STITCHING TOGETHER A SEAFLOOR | EDUCATOR

Next Generations Science Standards |

K-2-ETS1-2: Develop a simple sketch, drawing or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.

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.

Common Core Standards |

CCSS.ELA-LITERACY.WST.4: Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience.

S T E M

Pacing | 1-2 class periods

Background Needed | Technological tools and programs; problem-solving skills

Assessment | Extended Response Rubric provided

Materials/Resources |

- Photomosaic Set One - USS Macon wreck site (http://nautl.us/2es9bZW) (Image Credits: NOAA ONMS/URI Roman Lab/OET)
    - Printing tip: For each set of mosaic pieces you can put a dot or marker at the top of each image so students know which way is facing up.
    - Answer Key (http://nautl.us/2dRUxJp)
- Photomosaic Set Two - Point Dume seep site (http://nautl.us/2dL5eNw)
    - Answer Key (http://nautl.us/2dMhErR)
- Laptops or tablets with internet access (optional)

Overview

This module will introduce students to the basic techniques used to create deep sea photomosaics and the applications for this tool. Students will work in small groups to complete two paper photomosaics of real seafloor scenes by recognizing and comparing unique features among image squares. At the end of the activity, students will respond to conclusion questions demonstrating their understanding of the concepts involved with this lesson and be able to relate these concepts to real world ocean exploration.

Objectives & Learning Outcomes

- Students will understand and explain the importance of creating mosaics to observe seafloor structures.
- Students will be able to critically assess digital images, identifying unique features among images and creating a larger mosaic.
- Students will understand the general process of how photomosaics inform research and maritime history.

Guiding Questions

- If you wanted to image the bottom of a lake or ocean near your town that is deeper than divers can reach, what equipment would you need?
    - ✓ **Possible answers:** A boat or platform to get near the site, maps of the bottom to know what type of seafloor you'll encounter, camera, waterproof housing, lights to illuminate the seafloor with batteries or a water-safe power system, a mapping system to know where the pictures came from, cameras on poles, printers to take maps for viewing later. Special experts to identify items you see on the seafloor.

Links to Common Core Standards |

CCSS.ELA-LITERACY.SLS.1: Participate in collaborative conversations with diverse partners about topics and texts with peers and adults in small and larger groups.

CCSS.ELA-LITERACY.LST.1: Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.

Set The Stage!

To help students understand why photomosaics are important put a large map, poster, or drawing on display when students enter the room. Have students survey the scene through a spyglass (rolled paper or toilet paper roll) while closing the other eye. Ask students what happens to their field of view? Equate this to the underwater field of view- ROVs can only see a tiny portion of the whole scene at one time. Prompt students to think about the importance of adequate lighting by asking what would change in their procedure if the lights were out in the room.

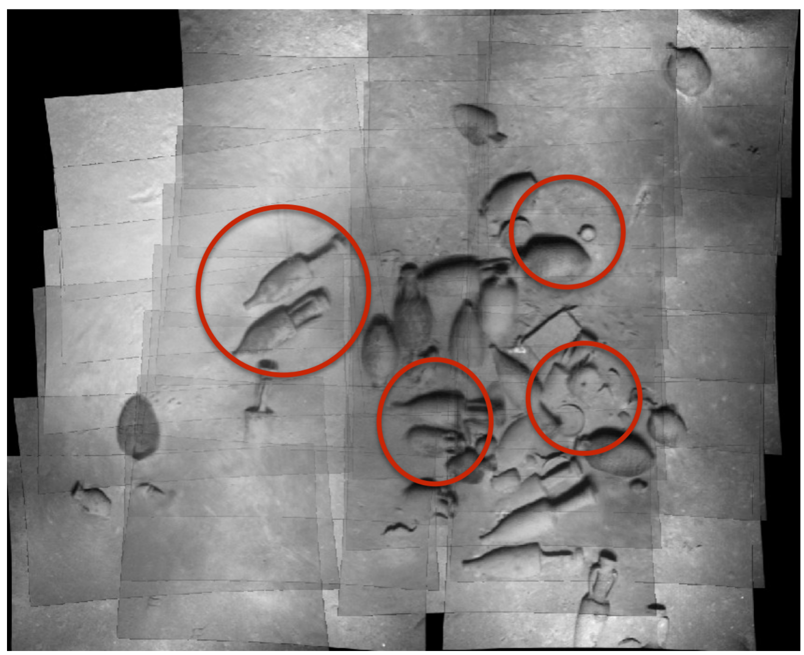
Guiding Questions Continued

- What factors make it difficult to capture images underwater, especially in the deep ocean?
  - ✓ **Possible answers:** Light is the most limiting factor for taking underwater images and creating deep sea mosaics. Light is quickly absorbed in water and there is no sunlight penetration in the deep ocean. Artificial lights must be used in underwater imaging, however an abundance of light can cause backscatter as light bounces back into the camera reflected by particles in the water column. Cameras also must be placed in stabilized, pressure compensated, waterproof housings.

- Practice identifying anchor points in an image

When stitching together a photomosaic, it is helpful to focus on unique features that really stand out in an image. Unique patterns and shapes make good anchor points. Finding these recognizable features in multiple photographs provides an anchor point to provide orientation for how photos map together.

Practice with a partner to identify some unique features in the boxes of the photomosaic at right.



- ✓ **Teacher's Tip:** It may be helpful to have a conversation about what makes for good identifying features. Areas with recognizable shapes or patterns are good identifiers. Images with distinct shadows are weak identifiers as the shadows will move and shift as the camera and lights move across the scene. Students should be able to hone in on these features as exampled above.

Extensions & Adaptations

Introductory |
For younger students, have them only complete one mosaic. The mosaic pieces can also be printed larger. For a whole class activity, line the students up and give them one mosaic piece each, hand them out in order by associated number (can write on back of pieces) and have each student take individual turns placing his or her piece on a large floor area to create the mosaic.

Extension |
Ask students to design a photomosaic survey of an outdoor feature like a playground, local building or their own bedroom. Plan the imaging survey with consideration for imaging frequency, lighting, data recording and image management. Cellphones make great low cost imaging platforms.

Activity/Tasks

Students will:

- complete guiding questions,
- assemble Mosaic One and Two,
- reflect on their learning by completing conclusion questions,
- return all mosaic pieces back to teacher.

Educator: Lesson Procedure/Directions

✓ **LESSON SET-UP |** It is suggested that students work in pairs to complete this module. It may be helpful to laminate the mosaic pieces so they can easily be re-used.

☐ Helpful tips:

- ✓ Each square can be labeled with a dot or some other marker so students know which direction is “up”.
- ✓ During the production of actual photomosaics, the time that each photo was taken is known which can help scientists and computer programs piece the mosaic together. To simulate this and make it easier for younger students, the back of the mosaic pieces can be numbered so students know the correct order to place them in. They will just have to figure out which sides match up on each of the pieces.

Additional Resources

- *Nova Nazi Attack on America* (Nautilus Exploration Program’s mapping technology provided the clues to resolve unanswered questions about a World War II U-boat; mapping technology feature begins at ~39 min. mark): https://www.youtube.com/watch?v=hn_WkSvU4lU

- “Automated generation of mosaics from video”: http://scholars.unh.edu/cgi/viewcontent.cgi?article=1579&context=ccom

- “Applications of Geo-Referenced Underwater Photo Mosaics in Marine Biology and Archaeology” https://darchive.mblwhoilibrary.org/bitstream/handle/1912/2783/20.4_ludvigsen_et_al.pdf?sequence=1

Conclusion Questions |

1. Which mosaic (One or Two) was more difficult or time-consuming to put together? What were some reasons you think this was?

   Look to student justification for their answers

2. Why is it important for the ROVs to travel across a scene taking images rather than stand in one place taking pictures like a panorama?

   If the ROV stayed in one place you would have different angles of imaging on items that are close to the camera versus far away. By flying above the scene all of the scene is imaged from the same perspective- straight down. Cameras that look at a scene from the side or from a stationary position also have the risk of casting long shadows across important parts of the scene. Moving the camera and lights together reduces the challenges of shadows over objects.

3. What are some of the variables you want to pay attention to when making a mosaic?

   Light, Camera focus, Distance from subject (what if the subject is high elevation versus low elevation?), Scale (how do you know how large the total mosaic is?) Obstruction from pollution, plankton, murky water or moving objects in the field (what if a school of fish swim through while you're imaging?)

4. What are some benefits for scientists to have underwater mosaics of their study sites? *Hint: Read the "Nautilus Newflash"!*

   Ability to detect scale and orientation of multiple features (i.e. multiple Cuvier's beaked whale feeding scars). Provides the big picture perspective to see if study plans are workable on this site. Provides scale and elevation. Individual images could provide detailed information (genus, species or biological populations). Ability to detect change over time by imaging an entire scene multiple times (Gulf of Mexico shipwrecks were mapped before, during and after the archaeological excavation). Mosaics make underwater sights easier to understand for outreach and education purposes.

5. What could be some other uses for photomosaics in non-ocean environments?

   Photomosaics are commonly used in making lands maps from helicopters or survey planes. Mosaicing is also used with images from satellites to construct extremely large objects from outer space.

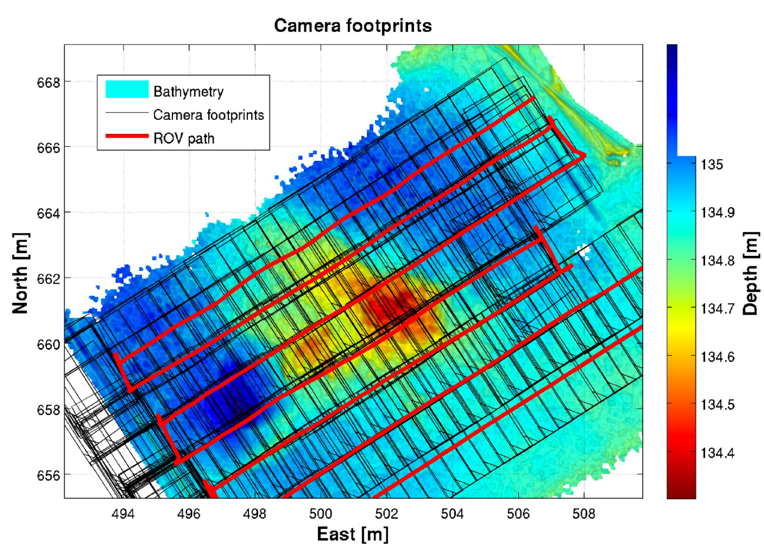
STITCHING TOGETHER A SEAFLOOR | STUDENT

Learning Goals

- Understand and explain the importance of creating mosaics to observe seafloor structures.
- Identify unique features of digital images to help create a larger mosaic.
- Understand the general process of how mosaics inform research and maritime history.

Introduction | On your deep sea exploration mission, you have identified a very shipwreck-shaped target on the seafloor. As the ROVs approach with bright lights shining you see one part of this massive feature. Up close you can see one piece of the ship very well, but can't see where this view fits in the larger picture. If you fly the ROV up or back for a larger view, you can not see the details of the wreck as light is absorbed quickly by water and particles cloud the view. To get a complete image of the shipwreck, you'll need to take many different views of small sections of the ship and combine them together into a larger mosaic.

When creating a seafloor photomosaic, mappers on E/V *Nautilus* use complex navigation software and high definition cameras to capture hundreds of thousands of images of interesting features. As the mosaic camera looks down from the bottom of the ROV, pilots fly *Hercules* in an ordered pattern, mowing the lawn, overlapping each pass to make sure all parts of covered. Like a puzzle, each photo must be combined with its neighbors to form a larger image. This is called stitching together a mosaic. Images are arranged by looking for similar identifying features in the perimeter of multiple photos. In a photomosaic, each image will slightly overlap the adjacent one. In this module, you will use this same technique to create two photomosaics of seafloor scenes mapped during Nautilus Exploration Program expeditions.



Underneath ROV Hercules' navigated "mowing the lawn" pathway, you can see the many overlapping camera images needed to mosaic map a seafloor feature.

Image credit: Dr. Christopher Roman, University of Rhode Island

STITCHING TOGETHER A SEAFLOOR | STUDENT

Helpful Resources:

- How Far Does Light Travel in Water? http://oceanservice.noaa.gov/facts/light_travel.html
- "WHOI Team Uses Advanced Imaging Data to Bring a New View of Titanic to the World" http://www.whoi.edu/page.do?pid=119036&tid=3622&cid=133629&c=2
- "Imaging the Deep Sea: Student Blog from AGU" http://blogs.agu.org/geospace/2016/05/04/imaging-deep-sea/

Guiding Questions |

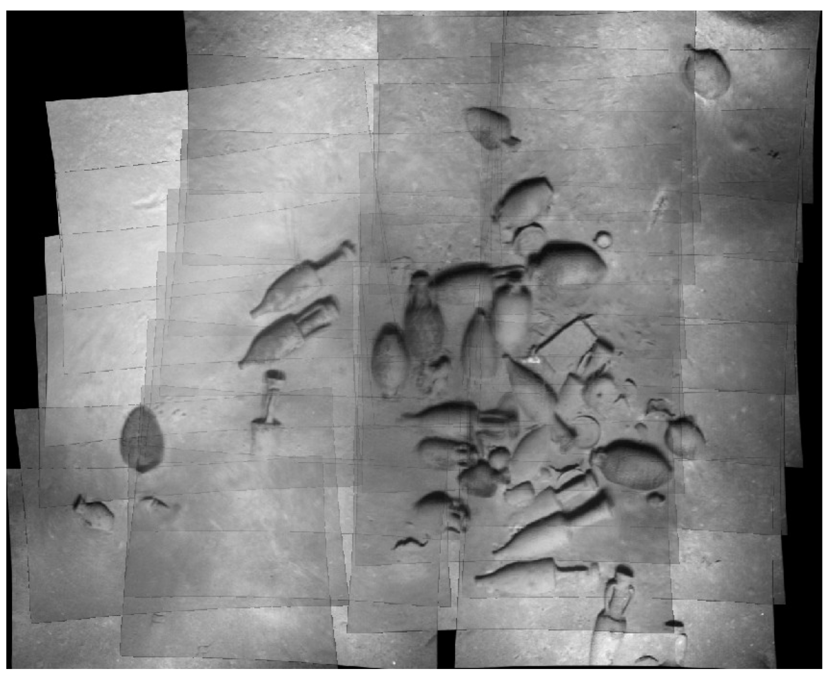
1. If you wanted to image the bottom of a lake or ocean near your town that is deeper than divers can reach, what equipment would you need?

2. What factors make it difficult to capture images underwater, especially in the deep ocean?

<u>Practice identifying anchor points in an image</u>

When stitching together a photomosaic, it is helpful to focus on unique features that really stand out in an image. Unique patterns and shapes make good anchor points. Finding these recognizable features in multiple photographs provides an anchor point to provide orientation for how photos map together.

Practice with a partner to identify some unique features in the boxes of the photomosaic shown at right. Circle these features on the photo.



NAUTILUS NEWSFLASH

Photomosaic mapping is a special capability of the Corps of Exploration to get better perspective on biological, geological and archaeological structures at our deep sea exploration sites.

‣ In 2012, the team imaged gouge marks in the sediments on Eratosthenes Seamount. These marks are thought to be evidence of a Cuvier's beaked whale feeding on seafloor creatures. Their discovery informed scientists about local feeding behavior. 2012 Oceanography Supplement (nautl.us/1OQQHPi)

‣In 2015, the team imaged a brine pool from the Gulf of Mexico showing the many different extremophile bacteria living in harsh saline conditions around the perimeter. (nautl.us/1WHkhtD) GoM2015-Oceanography

‣The Tempus Fugit vent on the Galapagos Rift is home to huge tube worm colonies fed by Earth's inner minerals. See them here (nautl.us/1Tkx2JD)

Procedure |

1. Each group will be given two sets of image pieces to construct two seafloor mosaics. Choose one set to start. Mosaic your images together using the method of identifying unique features in overlapping border zones as practiced above.

   Mosaic One is a segment of the USS *Macon* wreck site. This dirigible aircraft carrier crashed in the Pacific Ocean during a storm in 1935 while carrying four biplanes. Read more about the survey and mapping of this site. (http://nautl.us/256N4c7)

   Mosaic Two is a deep sea methane seep community off of Point Dume, California. Here natural gas and minerals seep through thick sediments feeding a large ecosystem of bacteria mats, clams, and vent chimneys. Learn more about this unique underwater America discovery here. (http://nautl.us/1OEyX4n)

2. Take a picture of your stitched together seafloor.
3. Arrange the second mosaic using the same strategy. And take a picture of your second stitched seafloor.
4. Pick up and return all mosaic pieces, then answer the conclusion questions below.

This photomosaic of Knidos F shipwreck was stitched from over 800 images. Detailed views of the ship's cargo of clay amphora allowed archaeologists to age the wreck off the coast of Turkey to the late Byzantine era approximating it at around 700 years old.

SCIENTIST SPOTLIGHT

Regina Yopak, Navigator, Ocean Engineer

"Using the underwater imaging system to properly map the seafloor is challenging since so many systems need to work together all at once: ROV pilots need to understand the survey goals, navigation (large-scale of the ship and fine-scale of the vehicle) need to be in sync, the cameras need specific sampling settings and the strobe lights must fire at the correct time for every image.

I find it really rewarding to orchestrate all the variables into the optimal settings so my mapping technology can help a scientist answer one of their hypotheses definitively."

Regina has a Bachelors degree in Physics & Environmental Science from Simmons College and a Masters of Science in Ocean Engineering from the University of Rhode Island.

Conclusion Questions |

1. Which mosaic (One or Two) was more difficult or time-consuming to put together? What were some reasons you think this was?

2. Why is it important for the ROVs to travel across a scene taking images rather than stand in one place taking pictures like a panorama?

3. What are some of the variables you want to pay attention to when making a mosaic?

4. What are some benefits for scientists to have underwater mosaics of their study sites? *Hint: Read the "Nautilus Newflash"!*

5. What could be some other uses for photomosaics in non-ocean environments?

Extended Response Rubric

OBJECTIVE	CRITERIA			
	4 Exemplary	3 Commended	2 Emerging	1 Developing
Content and Vocabulary |	Explanation uses appropriate vocabulary. Student is able to provide clear examples of the content or justify their response. Student is able to discuss application of the content. Response contains no content errors.	Explanation uses appropriate vocabulary. Student is able to provide some examples of the content or justify their response and is able to discuss application of the content. Response may contain minor errors that do not detract from overall understanding of the topic.	Student attempts to use appropriate vocabulary. Student attempts to provide some examples of the content or justify their response. Application of the content may be weak. Response may contain some errors.	Use of appropriate vocabulary is weak. Student does not attempt to provide examples of the content or justify their response. Application of the content is weak or nonexistent.
Language and Conventions |	Student produces clear and coherent writing in which the development, organization and style are appropriate to task, purpose and audience. Demonstrates an exemplary command of standard English conventions.	Student produces writing in which the development, organization and style are appropriate to task, purpose and audience. Demonstrates a command of standard English conventions; errors do not interfere with understanding.	Student produces writing in which some development, organization and style are appropriate to task, purpose and audience. Demonstrates a limited and/or inconsistent command of standard English conventions; errors may interfere with understanding.	Student produces writing in which there is limited development, organization and style appropriate to task, purpose and audience. Demonstrates a weak and/or inconsistent command of standard English conventions; errors interfere with understanding.
Total Score: ____________	**Comments:**			

How Large is Nautilus Nation?

Tracking the reach of Ocean Exploration Trust's education programs is essential in ensuring we are funded to continue making discoveries and inspiring the next generation of explorers.

Name: **My Community (City, State):**

Email Address:

School's Name:

Instruction date: **Grade level instructed:**

Subject area:

My education space is a...
❏ Classroom ❏ After school program / Club meeting ❏ Fair / Festival / Event ❏ Museum / Science Center ❏ Other. Tell us more:

Who did you engage in your teaching?
Students
Community Members

Select all the OET materials you used in your instruction:

- ❏ STEM Learning Modules. Which ones? ____________________
- ❏ Digital Resource Library materials. Which ones? ____________________
- ❏ Nautilus Live website: photo albums ☐ highlight videos ☐ live stream
- ❏ Meet the Team STEM mentor profiles
- ❏ Facebook (NautilusLive) ☐ Twitter (@EVNautilus) ☐ Instagram (@nautiluslive)
- ❏ Other. Tell us more: ____________________

____

What made working with OET resources valuable to your instruction (select all that apply)?

- ❏ Hands-on activities
- ☐ STEM career connections
- ❏ Easy to use lessons
- ☐ Standards-based lessons
- ❏ Website resource access
- ☐ Real world application of curricula topics
- ❏ Excitement of cutting-edge discoveries / Unfamiliarity of deep ocean
- ❏ Another reason. Tell us more: ____________________

____

Using OET resources increased my confidence in teaching my science, technology, engineering, or math subjects.	☐ Yes	☐ No
OET provided me with helpful and relevant teaching resources.	☐ Yes	☐ No
Using OET resources increased my awareness of STEM careers.	☐ Yes	☐ No
If yes, how so? How can we improve?		

Please scan this document or snap a picture of it with your phone. Email the feedback or questions to education@oet.org. You can also submit feedback online: http://nautl.us/2cp3PNu

Thank You For All You Do!