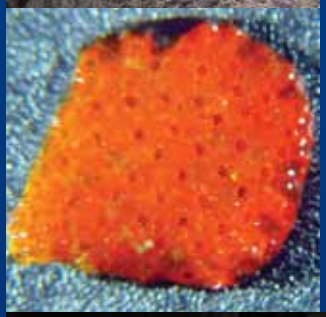
DEEP SEA EXPLORATION
INDEX2010
Sangihe Talaud
Indonesia-USA



INDEX/SATAL 2010

Four Good Reasons to Explore Indonesia's Deep Sea

During the summer of 2010, scientists from Indonesia and the United States will work together on an expedition to explore the deep sea surrounding Indonesia. This mission is called INDEX/SATAL 2010, since the expedition is focussed on INDonesia, EXploration, and the Sangihe Talaud (SATAL) region. Working from the Indonesian Research Vessel *Baruna Jaya IV* and the National Oceanic and Atmospheric Administration Ship *Okeanos Explorer*, these ocean explorers expect to find new deep-sea ecosystems, undiscovered geological features, and living organisms that have never been seen before. New discoveries are always exciting to scientists; but information from deep sea exploration is important to all Indonesians, because:

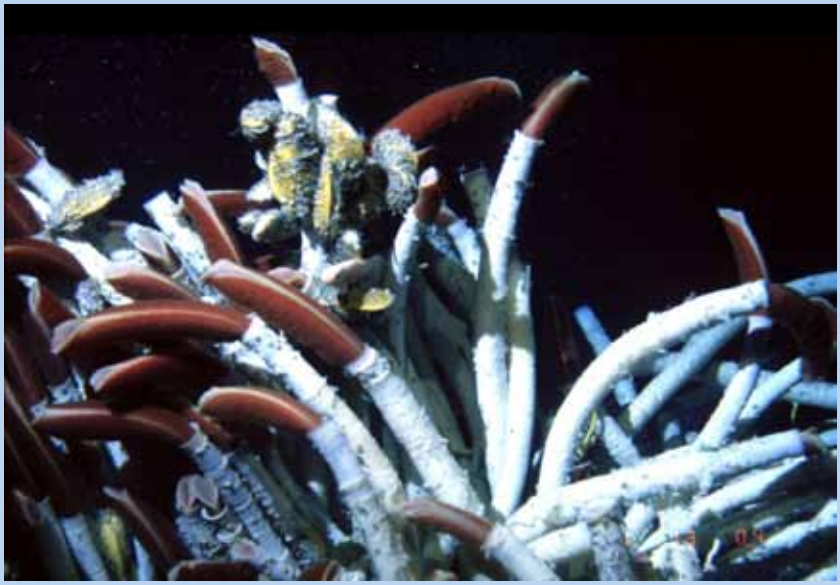
- The variety of life in deep sea ecosystems includes new species that can provide important drugs and other useful products.
- Some deep-sea ecosystems include large numbers of organisms that can be used for human food.
- Information from deep sea exploration can help predict earthquakes and tsunamis.
- Human benefits from deep sea systems are being affected by changes in Earth's climate and atmosphere.

These Fact Sheets and Discovery Activities are intended to help students learn more about reasons to explore Indonesia's Deep Sea.

For more information:
http://oceanexplorer.noaa.gov/okeanos/explorations/10index/welcome.html

Fact Sheet #1:

Deep sea ecosystems include new species that can provide important drugs and other useful products.

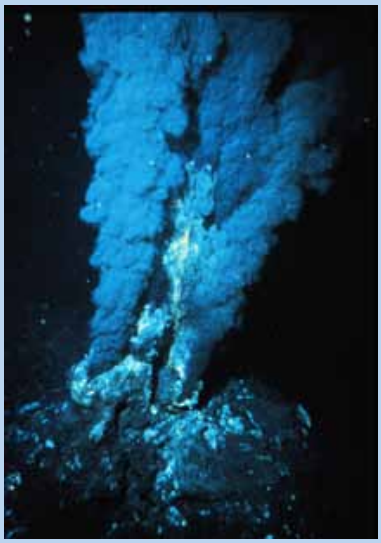


The giant tubeworm, Riftia pachyptila, from the hydrothermal vents at the East Pacific Rise at 2,500 m depth. Each individual in the photo exceeds one meter in length. *Image courtesy of Monika Bright, University of Vienna, Austria.*

Indonesia covers only 1.3 percent of Earth's land surface, yet it includes:

- 10 percent of the world's flowering plant species;
- 12 percent of the world's mammal species;
- 16 percent of all reptile and amphibian species;
- 17 percent of the world's bird species;
- 15 percent of the world's coral reefs;
- the highest number of coral species in the world (more than 600 identified species); and
- more than 2000 species of near shore fishes.

Indonesia is well-known as one of Earth's major centers of biodiversity (which means the variety of all forms of life). Although very little is known about Indonesia's deep sea, scientists expect to find high biodiversity, new ecosystems, and many species that have never been seen before.



Hydrothermal vent. *Image courtesy NOAA.*

Conditions in the deep-sea environment include very high pressures, total darkness, extreme temperatures, and toxic chemicals. Hydrothermal vents, for example, are deep sea habitats where hot fluids erupt from the seafloor. These habitats are found near mid-ocean ridges where Earth's tectonic plates are spreading apart (see Fact Sheet #3). The ridges are formed by hot lava that erupts between spreading tectonic plates. Hydrothermal vents are produced when cold seawater seeps into Earth's crust through cracks in the seafloor near mid-ocean ridges. As the seawater moves deeper into the crust, it is heated by molten rock. As the temperature increases, sulfur and metals such as copper, zinc, and iron dissolve from the surrounding rock into the hot fluid. Eventually, the mineral-rich fluid rises and erupts from openings in the seafloor. The temperature of the erupting fluid may be as high as 400°C, and contains hydrogen sulfide. When the hot hydrothermal fluid meets cold (nearly freezing) seawater, minerals in the fluid precipitate. The precipitated mineral particles give the fluid a smoke-like appearance, so these vents are often called black smokers or white smokers, depending upon the types of minerals in the fluid. Precipitated minerals may also form chimneys that can be several meters high.

The conditions around hydrothermal vents would be deadly to humans and many other species, but deep sea explorers have found living organisms with special adaptations that allow them to thrive in these extreme environments. Hydrothermal vent tubeworms are a famous example, and are briefly described in Discovery Activity #1. Some adaptations in deep sea organims produce new drugs and other useful products.

Chemicals from microorganisms found around hydrothermal vents are promising for treating bone injuries and cardiovascular diseases. Other deep-sea species produce powerful chemicals that act as antibiotic, anti-cancer, and anti-inflammatory drugs in humans. At present, almost all drugs produced from natural sources come from terrestrial plants, but marine organisms produce more drug-like substances than any group of organisms that live on land. Other examples of useful products include microscopic organisms from hydrothermal vent ecosystems that produce proteins used by crime scene investigators to make billions of copies of DNA. Proteins from other organisms are used to make sweeteners for food additives.

Discovery Activity #1:
Make a Hydrothermal Vent Tubeworm

Hydrothermal vent ecosystems do not depend upon green plants and sunlight for their food. Instead, they are able to use chemicals in hydrothermal fluids through a process called chemosynthesis. Most hydrothermal vent animals aren't able to use these chemicals all by themselves. Instead they have partnerships with other organisms, usually bacteria. Tubeworms, for example, have a large organ called a trophosome that contains chemosynthetic bacteria. They do not have a mouth, stomach, or intestines. The worms have long tentacles that stick out from the end of the tube. Inside the tentacles, the worm's blood contains hemoglobin (like human blood) that can absorb chemicals from the surrounding water. The blood carries these chemicals to bacteria living in the trophosome. The bacteria produce food that provides nutrition to the tubeworm.

What You Will Need

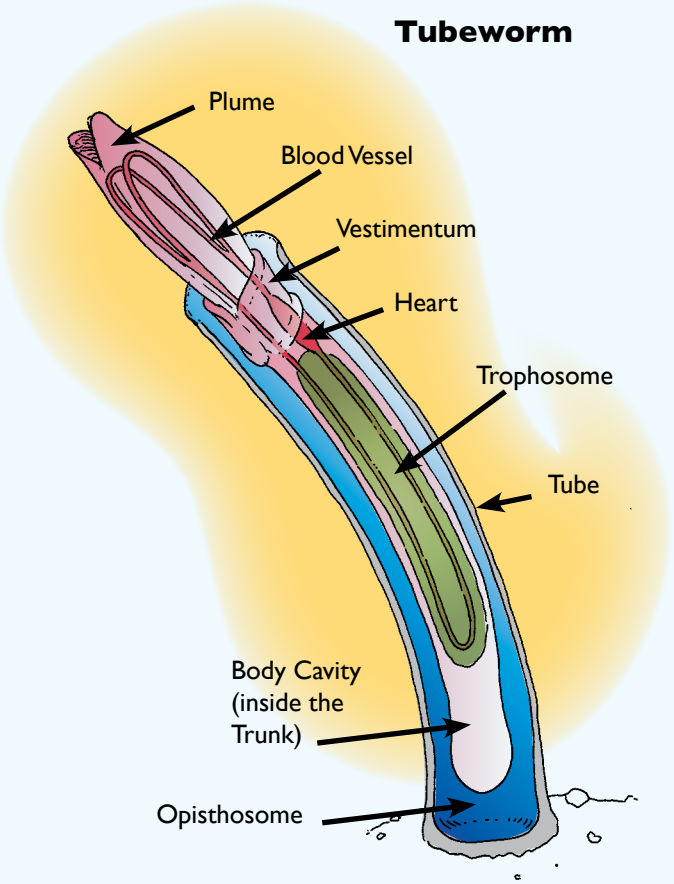
1. Materials to represent parts of the tubeworm (see the drawing). Here are some ideas:
   - Cardboard tubes for the trunk and tube
   - Pieces of wire for tentacles
   - Modeling clay or papier mâché for the vestimentum
   - Sponge for the trophosome
   - Small shells or beads to represent bacteria
2. Other supplies: glue, scissors, poster board or cardboard, colored markers and/or spray paint
3. Optional: a rotten egg in a tightly-closed jar

How to Do It

Since most of a tubeworm is hidden inside the tube, you should build your model as a "cut-away" (also called a cross section) so that the major structures can be seen. Here are the parts of a tubeworm that should be included in your model:

- **Tentacles** – All the tentacles together are called the "Plume;" these should be colored red, since they contain hemoglobin.
- **Vestimentum** – This is a muscular structure that has several functions:
  - It helps to hold the worm in its tube;
  - It generates new tube material;
  - It contains pores that release sperm or eggs during spawning;
  - It contains the tubeworm's version of a heart and a brain.
- **Trophosome** – This dark green-brown organ has a spongy texture, and contains bacteria that use oxygen, carbon dioxide, and hydrogen sulfide to make food for themselves as well as the worm; be sure to include something that represents bacteria.
- **Trunk** – This is where waste is stored, since tubeworms have no mouth, stomach, intestines, or anus.
- **Tube** – This is a hard hollow cylinder, and provides protection for the worm like the shells of other animals. The tentacles can be pulled completely inside the worm to avoid predators.
- **Opisthosome** – This organ (like the vestimentum) produces new tube material and helps anchor the worm in its tube.

A very noticeable feature about tubeworms is their smell. One of the chemicals used by chemosynthetic bacteria is hydrogen sulfide, which is what makes rotten eggs smell the way they do. If you want to include this feature in your model, you should probably put a rotten egg (or other source of hydrogen sulfide) in a glass jar with a tight-fitting lid so you can control the smell.

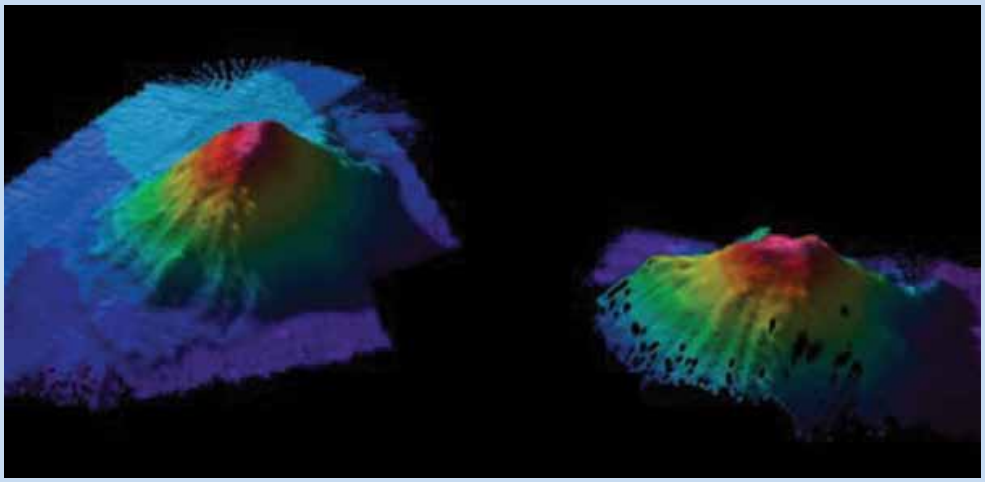


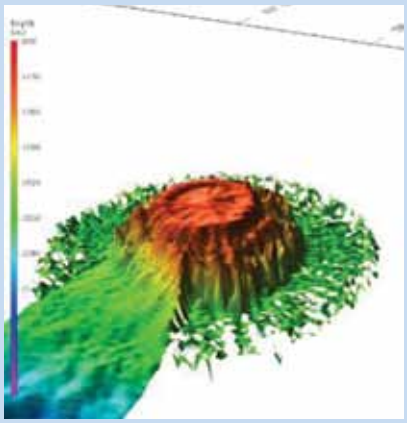
Fact Sheet #2:
Food from Deep Sea Ecosystems

Seamounts are undersea mountains that are usually the remains of submarine volcanoes. They rise more than 1,000 m from the deep sea floor and are entirely underwater. Seamount slopes are very steep, and produce current patterns that bring nutrients from deeper waters. These nutrients enhance the growth of marine plants that support complex food webs in the vicinity of seamounts.

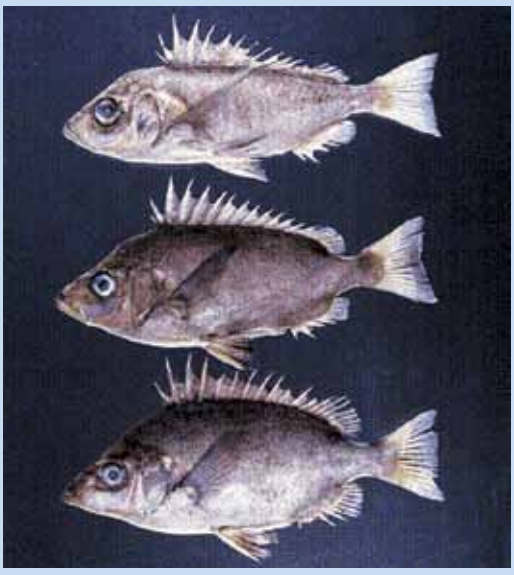
Most deep-water fishes are not considered commercially important as human food because their flesh lacks protein and has a watery consistency that makes them unattractive as food for humans. In the 1980's, however, fishermen discovered large populations of deep water fishes living around seamounts.

These fishes had firm, tasty flesh with high protein and lipid content. Moreover, these fishes were ten times more abundant than other deep-water fishes in neighboring areas. Unfortunately, many seamount species have been overfished. Seamount fish populations may be managed for smaller-scale artisanal fisheries that are sustainable and still provide food and economic benefits for local communities. This type of management depends upon information on deep sea ecosystems that can come from deep sea exploration.





Multibeam image of seamounts.



Grenadiers, oreos, and armorheads are tasty food fish found on many seamounts, but are in danger of overexploitation from large-scale industrial fishing operations. *All photos courtesy NOAA.*

Discovery Activity #2: Make a Volcano

Seamounts begin as underwater volcanoes that erupt when rocks melt below Earth's surface. Liquid rock is called magma, and tends to rise toward the surface. Magma collects beneath the surface in magma chambers, which often contain various gases as well as magma. When the magma and gases break through the Earth's crust, an eruption happens. If pressure builds up inside the magma chamber, the eruption may be very violent. Very hot magma flows easily over the Earth's surface, and produces flattened volcanoes called shield volcanoes. If the magma is cooler, it is sticky and flows more slowly, producing the familiar cone-shaped volcanoes called strato volcanoes. If the eruption is extremely explosive and violent, the top of the volcano may be blown completely away so that only the inside of the magma chamber remains. The collapsed depression is called a caldera.

What You Will Need

- Cardboard tube
- Sheets of newspaper
- Plastic tape or paper tape
- Corrugated cardboard, about 12 inches square
- Aluminum foil
- Modeling dough (see recipe below)
- Baking soda (enough to fill the cardboard tube at least half full)
- Vinegar, about eight ounces
- Sharp knife to cut the cardboard tube
- Optional: spray paint; spray glue; sand; food coloring

Warnings

1. Be careful with the knife! Cut on a flat cutting board, and keep your fingers away from the blade!
2. Wear protective gloves and eye shields when handling chemicals.

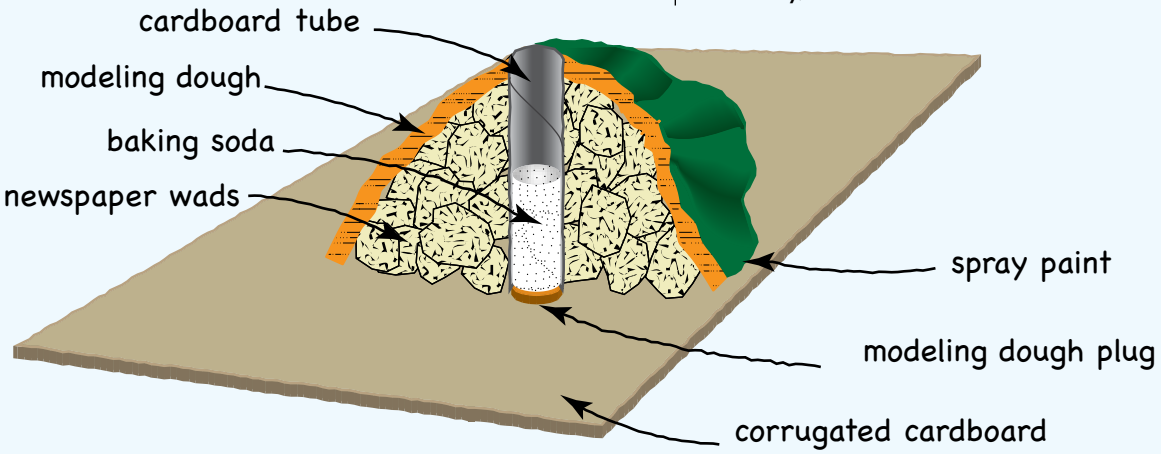
How to Do It

1. Cut the cardboard tube to a length of about eight inches. Plug the bottom of the tube with a piece of modeling dough.
2. Tape the cardboard tube to the piece of corrugated cardboard with plastic tape or masking tape.
3. Crumple sheets of newspaper into balls, and tape these onto the corrugated cardboard around the cardboard tube. Make several different size balls so the surface tapers upward from the edge of the cardboard to the top of the cardboard tube, giving your volcano its shape.
4. Cover the balls of newspaper with a sheet of aluminum foil or a rolled out sheet of homemade modeling dough. Leave a hole in the covering for the end of the cardboard tube. Fold the edges of the foil under the corrugated cardboard sheet.
5. Optional: Decorate your model. Spray with green and brown spray paint. You may also want to spray on glue and dribble sand onto the glue before it dries.
6. Fill the cardboard tube at least half full of baking soda. If desired, mix several drops of red food coloring into the vinegar to give a molten lava appearance.
7. Take your model outside before erupting! Pour the vinegar into the tube, and stand back!

Recipe for Homemade Modeling Dough

- 1 cup flour
- 1/2 cup salt
- 1 cup water
- 1 tablespoon cooking oil
- 2 teaspoon cream of tartar
- (Optional) food coloring

Mix all ingredients together and heat slowly, stirring constantly, until the mixture is thick and doughy. Let the mixture cool until it can be handled. Knead the dough ball a few times, then wrap in foil to store.



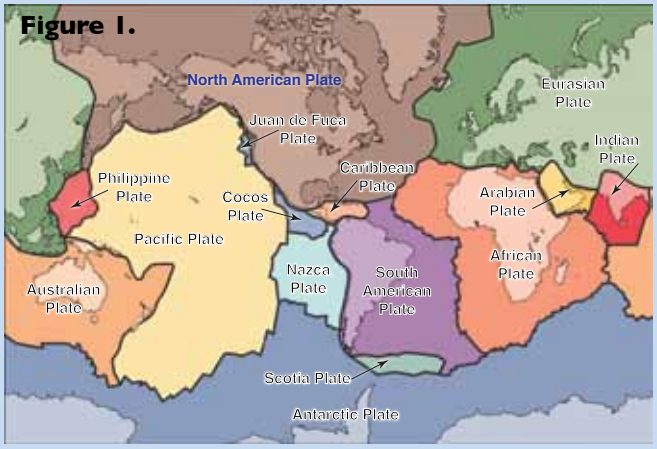
Fact Sheet #3:

Deep sea exploration can help predict earthquakes and tsunamis.

The geology of the seafloor around Indonesia is very complex and active. Active geology means that the land and seafloor of Indonesia frequently experience volcanoes, earthquakes, and tsunamis. Volcanoes in Indonesia have caused more human fatalities and generated more tsunamis than any other volcanic region on Earth. The reason for this geologic activity is that Indonesia is located at the junction of several tectonic plates that make up Earth's crust. Collisions between these plates cause volcanoes and earthquakes, and may also cause tsunamis.

On a global scale, Earth's crust seems to be divided into 14 large plates (Figure 1). At this scale, Indonesia is located at the junction of the Eurasian, Pacific, India, and Australian Plates. In many places, including Indonesia, there are also many smaller plates that make the geology much more complex. Figure 2 illustrates some of these smaller plates and their movement. The India and Australian Plates are pushing underneath the Burma and Sunda Plates, forming an arc of volcanoes in western Indonesia. To the east, several smaller plates collide in various ways that also produce earthquakes and volcanoes.

Figure 1.



Motion between these plates is not constant, because friction between the plates tends to keep them from moving. But while they are not moving, tectonic forces cause stresses to accumulate in the upper plate which gradually becomes deformed. Stresses may accumulate over centuries, until the deformation suddenly releases causing the plate to rebound. This plate motion produces an earthquake, as well as a giant underwater "kick" that generates a tsunami. The Banda Aceh earthquake and tsunami on December 26th, 2004 was caused by a sudden slip when the India Plate slid beneath the Burma Plate.

Deep sea explorations in other areas have mapped deformation patterns in tectonic plates, and used these patterns to predict earthquake and tsunami hazards. Similar information from Indonesia's deep sea can be used to help prepare for these hazards.

Discovery Activity #3:

Solve a Tectonic Puzzle

Make a copy of Figure 2 (following page) by
(a) Photocopying, OR
(b) Tracing, OR
(c) Drawing boundaries of tectonic plates onto a map of the Indonesian region.

If you are an educator, you may want to have students prepare copies using option (b) or (c).

Cut out each of the tectonic plates, and mix up the pieces. Now, assemble the plates into their correct positions. Turn this into a contest by measuring the amount of time required to place all of the plates in their correct positions.

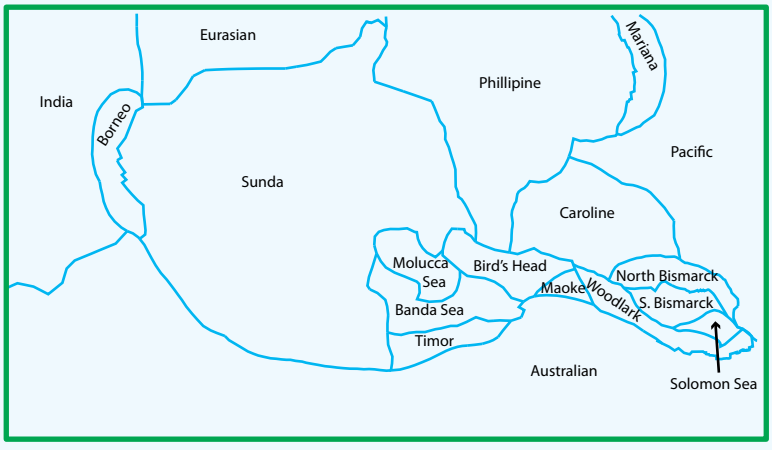


Plate boundaries. Students should cut along the blue lines on Figure 2 on the following page as shown above.

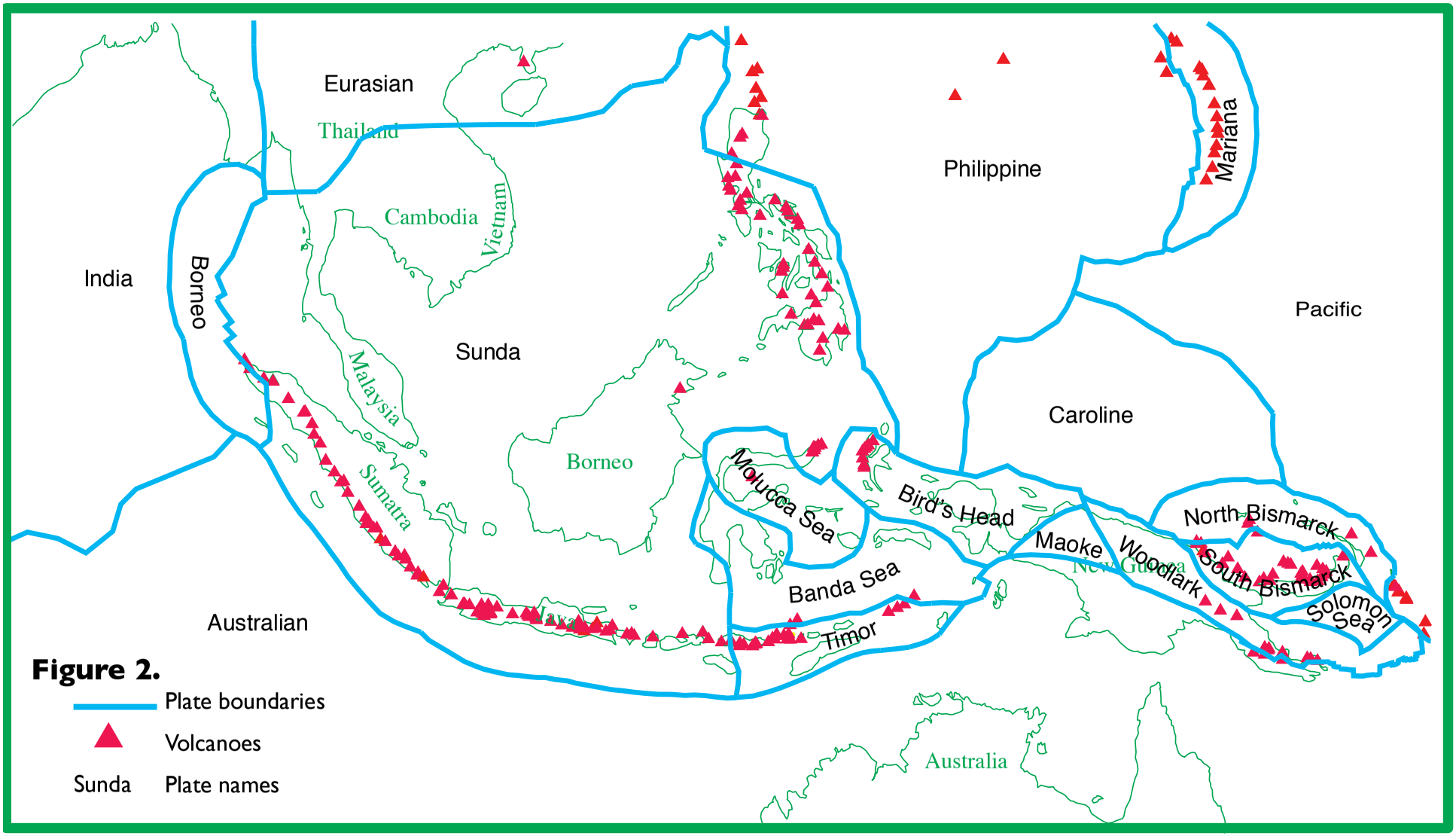

Eurasian
Thailand
Cambodia
Vietnam
India
Borneo
Sunda
Malaysia
Sumatra
Borneo
Philippine
Mariana
Pacific
Caroline
Moluccа Sea
Bird's Head
Maoke
New Guinea
Woodlark
North Bismarck
South Bismarck
Solomon Sea
Banda Sea
Java
Timor
Australian
Australia
Plate boundaries
Volcanoes
Sunda
Plate names

Figure 2.

Fact Sheet #4:
Changes in Earth's Climate are Affecting Deep Sea Systems

Earth's average temperature is now warmer than it has been at any time since at least 1400 AD. It is important to remember that averages include numbers that are higher and lower than the "average" value. So the warming in some areas can be much higher than the average while other areas may actually be cooler. Debate continues about the causes of climate change, but it is clear that

- Mountain glaciers are melting;
- Polar ice is decreasing;
- Springtime snow cover has diminished;
- Ground temperature has been increasing in many areas;
- Sea level has risen by several inches in the last 100 years.

Sea level rise makes coastal communities more vulnerable to storms and flooding. Another concern for Indonesia is the effect of higher temperatures on coral reefs. Many scientists believe that the health of coral reefs around the world is declining because of multiple stresses, one of which is increased water temperature.

While the deep sea might seem to be far away from the atmosphere, deep sea currents transport heat between all of the world's oceans. This deep ocean circulation is sometimes called the "global conveyor belt," and has a significant influence on Earth's climate. Some scientists are concerned that warmer temperatures at the ocean surface and increased freshwater inflow from melting ice may weaken the global conveyor belt. Ocean exploration can provide some of the essential knowledge about ocean-atmosphere interactions that is needed to understand, predict, and respond to these impacts.

Interaction between Earth's ocean and atmosphere is producing another stress that affects many marine organisms. Carbon dioxide in Earth's atmosphere has been increasing for many years, and this has caused more carbon dioxide to be dissolved in the ocean. This increase in dissolved carbon dioxide is causing ocean waters to become more acidic. Increased acidity interferes with the formation of shells and other skeletal structures in corals, shellfish, echinoderms, plankton and many other ocean plants and animals.

Limacina helicina, a free-swimming planktonic snail. These snails, known as pteropods, form a calcium carbonate shell and are an important food source in many marine food webs. As levels of dissolved CO_2 in sea water rise, skeletal growth rates of pteropods and other calcium-secreting organisms will be reduced due to the effects of dissolved CO_2 on ocean acidity. Image credit: Russ Hopcroft, UAF/NOAA.

Discovery Activity #4:
Make a Wall Magazine

Many people do not think about the deep sea and do not understand why deep sea exploration is important. A very important part of science and exploration is communicating results to other people. One way to do this is by creating a Wall Magazine. Based on information in these facts sheets and other sources, make a Wall Magazine that explains why it is important to explore Indonesia's deep sea. Be sure to explain biodiversity and why it is important, including the idea that new species may provide important drugs, food for humans, and other useful products. Your Wall Magazine should also mention that deep sea exploration can help predict natural disasters, and how climate change may affect Indonesians and their environment.

Be creative with the layout and content of your Wall Magazine. For example, the overall shape might look like a fish or shell. You will probably want to include illustrations, but you could also add your own essays, poems, short stories, songs, or other artwork. Present and explain your Wall Magazine to school groups, parents, or members of your community.

[**Note for Educators:** Wall Magazines are a powerful and entertaining way to enhance students' skills in writing and communication, information search and analysis, and presenting ideas in an aesthetic yet meaningful manner. Some of the best Wall Magazines consist of text and illustrations created entirely by students themselves.]