Shipwreck Explorers!

Lesson Specifications

Grade Level

6-8

Timeframe

Three 45-min class periods

Materials

Teacher:

- computer, projector, whiteboard, or chart paper

Students:

- Shipwreck Explorers Student Guide (1 per student)
- 1 internet enabled device per 2-3 students
- Simulation materials see “Elaborate” for list
- Evaluation Rubric (1 per student)

Key Words

argue, communicate, design, evaluate, model, obtain

Standards

NGSS: MS-ETS1-1, MS-ETS1-4
Ocean Literacy: Principle #6, Principle #7

A lithograph of schooner *St. Peter*. Photo: NOAA

A diver explores the 470-foot cargo freighter *Nordmeer* in Lake Huron. Photo: NOAA

Activity Summary

In pairs or groups of three, students explore the wreck of schooner *St. Peter*, which lies in approximately 120 feet of water in the proposed Lake Ontario National Marine Sanctuary. Students then become shipwreck explorers looking for other shipwrecks within the sanctuary boundary. They research the technologies used by maritime archaeologists to locate and image shipwrecks and participate in simulations of the use of two of these technologies, sonar and photogrammetry. Finally, students create a digital information display summarizing the process of shipwreck exploration for possible use in a fictional visitor center of the proposed Lake Ontario National Marine Sanctuary.

Learning Objectives

Students will be able to:

- Make an argument from evidence in order to evaluate the information required for locating a shipwreck.
- Obtain, evaluate, and communicate information about technologies used to discover and image shipwrecks.
- Develop and use a model that simulates use of relevant technologies.
- Design a tool of effective science communication that illustrates the process and technologies involved in shipwreck exploration.

A diver swims over the shipwreck *St. Peter.* Photo: NOAA

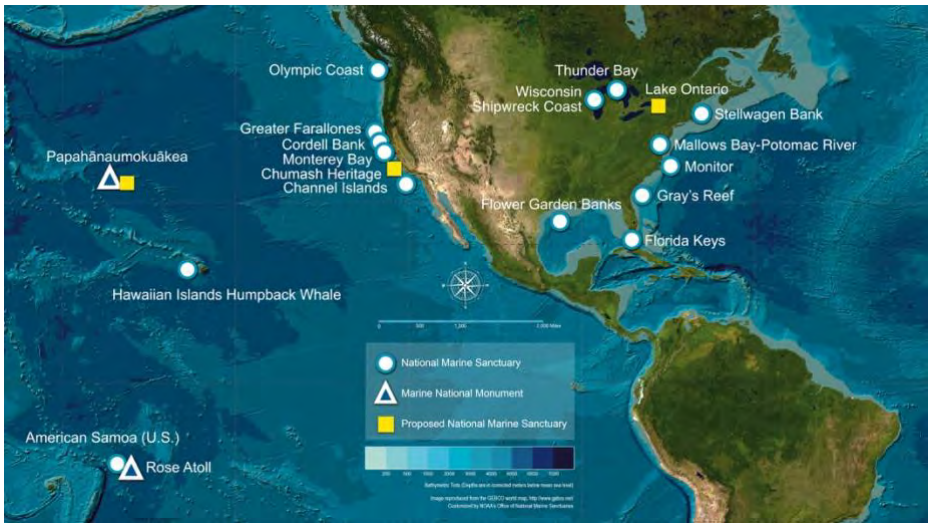
Suggested Implementation Timeline

Day	Suggested In-Class Work	Suggested Homework
1	Complete *Engage* and *Explore* in pairs or small groups Independently begin *Explain*	Independently complete *Explain*
2	Give students the opportunity to discuss their *Explain* research and ask clarifying questions of the instructor Complete *Elaborate* in pairs or small groups	Independently complete *Evaluate*
3	Students view and give feedback on information displays of peers	N/A

Background Information

National Marine Sanctuaries and Maritime Heritage

NOAA's Office of National Marine Sanctuaries serves as the trustee for a network of underwater parks encompassing more than 620,000 square miles of marine and Great Lakes waters. The network includes a system of 15 national marine sanctuaries and Papahānaumokuākea and Rose Atoll marine national monuments. Few places on the planet can compete with the diversity of the National Marine Sanctuary System, which protects America's most iconic natural and cultural marine resources. The system works with diverse partners and stakeholders to promote responsible and sustainable use.



Map of current and proposed sites within the National Marine Sanctuary System. Photo: NOAA

The National Marine Sanctuary System includes a strong commitment to maritime heritage, which is the study of human interactions with the ocean and coastal lands and waters. Maritime heritage seeks to preserve valuable historical, cultural, and archaeological resources above and below the waves, including not only physical resources, such as shipwrecks and archaeological sites, but also intangible resources such as cultural practices and traditions. The study of maritime heritage enriches our understanding of how exploration, trade, and the transportation of goods and people affected the country's development and continues to influence the character and economies of coastal communities.

The Great Lakes and the Shipping Industry

The Great Lakes system includes lakes Superior, Michigan, Huron, Erie, and Ontario, as well as a number of rivers and tributaries that connect the lakes to each other and, via the St. Lawrence River, to the Atlantic Ocean. Together, they hold about 90% of the surface freshwater in North America and approximately 20% of the world's surface freshwater supply. Forty million residents of the United States and Canada depend on this system for clean drinking water. Additionally, the Great Lakes watershed supports 7% of the agricultural production of the United States and 25% of Canadian agriculture.

Spanning more than 750 miles (1,200 kilometers) from west to east, the Great Lakes provide water for drinking, transportation, power, recreation, and many other uses. Commercial and sport fishing, agriculture, recreation, tourism, manufacturing, and shipping are all important to the region. These activities create jobs and provide goods and services. If the Great Lakes region were its own country, it would have the third largest economy in the world with a gross domestic product of $6 trillion. Much of it is due to the trade between Canada and the U.S. for goods and services.

In the mid-19th century, the inland waterways of the Great Lakes became busy highways for trade in goods, such as wheat, corn, lumber, coal, and iron ore, and provided transportation for millions of people moving west. Fleets of ships served industries around the lakes and helped grow port cities, such as Cleveland, Detroit, and Chicago. The shipping industry also shaped the character of smaller industrial centers fueled by Great Lakes trade such as Oswego, New York at the eastern end of Lake Ontario and considered the point of entry for Great Lakes shipping.

Leafield was a steel freighter used on the Great Lakes for the ore and grain trade. Photo: Edward J. Dowling Collection, University of Detroit-Mercy (courtesy of Great Lakes Maritime Collection, Alpena County George N. Fletcher Public Library)

While all types of cargo are currently transported on the Great Lakes, bulk cargo accounts for most commercial shipping in the region. Bulk cargo includes products that are loose and unpackaged, such as grain, sand, or coal. The primary cargo shipped via the Great Lakes include iron ore used in steel-making, coal for generation of electricity, limestone used in cement and road-production, agricultural projects, finished steel, and project cargo like turbine blades for wind-energy projects.

Great Lakes Shipwrecks

The Great Lakes are among the most treacherous waters in the world. Powerful storms are common, especially in late fall, and often form quickly giving little warning. As the shipping industry expanded in the 19th century, loss of vessels, cargo, and crew became very real factors affecting the industry and the people who relied upon it. In 1871, there were 591 maritime accidents—one for every four boats on the Great Lakes. Maritime historians estimate that there are upwards of 6,000 shipwrecks, most awaiting discovery, in the Great Lakes.

The cold, freshwater of the Great Lakes preserves the structural integrity of vessels sunk hundreds of years ago, making it possible to observe details of the vessels structure and cargo, and in some cases, even the personal items brought on board by the crew. Unlike their saltwater counterparts, freshwater shipwrecks have not experienced the same deterioration from shipworms (a saltwater clam) burrowing through their wooden hulls. Since saltwater speeds metal deterioration, iron and steel vessels also maintain their structural details much longer in freshwater. The quality of the shipwrecks found throughout the Great Lakes make them a top destination for many wreck divers and shipwreck explorers interested in experiencing each vessel.

A diver exploring the wreck of the schooner *St. Peter* in Lake Ontario. Photo: Nick Zachar/NOAA

Lake Ontario National Marine Sanctuary & the Wreck of the Schooner St. Peter

In 2017, the city of Oswego, New York and four counties (Oswego, Jefferson, Wayne, and Cayuga) submitted a proposal advocating for the creation of Lake Ontario National Marine Sanctuary (LONMS). The proposed sanctuary would protect a collection of historically important shipwrecks and foster public engagement with the area's unique maritime heritage through education and tourism. In 2019, in response to this community-based proposal, NOAA announced its intention to designate a sanctuary in eastern Lake Ontario and the Thousand Islands region of the St. Lawrence River.

In the 19th century, schooners, a type of wooden sailing ship, were the workhorse of Great Lakes shipping. A schooner is a ship rigged with fore-and-aft sails on two or more masts. Some schooners have a third mast, called the mizzenmast, located towards the stern, or back of the ship. The fore-and-aft rigging of schooners made them fast, maneuverable, and economical because they required fewer crew members to manage the sails. A schooner's sails were rigged fore-and-aft, meaning along the line of the keel, the timber at the lowest part of the ship forming the foundation for all other ship parts.

A lithograph of the schooner *St. Peter.* Photo: NOAA

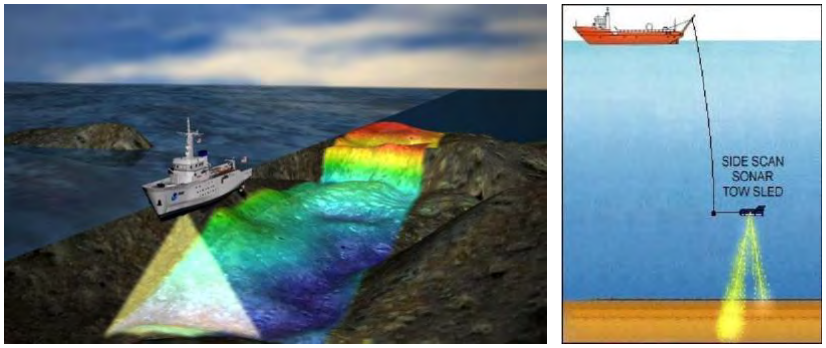
St. Peter was a 3-masted schooner built in 1873. The vessel measured 135 ft in length, 26 ft in beam (width), and 12 ft depth of hold (space for cargo). In October of 1898, *St. Peter* was bound for Toledo, Ohio carrying a cargo of coal when it encountered a blizzard producing 20-foot seas and 70 mile per hour winds. The captain turned to try to outrun the storm but was unsuccessful. After a 12-hour battle, the schooner rolled and sank west of Sodus Bay off the coast of New York. The captain was rescued, but his wife and the seven-person crew lost their lives. The shipwreck was rediscovered in 1971 in approximately 120 feet of water. The masts were removed by salvage crews; however, the deck and lower hull remain intact.

Shipwreck Exploration

Maritime archaeological resources, such as shipwrecks, offer valuable insight into past communities, their values, and their livelihoods. Identification and exploration of these resources presents researchers with opportunities to understand the past, identify relationships between past and present communities, and foster opportunities to connect with these resources and this heritage.

The process of shipwreck exploration begins with research. For example, in building an understanding of the maritime heritage of Eastern Lake Ontario, researchers used primary sources such as newspaper articles to compile a list of shipwrecks potentially located within the boundary of the proposed sanctuary. Researchers recorded the vessel's name, cargo, and accounts of the wrecking events. They then researched key pieces of information that could help with vessel identification if wreckage was found. For example, they used builder's plans to identify vessel dimensions such as length and width (referred to as "beam"), and features like the number of masts, deck machinery, and hull shape. Once the list of potential shipwrecks was created, researchers then established a search location where the vessel remains may be located. Researchers primarily use eye-witness accounts that document the vessel's last known position to generate a search area. This area is then refined using historical weather data, current and tidal models, and nautical charts that depict underwater terrain.

Once the search area is defined, there are many technologies researchers may use to help locate wreckage. Sonar, or sound navigation and ranging, is a tool that uses acoustic echoes to visualize underwater features. A pulse of sound is emitted into the water. Objects in the path of the sound pulse cause the sound to bounce off and return an "echo." By determining the time between the emission of the sound pulse and the "echo," the distance to and some features of the object can be determined. Many shipwrecks have been located by amateur wreck explorers using single-beam sonar. Maritime archaeologists and other professional scientists often have access to more advanced sonar systems like side scan and multibeam sonar. Many searches begin with multibeam sonar and once a specific target area is identified, side-scan sonar will be used to gather more detail. Surveyors are looking for underwater features that appear human-made. Natural features rarely have the straight lines seen in human-made structures. The presence of straight lines and unnatural shapes may indicate a debris trail or the remnants of the shipwreck itself. Scientists may also use magnetometers to detect changes in the magnetic field caused by iron artifacts associated with the shipwreck or part of the vessel structure.



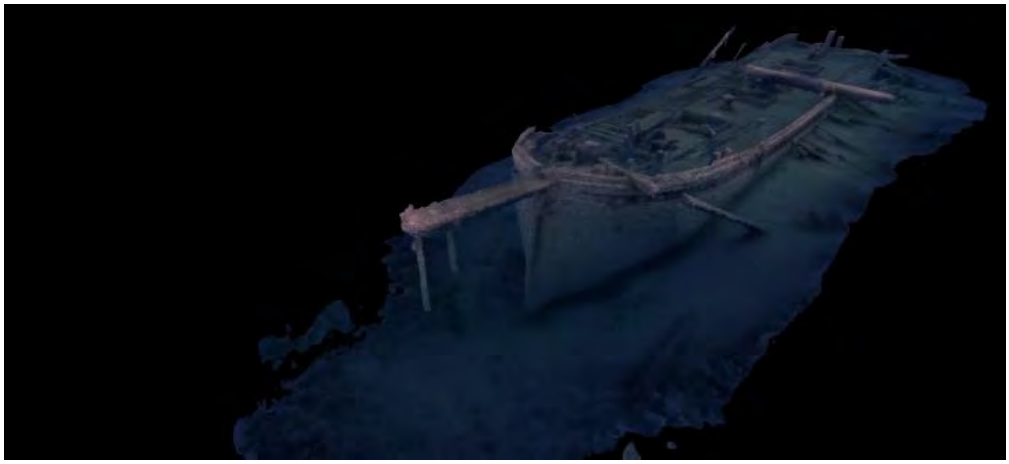
(Left) A representation of multibeam sonar. (Right) A representation of side scan sonar.
Photos: (left) NOAA; (right) Thunder Bay 2001, Institute for Exploration, NOAA-OER

Once wreckage is located, submersibles, such as remotely operated vehicles (ROVs) or pre-programmed robots called autonomous underwater vehicles (AUVs), can collect detailed images of the shipwreck. These images may be used to make a three-dimensional map of the wreck site using a process called

photogrammetry. If you deconstruct the word photogrammetry, you see it contains “photo,” meaning light, “gram,” meaning drawing, and “metry,” meaning measurement. Therefore, photogrammetry is the use of photographs to make measurements and models.

Someone wishing to employ photogrammetry to model a shipwreck takes a series of overlapping images of the wreck site. Photogrammetry software then triangulates all those image points to create an accurate model of the shipwreck, with the distance between the points plotted to scale. Divers may be sent to survey the shipwreck and collect images, or the images may be collected using an ROV or AUV. For more information on these tools, please visit Exploration Tools from NOAA.

Once data has been collected, scientists try to identify the shipwreck by matching their observations to their research on the vessel's dimensions, cargo, and last known location. Sometimes researchers get lucky and the vessel’s name plate or its bell, which both show the vessel name, are located on site. Otherwise, scientists use the process of elimination to identify vessel candidates for the site.



A photogrammetric model of the shipwreck *St. Peter.* Photo: NOAA

Once an identification has been made, archaeologists use the artifacts present on site to draw inferences about the history of the vessel and those who worked on board. Artifacts may offer clues as to how the crew lived and worked. For example, the presence of cannon may suggest that the crew needed to defend their cargo while traveling through dangerous waters; recreational artifacts, such as game pieces or musical instruments, offer insight into how crew members relaxed. Similarly, objects like cooking pots, glass bottles, and ceramic dishes shed light on the foods the crew ate and their preparation while on board.

The conclusions made from these observations vary and are often related to material preservation. Sites that are buried quickly in sediment often have better preservation than those exposed to the elements. Site location also matters. While wood can be easily degraded in tropical saltwater, cold fresh water preserves many organic materials including wooden furniture, cloth sails, and even cargoes of food. Metal artifacts degrade at slower rates than wood; large iron objects such as cannons and steam boilers are often well-preserved. Propellers, hinges, and port holes are also often found as these were made from metals such as brass and bronze. These materials do not corrode easily and are thus more likely to be preserved.

There are many regulations and laws governing how people interact with shipwrecks. Shipwrecks are best studied using non-invasive techniques such as sonar and photogrammetry. In rare cases, further

excavation may be undertaken by trained archaeologists who recover artifacts for further study and preservation.

Vocabulary	
maritime heritage	the study of human interactions with the ocean and coastal lands and waters
photogrammetry	the name for a group of technologies that use images to make measurements and generate models
schooner	a type of wooden sailing vessel with at least two masts and fore-and-aft rigged sails; sails run from bow to stern in line with the keel (the timber that runs bow to stern, forming the backbone of the vessel)
shipping	the transport of goods via waterways
shipwreck	the remains of a vessel that is located sunken to the bottom of a body of water
sonar	stands for **so**und **na**vigation and **r**anging; a technology used to detect underwater objects and to measure water depth via emitting sound pulses and detecting and timing their return after being reflected

Preparation

1. Review all digital and text assets listed in the Instructor Guide. Make sure you are familiar with the technology used to view and manipulate the 360° videos. Be prepared to model this for the students.
2. Review all relevant content background information.
3. Review the learning objectives and activity summary.
4. Gather and prepare all necessary materials for Parts 1 and 2 of the *Elaborate* simulation (materials listed below). It is suggested that you complete the simulation prior to conducting it with students so that you are familiar with the experience and can anticipate potential pitfalls.
    - To make the lake bed models, it is suggested that you use salt dough and a shoe box without a lid. Layer the salt dough on the bottom of the shoe box. Use your fingers to create uneven areas simulating natural topography. Note: it can take up to five days for a salt dough model to dry depending on your climate. A step-by-step procedure for making salt dough is linked here.
    - Use a small collection of plastic building blocks to construct a "shipwreck." It is recommended that your "shipwreck" be approximately a third of the length of the shoebox and half the height. This will give enough variability for students to "locate" the shipwreck during the simulation.
    - Once the salt dough lake bed is dry, affix the "shipwreck" to the lake bed with a few small loops of tape. Place the "shipwreck" roughly in the center of the shoebox. Cover the top of the shoe box with aluminum foil to simulate the surface of the water so the foil lies evenly across the top of the shoe box.
5. Practice the technology used in Part 2 of the *Elaborate* simulation. As you become familiar with the technology in the photogrammetry simulation, please keep in mind that most 3D scanning apps are intuitive, especially for students. In addition, many useful tutorials exist online. It is encouraged that you find an app that is available for both Apple and Android devices. Download

the 3D scanning app onto the devices in advance. This aspect of the simulation can be done as a demonstration at the discretion of the instructor.

Procedure

Engage – Exploring the Wreck of the Schooner St. Peter

1. Give students time to watch and investigate "Explore the Blue: 360° Lake Ontario Schooner *St. Peter*." Encourage them to pause the video and "look around." Have students record observations of the shipwreck. They may do this using bullet-point phrases or pictures. Prompt students to record at least two questions using the prompt "I wonder...".
2. Place students into groups of two to three. Give them time to discuss their observations and questions. Model a productive discussion by encouraging students to restate and/or extend their peers' contributions. Each time a student shares an idea, other group members should facilitate the discussion by either restating the point in their own words or building upon the point with a new, but related, idea.
3. After small group discussions, bring the whole group together and allow students to share their observations and questions. Help students understand that the purpose of a national marine sanctuary is to protect important cultural and natural areas while allowing for responsible public use and enjoyment of them. Share a map of the location of the proposed Lake Ontario National Marine Sanctuary.

Explore – Searching for Shipwrecks

1. In their groups, prompt students to imagine they are maritime archaeologists searching for shipwrecks in the proposed Lake Ontario National Marine Sanctuary and to consider the following questions. Encourage students not to be concerned with whether their answers are correct but with ensuring that their ideas are well-reasoned.
    - How do you think you could determine the search area for a shipwreck?
    - What information do you think would be useful to a maritime archaeologist and why?
    - Once wreckage is found, how do you think a shipwreck is identified?
    - What tools do you think are used to locate shipwrecks?
    - What parts of a vessel might remain to be found by shipwreck explorers?
2. Write the following headings on the whiteboard or on pieces of chart paper: "Determining the Search Area," "Useful Info," "Identifying," "Tools," and "Vessel Remains." Give each group a marker and, based on their group discussion, have them write at least one bullet-point phrase under each heading. Once all groups have shared their ideas, look for the main ideas represented for each topic.

Explain – Tools of Shipwreck Explorers

Part 1 – Exploration Tools Research

1. Students will begin by watching the NOAA video What is Sonar? They will then use the NOAA Exploration Tools website to research tools used by marine archaeologists when searching for and imaging shipwrecks. If students use additional websites for clarification, they must ensure

those sources are credible and cite them. The table below is included to guide and organize student research. Students will likely need to copy the table into another document to provide adequate space for their notes. Emphasize the importance of writing at least two questions. These can be either clarification or extension questions.

Exploration Tools Research	
Tool	Description of Tool & Its Use
Sonar (general)	
Side scan sonar	
Multibeam sonar	
Submersibles	
Photogrammetry	
Magnetometer	
Citations	
Questions for my instructor	

Part 2 – Exploration Tools Discussion

1. Beginning with "Sonar (general)," have students discuss their research with a peer for two minutes per tool. For each tool, students will change partners for a total of six different peers. As they discuss each tool, encourage the students to add what they learned to their notes, with the expectation that they must add at least one new thought per tool to their research.
2. Provide students with an opportunity to ask clarification and/or extension questions of the instructor.

Elaborate – Simulating a Shipwreck Search

Part 1 – Simulating a Shipwreck Search Using Single Beam Sonar

In this aspect of the learning experience, students will simulate how the use of single beam sonar helps marine archaeologists locate shipwrecks. It is recommended that students complete the simulation in a small group. Please refer to guidelines in the Student Guide.

An alternative procedure for simulating the use of sonar to locate a shipwreck can be found in the document "Shipwreck of the Deep: An Educator Guide with Activities in Science, Technology, Engineering and Math."

Materials List per group of 2-3 students
o shoebox, top removed, with salt dough lake bed o a small collection of Legos (or similar) to build “shipwreck” o enough aluminum foil to cover shoebox o 1 cm grid paper printed large enough to cover top of shoebox o 3-4 wooden skewers: optional: mark with 1 cm increments to aid student measurement o ruler with metric markings o pencil with eraser o tape o marker o graph paper or access to spreadsheet program

Part 2 – Simulating Photogrammetry to Model Shipwrecks

In this aspect of the learning experience, students will simulate how photogrammetry can be used to model shipwrecks. It is recommended that students complete the simulation in a small group. Please refer to guidelines in the Student Guide.

Materials List per group of 2-3 students
o smartphone or tablet with 3D scanning app downloaded; most 3D scanning apps require a printed scanning mat NOTE: This part of the learning experience can be done as demonstration as opposed to pairs or a small group depending on internet enabled devices available for students. App download and implementation is dependent on the operating system of available device(s).

Evaluate – Communicating the Science of Shipwreck Exploration

In this aspect of the learning experience, students will create a digital information display for use in a fictional visitor center of the proposed Lake Ontario National Marine Sanctuary. Students should complete this portion of the learning experience individually.

Part 1 – Revisiting the Shipwreck *St. Peter*

Give students time to revisit “Explore the Blue: 360° Lake Ontario Schooner *St. Peter.*” Prompt them to take screenshots of the video for use in their digital displays.

Part 2 – Designing a Digital Information Display

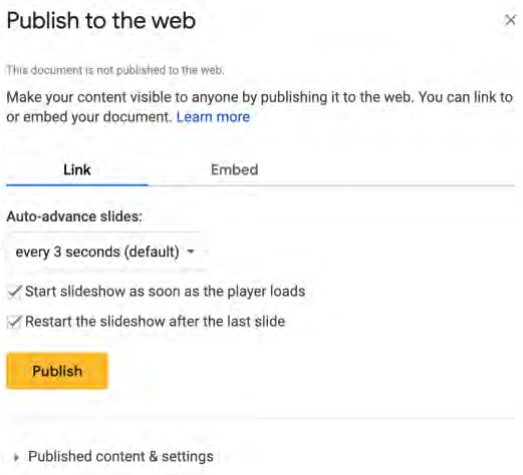
Give students time to design their display which should be a series of at least four slides. Their display should summarize how marine archaeologists locate and image shipwrecks. Each slide should have a title, an image with a caption, and at least two bullet-point phrases communicating important information. Their images should come from the “Explore the Blue: 360° Lake Ontario Schooner *St. Peter.*” It is recommended that students use Google Slides. The checklist below can be used by students to plan and review their work.

Digital Information Display Checklist *Every slide in the display should:*
❑ include a clear title presenting a big idea about the science of shipwreck exploration.
❑ present at least two supporting ideas for each big idea.
❑ provide an image illustrating each big idea; each image must have a caption and proper citation.
❑ use correct grammar, spelling, and punctuation and be visually appealing.

Part 3 – Providing Feedback on Information Displays

The directions below explain how students can use Google slides to display their work for peer feedback:

1. Have students display their work using the directions below:
    - Click "File" → "Publish to the web." The dialogue box below will appear:



    - Make sure to click "Start slideshow as soon as the player loads" and "Restart the slideshow after the last slide."
2. Have students participate in the "gallery walk" where they have the opportunity to view the work of at least two peers. Use the feedback table below as a guide. Students will need to use a different table for each peer for whom they provide feedback.

Digital Information Display Feedback Table	
Something I like	
A suggestion	

Part 4 – Self Reflection

Have students complete the self-reflection on their Student Guide.

<table>
<tr><th colspan="3">Education Standards</th></tr>
<tr><td>Next Generation Science Standards</td><td colspan="2">Performance Expectations:
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-ETS1-4. 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.
Disciplinary Core Ideas:
ETS1.A: Defining and Delimiting Engineering Problems
ETS1.C: Optimizing the Design Solution
Science and Engineering Practices:
Asking Questions and Defining Problems; Analyzing and Interpreting Data; Developing and Using Models
Crosscutting Concepts:
Patterns; Scale Proportion and Quantity; Systems and System Models</td></tr>
<tr><td>Common Core State Standards</td><td>Language Arts:
Integration of Knowledge and Ideas:
CCSS.ELA-Literacy.RST.6-8.7
CCSS.ELA-Literacy.RST.6-8.9
CCSS.ELA-Literacy.RI.6-8.7
Production and Distribution of Writing:
CCSS.ELA-Literacy.WHST.6-8.4
CCSS.ELA-Literacy.WHST.6-8.6</td><td>Comprehension and Collaboration:
CCSS.ELA-Literacy.SL.6-8.1
CCSS.ELA-Literacy.SL.6-8.2
Text Types and Purposes:
CCSS.ELA-Literacy.WHST.6-8.1
CCSS.ELA-Literacy.WHST.6-8.2
CCSS.ELA-Literacy.W.6-8.7
CCSS.ELA-Literacy.W.6-8.8
CCSS.ELA-Literacy.W.6-8.9</td></tr>
<tr><td>Ocean Literacy Principles</td><td colspan="2">Ocean Literacy Principle #6: The ocean and humans are inextricably interconnected.
b. The ocean provides foods, medicines, and mineral and energy resources. It supports jobs and national economies, serves as a highway for transportation of goods and people, and plays a role in national security.
Ocean Literacy Principle #7: The ocean is largely unexplored.
d. New technologies, sensors and tools are expanding our ability to explore the ocean system. Scientists are relying more and more on satellites, drifters, buoys, subsea observatories and unmanned submersibles.
e. Use of mathematical models is an essential part of the ocean systems. Models help us understand the complexity of the ocean and of its interaction with Earth’s interior, atmosphere, climate and land masses.
f. Ocean exploration is truly interdisciplinary. It requires close collaboration among biologists, chemists, climatologists, computer programmers, engineers, geologists, meteorologists, meteorologists, physicists, animators and illustrators. And these interactions foster new ideas and new perspectives for inquiries.</td></tr>
</table>

Additional Resources

For more information about the Great Lakes watershed, the proposed Lake Ontario National Marine Sanctuary, or the historical, economic, and ecological importance of Great Lakes shipwrecks, please see the links below. **The inclusion of links and/or apps in this guide does not imply endorsement or support of any of the linked information, services, products, or providers.*

Proposed Lake Ontario National Marine Sanctuary Storymap
https://storymaps.arcgis.com/stories/9ab4046b9bc94ccaa895a481b8ce4c4b

Shipwreck of the Deep An Educator Guide with Activities in Science, Technology, Engineering and Math
https://nmsmonitor.blob.core.windows.net/monitor-prod/media/archive/education/pdfs/shipwreck_of_deep_draft.pdf

Multibeam Sonar
https://deepoceaneducation.org
https://deepoceaneducation.org/resources/falkors-mapping-program-and-seabed-2030/
https://www.youtube.com/watch?v=-mYdhe4fAGI
https://oceanexplorer.noaa.gov/edu/themes/seafloor-mapping/multimedia.html#cbpi=media/video/multimedia-animation.html

Shipwrecks as Habitats
https://sanctuaries.noaa.gov/earthisblue/wk208-shipwrecks-habitat-feature.html

Marine Heritage
https://sanctuaries.noaa.gov/maritime/

Shipwreck Tour
https://www.youtube.com/watch?v=W3wONHSjAWk

Threats to the Great Lakes Watershed
https://www.regions.noaa.gov/great-lakes/index.php/regional-snapshots/
https://www.epa.gov/greatlakes

For More Information

Shipwreck Explorers! Instructor Evaluation Rubric

Name:

Glows: Things I can do well	Standard	Grows: Things that I need to improve
	Student can explain, by using examples, the information useful to scientists in locating a shipwreck.	
	Student can explain, by using examples, technologies used to discover and image shipwrecks.	
	Student can simulate how sonar and photogrammetry are used to locate and image shipwrecks.	
	Student can design a tool of effective science communication that illustrates the process and technologies involved in shipwreck exploration.	
	Student appropriately contributed to both small and whole group discussions.	
	Engage: Student observations of *St. Peter* met requirements. Student appropriately responded to topics for further investigation prompts.	
	Explore: Student contributed appropriately to crafting, sharing, and discussing Archaeology Team Responses.	
	Explain: Student research on exploration tools was appropriately detailed and accurate.	
	Elaborate: Student effectively followed directions in both simulations.	
	Evaluate: Student digital display contains all required elements. Student can provide constructive feedback on the work of peers.	

Comments:

Shipwreck Explorers! Student Guide

Guiding Expectations

In this learning experience, you will assume the role of a marine archaeologist searching for shipwrecks within the proposed Lake Ontario National Marine Sanctuary. National marine sanctuaries are protected waters that include important habitats and archaeological sites. You will participate in a virtual dive of the wreck of a ship named *St. Peter*, which is a type of ship called a schooner. You will research the tools scientists use to locate and image shipwrecks and demonstrate your knowledge by creating a digital display that could be used in a fictional visitor center of the proposed Lake Ontario National Marine Sanctuary.

A diver on the shipwreck *St. Peter.* Photo: NOAA

Engage – Exploring the Wreck of the Schooner St. Peter

1. As directed by your instructor, watch *Explore the Blue: 360 Lake Ontario Schooner St. Peter.* Explore as you "look around" using the 360° functionality of the video. Record at least five observations of the shipwreck in the table below. Observations do not need to be complete sentences, but should be complete thoughts. They should be understood by another person without additional explanation.

Schooner *St. Peter* Observations	
Observation #1	
Observation #2	
Observation #3	
Observation #4	
Observation #5	

2. After completing your observations, generate at least two topics for further investigation by completing the prompt "I wonder..." Topics can be related to the wreck *St. Peter*, shipwrecks in general, tools used to locate and image shipwrecks, or the environment of Lake Ontario. Record your responses in the space below.

Topics for Further Exploration	
I wonder...	
I wonder...	

3. Discuss your observations and topics for further explanation in a small group. Each time a peer shares an idea, facilitate the discussion by either restating their point in your own words or building upon their point with a new, but related, idea. Record any notes in the space below.

Photomosaic image of the wreck of *Defiance*, a wooden schooner that sank in 1854 in Lake Huron. The wreck is currently protected as part of Thunder Bay National Marine Sanctuary. Photo: NOAA

Explore – Searching for Shipwrecks

1. Imagine you are part of a team of marine archaeologists searching for shipwrecks within the proposed Lake Ontario National Marine Sanctuary. Within your group, respond to the questions below. Each response should include at least two to three ideas. Answers may be written as bullet-point phrases. Record your responses in the table below.

Archaeology Team Responses	
Question	Response (2-3 ideas)
How do you think you could determine the search area for a shipwreck?	
What information do you think would be useful to a shipwreck explorer and why?	
Once wreckage is found, how do you think a shipwreck is identified?	
What tools do you think are used to locate shipwrecks?	
What parts of a ship might remain to be found by shipwreck explorers?	

2. Within your group, choose at least one idea from each question to share with the whole group. As directed by your instructor, write your idea in the designated location. Use the space below for notes.

3. Review all of the ideas shared by all groups. Work together as a whole group to determine the main ideas for each topic. In the space below, identify the main idea for each topic.

Explain – Tools of Shipwreck Explorers

Photo: David J. Ruck/NOAA

The ROV pictured on the left recently helped identify the wreck of the USS *Conestoga*, which sank in 1921 and is now protected as part of Greater Farallones National Marine Sanctuary off the coast of California. The diving conditions at this site included limited visibility, strong currents, and a high population density of white sharks, making ROV exploration of the shipwreck a better choice than putting divers in the water.

Part 1 – Exploration Tools Research

1. Watch the video What is Sonar?. Record a description of sonar and its use in the first row of the research table below.
2. Use the website Exploration Tools to learn about the other tools listed in the table below. Write information in your own words; do not copy/paste from the source.

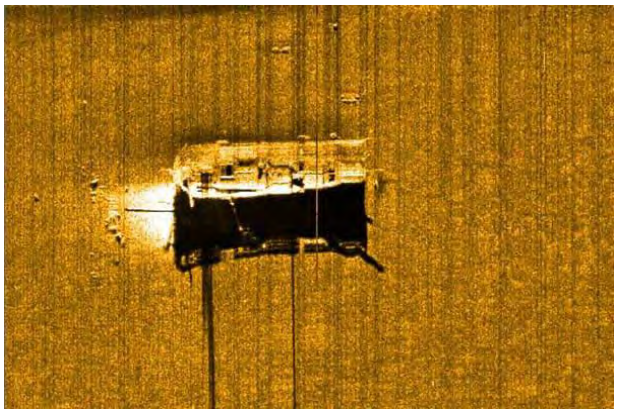
Exploration Tools Research	
Tool	Description of Tool & Its Use
Sonar (general)	
Side scan sonar	
Multibeam sonar	
Submersibles	
Photogrammetry	
Magnetometer	
Citations	
Questions for my instructor	

Exploration Tools Research Citations of Extra Sources

Part 2 – Exploration Tools Discussion

1. As directed by your instructor, discuss your research on each tool with a partner. After discussing each tool, add at least one new piece of information, idea, or thought to your table. Use the space below for any additional notes.

2. Once your partner discussions are complete, ask your instructor any remaining questions you might have. Use the space below to record additional notes.



Side scan sonar image of the shipwreck *Defiance*, a two-masted schooner sunk in 1854 in Lake Huron after colliding with another schooner. Photo: NOAA

Elaborate – Simulating a Shipwreck Search

Part 1 - Simulating a Shipwreck Search Using Single Beam Sonar

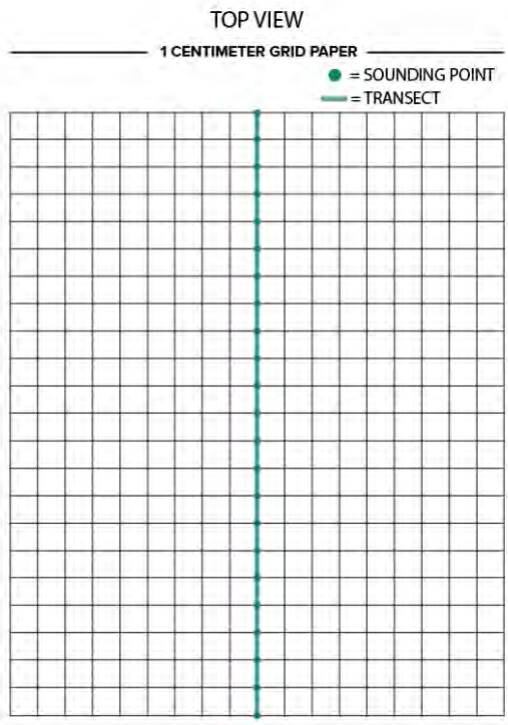
In this activity, you will model the use of single beam sonar to identify a potential wreck area to be investigated further using more advanced sonar technology. Many shipwreck search areas were initially located by amateur explorers using widely accessible single beam sonar.

Materials List

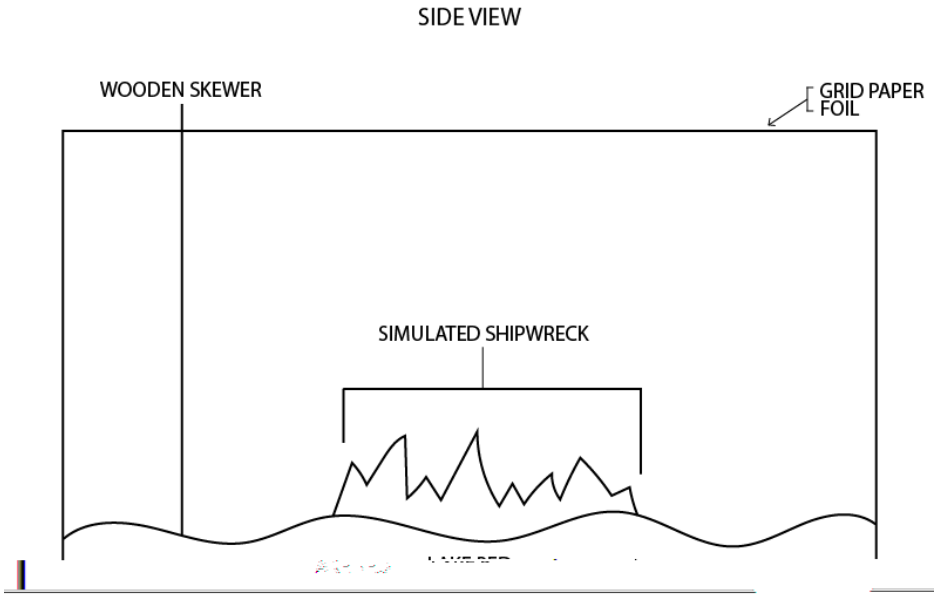
- 3D lake bed model with simulated shipwreck, covered in aluminum foil
- 1 cm grid paper
- Wooden skewers
- Ruler with metric markings
- Pencil with eraser
- Tape
- Marker
- Graph paper or access to spreadsheet program

Simulation Directions

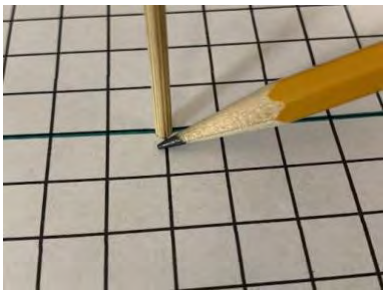
1. In your small group, gather all the materials listed above.
2. The aluminum foil represents the water's surface. Do not remove the foil until directed. Use the image on the next page to guide you through steps 3–5.
3. Place the grid paper on top of the foil. Mark the approximate center of the model on the grid paper. You'll want to mark the center from the length of the model as opposed to the width. Remove the graph paper, leaving the foil in place.
4. Using a ruler, mark a straight line across the grid paper to represent a transect line. The line should extend from one edge of the grid paper to the opposite edge, running parallel to the long edge of the model, and be roughly in the center.
5. Tape the grid paper on top of the foil with the transect line centered over the model.



6. Use a wooden skewer to simulate a sonar depth sounding. Begin at 0 cm (set 0 cm as one end of the transect line) and then simulate a sounding at each 1 cm mark along the transect line. To take a sounding, insert the skewer vertically through both the grid paper and the foil. Use the image below to guide you.

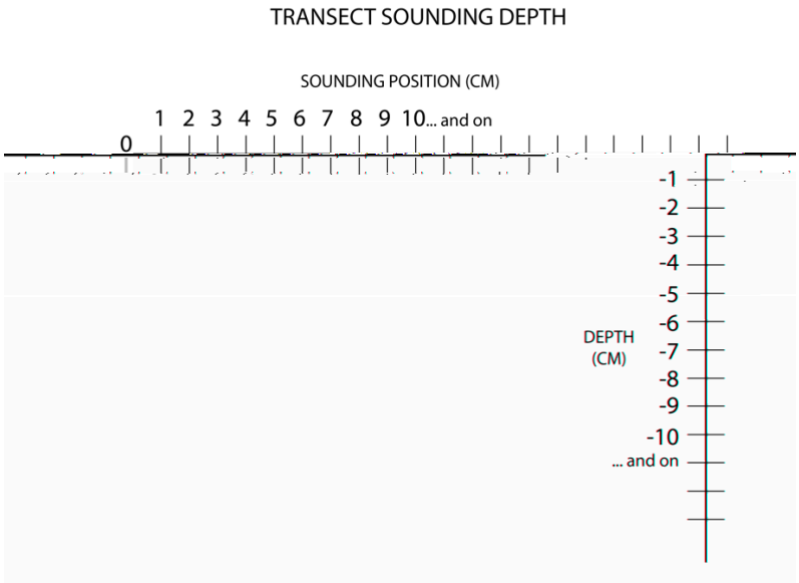


7. For each sounding point on the transect, measure the distance in centimeters that the skewer is inserted. This is equivalent to the depth. To do this, mark the location where the skewer meets water (paper) with pencil. Carefully pull out the skewer and measure to your pencil mark. Record each depth at the proper location on the grid.



Note that depth measurements (below the paper, or water line) are negative because they represent elevations below sea level. Erase the pencil mark on the skewer before proceeding to the next sounding.

8. Use the data on your grid paper to graph the depth measurements along the transect line. If making the graph by hand:
    a. Record the position of each sounding on the x axis.
    b. Record the depth from the water line on the y axis.
    c. A sample graph setup is below:



If using Google sheets or Excel:
    a. Record the sounding position in the first column.
    b. Record the depth from the water line on the y axis.
    c. To make the graph, go to Insert → Chart.
    d. Then, in the Chart Editor, select a Line Chart.

9. Use your graph to identify the area of the transect that most likely represents the location of the wreckage. Circle the area on your grid paper.

Part 2 - Simulating Photogrammetry to Model Shipwrecks

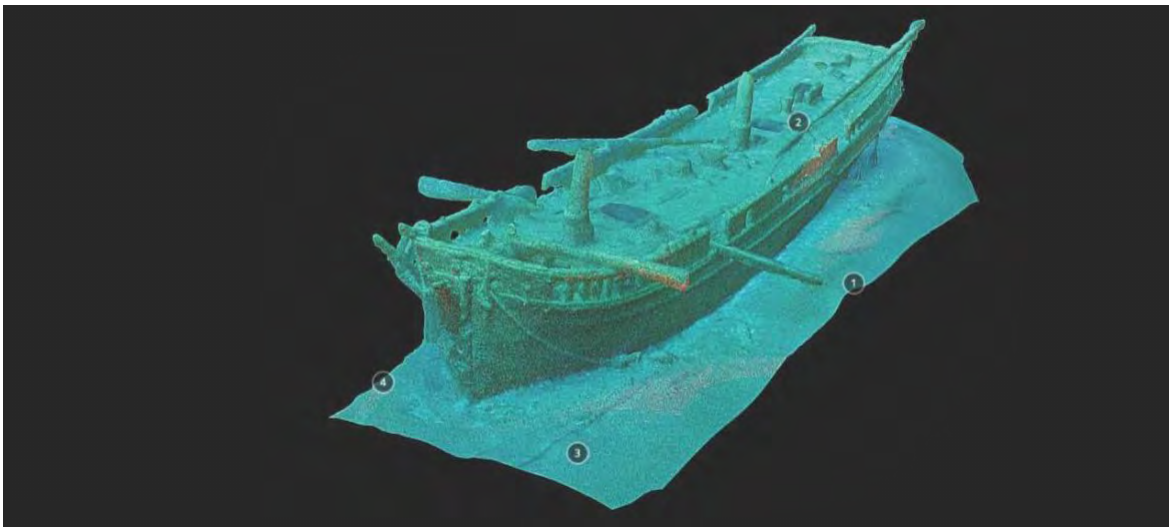
Imagine that you are part of a team of divers on an expedition to use photogrammetry to make a 3D model of the shipwreck you have discovered. In photogrammetry, the diver takes a series of overlapping photographs of the shipwreck. Photogrammetry software then triangulates all those image points to create an accurate model of the shipwreck, with the distance between the points plotted to scale. 3D scanning apps use a similar method to create models.

Materials List

- Simulated shipwreck
- Device with 3D scanning app downloaded
- Printed scanning mat

Simulation Directions

1. Remove the grid paper and aluminum foil from your lake model. Carefully, remove the "shipwreck" from the model.
2. Place the "shipwreck" in the center of the printed scanning mat.
3. As directed by your instructor, follow the app directions to produce a 3D model of the "shipwreck." Record your notes in the space below.



A photogrammetric image of the shipwreck *Defiance*. Photo: Kyle Spangler/NOAA

Evaluate – Communicating the Science of Shipwreck Exploration

Imagine that you have been asked to create a digital information display that will be used to teach visitors to the proposed Lake Ontario National Marine Sanctuary about shipwreck exploration. Follow the steps below to complete this task.

Part 1 – Revisiting the Shipwreck *St. Peter*

1. Revisit the "Explore the Blue: 360° Lake Ontario Schooner *St. Peter*." Take screenshots of the video to use in your digital display. Be prepared to provide specific reasoning for the images you have chosen. This reasoning should be reflected in the image captions.

Part 2 – Designing a Digital Information Display

1. Create your digital display. Your display should be a series of at least four slides that summarizes how marine archaeologists locate and image shipwrecks. Each slide should have a title, an image with a caption, and at least two bullet-point phrases communicating important information. The checklist below can be used to plan and review your work.

Digital Information Display Checklist *Every slide in the display should:*
❑ Include a clear title presenting a big idea about the science of shipwreck exploration.
❑ Present at least two supporting ideas for each big idea.
❑ Provide an image illustrating each big idea; each image must have a caption.
❑ Use correct grammar, spelling, and punctuation and be visually appealing.

Part 3 – Providing Feedback on Information Displays

1. Display your work as directed by your instructor.
2. View and provide feedback on the work of at least two peers as directed by your instructor. Use the included feedback tables.

Digital Information Display Feedback Table – Peer #1	
Something I like	
A suggestion	

Digital Information Display Feedback Table – Peer #2	
Something I like	
A suggestion	

Part 4 – Self Reflection

1. Complete the following Self-Reflection.

Shipwreck Explorers! Self-Reflection

Glows: Things I can do well	Standard	Grows: Things that I need to improve
	I can explain, by using examples, the information useful to scientists in locating a shipwreck.	
	I can explain, by using examples, technologies used to discover and image shipwrecks.	
	I can simulate how sonar and photogrammetry are used to locate and image shipwrecks.	
	I can design a tool of effective science communication that illustrates the process and technologies involved in shipwreck exploration.	
	I appropriately contributed to both small and whole group discussions.	
	Engage: My observations of *St. Peter* met requirements. I appropriately responded to the topics for further investigation prompts.	
	Explore: I contributed appropriately to crafting, sharing, and discussing Archaeology Team Responses.	
	Explain: My research on exploration tools was appropriately detailed and accurate.	
	Elaborate: I effectively followed directions in both simulations.	
	Evaluate: My digital display contains all required elements. I provided constructive feedback on the work of my peers.	

Respond to the following prompts in 1-2 sentences.

My favorite part of the Shipwreck Explorers! was…

The most important thing I learned is…

Something I'd like to know more about is…