watch (farallones.noaa.gov/science/beachwatch.html) For nearly 22 years, Beach Watch volunteers have conducted bi-monthly surveys of 150 miles of the California coast.
LiMPETS, The Long-term Monitoring Program and Experiential Training for Students, (http://limpets.org) is an environmental monitoring and education program involves students, educators, and volunteer groups across California.
Marine Debris Tracker (marinedebris.noaa.gov/partnerships/marine-debris-tracker) This mobile application lets people report litter on the water anywhere in the world.
Phytoplankton Monitoring Network (coastalscience.noaa.gov/research/stressor-impacts-mitigation/pmn/) This volunteer network was established to monitor marine phytoplankton and harmful algal blooms.
Reef Monitoring in Guam (coralreef.noaa.gov/aboutcrcp/news/featuredstories/feb16/guam.html) The Guam Community Coral Reef Monitoring Program (GCCRMP), launched in 2012, is highly active in the community and continues to grow in its outreach and reef management capabilities every year.
Channel Islands Naturalist Corps (channelislands.noaa.gov/involved/apply.html) The Channel Islands Naturalist Corps, a joint volunteer program between Channel Islands National Marine Sanctuary and Channel Islands National Park, offers a new training class every two years.

About the Authors

John McLaughlin is an Education Program Manager with NOAA's Office of Education. He works with students, teachers, and the public, engaging them in meaningful, citizen science projects. He can be reached at john.mclaughlin@noaa.gov.

June Teisan is a National Board-certified teacher who brought science to life for students on Detroit's northeast border for 27 years and now designs and delivers vibrant learning experiences for students and fellow teachers across the country. Dr. Teisan served as 2008 Michigan Teacher of the Year and was awarded the White House Presidential Award for Excellence in Science Teaching in 2005. She was an Albert Einstein Distinguished Educator Fellow in Washington, D.C. in 2014-2015 in the Office of Education at the National Oceanic and Atmospheric Administration. Dr. Teisan is actively involved in education policy and advocacy efforts at the state and national level. She is passionately committed to widening opportunities for under-represented and under-served students in the STEM fields and is committed to supporting urban and early-career educators with rich, innovative professional development. She can be reached at jlteisan@gmail.com.

Conclusion

You can find a searchable catalog these and other citizen science projects supported by NOAA and its fellow Federal government agencies at (citizenscience.gov). Also, SciStarter (scistarter.org) is a site that offers access to a broader range of projects and includes a project finder utility that allows you to search by subject area and appropriateness for student age range. Learn more about Citizen Science at NOAA (oceanservice.noaa.gov/citizen-science/). Consider using these tools to empower your students to do robust, authentic science. Start with a simple activity and watch students soar!

References

Bonney R, Phillips T, Ballard H, and Enck J. (2015). *Can citizen science enhance public understanding of science?* In: Public Understanding of Science (1-15). Available at: researchgate.net/publication/282669254_Can_citizen_science_enhance_public_understanding_of_science

National Academies of Sciences, Engineering, and Medicine. (2018). *Learning Through Citizen Science: Enhancing Opportunities by Design.* Washington, D.C.: The National Academies Press. Available at nap.edu/catalog/25183/learning-through-citizen-science-enhancing-opportunities-by-design

National Research Council. (2007). *Taking Science to School. Committee on Science Learning, Kindergarten Through Eighth Grade*. Washington, DC: National Academies Press. Available at: nap.edu/catalog/11625/taking-science-to-school-learning-and-teaching-science-in-grades

Wals E, et al. (2014). Convergence Between Science and Environmental Education, *Science*, May 2014, Vol. 344, Issue 6184, pp. 583-584. Available at: science.sciencemag.org/content/344/6184/583.full

National Earth Science Teachers Association Events at the 2019 NSTA National Conference in St. Louis

*We have a number of exciting sessions! To find our sessions, enter **NESTA** as the keyword when searching events online at NSTA's session browser for the conference. On Friday, April 12 and Saturday, April 13, we have a series of sessions all in the **Annex** of the **America's Center Convention Complex**. Don't miss out on our Share-a-Thons and the events below.*

www.nestanet.org

Friday, April 12

2:00 – 3:00 p.m. **AGU-NESTA Sponsored Lecture: Dr. Theresa Damiani**

Finding Our Way: The Science Behind Today's GPS Revolution

Getting from place to place is a daily activity for most people. Now, many of us use the U.S. Global Positioning System (GPS) through our smartphone, car, or other navigation device to do that. This talk explores the science of GPS and mapping, how it allows us to quickly and easily find our way through the world, and the sometimes, unexpected ways in which it is revolutionizing our society.

Ferrara Theatre, America's Center Convention Complex

Saturday, April 13

3:30 – 4:30 p.m. **NESTA's exciting Rock, Mineral, and Fossil Raffle!**

Annex, America's Center Convention Complex

6:30 – 8:00 p.m. **NESTA Friends of Earth Science Reception**

Crystal Ballroom, Marriott St. Louis Grand

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Education Community

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oceanservice.noaa.gov/education/planet-stewards/

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A NOAA Planet Stewards stewardship Project:

- Conserves, restores, or protects human communities and/or natural resources from environmental impacts
- Meets a local need or addresses a local issue
- Is action-based. It involves participants in hands-on activities that create change
- Involves participants directly with the project coordinator i.e. educator
- Has outcomes that can be evaluated quantitatively
- Uses NOAA's science and resources
- Is related to NOAA's mission

A good project is:

- **Manageable:** your project is a reasonable size for you
- **Meaningful:** Your project is meaningful to the participants Success stems from empowerment
- **Quantifiable and Motivational:** Your project has a measurable outcome and encourages full participation

Examples of Past Projects:

- Making a Living Shoreline
- Restoring a Tall Grass Prairie
- Managing Storm Runoff with Rain Gardens
- Bringing Native Plants Back to Hawaii
- Restoring Native Plants in Hawaii
- Creating Climate and Weather Ready Students
- Engaging Students in Waste Reduction and Composting
- Taking Action to Achieve Water and Energy Savings
- Building Resilient Communities through Coastal Dune Restoration & Education

The Stewardship Community Process

1. Apply to PSEP with a project idea Fall 2018
2. Get assigned to a peer feedback group
3. Meet monthly to discuss & get feedback on projects
4. Refine your project ideas and budget
5. Apply for funding in Spring 2018. Start project in Fall 2019

oceanservice.noaa.gov/education/planet-stewards

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Issue	Submission Deadline	Publication Date
Spring	January 15	March 1
Summer	April 15	June 1
Fall	July 15	September 1
Winter	October 31	January 1

For further information contact
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- Two years - $80
- Three years - $120

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$100 - $249/year

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NESTA encourages articles that provide exemplary state-of-the-art tested classroom activities and background science content relevant to K-12 classroom Earth and Space Science teachers.

- Original material only; references must be properly cited according to APA style manual
- Clean and concise writing style, spell checked and grammar checked
- Demonstrates clear classroom relevance

Format Specifications

- Manuscripts should be submitted electronically – Microsoft Word (PC or Mac)
- Length of manuscript should ***not*** exceed 2000 words.
- All submissions must include a summary/abstract.
- Photos and graphs: may ***not*** be embedded, but must be submitted as separate files, of excellent quality and in PDF, EPS, TIFF or JPEG format. 300 dpi minimum resolution. Color or black and white are both accepted.
  - References to photo/chart placement may be made in the body of the article identified with some marker: <Figure 1 here> or [Figure 1 in this area].
- Website screen shots: If you wish to include "screen shots" within your article, please also supply the direct link to the site, so TES can go online and grab the same screen shots at as high a resolution as possible. ***Note:*** When used, screen shots will produce a poorer image than a digital photograph, thus their inclusion in your article will produce an image that will look less crisp and bitmapped.
- Figures should be numbered and include captions (Figure 1. XYZ.).
- Captions, labeled with a clear reference to their respective photo/chart/image, must be submitted in a separate file, or they may be placed at the end of the manuscript where they can easily be removed and manipulated by the editor.
- If using pictures with people, a signed model release will be required for EACH individual whose face is recognizable.
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For further information contact
Dr. Carla McAuliffe, Executive Director –
Carla_McAuliffe@terc.edu

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