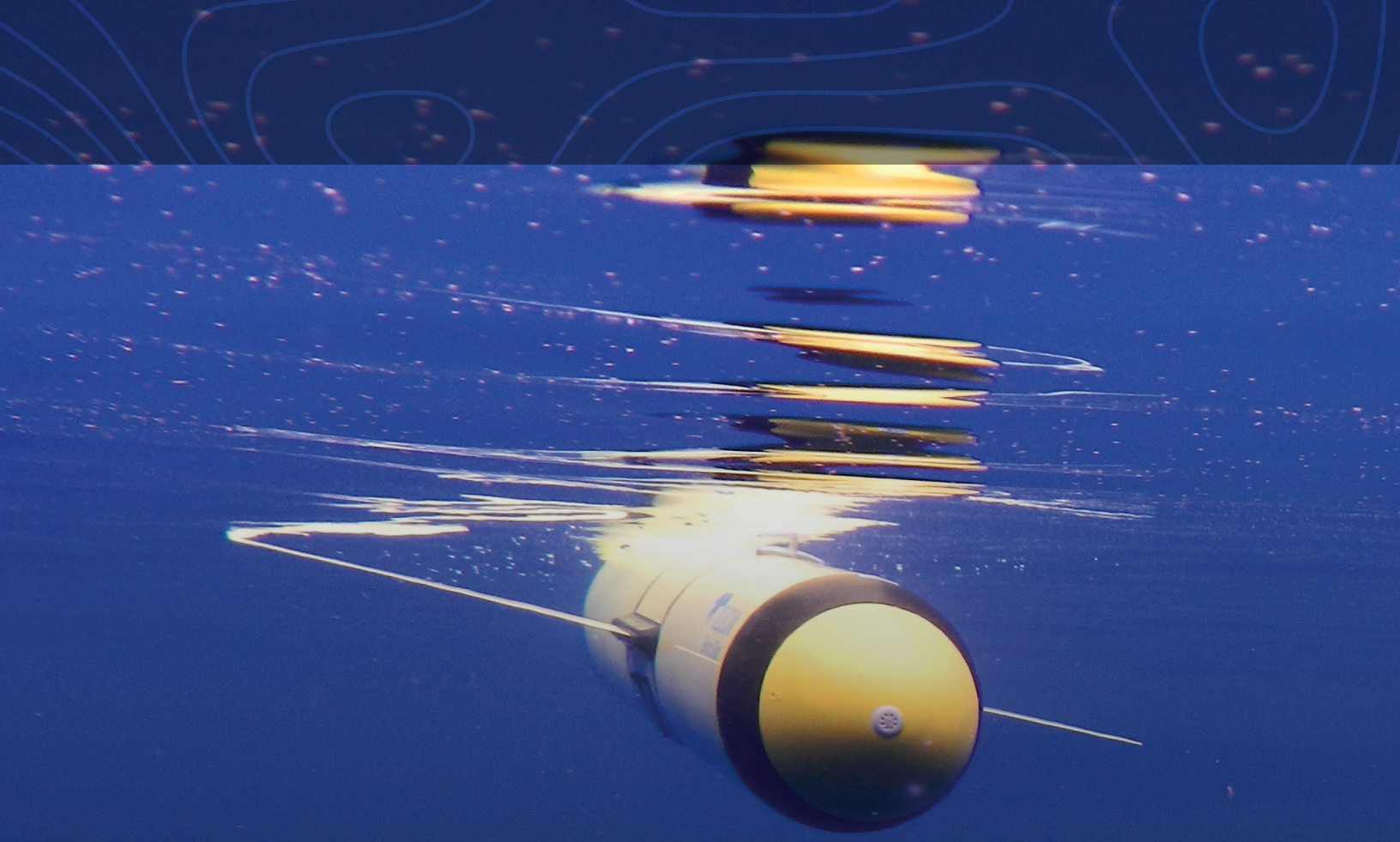
EXPLORERS OF THE DEEP

4-H STEM CHALLENGE

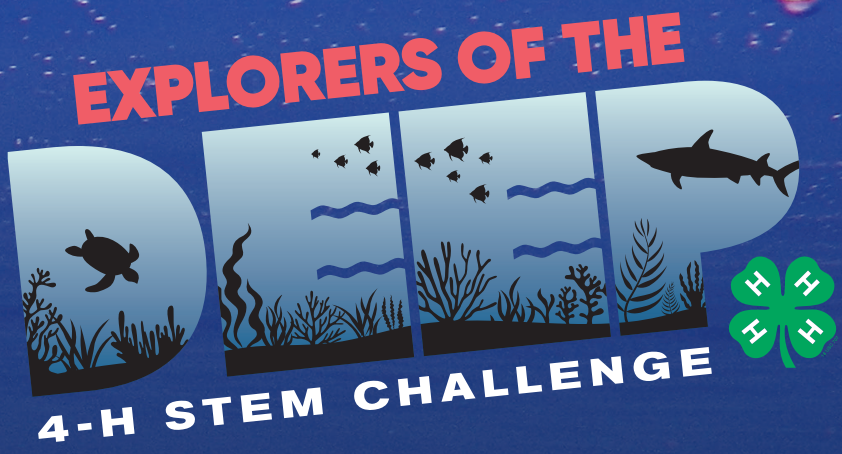
FACILITATOR GUIDE



Kit Materials

The following materials are included in this kit. If you want to create additional printable materials, they are available online at **4-H.org/STEMChallenge**.

- **Facilitator guide**
- **Youth guide**
- **Ocean robot**
- **Mission cards**
- **Ocean Expedition board game**
  - **Board**
  - **Glider game pieces**
  - **Game cards**
  - **Trivia cards**
  - **Instructions**
- **Ocean Communicator matching cards**



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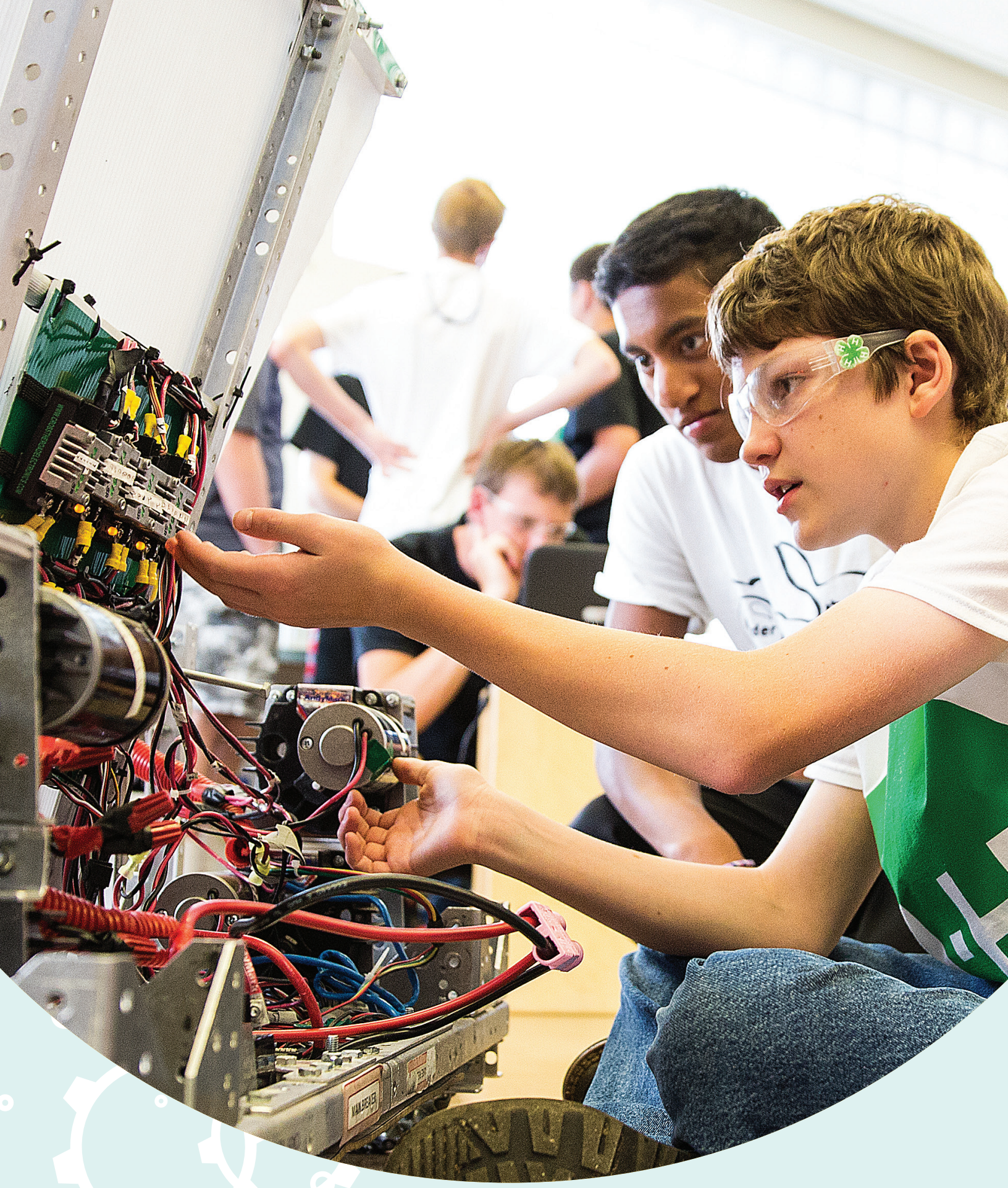


4-H STEM Challenge

Although October is officially 4-H STEM Month, youth take part in the 4-H STEM Challenge all year round. With your help, we can spark an interest in STEM for all youth, making hands-on learning accessible to everyone!

Preparation: Get ready to facilitate ***Explorers of the Deep*** by reading through this guide. Focus on the Facilitator Preparation section for a concise overview of how to prepare. For families or youth working on their own, the activity sections in the Youth & QuickStart Guide provide a quick-start way to begin engaging with the activities right away.

Plan: October is 4-H STEM Month and we encourage educators to plan challenge events during this month. An event can be as simple as doing an activity for a class lesson or teaching a few youth at home, or as big as planning a large community event. Re-use or purchase more kits year round to bring STEM to more youth!

Check-in: Visit **4-H.org/STEMChallenge** for the latest updates! This webpage is your resource to help you make the most of the 4-H STEM Challenge, including promotional materials, printable resources and webinars for adults and teens to better facilitate your event.

Share: Tell your friends and colleagues about the 4-H STEM Challenge and share on social media using **#4HSTEMChallenge**.

Introduction

4-H is the largest youth development organization in the United States, serving nearly six million youth each year. Our philosophy is to provide young people with fun and engaging educational experiences that give them a chance to learn from each other and develop important life skills such as problem solving, perseverance and teamwork. We strive to develop and implement programs that help youth thrive and find the spark that drives their interests to learn more and stay engaged in STEM.

Learn more at **4-H.org.**

This year, we've partnered with Rutgers, The State University of New Jersey, Bayer, Nickelodeon and Corteva to develop activities that take youth on an ocean exploration–with robots. The challenge activities are designed to help youth develop observational and critical thinking skills while exploring the interconnections between the ocean and humans, regardless of where they live. The activities are based on the long-standing Ocean Literacy Principles and Fundamental Concepts, developed by ocean scientists and K–12 educators in 2005. We've chosen the topic of the ocean and ocean literacy because understanding the ocean is essential to protecting the planet.

Learn more about the seven ocean literacy concepts and how they are being used around the world at **marine-ed.org/ocean-literacy/overview**.

Facilitator Preparation

This guide is designed to assist you with facilitating the three Explorers of the Deep activities: **Ocean Robot Test Tank, Ocean Expedition** and **Ocean Communicator.** The activities provided in this kit will help participants build confidence and STEM abilities, as well as an appreciation and awareness of the ocean and their connections to it.

You do not need prior experience with STEM to share the Explorers of the Deep challenge with youth. All of the activities are designed to make it easy for everyone, including teen leaders, to facilitate. Each activity includes a set of opening questions and closing reflective questions to enhance the learning and fun of the experience! Explorers of the Deep is designed for ages 8-14, and the activities can engage everyone from those inexperienced in STEM to budding young scientists.

Use the different types of facilitation information listed below:

SUGGESTED SCRIPT

Context setting material you can read to the entire group.

FACILITATOR TIPS

Strategies to help effectively engage your group.

DIVE DEEPER

Places to facilitate conversation and increase group understanding.

IMPORTANT VOCABULARY

Background reference terms for your convenience and support.

CAREER CONNECTION

Opportunities for facilitators to suggest careers linked to the activities.

Planning your *Ocean Explorers* Event

Explorers of the Deep is adaptable to a range of space and time constraints. All of the activities have an optional technology component. The **Ocean Robot Test Tank** ideally requires a water source and large container to serve as the test tank. If you don't have access to these items, this activity can be modified accordingly. The kit also comes with QR codes and web links throughout the workbook that link to supplemental videos and augumented reality (AR) interactives to engage youth in addtional content.

The three activities can be led individually or together, in any combination, making it easy to integrate in- or out-of-school time (OST) learning. Activities can be completed in one session or over several sessions. Here are some examples of how you might organize the activities:

	OCEAN ROBOT TEST TANK	OCEAN EXPEDITION BOARD GAME	OCEAN COMMUNICATOR
FULL VERSION	90 minutes (Activity parts I, II and III)	65 minutes (Board game and Trivia)	90 minutes (Matching cards, pre discussion and group discussion of PSA)
SHORT VERSION	45 minutes (Activity parts I and II)	45 minutes (Board game only)	40 minutes (Matching cards and group discussion of PSA)

Facilitating the Activities

Explorers of the Deep was designed to be adaptable for various facilitators and youth groups. **If you're a parent or educator who prefers to have the kids self-direct, the Youth Guide can be used as a quick start guide.** If you are an educator, this facilitation guide offers opportunities and information on how to engage young people in social interaction and collaboration as they learn about the ocean and climate change. We encourage learning through conversation where youth can tap into their prior knowledge and share their ideas and insights. We encourage facilitators to follow this simple experiential learning format of Engage, Explore and Make Meaning.

Ocean exploration and research are important tools that help scientists, policy makers, communities and individuals prepare for and adapt to changing ocean conditions. Many of these changes in ocean conditions are a result of climate change. The impacts of climate change include melting glaciers and ice sheets, increasing ocean temperatures, declining fisheries and an increase in the frequency and severity of storms. Since Earth is an ocean planet, these impacts affect humans and organisms all around the world, regardless of their proximity to the ocean.

Engage-Explore-Make Meaning

LEARNING CYCLE: SCAFFOLDED APPROACH TO TEACHING THAT INCLUDES THREE PHASES	YOUR ROLE: FACILITATOR TIPS FOR USING THE LEARNING CYCLE
Engage - Set the stage for learning. Spark interest and spur youth to build on their prior knowledge by recalling past or present connections that are relevant to the learning experience.	• Create interest, curiosity, focus and anticipation about topics to be explored. • Give youth engaging discussion prompts.
Explore - Encourage interest and questions. Engage in activities that model real phenomena and serve as a reference point for the entire group.	• Encourage youth to work together, independent of direct instruction from the facilitator. • Provide only as much instruction and information as necessary to set the group up for successful independent exploration.
Make Meaning - Ask youth to generate explanations of the concepts they are learning and to reflect on what they have learned and how they learned it.	• Ask youth to explain ideas, concepts, definitions and science practices in their own words. Ask for evidence, results and clarification from youth to help guide them to make sense of their experience. • Provide opportunities for youth to apply vocabulary, skills and explanations to new issues related to the ocean and climate change. • Prompt youth to think about their former ideas about the ocean and evolve new ideas.

Explorers of the Deep Activity Overview

Ocean Robot Test Tank

In this activity, youth prepare their ocean robot for a research mission. Participants "ballast" their ocean robot by adding weights to create the sinking and floating behavior of a real ocean robot. Finally, they investigate data collected by ocean robots and learn about the value of ocean exploration.

Ocean Expedition

In this activity, youth play a board game to navigate their ocean robot around the world while learning key ocean concepts. Topics include aquaculture, climate change, innovation, human impact and the ocean ecosystem.

Ocean Communicator

In this activity, youth investigate challenges that ocean scientists, engineers and technologists are currently addressing. Each challenge requires innovations and technical solutions that inspire public action.

Ocean robots are machines that roam the ocean depths from the surface to the seafloor, allowing humans to explore our global ocean. They come in many shapes and sizes and use sensors to measure important information about the ocean, like temperature and salinity (the saltiness of the water). Robots can be directly controlled through a cable, or left alone as autonomous explorers that can independently navigate our global ocean. Ocean robots have a lot of different names. Some ocean robots, called Autonomous Underwater Vehicles, or AUVs, are deployed in the ocean by scientists and undergraduate students. They are controlled via satellite signals to collect data. Scientists here at Rutgers University call them gliders, because they "glide" in a zig-zag pattern through the water.

ACTIVITY:

Ocean Robot Test Tank

By the end of the lesson, youth will be able to:

- understand how ocean robots (gliders) work through exploration of density and buoyancy.
- explore the data collected by ocean robots and think about why it is important to understand climate change and its impact on ocean systems.

Materials:

- Mini ocean robot
- Mission cards (6)
- Youth guide

Materials not included in kit:

- Waterproof container to serve as a test tank for ocean robot. Note: We recommend a plastic container that is atleast 12x12 inches and 6 inches deep
- Water source
- Household items to act as ballast weight (e.g., coins, washers, screws, bolts, rocks, fishing weights, etc.)
- Optional: Salt. See step 16 on page 21 for details. See pages 18 and 19 for more suggestions.

IMPORTANT VOCABULARY

Ocean Robots: Autonomous underwater vehicles (AUVs) are ocean robots that scientists deploy in the ocean (or any large body of water) and control via satellite signals to collect data. There are many different kinds of AUVs. These robots help us learn about the ocean from the surface to the deepest trenches. Ocean robots come in many shapes and sizes and use sensors, or sampling instruments, that measure important information about the ocean, like the temperature of the water or its salinity (saltiness).

Gliders: Gliders are a type of ocean robot. They are autonomous underwater vehicles (AUVs) that scientists put in the ocean and control with regular satellite connections to update commands and retrieve data. They surface to call home and send collected information back to the scientists.

Buoyancy: An object's potential to float or sink in a liquid.

Density: How much mass there is in a certain volume. Objects that have more mass/volume are more dense. The density of seawater varies according to its salinity and temperature.

Ballast: Something (usually weights) that provides stability or increased mass. Ballast is used to improve the stability of an ocean robot and to match the range of water densities it may encounter.

Engage

Core Activity . 10 min

SUGGESTED SCRIPT

Welcome to the 4-H Ocean Explorer STEM Challenge! This will be an exciting opportunity for us to build STEM knowledge by exploring the world's ocean—and focus on how the ocean impacts you and how you impact the ocean. Everyone recognizes the word "ocean." What does the word ocean make you think of?

Have each person share one or two words to describe what comes to mind.

DIVE DEEPER

You might want to start by showing a video of your choice about the ocean and ask the group to share what they notice, or for them to jot down some things they find interesting or questions they might have. Alternatively, put up a poster or pass out various ocean images. This introduction will help elicit more ideas and more engagement from everyone. There are no wrong answers. If you have a large enough group, you can create a Word Cloud (**wordclouds.com**) with everyone's responses for fun.

Explore

Core Activity . 35 min

Part I: Mobilize the Mission

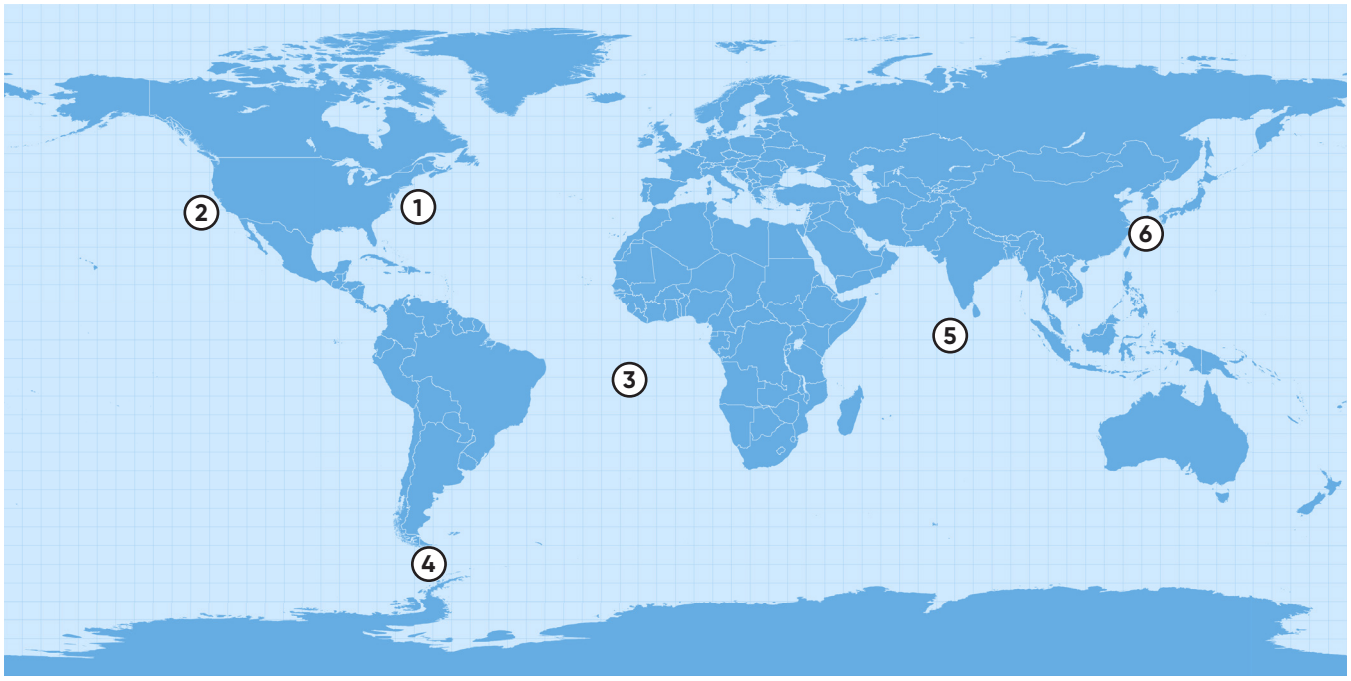
1. Invite the group to think about where they will be sending their ocean robot.
2. Have them choose one of the six numbered locations marked on the map in their Youth Guide. Participants may work in pairs or small groups so that all sites are selected.
3. Direct the participants to find the mission card that matches the number they chose on the map and take a few minutes to read about the location and mission description of their robot.
4. Have them discuss with a partner and fill out their Youth Guide.

FACILITATOR TIP

Encourage the group to think about the following:

- **Logistics:** How will they get the robot to its study site? Will they have to carry it on a ship to the location? Note that gliders weigh approximately 150 lbs and are about 8 feet long.
- **Importance:** What is important about the science mission? Why should people care about it? Why use a robot in this science mission?
- **Engineering Design:** What sensors might be helpful to have on the robot to help achieve the mission?

Ask the group to think about how they will mobilize their scientific mission. How will they get there? Ask them to draw a line representing their journey from where they will depart to where they will mobilize or start the mission:



Mobilize the Mission: Click on the QR code to the left to get a message from your ocean robot pilots and fellow researchers, Dave and Nicole.

See sample answers below:

Where do you live? City/State Name:

Des Moines, Iowa

Will you need to fly on an airplane to get to your study location?

Yes. My mission is to Antarctica!

What airports or port cities could you use to get to your study location?

Des Moines International Airport to Houston, TX to Santiago, Chile

to Punta Arenas, Chile

Do you need to put it on a research vessel to get it to the study location?

Yes. Take a ship from Punta Arenas through the Drake Passage

to the Western Antarctic Peninsula

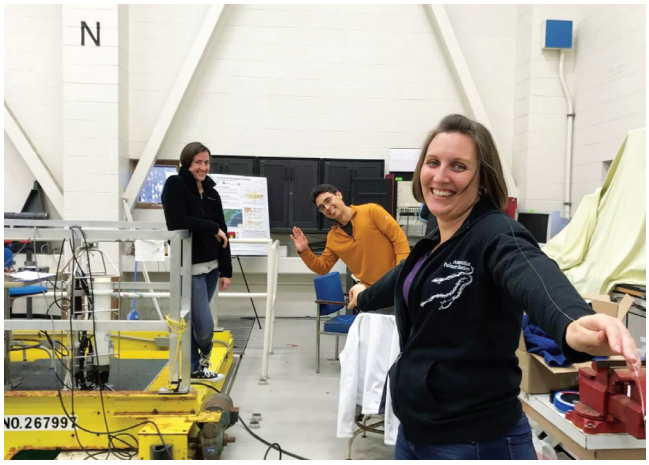
FACILITATOR TIP

Don't worry too much about the accuracy of their responses, it's more important that they have explored the geography of the mission location. It will be fun for them to brainstorm different modes of transportation to make their trip.

5. **Optional:** Once the youth have planned their mission, if they have a smartphone or computer avaible, they can use the QR code or web link provided in the guide to view the "Expedition Mobiliztion" video. In this video, they will meet the scienitsts that work with ocean robots, who will join them on this mission.

Part II: Ocean Robot Test Tank

In this next part of the activity, the group will become ocean robot pilots. Participants will make their robot neutrally buoyant in preparation for its research mission.



Ocean robot pilots, Dave and Nicole, welcome you to the COOL lab. Help us get ready for the research mission!

SUGGESTED SCRIPT

Let's join David Aragon and Nicole Waite, ocean robot pilots at the Center for Ocean Observing Leadership, or COOL laboratory for short, at Rutgers University. As fellow ocean robot pilots, you are going to ballast your ocean robot to make sure it will work properly during its mission. When we "ballast" an ocean robot, it means that we add or subtract weight from it so that the robot's density is slightly less than the density of the water where it will be deployed. This will allow the robot to float just below the surface, making it neutrally buoyant. The density of seawater depends on its temperature and salinity; cold water is denser than warm water and salty water is denser than fresh water.

Ocean robot pilots use a test tank to test their robots. They add weights on top of the robot until it floats evenly in the water. Then, once they know the weight needed, they add that amount of weight to the inside of the glider.

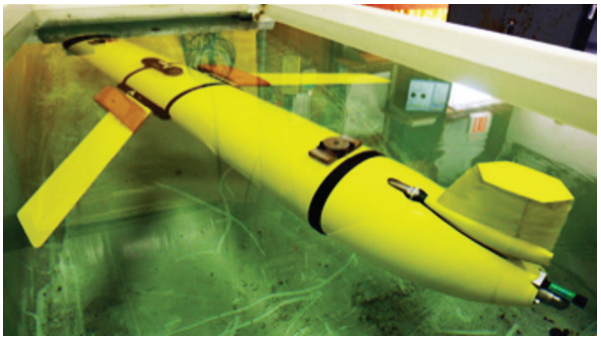
1. Ideally, participants will work in groups of two to complete this part of the activity. Have each group take the ocean robot out of the 4-H Explorers of the Deep STEM Challenge kit and spread out the parts. They should have a **main body, wings, stickers** and a **rudder**.

2. Affix the wings to the side of the ocean robot. **Note:** The wings will help it move or "glide" through the water. Scientists often call these robots "gliders" because the wings are essential to it operating properly in the water.

3. Attach the rudder and a sticker. In the Youth Guide, encourage groups to explore the diagram explaining the internal design of the robot.

4. Finally, use the rubber bands to hold the glider together.

5. Discuss what the ocean robot shape looks like and what adaptations might help them stay near the surface of the ocean. **Note:** The wings help the glider with its stabilization in the water.

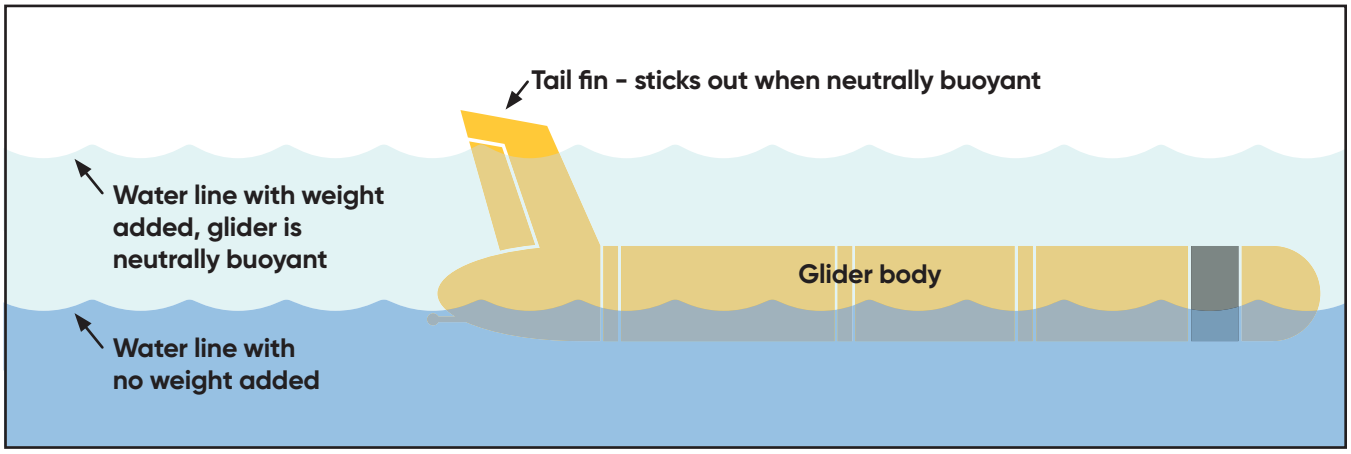


Picture of a glider being ballasted in a test tank.

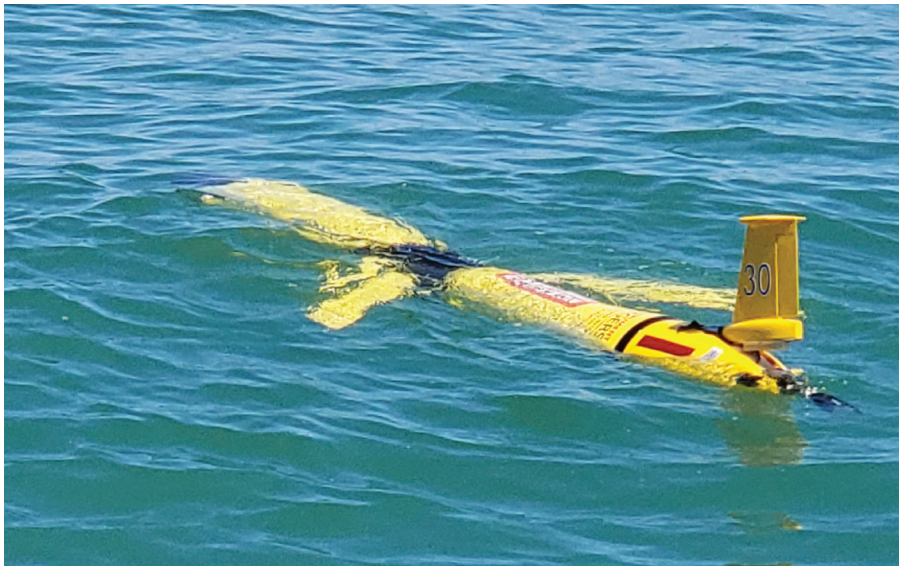
6. Set up aquariums or buckets of water to act as test tanks for glider ballasting.

7. Have participants place the glider in the water and observe what happens.
    a. Ask them why they think it floats.
    b. Explain that comparing the density (mass/volume) of the glider to the density of water is how we can prove that the glider floats and how we can figure out how to achieve neutral buoyancy.
    c. Explain that they will be sharing household materials (see charts on pages 18 and 19 for ideas) to adjust the density of the glider and make it neutrally buoyant, as shown in the image below.

8. Before they start ballasting the robot, ask the participants to anticipate how much weight they think they will need to make the robot become neutrally buoyant.
    a. Remind them what it means to be neutrally buoyant–that is the glider should neither sink or rise but instead rest just below the surface of the water.



Ballasting your ocean robot starts with understanding the density of both the water and the robot. The goal is to adjust the glider density so it is slightly less (.95 grams/milliliter) than that of the water (freshwater density – 1 gram/millimeter). See step #9 for an explanation.



9. **Optional:** Solving for the amount of weight needed to ballast the glider.
    a. This step is especially important for facilitators using this kit in a classroom setting. If you opt not to do it, proceed to Step 10 .

b. We know:

Glider weight: 50 grams (g) **Glider volume: 180 milliliters (ml)**	**Density of freshwater:** **1 gram/milliliter**

c. Solve for glider density:

Density = weight/volume = 50 g/180ml = 0.28 (g/ml)

d. Compare to the density of freshwater: floats.

Since 0.28(g/ml) is less than 1 (g/ml) the glider floats.

e. For the glider to be neutrally buoyant the density needs to be slightly less than that of water:

Between 0.95 and 0.98 (g/ml).

f. We cannot change the volume of the glider, but we can change the weight.
If we use 0.97 (g/ml) as the "goal weight" the calculation is:

0.97 (g/ml) x 180 (ml) = 175g

Therefore, the glider needs to weigh a total of 175 grams to achieve neutral buoyancy.

g. Remind the participants that the empty glider weighs 50 grams.

175 - 50 = 125 grams of weight that needs to be added to the glider

10. Tell the group they need to add about **125 grams** of weight to the glider to achieve neutral buoyancy.

11. Ask the youth to select items from the table below to add **125 grams** to their glider.
    a. Provide a list of the materials they have access to and approximate weights. You may find the charts on the following pages helpful.

12. This chart provides alternate materials to complete the task. Ask them to record their item list in the Youth Guide before selecting and testing the items.
    a. Youth may go to a designated area of the activity space to collect their items for testing. You might assign another participant to be the "materials project manager" and distributor of the materials for testing. They can check the math of the glider pilot and make sure they are adding up to about 125 grams.

Ballasting Weights:

OBJECT	APPROXIMATE WEIGHT OF 1 ITEM(g)	APPROXIMATE NUMBER OF OBJECTS BETWEEN 100 & 125 GRAMS
MIXED COINS * THIS COMBINATION WORKED BEST	• Quarters 5g • Dimes 2g • Nickels 5g • Pennies 2.5g	• 13 Quarters and • 5 Dimes and • 3 Nickels and • 8 Pennies
INDIVIDUAL COINS	• Quarter 5g • Dime 2g • Nickel 5g • Penny 2.5g	• 25 Quarters or • 60 Dimes or • 25 Nickels or • 50 Pennies
GLASS GEMS	4g	25
DECORATIVE STONES	7g	17
ROCKS (FROM YARD)	10g	11
FISHING WEIGHTS	5g, 7g, 10g or 15g	Varies depending
SOCKETS	• 19mm-60g • 16mm-40g • 14mm-56g • 9mm-12g	Varies depending

This list provides other ideas for materials you can use to fine tune your ocean robot's buoyancy.

OBJECT	APPROXIMATE WEIGHTS (g)
Screws, washers, bolts, nuts, etc.	Ex: • Every 10, ½ in screws weighs 6g • ¼ in nut weighs 2g • ½ in nut weighs 12g
Pushpins	20 weighs 6g
Small magnets	5g each
Modeling clay (1 tube)	22g
Dried beans, popcorn kernels or rice	¼ cup of each weighs between 35g and 50g
Marbles	5g each
House key	10g
Sand or Soil	Varies depending on material

This list is not exhaustive. There are many household materials that would fulfill the objective of this activity.

Note: Use water-safe materials! (Example: No batteries, key fobs, wires, lights, etc.)

13. Putting the glide in a glider: Have the group watch a short video on how gliders move in the water column. Participants will notice that the glider moves in a zig-zag or saw-tooth pattern collecting data as it moves up and down through the water.

    a. Optional: Ask participants to shift the weight to the front nose cone of the glider to create a downward trajectory.

    b. Then, shift the weight distribution to the tail of the mini glider to create an upward trajectory. **Note:** These movements should occur as slowly as possible; real gliders need time to collect valuable scientific data.

    c. Give them time to experiment with their models and make modifications as needed. Have them record each modification and give their rationale in the youth guide.

14. One team member will be in charge of timing how long the ocean robot takes to make both an upward and downward path. Instruct the group to begin timing when the robot is placed on the surface and end timing when any part touches the bottom of the tank for the downward trajectory. For upward, start timing when the glider is completely submerged and end when any part reaches the surface.

15. As a large group, have a discussion about what worked best to keep the gliders neutrally buoyant and why it is a difficult goal to accomplish.

DIVE DEEPER

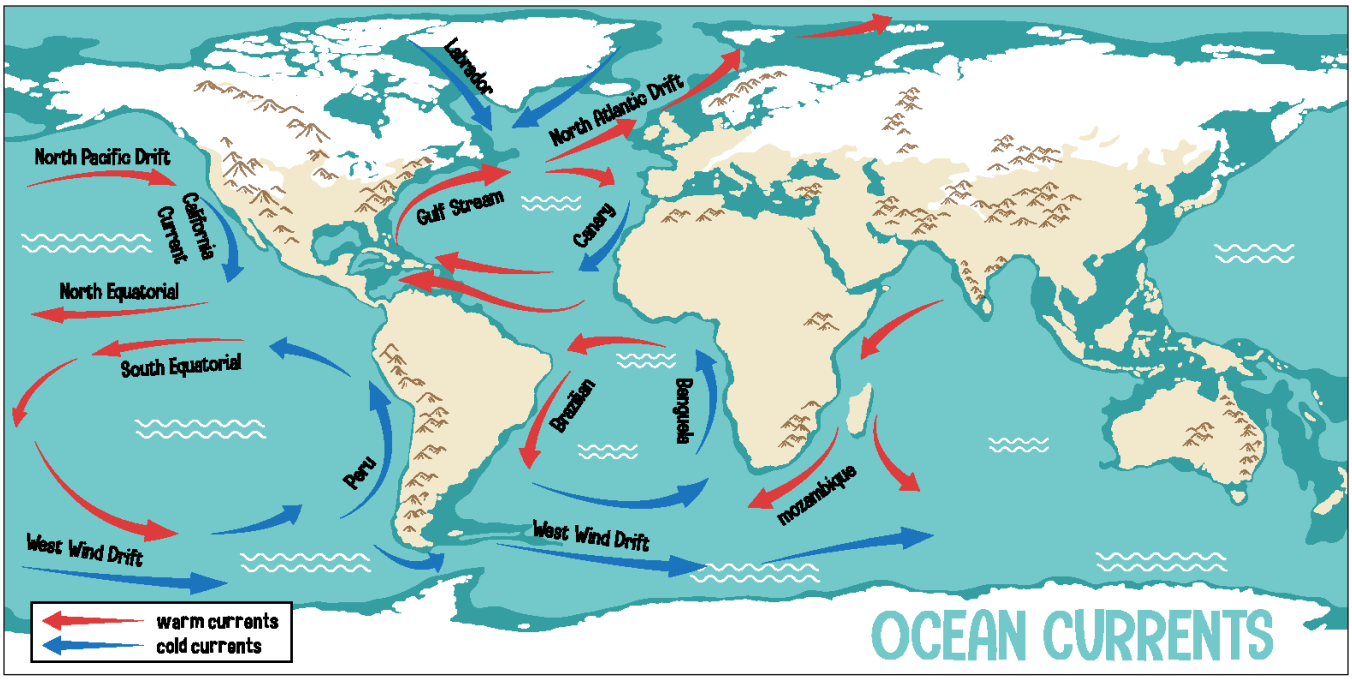
After discussing, ask them to watch the video from the QR code in their Youth Guide, which describes how engineers ballast an ocean robot.

FACILITATOR TIP

Remind the youth of the definitions of buoyancy and density. Ask the participants to explain what they think each definition means in their own words. Ask the question: Why do you think these ideas might be important for the mission? After they have discussed the prompts and video, ask them to share what they discovered, any questions they have and then share the suggested script.

SUGGESTED SCRIPT

Buoyancy is an object's ability to float. Think about a piece of styrofoam and a brick. Which one will float and which will sink when placed in water and why? The styrofoam will float and the brick will sink because of differences in density between the object and the water. Density is the relationship between mass and volume, or how much of something (how tightly packed the molecules (stuff) of a substance are) in a given amount of space. The brick is denser than water and will sink because it has more mass in the same amount of volume. Styrofoam is less dense than water, so it will float. But do you think the density of water can change? (Give them a moment to think and discuss with a partner.) Yes it can! Salinity (a measure of the saltiness of water) and the temperature affects the density. Salty water is denser than fresh water because there is more stuff (the added salt) in the same amount of space.



DIVE DEEPER

Participants may wonder why the salinity is not exactly the same across the global ocean. Ask them to hypothesize: What could cause the temperature and salinity of the ocean to vary across the world's ocean basins? Remember, there is only one ocean! Processes like evaporation of ocean water and the formation of sea ice can increase the salinity of the ocean, while the input of fresh water from rivers, precipitation (rain, snow) and the melting of ice can decrease the salinity of the ocean.

16. If time permits, have them test the neutral buoyancy of their robot in salty water. We suggest using about ½ cup of salt for every liter of water. Ask them to observe: Does it sink or float faster?

DIVE DEEPER

The group may want to know more about how the ocean robot works. Discuss with the group:

- What did you do if your ocean robot floated on the surface? How about if it sank to the bottom?
- What are the advantages to robots of achieving neutral buoyancy?
- How did you feel when your robot model didn't achieve neutral buoyancy? What changes did you make to ensure success? (Sometimes a scientist will work on the same problem for years!)
- What methodology worked best? What materials worked best?

Make Meaning

Optional Activity . 45 min

Part III: Diving into Data

Use the Youth Guide to encourage the group to explore paths (transects) and data collected on the robot's journey. The mission cards explain how the robots are deployed from a research vessel and monitored back in the lab via satellite communication. Ocean robots run off a battery supply and can sometimes be thrown off course by strong currents.

Have youth take out their mission card from earlier and explore the data side. Encourage youth to interpret the data and answer the questions on the card.

DIVE DEEPER

Sometimes ocean robots are hit by boats or attacked by ocean organisms. You may want to show this video of a great white shark attacking an ocean robot. See **youtube.com/watch?v=faZw3lFJOXs**.

Career Connections

Biological Oceanographer: A scientist or marine biologist who studies plants and animals in the marine environment. They are interested in the numbers and types of marine organisms, how they develop, relate to one another and adapt to their environment.

Chemical Oceanographer: Scientists that examine the chemical composition of the ocean. Their work may include analysis of seawater components, the effects of pollutants and the impacts of chemical processes on marine organisms.

Physical Oceanographer: Scientists that explore fluid motion and patterns of ocean circulation. They are interested in properties such as temperature and salinity. They study the ocean's physical processes such as waves, currents, eddies, gyres and tides.

Ocean Modeler: Scientists that develop and interpret numerical models of ocean properties and their circulation. Models play a large role in our understanding of the ocean's influence on weather and climate.

Ocean Engineer: A type of engineer that designs and builds instruments and scientific sampling tools that can endure the harsh conditions of the ocean environment.

Maritime Lawyer: The International Maritime Organization (IMO) is a specialized agency of the United Nations that oversees laws and rules involving the ocean around the world. These rules may relate to safety at sea, trade among countries and pollution prevention.

Marine Communicator: There are many ways to be a marine communicator. Some scientists serve as advisors to policymakers. For example, the Intergovernmental Panel on Climate Change (IPCC) provides policymakers with information on human induced climate change. Other communicators may spend their careers educating the public on ocean issues to inspire change.

ACTIVITY:

Ocean Expedition

By the end of the lesson, youth will be able to:

- identify ways they are connected to the ocean, regardless of where they live;
- understand challenges scientists and engineers face when researching the ocean;
- recognize that there is only ONE ocean on Earth;
- appreciate the mysteries of the ocean and what is still left to discover and learn.

SUGGESTED SCRIPT

The ocean affects Earth by shaping its features, making it habitable, influencing the weather and climate and providing biodiversity of life. Humans and the ocean are interconnected, yet it remains largely unexplored. While playing this game, you will explore the ocean and technology scientists use to understand it.

Engage

Optional Activity . 10 min

For the enhanced version: Before playing the board game, have the group think about their ocean knowledge. Engage youth with a Think, Pair, Share.

Think: Have the group think about the ocean. What are some things they know about the ocean? What are they curious about?

Pair: With a partner, discuss ideas and responses.

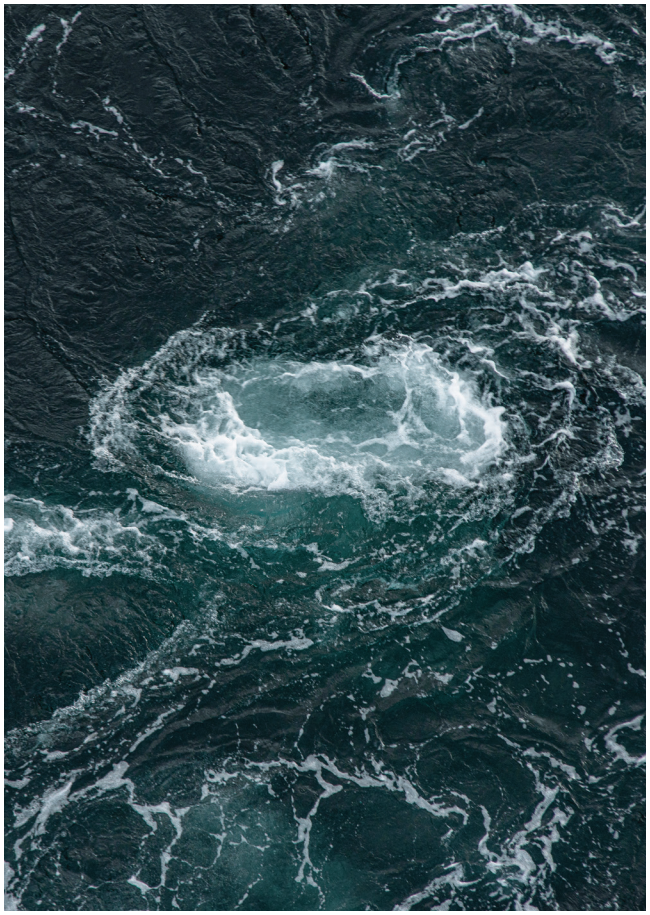
Share: Have a member of each group share their group's thoughts. Share with the youth that the ocean remains largely unexplored. The ocean covers 70% of Earth, but less than 20% of it has been mapped, observed and explored.

Explore

Core Activity . 45 min

For the short version, this is the main activity. Have the group play the Ocean Expedition board game. The instructions are below and included in the game box.

If the players would like, they may add an ocean trivia component to the game. The rules and steps listed in the instructions remain the same. All trivia questions are either multiple choice or true or false.



IMPORTANT VOCABULARY

Gliders: Gliders are a type of ocean robot. They are autonomous underwater vehicles (AUVs) that scientists put in the ocean and control with satellite connections to update commands and retrieve data. They surface to call home and send collected information back to the scientists. The "Surface!" spots on the board are trivia spots.

Gyres: Gyres (pronounced jai-ur) are large circular ocean currents found in the five ocean basins. Wind, tides, the Earth's rotation and differences in temperature and salinity all drive ocean currents. There is only one ocean but five ocean basins. Some of these are labeled on the board and you can even get caught in them.

Aquaculture: The farming or cultivation of organisms that live in the water including kelp, fish and shellfish.

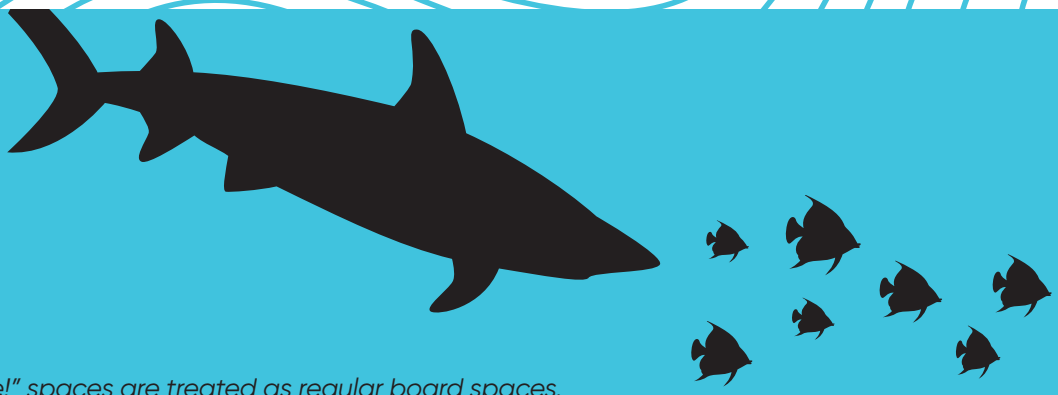
Phytoplankton: These organisms are the drifters and primary producers of the ocean. They form the base of most ocean food webs. Primary producers are organisms that make their own food, often by using sunlight.

Augmented Reality (AR) QR codes

If you have a smartphone, when you reach the designated spots on the board (Embark, Stuck in Gyre, Sea Ice and Mission Accomplished), scan the code with your phone and watch the animation. If you don't have a smartphone, AR videos can be found at **4H.org/OE0**. If you don't have access to the internet, the game can still be played and enjoyed.

Instructions without Trivia Questions

Recommended for grades 2-4



FACILITATOR TIP

In this version of the game, "Surface!" spaces are treated as regular board spaces.

1. Each person or team chooses a game piece and places it at the starting location.
2. Shuffle the deck of game cards and place them in a location that all players can access. Also shuffle the trivia card deck, as this version has an optional trivia component.
3. The person with the closest birthday goes first. Then, gameplay continues clockwise from that player.
4. The first player chooses a card from the deck. The card will reveal a scenario or fact and game instructions. Read the card out loud to the other players and move your game piece accordingly.
5. A player may land on a negative space on the board, including: "Stuck in a gyre!", "Sea Ice!", "Battery died!", "Garbage Patch!" and "Giant Squid Attack!" Landing on one of these spaces requires a decision. Either the player can do nothing, and they must skip their next turn, or they can choose "Emergency Surface", which allows them a chance to correctly answer a trivia question. If answered correctly, they move ahead one space and don't skip their turn. If they are incorrect, they must skip their next turn and move back two spaces.
6. If a player lands on a "Shortcut!" space, at the end of their turn, they may immediately move to the space the arrow leads to. If a player lands on a "Shortcut!" space because of the action of another player, they may also immediately move.
7. When the action on the game card has been completed, the turn is over and the next player chooses a card.
8. If the deck runs out during play, reshuffle and start again.
9. The first player to reach the end location wins the game. If more than two players are playing, the game may continue with the active players until all but one player has reached the end location.

Notes

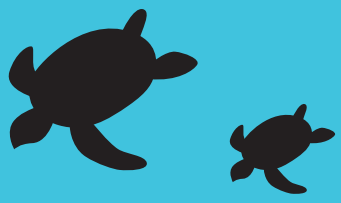
- If choosing the "Emergency Surface" option, another player will pick the top card off the trivia deck and read the card aloud. It is important to have a different player read the trivia question because the answers are shown on the cards.
- Players must always follow the rules of these board spaces, regardless of how they got there (Example: if another player sends your game piece back to land on one of these spots).
- A player can land on the same negative space more than once in a game and will have to lose their next turn each time.
- If a player must skip their next turn, but is moved off of the negative space due to the actions of a different player, they may move but must still skip their next turn.

Instructions with Trivia Questions

Recommended for grades 5 and above

For older players, we recommend adding an ocean trivia component to the game. The rules and steps listed in the instructions remain the same, except now trivia is played any time a player reaches a "Surface!" space.

1. Shuffle the deck of trivia cards and place them in a location that all players can access.
2. When a player reaches a "Surface!" space they must stop, regardless of their card's instructions. For example, if a player is one space behind a "Surface!" space but choose a card that says, "Advance five spaces" they may only advance one space to the "Surface!" space.
3. Once on the "Surface!" space, another player will pick the top card off the trivia deck and read the card aloud. It is important to have a different player read the trivia question because the answers are shown on the cards.
4. After the player has chosen their answer, the player asking the question will read the answer and explanation aloud.
5. If the player is correct, they may move the number of spaces indicated on the trivia card. Then their turn is then over.
6. If the player is incorrect, they must move back three spaces, but do not have to stop at the "Surface!" space and answer another question when they reach it again.
7. Each player only needs to pass each "Surface!" space once. For example, if a player has landed on a "Surface!" space, they no longer need to answer more questions if landing on it a second time. The "Surface!" space is now a regular space for that player.
8. If the deck runs out during play, reshuffle and start again.
9. The first player to reach the end location wins the game. If more than two players are playing, the game may continue with the active players until all but one player has reached the end location.



Make Meaning

Optional Activity . 10 min

For the enhanced version: Encourage the group to think about two things they learned or that surprised them while playing the board game and have them write them down in their Youth Guide. Pair with another member of the group and compare the information they learned. Have groups share some of their ideas with the larger group and encourage discussion.

ACTIVITY:

Ocean Communicator

IMPORTANT VOCABULARY

Public Service Announcement (PSA): An announcement made for the good of the public to motivate them to do something in order to achieve an aim, deal with a problem or advocate for a specific issue.

Letter to the Editor (LTE): A letter written to a newspaper or other publication to share a viewpoint on a current issue important in your community, state or country.

By the end of the lesson, youth will be able to:

- make connections between specific ocean challenges and climate change, the impacts on life (both human and animals) and how science is being used to address those challenges.
- create a Public Service Announcement (PSA) to inform their community about a specific ocean-related challenge and science innovation used to address it. Youth can choose from a variety of creative mediums to express their ideas about climate change and the ocean and what actions people can take at home!

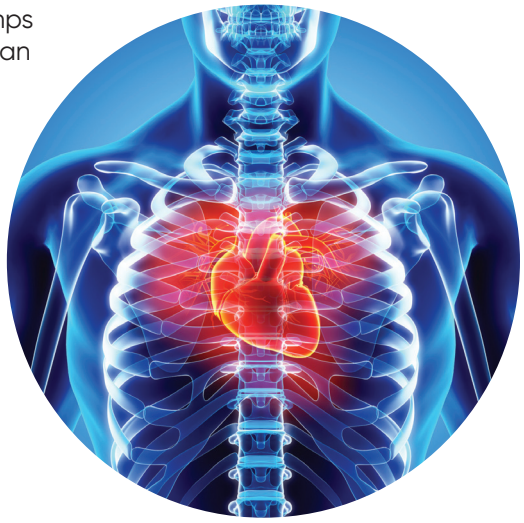
SUGGESTED SCRIPT

Many of us don't have direct experience with the ocean beyond an occasional seafood meal or a view from the coast while on vacation, however, you are directly connected to the ocean in your daily life! Did you know the air you breathe, the food you eat and the rain that falls around you are all connected to the ocean's role in the life of the planet? The ocean has a major role in how the planet functions.

The ocean, atmosphere and land are all connected. For example, the ocean and atmosphere are connected through the exchange of water in the form of precipitation and evaporation. The ocean is a huge contributor to the weather we experience and the long-term climate of our planet Earth. The health of our ocean is changing because of climate change. What happens in each part of the ocean affects the other parts. It is ONE big ocean!

FACILITATOR TIP

Ask the group to think of the planet as a body! Just like our heart pumps blood through our entire body, distributing oxygen and medicine, ocean currents are the circulatory system of the planet distributing heat, nutrients, oxygen and pollution through our global ocean.



Disruptions to the ocean's health can cause wider harm and injury to our amazing planet ecosystem. In this activity, youth investigate various challenges related to the ocean, how they affect humans and how scientists and the public are working to find solutions.

Engage

Optional Activity . 10 min

First, have the group look at the list of the challenges in their Youth Guide independently and write down anything they know about them.

Next, lead a discussion with the group. Ask them if they can give real life examples of where they have heard of or experienced these ocean challenges (listed on page 30), and why the challenges are a problem for the planet.

DIVE DEEPER

You can use the prompts and examples below to jump-start their discussions and ask them to debate and discuss in groups:

- **Frequency of Storms:** Some of the largest and most powerful storms, including hurricanes and cyclones, form over the ocean. Ocean robots are used to help predict storm paths and intensity.
- **Melting Glaciers and Rising Waters:** Approximately 10% of the planet is covered by ice. As global temperatures rise, glaciers melt more quickly, causing sea level rise to increase.
- **Plastics in our Ocean:** Plastics make up a lot of everyday products including water bottles, food containers, eyeglasses and even bathing suits. The COVID-19 pandemic has led to an increased demand for single-use plastic. As a result, more than eight million tons of pandemic-associated plastic waste have been generated globally, with more than 25,000 tons entering the global ocean! **(tinyurl.com/2p8wdyjj)**
- **Ocean Acidification:** An increase in carbon dioxide (CO_2) in the atmosphere and ocean can cause the ocean to become more acidic. This is causing problems for many marine organisms including clams, oysters and other shellfish.
- **Oil Spills:** As a result of the largest oil spill in American history, Deepwater Horizon (2010), approximately 134 million gallons of oil spilled into the ocean - that is equivalent to the volume of over 200 Olympic-sized swimming pools! The U.S. Coast Guard is primarily responsible for cleaning up oil spills. Trained experts use various equipment and tactics to contain or remove oil from the environment when a spill occurs. **(noaa.gov/education/resource-collections/ocean-coasts/oil-spills)**
- **Overfishing:** Overfishing can affect biodiversity. Biodiversity can be defined as the variety of life in the world or in a particular habitat or ecosystem. When fish populations began to decrease because of overfishing, it upsets the balance of food webs and biologic systems. **(nationalgeographic.com/environment/article/critical-issues-overfishing)**
- **Nutrient Runoff:** When it rains, many things like excess lawn fertilizer, soil erosion from river banks and the clearing of land (deforestation) and sewage flow into our waterways. This causes algal blooms that degrade the water quality. Two symptoms of runoff are hypoxia (or oxygen depletion) and harmful algal blooms which, among other things, can destroy aquatic life in affected areas.

Explore

Core Activity . 20 min

1. If possible, have youth work in pairs or groups of three. Have them spread out the 14 *Ocean Communicator Cards*.
2. Match the seven pairs of *Ocean Communicator Cards*, connecting each challenge with its corresponding real-world image.

   Note: *Ocean Acidification* and *Nutrient Runoff* are higher level cards that can be included for more advanced, or older, participants. It is up to the discretion of the facilitator to gauge which challenges to include.

FACILITATOR TIP

The card matching game will connect seven images with specific ocean topics and facts. Each ocean topic has four key points: the Challenge, Motivation, Innovation and Solutions.

- **The Challenge:** A short background section to understand the problem.
- **Motivation:** How does this challenge impact humans or marine life? Why should I care about this?
- **Innovation:** How are scientists using innovations to learn about the problem? You can relate this back to the ocean robots.
- **Solutions:** What are the options for addressing or solving the challenge? This could be a number of things, such as new science innovation, public action, civic engagement or education!

DIVE DEEPER

Engage them in discussing examples of challenges we are currently experiencing on Planet Earth from the motivation sections of the challenge cards. Encourage them to think about why we should care about these challenges and how they impact us.

FACILITATOR TIP

Notice on the top of the cards the ocean challenges are organized around three different categories: **Climate Change, Pollution** (Non-point source or Point source) and **Biodiversity**.

1. **Climate Change:** Climate change results from both human activities and natural causes. Human activities include the emission of heat-trapping greenhouse gasses, such as carbon dioxide, into the atmosphere and changes in land-use patterns, such as agriculture and urbanization. **(tinyurl.com/enyxramp)**
2. **Pollution:** Pollution refers to the contamination of water, land or the air by waste or substances that can adversely impact the environment and human health. **(tinyurl.com/56ft4b7n)**
   - **Non-point source:** Often called "people pollution'', or pollution from sources that can't be tied to a specific location, such as city streets and farm fields.
   - **Point source:** Pollution coming from a single known point, such as a factory or sewage treatment plant.
3. **Biodiversity:** The species number, variety and essential interdependence of all living things. This includes the genetic differences among them, the communities and ecosystems in which they occur and the ecological and evolutionary processes that keep them functioning. **(tinyurl.com/2dx882sv)**

Make Meaning

Core Activity . 20 min (minimum)

Discuss how lucky we are to live on Planet Earth. It is a unique and wonderful place! We have a duty as humans to take care of the natural world for ourselves and for future generations. The ocean does not belong to us, we are the caretakers, and we must pass it on in good condition to those who follow us.

While looking at the challenge cards, have the group select one challenge that interests them the most. They can also do their own research or brainstorm their own solutions. The sky's the limit! They can work individually, in pairs or as a group to tackle their challenge of choice.

Next, ask them to create a Public Service Announcement (PSA). Encourage them to use one of the mediums listed below to create their PSA about why their friends, family, peers, community and the public at large should be interested in and care about their selected challenge. Facilitate a discussion on why it is important to generate public awareness on issues and how they think their call to action can make an impact and help solve these ocean challenges.

FACILITATOR TIP

Explain that a PSA is like a billboard you see on a highway, or an ad on YouTube or social media.

Instructions

Part I - Design Your Message

Youth will use the 4-H message planner worksheet to brainstorm their ideas and craft their message. Encourage them to use the 4-H guide to organize their thoughts:

1. Use your **HEAD** to make people think.
2. Use your **HANDS** to create a call to action.
3. Use your **HEART** to make people feel something.
4. Use your **HEALTH** to address improving our world's ocean.

4-H Strong

You have the power to make a change!

Every day, young people across the nation are standing up, lending their voice, and rolling up their sleeves to make changes and improve the health of our ocean planet. In 4-H we make the best better! Craft an impactful message to your family and friends:

HEAD

What is the problem? Explain the ocean challenge you want to address in your own words.

HEART

Why should we care about it?

HANDS

What is the solution? Can you explain an innovative idea you have to solve the problem?

HEALTH

How would this innovation meet the challenge/solve the problem to restore the ocean's health?

Who am I going to share this message with?

We have a duty to take care of Planet Earth for ourselves and for future generations. Let's be caretakers of the ocean and pass it on in good condition to those who follow us.

Instructions

Part II - Create your PSA

Youth will use one of the mediums below to create a PSA about why they believe other people should be interested in and care about their selected challenge.

Public Service Announcement Tips

Facilitators may limit or expand the PSA options if desired. Encourage youth to focus on getting the public to care about their topic and why it is important and should matter to everyone, e.g., connections to the food web, climate change, biodiversity, carbon emissions, ocean pollution, aquaculture, air and water quality, property damage and threat to living things.

Suggested discussion prompts to help youth create a convincing awareness campaign about the challenge they selected:

- *Can you think of specific ocean-related science innovations, which may or may not already exist, that could provide solutions to the challenge you selected?*
- *What kind of public advocacy campaign could address the challenge?*
- *What does the public need to know about the challenge?*
- *What can the public do to bring awareness to the challenge?*
- *What can policy makers and industry leaders do to solve the challenge?*

PSA Options

1. **Take Action in your Community:** Even if youth do not live in a coastal state, there are many ways youth and communities around the country can take action and help to address ocean-related challenges. (See resource for ideas on taking action to help our ocean from NOAA.) Encourage youth to plan and organize an action event in their community centered around their ocean challenge of choice.

   Ask youth: In what ways can their community help to address the specific ocean challenge? What can be done at home, in their neighborhood or state or on the water to help solve the ocean challenge? What sectors or individuals can be contacted to help take action to address their ocean challenge of choice?

   Discuss the idea that communities around the country are affected by ocean issues in different ways. For example, think about the problem of plastics and marine debris. While beach communities in Florida may be concerned with abandoned vessels, communities in the Northeast might be more concerned with lost fishing gear. If you live inland, trash can end up in streams and rivers, eventually flowing to the ocean. Finding solutions that work for your community makes the fight against marine debris more effective. By working together as a community, we can have a larger impact! (See source in Youth Guide for taking action specifically on Marine Debris from NOAA.)

2. **Creative Art Piece:** The art piece should express why their friends, family and peers should be interested in and care about their selected ocean challenge and innovation. Creations can be a drawing, painting, collage, sculpture, textile piece, photograph, craft or other creative representation.

   Remind youth: Artistic pieces are a great way to express yourself and call attention to a specific challenge or issue. Also, they can often be entered into 4-H fairs and contests.

3. **Letter to the Editor (LTE) or a local or state representative(s).** Write to their local newspaper about the importance of understanding their ocean challenge of choice, what scientists are doing to combat the challenge and why it is important to understand the specific challenge and its effects on life and the planet. Youth can use the template in their student handout to create their letter. Have them locate their state representatives or local legislators using the following sites:

   house.gov/representatives/find-your-representative

   congress.gov/state-legislature-websites

Your Address:
Date:

Dear Editor (or name of policymaker),

I am writing to express my views on (state your ocean challenge and why you think it is important to address):

_____

_____

There are numerous things we can do to help. First, (name a solution to address the challenge, along with an innovation):

_____

_____

Secondly, (name another solution or innovation to address the challenge):

_____

_____

In addition, (explain what the public and your community can do to address the challenge):

_____

_____

To conclude, I feel that (your concluding thoughts on the challenge and hopes for the future):

_____

_____

Thank you for your time. I hope you give my suggestions your serious consideration.

Sincerely,

_____

4. **Creative Writing Piece**: The creative writing piece could be a poem, short story or song that expresses their interest in the challenge and why it is important. For shorter time periods, a poem may be the best option for sharing their thoughts about their challenge. In many cases, these creations can be shared in local contests and 4-H fairs.

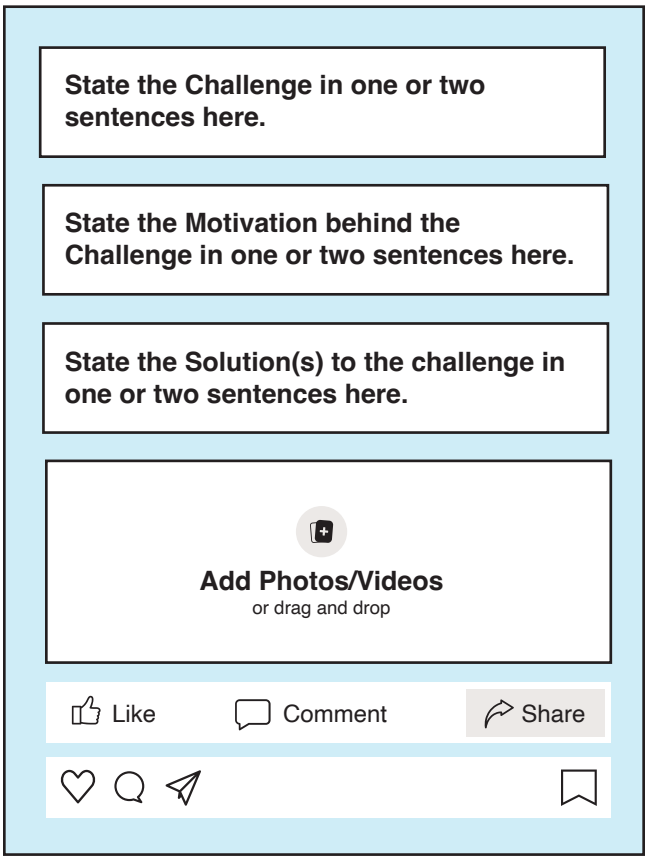
FACILITATOR TIP

Social media is another great way to reach and inspire others! **For younger youth without access to social media, facilitators can help youth post, with permission, on an adult family member's or facilitating organization's accounts.** Remind youth that they are never too young to get involved with important topics! Encourage them to fill out the template in their Youth Guide.

For youth allowed to post to social media:

Youth can use the social media template (pictured right) in their Youth Guide to draft a post showcasing the challenge they selected and the medium or action they took to address the challenge. They can touch on the four main components in their post: *Challenge, Motivation, Innovation and Solution(s)*. The post can contain an image or short video to express their message about why the specific ocean innovation and challenge matter to them, their community and the rest of the world.

Please use the hashtag **#4HSTEMChallenge** so we can see their posts and tag **@4HRutgersSci** and **@4H** so we can repost them!



Next Generation Science Standards (NGSS)

These activities intersect with several standards from the Next Generation Science Standards (NGSS) and the Ocean Literacy Principles (OLP) developed by the National Marine Educators Association. We have selected a few representative standard cross cuts between the NGSS and OLP. Please see the Handbook for Creating Ocean Literacy at **marine-ed.org/ocean-literacy/handbook** for more information.

Activity #1 - Ocean Robot Test Tank:
NGSS

MS-ETS1-1:
Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

MS-ETS1-2:
Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

MS-ETS1-3:
Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

MS-ETS1-4:
Develop a model to generate data for iterative testing and modification of a proposed object, tool or process such that an optimal design can be achieved.

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.

See **nextgenscience.org/topic-arrangement/msengineering-design** for an explanation of practices, disciplinary core ideas and cross cuts.

Activity #2 - Ocean Expedition:
NGSS

MS-ESS3-3:
Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

Ocean Literacy Principles:
marine-ed.org/ocean-literacy/overview

1. Earth has one big ocean with many features.
2. The ocean and life in the ocean shape the features of Earth.
3. The ocean is a major influence on weather and climate.
4. The ocean makes Earth habitable.
5. The ocean supports a great diversity of life and ecosystems.
6. The ocean and humans are inextricably interconnected.
7. The ocean is largely unexplored.

Polar Literacy Principles:
polar-ice.org/polar-literacy-initiative/

Principle #1: The arctic and antarctic regions are unique because of their location on earth.

Principle #2: Ice is the dominant feature of the Polar Regions.

Principle #3: Polar regions play a central role in regulating earth's weather and climate.

Principle #4: The polar regions have productive food webs.

Principle #5: The poles are experiencing the effects of climate change at an accelerating rate.

Principle #6: Humans are a part of the polar system. The arctic has a rich cultural history and diversity of indigenous peoples.

Principle #7: New technologies, sensors and tools — as well as new applications of existing technologies — are expanding scientists' abilities to study the land, ice, ocean, atmosphere and living creatures of the polar regions.

Activity #3 - Ocean Communicator:
NGSS

MS-ESS3-3:
Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

MS-LS2-4:
Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

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.

Additional Resources

Monterey Bay Aquarium Research Institute
mbari.org

Virginia Institute of Marine Science, The Bridge
masweb.vims.edu/bridge/index.cfm

Rutgers University, Department of Marine & Coastal Sciences
marine.rutgers.edu

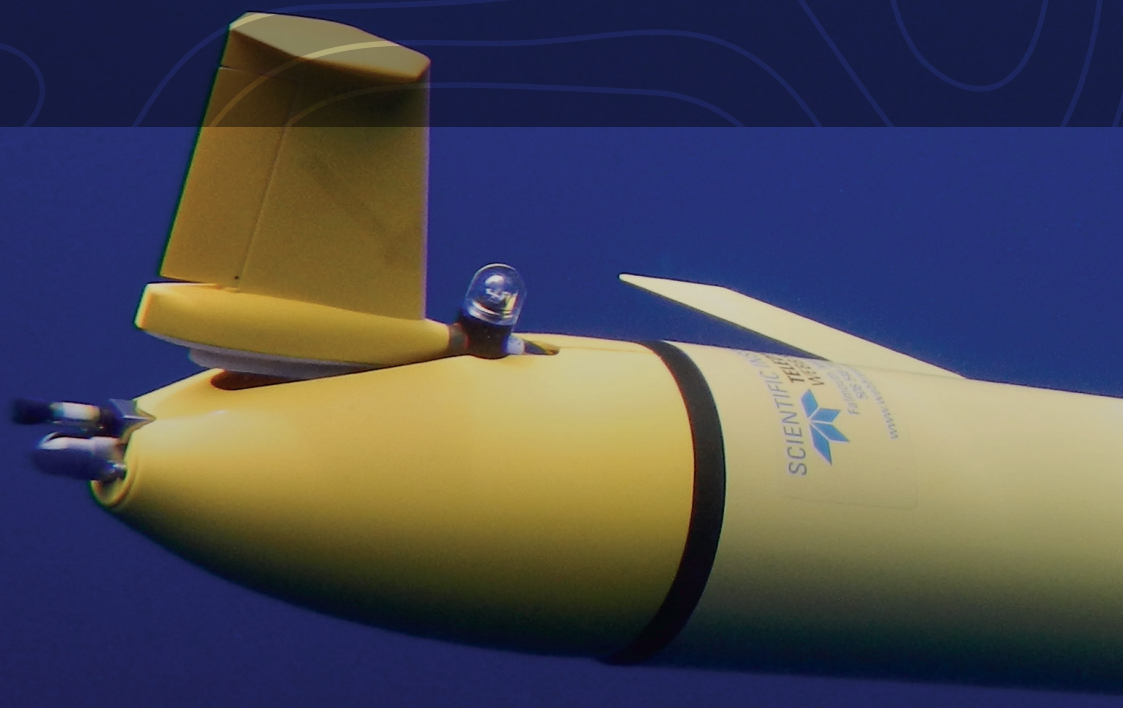
Center for Ocean Observing Leadership (COOL)
rucool.marine.rutgers.edu

Polar Science Literacy
polar-ice.org

Sea Grant
NOAA Educaiton
noaa.gov/education

Dedication

This guide is dedicated to Jeanette Rea Keywood from NJ 4-H. This guide is full of her energy and love for 4-H.



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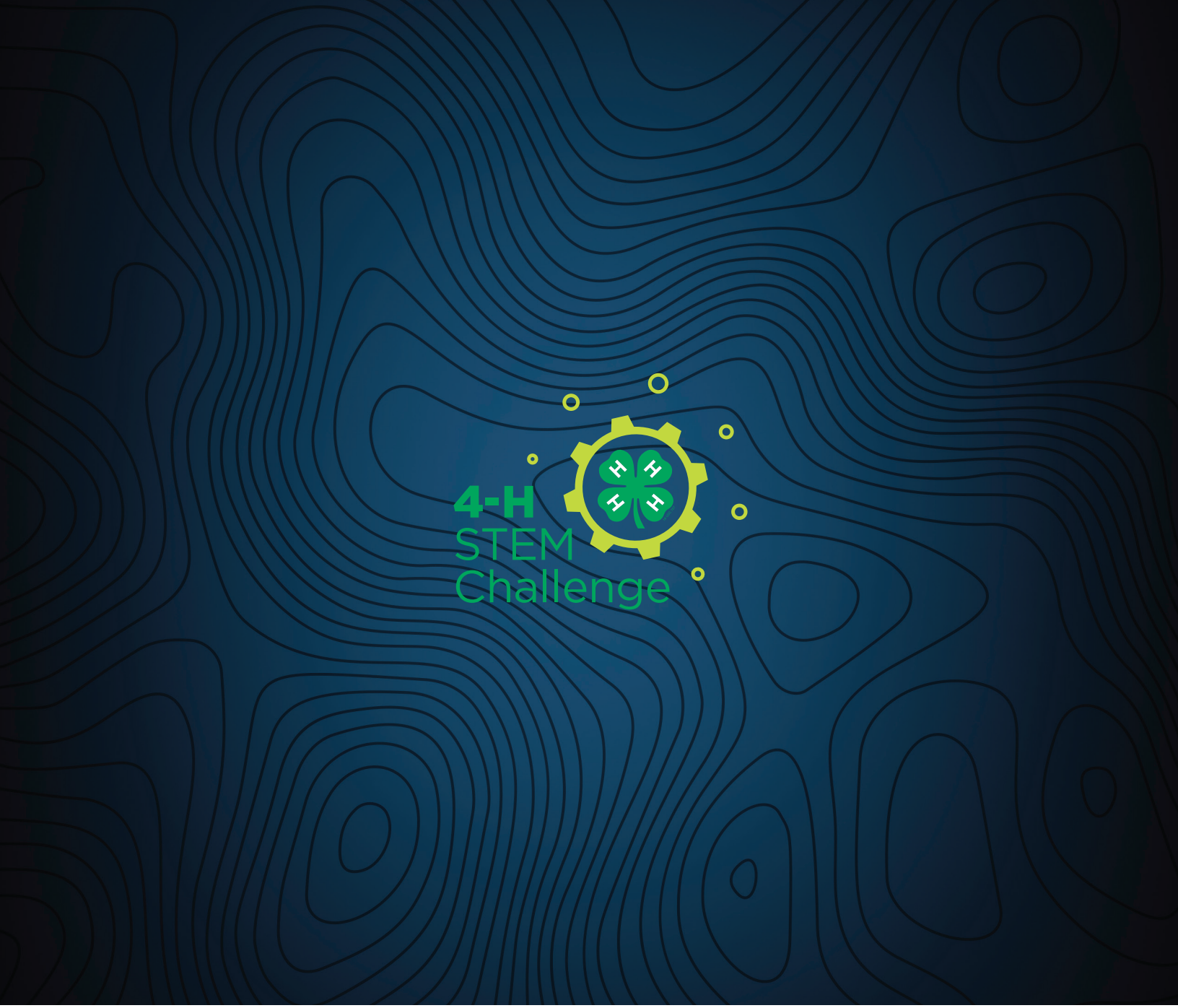

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In 4-H, we believe in the power of young people. We see that every child has valuable strengths and real influence to improve the world around us. We are America's largest youth development organization—empowering nearly six million young people across the U.S. with the skills to lead for a lifetime.

Learn more online at **4-H.org/STEMChallenge**.