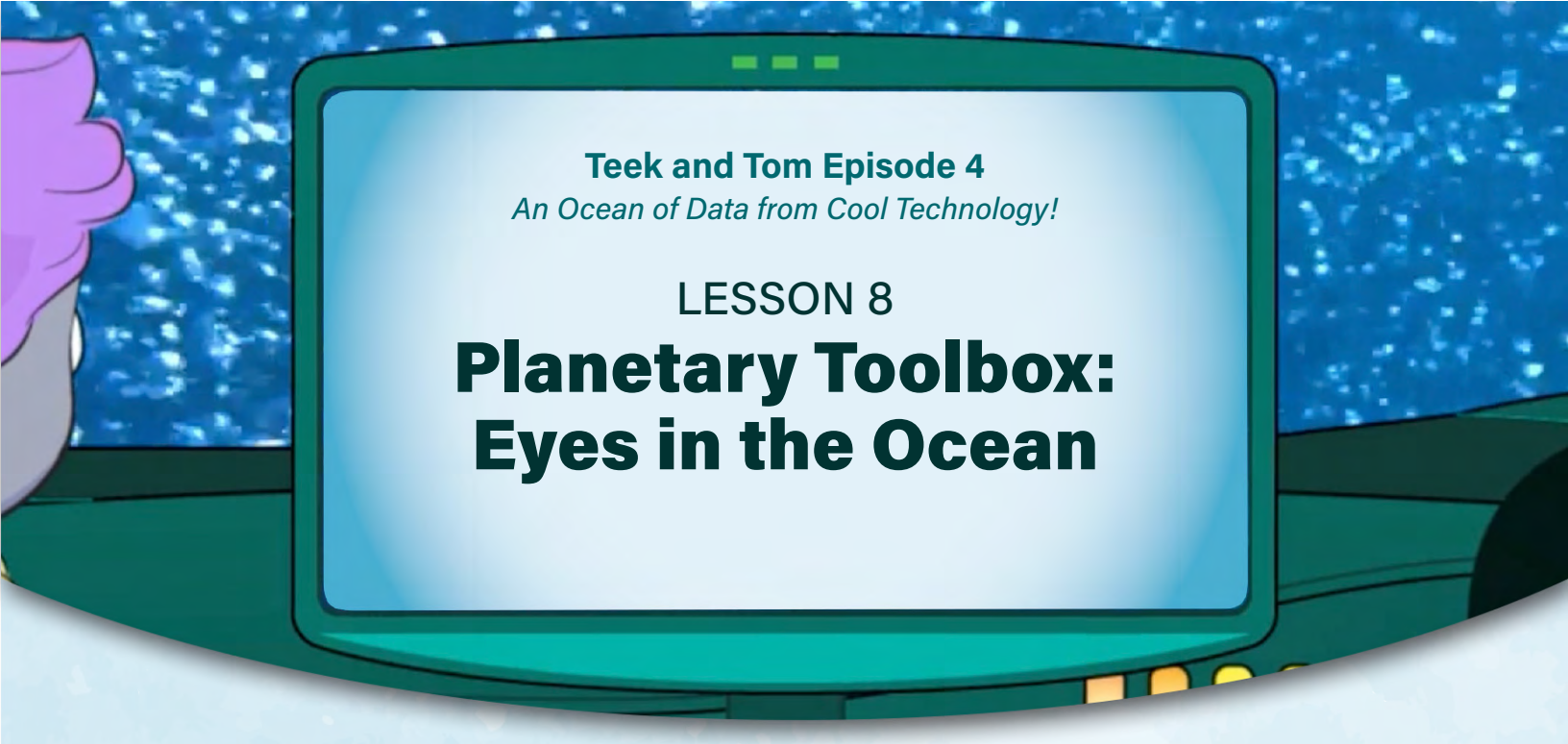


Teek and Tom Episode 4

An Ocean of Data from Cool Technology!

LESSON 8

Planetary Toolbox: Eyes in the Ocean

All URLs were reviewed and accurate at the time of this lesson's publication. If you should come across a non-operational link, contact NOAA Ocean Service Education at oceanserviceseducation@noaa.gov. All images are credited to NOAA unless otherwise noted.

Introduction

In episode 4, scientist Tom introduced technology NOAA uses to study the ocean. He discussed satellites that monitor Earth from space, using sonar and wave gliders, as well as the remotely operated vehicle (ROV) *Deep Discoverer.*

Oceanographic tools such as buoys, gliders, and floats provide a variety of data, including air and water temperature, wave height, wind direction, and speed at and below the ocean surface. All of the data provided by these technologies are brought together in computer models to predict severe weather and to provide information for ocean shipping.

Hydrography is the science that deals with measuring and describing the physical features of bodies of water (AKA mapping the seafloor). Since the ocean floor is not visible to us, it can be difficult to map, so scientists must use sonar. Sonar stands for **So**und **Na**vigation and **R**anging.

Active sonar systems emit a pulse of sound into the water, which bounces off the seafloor, creating an "echo." Seafloor depth is calculated based on the length of time between the sonar emitting a pulse of sound and how long it takes to receive its "echo." Contemporary seafloor mapping is often conducted using multibeam sonar systems on marine vessels. The data that a multibeam sonar provides allows scientists to collect a very detailed view of the ocean floor. Even with today's technology, only 26% of the ocean floor has been mapped with modern high-resolution technology.

The NOAA Ship *Okeanos Explorer* is the only federal vessel dedicated to exploring our largely unknown ocean. From this 224-foot-long ship, data are collected using a variety of advanced technologies to explore and characterize unknown or poorly known deepwater ocean areas, features, and phenomena at depths of 250 to 6,000 meters (820 to 19,700 feet). Most of the scientists participating in expeditions

on *Okeanos Explorer* can remain on shore thanks to telepresence technology.

Since the ocean is not a convenient place to conduct research, scientists collect samples of water, sediment, flora, and fauna to study in laboratories aboard the ship or ashore. Scientists also create instruments and automated laboratories to operate autonomously on the seafloor or at different ocean depths. Water sampling at sea can be as simple as dropping a bucket over the side of a ship or as technical as sending large water bottles thousands of meters toward the seafloor on a wire. Electronic instruments called CTDs measure the water's conductivity, which reflects its salinity, and temperature at various depths as it descends through the water, taking continuous measurements.

Research vessels like the *Okeanos Explorer* also transport ROVs to study sites and provide staging, servicing, and monitoring platforms for them. ROVs can be lowered alone on a cable or in a protective vehicle. Cameras on the ROV serve as "eyes" for researchers, who receive video signals and control the vehicle via a fiber-optic cable. An ROV can explore, take photographs, collect samples, or handle instruments, operating around the clock for many consecutive days — something that scientists in a small research submersible just can't do.

The ROV *Deep Discoverer* carries no passengers and is connected to research vessels like the *Okeanos Explorer* via a long cable. It is remotely piloted by engineers on the ship and capable of diving to depths of 3.7 miles (6,000 meters). The *Deep Discoverer* can record high-definition video, collect biological, geological, and water samples, and measure physical characteristics of the ocean such as salinity, water temperature, depth, and dissolved oxygen. All of this information helps us better understand the deep ocean environment.

Live video from *Deep Discoverer* travels from the seafloor to the ship and then via satellite connection to scientists on shore who use the real-time video to guide the ROV's pilots on where to go and which samples to collect.

Lesson Summary

Students will investigate ocean exploration tools used to monitor the physical parameters of the ocean floor, water temperature and salinity, ocean currents, and biological components. They will compare the tools' weaknesses and strengths, then select tools to investigate a remote part of the ocean. Finally, they will select a tool that might be used to explore Saturn's moon, Titan.

Objectives

- Students will be able to identify several instruments that provide data about the ocean at its surface and at different depths.
- Students will be able to explain how sonar is used to map the ocean floor and find natural and man-made features.

Estimated Time

It is estimated that one to two 45-minute class periods are needed for each lesson. This does not include the time required to view Episode 4 of Teek and Tom, *"An Ocean of Data from Cool Technology!"*, 12:23 minutes (https://oceantoday.noaa.gov/teekandtom/episode-4.html).

Education Standards

The lessons that accompany the Teek and Tom series were designed for upper elementary and middle school students. The standards addressed are abbreviated here. A full list of standards is available in Appendix A (https://oceantoday.noaa.gov/teekandtom/educators-guide/appendix-a.pdf).

Next Generation Science Standards

- 3-5-ETS1: Engineering Design. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- MS-ETS1-2: Engineering Design. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

Common Core English and Language Arts: Writing Standards Grades 4-5

Common Core Mathematics: Measurement and Data - Represent and interpret data.

College, Career, and Civic Life (C3) Framework for Social Studies: Geographic Representations

Materials

For a class of 30

- Students will need printouts of student record sheets, graphs, and/or maps to carry out the activities. Student record sheets are located at the end of this lesson.
- If you would like to provide the maps/graphics on a projection system, students will only need the student record sheets. Depending on the configuration of your classroom, we recommend one set per student or group.
- All maps/graphics presented in the activity are available as a slide set to project or present while teaching these activities. (https://oceantoday.noaa.gov/teekandtom/educators-guide/slide-set-8.zip)

Preparation

No special preparation is needed for this lesson.

Earth Curiosities

A New Hawaiian Island?

Loihi is the newest member of the Hawaiian volcanoes. It is an undersea mountain rising more than 3000 meters above the floor of the Pacific Ocean. Both Loihi and Kilauea volcanoes sit near Mauna Loa volcano, an older, larger, and still active volcano on the Big Island of Hawaii. Loihi (in the red circle on the map) sits submerged in the Pacific off the southeastern coast of the Big Island of Hawaii. Don't plan on visiting soon. Loihi won't appear above the surface of the sea for tens of thousands of years.

Credit: Hawaii_Island_topographic_map en.svg: *Hawaii_Island_topographic_map-fr.svg: Sémhurderivative work: Kmusser (talk)derivative work: Kmusser (talk) - Hawaii_Island_topographic_map en.svg, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=6085217

InvesTeekation Pathway

ENGAGE

Part 1. Engage

This shipwreck mystery activity is based on real wrecks in Thunder Bay National Marine Sanctuary. The GPS location recorded for the mystery wreck is N45°14.058' W83°16.707' if you and your students would like to find the wreck on a chart. These coordinates are enunciated: 45 degrees 14.058 minutes north, by 83 degrees 16.707 minutes west. Here is a little more information about each potential shipwreck option. You can share this information after the students identify which ship they think Teek and Tom found.

Maid of the Mist

This small schooner encountered a strong gale off Huron Beach while awaiting a load of cedar posts. The ship dragged anchor, grounded, and broke its keel.

John J. Audubon

On October 20, 1854, the *Audubon* sailed north for Chicago with a load of iron railroad tracks. At 1:30 a.m., the southbound *Defiance* emerged from the darkness and fog, striking *Audubon*'s midsection. The collision cut a hole deep in Audubon's hull, and she sank quickly. The crew survived.

Defiance

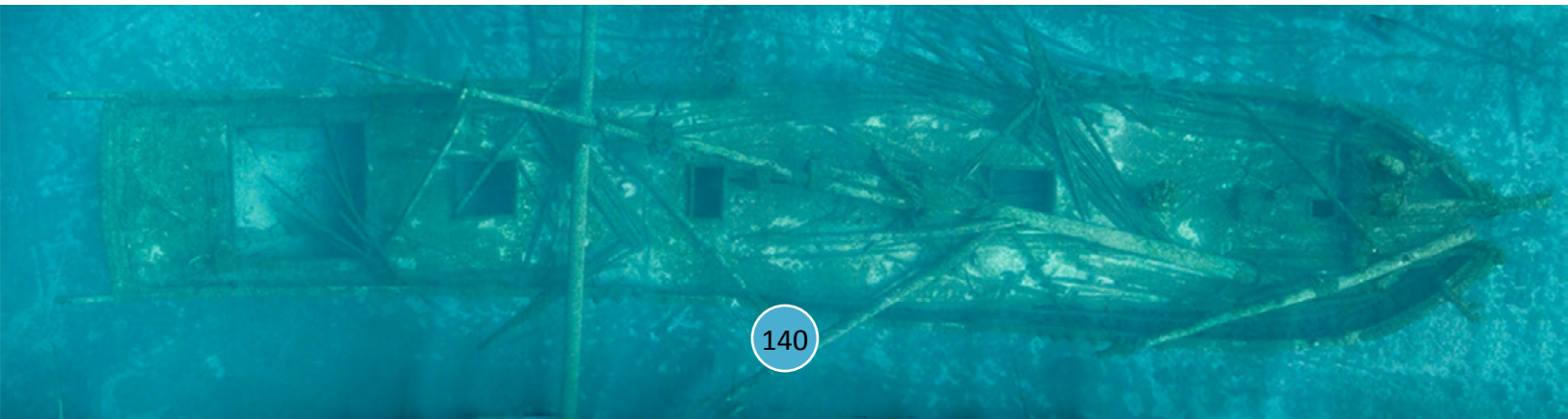
On October 20, 1854, *Audubon* and *Defiance* collided and fatally damaged both vessels. The *Defiance* sank a few miles away. The crew survived. *Defiance* and *Audubon* rest intact in more than 170 feet of water. Dr. Robert Ballard and Jean-Michel Cousteau have studied the pair of wrecks, helping to bring national attention to these underwater treasures.

Pewabic

The loss of the steamer *Pewabic* due to a collision with its sister ship *Meteor* resulted from bad decisions and not bad weather. A few miles south of Thunder Bay Island, *Pewabic*'s wheelsman suddenly turned his vessel into the path of the oncoming *Meteor,* cutting a huge gash into the side of *Pewabic*. Although Meteor rescued many of the estimated 150 passengers, at least 35 drowned in Thunder Bay's worst maritime disaster. Today, *Pewabic* is a gravesite and silent memorial to those who died in its sinking and salvage.

D.R. Hanna

This ship was carrying wheat from Duluth, Minnesota, to Buffalo, New York. The steamer *Quincy A. Shaw* collided with and sank the steel freighter. The *Hanna* rolled over and now rests upside down on the lake bottom. It is the largest wreck in Thunder Bay National Marine Sanctuary.

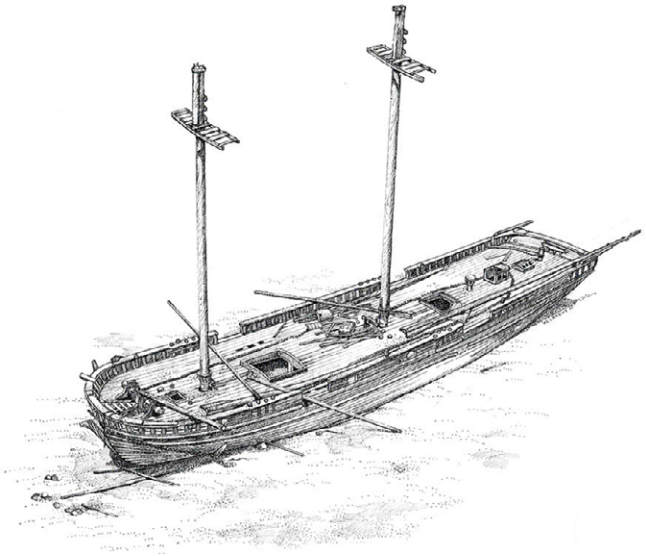


1. Which ship do you think Teek and Tom found?

   Defiance

2. What evidence leads you to think this is the correct ship?

   Maid of the Mist was too short. D.R. Hanna was made of metal and built in the 1900's. Of the wooden ships left, the Defiance was the only one with a cargo of grain that would "disappear" over time. The rail iron from John J. Audubon and the ore from the Pewabic would have been left behind for divers to find.



The Defiance

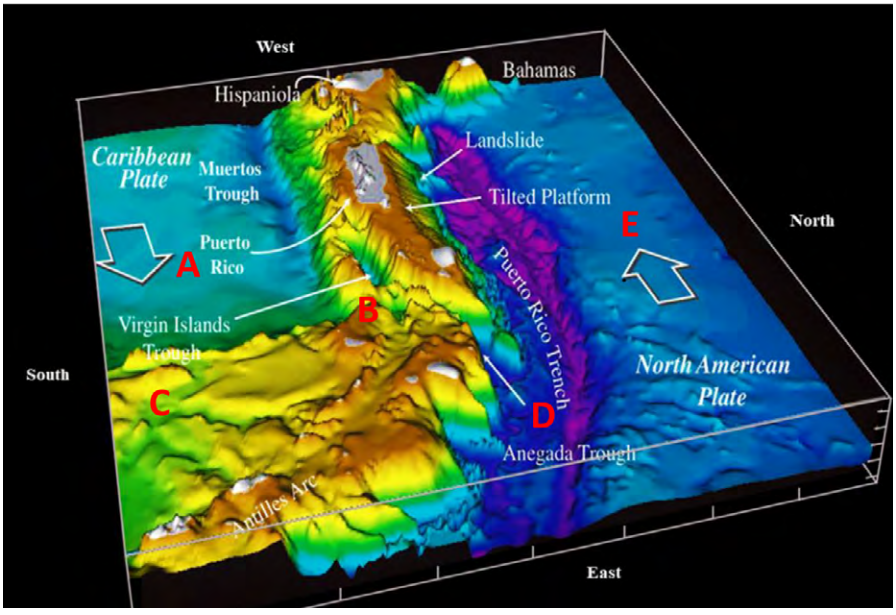
EXPLORE

Part 2. Explore

Students will examine several sonar images, looking for clues to identify each mystery.

1. *The images include a crane that fell to the ocean floor and a lost WWII B-25 Mitchell aircraft in New Guinea.*

2. The seafloor image that the students use is a color-shaded bathymetry map of the northeastern Caribbean. The white tips of the mountains show islands like Puerto Rico, the Virgin Islands, and the Bahamas. The features of this map are indicated below.



A. Island
B. Mountain range
C. Valley
D. Trench
E. Plain

3. What is the shallowest depth in this image? *0 meters (sea level or above)* What kind of feature does this represent? *Island*

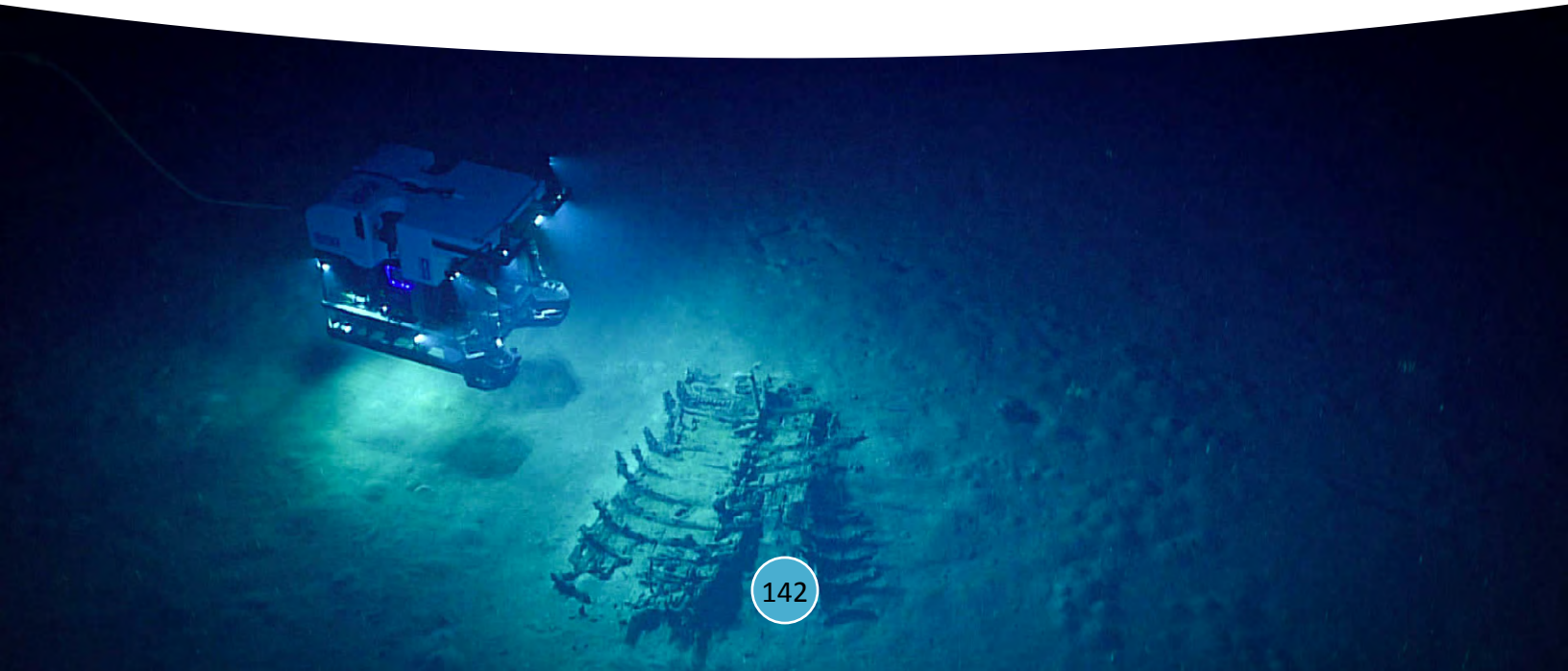
4. How deep does the trench go? *4400 meters*

EXPLAIN

Part 3. Explain

Many tools can be used to collect data about the ocean. Some tools can be operated remotely, some autonomously, and some require human interaction. Students may have some of these responses.

Exploration Tool	Type of data collected	Strength of this tool for collecting ocean data	Weakness of this tool for collecting ocean data
Sonar	*Depth and contours of the ocean bottom*	*Very detailed maps of the ocean floor and its features*	*Need a ship for this tool*
Ocean Glider	*Monitor temperature, currents, and other ocean conditions*	*Can collect data in remote locations safely and at relatively low cost*	*Cannot go very deep into the ocean , only 1,000 meters*
Ocean Drifter	*Sink to a particular depth and remain there collecting data about temperature and salinity*	*Low cost and can collect data down to 2,000 meters. Can be programmed*	*Cannot go very deep into the ocean*
Wave Glider Surfboard	*Ocean temperatures, currents, and salt content*	*Low-cost, autonomous robots that travel at the ocean surface*	*Only collects information at the surface*
Okeanos Explorer	*Sonar, CTD instruments that collect conductivity, temperature, and depth*	*Carries ROVs that can collect additional data. Can travel anywhere in the ocean*	*Ships require a crew and are costly*
ROV *Deep Discoverer*	*Can take high-definition video and has many tools to collect data*	*Can collect water and biological samples from very deep*	*Must be launched from a ship*



ELABORATE

Part 4. Elaborate

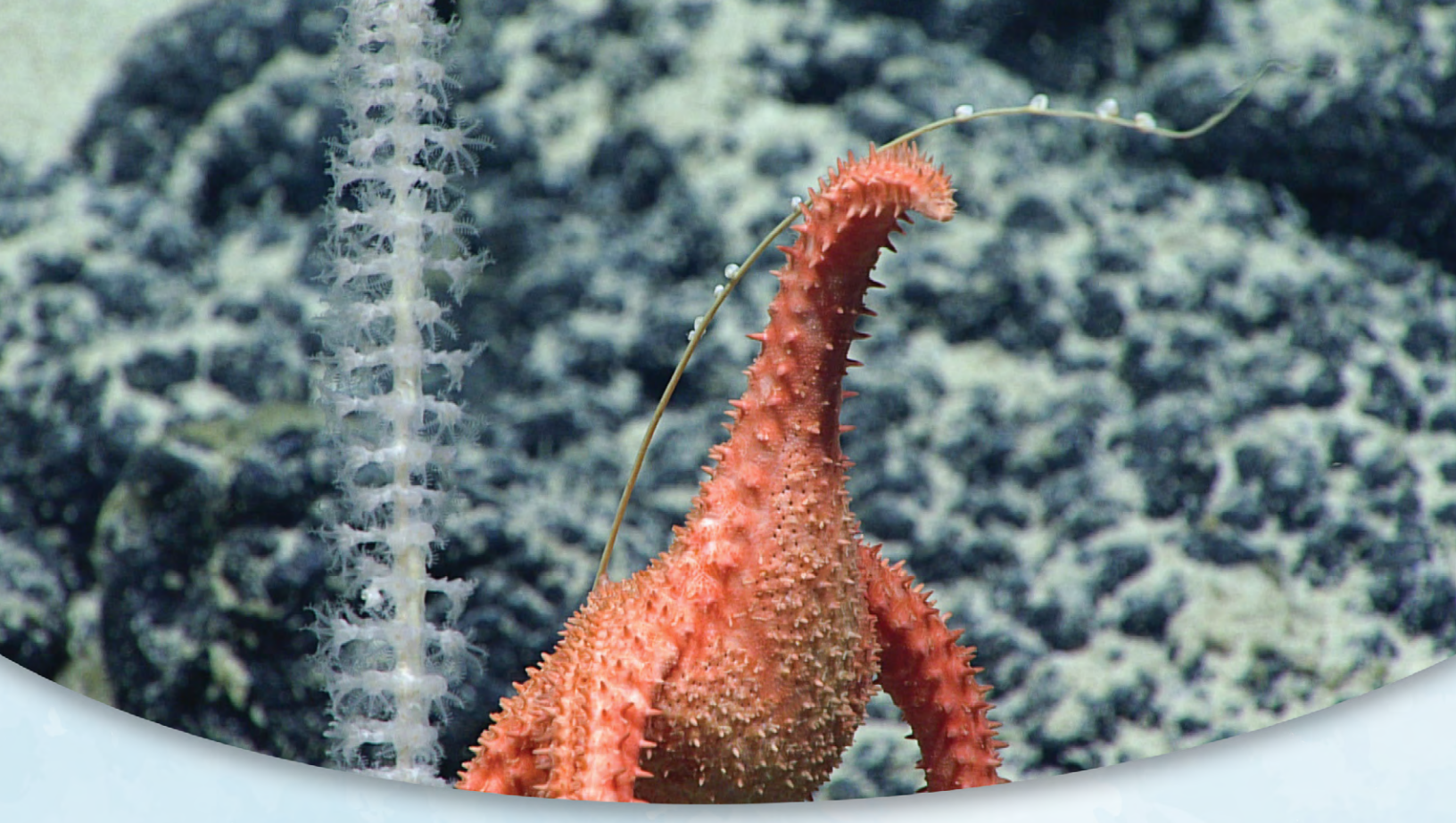
The description of the remote ocean in this activity is actually in the Pacific Remote Islands Marine National Monument. This area of 495,189 square miles (1,282,534 square kilometers) is in the central Pacific Ocean and has seven islands and atolls: Baker, Howland, and Jarvis Island; Johnston, Wake, and Palmyra Atoll; and Kingman Reef. You might recall some of these names from World War II history. It is one of the most pristine tropical marine environments in the world. Forty-five coral species and large populations of seabirds, sea turtles, whales, and reef sharks are found here as well. Many nationally and internationally threatened, endangered, and depleted species thrive at Palmyra and Kingman, including sea turtles, pearl oysters, giant clams, reef sharks, coconut crabs, fishes, and dolphins. Both Palmyra Atoll and Kingman Reef support higher levels of coral diversity (180–190 species) than any other atoll or reef island in the central Pacific. Students may record responses similar to the ones below about the exploration tasks in this remote part of the ocean.

Task	Tool	Why did you choose this tool?
Investigate the ocean currents around the surface of the islands	*Wave glider or drifter*	*Both of these float and record data about the currents*
Map the geologic features of the deep ocean floor	*Sonar on the Okeanos Explorer*	*Sonar can map the ocean floor but is done on a ship*
Record water temperatures from the surface to the ocean floor	*Ocean glider, drifter, or CTD on the Okeanos Explorer*	*All of these tools can be programmed to record temperatures at different depths and send the data back*
Identify and sample the creatures of the deep ocean	*ROV Deep Discoverer*	*The ROV has 2 manipulator arms for collecting samples.*

EVALUATE

Part 5. Evaluate

Saturn's largest moon, Titan, is bigger than Earth's moon and even larger than the planet Mercury. Titan has a dense atmosphere, and it's the only world besides Earth with standing bodies of liquid, including rivers, lakes, and seas, on its surface. Like Earth, Titan's atmosphere is primarily nitrogen. Liquids rain down from clouds, flow across its surface, fill lakes and seas, and then evaporate back into the sky, similar to Earth's water cycle. Scientists also think that Titan has an ocean of water. So far, we have only been able to look at Titan from the atmosphere. Students should consider what they have learned about tools for ocean exploration and design a probe that might be useful to collect data on a remote place like Titan. They are asked to write a description and then draw a diagram of the instrument that could be used to explore Titan.



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Extensions

A number of locations, technologies, and information are noted in this lesson. Some links to explore this content in greater depth are located below.

Thunder Bay National Marine Sanctuary (https://thunderbay.noaa.gov/)

2017 Laulima O Ka Moana: Exploring Deep Monument Waters Around Johnston Atoll (https://oceanexplorer.noaa.gov/okeanos/explorations/ex1706/dailyupdates/dailyupdates.html#cbpi=july25.html). Scroll down the page and view the video: "July 27, 2017: Dive 11."

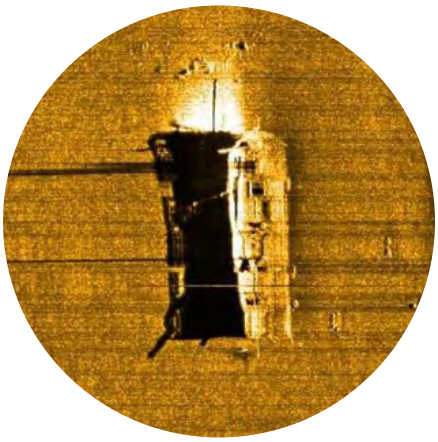
ROV Deep Discoverer: Voyage to the Ridge 2022 (https://oceanexplorer.noaa.gov/okeanos/explorations/22voyage-to-the-ridge/welcome.html).

These Ocean Today Videos will be helpful for student understanding during discussions about their ideas.

- Ocean Time Capsules (https://oceantoday.noaa.gov/oceantimecapsules/)
- Explore with Us (https://oceantoday.noaa.gov/explorewithus/)
- Ocean as a Lab: ROVs (https://oceantoday.noaa.gov/oceanasalab_rovs/)
- Ocean Science Robots (https://oceantoday.noaa.gov/oceanrobots/)
- Mission: Exploration (https://oceantoday.noaa.gov/missionexploration/)

Student Record Sheets

PART 1. It's a Mystery Shipwreck!



While Teek and Tom were exploring the Great Lakes in the spaceship *BARY*, they found a shipwreck in 185 feet of water in Lake Huron.

There are some clues about the ship from the site.

- The ship was over 100 feet long.
- It was constructed out of wood.
- The ship was built in the mid-1800s.
- The cargo disappeared quickly because no trace was left.

Good records exist for the shipwrecks in Lake Huron. Teek did some research and identified five ships that are believed to have sunk near this area. Take a look at the clues and decide which of these shipwrecks might be the mystery ship that Teek and Tom found.

Ship Name	Vessel Type	Construction Information	Cargo	Length
Maid of the Mist	Sail: wooden two-masted schooner	Launched in 1863	Cedar posts	90 feet
John J. Audubon	Sail: wooden two-masted schooner	Launched in 1854	Rail iron	148 feet
Defiance	Sail: wooden two-masted schooner	Launched in 1848	Grain	115 feet
Pewabic	Wooden passenger and freight steamship	Launched in 1863	Copper and iron ore; passengers	200 feet
D.R. Hanna	Steel freighter	Launched in 1906	Grain	532 feet

1. Which ship do you think Teek and Tom found?

2. What evidence leads you to think this is the correct ship?

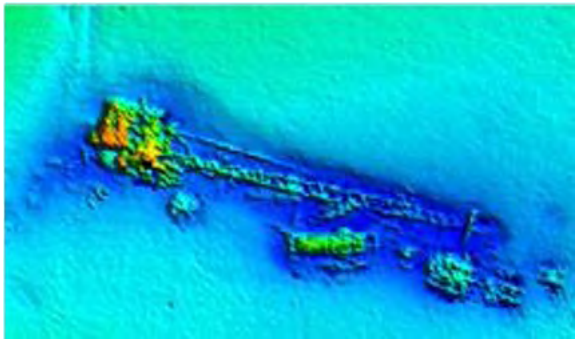
PART 2.

The image that Teek and Tom took of the mystery shipwreck was a sonar image. In episode 4, scientist Tom introduced technology like sonar that NOAA uses to study Earth's ocean. Sonar is short for Sound Navigation and Ranging.

Sonar systems emit a pulse of sound into the water, which bounces off the seafloor, creating an "echo." Seafloor depth is calculated based on the length of time between the sonar emitting a pulse of sound and how long it takes for it to receive its echo.

Sometimes, when the seafloor is being mapped, other objects are found. Here are a couple of items found using sonar.

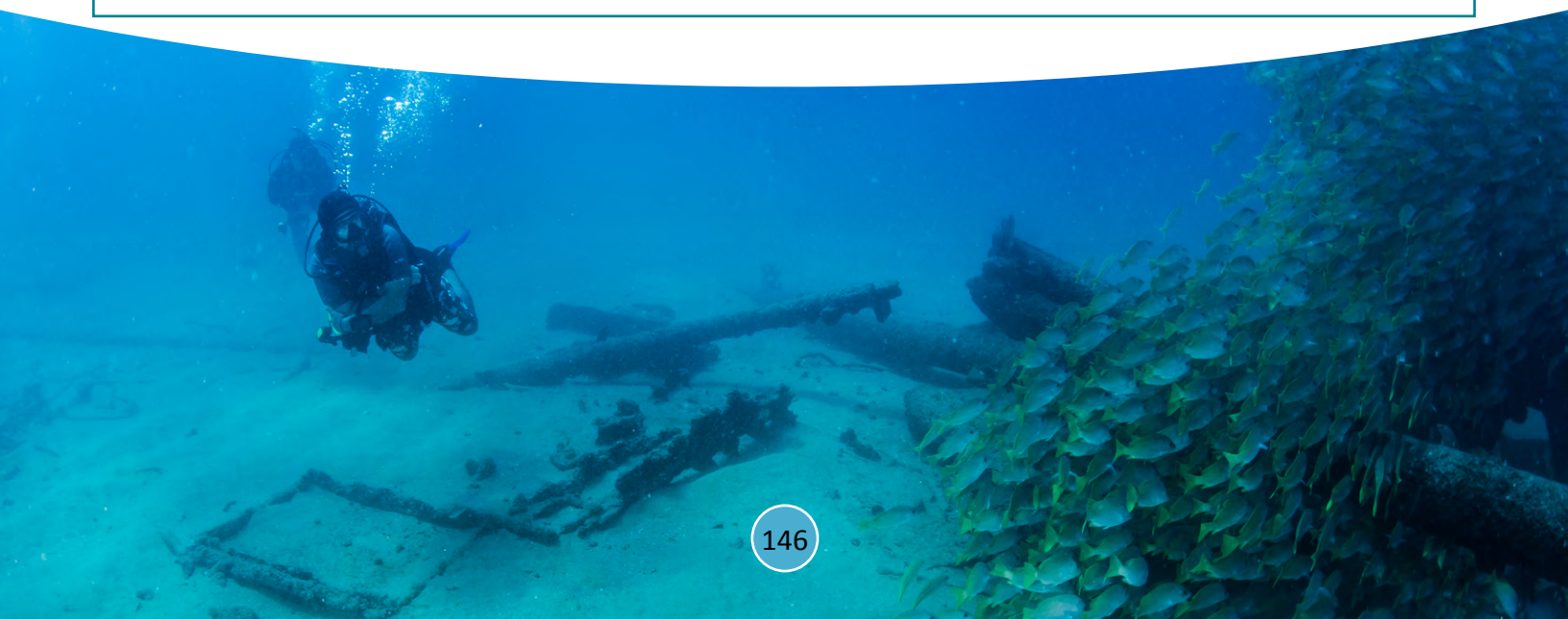
Illustration courtesy of NOAA Ocean Exploration.



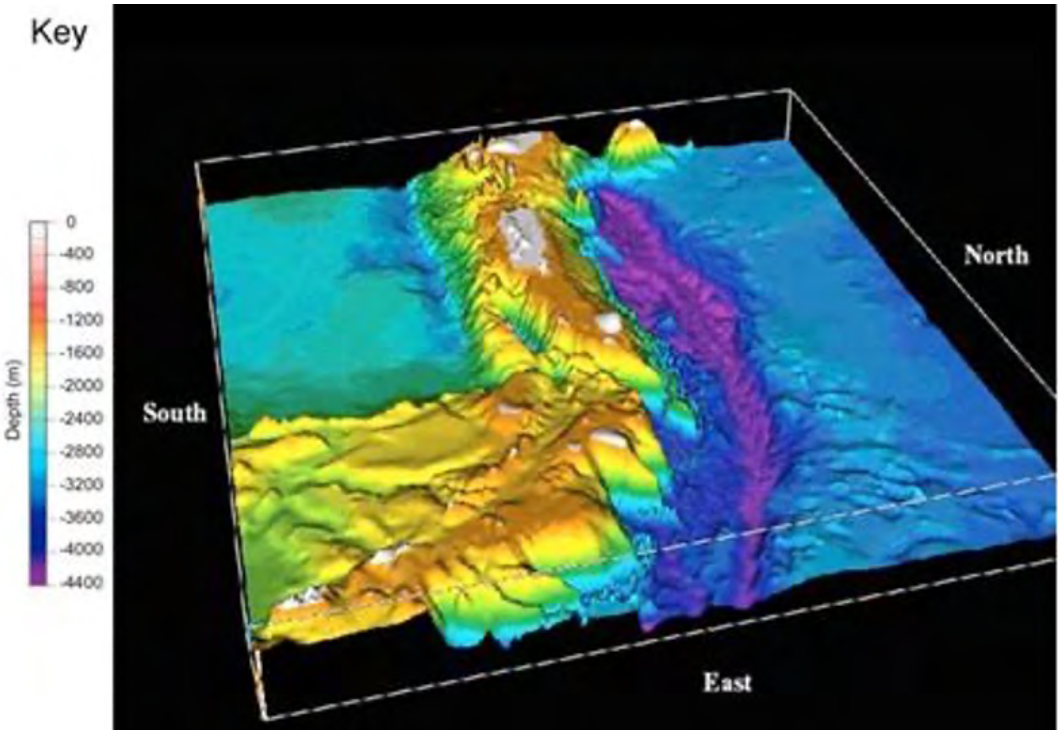
Mystery object #1

Mystery object #2

1. Discuss with a partner what you think these objects are. What evidence supports your ideas?



2. The seafloor contains many physical features like mountains, valleys, trenches, and plains. The use of sonar can map these features. Take a look at this seafloor image in the Caribbean region of the Atlantic, and identify an island, a mountain range, a valley, a trench, and a plain. Draw a line to the feature on the map from the list on the right.



A. Island

B. Mountain range

C. Valley

D. Trench

E. Plain

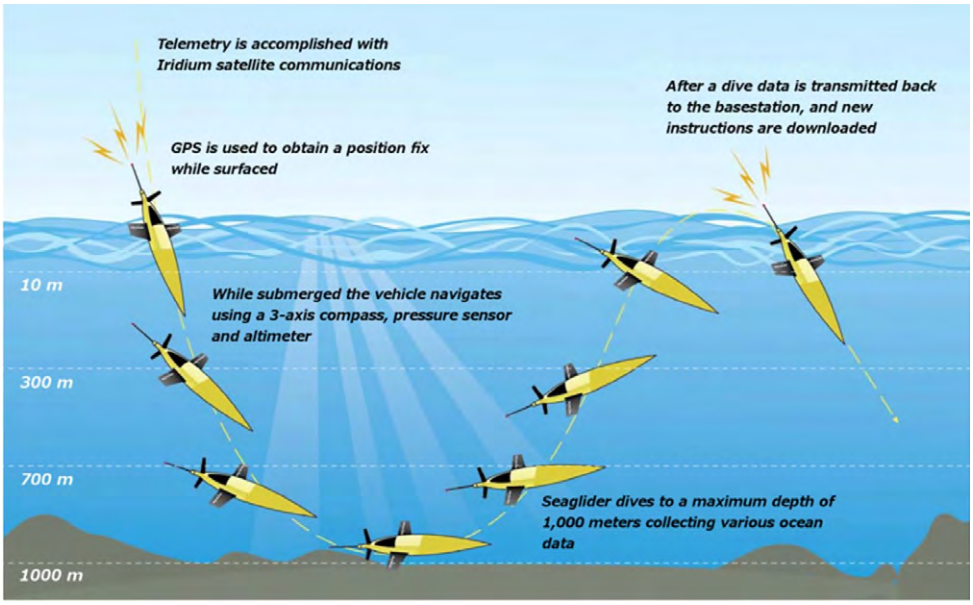
3. What is the shallowest depth in this image? What kind of feature does this represent?

4. How deep does the trench go?

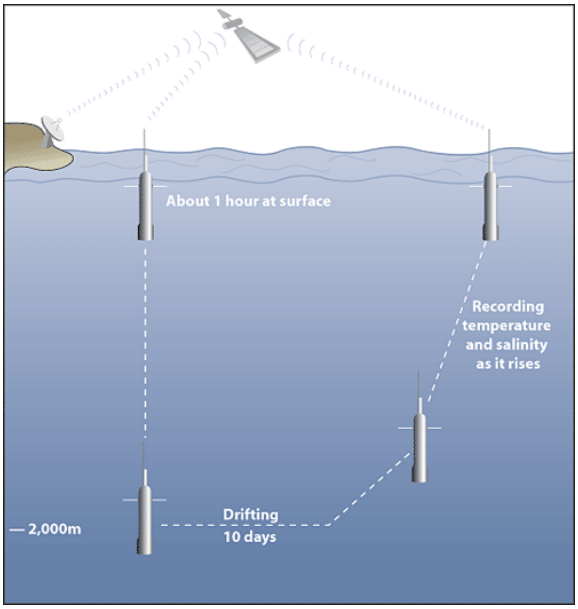
Credit: Shutterstock

PART 3.

Sonar has been used for many years to map the ocean floor, but there are other tools that Teek and Tom discussed in episode 4 that can help explore the ocean. One example is an **ocean glider** that does not need human assistance while traveling. These little robots can collect data in remote locations safely and at a relatively low cost. Glider sensors can monitor temperature, currents, and other ocean conditions.



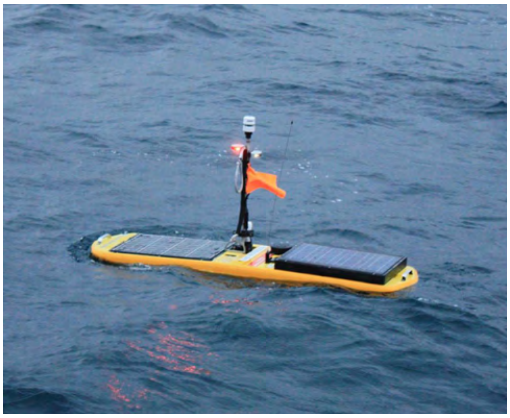
Ocean Glider



Ocean Drifter

Ocean drifters are programmed to sink to a particular depth and remain there for a specific period of time. At that depth, which scientists call a "parking depth," the profiling float drifts with the currents, collecting data it sends back to the scientists via satellite when it returns to the ocean's surface.

Wave gliders are small autonomous robot surfboards that travel at the ocean surface through wave energy, collecting ocean temperatures, currents, and salt content. Solar panels on top of the gliders power the sensors, which transmit the data back to satellites.



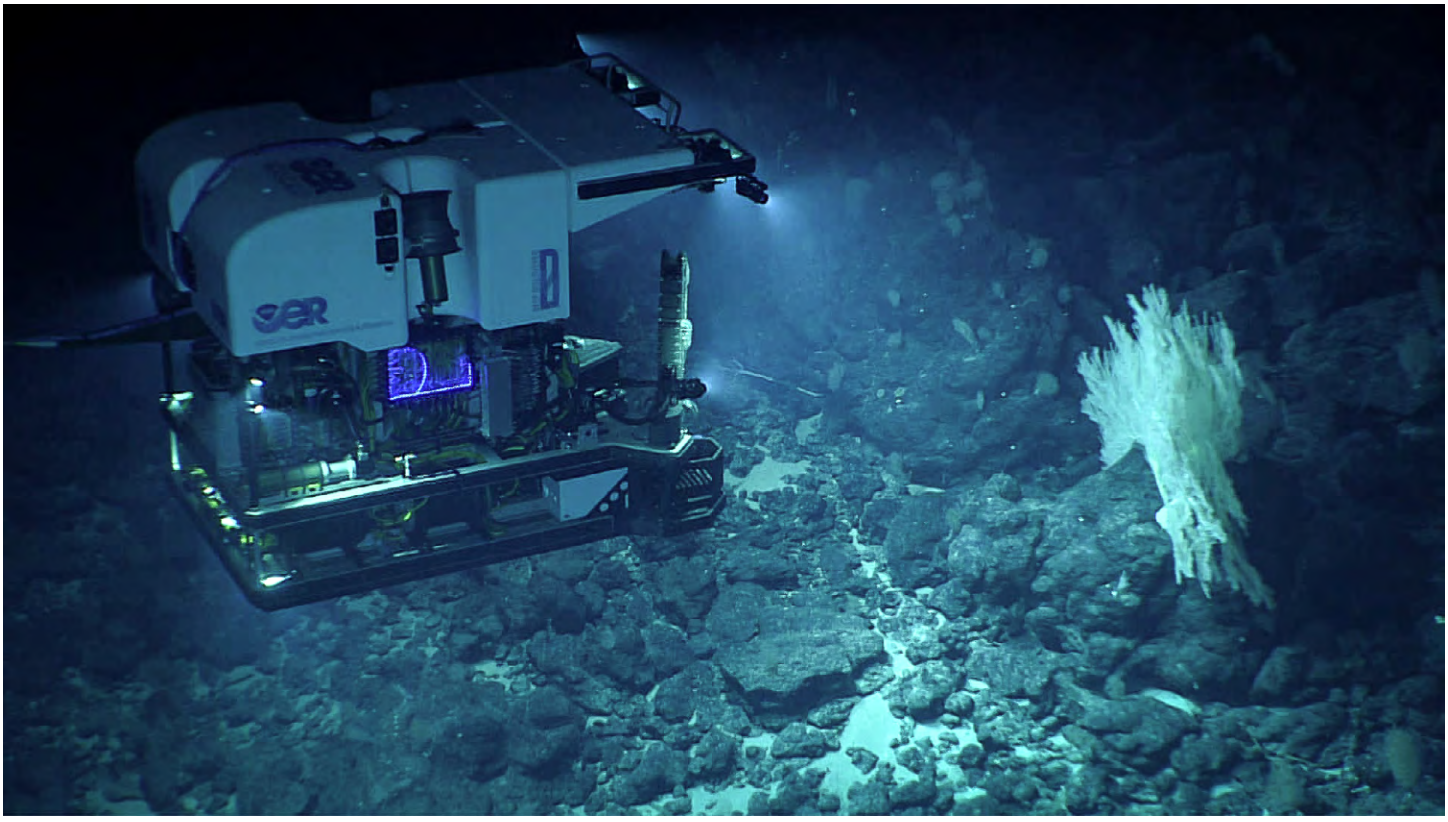
Wave glider surfboard

Okeanos Explorer

CTD instrument

The NOAA Ship ***Okeanos Explorer*** is equipped with mapping sonars and CTDs, which measure conductivity, temperature, and depth. This equipment is put into the water from the ship to measure the chemical and physical properties of the water at many depths.

The ***Okeanos Explorer*** also carries a remotely operated vehicle (ROV), the ***Deep Discoverer,*** capable of diving to depths of 3.7 miles. It cannot carry people, but it can capture high-definition video. It also has many tools to collect samples to help us better understand the deep-ocean environment. It is equipped with two manipulator arms and bottles for water collection, as well as sampler jars for collecting delicate biological samples.



ROV *Deep Discoverer*

Complete the chart below about some of the tools used for ocean exploration.

Exploration Tool	Type of data collected	Strength of this tool for collecting ocean data	Weakness of this tool for collecting ocean data
Sonar			
Ocean Glider			
Ocean Drifter			
Wave Glider Surfboard			
Okeanos Explorer			
ROV *Deep Discoverer*			

PART 4.

We have only mapped 26% of the ocean floor and explored 5% of the world's ocean. That means that **95%** of our ocean is unexplored. Teek would like to use some of NOAA's exploration tools to investigate a new area he and Tom discovered in a remote place on Earth. You and a small team will develop a plan to study this part of the ocean using some of the tools you have learned about in this lesson. Here is a description of the area that was found.

> *This remote part of the Pacific Ocean has several islands surrounded by shallow coral reefs. The islands are old volcanoes that drop off sharply to the deep floor of the Pacific Ocean. The coral reefs and ocean floor are home to a wide variety of animal and plant life.*

Record the tools for ocean exploration that you suggest Teek and Tom might use to complete some tasks in this remote part of the ocean.

Task	Tool	
Investigate the ocean currents around the surface of the islands		
Map the geologic features of the deep ocean floor		
Record water temperatures from the surface to the ocean floor		
Identify and sample the creatures of the deep ocean		

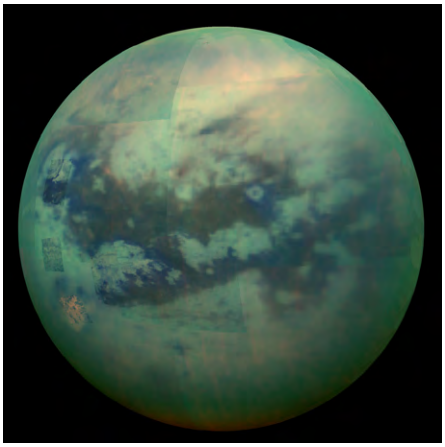
Credit: Shutterstock

PART 5.

Titan is a moon of Saturn that has an ocean of water. So far, we have only been able to look at Titan from the atmosphere as spacecraft fly by. In the future, spacecraft will be sent to land on Titan to take a closer look at its surface and ocean.

This image shows an infrared view of Titan from NASA's Cassini spacecraft. It was taken during Cassini's flyby on November 13, 2015.

Consider what you have learned about tools for ocean exploration and design a probe that might be useful to collect data on a remote place like Titan.



Credit: NASA. A composite image of Saturn's moon Titan taken by the Cassini spacecraft.

Write a description of your probe and explain why you chose this type of instrument.

Now, draw a diagram of your probe. Be sure to label the instruments that will collect data.