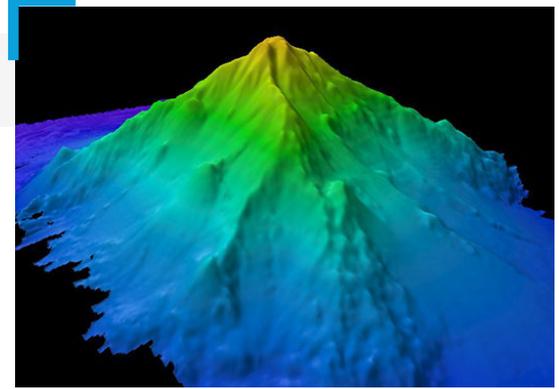




Investigation: Formation of Seamounts and Island Chains

Overview

TOPIC:	Seamounts and Island Chains
FOCUS:	Students analyze data and images to make sense of the processes that form seamounts and island chains.
GRADE LEVEL:	6th-8th Earth Science
TIME NEEDED:	Two 45-50 minute class periods (plus additional time for optional extension)



Kahalewai seamount mapped during the Mountains in the Deep: Exploring the Central Pacific Basin expedition. *Image courtesy of NOAA Ocean Exploration.*

PHENOMENON (DRIVING QUESTION) How do seamounts and island chains form in the middle of the ocean?

- OBJECTIVES/ LEARNING OUTCOMES:** Students will:
- Develop and use a model to explain how the distribution of seamounts and island chains provides evidence of past and current tectonic processes.
 - Analyze and interpret data to assess patterns in the formation of seamounts and island chains.

Performance Expectation (PEs)
MS-ESS2-3 (PE)

Disciplinary Core Ideas (DCIs)
MS-ESS1.C: The History of Planet Earth
MS-ESS2.B: Plate Tectonics and Large Scale System Interactions

Crosscutting Concepts (CCs)
Patterns
Systems and System Models

Science & Engineering Practices (SEPs)
Analyzing and Interpreting Data
Developing and Using Models
Obtaining, Evaluating, and Communicating Information

COMMON CORE CONNECTIONS
ELA-LITERACY.RST.6-8.4; 8.7; 8.9

OCEAN LITERACY ESSENTIAL PRINCIPLES AND FUNDAMENTAL CONCEPTS
Principle 1: FC b



Overview cont.

MATERIALS

Student Handouts

One per group, print or share digital copies

- [Hawaiian Map and Data Table](#)
- [Alaskan Map and Data Table](#)

One per student, print or share digital copies

- [Shaving Cream Seamount Graphic Organizer](#)
- [Seamount/Island Chain Model Template](#)

Seamount Investigation Demo (teacher demonstration or small group activity)

Materials for one set-up:

- Foamy regular shaving cream
- Large grease splatter screen/guard

EQUIPMENT:

- Computer and projector for class viewing of videos and slides or online sharing capability
- White board and dry erase marker or online platform to record class findings
- Student notebooks for students to record their observations, questions, and explanations
- *Optional: Student laptops or tablets for extensions and/or additional research*

SET-UP INSTRUCTIONS: For online learning:

- Share links or digital copies of all materials listed above with students using a preferred online platform.

For in-person instruction:

- Cue up all videos and slides for student viewing.
- *If projecting these for the class is not an option, print or share digital copies with students.*

Hawaiian Map and Data Table

Hawaiian Volcanic Island/Seamount Map

Seamount Name	Approximate Age (Ma)	Approximate Distance from Hawaii (km)	Approximate Depth (m)
Hawaii	0.0	0	4000
Kauai	0.5	150	3500
Niihau	1.0	300	3000
Molokai	1.5	450	2500
Oahu	2.0	600	2000
Molokai	2.5	750	1500
Molokai	3.0	900	1000
Molokai	3.5	1050	500
Molokai	4.0	1200	0
Molokai	4.5	1350	500
Molokai	5.0	1500	1000
Molokai	5.5	1650	1500
Molokai	6.0	1800	2000
Molokai	6.5	1950	2500
Molokai	7.0	2100	3000
Molokai	7.5	2250	3500
Molokai	8.0	2400	4000
Molokai	8.5	2550	4500
Molokai	9.0	2700	5000
Molokai	9.5	2850	5500
Molokai	10.0	3000	6000
Molokai	10.5	3150	6500
Molokai	11.0	3300	7000
Molokai	11.5	3450	7500
Molokai	12.0	3600	8000
Molokai	12.5	3750	8500
Molokai	13.0	3900	9000
Molokai	13.5	4050	9500
Molokai	14.0	4200	10000
Molokai	14.5	4350	10500
Molokai	15.0	4500	11000
Molokai	15.5	4650	11500
Molokai	16.0	4800	12000
Molokai	16.5	4950	12500
Molokai	17.0	5100	13000
Molokai	17.5	5250	13500
Molokai	18.0	5400	14000
Molokai	18.5	5550	14500
Molokai	19.0	5700	15000
Molokai	19.5	5850	15500
Molokai	20.0	6000	16000
Molokai	20.5	6150	16500
Molokai	21.0	6300	17000
Molokai	21.5	6450	17500
Molokai	22.0	6600	18000
Molokai	22.5	6750	18500
Molokai	23.0	6900	19000
Molokai	23.5	7050	19500
Molokai	24.0	7200	20000
Molokai	24.5	7350	20500
Molokai	25.0	7500	21000
Molokai	25.5	7650	21500
Molokai	26.0	7800	22000
Molokai	26.5	7950	22500
Molokai	27.0	8100	23000
Molokai	27.5	8250	23500
Molokai	28.0	8400	24000
Molokai	28.5	8550	24500
Molokai	29.0	8700	25000
Molokai	29.5	8850	25500
Molokai	30.0	9000	26000
Molokai	30.5	9150	26500
Molokai	31.0	9300	27000
Molokai	31.5	9450	27500
Molokai	32.0	9600	28000
Molokai	32.5	9750	28500
Molokai	33.0	9900	29000
Molokai	33.5	10050	29500
Molokai	34.0	10200	30000
Molokai	34.5	10350	30500
Molokai	35.0	10500	31000
Molokai	35.5	10650	31500
Molokai	36.0	10800	32000
Molokai	36.5	10950	32500
Molokai	37.0	11100	33000
Molokai	37.5	11250	33500
Molokai	38.0	11400	34000
Molokai	38.5	11550	34500
Molokai	39.0	11700	35000
Molokai	39.5	11850	35500
Molokai	40.0	12000	36000
Molokai	40.5	12150	36500
Molokai	41.0	12300	37000
Molokai	41.5	12450	37500
Molokai	42.0	12600	38000
Molokai	42.5	12750	38500
Molokai	43.0	12900	39000
Molokai	43.5	13050	39500
Molokai	44.0	13200	40000
Molokai	44.5	13350	40500
Molokai	45.0	13500	41000
Molokai	45.5	13650	41500
Molokai	46.0	13800	42000
Molokai	46.5	13950	42500
Molokai	47.0	14100	43000
Molokai	47.5	14250	43500
Molokai	48.0	14400	44000
Molokai	48.5	14550	44500
Molokai	49.0	14700	45000
Molokai	49.5	14850	45500
Molokai	50.0	15000	46000
Molokai	50.5	15150	46500
Molokai	51.0	15300	47000
Molokai	51.5	15450	47500
Molokai	52.0	15600	48000
Molokai	52.5	15750	48500
Molokai	53.0	15900	49000
Molokai	53.5	16050	49500
Molokai	54.0	16200	50000
Molokai	54.5	16350	50500
Molokai	55.0	16500	51000
Molokai	55.5	16650	51500
Molokai	56.0	16800	52000
Molokai	56.5	16950	52500
Molokai	57.0	17100	53000
Molokai	57.5	17250	53500
Molokai	58.0	17400	54000
Molokai	58.5	17550	54500
Molokai	59.0	17700	55000
Molokai	59.5	17850	55500
Molokai	60.0	18000	56000
Molokai	60.5	18150	56500
Molokai	61.0	18300	57000
Molokai	61.5	18450	57500
Molokai	62.0	18600	58000
Molokai	62.5	18750	58500
Molokai	63.0	18900	59000
Molokai	63.5	19050	59500
Molokai	64.0	19200	60000
Molokai	64.5	19350	60500
Molokai	65.0	19500	61000
Molokai	65.5	19650	61500
Molokai	66.0	19800	62000
Molokai	66.5	19950	62500
Molokai	67.0	20100	63000
Molokai	67.5	20250	63500
Molokai	68.0	20400	64000
Molokai	68.5	20550	64500
Molokai	69.0	20700	65000
Molokai	69.5	20850	65500
Molokai	70.0	21000	66000
Molokai	70.5	21150	66500
Molokai	71.0	21300	67000
Molokai	71.5	21450	67500
Molokai	72.0	21600	68000
Molokai	72.5	21750	68500
Molokai	73.0	21900	69000
Molokai	73.5	22050	69500
Molokai	74.0	22200	70000
Molokai	74.5	22350	70500
Molokai	75.0	22500	71000
Molokai	75.5	22650	71500
Molokai	76.0	22800	72000
Molokai	76.5	22950	72500
Molokai	77.0	23100	73000
Molokai	77.5	23250	73500
Molokai	78.0	23400	74000
Molokai	78.5	23550	74500
Molokai	79.0	23700	75000
Molokai	79.5	23850	75500
Molokai	80.0	24000	76000
Molokai	80.5	24150	76500
Molokai	81.0	24300	77000
Molokai	81.5	24450	77500
Molokai	82.0	24600	78000
Molokai	82.5	24750	78500
Molokai	83.0	24900	79000
Molokai	83.5	25050	79500
Molokai	84.0	25200	80000
Molokai	84.5	25350	80500
Molokai	85.0	25500	81000
Molokai	85.5	25650	81500
Molokai	86.0	25800	82000
Molokai	86.5	25950	82500
Molokai	87.0	26100	83000
Molokai	87.5	26250	83500
Molokai	88.0	26400	84000
Molokai	88.5	26550	84500
Molokai	89.0	26700	85000
Molokai	89.5	26850	85500
Molokai	90.0	27000	86000
Molokai	90.5	27150	86500
Molokai	91.0	27300	87000
Molokai	91.5	27450	87500
Molokai	92.0	27600	88000
Molokai	92.5	27750	88500
Molokai	93.0	27900	89000
Molokai	93.5	28050	89500
Molokai	94.0	28200	90000
Molokai	94.5	28350	90500
Molokai	95.0	28500	91000
Molokai	95.5	28650	91500
Molokai	96.0	28800	92000
Molokai	96.5	28950	92500
Molokai	97.0	29100	93000
Molokai	97.5	29250	93500
Molokai	98.0	29400	94000
Molokai	98.5	29550	94500
Molokai	99.0	29700	95000
Molokai	99.5	29850	95500
Molokai	100.0	30000	96000

Alaskan Map and Data Table

Alaskan Seamounts and Seamount Chain Map: NE Pacific and Gulf of Alaska

Enderberg Seamount
Wrangell Seamount
Cable Pipe
Rising Star

Left Margin
Right Margin

500 km

Alaskan Seamounts - Current location of Cobb Hotspot

Cobb Seamount Seamount

Seamount Name	Approximate Age (Ma)	Approximate Distance from Alaska (km)	Approximate Depth (m)
Enderberg	0.0	0	4000
Wrangell	0.5	150	3500
Cable Pipe	1.0	300	3000
Rising Star	1.5	450	2500
Wrangell	2.0	600	2000
Cable Pipe	2.5	750	1500
Rising Star	3.0	900	1000
Wrangell	3.5	1050	500
Cable Pipe	4.0	1200	0
Rising Star	4.5	1350	500
Wrangell	5.0	1500	1000
Cable Pipe	5.5	1650	1500
Rising Star	6.0	1800	2000
Wrangell	6.5	1950	2500
Cable Pipe	7.0	2100	3000
Rising Star	7.5	2250	3500
Wrangell	8.0	2400	4000
Cable Pipe	8.5	2550	4500
Rising Star	9.0	2700	5000
Wrangell	9.5	2850	5500
Cable Pipe	10.0	3000	6000
Rising Star	10.5	3150	6500
Wrangell	11.0	3300	7000
Cable Pipe	11.5	3450	7500
Rising Star	12.0	3600	8000
Wrangell	12.5	3750	8500
Cable Pipe	13.0	3900	9000
Rising Star	13.5	4050	9500
Wrangell	14.0	4200	10000
Cable Pipe	14.5	4350	10500
Rising Star	15.0	4500	11000
Wrangell	15.5	4650	11500
Cable Pipe	16.0	4800	12000
Rising Star	16.5	4950	12500
Wrangell	17.0	5100	13000
Cable Pipe	17.5	5250	13500
Rising Star	18.0	5400	14000
Wrangell	18.5	5550	14500
Cable Pipe	19.0	5700	15000
Rising Star	19.5	5850	15500
Wrangell	20.0	6000	16000
Cable Pipe	20.5	6150	16500
Rising Star	21.0	6300	17000
Wrangell	21.5	6450	17500
Cable Pipe	22.0	6600	18000
Rising Star	22.5	6750	18500
Wrangell	23.0	6900	19000
Cable Pipe	23.5	7050	19500
Rising Star	24.0	7200	20000
Wrangell	24.5	7350	20500
Cable Pipe	25.0	7500	21000
Rising Star	25.5	7650	21500
Wrangell	26.0	7800	22000
Cable Pipe	26.5	7950	22500
Rising Star	27.0	8100	23000
Wrangell	27.5	8250	23500
Cable Pipe	28.0	8400	24000
Rising Star	28.5	8550	24500
Wrangell	29.0	8700	25000
Cable Pipe	29.5	8850	25500
Rising Star	30.0	9000	26000
Wrangell	30.5	9150	26500
Cable Pipe	31.0	9300	27000
Rising Star	31.5	9450	27500
Wrangell	32.0	9600	28000
Cable Pipe	32.5	9750	28500
Rising Star	33.0	9900	29000
Wrangell	33.5	10050	29500
Cable Pipe			

Educator Guide

Background

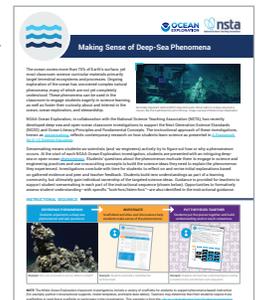
Thousands of seamounts have been discovered worldwide. One of the longest of these chains is known as the Cobb-Eickelberg chain and was explored during the [NOAA Ocean Exploration Expedition: Exploring Alaska's Seamounts](#). What formed these underwater mountains (some of which were once islands)? Why are they arranged in chains? Seamounts and island chains are the products of underwater volcanoes and may have several origins.

Scientists hypothesize the seamounts in the Cobb-Eickelberg chain were produced by eruptions of the Cobb Hotspot, a source of magma from within the Earth's mantle. While the location of this hotspot has basically remained the same, the overlying Pacific Plate has been moving to the northwest. The volcanoes produced by the hotspot are aligned in the same direction the plate moves. Axial Volcano is currently active and the most recent volcano produced by the Cobb Hotspot.

The Hawaiian Islands and seamounts are also an example of plate motion over an underlying hotspot. The Hawaiian-Emperor Seamount chain is evidence that the Hawaiian Hotspot has been active for at least 80 million years. This hotspot provides magma for an active eruption on the Big Island of Hawaii and produces eruptions on the seamount Kama'ehuakanaloa, which may eventually become the newest Hawaiian island.

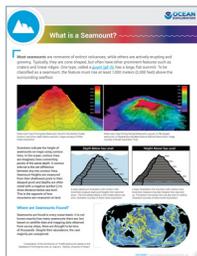
Educator Note

- Students should be familiar with convection currents and plate tectonics.
- A variety of student interaction techniques and examples of student questions are provided throughout this activity to engage students in the process of sensemaking to move their learning forward.
- [Learn more](#) about the instructional strategies and tools included in the NOAA Ocean Exploration student investigations.

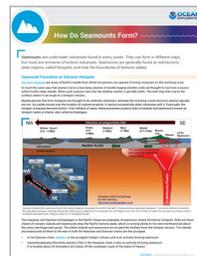


FOR MORE INFORMATION:

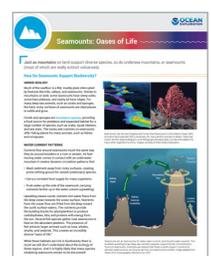
► [What is a Seamount? Fact Sheet](#)



► [How Do Seamounts Form? Fact Sheet](#)



► [Seamounts: Oases of Life Fact Sheet](#)



Educator Guide cont.

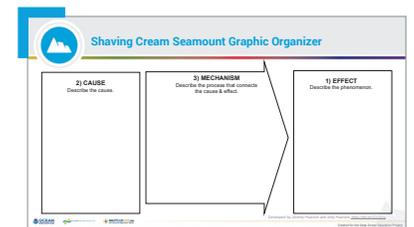
Investigate

Lead a discussion to identify some patterns/similarities in the students' questions. Point out that many students have questions about why the oldest volcanoes have not erupted in long periods of time, and that the age of the islands and seamounts within the chain increase the further away they are from the active volcano. Also, note that some students suggested the volcanic activity is probably connected to the hotspots that are identified on the map.

Guide students in identifying investigations they could conduct to answer their questions. Record these ideas in the "Investigate" column of the chart you created for the class. Since some of these questions could be answered by students looking up information about hotspots and plate tectonics, facilitate a discussion about what sources would be considered reliable. Ask students if they can identify agencies that could provide reliable information and put the suggestions under the "Investigate" column.

Suggested prompts include:

- *What could we do to answer some of the questions you've listed?*
- *It seems like many of you have questions about why the seamounts/islands appear to be in a line. How can we find out more about that?*
- *It looks like there might be some questions about why some of the islands or seamounts are active volcanoes and some are not. How can we learn more about this?*
- *How should we go about doing this research? With so much information on the internet, what kind of sources should we search to get reliable information?*



Tell students they will now be conducting an investigation to gather evidence that will help them make sense of the patterns they observed on the maps and data tables.

Activity: Shaving Cream Seamounts Demonstration

This activity can be conducted as a teacher demonstration or as a small group of three or four students. For distance learning, consider videotaping the demonstration and uploading it to your learning platform.

- Use a grease splatter screen and foaming shaving cream for this activity.
- Ask the students to think about what the grease splatter screen and the shaving cream represent in this model (plate, magma, and/or hotspot)
- Demonstrate the procedure to the students.
 - a. Hold the screen *above* the nozzle of the can of shaving cream. Keeping the can in place, gently release a small squirt of shaving cream to produce a small mound on the top of the screen.
 - b. Slowly move the screen in one direction (simulating plate movement), and squirt a series of consecutive mounds. Make 4 or more mounds. *Be sure to practice this in advance!*
- Now, using the screen and shaving cream, have the students reference the [Hawaiian Map and Data Table](#) to recreate the pattern of the seamounts.
- When all groups have successfully completed the activity or seen it demonstrated, provide them with the [Shaving Cream Seamount Graphic Organizer](#). Have each student complete this and share their thinking within their group.
- Share this graphic organizer in a way that the whole class can see it, allowing students to share their thinking and complete a class graphic organizer for consensus.

TEACHER NOTE

Students will need an opportunity to practice creating a seamount chain on the screen.

Educator Guide cont.

Investigate cont.

Redirect students to the original class “Notice/Wonder/Investigate” chart. Identify the questions that students posed that have been answered to this point. Add the additional questions that have surfaced as a result of the seamount demonstration. Tell students that they will now work to gather evidence that explains where the magma that formed the hotspots comes from, and what mechanism is “driving” the seafloor to move over the hotspot. Tell students to add the evidence to their individual graphic organizer.

Students can move through each of the additional resources individually or in pairs. Student groups might also be divided to “jigsaw” each of the additional resources and come back together to share their findings.

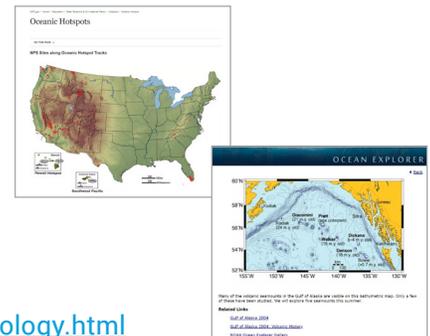
Readings

Hawaii Resources:

- <https://www.nps.gov/subjects/geology/plate-tectonics-oceanic-hotspots.htm>
- <https://pubs.usgs.gov/gip/dynamic/hotspots.html>

Alaska Resources:

- https://oceanexplorer.noaa.gov/explorations/04alaska/background/volcanic/media/gofae03_map.html
- <https://oceanexplorer.noaa.gov/explorations/02alaska/background/geology/geology.html>

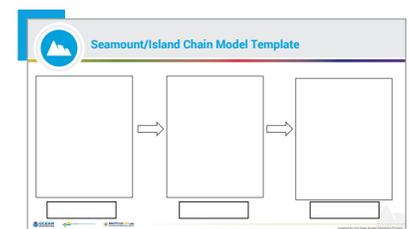


TEACHER NOTE

Optional: Use these [Plates on the Move](#) and [Plate Motion](#) simulations as additional resources for student engagement and review of tectonic processes.

Put the Pieces Together

Ask students to draw a model explaining how seamount chains form using everything they have learned. Remind them to identify the components and the relationships between those components in order to make their thinking as visible as possible. Provide students with the [Seamount/Island Chain Model Template](#), allowing them to modify as needed.



Allow time for students to create their models individually and then share and explain their models in small groups. Give students time to identify the similarities and differences between all the models that were shared. Have the students create a group model that best represents their group’s thinking.

Conduct a gallery walk, with one student being a spokesperson for each group. The members who rotate will identify similarities and differences between their model and the other groups’, and provide feedback to the other groups.

After rotating to all the groups, have students return to their original group and make revisions to their model template based on their feedback and observations.

Ask students to finalize their models and write a short summary explaining the processes that form seamounts and island chains.

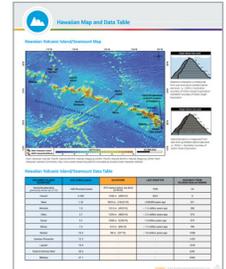
Educator Guide cont.

Extension

- Using the [Hawaiian Map and Data Table](#), have students calculate the Pacific Plate's approximate velocity. You may need to help students deal with large numbers and decimal places.

The basic calculation is $\text{velocity} = \text{distance} \div \text{time}$, which in the case of Midway is $2,432 \text{ km} \div 27,700,000 \text{ yr} = 0.0000877 \text{ km/yr} = 0.0877 \text{ m/yr} = 8.77 \text{ cm/yr}$.

The same calculation for Nihoa is $780 \text{ km} \div 7,200,000 \text{ yr} = 10.8 \text{ cm/yr}$.



Scientific Terms

Tectonic processes: Processes related to the interaction between, or deformation of, rigid plates forming the crust of the Earth.

Seamount: An undersea mountain-like formation often created by volcanic activity with a peak that does not rise to the ocean surface.

Geologic hotspot: A hotspot is a large plume of hot mantle material rising through the sea floor from deep within the Earth.

Assessment

Opportunities for formative assessment are embedded throughout the lesson. The student models and explanations that are developed at the end of the lesson could be used as an opportunity for summative assessment of learning.

LOOK FORS:

The following components should be included in students' final explanations.

- A hotspot is a large plume of hot mantle material rising through the seafloor from deep within the Earth.
- Hotspots provide magma for active eruptions which may eventually become new islands.
- Eruptions can be caused by subduction processes or plate motion over an underlying hotspot.
- Seamounts can form as a plate moves over a hotspot.
- Seamounts produced by a hotspot are aligned in the same direction the plate moves.
- Seamounts are progressively older the further they are away from the largest and most active volcano.
- Old islands formed within a seamount chain could get smaller with age (and are farther away from the hotspot).

Seamounts

- Page 1:** ▶ Seamount (image): <https://oceanexplorer.noaa.gov/facts/seamounts.html>
- Page 2:** ▶ Hawaiian Map and Data Table (pdf): <https://oceanexplorer.noaa.gov/edu/materials/hawaiian-map-data-table.pdf>
 ▶ Alaskan Map and Data Table (pdf): <https://oceanexplorer.noaa.gov/edu/materials/alaskan-map-data-table.pdf>
 ▶ Shaving Cream Seamount Graphic Organizer (pdf): <https://oceanexplorer.noaa.gov/edu/materials/seamount-graphic-organizer-model-template.pdf>
 ▶ Seamount/Island Chain Model Template (pdf): <https://oceanexplorer.noaa.gov/edu/materials/seamount-graphic-organizer-model-template.pdf>
- Page 3:** ▶ NOAA Ocean Exploration Expedition: Exploring Alaska's Seamounts (webpage): <https://oceanexplorer.noaa.gov/explorations/02alaska/welcome.html>
 ▶ Making Sense of Deep-Sea Phenomena (pdf): <https://oceanexplorer.noaa.gov/edu/materials/NOAA-NSTA-sensemaking-phenomenon.pdf>
 ▶ What is a Seamount? (fact sheet): <https://oceanexplorer.noaa.gov/edu/materials/what-is-a-seamount-fact-sheet.pdf>
 ▶ How Do Seamounts Form? (fact sheet): <https://oceanexplorer.noaa.gov/edu/materials/how-seamounts-form-fact-sheet.pdf>
 ▶ Seamounts: Oases of Life (fact sheet): <https://oceanexplorer.noaa.gov/edu/materials/seamounts-oases-of-life-fact-sheet.pdf>
- Page 4:** ▶ Hawaiian Map and Data Table (pdf): <https://oceanexplorer.noaa.gov/edu/materials/hawaiian-map-data-table.pdf>
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- Page 5:** ▶ Hawaiian Map and Data Table (pdf): <https://oceanexplorer.noaa.gov/edu/materials/hawaiian-map-data-table.pdf>
 ▶ Shaving Cream Seamount Graphic Organizer (pdf): <https://oceanexplorer.noaa.gov/edu/materials/seamount-graphic-organizer-model-template.pdf>
- Page 6:** ▶ Oceanic Hotspots (website): <https://www.nps.gov/subjects/geology/plate-tectonics-oceanic-hotspots.htm>
 ▶ Hotspots (website): <https://pubs.usgs.gov/gip/dynamic/hotspots.html>
 ▶ Gulf of Alaska (website): https://oceanexplorer.noaa.gov/explorations/04alaska/background/volcanic/media/gofae03_map.html
 ▶ Volcanic History of Seamounts in the Gulf of Alaska (website): <https://oceanexplorer.noaa.gov/explorations/02alaska/background/geology/geology.html>
 ▶ Plates on the Move Game (website): <https://www.amnh.org/explore/ology/earth/plates-on-the-move2/game>
 ▶ Plate Motion (website): https://sepuplhs.org/middle/third-edition/simulations/plate_motion_sim.html
 ▶ Seamount/Island Chain Model Template (pdf): <https://oceanexplorer.noaa.gov/edu/materials/seamount-graphic-organizer-model-template.pdf>
- Page 7:** ▶ Hawaiian Map and Data Table (pdf): <https://oceanexplorer.noaa.gov/edu/materials/hawaiian-map-data-table.pdf>

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