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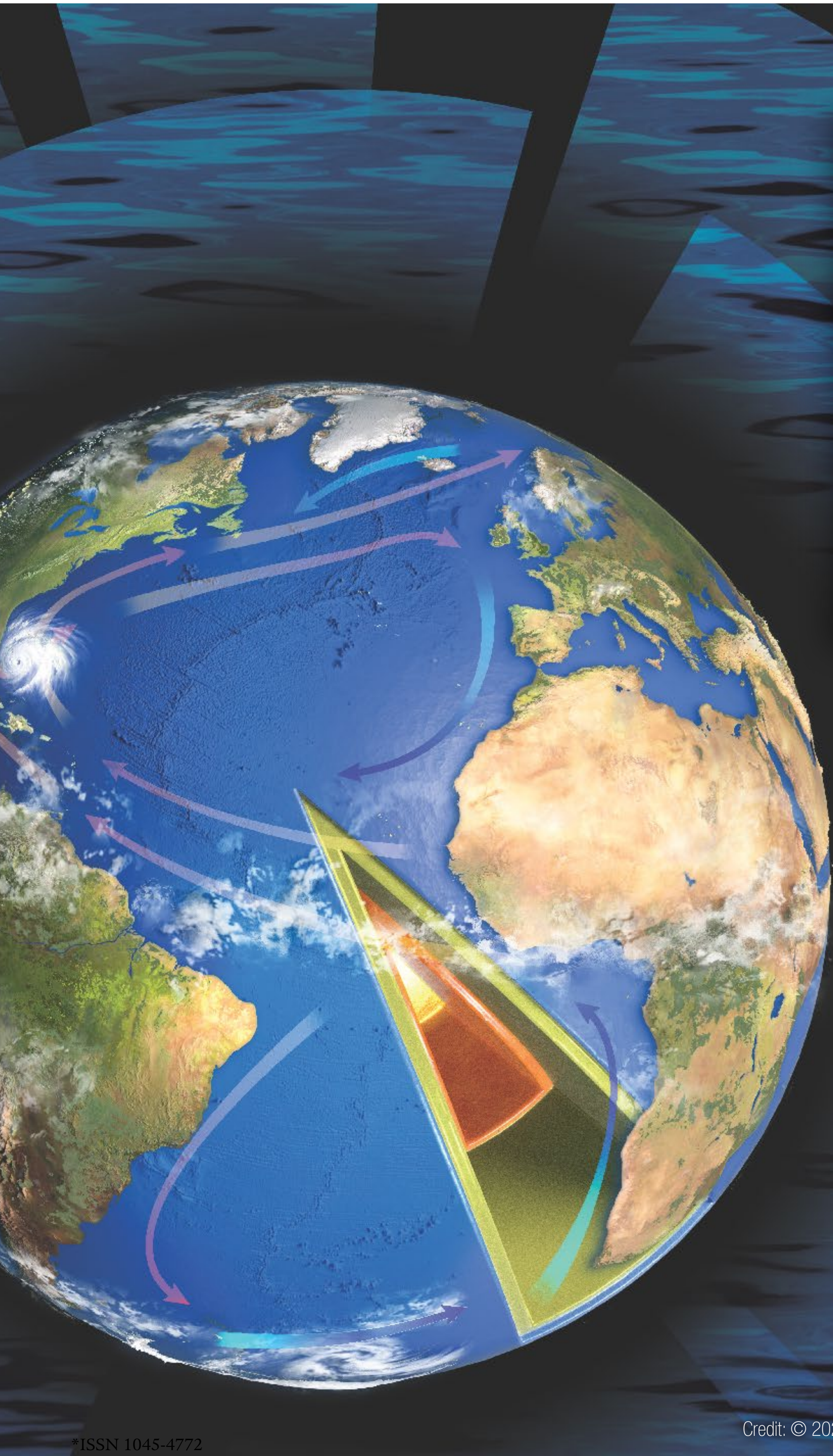

INSIDE THIS ISSUE

This image is from the 2021 Earth Science Week Activity Calendar, a monthly water-themed activities for 2021-2022 at (earthsciweek.org)

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Letter from the Guest Editor

Water Today and for the Future

Earth Science Week 2021

By Geoff Camphire, Associate Director of Communications at the American Geosciences Institute.

Water is a vital resource for all living things, and education about water has never been more important. To help all citizens effectively understand, conserve, and protect water, Earth Science Week (ESW) 2021 celebrates the theme of "Water Today and for the Future" on October 10-16, 2021.

This theme engages young people and others in exploring the importance of water — and water science — for living things, Earth systems, and the many activities that people undertake that depend on and/or affect water. Individuals of all backgrounds, ages, and abilities are being encouraged to build an understanding of water's role in timely topics including energy, climate change, the environment, natural hazards, technology, industry, agriculture, recreation, and the economy. Organized by the American Geosciences Institute (AGI) in partnership with dozens of organizations, this weeklong celebration provides materials, activities, and opportunities for audiences in both formal and informal education settings, including some new resources that participants find useful year after year.

A Growing Online Resource

The Earth Science Week Online Toolkit, launched in 2018, has become a rapidly growing compendium of visually rich resources such as classroom activities, posters, news articles, career information, teacher professional development resources, and more. More than a dozen highly visual resources about water science have been recently added to the Online Toolkit. These include posters, infographics, and other items covering topics such as ocean acidification, coral reef restoration, groundwater, floods, hurricanes, and the hydrologic cycle.

The educational resources, developed by AGI and partners, include many specific to this year's theme as well as other topics in the Earth science. Some can be found in the printed Earth Science Week Toolkit, while others are available only electronically. Online Toolkit resources are organized to support the Next Generation Science Standards (NGSS). Users can search by type of resource, theme, language, disciplinary core ideas, crosscutting concepts, science and engineering practices, and more.

The Education GeoSource database, provides a rich collection of free geoscience curricula, classroom activities, teacher professional development opportunities, science education standards, virtual field trips, teaching ancillaries, and other education resources, created by AGI and additional organizations. New this year to the database is a number of "curated collections" that focus on resources provided by or endorsed by a specific organization and highlighting this year's water science theme. For example, the Soil Science Society of America (SSSA) (americangeosciences.org) collection features nearly a dozen activities, labs, and videos on topics including soil physics, biology, and chemistry, conservation, soils in urban environments, and water. Activities span K-12 and are aligned to NGSS disciplinary core ideas. One activity called "Got Clean Lakes? Thank Your Soil," invites students to explore soil, rainfall, runoff, landcover, land use, and reservoirs.

NASA's Global Precipitation Measurement Mission (GPM) collection showcases 12 activities, career information, datasets, videos, and speaker guides based on GPM resources and data. These NGSS-aligned activities are designed for students from kindergarten to the introductory undergraduate level, with an emphasis on elementary and middle school. A sample item is "Who's Using GPM Data," profiling people and projects using GPM data to address some of society's big challenges. Other organizations will be adding their own curated collections to highlight the resources they provide and/or endorse for use by educators.

Back With a Twist

Longtime participants will find familiar materials and opportunities in this year's Earth Science Week celebration — with some fresh perspective. The program poster, for example, focuses predictably on 2021's "Water Today and for the Future" theme to help poster teachers and students celebrate Geologic Map Day on Friday, October 15. Hosted by the U.S. Geological Survey, the Association of American State Geologists, the National Park Service, the Geological Society of America, and NASA in partnership with AGI, Geologic Map Day promotes awareness of the study, uses, and importance of geologic mapping for education, science, business, and a variety of public policy concerns. The poster uses an artistic representation of Earth's systems along with icons to engage viewers in thinking about the roles and sources of water in our world, as well as water-related issues. These graphics encourage students to closely examine the Lake Powell reservoir on the Colorado River, and to consider the ways water affects the geology and Earth's landscapes. Maps and images from the Utah Geological Survey, the Coastal National Elevation Database, the National Geologic Map Database, and others are provided along with step-by-step instructions guide students through multiple classroom activities.

The Earth Science Week Webinar Series is back this year, tackling "Water Frontiers" topics, an array of thought-provoking, timely issues relating to water and water science. AGI invites educators, students, and geoscience enthusiasts to participate throughout the week and beyond. The webinar series is aimed at the general public and education community and the features presentations hosted by scholars and experts. Webinars are available in many languages, with multilingual captioning.

AGI again is sponsoring four contests honoring this year's theme. Teams and individuals of any age are invited to submit brief videos that showcase their perspective on "Water Is Part of Life Around the World." The photo contest, open to all ages, asks participants to shine a spotlight on "Water as a Resource in My Community.

The visual arts contest encourages students from kindergarten through grade five to explore "Water and Me." "How We Understand, Use, and Protect Water" is the subject of the essay contest, targeting grades six through nine. These contests allow both students and the general public to participate in the celebration, learn about Earth science, and compete for prizes.

Figure 1a. An Earth Science Week Photography Contest entry for the 2020 theme, "Earth Materials in Our Lives," by Ella Giguere

Figure 1b. An Earth Science Week Photography Contest entry for the 2020 theme, "Earth Materials in Our Lives," by Tori Judy.

Figure 2. A 2020 Earth Science Week Visual Arts Contest entry by Elizabeth Xu.

Figure 3. A 2020 Earth Science Week Visual Arts Contest entry by Everett Lee.

Figure 4. A 2020 Earth Science Week Visual Arts Contest entry by Justin Xu.

Going International

Earth Science Week's global reach is nothing new, but has become a deliberate and active emphasis for the program. Over the past two decades, ESW has spread from the United States to more than 25 nations around the world, including Australia, Bangladesh, Canada, India, Japan, Portugal, Spain, and the United Kingdom. Now AGI is offering new opportunities and guidance for government agencies, private corporations, and other organizations around the world looking to get involved.

Language is not necessarily a barrier, as AGI makes key materials such as the program logo available for translation into languages other than English. Similarly, event locations may vary from secondary-school classrooms to university settings, museums, science centers, parks, corporate facilities, and homes. And because Earth Science Week can be celebrated any time that works in a given location, the timing of the event also does not need to be an obstacle for partners in parts of the world where school schedules or other factors might make times other than October the better choice for the celebration.

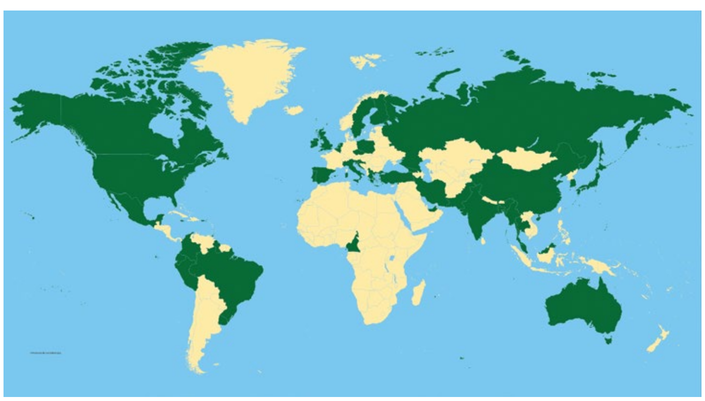

Figure 5. Nations Participating in Earth Science Week, 2016-2020 (in green)

American Geosciences Institute, map base ©Shutterstock.com/dikobraziy

Peg Steffen***The Earth Scientist*** is the journal of the National Earth Science Teachers Association (NESTA). It is published quarterly (January, March, June, September) and distributed to NESTA members.

To become a member of NESTA visit nestanet.org.

To get more information about NESTA or advertising in our publications, contact, nestaearthscientist@gmail.com.

DESIGN/LAYOUT
Patty Schuster, Page Designs

Earth Science Week's annual photography and video contests are open to audiences around the world. Individual members of all AGI Member Societies and members of AGI's International Associate Societies are eligible to participate in the photo contest, while the video contest is open to everyone. Though previously open only to residents of the United States, the contests have always been a major part of Earth Science Week.

Educators can compete as well. Given annually, the Edward C. Roy Jr. Award for Excellence in K-8 Science Teaching is presented to one teacher of grades K-8 in the United States or Key Stages 1-3 in the United Kingdom each year. The award recognizes leadership and innovation in Earth science education, and provides the winner with a cash prize and an additional travel grant to attend the National Science Teaching Association Annual Conference.

Whoever — and wherever — you are, you can join the celebration of Earth Science Week 2021!

About the Author

Geoff Camphire is Associate Director of Communications at the American Geosciences Institute. For more information, visit www.earthsciweek.org or email info@earthsciweek.org.

Sharon M. Stroud

Earth Science Educator, 1948-2021

Sharon Stroud and Jeff Callister on 2005 NESTA Field Trip in Dallas.

Photo credit: Tom Ervin

Sharon Stroud was a long-time science educator who dedicated her life to the profession of teaching. She spent 30 years at Widefield School District in Colorado and was also very active in professional organizations. Sharon served in many leadership roles, led numerous summer teacher workshops and authored publications for earth science educators. She was **the** first elected President of NESTA and served from 1986-88. Sharon originated the concept of "Share-a-thons", which are now regularly featured events by many NSTA-affiliated organizations. Many people who knew her legacy lovingly refer to share-a-thons as "Sharon-thons".

Sharon was an annual donor of spectacular geologic specimens to our NESTA rock raffles.

As her health deteriorated, Sharon could be found in a wheelchair attending NESTA events piloted by Jeff Callister. In 2013 in San Antonio, Sharon was honored with NESTA's *"Jan Woerner and Harold B. Stonehouse Award for Lifetime Achievement"*.

We are thankful to Sharon for her leadership, generosity and love.

What's in Your Water?

Peg Steffen, Editor for The Earth Scientist

A quick survey of the inclusion of "water" in the Next Generation Science Standards (NGSS, 2013) shows how pervasive the topic is at all grade levels. The results of an informal search included; movement of water, roles of water, patterns of water, properties of water, motion of water, cycling of water, fresh and salt water, and dependence on water. It is integrated in life, physical and Earth/space sciences with many applications in engineering and technology.

Water is a limited resource. The total amount of water in the world does not change over time and cannot be replenished if lost. A model globe shows about 70% of the earth is covered in water. Of that total water, 97% is in the oceans and is undrinkable without desalination treatment (to remove salt). Of the remaining fresh water, less than one half of one percent is available in surface sources like lakes, rivers, and swamps. Fresh water is becoming increasingly scarce in some parts of the world due to changing weather patterns and a growing population. You can highlight the relative amounts of water resources for your students with a quick simulation in Part 2 of *"Water, Water Everywhere"*. Then have your students track how much water they use at school and home for a week in Part I of that same activity. The results will be an eye opener for your students.

Another great starting place for elementary students to understand their ties to water resources is for them to be able to identify close bodies of water and where they flow. Younger students may only focus on water close to home, with older students being able to pinpoint their watershed address on a map. Activities from the Watershed Tourist provide lessons for grades 2-5.

The Environmental Protection Agency (EPA) has compiled water cycle, ground water and drinking water activities for grades K-high school. The ones below are for Grades K-3.

Grade	For Students	Lesson Plans and Teacher Guides
K-3	• Thirstin's water cycle adventure • Thirstin's water cycle • Thirstin's wacky water adventure • Interactive water cycle • Interactive build your own aquifer	• Thirstin builds an aquifer • Thirstin's ground water movement activity • How people get their water

The Global Learning and Observations to Benefit the Environment (GLOBE) Program provides students with the opportunities to meaningfully contribute to our understanding of the Earth system and global environment. In the water module students learn how aquatic critters help describe a creek and the importance of observational study.

By the end of this module, students will understand how scientists use macroinvertebrates to study water quality, know how to take measurements with scientific tools, and how to apply their measurements to a scientific investigation.

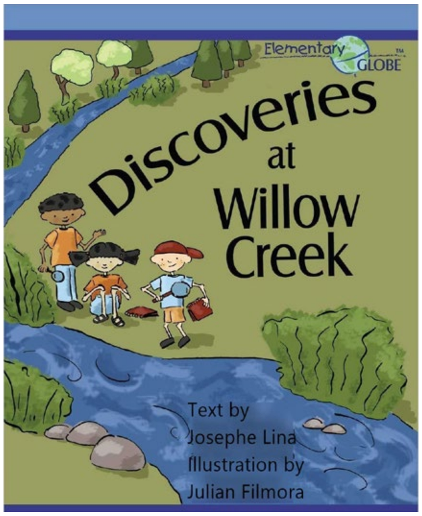

Figure 1. The storybook *Discoveries at Willow Creek* is available in printer-friendly, print on-demand and as an eBook (https://www.globe.gov/web/elementary-globe/overview/water).

Water is a vital resource and we need to understand where it comes from and how to make sure we will have enough drinkable water in the future. Teachengineering.org provides lessons for K-12 with applications of science and technology in many topics. For older students, identifying safe and suitable drinking water provides a real-life environmental engineering challenge. Students are introduced to dissolved organic matter (DOM) and the role it plays in identifying drinking water sources. They learn about drinking water treatment processes and finally develop their own water filtration system (https://www.teachengineering.org/lessons/view/cub_drink_lesson01).

Throughout history, contaminated water has been responsible for outbreaks of health problems and the spread of disease. One historic event in 1854 demonstrated the importance of clean water. Dr. John Snow is considered one of the founding fathers of modern epidemiology. As London suffered a series of cholera outbreaks during the mid-19th century, Snow theorized that cholera was an organism that reproduced in the human body and was spread through contaminated water. At that time, people believed that diseases were only carried in the air. His use of maps and investigative techniques are important in tracking the sources and causes of diseases today. A lesson in Part 4 of *"Water, Water Everywhere"* asks students to retrace the map and data that Dr. Snow used to identify the source of contamination. Slides and discussion questions are part of the supporting materials (https://digitalcommons.imsa.edu/model_ngss_lessons_4_5/11/). Interestingly, Dr. Snow was met with sceptics about his ideas but after a trial of his solution, was successful in proving his hypothesis that cholera was spread by contaminated water. His case is a fascinating story of the use of science data to save lives (http://www.ph.ucla.edu/epi/snow/snowcricketarticle.html).

Reference

NGSS Lead States. (2013). Next Generation Science Standards: For states, by states. Washington, DC: The National Academies Press. https://www.nextgenscience.org/

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

Geoscientists Help Save Lives Globally

Katie Burk, Director of Development, SEG Foundation
Pallavi Bharadwaj, Program Manager, Geoscientists without Borders®

Abstract

Since 2008, the Geoscientists without Borders® (GWB) program, founded by the Society of Exploration Geophysicists (SEG), has been working to build resilient communities where geoscience expertise and technology can be applied. GWB has a multidisciplinary mandate to use geoscience and technology to respond to humanitarian needs, while ensuring long-term sustainability within the impacted community by engaging the next generation of geoscientists. Projects are directed by geoscientists from universities or other nonprofits, in collaboration with local communities, educational institutions, and government and humanitarian agencies.

The important work that geophysicists do is having a tremendous impact on some of the most significant problems facing humanity (https://seg.org/WhatGeophysicistsDo).

Introduction

Many of the world's most pressing humanitarian issues fall into categories where geoscientists can make significant contributions because of their unique and advanced knowledge about the Earth. These issues include Water, Sanitation, and Hygiene (WASH); food security; disaster risk reduction (landslides, earthquakes, tsunamis, volcanoes); and environmental and cultural conservation. These are topics that relate closely to today's STEM curriculum standards. Looking at how these issues are addressed by geoscientists and others can provide real-world examples that demonstrate the relevance of many Earth system phenomena to individuals and communities. GWB has provided over US$3 million to humanitarian projects by helping to fund more than 50 projects in over 31 countries to date. GWB projects have involved more than 675 students, 75 university partners, 67 community partners, and 18 industry partners.

For educators who are implementing the Next Generation Science Standards (NGSS, 2013), GWB humanitarian relief projects provide rich illustrations of Earth and Space Science disciplinary core ideas, especially those addressing ESS3: Earth and Human Activity. Projects related to the water have included locating water wells in refugee camps in Kenya and Uganda, improving agriculture through precise irrigation in Ghana and Laos, and helping communities understand tsunami risk in Indonesia. Other aspects of human interactions with Earth's system can be addressed through attention to other GWB projects, such as a project that built early warning system capacity for a volcano in Guatemala.

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Importantly, connections between science, technology, society and the environment (see NGSS Appendix J) are also prominent in these projects. For example, the water management project undertaken in the Kakuma Refuge Camp (see inset) shows the influence of science, engineering, and technology on the refugees in the camp.

Water Management in Kenya

The Kakuma Refugee Camp occupies a semi-arid, impoverished corner of Kenya. Home to over 185,000 African war refugees, the camp has depended entirely on groundwater pumped from wells. Rapid expansion of the camp required additional water sources to provide an adequate water supply. In the process of preparing for water exploration, it was realized that high fluoride in many of the existing wells was causing illnesses and skeletal deformities in refugees.

GWB project leads, in collaboration with Kenyan geoscientists, students, and community partners, used advanced geophysical technology and knowledge of the local geography to locate drilling sites for six new wells. The project successfully achieved a high-quality, safe water supply for the camp as well as for surrounding areas.

Figure 1. Public primary school in Kakuma town. Photo Credit: Paul Bauman

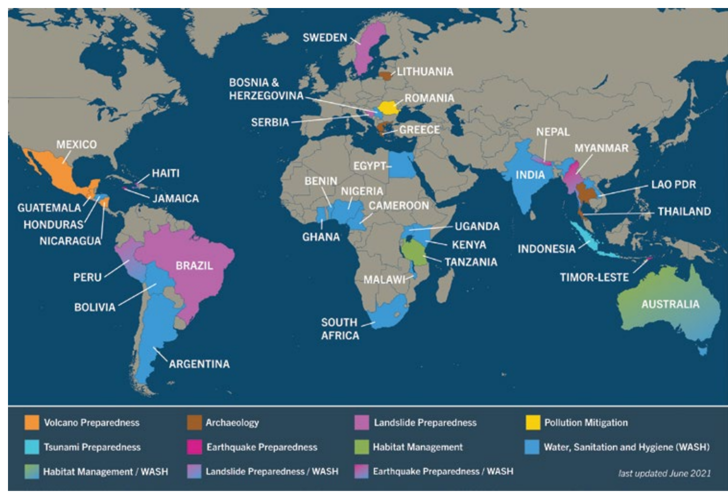

Figure 2. Latest Geoscientists *without* Borders® project map. Educators interested in introducing students to the UN-SDGs might find a poster created for this year's Earth Science Week kit useful. It can be seen in the Earth Science Week Online Toolkit: Geoscientists Without Borders: Advancing Humanitarian Geoscience Solutions Worldwide flyer.

GWB projects also help to achieve the United Nations Sustainable Development Goals (UN-SDGs). The seventeen goals are part of an international initiative called "The 2030 Agenda for Sustainable Development", which has been adopted by all the United Nations Member states. GWB projects can also be used to highlight ways that Earth and Space Science understanding supports one or more of the SDGs.

Educators around the world are working to incorporate the UN-SDGs into instruction in a movement referred to as Education for Sustainable Development (ESD). ESD empowers learners of all ages with the knowledge, skills, values and attitudes to address the interconnected global challenges, including climate change, environmental degradation, loss of biodiversity, poverty and inequality. UNESCO has developed a toolbox to provide an evolving set of selected resources to support Member States, regional and global stakeholders to develop activities in the five priority action areas and activities in support of six key areas of implementation.

The long term vision of SEG is to grow GWB through increased visibility, membership, partnerships, new activities, and wider offerings, in addition to the two grant funding cycles every year (January 15 and July 15).

Please send your questions to withoutborders@seg.org.

References

NGSS Lead States (2013) Next Generation Science Standards: *For States, By States*. Washington, DC: The National Academies Press. https://www.nextgenscience.org/

Table 1. Summary of selected GWB projects, relating each to a primary UN Sustainable Development Goal

UN-SDGs	Brief description and primary goal of GWB project	Project impact
1 No Poverty	**Kenya:** Improve the water supply of the Kakuma Refugee Camp, home to more than 185,000 residents from more than 16 countries in East Africa. Results include the United Nations High Commissioner for Refugees now encouraging camps to become self-sufficient economic entities.	Provided clean water supply to approximately 100,000 refugees, and there is an ongoing study to develop a small-scale agricultural economy.
2 Zero Hunger	**Peru:** Generate a hydrogeological model for the Ramuschaka Watershed in Zurite. Information gathered was used to design and assist in the construction of a reservoir and irrigation canal network for the small holding agriculture.	A 1.3 km long canal was dug to benefit 100 families for dry-season irrigation and livestock keeping.
3 Good Health and Well Being	**Cameroon:** Explore a better understanding of aquifer system for prevention of cholera outbreaks and to enhance technical capacity of geophysical survey in local communities including universities and non-profit organizations.	Trained 13 graduate and more than 30 undergraduate students in geophysical techniques.
4 Quality Education	**Bolivia:** Provide a better understanding of the aquifer systems in Challapampa, Pukarani and Cochabamba, which are essential for the water supply for approximately 300,000 to 400,000 people in west and central Bolivia to avoid overexploitation and contamination.	Four knowledge-transfer seminars conducted with locals, and two PhD, seven MSc, and seven BSc degrees were earned. One of the students teaches in Bolivia, serving as a role model to local students for pursuing career in geosciences.
5 Gender Equality	**Myanmar:** Improve water security in rural Mon State by enabling engineers, students, and researchers to use electrical geophysical methods to locate sustainable water supplies, and train local people including women in geoscience techniques.	Participants surveyed 20 local villages using open-source software modeling and inversion via a "training of trainers" model.
6 Clean Water and Sanitation for all	**Argentina:** Locate sustainable groundwater resources for an Aboriginal community in the Chaco Province by using electrical prospecting methods for paleochannels.	Participants located and drilled 10 wells to benefit 100 families and trained 10 graduate and 50 undergraduate students.
7 Affordable and Clean Energy	**India:** Study the mitigating factors affecting water supply in the Salri Watershed in Madhya Pradesh and evaluate the aquifer's downstream capacity of the water harvesting structure.	Seven wells were drilled to support groundwater monitoring studies and help secure a reliable water resource for the villagers.
8 Decent Work and Economic Growth	**Uganda:** Provide improved access to drinking water in Acholiland and refugee camps in the West Nile, as well as provide participants with training and skills in geosciences and mechanics to earn a decent wage.	Trained 33 Acholi students to drill seven wells in seven villages, and repaired 17 hand pumps for improved water supply to 4,700 villagers and formed small-business enterprises in the area.
9 Industry, Innovation and Infrastructure	**Malawi:** Locate new wells for providing clean drinking water to the villagers in southern Malawi, and build geoscience capacity (enhance the Water Resources Program at the University of Malawi), as geophysical surveys are commonly required by NGO's and government agencies before new boreholes are sited or permitted.	Productive boreholes for water were dug in four villages. Trained local students and added geophysics to the local curriculum.
10 Reduced Inequalities	**Lao PDR:** Build in-country human and institutional capacity for resilience in agricultural productivity through sustainable use of groundwater for local farmers in the Vientiane Plain.	Trained 25 local students and 20 government and university participants in geophysical techniques and application to benefit local smallholder farmers' irrigation.
11 Sustainable Cities and Communities	**Haiti:** Assess disrupted groundwater conditions in Leogane, due to newly paved roads and storm water drainage structures, using a cost-effective manner and a non-intrusive geophysical approach.	Discovery of a second deeper aquifer with coliform-free water. Trained students in geophysical techniques and provided report to Haiti Engineering for dissemination to the community.
12 Responsible Consumption and Production	**Peru:** Quantify hydrology of the Ramuschaka Watershed, which drains through the western sector of Zurite. The community requires detailed information to guide sustainable water-management practices.	Engaged nine graduate and 19 undergraduate students to map the Ramuschaka Watershed.
13 Climate Action	**Ghana:** Curb seasonal rural-urban migration to big cities in search of meager or nonexistent jobs due to changing climate. Enable dry season farming, which is critical to poverty reduction and socioeconomic development.	Developed a precision irrigation framework. Two workshops were organized to educate over 150 farmers about efficient irrigation water management.
14 Life Below Water	**Tanzania:** Form the framework for defining small protected zones that will secure the health and productivity of the littoral (near shore part of the lake) fishery.	Set standards for conservation geophysics research on large lakes in support of fisheries in eastern Africa to help ensure food security and livelihood.
15 Life on Land	**South Africa:** Restore sufficient water supply to the Dayspring Children's Village (school) and document the effect of invasive trees on groundwater for broader application throughout South Africa.	Quantified the groundwater effects by removing invasive trees. Properly sited a new productive borehole.
16 Peace, Justice and Strong Institutions	**Lithuania:** Illuminate the beginning of the Holocaust in Kaunas, what was then the capital of Lithuania, by providing nondestructive evidence of the mass murders at Fort IX and a snapshot of a Jewish town at the onset of World War II.	Noninvasive drone-based mapping techniques proved to provide a more-rapid and less-evasive approach to mass-burial mapping.
17 Partnerships for the Goals	**Partnerships is at the core of GWB.** The mark of a strong GWB project is the partnership between the host and in-country institution to bring together project leads, students, and diverse teams to carry out the plans by engaging local communities and stakeholders.	Partnerships ensure the long-term sustainability of all GWB-funded projects.

About the Authors – Geoscientists Help Save Lives Globally

Katie Burk has more than 20 years of experience working for non-profit organizations. For almost 15 years, she has been directly involved with SEG Foundation activities, from program management to capital campaign fundraising and donor stewardship. As the Director of Development, she leads the development activities through active fundraising, implementation of comprehensive development plans, compassionate donor stewardship, oversight of financial and administrative functions, and effective engagement with the SEG Foundation Board of Directors and committee members. Katie can be contacted at foundation@seg.org.

Pallavi Bharadwaj, is M.Sc. in Environmental Science and Public Health, with over 15 years of global development experience in South Asia and the US. She has worked from grassroots to international non-profit organizations, grant-making as well multilateral agencies. Her area of focus is water, sanitation and hygiene (WASH) related issues and how water impacts various aspects of our societies and communities (gender, disabled, socio-economics among others). At SEG, she manages the full cycle of grant-making for Geoscientists *without* Borders® and supports the volunteer committee, in addition to help promote the program. She is a regular contributor to various WASH publications and mentors young professionals along with volunteering at various non-profits as their board member. Pallavi can be contacted at withoutborders@seg.org.

NGSS-ESS Working Group

The NGSS-ESS Working Group is a collaboration between the National Association of Geoscience Teachers, the National Earth Science Teachers Association, and the American Geosciences Institute supporting implementation of the Earth and space science Next Generation Science Standards.

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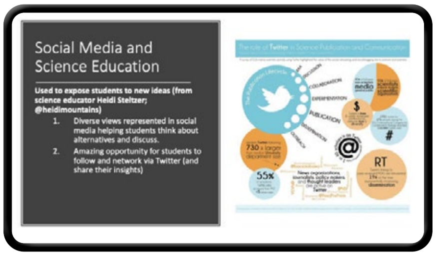
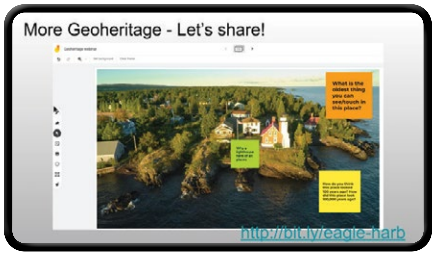
To learn more about our programming and to receive notifications of upcoming webinars: **https://bit.ly/joinNGSS_ESS**

To view past webinars visit AGI's YouTube channel: **https://bit.ly/webinarsNGSS**

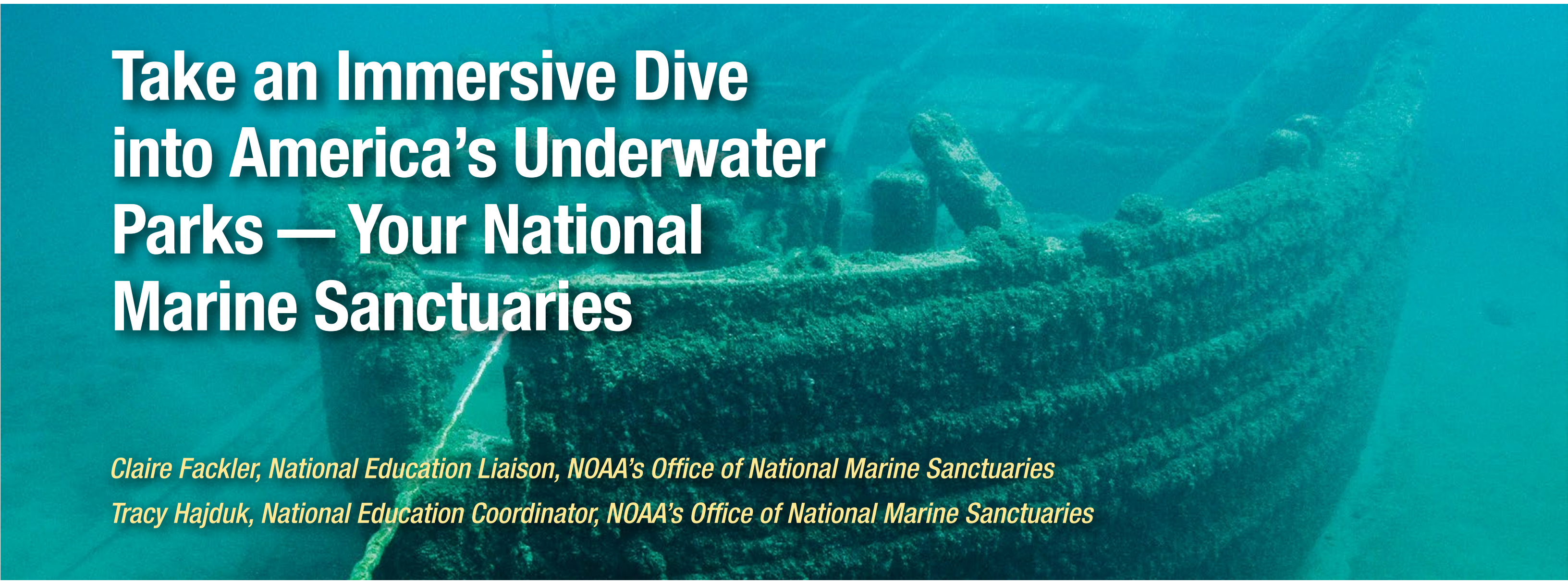




Sample presentation slides from NGSS-ESS Working Group webinars.
Top slide courtesy of Twin Cities PBS, https://www.tpt.org; Bottom: Drone photo by Steve Brimm Photography

Take an Immersive Dive into America's Underwater Parks — Your National Marine Sanctuaries

Claire Fackler, National Education Liaison, NOAA's Office of National Marine Sanctuaries
Tracy Hajduk, National Education Coordinator, NOAA's Office of National Marine Sanctuaries



Shipwreck of the schooner E. B. Allen sunk by collision rests in Lake Huron, Michigan at Thunder Bay National Marine Sanctuary.
Credit: NOAA/NOS/Thunder Bay National Marine Sanctuary

Abstract

The National Oceanic and Atmospheric Administration (NOAA) manages the National Marine Sanctuary System, which encompasses over 620,000 square miles of underwater parks that protect special marine places in the United States. Due to the need to snorkel or dive to explore the breathtaking underwater world of national marine sanctuaries, many Americans have not had the pleasure of experiencing these iconic ocean parks. For some, these ocean or Great Lakes treasures exist only through the imagery or videos they may have seen that cannot fully capture the true beauty and significance of these spectacular places. Educators are challenged with teaching students about these places – the Earth processes that formed them and the biodiversity of life there – but often are unable to bring students on field trips to explore these places first hand. New technology, underwater virtual reality (VR) video, is paving the way for an immersive experience helping students to access underwater national treasures.

Introduction

That first breath underwater is often one of the most memorable for any new diver. The glimpse of a completely foreign world that makes it feel like you are so far away, but is literally just feet from the comfort of the water's surface where you just were. Divers lucky enough to dive in national marine sanctuaries – America's underwater parks – often emphasize that their experience was enhanced by marine life encounters, elaborate coral reefs, towering kelp forests, and historic shipwrecks. And now this experience is not just for divers, but for anyone with a phone, computer, or VR headset.

NOAA's Office of National Marine Sanctuaries would like to introduce you to [Sanctuaries 360°](#) a collection of immersive underwater VR video experiences that brings national marine sanctuaries to viewers not only in the United States, but from all over the world. Filmed using industry-leading 360° underwater and land-based camera systems, these videos can be viewed on phones, tablets, computer screens, and VR headsets, empowering anyone to visit these underwater parks anytime, anywhere. "Using VR can eliminate barriers that may have kept someone from being able to experience our national marine sanctuaries," says John Armor, Director of NOAA's Office of National Marine Sanctuaries. "Never before have these underwater parks been so accessible and available to the public."

> These VR video experiences won a People's Voice Webby Award in the Virtual and Remote – Science and Education category. https://sanctuaries.noaa.gov/news/apr21/webby-awards-2021.html

VR has become an increasingly popular form of media that excites viewers of all ages. More places and experiences are being captured and shared in 360 degrees every day, and the technology is rapidly advancing. VR is the next big wave of audience engagement, including in schools and informal learning settings. The immersive nature of VR allows for the media to feel more like a human experience than a display on a screen. VR encourages interaction; viewers experience the most when they move around and see the content all around them, allowing them to connect with it through their own unique adventure. "As a diver, this immersive VR experience is the closest thing you can get to actually diving in the marine environment," says Kate Thompson, Chief of the Education and Outreach Division at NOAA's Office of National Marine Sanctuaries. "You are able to look down and investigate the seafloor or turn around to see the diver next to you. As a sea lion darts through the underwater arch, you can shift around with your headset and interact with it as you would in real-life."

Figure 1. A young student gets immersed by donning a VR headset and exploring one of America's underwater parks virtually.
Credit: Claire Fackler, NOAA Office of National Marine Sanctuaries.

Sanctuaries 360° offers immersive experiences that guide the viewer through America's national marine sanctuaries. From the kelp forests in Channel Islands National Marine Sanctuary to the sunken shipwrecks in Thunder Bay National Marine Sanctuary, which is also known as 'Shipwreck Alley.' Viewers can also experience the biodiversity that Hawaiian Islands Humpback Whale National Marine Sanctuary offers, or head down to Florida and check out the ongoing coral restoration efforts in Florida Keys National Marine Sanctuary. Sanctuaries 360° takes you below the surface in a fun, interactive, and educational way.

The following four videos kick off the Sanctuaries 360° series brought to you by NOAA's Office of National Marine Sanctuaries. Viewers will encounter sea lions, sharks and sea turtles, restore coral reefs, and tour a shipwreck in Lake Huron. Florida Keys National Marine Sanctuary protects some of the most iconic coral reefs in the world, but corals are suffering from disease and other stressors. Fortunately, NOAA and our partners are working together to restore these critical coral reefs. Grab your mask (okay, headset) and watch divers restore the reef by planting healthy corals that will grow into thriving colonies. Start exploring national marine sanctuaries through your fingertips with these videos below and stay tuned for more immersive content to come including videos and lessons about shipwrecks in the proposed Lake Ontario National Marine Sanctuary.

Explore the Blue: 360° Coral Restoration

Figure 2. Florida Keys National Marine Sanctuary holds some of the most iconic coral reefs in the world, but they are suffering from disease and other stressors. Fortunately, NOAA and our partners are working together to restore these critical coral reefs. Dive in to see this restoration work in action at a coral nursery.
Credit: NOAA

Explore the Blue: 360° Sea Lion Encounter

Figure 3. Located off the coast of Southern California, Channel Islands National Marine Sanctuary is a biological hotspot. Swim along with a playful sea lion as it takes you on a tour through the sanctuary's kelp forests and rocky outcrops.
Credit: NOAA

Explore the Blue: 360° Hawaiian Adventure

Figure 4. Come along and explore with green sea turtles (*honu*) as we take you around Hawaiian Islands Humpback Whale National Marine Sanctuary. Learn how Hawaii's volcanic islands were formed, swim with whitetip reef sharks (*mano*), and watch your new turtle friends kick back and relax at the turtle spa.
Credit: NOAA

Explore the Blue: 360° Shipwreck Alley

Figure 5. National marine sanctuaries protect more than just aquatic life. Places like Thunder Bay National Marine Sanctuary, located in Lake Huron, safeguard our nation's maritime history. Join your dive buddies on a visit to *D.M. Wilson,* one of the hundreds of shipwrecks protected in Thunder Bay National Marine Sanctuary.
Credit: NOAA

Lesson Plans Aligned to the Next Generation Science Standards

What started as a collection of 360° photographs from a number of locations within eight of our national marine sanctuaries, has grown with a collection of videos as well as educational resources for middle school classrooms to allow a viewer to become immersed in these special places. The NOAA Office of National Marine Sanctuaries worked with Ocean First Education to develop free lesson plans for grades 6-8 aligned to the Next Generation Science Standards (NGSS, 2013), ocean literacy, and climate literacy to take your students deeper into each video while meeting many Earth science standards too. These lessons were developed for educators to further engage middle school students with the virtual dive experience. Educators will be able to guide students to identify species, compare and contrast ecosystems, visualize the human impact on the changing ocean, and experience close up encounters with marine life. The lessons incorporate the videos and take a deeper dive into the species, resources, and characteristics of the national marine sanctuaries featured.

Lesson: Your National Marine Sanctuaries, Compare and Contrast Aquatic Ecosystems

This mini-research project introduces students to America's underwater parks by comparing and contrasting the various marine sanctuaries. Through a deeper dive into the digital resources offered, including four 360° videos, students learn how national marine sanctuary sites are designated and why they are important for protecting and preserving the ocean and Great Lakes. Students will then conduct independent or small group research on specific national marine sanctuaries using 360° videos, photos, and print resources. Students will use the information they collected to compare and contrast the four different sites and create a slideshow that will be presented to peers upon completion.

Lesson: Florida Keys National Marine Sanctuary, Design a Coral Nursery

Students will dive deeper into the coral restoration work that the 360° video highlights. Students will research the ecology of coral reefs, natural and human threats to corals, and the science of coral restoration. Students will design and make an argument for a proposed new coral nursery to be placed within Florida Keys National Marine Sanctuary.

Lesson: Channel Islands National Marine Sanctuary, Adapting to a Cold Marine Environment

This three-part investigation will introduce the unique Channel Islands National Marine Sanctuary's plants and animals that live and thrive in the cold-water marine environment and learn about specific adaptations necessary for survival in this habitat. Students will then design an experiment to model insulation, comparing how humans and sea lions have specific adaptations (or requirements) to help them survive in cold water environments.

Lesson: Hawaiian Islands Humpback Whale National Marine Sanctuary, Species Conservation

In the Hawaiian Islands Humpback Whale National Marine Sanctuary 360° video, students learn about the diversity of life found in the Hawaiian Islands. Students will explore the ecology of three different species, their importance to Native Hawaiian culture, and the conservation measures in place for their protection. Students will produce a tri-fold brochure meant to teach visitors of the sanctuary about the ecology of their assigned species and its importance to Native Hawaiian culture.

Lesson: Thunder Bay National Marine Sanctuary, Historical and Ecological Importance of Shipwrecks

Tied to the virtual dive on the wreck of *D.M Wilson*, students research the historical, ecological, and economic importance of Thunder Bay National Marine Sanctuary. Students create a digital infographic that communicates the importance of preserving a shipwreck.

America's marine sanctuaries are places of hope, inspiration, biodiversity and resilience. And now, diving into them with your students is at your fingertips. So ready, set, dive!

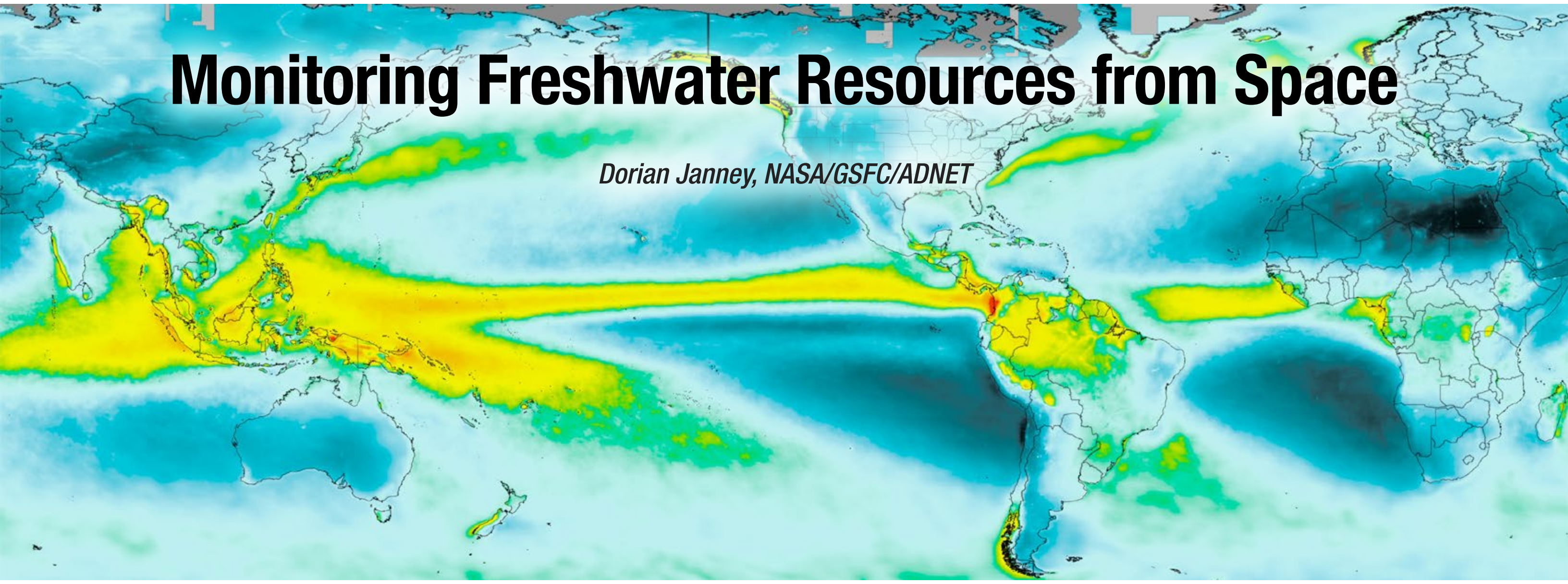
Reference

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

About the Authors

Claire Fackler is a National Education Liaison and National Volunteer Coordinator for the NOAA Office of National Marine Sanctuaries. She has worked for NOAA for the past 21 years to bring the ocean into America's classrooms and homes with a mission to inspire ocean and climate literacy and conservation through national marine sanctuaries. She works with various partners on national and regional educational programs that enhance public awareness, understanding, and appreciation of the marine environment. Though unconventional, she has a Bachelor of Arts in psychology from the University of California Santa Barbara, yet her passion for ocean conservation puts her in the marine education line of work. Claire is a Certified Interpretive Guide (CIG) and also a CIG Trainer through the National Association for Interpretation, a University of California Climate Steward, as well as a member of the National Science Teachers Association and National Marine Educators Association. She can be reached at claire.fackler@noaa.gov.

Tracy Hajduk is the National Education Coordinator for the NOAA Office of National Marine Sanctuaries. She has worked for NOAA for the past 12 years coordinating national partnerships to help increase ocean and climate literacy and access to national marine sanctuaries through education. Previous to her time with NOAA, Tracy was the Outreach Coordinator at Northeastern University's Marine Science Center and was adjunct faculty at Northeastern University's School of Professional Studies teaching a course on using field experiences to meet science education standards in the classroom. Tracy started her career as a member of the Education Department at the New England Aquarium. She has a Master's Degree in Education from Northeastern University and a BS in Ecology and Evolutionary Biology from the University of Connecticut. Tracy enjoys connecting all people, especially students and teachers, to our ocean and Great Lakes and finding ways to inspire people to learn about, explore, enjoy and be stewards of these special places. She can be reached at tracy.hajduk@noaa.gov



Monitoring Freshwater Resources from Space

Dorian Janney, NASA/GSFC/ADNET

Average annual rainfall (mm/year) for June 2000 - May 2019 computed using the Integrated Multi-satellite Retrievals for GPM (IMERG).

Photo credit NASA Goddard Scientific Visualization Studio.

Abstract

NASA's Global Precipitation Measurement (GPM) mission observes precipitation as it falls from clouds to the Earth and updates those measurements globally every thirty minutes. Being able to know when, where, and how much precipitation is falling enables many decision-makers to have vital data to respond to the needs of living things and to help us respond to the challenges of both climate change and human population growth. In this article, teachers will find a variety of NASA-created education and outreach resources to help them share the science, technology, and real-world applications behind GPM; one of NASA's preeminent Earth-observing satellite missions.

Introduction

You might be surprised to learn that there is a NASA satellite mission that is measuring how much precipitation falls from the clouds to the surface of Earth. The mission enables us to keep track of Earth's most precious natural resource, freshwater! The Global Precipitation Measurement (GPM) mission is a joint effort between NASA and the Japanese Space Agency (JAXA) and is supported by an international collaboration of Earth-observing satellites. This is a follow up mission to the Tropical Rainfall Measurement Mission (TRMM), which was also a joint effort between NASA and JAXA. TRMM launched in 1997 and was measuring liquid precipitation as it fell from the clouds to the ground in the mid-latitudes. By the time GPM launched in 2014, the state-of-the-art technology had improved. Now the updated GPM Core Observatory can measure both liquid and frozen precipitation. By including data from several other Earth observing satellites that were measuring other environmental parameters, GPM can measure precipitation falling to the ground from clouds all over the world and updates these measurements every 30 minutes! Check out an animation of the last 7 days of GPM's precipitation observations at our Science Visualization Studio website.

Figure 1. Global Precipitation Measurement Mission

Photo Credit: NASA

Over two decades of global precipitation data is freely available and easy to download and analyze. As a result, many different end-users are finding that knowing where, when, and how much precipitation has fallen in specific locations is enabling them to manage these vital freshwater resources. There are a wide variety of ways in which these data are being used for real-world applications for societal benefit. These include such things as helping us better understand our water cycle, knowing how much precipitation falls during a flooding event, and providing low-cost insurance policies for family farmers in developing countries. You can learn more about the many ways that GPM data are being used at GPM "Applications" webpage.

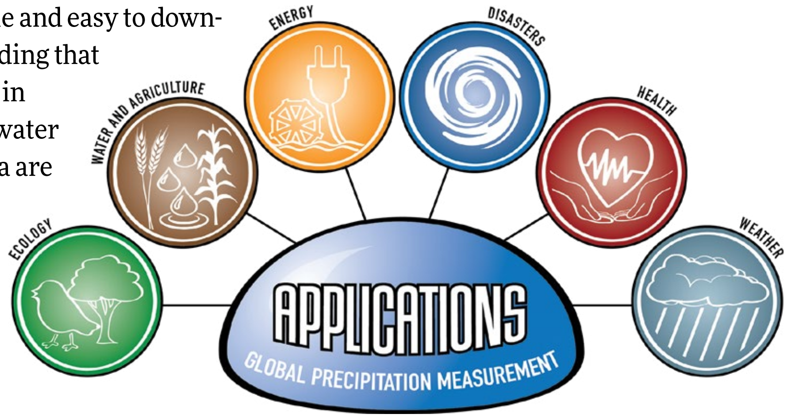


Figure 2. There are six main categories of end-users of GPM data Photo Credit: NASA/GPM

Animals rely on precipitation to have freshwater available to them, and the impacts of climate change are already having a profound effect on ecosystems. Changes in temperature and precipitation patterns affect species and communities in diverse ways which can lead to declines in species and species diversity, changing interactions between species, and modifications of ecosystems. Imagine how an ecologist studying the movement of animals might be interested in the impact of precipitation on animal migration? While ecologists have many tools to use in the field, having access to global data sets greatly enhances their ability to better understand many of the factors involved in where and when animals migrate.

Figure 3. Researchers used clues from GPS tracking of zebras and satellite data to predict when the zebras will be on the move. Photo Credit: NASA

Effective ecosystem management is critical to maintaining and repairing natural environments to reliably support human needs while conserving and sustaining ecological services and diversity. Satellites from many countries collect and freely share their environmental data, which proves to be a huge benefit to helping improve life around the globe. Learn more about how GPM and other NASA Earth observations are supporting the work of animal ecologists in this teaching resource entitled "*Connecting Animal Ecologists to NASA Data*".

Agriculture is another important end-user group of GPM data. Freshwater from precipitation can result in the success or failure of both farming and ranching efforts. Dr. Faisal Hossain, a civil and engineering professor with the University of Washington, has been working closely with wheat farmers in India and Pakistan to help them reduce the need to use precious freshwater resources from rivers to irrigate their crops by using GPM data to tell them when precipitation will be heading their way. Today, India and Pakistan are among the world's most water-scarce countries. A growing competition over finite water resources will have serious implications for farmers in those countries and thus impact the region's food security. The GPM Outreach team has developed a suite of teaching resources, including videos and lesson plans, to help educators share the

Figure 4. Farmer checking his cell phone to see whether to release water from the nearby river into his fields. Photo credit: F. Hossain

story of how using satellite data is presenting a life-changing opportunity to those in water-scarce countries.

Rain, snow, and other forms of precipitation affect all life on Earth. For example, rain falls and nourishes the crops we eat, fills the reservoirs of water we drink, and is an integral part of everyday weather and long-term climate trends. Knowing where, when, and how much precipitation is falling is essential to life as we know it. Helping students to understand the science and technology behind Earth-observing satellite missions as well as the real-world applications for these data can steer them to explore how we are working together across nations to respond to the needs of all living things on our home planet. GPM's "Precipitation Education" website provides many valuable teaching resources including "Water for Wheaties", lesson plans for K-5, middle school and high school. (https://gpm.nasa.gov/education/societal-applications) The lessons are aligned with the NGSS and include videos, slides, GPM data, rubric, interviews with experts, and a note-taking organizer. Students work in small groups to understand how wheat is grown in different regions of the world, the differences between weather and climate and the scarcity of freshwater in Pakistan. Students use the GPM data to explore the amount of precipitation that has fallen in Pakistan and Kansas over the past two decades and make recommendation for how farmers can prepare for water shortages. Finally, they consider ways that they can reduce the use of freshwater in their own lives.

About the Author

Dorian Janney, MS in General and Special Education, has a passion for sharing the wonders of NASA's science and exploration with others across all age levels! For over three decades, she taught public school in both special and general education settings across all grade levels. She was an Einstein Fellow Finalist and achieved National Board Certification in Science Education, served on numerous education working groups, and wrote science curriculum for the country. She has served as the Global Precipitation Measurement (GPM's) Education and Outreach Coordinator for ten years, and develops resources to help share the science, technology, and real-world applications of GPM with others. She serves on The GLOBE "Mission Mosquito" and "Trees Around the GLOBE" campaigns and is a Mentor GLOBE trainer and a member of the GLOBE Education Working Group. She can be reached at dorian.w.janney@nasa.gov.

The Great Pacific Garbage Patch: Plastic in the Ocean

James T. McDonald, Central Michigan University

Marine debris on Green Island, Kure Atoll, Papahanaumokuakea Marine National Monument

Photo Credit: Claire Fackler, NOAA CINMS

Abstract

The Great Pacific Garbage Patch (GPGP) is an intriguing and well-publicized environmental problem. Through exploring this complex issue, students gain insight into aspects of chemistry, oceanography, fluids, environmental science, life science and even international policy. These suggested learning ideas for grades 6-8 will encourage students to explore important concepts about the ocean and how humans impact its health.

Introduction

Garbage patches are large areas of the ocean where litter, fishing gear, and other debris – known as marine debris – collects. They are formed by rotating ocean currents called "gyres". This swirling soup of trash up to 10 meters deep and just below the water surface is composed mainly of non-degradable plastics. These plastic materials trap aquatic life and poison them by physical blockage or as carriers of toxic pollutants. The problem relates to materials science and the advent of plastics in modern life, an example of the unintended consequences of technology. These grade 6-8 unit suggestions provide ways for an instructor to use existing educational resources about plastic pollution in the classroom. Students will learn about the types of plastic debris that collects in the sea and how ocean currents have caused the development of phenomena like the Great Pacific Garbage Patch. The lesson ideas emphasize the importance of reducing plastic pollution in the ocean and allow students to investigate phenomena that they may see referenced in many places. Depending on the amount of time an instructor wishes to spend on these activities, a lesson sequence

Table 1. Earth and Human Activity

Performance Expectation

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.

Dimensions	Classroom Connections
Science and Engineering Practices	
Engaging in Argument from Evidence • Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model by a phenomenon or a solution to a problem.	• Students construct explanations to their peers about an aspect of marine debris. They can also write a letter to an elected official or a relative, explaining what they learned.
Disciplinary Core Idea	
ESS3C: Human Impacts on Earth Systems • Typically, as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (MS-ESS3-4)	• Students can analyze the amount of plastic that they go through as a family in a week and then connect how plastic can work its way into the ocean current system.
Cross-Cutting Concepts	
Cause and Effect • Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-ESS3-4)	• Students predict how the Great Pacific Garbage Patch developed by ocean currents in the Pacific Ocean.

may take days or several weeks. Investigations provide many connections to the Next Generation Science Standards (NGSS, 2013)

Misconceptions

At the beginning of a new unit of science instruction, it is a good idea to check for and research possible student misconceptions. Here are three common student misconceptions about the Great Pacific Garbage Patch.

Misconception #1: The Great Pacific Garbage Patch can be seen from space.

The Great Pacific Garbage Patch isn't one giant mass of trash, nor is it a floating island. Barely 1 percent of marine plastics are found floating at or near the ocean surface. There is now, on average, an estimated 70 kilograms of plastic in each square kilometer of seafloor. These individual pieces of plastic are smaller than one might expect. Much of it is microplastics, with lots of open water in-between the particles. "Because microplastics are smaller than a pencil eraser, they are not immediately noticeable to the naked eye," the National Oceanic and Atmospheric Administration (NOAA) (https://marinedebris.noaa.gov/movement/great-pacific-garbage-patch), "It's more like pepper flakes swirling in a soup than something you can skim off the surface." These tiny bits of broken-down plastics are pervasive and easily mistaken for food by marine animals.

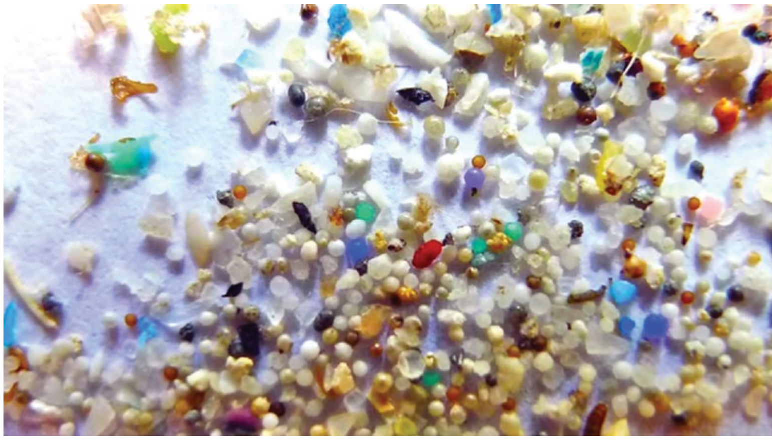


Figure 1. Close up of Microplastic beads found recently in the Great Lakes. (https://www.ijc.org/en/history-and-evolution-microbead)

Misconception #2: It's twice the size of Texas.

It is hard to determine the size of a garbage patch because the boundaries are constantly shifting. Natural forces like winds and ocean currents push and pull the debris into new directions. The particles also move up and down the water column. In other words, while the surface of the patch could span an area that's double the size of Texas, this measurement doesn't necessarily paint an accurate or total picture of the problem. The true problem lurks in the deep: 94 percent of the ocean's plastic can be found on the seafloor (Petsko, 2019).

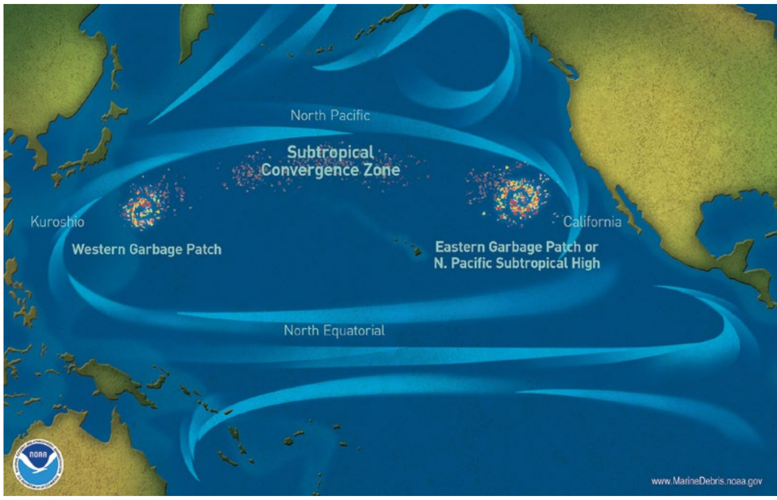


Figure 2. Garbage patches are large areas of the ocean where litter, fishing gear, and other debris - known as marine debris - collects. They are formed by rotating ocean currents called "gyres. https://marinedebris.noaa.gov/info/patch.html

Misconception #3: Ocean cleanups can solve the garbage patch problem.

Because of the complex forces of nature at work and the tiny size of microplastics, ocean cleanups are not a feasible solution. According to NOAA, it would take 67 ships an entire year to clean up less than one percent of the North Pacific Ocean. On top of that, current technologies may cause harm to marine life, scooping them up along with the trash they attempt to target. The other issue is that ocean cleanups fail to get to the core of the problem. What happens to plastic debris after it's collected? It certainly doesn't disappear. Recycling can't solve this crisis, either. Only 9 percent of all plastic waste ever produced has been recycled. That's why ocean cleanup campaigns encourage companies to offer plastic-free alternatives and persuade governments to pass legislation limiting single-use plastics. Proactive solutions – not reactive ones

– will be the key to cleaning up our oceans once and for all. It's time we disprove the myths and save our oceans from the plastic pollution crisis before it's too late (Petsko, 2019).

Universal Design for Learning (UDL) is a proactive approach to designing learning experiences to be accessible for all students. There are three principles of UDL; engagement, representation, and expression. UDL is also an overarching approach focused on the inclusive design of the whole learning environment at the outset. UDL aims to ensure all students have full access to everything in the classroom, regardless of their needs and abilities. Students are supported to self-direct learning and monitor progress.

Here are some UDL suggestions for use within the Great Garbage Patch learning unit:

- **Engagement:** Provide choices in how students can present their conclusions and explanations of how to address the issue of plastics in the ocean. Several choices are offered in the Evaluate stage of the 5E model below.
- **Representation:** Assist student to clarify vocabulary and symbols with hyperlinks, footnotes, illustrations, diagrams, definitions, and explanations to help students with key terms and symbols in a text. Encourage students to develop their own definitions, as the unit goes on, for key terms rather than define terms for students. The interactions with the terms within the context of the information being read in the Explore section below will allow students to derive meaning from key information.
- **Expression:** Use multiple tools for construction and composition. Consider sentence starters, sentence strips, text-to speech, or speech-to-text software, virtual or concrete manipulatives, spell-checkers, or web applications. During the discussion following the reading of articles, sentence starters can be used for students to offer their thoughts. Examples include: "I think...", "I agree because...", "I disagree because...", and "My evidence for that is...".

Lesson ideas that incorporate the 5E Learning Cycle are listed below that will work in a variety of teaching situations and grade levels.

Engage

Find out about students' prior knowledge, and ask some probing questions. Choose an option that works for you:

- Read a book to the class that highlights topics covered during the unit.
- As a class, make a list of examples of plastics that might enter the ocean and their sources. What problems do these pollutants make for marine life?
- Use an aquarium or large glass container to simulate what plastic in the ocean may look like. Bring plastic water bottles, six-ring soda-can holders, drinking straws, plastic line, etc., and drop them into the water. Swirl the water with a ruler to distribute the items evenly. Ask students to think about the effect that ocean currents would have on this debris if it were in the sea.
- Create and conduct a formative assessment that would tell you about students' prior knowledge.
- Show an introductory video
  marinedebris.noaa.gov/videos/trash-talk-what-great-pacific-garbage-patch-0

Children's Literature Suggestions for Students in Younger Grades

Abbing, M.R. *Plastic Soup: An Atlas of Plastic Pollution.* Plastic Soup Foundation.
Plastic trash now lurks on every corner of the planet and *Plastic Soup* brings this challenge to brilliant life for readers. *Plastic Soup* highlights a diverse array of projects to curb plastic waste and raise awareness, from plastic-free grocery stores to innovative laws and art installations. According to some estimates, if we continue on our current path, the oceans will contain more plastic than fish by the year 2050.

Freinkel, S. (2011). *Plastic: A Toxic Love Story.* Houghton-Mifflin.
The author tells her story through eight familiar plastic objects: comb, chair, Frisbee, IV bag, disposable lighter, grocery bag, soda bottle, and credit card. Her conclusion: we cannot stay on our plastic-paved path. And we don't have to. *Plastic* points the way toward a new creative partnership with the material we love to hate but can't seem to live without.

Moore, C. (2012). *Plastic Ocean: How a Sea Captain's Chance Discovery Launched a Determined Quest to Save the Oceans.* Avery
In 1997, environmentalist Charles Moore discovered the world's largest collection of floating trash, the Great Pacific Garbage Patch, while sailing from Hawaii to California. Moore was shocked by the level of pollution that he saw. And in the last 20 years, it's only gotten worse—a 2018 study has found that the vast dump of plastic waste swirling in the Pacific Ocean is now bigger than France, Germany, and Spain combined—far larger than previously feared.

- Warning about preloading vocabulary: Many science educators focus on pre-teaching technical vocabulary at the start of the unit to help students become comfortable with science discourse. This approach is especially common with students from historically marginalized communities, in particular emerging multilingual students. However, it is much more productive to support learners as they organically develop language (terms, phrases) that interprets and explains phenomena, rather than asking them to merely acquire terms. Additionally, it is key for equity that educators identify, value, and leverage students' home languages (Suarez, et al. 2018).

Explore

Have small groups of students learn about the issue. Then using a jigsaw collaboration method, have members from each group speak to one another so that they can get an overview of the complexity of the problem. Potential sources of information:

- Read about how the Great Pacific Garbage Patch developed and what impact it is having on the marine environment.
- Read about the various types of pollution including water pollution.
- Find out about the different types of debris found in the ocean and the harm it does to the environment as well as ways we can reduce ocean litter.
- Follow explorer Shannon Switzer as she travels along a San Diego river to the ocean to find out why the ocean is becoming so polluted with plastics.
- Find out how an ocean gyre contributes to ocean pollution.
- Listen to a podcast from NOAA about how trash makes it way to the sea.

Explain

Allow students to regather in their home group to discuss what they found out about the issue. Have them write down some questions, summarize the important information, and prepare to share their conclusions with the rest of the class. Facilitate the discussion by asking probing questions and making sure that students are listening to one another, giving eye contact to other students, using evidence to support conclusions and explanations, and asking questions of one another.

Elaborate

Explore how plastic collects and moves in the ocean through investigations about ocean currents and how plastic breaks down in the ocean.

- As a class complete the Mapping Ocean Currents, where students learn how ocean water moves, carrying plastics far from their origins.
- Students simulate ocean surface currents, observing how winds cause surface currents and how landmasses affect the movement of the currents.
- Students find out how much trash a family generates in a week, a year, and ten years. Then connect that information to the Great Pacific Garbage Patch in the Perils of Plastic activity.
- Challenge student teams to devise a method to remove the most plastic microbeads from a provided commercial personal care product—such as a facial cleanser or body wash.

Evaluate

- Ask students to write a letter to a relative or elected official, explaining what they learned about ocean plastic.
- Have students work on an individual or collaborative poster about some aspect of plastics in the ocean.
- Have students work on an individual or collaborative presentation about some aspect of plastics in the ocean.

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Petsko, Emily (2019). "Three Misconceptions about the Great Pacific Garbage Patch", https://oceana.org/blog/3-misconceptions-about-great-pacific-garbage-patch

About the Author

James T. McDonald is a Professor of Science Education at Central Michigan University in the Department of Teacher Education and Professional Development. Jim's teaching experience includes 10 years of teaching elementary and middle level students. His earth science research interests include student misconceptions in astronomy, earth processes, space sciences, and oceanography. Dr. McDonald's field research experiences include archaeology, paleontology, radio astronomy, volcanoes, national park geology, and oceanography investigations. He can be reached at jim.mcdonald@cmich.edu.

Too much or too little: Empowering Students to Plan for Flooding and Drought Resiliency

Katya A. Schloesser, University of Colorado Boulder, Cooperative Institute for Research in Environmental Sciences
Josh Kurz, Pagosa Springs High School
Anne U. Gold, University of Colorado Boulder, Cooperative Institute for Research in Environmental Sciences

Jamestown, Colorado October 2, 2013 — Flood damage in Jamestown, a house is torn apart by the James river.

Photo: Michael Rieger/FEMA

Abstract

The impacts of climate change are being felt across the country with droughts getting longer and more severe and flooding occurring more frequently. Colorado has experienced significant extreme weather events in the last ten years, and consequently has begun a statewide effort to incorporate resilience into short and long-term planning across state and local governments. As communities undergo resilience planning processes, today's students (tomorrow's leaders) are often unaware of these efforts and are left out of the planning process. The HEART Force curriculum empowers students with the knowledge to participate in the resilience conversation in their own community, with place-based hazard education that includes authentic data analysis, a scenario-based role-play game and design thinking to create resilience strategies in their community. The curricular unit culminates with a Community Resilience Expo, where students engage with community members as resilience experts and share their ideas. HEART is a novel approach in that it uses several current instructional strategies (place-based learning, project-based learning, gamification, and design thinking) to empower students to make their community more resilient to drought and floods.

Introduction

Communities across the American Southwest are facing unprecedented water shortage challenges due to warming temperatures, a reduced snowpack, and increasing demand for water. The southwest has seen historic drought conditions in 2020 and a majority of the region as of June 2021 is in exceptional drought. Flooding also continues to pose a threat as a costly and dangerous phenomenon. For example, in September 2013, unprecedented flooding disrupted 24 counties in northern Colorado which resulted in over $4 billion in damage. Rebuilding efforts are still ongoing. Whether it's too much or too little water, rural communities face additional challenges in responding to these hazards due to limited emergency infrastructure and emergency personnel and a more dispersed population.

The Hazard Education Awareness and Resilience Task (HEART) Force curriculum was designed to increase resilience to drought, flood, and wildfire in rural Colorado communities. The units have been designed for teachers to focus in depth on one hazard; we will focus on the flood and drought units in this paper. The curriculum was written with NGSS (NGSS, 2013) in mind (MS-ESS3-2, HS-ESS3-1) for secondary science classrooms, and guides students to explore the causes, impacts, history, risks, and potential resilience strategies for their own communities. All curriculum materials are freely available for download. While the curriculum is specifically written for Colorado classrooms, it can be adapted for other states by substituting appropriate state datasets and resources.

The curriculum employs a project-based learning approach that calls upon local community experts and stakeholders to partner with students to develop resilience action projects for their community. The full unit takes 4-6 weeks to teach, but is designed for teachers to be able to teach stand-alone lessons if they choose. Each unit consists of three components, a jigsaw data analysis lesson that introduces the hazard (flood or drought), a scenario-based role play game for students to address the hazard as it occurs in their community, and an opportunity for students to develop resilience projects to present at a Community Resilience Expo.

The lesson progression is loosely based on NOAA's Steps to Resilience (https://toolkit.climate.gov/#steps), which begins by exploring hazards, then assessing risk and vulnerability, investigating options, prioritizing and planning, and ultimately taking action.

The HEART Force curriculum has been classroom tested by Colorado secondary science teachers, and has undergone scientific review by NOAA scientists. The hazard lessons and scenario-based role play games have been accepted into the CLEAN collection (cleanet.org). The curriculum design was informed by an educator needs assessment (Boyd et al., 2021) to meet the needs of Colorado science teachers.

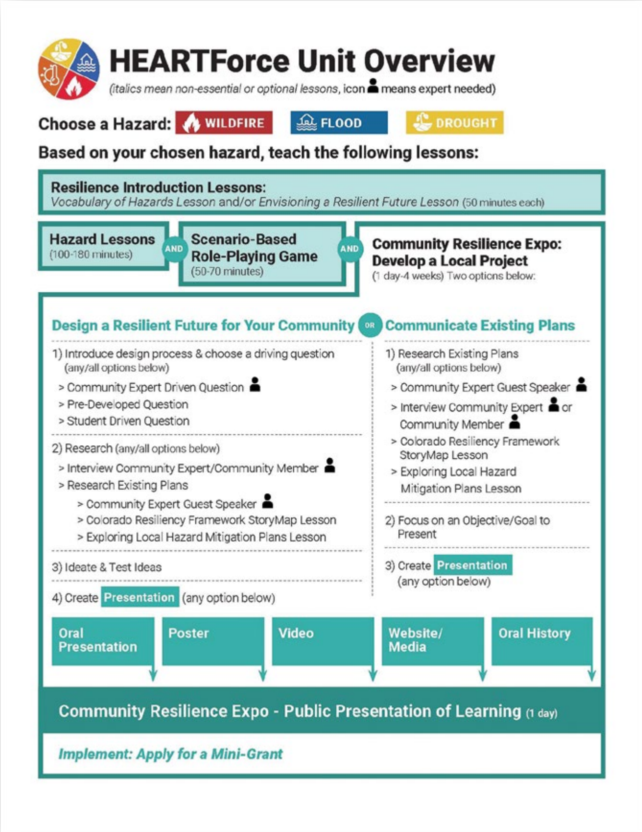

Figure 1. The HEART Force Unit Overview outlines different learning pathways for the Community Resilience Expo.

HEART Force Drought Unit

The drought unit consists of three lessons: the Colorado Drought lesson (differentiated for middle and high school classrooms), the HEART Force Drought Game, and the Community Resilience Expo (a variety of implementation pathways are provided). The middle and high school drought lessons each utilize a jigsaw format for small groups of students to dig into primary resources and drought datasets in depth, then students share their learnings with their classmates, to collaborate and develop a final product. If teachers have the time, students can complete all sections of the jigsaw for deeper understanding. Each drought and flood lesson utilizes the 5E format, each with sections that may include an Engage, Explore, Explain, Elaborate and Evaluation activities.

The middle school lesson is estimated to take 135 minutes and we recommend teachers budget 3-4 days for the lesson in their instructional calendar. Students begin by watching a news clip about the impacts of drought conditions in Colorado in 2018, and a video explaining how drought levels are measured, created by the Community Collaborative Rain, Hail and Snow Network (CoCoRaHS) (cocorahs.org). Students then break into jigsaw groups and use primary resources and authentic datasets to explore the following topics; drought causes and impacts, history of drought in Colorado, the 2018 American Southwest drought, observations of the 2018 drought in Colorado, current drought conditions, and drought preparation and response. In the summative activity for the lesson, students reassemble in different groups to create a drought news story, in the format of their choosing (written, audio or video) to educate their community about drought.

The high school lesson centers around the CoCoRaHS video that explains how drought conditions are assessed. In a jigsaw format, students assume the role of different types of scientists working for the US Drought Monitor, as climatologists, soil scientists, surface water hydrologists and irrigation district managers. Each group analyses data from the 2013 drought, and creates slides to share with their classmates. In the following activity, students reassemble into drought classification teams, with a scientist from each group. Students attempt to classify the severity of the 2013 drought using a Drought Classification Table modeled from the table used by the US Drought Monitor. Students learn about the uncertainty and complexities of classifying drought, and the various factors that influence drought. To wrap up the lesson, students discuss how climate change is affecting drought, and write a letter to the editor of the local newspaper that summarizes their findings, including an assessment of current local drought conditions.

After completing the hazard lessons, middle and high school students apply what they've learned in the HEART Force Drought Game, a scenario-based role-playing game in which students take on the roles of different community members working together to invest in different drought resilience strategies. Student teams select strategies such as educational outreach to farmers and ranchers on improving soil health or building a new wastewater recycling facility. Next, the teacher begins the game with a roll of the dice to see which drought outcomes occur. Outcomes include a wildfire outbreak in a nearby forest, lawsuits over water rights, or a decrease in crop and rangeland production. Depending on which investments each team made, they may lose water in their "reservoir" (a graduated cylinder), or maintain an adequate water supply for their town. With each round, drought conditions worsen, and students see how their investments play out. At the end of the game, students reflect on which drought resilience investments could work in their communities, and consider which investments had the most bang for the buck.

HEART Force Flood Unit

The flood unit utilizes a similar structure as the drought unit, beginning with a lesson, followed by a game, and ending with the Community Resilience Expo. Similar to the Drought unit, the middle school flood lesson employs a jigsaw format. Students use different data sources to explore the phenomenon of flooding and flash flooding in Colorado, and use the 2013 Front Range Floods as a case study to understand how different factors (weather, topography, and human settlement) can influence flooding. One jigsaw group uses the National Weather Service's flood safety page to learn how to respond to a flood. In the reorganization of the jigsaw groups, students come together to create a local news story to educate their community about the risks of flooding.

The high school lesson also uses the jigsaw format as students dig deeper into various datasets to answer the following questions:

- Which scenarios are most likely to cause floods in our community?
- Based on the past, how could floods impact our community in the future?
- What time of year do floods generally occur in our area?
- What strategies exist to minimize the impacts of floods?
- How do scientists expect the size and frequency of Colorado's floods to change in the future?

All groups complete an activity using a GIS map of FEMA's floodplains, to answer the question, "What areas in our community have the most risk?" By exploring the flood risk in their community, students begin to narrow in on vulnerable areas to focus on when developing a community resilience action project.

The high school lesson is based on a flood unit co-author Josh Kurz taught in early 2020 to the Pagosa Springs High School global science class. Students investigated flooding along the San Juan River through downtown Pagosa Springs. During the unit, students read a historic account of the area's largest flood on record, and used United States Geologic Survey (USGS) water data to identify the local flood stage and magnitude of 100-year flow. Next, students used ArcGIS to identify infrastructure prone to flooding, and then researched flood mitigation strategies. Students had the opportunity to visit the highest risk flood zone in the field with the town planner, where they discussed the town's future flood risk mitigation plans. Finally, a community expert panel, consisting of the town planner, a civil engineer, and representatives from the National Resources Conservation Service (NRCS), Firewise USA, and the local Colorado State University Extension Office, led a classroom forum on the community's flood resilience. By the end of the unit, students developed a place-based understanding of flood-related hazards and mitigation strategies in their own community.

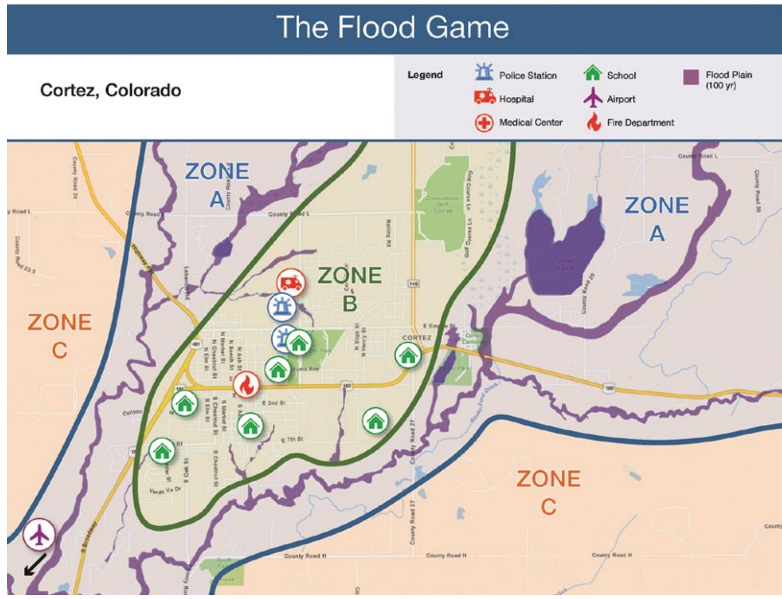

Figure 2. An example map of different Zones for the HEART Force Flood Game for Cortez, Colorado.

The HEART Force Flood Game is a different format than the Drought Game, given the shorter time frame of a flood. In this game, students begin their hazard scenario with a map of their own community (provided by the game developers), divided into three zones. Teams are assigned to the different zones; Zone A includes residents in the floodplain, Zone B is a little further away, and Zone C is completely out of the floodplain.

The game takes place in rounds, in which students are given resources at random, such as road barricades, sandbags, an emergency shelter and supplies, etc. At the beginning of each round, each team is given an Emergency Update, which directs them to a certain level of flooding they must respond to using the provided Flood Response Guidelines.

Students can respond to needs using the resources they have, or by using "creative solutions" with the resources they were given. They can also collaborate with other teams to trade resources. The game inspires students to be nimble and creative, and think about the challenges their community could face in the event of a flood. Equipped with this experience the students can more easily imagine what resilience measures might benefit their community.

The Flood Game

Flood Response Guidelines

As the flood progresses, your community will face increasing risk. Use this guideline to think about what resources you need to respond to the changing situation.

Flood Levels	Immediate Actions	Secondary Actions
Level 0 No Flooding	No flood control action needed—address the **Community Challenge.**	
Level 1 Flood Warning	**Task a:** Send alert with automated alert/notice system via email, social media, reverse 911 **Task b:** Volunteer teams ready to move equipment to vulnerable river banks **Task c:** Confirm alternate evacuation routes **Task d:** Emergency personnel on alert and ready **Task e:** Request additional police officers to be available with traffic redirection	**Task f:** Have road signs or road barricades ready to deploy to vulnerable roadways **Task g:** Volunteer team ready to help with evacuation **Task h:** Arrange alternative school facilities **Task i:** Organize neighborhood info meeting
Level 2 Minor Flooding	**Task a:** Send alert with automated alert/notice system **Task b:** Deploy volunteer teams to evacuate people and businesses in the flood zone **Task c:** Preparation of sandbags **Task d:** Use road barricades to close vulnerable roads **Task e:** Arrange alternative school facilities	**Task f:** Prepare city's flood pumps **Task g:** Assemble volunteer safety supplies **Task h:** Coordinate a volunteer team to assist those who need help evacuating or protecting their homes **Task i:** Find replacement for flooded day care center
Level 3 Moderate Flooding	**Task a:** Send alert with automated alert/notice system **Task b:** Provide volunteer safety supplies to volunteers **Task c:** Make state emergency response request **Task d:** Activate city's flood pumps **Task e:** Use a volunteer team to assist those who need help evacuating or protecting their homes	**Task f:** Designate alternative evacuation route **Task g:** Set up emergency shelters & supplies **Task h:** Place public transportation systems on standby **Task i:** Address neighborhood power outage
Level 4 Major Flooding	**Task a:** Send alert with automated alert/notice system with flood warning and evaluation route **Task b:** Coordinate volunteer teams to repair additional bank/levee vulnerabilities **Task c:** Activate emergency shelters & supplies **Task d:** Activate public transportation system for assistance with evacuation **Task e:** Activate secondary volunteer teams to support first responders (childcare, etc.)	**Task f:** Police officers monitor roadways to ensure that evacuees can get out **Task g:** Deploy additional road signs to help with increases in evacuation efforts **Task h:** Deploy medic team for affected residents **Task i:** Fix leaking roofs in neighborhood

Figure 3. The list of Flood Response Guidelines, which students use to respond to different needs as different levels of flood warnings occur in different zones throughout the game.

HEART Force Community Resilience Expo Lessons

In the final part of the HEART Force curriculum, students apply what they've learned in the lessons and game and work with classmates, community experts and stakeholders to develop a resilience action project, which is showcased in a public presentation of learning at a Community Resilience Expo. Teachers are allowed maximum flexibility to choose the learning pathway that fits their classroom and students' learning styles best. The main three suggested pathways for the Expo include 1) communicating existing Hazard Mitigation Plans, 2) a design challenge to develop resilience strategies, or 3) utilizing

Earth Force's Community Action and Problem-Solving Process. Communicating existing plans is the most traditional learning pathway, and has students dig into their Local Hazard Mitigation Plan and share planning efforts that are underway in their community. Both the design challenge and the Earth Force process use processes that encourage student creativity, teamwork, communication, and agency. Pedagogical guidance for teachers is provided to implement these learning pathways.

We envision Community Resilience Expos as an opportunity to bring together diverse community members to learn about the importance of resilience planning for natural hazards. Expos also serve as an opportunity for students to receive feedback on their ideas and elevate students as leaders in their community, capable of contributing to and/or leading the community resilience conversations. As part of our educational research, we're investigating how these expos affect student's sense of self-efficacy and empowerment.

Conclusion

Today's students will inherit the increasing risks of wildfires, drought, and flooding. This curriculum equips students with the understanding of how to respond to these hazards as they occur, and how to take a proactive approach in planning for these hazards and contribute to their local community's resilience. As we continue to strive for community prosperity, health, and wellbeing, it is essential that we not only respond to these hazards, but plan for them and ensure that all community members are ready if and when they occur.

References

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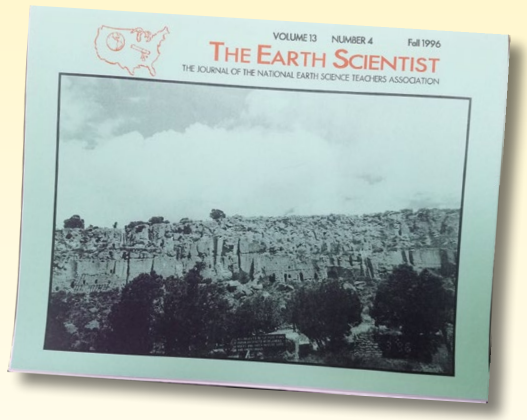
25 Years Ago in TES



Twenty-five years ago, in 1996, TES was in its thirteenth year of publication. The focus of this Fall issue was meteorology. The front cover was a photo showing cumulus clouds developing over the Puye Cliff dwellings, northeast of Santa Fe, NM. These sandstone cliffs were home to about 1500 Pueblo Indians from A.D. 1250 to 1577. The Fall issue led off with a seven-page Guide to Air Masses, Fronts and Associated Weather. Next was an eight-page article which dealt with air masses and the influence of the Great Lakes on those air masses. A six-page article was included which shared information regarding a 1992 NSF funded program "Kids as Global Scientists", and how classroom students could become involved using "Blue Skies". Finally, there was a discussion of the Trends in International Mathematics and Science Study (TIMSS), a comprehensive and reliable comparison of half a million 8th grade students from 41 nations, and its lessons for Earth Science teaching and learning.

By Tom Ervin

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The USGS Utah Water Science Center and the Woods Hole Coastal and Marine Science Center conducted a collaborative geophysical research effort within Lake Powell, UT-AZ to map the bathymetry of the lake and characterize shallow sediment deposition near the mouths of the San Juan and Colorado Rivers.

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