



WATCHING IN 3D

Exploring with Multibeam Sonar

CASE STUDY 1: Exploring an Underwater Volcano

(Kawio Barat)

What is an Underwater Volcano?

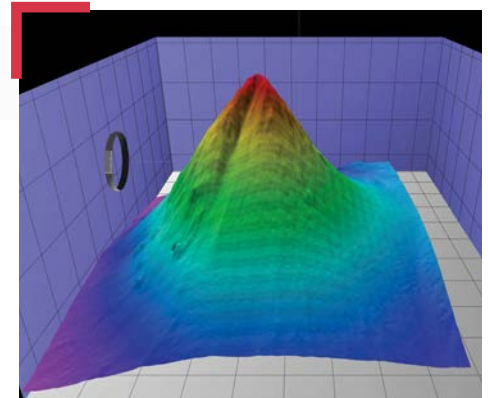
Submarine volcanic eruptions are characteristic of rift zones where crustal plates are being formed. These rift zones are known as seafloor spreading centers because they are places where tectonic plates are moving away from each other. Most seafloor spreading centers lie at depths greater than 2,000 meters (1.2 miles) and, as a consequence, approximately three-quarters of all volcanic activity on Earth occurs as deep, underwater eruptions.

Spreading center volcanic eruptions typically produce basalt, the primary rock that makes up oceanic crust. Submarine basalt flows often have a “pillow” shape but they can also produce smooth sheet flows like basalt eruptions on land.

Submarine eruptions most commonly occur along spreading centers, like the Mid-Atlantic Ridge and the East Pacific Rise, where the plates are moving apart at relatively rapid rates. However, they also occur in places where crustal plates collide and one plate dives beneath the other and is ultimately remelted. In such regions, known as subduction zones, the volcanic rock type is typically andesite, which is a product of the melting of the plate being subducted. Andesitic eruptions are usually violent and are only approachable because their explosiveness is dampened by the depths at which they occur.

A third type of submarine eruption occurs as a consequence of a magma plume rising through the Earth’s crust overlying an area of melting in the Earth’s mantle. These eruptions are known as hotspot volcanoes and they often form chains of volcanic islands and seamounts.

Submarine volcanoes are also interesting because of the unique habitats they create. Seamounts are often areas of high biological diversity; their shape acts to deflect food-carrying currents upward, attracting a variety of sessile organisms and those that feed on them. Some animals can even metabolize inorganic compounds emitted during volcanic activity, forming unique chemosynthetic communities around areas of hydrothermal venting.



Fledermaus 3D image of Kawio Barat.

Four key technologies are used to gather baseline information on areas of ocean exploration:



1 Listen
Multibeam sonar mapping system



2 Test
Conductivity, Temperature and Depth profilers (CTDs)



3 Photograph
Remotely Operated Vehicles (ROV)



4 Share
Telepresence technologies

This activity will guide you through the exploration of the Kawio Barat seamount, also an underwater volcano, using the [NOAA Ocean Exploration Data Atlas](#) (a searchable, interactive expedition data map) and a demonstration video of [Fledermaus](#), a mapping data visualization software used by ocean explorers to view [multibeam sonar](#) data and images in 3D. Multibeam sonar is one of the most powerful tools available for modern deep-sea exploration and can create high-resolution maps and three dimensional models.

You will also be introduced to the NOAA Ocean Exploration website and the [INDEX-Indonesia-USA Deep-Sea Exploration of the Sangihe Talaud Region Expedition](#) web pages where Kawio Barat was studied.



What Underwater Volcano are we Exploring?

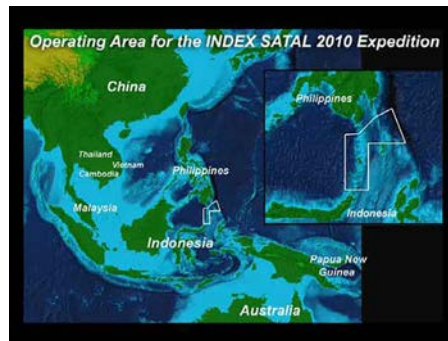
Surveyed during the 2010 INDEX-SATAL expedition, the conical submarine Kawio Barat volcano sits just west of the Sangihe volcanic arc between Sulawesi Island in Indonesia and Mindanao Island in the Philippines. Many of the Sangihe islands contain active volcanoes that have erupted within the last 100 years (including Ruang, Karangetang, Banua Wuhu, and Awu).

To learn more about the complexity of this dynamic region [read this background information](#).

In 2010, an international team of U.S. and Indonesian scientists and technicians worked side-by-side on two ships, the NOAA Ship *Okeanos Explorer* and the Indonesian research vessel *Baruna Jaya IV*, and at Exploration Command Centers (ECCs) ashore. They conducted investigations on the diversity and distribution of deep-sea habitats and marine life in Indonesian waters. They focused on the water column and benthic environments in unknown ocean areas in SATAL – a contraction of Sangihe and Talaud – two island chains stretching northeast of North Sulawesi. *Okeanos Explorer* focused on mapping waters deeper than 2,000 meters during the expedition, while *Baruna Jaya IV* collected multibeam sonar mapping data down to 2,000 meters.

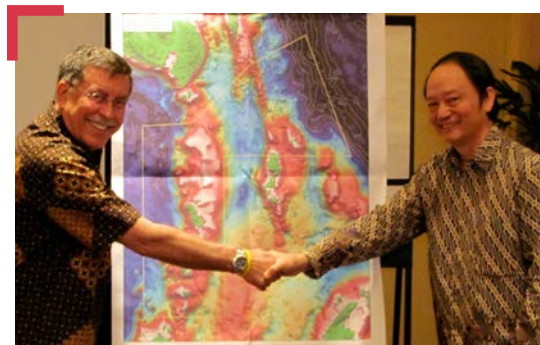
Kawio Barat was one of the first underwater seamounts mapped during this cruise. The impressive volcano rises some 3,800 meters (12,467 feet) above the surrounding seafloor. Images from mapping results over Kawio Barat were shared with scientists in real time, from which sites were selected to deploy the Conductivity, Temperature and Depth Profiler (CTD) and the remotely operated vehicle (ROV).

Map of the operating area for INDEX-SATAL 2010. The white outlined box is where both the *Baruna Jaya IV* and *Okeanos Explorer* conducted joint operations. Image courtesy of NOAA Ocean Exploration.



INDEX-SATAL: A Priority for Two Ocean Nations

The Indonesia-USA Deep-Sea Exploration of the Sangihe Talaud Region (INDEX-SATAL 2010) expedition kicked off a new era of scientific cooperation between the United States and Indonesia. President Susilo Bambang Yudhoyono of Indonesia encouraged the joint expedition and it was supported by the U.S. Ambassador to Indonesia.



Dr. Sugiarta and Dr. Steve Hammond shake hands after agreeing upon the planning area of operations for the INDEX-SATAL expedition. Image courtesy of NOAA Ocean Exploration.



Close-up imagery showing a type of goose-neck barnacle, shrimp and a scaleworm on Kawio Barat submarine volcano. Image courtesy of the NOAA Ocean Exploration, INDEX-SATAL 2010.



Student Investigation: Exploring an Underwater Volcano with Multibeam Sonar Tools

TOOL 1: Exploring an Underwater Volcano with the NOAA Ocean Exploration Data Atlas

Now that you know more about underwater volcanoes, let's use the NOAA Ocean Exploration Data Atlas to explore the Kawio Barat underwater volcano.

OPEN THE ATLAS LINK:

▶ <https://www.ncei.noaa.gov/maps/ocean-exploration-data-atlas/>

INPUT THE EXPEDITION DETAILS:

Minimum Y(ear): 2010

Maximum Y(ear): 2010

Expedition Name: EX1004L2 (select code in the left hand drop down menu) - INDEX - Indonesia-USA Deep-Sea

Exploration of the Sangihe Talaud Region (expedition name will appear in the right hand sidebar)

Platform Name (vessel): NOAA Ship *Okeanos Explorer*



EX1004L2: "EX" is used as an abbreviation for the NOAA Ship *Okeanos Explorer*, the last two digits of the year of the cruise (10), the number of the cruise (fourth-04 cruise for 2010), and the segment or leg ((second leg-L2 of cruise-04).

CLICK ZOOM TO RESULTS

PLOT ON MAP: Use your center mouse button to zoom in until the names of the ROV dives appear.

LOOK CLOSER: Holding the left mouse button down, shift the map and zoom in to find the Remotely Operated Vehicle (ROV) Dives 1 and 2 (EX1004L2_DIVE 01 and 02). Discuss the following questions with your group.

1. What do you think the ship was doing here to make those lines on the map? Can you think of anything in your life that makes similar patterns? _____

DIVE IN: Zoom in to get a closer look at the Kawio Barat volcano (ROV Dive 1).

2. What do you notice? _____

ZOOM OUT: Zoom back out to see where this volcano sits on the globe.

3. Describe its location. _____

4. Zooming in and out around the volcano, what other seafloor features do you notice/recognize on the map? _____



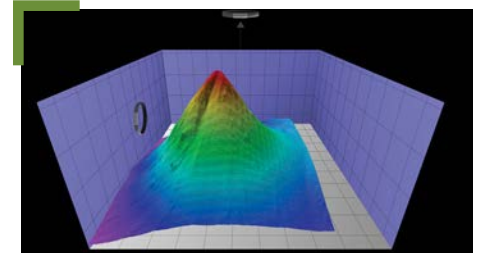
Student Investigation: Exploring an Underwater Volcano with Multibeam Sonar Tools *cont.*

TOOL 2: Exploring an Underwater Volcano with Fledermaus

Now that you have found these two ROV dives, you will view a video exploration of the Kawio Barat underwater volcano within a platform called Fledermaus. This is a 3D data visualization system used to view and manipulate 3D models of seafloor features, provide insight into the geological structure of an area, and help to pinpoint ideal locations for further exploration. Use the video to help you discuss and answer the questions below.



Fledermaus, pronounced "FLEE-der-mouse," is the German word for bat.



WATCH: [CASE STUDY 1 FLEDERMAUS VIDEO](#)

EXPLORE: Based on your video observations, answer the questions below.

1. How deep are the deepest parts of the image? _____ How deep is the shallowest part of this volcano? _____
2. What is the approximate width of the volcano at its base? _____
3. What did you see as the steepest slope on this volcano? _____

THINK ABOUT IT

4. Scientists often explore rugged, steep areas and crevices. Why might the exploration team find those areas most interesting? _____
5. If you were the scientist leading this expedition and exploring this region for the first time, where would you choose to send an ROV? Why? _____

6. What considerations do you think need to be made when deciding what regions to select for further exploration?

Student Investigation: Exploring an Underwater Volcano with Multibeam Sonar Tools *cont.*

TOOL 3: Expedition Web Pages

Now that you have explored the 3D map of the Kawio Barat underwater volcano, check out INDEX-SATAL 2010 **EXPEDITION WEB PAGE** on the NOAA Ocean Exploration website to learn more about what was studied here and some of the discoveries that were made.

- ▶ <https://oceanexplorer.noaa.gov/oceanos/explorations/10index/welcome.html>

HERE YOU CAN...

- read the Mission Overview
- read the Mission Logs
- view beautiful imagery, videos and more!

BE THE EXPLORER

What was discovered?

On the [INDEX-SATAL 2010 Expedition web page](#), click Mission Logs.

READ the [Mission Log from June 26, 2010](#).

1. Why do you think a variety of scientists is necessary to fully explore an area? _____

READ the [Mission Log from June 27, 2010](#), the day after the ROV explored the Kawio Barat volcano.

2. What were the explorers looking for? _____

READ the [Mission Log from June 30, 2010](#).

3. What geological feature was found and what animals were observed? _____

READ the [Mission Log from July 11, 2010](#).

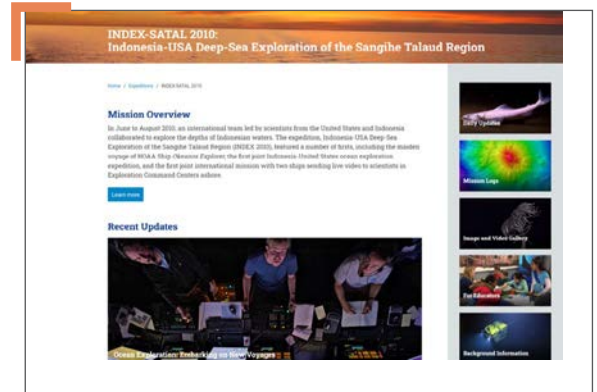
4. What were the scientists surprised to see when the ROV descended to a different volcanic cone-shaped seamount? _____

THINK ABOUT IT

WATCH the [Kawio Barat highlights video](#) and note your observations.

WATCH the [2016 Oases of Life](#) from a different nearby expedition to the Marianas.

5. Discuss with a peer and name 3 things that amaze you about this habitat. _____





Underwater Volcano Lesson URLs/Links

- Page 1:**
- ▶ Tectonic plates: <https://oceanexplorer.noaa.gov/facts/plate-boundaries.html>
 - ▶ Pillow basalts: <https://oceanexplorer.noaa.gov/oceanos/explorations/ex1605/dailyupdates/media/video/0503-pillow/0503-pillow.html>
 - ▶ Mid-Atlantic Ridge: <https://oceanexplorer.noaa.gov/facts/mid-ocean-ridge.html>
 - ▶ East Pacific Rise: <https://www.mbari.org/the-geologic-setting-of-the-gulf-of-california/>
 - ▶ Subduction zones: <https://oceanexplorer.noaa.gov/facts/tectonic-features.html>
 - ▶ Hotspot volcanoes: <https://oceanexplorer.noaa.gov/facts/volcanic-hotspot.html>
 - ▶ What is a Seamount? Fact Sheet (PDF): <https://oceanexplorer.noaa.gov/edu/materials/what-is-a-seamount-fact-sheet.pdf>
 - ▶ Chemosynthesis Fact Sheet (PDF): <https://oceanexplorer.noaa.gov/edu/materials/chemosynthesis-fact-sheet.pdf>
 - ▶ Listen: <https://oceanexplorer.noaa.gov/edu/materials/multibeam-sonar-fact-sheet.pdf>
 - ▶ Test: <https://oceanexplorer.noaa.gov/technology/ctd/ctd.html>
 - ▶ Photograph: <https://oceanexplorer.noaa.gov/edu/materials/rov-fact-sheet.pdf>
 - ▶ Share: <https://oceanexplorer.noaa.gov/technology/telepresence/telepresence.html>
 - ▶ Multibeam Sonar Fact Sheet (PDF): <https://oceanexplorer.noaa.gov/edu/materials/multibeam-sonar-fact-sheet.pdf>
- Page 2:**
- ▶ INDEX-SATAL Expedition Web Page: <https://oceanexplorer.noaa.gov/oceanos/explorations/10index/welcome.html>
 - ▶ INDEX-SATAL overview (map): <https://oceanexplorer.noaa.gov/oceanos/explorations/10index/background/plan/plan.html>
 - ▶ Background Information: <https://oceanexplorer.noaa.gov/oceanos/explorations/10index/background/geology/geology.html>
 - ▶ INDEX-SATAL partnership: <https://oceanexplorer.noaa.gov/oceanos/explorations/10index/background/partnership/partnership.html>
 - ▶ Map of operating area for INDEX-SATAL 2010 Image:
https://oceanexplorer.noaa.gov/oceanos/explorations/10index/background/plan/media/10index_operating_area_hires.jpg
 - ▶ Organisms living on the volcano (photo): https://oceanexplorer.noaa.gov/oceanos/explorations/10index/logs/photolog/photolog.html#cbpi=/oceanos/explorations/10index/logs/photolog/media/barnacle_zoom.html
- Page 3:**
- ▶ NOAA Ocean Exploration Data Atlas: <https://www.ncei.noaa.gov/maps/ocean-exploration-data-atlas/>
- Page 4:**
- ▶ Fledermaus Video: Underwater Volcano, Kawio Barat: https://oceanexplorer.noaa.gov/edu/materials/CaseStudy1_KawioBarat_Volcano.mp4
- Page 5:**
- ▶ INDEX-SATAL Expedition Web Page: <https://oceanexplorer.noaa.gov/oceanos/explorations/10index/welcome.html>
 - ▶ Mission Log (June 26, 2010): <https://oceanexplorer.noaa.gov/oceanos/explorations/10index/logs/june26/june26.html>
 - ▶ Mission Log (June 27, 2010): <https://oceanexplorer.noaa.gov/oceanos/explorations/10index/logs/june27/june27.html>
 - ▶ Mission Log (June 30, 2010): <https://oceanexplorer.noaa.gov/oceanos/explorations/10index/logs/june30/june30.html>
 - ▶ Mission Log (July 11, 2010): <https://oceanexplorer.noaa.gov/oceanos/explorations/10index/logs/july11/july11.html>
 - ▶ Kawio Barat Highlights (video): https://oceanexplorer.noaa.gov/oceanos/explorations/10index/background/info/media/movies/ex_kawio_barat_highlights_960.mp4
 - ▶ Oases of Life (video): <https://oceanexplorer.noaa.gov/edu/themes/vents-and-volcanoes/multimedia.html#cbpi=media/video/multimedia-ventsrimp.html>

Information and Feedback



We value your feedback on this activity package, including how you use it in your formal/informal education settings. Please send your comments to: oceaneducation@noaa.gov. If reproducing this lesson, please cite NOAA as the source, and provide the following URL: <https://oceanexplorer.noaa.gov>.