Dear Teachers,

Welcome in advance to the *Coral Reef* Student Classroom Program! Our Classroom programs are designed to connect teachers and students to science by providing classroom curricula and fieldtrip programs.

In this packet you will find:

- Pre and post-visit activities to use in your classroom
- Content and logistical information on the student fieldtrip program
- Exhibit Scavenger Hunt for students
- Other Resources & References to use in your classroom

The Coral Reef program is designed to help bridge classroom curriculum to the museum fieldtrip experience by reinforcing 4th and 5th grade life sciences standards, and K through 5th grade social studies standards. Research has shown that when students have some prior learning of a topic before a field trip, they will better be able to incorporate new ideas into their prior knowledge. Therefore, the enclosed materials are intended to prepare you and your students for the field trip experience.

Thank you for choosing to participate in the program. If there is anything that we can do to help you plan your trip or improve the programs that we offer, please don't hesitate to contact me!

Happy Exploring,

Lindzy Bivings

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Teacher Resource Guide

Coral Reef

Field Trip Program

Grades 4 – 5

Made possible by a generous donation from the
Arthur and Toni Rembe Rock Fund.
www.calacademy.org/teachers/rockprogram

Teacher Resource Guide

Coral Reef

Grades 4 - 5

Contents

CALIFORNIA ACADEMY OF SCIENCES

Coral Reef Classroom Program

California Content Standards

This activity reinforces the following correlated California content standards: **1a, 1b, 1c, 2a and 2b** (See page 32).

Objectives

In this classroom activity, students will:

1. Learn basic reef-building coral biology, including their colonial structure and symbiosis with zooxanthellae.
2. Study coral specimens up close.
3. Enact the exchange between zooxanthellae and their coral hosts.
4. Explore the causes and concerns about coral bleaching.
5. Brainstorm practices people can adopt to reduce global warming and coral bleaching.

Summary

Students learn about reef-building corals by practicing the study of coral specimens and "living" corals as a biologist might. This program is divided into two main parts: 1) the study of coral specimens through focused drawing excercises; and 2) the demonstration of the exchange between corals and their algae symbionts in the form of a student skit. Between these activities, instructors relate and review important concepts in coral biology and conservation. The final minutes of this program are devoted to a class discussion of the threats facing coral reefs and how we humans can mitigate them.

Teachers may pair this program with a Coral classroom kit teacher workshop and rental. For more information on the Coral Kit and Teacher Workshop, please visit: http://www.calacademy.org/teachers/erk.php

Field Trip Program Outline

Welcome to the Academy!

- We talk about the scientific research of the Academy and the use of research collections.

Coral Reef Conservation Slideshow Part 1

- What is coral?
- Reef building corals form colonies of countless polyps.
- Living corals can be very colorful.

Coral Specimen Study

- Students will study coral skeleton specimens by drawing them.
- Students draw a chosen specimen on Study Sheet, before drawing the living coral on overlay.

Coral Reef Conservation Slideshow Part 2

- How do corals eat? We explain the relationship between corals and zooxanthellae.
- We describe the marine environment zooxanthellae require in order to be healthy.

Coral Bleaching Skit

- We have 3-4 volunteers act as coral polyps, wearing white tunics.
- We have 2-3 students act as ocean currents, wearing blue tunics.
- We enact scenarios in which currents give corals zooxanthellae and then take them away.
- Original polyps may die and new corals may come stand beside them (if time allows).

Study Sheet Questions and Slideshow Part 3

- We have students answer questions on back of the Study Sheet using slides for review.

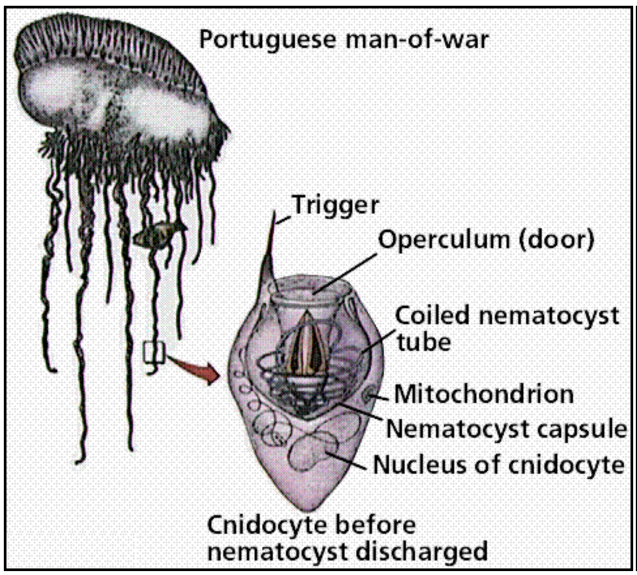
Conclusions

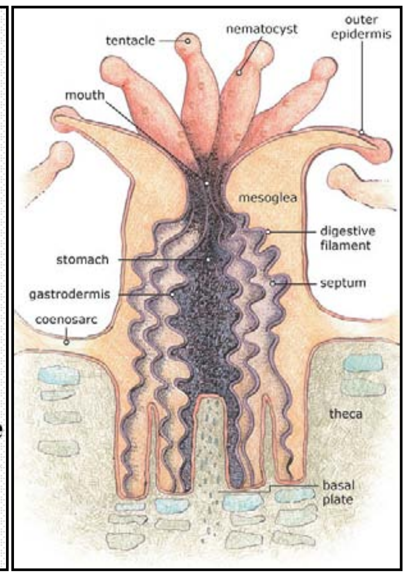
- We list threats to coral reefs on the whiteboard.
- We list measures students may take to help protect reefs.

Background Information

Corals as Animals

Corals belong to the **phylum** *Cnidaria* that contains hydras, sea anemones, corals and jellyfish. Cnidarians are radially symmetrical animals with an opening at one end. This opening is used to both take in food and expel waste materials. The opening is surrounded by **tentacles** that are used to capture food. The tentacles have specialized stinging structures called cnidocytes. The body of a coral animal is called the coral **polyp**.



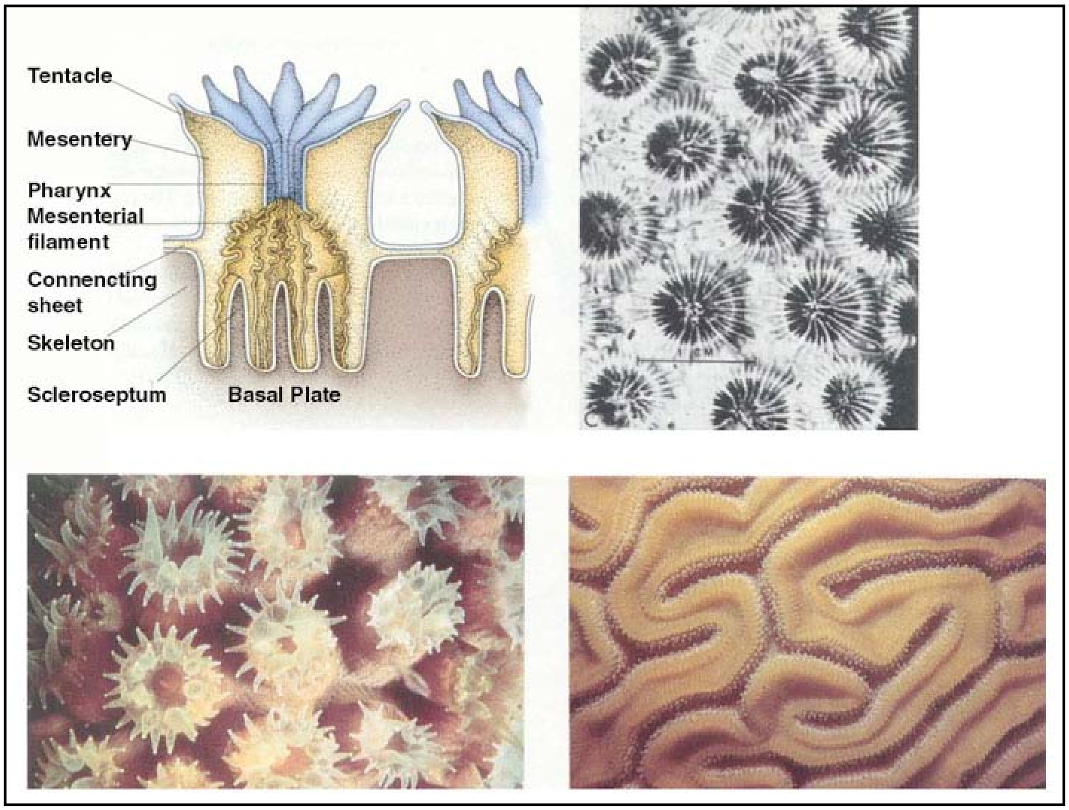


Students may initially think that corals are plants. The following are differences between plants and animals:

Plants	Animals
Plants use the sun's energy to make food through a process known as photosynthesis**.**	Animals cannot produce their own food from the sun and must eat other organisms in order to get energy.
Plants have chlorophyll **in their cells to capture light energy.**	Animals do not have chlorophyll in their cells.
Plant cells have walls.	Animal cells don't have walls and their cells are more flexible and variable in shape.

Within the phylum **Cnidaria**, there are two subclasses that contain coral: Hexacorallia and Octocorallia.

Hexacorallia contains hard corals (stony corals), which secrete a hard, external limestone skeleton. A hard coral polyp extracts calcium carbonate from the ocean water and deposits it in layers around the lower half of its body, forming a cup-shaped shell. Colonies of coral polyps fuse their limestone shells; and it is these fused shells that form the hard, rock-like structure of coral "skeletons." These animals are called reef-building corals because the skeletons remain after the corals die and form a base upon which other corals can settle.



Hard corals are classified within Hexacorallia because their tentacles are arranged around the mouth in multiples of six. Hard corals grow in three basic forms: massive, branching, and plate. Examples include brain coral (a massive coral), elkhorn (a branching coral), and leaf coral (a plate coral).

Brain coral

Elkhorn coral

Plate coral

Octocorallia contains soft corals that do not produce a hard skeleton. These animals do not significantly contribute to the building of a reef. When a soft coral animal dies, its tissue decomposes and disappears. Soft corals are classified within Octocorallia because their tentacles are arranged around the mouth in multiples of eight. Soft coral polyps are generally attached to fleshy, flexible bases that sway in the ocean currents.

Zooxanthellae

Hard corals and some soft corals host **zooxanthellae** within their tissue. Zooxanthellae are microscopic, single-celled plants, belonging to a group called dinoflagellates. Like terrestrial plants, zooxanthellae are able produce their own food through photosynthesis. Zooxanthellae are found inside translucent, outer tissues of corals as well as other marine organisms. They also live freely in the water column. Zooxanthellae need sunlight in order to photosynthesize; therefore, they cannot live in deep or dirty water.

Zooxanthellae that live in marine animals have a mutually **symbiotic** relationship with their host. This means that both the coral and the zooxanthellae benefit from being in the relationship. The zooxanthellae photosynthesize from within their host. Photosynthesis produces sugars essential for the zoothanthellae to grow and these sugars also provide nutrition to the host organism. In return, the host coral assists the growth of the zooxanthellae by passing on some of its dissolved organic waste which the zooxanthellae use as a nutrient source.

This symbiotic relationship between zooxanthellae and coral polyps is complex and intimately linked. The following are some of the details of that relationship:

- During photosynthesis, zooxanthellae use CO_2, H_2O, and sunlight to produce O_2 and carbohydrates (sugars).
- During respiration, coral polyps use O_2 and C to produce CO_2.
- The zooxanthellae use the CO_2 produced by the coral polyp in photosynthesis and N (nitrogen) waste products from the coral polyp for food.
- The coral polyp uses O_2 produced by the zooxanthellae to "breathe" during respiration and uses the carbohydrates (sugars) produced by the zooxanthellae for some of its food.

In addition to getting sugar from their zooxanthellae, coral polyps can also act as micro-predators, catching microscopic plankton with their tentacles.

In their larval form, many corals have no zooxanthellae and must acquire them from the water column. The juvenile coral filters its food and zooxanthellae from the seawater. Once in the stomach of the host, zooxanthellae are passed into the outer flesh of the organism. Zooxanthellae multiply by cell division.

Field Trip Logistics

When you arrive at the California Academy of Sciences a guest services staff member will greet your class at the bus or when you walk up. They will check you in and lead your class into the museum.

Where is my program?

Once inside the museum, you will need to go to the Classroom on Level 3, near the Naturalist Center to meet the educators of your program at the appointed time.

How can I prepare my chaperones for the visit?

We offer 2 page chaperone guides in English, Spanish and Chinese. These are designed to help you plan your visit with them before arriving at the Academy. They include a map of the main floor, suggestions for guiding their group through the museum and questions they can use with the students to deepen their learning experience. You can find them on our website at:
English: http://www.calacademy.org/teachers/upload/docs/chaperone_guide.pdf
Spanish: http://www.calacademy.org/teachers/upload/docs/chaperone_guide_spanish.pdf
Chinese: http://www.calacademy.org/teachers/upload/docs/chaperone_guide_chinese.pdf

Where can we eat lunch?

If your students have brought their lunches, they can eat outside at the tables provided on the east side of the building, the side with the penguins and Galapagos tortoises. Students may also sit on the grass outside on the west side of the building. Feel free to have the students hands stamped upon exit, so that you can eat outside the Academy grounds and return to visit after they have eaten.

Exhibit Connections

If you have extra time before or after your visit, we highly recommend you spend some time in the exhibits. It is unrealistic to see every exhibit during the field trip and so we recommend choosing a few to go to. The exhibits that connect to the field trip program are listed below. You may come preview the exhibits for free before your field trip. Just show your field trip confirmation at the door.

- Philippine Coral Reef:
  At a depth of 25 feet and holding 212,000 gallons of water, the Philippine Coral Reef is one of the deepest exhibits of live corals in the world. It houses a broad range of aquatic life from the coral reefs and mangroves of the Philippines, one of the most diverse reef systems in the world. These animals include delicate soft and hard corals, blacktip reef sharks, stingrays, and more than 2,000 colorful reef fish.

- Northern California Coast:
  The 100,000-gallon Northern California Coast tank replicates the habitats of the Gulf of the Farallones National Marine Sanctuary. A walkway along the surface allows visitors to smell the seawater and witness the filling and draining of tidepools as waves spill onto a small beach. A large, L-shaped underwater window reveals the eels, anemones, sea stars, rockfish, herring, sardines, and urchins that live beneath the water's surface. Nearby tanks feature a giant sea bass and a giant Pacific octopus. There's also Discovery Tidepool where visitors can touch and examine a wide variety of ocean creatures.

- Altered State:
  The Altered State exhibit explores the effects of climate change on California's natural habitats, such as the Farallon Islands, and on the planet at large. Measure the impact of everyday decisions on a carbon scale and share ideas for treading more lightly on the planet. This exhibit is supported by Pacific Gas and Electric Company

Stony Coral Scavenger Hunt

Objectives

Through this scavenger hunt, students will look in the aquarium for living corals that match the coral skeletons on their worksheet. Students will discover more about the habitat of these corals and their role within the reef community.

Materials

1. Stony Corals Scavenger Hunt Worksheet (1 per student)
2. Pencil
3. Colored pencils (optional)
4. Clipboard or hard writing surface (optional)

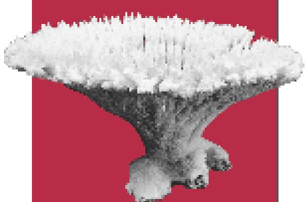
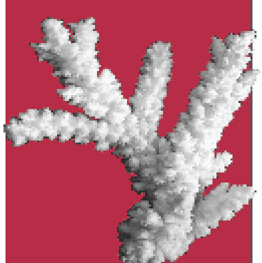
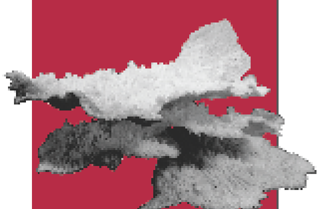
Notes

This scavenger hunt is the reverse of the classroom activity for Coral Reefs. Here students find living specimens and see if they can figure out what the skeleton below might look like. Their familiarity with the skeletons from class will help them. The aquarium is a noisy place, so you may find it easier to distribute the worksheets to the chaperones and have them lead the hunt with their individual groups.

Stony Corals Scavenger Hunt

Coral Reefs

You have been hired by the California Academy of Sciences to help find endangered stony corals. While exploring the various reef exhibits, see if you can find living animals that match the pictures of the skeletons below. When you find a living coral that matches a skeleton, draw the living coral in the box to the right and answer the following questions.

Coral Skeletons		
 Cauliflower Coral	Draw the living coral here	What color is the living coral? Why is it that color?
 Table Coral	Draw the living coral here	Does this coral get much sunlight, or does it live in the shadows?
 Branching Coral	Draw the living coral here	Why do you think this coral colony is shaped this way?
 Plating Coral	Draw the living coral here	What animals do you notice around this coral?

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Mapping Animal Behavior Scavenger Hunt

Objectives

Students will make behavioral observations of fish in a reef community, just like an Academy scientist would. Students will discover more about the activity of fish by focusing on four common behaviors of fish: eating, resting, chasing and pooping.

Materials

1. Mapping Animal Behavior Worksheet (1 per student)
2. Pencil
3. Colored pencils (optional)
4. Clipboard or hard writing surface (optional)

Notes

Many students will never have made behavioral observations before. As the Academy is a noisy place, it will be difficult to give instructions to an entire class. It may be useful to practice making behavioral observations before visiting the Academy. Students could choose 4 behaviors and then observe their classmates on the playground or eating lunch, making a map and legend of those behaviors. After visiting the Academy, they can then compare their maps of human behavior with their maps of fish behavior.

Mapping Animal Behavior — Coral Reefs

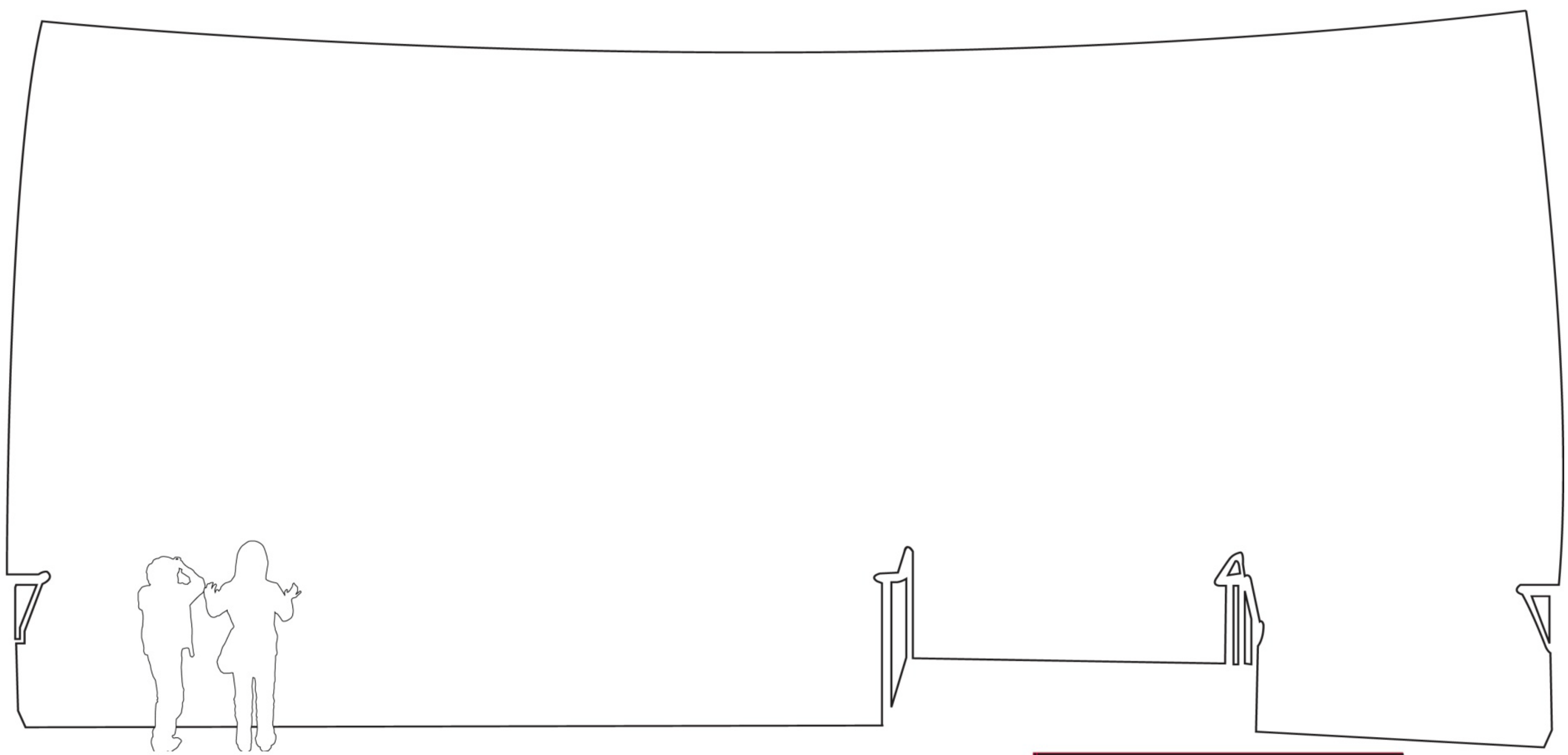
Name: ____________________

Date: ____________________

Start Time: ____________________

End Time: ____________________

What to do: Sit down in front of the large Philippine coral reef tank for at least 7 minutes. Use the outline of the tank and the map legend below to create a "Behavior Map." When you observe a fish doing a behavior, draw the symbol on your map where it occurred. You may add your own symbols too!



1.) Which behavior did you observe the most? ____________________

2.) Why do you think that behavior occurred more than the others?

____

Map Legend

△ Eating	Chasing
Resting	● Pooping

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Behavioral observations continued...

Coral Reefs

There are over 4,000 fish in this tank that Academy biologists study by observing their behaviors (A behavior is how an animal reacts to the environment, its personal needs and other organisms around it.) Discuss the following questions with your group and write down your observations.

Fish Interactions (schooling, chasing, competing, ignoring, hiding, defending, mating, etc.):	
Watch a group of two or more fish of the same species. How do they interact with each other?	How do fish from different species interact with each other?

Other Observations:	
What other animal behaviors do you notice?	Play a matching game! Describe a type of fish and its behaviors while other classmates and chaperones try to guess which one it is. What types of clues are most helpful?

Scientists ask many questions:	
Write down a few questions you have about the animals, their behaviors, or the exhibit.	Ask a docent (person wearing an orange coat) or visit the Naturalist Center on Level 3 to get an answer to one of your questions. Write your answer here.

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To learn more about what our scientists study and to get more fun activities like this one visit our website: www.calacademy.org/teachers.

Pre-Visit Activity: Build a Coral Polyp

GRADE LEVEL	3rd-5th; California Content Standards for 3rd and 4th
SUBJECTS	Life Sciences
DURATION	Preparation: 10 minutes Activity: 35 minutes
SETTING	Classroom

Correlated California State Content Standards

Grade 3: Life Sciences **3a and 3b**
Grade 4: Life Sciences **3d** (See page 46).

Objectives

In this lesson, students will:

1. learn the anatomy of a coral polyp.
2. review the differences between plants and animals.
3. learn about the unique symbiotic relationship between corals and zooxanthellae.

Materials

1. paper towels/rag for clean-up
2. plates (1 per student)
3. toothpicks (1 per student)
4. plastic straw (1 per student)
5. section of large banana (1 per student)
6. sour candy straws or twizzlers cut into 1 inch pieces (6 per student)
7. sugar sprinkles (same color as the sour candy straws or twizzlers)
8. jam
9. round crackers (1 per student)
10. oyster crackers (5-6 per student)
11. transparency of coral polyp illustration
12. coral polyp worksheets (1 per student)
13. colored pencils, crayons, or markers

Background

Corals are animals that belong to the phylum Cnidaria, which contains sea anemones, jellyfish, hydra, and corals. The name "Cnidaria" comes from the Greek word "cnidos" which means stinging nettle. Cnidarians are radially symmetrical with an opening at one end that is surrounded by tentacles. The tentacles have specialized stinging structures called nematocysts that are used for protection and to capture prey. The tentacles bring food into the animal's one opening, which is used both to take in food and to expel waste materials. The coral animal, made up of its tube-shaped body, its tentacles, and its mouth, is called a coral polyp.

There are two main types of corals: hard corals and soft corals. Hard corals are classified within the subclass Hexacorallia because their tentacles are arranged around the mouth in multiples of six ("hexa" = six). They are called hard corals because they extract calcium and carbon from the ocean water and deposit a hard calcium carbonate skeleton that surrounds the lower portion of the body. Coral polyps fuse their skeletons together and form large coral colonies. These fused polyps are the basis for coral reefs. Coral polyps extend their tentacles from their skeleton to feed and withdraw into the skeleton for protection. Thus, the appearance of a coral colony can look very different depending on whether the polyps are extended or not. When hard coral polyps die, the calcium carbonate skeleton remains intact. You can often find pieces of white coral, the remains of former coral colonies, washed up on tropical beaches.

Soft corals are classified within the subclass Octocorallia because their tentacles are arranged around the mouth in multiples of eight ("octo" = eight). Soft corals do not produce a hard external calcium carbonate skeleton and therefore do not contribute significantly to the building of reefs. They do however have small, hard internal structures called spicules, which are uniquely shaped for each species and are used to help identify soft corals. When soft coral polyps die, they decompose and simply disappear, except for their small spicules.

Hard corals and some soft corals contain zooxanthellae within their tissue. Zooxanthellae are marine algae, some of which are free living and some of which live inside the translucent, fleshy tissue of many corals and other marine organisms. Zooxanthellae that live in marine animals have a mutually beneficial symbiotic relationship with their host. This means that both the coral and the alga benefit from being in the relationship. The zooxanthellae photosynthesize from within their coral host and produce sugars that provide nutrition to both the zooxanthellae and the coral. In return, the coral provides protection and assists the growth of the zooxanthellae by passing on some of its waste, which the zooxanthellae use as a nutrient source. It is the colorful zooxanthellae that give coral their different colors and because zooxanthellae need sunlight to perform photosynthesis, they are the reason why corals need sunshine to survive.

If coral is affected by an environmental stress such as increased temperature or sedimentation, the zooxanthellae leave the coral and the coral turns white. This is termed coral bleaching. Although zooxanthellae can live freely in the water without coral, corals that normally contain zooxanthellae in their tissue cannot survive for long without their symbiotic algae. They will slowly starve. Thus, coral bleaching can be lethal for the coral if the coral polyps do not reacquire zooxanthellae. The phenomenon of coral bleaching is of particular concern as sea surface temperatures rise with human-induced climate change.

Activity

Preparation

1. Set out enough plates for each student to have one.
2. On each plate, place…
   - 1 piece banana
   - 1 toothpick
   - 1 straw
   - six candy straws/twizzlers
   - small pile of sprinkles
   - 6-8 oyster crackers
   - 1 round cracker
   - small amount of jam

Discussion

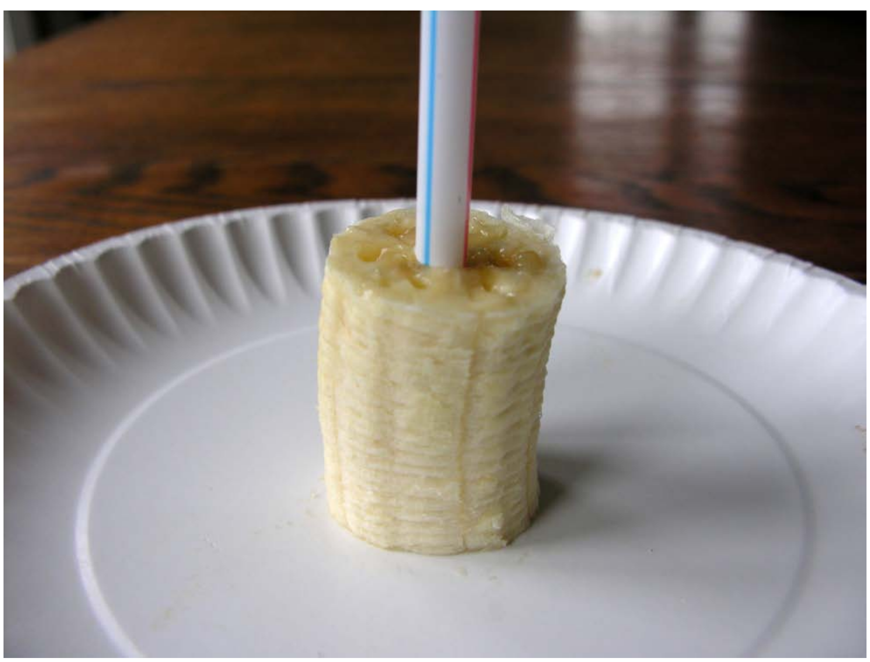
1. Ask students, "How many of you think coral is a plant? How many of you think coral is an animal?"
2. Corals are animals! Go over some of the big differences between plants and animals. Make a table on the board.

PLANTS	ANIMALS
Plants use the sun's energy to make food through a process known as **photosynthesis**.	Animals cannot produce their own food from the sun and must eat other organisms in order to get food and energy.
Only plants have roots, stems and leaves.	Animals do not have roots, stems and leaves.
Plants generally do not move from one place to another.	Animals generally can move to catch food.
Plants have **chlorophyll** in their cells to	Animals do not have chlorophyll in their cells.

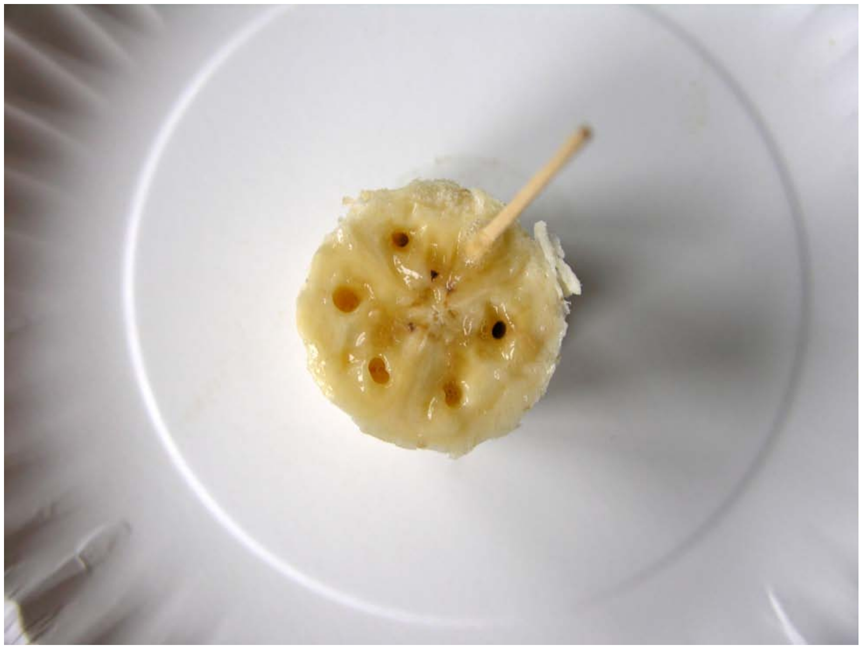
capture light energy.	
Plant cells have walls.	Animal cells don't have walls and their cells are more flexible and variable in shape.

3. Show students the coral polyp overhead transparency and discuss all of the labeled parts: tentacles, mouth, gut, skeleton, and zooxanthellae. Find pertinent information for this discussion in the background section above. (Note that it is very difficult to draw a typical coral polyp as there is a lot of variation in their forms. This illustration shows the basic components of coral polyps. Although the skeleton sits underneath the polyp in this illustration, the skeleton is actually outside the polyp itself and the polyp can contract and retract inside the calcium carbonate skeleton for protection.)
4. Ask students, "What makes this coral polyp an animal?" *(It eats other organisms by capturing them with its tentacles. It does not have plant parts. It cannot make food from the sun's energy without the help of zooxanthellae.)*
5. Tell students they are going to do a very cool activity: make an edible coral polyp.
6. Hand out one plate of materials to each student.

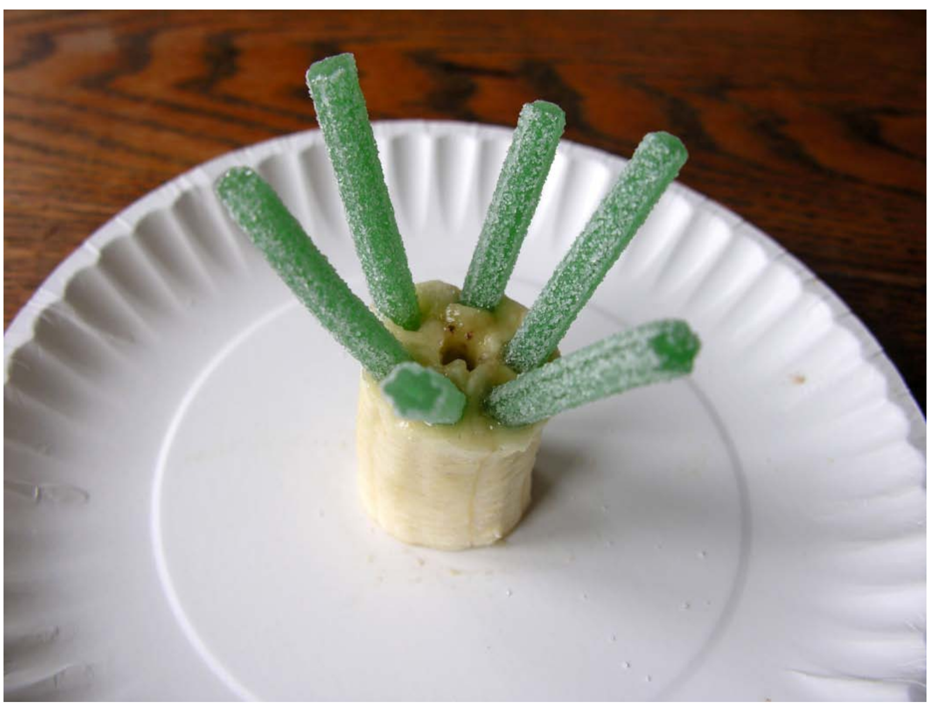
Directions for Making a Coral Polyp



1. Make a hole (the mouth) in the top half of the banana with a straw. Be careful not to go all the way through the banana as coral polyps have one hole, not two.



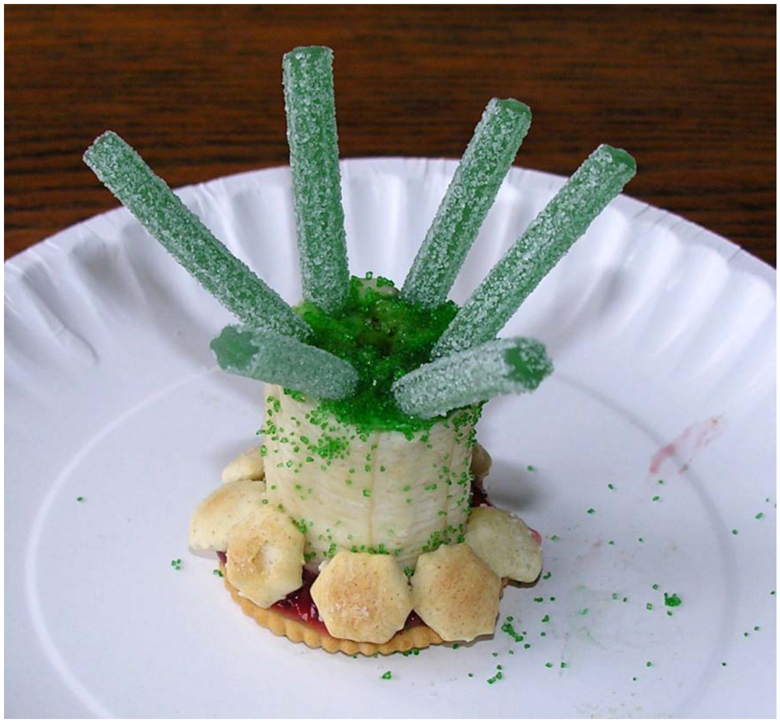
2. Create six holes with a toothpick surrounding the central mouth.



3. Poke 6 candy straws or twizzlers (the tentacles) into the holes.

4. Add sprinkles (zooxanthellae) to the banana.

5. Add round cracker and jam (coral is attached to the substrate).



6. Add oyster crackers around the base (calcium carbonate skeleton).

7. Students can place individual coral polyps together to form a colony.

Wrap-Up

- Hand out one coral polyp worksheet to each student.
- Students draw their coral polyp and answer the questions on the worksheet.
- Remind students that there are a lot of different animals that live on reefs. People sometimes call coral reefs the "rainforests of the ocean" because there are so many different animals there just like in the rainforests.
- Tell students they can pretend to be predatory fish, such as parrotfish, that eat coral. Students can eat their polyps, but since fish don't have hands encourage your students to eat without using their hands.
- Discuss coral reef threats and conservation with your students.
- Explain that coral reefs are in danger of disappearing because of changes that people are making to the oceans.
- What do you think people are doing to change the reefs? (*fishing too much, polluting, physically damaging the reef by taking coral or anchoring on top of coral, breaking off coral while swimming, taking coral for jewelry, developing coastal areas which can cause increased sediment in the water and smother coral, and climate change is making the water too warm and too acidic)*
- What can we do? (*Reduce, reuse, and recycle to help stop pollution, don't get too close to reefs, don't buy coral jewelry, reduce fossil fuel emissions associated with climate change, and help spread the word to friends and family).*

References

Adapted from:
1. Ayres, R. California Academy of Sciences. *Coral Polyp Party.*

2. California Academy of Sciences' Educator Resource Materials. (2007). *Coral Symbiosis: Coral Polyp and Zooxanthellae.*

University of California Museum of Paleontology, Taxon Lift. *Introduction to Cnidaria.* Retrieved April 28, 2008 from http://www.ucmp.berkeley.edu/help/taxaform.html

Pre-Visit Activity: Colorful Fish Adaptations

GRADE LEVELS	3rd-5th; California Content Standards for 3rd and 4th
SUBJECTS	Life Sciences, English Language Arts
DURATION	Preparation: 20 minutes Activity: 30-45 minutes
SETTING	Classroom

Correlated California State Content Standards

Grade 3: Life Sciences **3a**; English Language Arts: Listening and Speaking **1.9**
Grade 4: Life Sciences **3b**; English Language Arts: Listening and Speaking **1.9**
(See page 46)

Objectives

In this activity, students will:

1. learn that color is an important adaptation for many coral reef fish.
2. learn how to write haiku and practice their speaking skills by reciting their own haiku.

Materials

blank paper (1 per student)
colored pencils, crayons, or markers
pictures of fish with color adaptations

Teacher Background

This classroom activity will focus on the colorful adaptations of coral reef fish. The associated sketching activity at the California Academy of Sciences, Colorful Coral Reef Sketching, will take a broader look at color and will allow students to look for creatures of every color of the rainbow.

Coral reef fish have a huge variety of colors and patterns. Because coral reefs are in clear water, colorful adaptations can be seen and can serve a variety of functions. Although there are many different functions for these colors and patterns, the two main functions are to camouflage or to signal to other fish. Below is a table that details some of the specific kinds of camouflage and signaling.

Camouflage	Signaling
Misdirection – some coloring may direct a predator in the wrong direction. For example, some fish have spots near their tails that look like eyes. These eyespots encourage predators to attack the tail end instead of the head, enabling the prey fish to escape.	Display gender – in most fish species the males and females look the same, but in some species, coloration helps distinguish what gender an individual fish is.
Disruptive – some patterns such as stripes or spots can help camouflage a fish by breaking up its outline. A predator might only see the stripes or spots and not recognize it as a fish.	Looking for a mate – some coloration helps fish find a mate. In certain species, fish actually change color when they are about the spawn.
Countershading – some fish are dark on top and lighter on the bottom. This is called countershading. From below the fish blend in with the light surface water and from above they blend in with the dark, deep water.	Advertise – colors and patterns can advertise a number of different things including that a fish is poisonous.

Preparation

Print or find a book with a few pictures of coral reef fish with color adaptations. Examples of fish to look for are detailed below.

- Misdirection: Many butterflyfish, including the threadfin butterflyfish (*Chaetodon auriga*), have eyespots that misdirect predators.
- Disruptive: Many bannerfish have disruptive stripes. Many grouper have disruptive stripes or spots.
- Countershading: Examples of fish with countershading include tuna, mackerels, and blacktip reef sharks.
- Display gender: Male and female wrasses, parrotfish, and angelfish tend to look quite different from one another.
- Looking for a mate: Male sergeant-majors develop white masks when preparing to mate.
- Advertise: Lionfish have bold black, white, and red colors that advertise their poisonous spines

Activity

Introduction

- Go over the term adaptation with your students, giving a few examples.

- Tell your students you are going to take a trip to the California Academy of Sciences and see a living coral reef that is extremely colorful. Color is an adaptation that can help organisms survive.
- Tell them that before their trip, they are going to create their own colorful coral reef fish.
- Show students the pictures of fish with color adaptations.
- Ask your students why coral reef creatures might have the adaptation of color.
- Use the table in the teacher background section to write a list on the board of reasons why fish have color adaptations. *(In general, they have color adaptation to signal something or to camouflage from something.)*
- To simplify the activity, choose either camouflage or signaling.

Procedure

1. Tell students to choose one of the reasons for color adaptations listed on the board.
2. Tell students to invent and draw a fish that uses its color for the function they have chosen. For example, one student might choose to draw a fish that misdirects its predators with eyespots.
3. Once students have completed their drawings, tell students that they will now write a brief haiku, a kind of poem, to explain their fish's color adaptation.
4. Instruct students on how to write haiku. Haiku are short poems with only three lines consisting of five syllables, seven syllables, and then five syllables again, in that order.
5. Practice recognizing how many syllables are in a word. Say a word such as "coral" and have the students clap for each syllable. Repeat with words of varying syllables until students seem to get the idea.
6. Use the sample haiku below, which is written about countershading, to help students in their composition. You can read it aloud, helping the students count the syllables as you go, and/or write in on the board.

I am dark on top	(five syllables)
But much lighter underneath	(seven syllables)
To trick predators	(five syllables)

Wrap-Up

1. One at a time, ask students to stand up and read their haiku.
2. Remind them to use pace, rhythm, and pauses to convey the poem appropriately.

References

Broad, G. (2003). *Fishes of the Philippines.* UK: Anvil Publishing Inc.

California Academy of Sciences' Steinhart Aquarium text.

Where in the World are Coral Reefs?

GRADE LEVEL	4^{th} – 8^{th}; California Content Standards for 4^{th} and 6^{th}
SUBJECTS	Life Sciences, Historical and Social Sciences
DURATION	Preparation: 15 minutes Activity: 20-30 minutes
SETTING	Classroom

Correlated California State Content Standards

Grades K-5: Historical and Social Sciences Analysis Skills: Chronological and Spatial Thinking **4**
Grade 4: Life Sciences **3a and 3b**
Grade 6: Life Sciences **5e**
(See page 46)

Objectives

In this activity, students will:

1. learn where coral reefs naturally exist.
2. learn the environmental factors that are necessary for coral reef growth.

Materials

for each group, one set of maps, including

- blank "Where in the World is Coral" map
- map showing cold currents
- map showing ocean depth
- map showing rivers
- map showing distribution of coral

Teacher Background

Coral reefs are primarily found in warm tropical oceans between 30° North *latitude* and 30° South latitude. However, coral reefs occur in very specific distributions within this zone because they are highly sensitive to a number of factors discussed below.

Temperature is extremely important for coral reef growth. The optimum temperature for the growth of reef-building corals is 20-28°C. If the temperature is below 18°C, coral growth is limited. If the temperature is too high, the zoothanthellae will evacuate the coral tissue. Seawater temperatures are affected by complex ocean currents that in turn result from physical factors such as land masses, gravity, the Earth's spin, and wind. For our purposes, it is important to note the presence of five major *cold currents* that exist between 30°N and 30°S. These currents are known as the California, Peru, Benguela, Canary and Western Australian currents. These currents bring unusually cold water from the bottom of the ocean into warmer areas, preventing coral reef growth. All of these cold currents are found along the Western coasts of major continents.

Light is critical in maintaining the symbiotic association between corals and symbiotic algae (zooxanthellae). The intensity of light greatly affects photosynthetic rates of the zooxanthellae, indirectly impacting coral growth and survival. Abundance of corals decrease rapidly with depth due to reduced light levels. In clear tropical waters, corals may live as deep as 150 feet (48 m), with a limited number of species found beyond that depth.

Excessive *sedimentation* reduces available light for coral growth. Rivers bring silt into marine environments and that is why corals do not grow where rivers empty into the ocean. Excessive sedimentation reduces available light, inhibiting photosynthesis by the symbiotic algae. Silt also settles on the coral surface, blocking feeding and respiration.

Corals, additionally, require *salinities* between 30 and 40 parts per thousand. The amount of dissolved salts in the water is referred to as salinity and is measured in parts per thousand (ppt). Most of the world's oceans fall within the range of corals' salinity requirements with the exception that coral reefs are not found near the mouths of rivers because the salinity is too low.

Sixty percent of the world's reefs are in the Indian Ocean and the Red Sea, 25% are in the Pacific Ocean, and 15% are in the Caribbean Ocean.

Complex ocean currents that influence seawater temperature, location of land masses, location of river mouths, and ocean depth are all factors that influence where corals can grow. In general, corals ***will not*** be found in areas of high latitude, with cold ocean currents, deep water, or near river mouths.

Activity

Preparation

1. Make copies of the maps, providing one complete set for each group of students
2. Familiarize yourself with the transparencies and the information that they display.

Introduction

- Discuss with students the factors that are required for coral to grow successfully. Reef-building corals need warm water temperatures, plenty of sunlight, and the correct salinity. As a result, these corals CANNOT live:

  - in cold water. Water north of 30°N or south of 30°S is too cold. Cold currents are also inhospitable.
  - in deep water. Not enough light is available for photosynthesis in deeper waters.
  - near river mouths. The salinity of the water is too low in areas where rivers are feeding freshwater into the sea. In addition, rivers deposit sediments that cloud the water and block the light needed for photosynthesis.
- Explain to students that they will be trying to predict where in the world coral reefs should be able to grow. The students will study maps that show the global distribution of cold water currents, deep and shallow water, and river systems. Based on this information, they will identify areas where the conditions are right for coral growth.

Procedure

1. Distribute the blank map, the cold current map, the depth map, and the river systems map. Review with your students what each map shows. (Do not distribute the map showing the distribution of coral yet!)
2. Instruct them to draw stars (or some other symbol) on the blank map to label locations where they think coral reefs could grow successfully. Each group should try to choose three locations.
3. Remind them to discuss the question with their group members, and to keep all the necessary factors in mind.
4. If desired, you could assign one student in each group to be responsible for each map. In other words, one student would be an "expert" on the cold current map, one the expert on the ocean depth map, and one on the rivers map. The student in charge of the map is responsible for making sure the locations chosen by the group meet the criteria of their particular map. This will help students remember to consider all the data as they make their predictions. Alternatively, the group can work collectively, with all students looking at all maps.
5. Give each group a chance to share their predictions with the class. Have them explain how they chose their locations. If desired, you could also require them to write an explanation of their selections, describing how each location meets the needs of the reef-building corals and how they figured that out.
6. After the predictions have been made, distribute the map showing the actual distribution of coral reefs. Let students check their predictions against the real distribution and give them time to discuss the results.

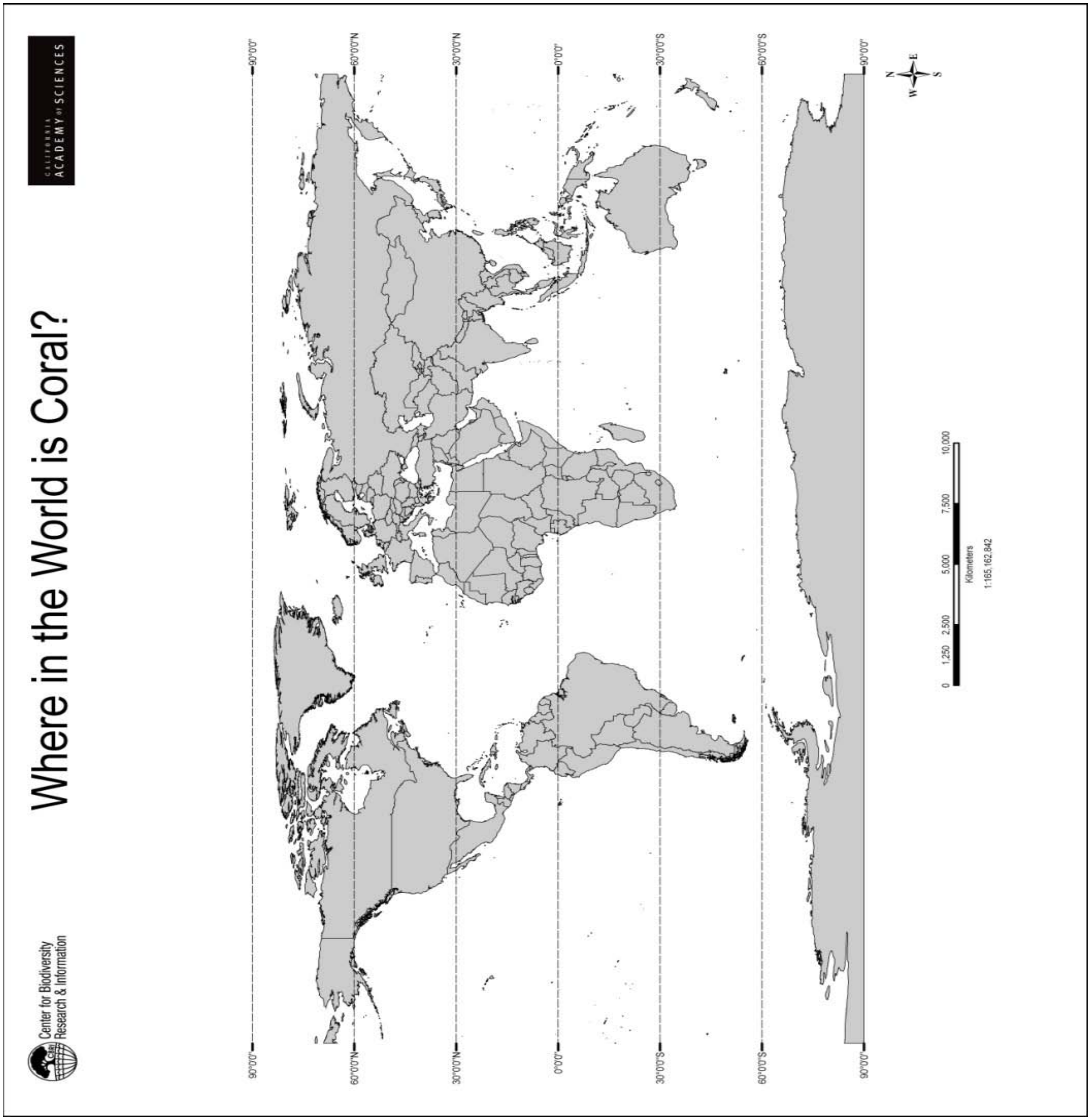
Wrap-Up

Discuss the following questions:

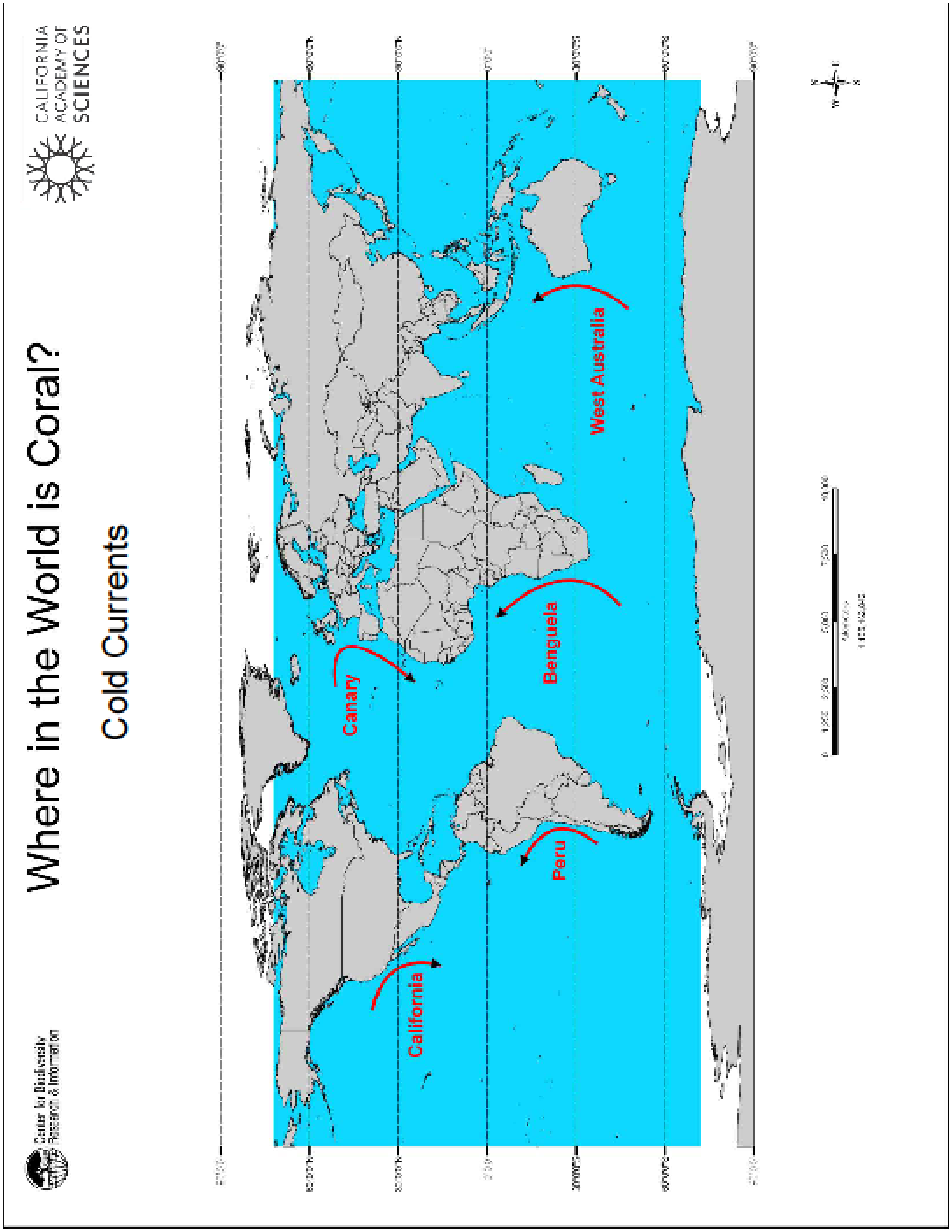
- How closely do your maps match the actual distribution of coral reefs?

- What are some reasons that the match might not be perfect?
- Why might there be some areas that have the right combination of conditions, but do not actually have coral reefs? *(The fact that it is* possible *for coral reefs to form in a certain area doesn't necessarily mean that they* will *form. In addition, other local factors may prevent reefs from forming.)*

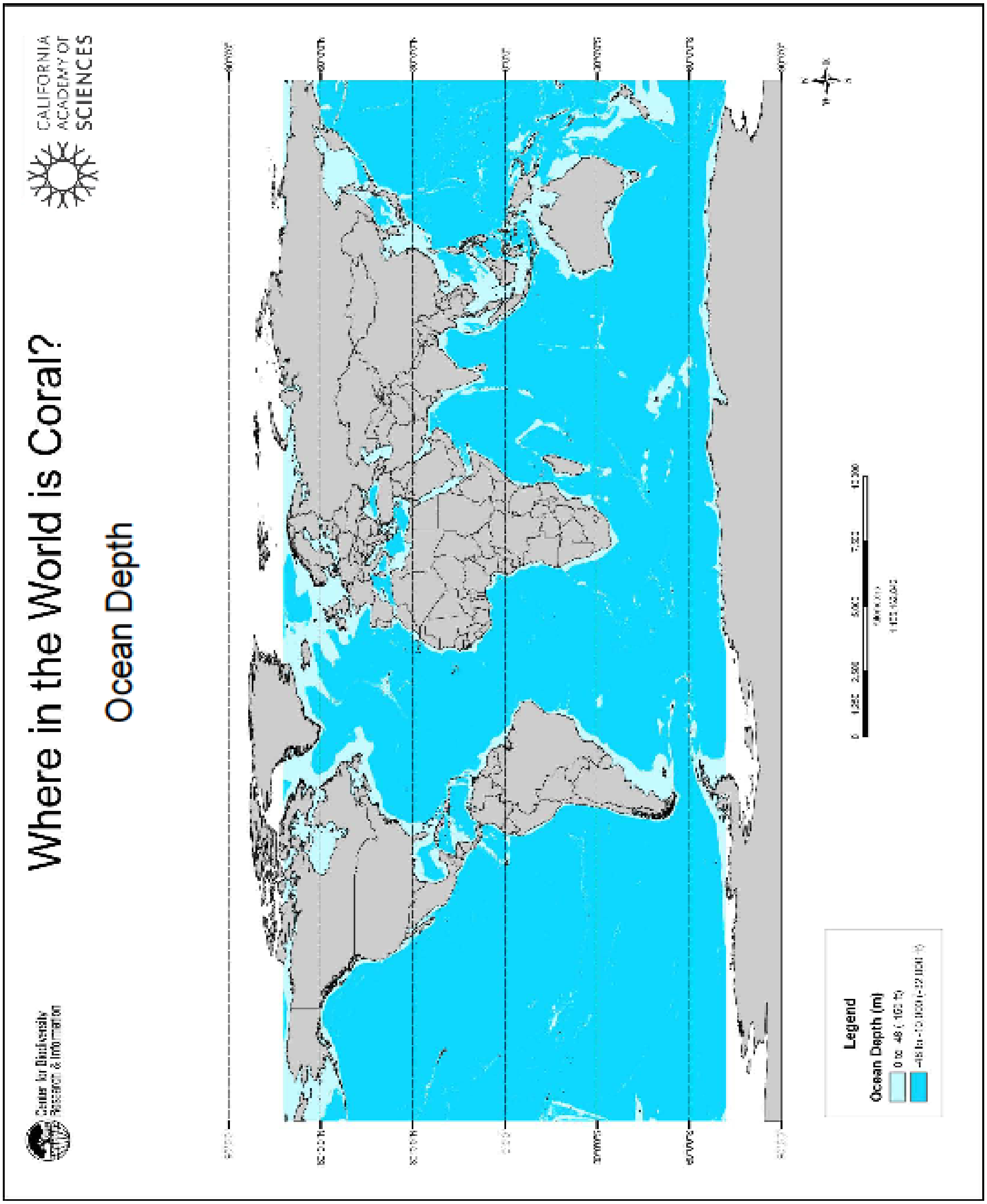
Student Map Side 1



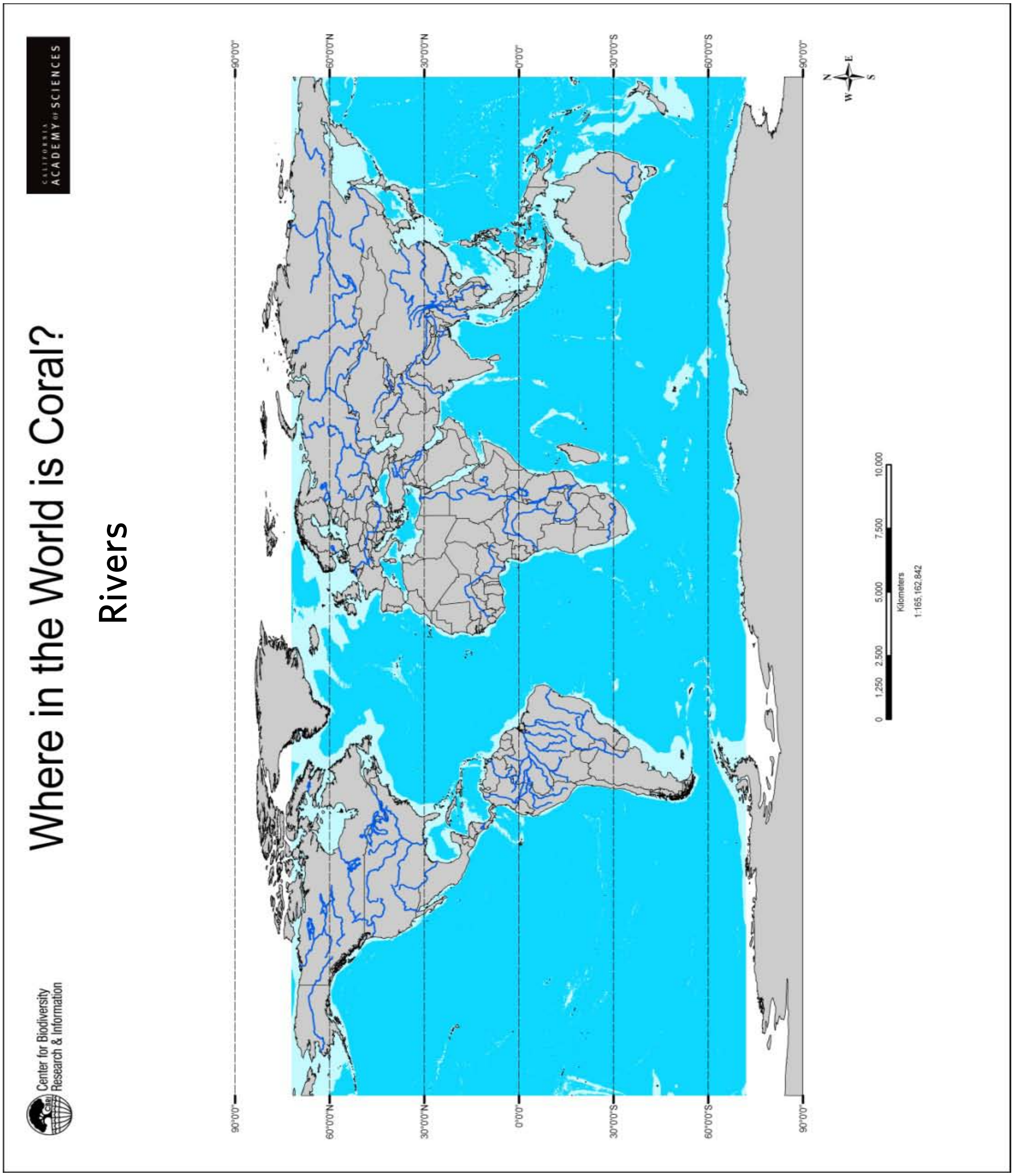
Transparency 1



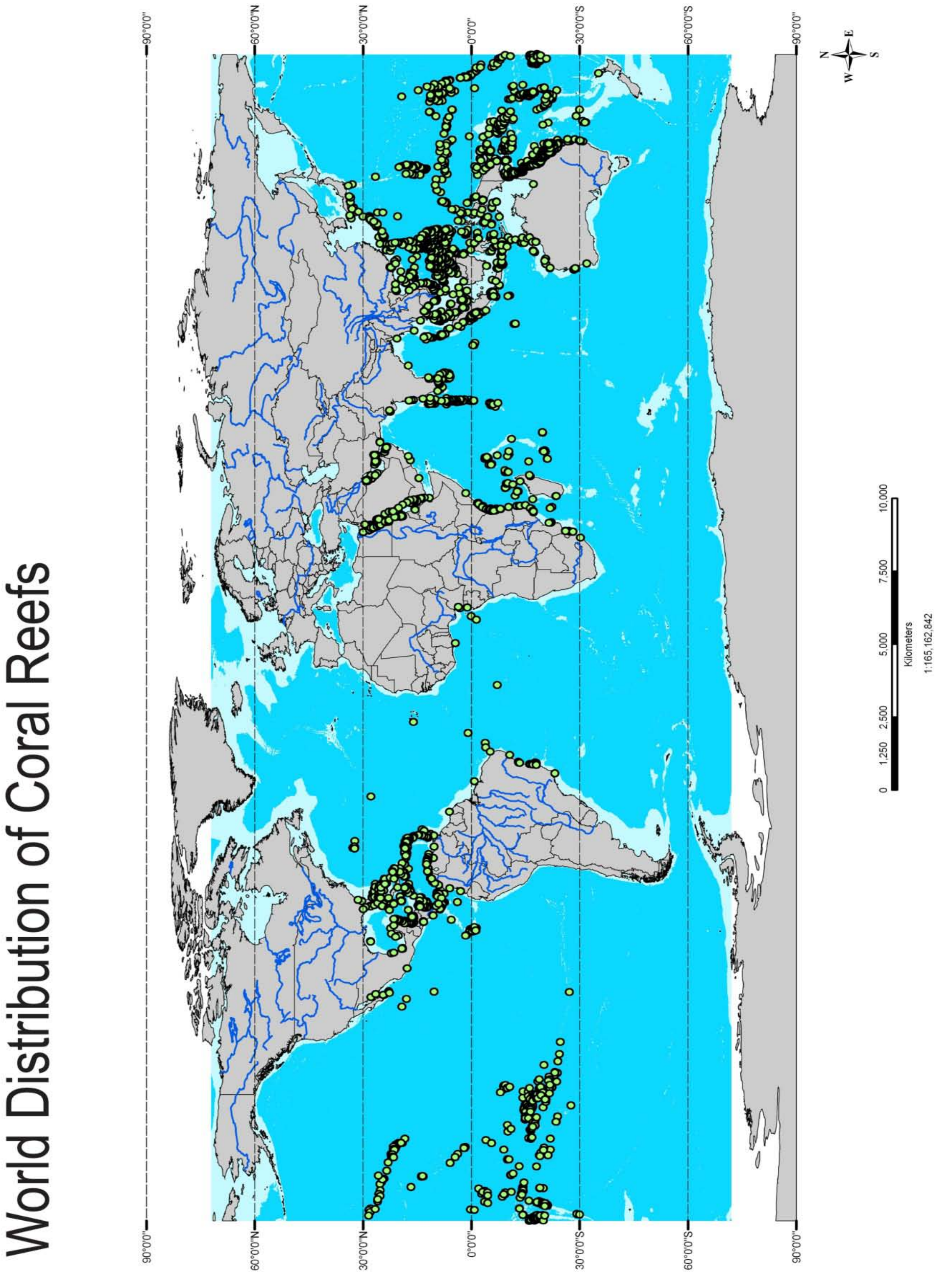
Transparency 2



Transparency 3



Transparency 4



Post-Visit Activity: Sustainable Fishing in the Philippines

GRADE LEVELS	3rd-8th; California Content Standards for 3rd, 4th, 6th, and 7th
SUBJECTS	Life Sciences, Investigation and Experimentation, Earth Sciences
DURATION	Preparation: 5 minutes Activity: 20-45 minutes
SETTING	Classroom

Correlated California State Content Standards

Grade 3: Life Sciences **3c and 3d**; Investigation and Experimentation **5c**
Grade 4: Life Sciences **2b**
Grade 6: Earth Sciences **6b**
Grade 7: Life Sciences **3e**
(See page 46)

Objectives

In this game, students will:

1. learn that unsustainable fishing risks depletion and extinction of fish populations.
2. learn that some unsustainable fishing practices directly damage coral reefs.
3. brainstorm solutions to protect coral reefs and fish for future generations.

Materials

two or three bags of popped, plain popcorn (amount depends on class size)
small paper cups (1 per student)
large paper plates (1 per group)
spoons (1 per group)
straws (1 per student)
watch (for timing the activity)
Fishing Log (1 per student)

Teacher Background

The strikingly colorful coral reef display at the California Academy of Sciences is a Philippine coral reef. The Philippines are considered the marine and coastal biodiversity center of the world. The coral reefs in this part of the world are some of the most diverse, but also some of the most threatened. Human impacts such as pollution, climate change, development, and unsustainable fishing practices have damaged these reefs.

Luckily, Filipinos have been working hard to preserve local marine ecosystems. Through the delivery of educational programs, the implementation of sustainable fishing practices, and the establishment of marine parks and reserves, Filipinos are committed to preserving their reefs. The success of these preservation strategies is important for the coral reefs themselves, the community of organisms that inhabits the reefs, the tourists that enjoy these waters, and the Filipino people. Coral reefs in the Philippines offer very important services to local people, providing food, sources of income, and protection from storms.

The struggle to preserve coral reefs is extremely important in the Philippines because of the incredible marine diversity and the high degree of threat, but conserving coral reefs is a critical issue all around the world. The very same issues facing Philippine reefs endanger reefs all over the world. Because reefs all over the world are threatened, now is a critical time for coral reef conservation. In this activity, we will concentrate on one particular threat to coral reef ecosystems: unsustainable fishing. Although there are many unsustainable and destructive fishing practices, two of the most harmful practices in the Philippines are blast fishing and cyanide fishing. Blast fishing or dynamite fishing uses explosives to stun or kill creatures that live on the reef. This practice allows fishers to harvest a lot of fish at one time with a relatively simple method, but also causes a lot of destruction. The explosions can cause huge craters in the coral resulting in coral death, slower re-growth of coral, and destruction of fish populations. The practice has been used for centuries. Although blast fishing is used all over the globe, it is particularly pervasive in Southeast Asia.

The practice of cyanide fishing uses the toxin cyanide to stun fish, which makes it easier to collect them. The cyanide damages coral reefs because it stresses the coral polyps' symbiotic algae, zooxanthellae. The coral loose their zooxanthellae, which can be fatal to the coral. Cyanide also damages non-target fish, many invertebrates, eggs, larvae, and microorganisms. Further damage is caused when fishers use hammers to break the reef in order to retrieve fish that have retreated away from the cyanide into the crevices and cracks of the coral reef. Fish populations are diminished both because of the quantity of fish caught and because of the associated habitat destruction. Cyanide fishing was first used in the Philippines in 1962, primarily for the live fish aquarium trade, but the practice has become widespread and is now used throughout Southeast Asia to supply live reef fish to aquariums and restaurants.

Blast fishing and cyanide fishing result in damage to coral reefs and to fish populations. They can decrease the reproductive population of fish and thus decrease the amount of fish available in subsequent years. These practices can also contribute to the extinction of a population or an entire species of fish or coral. Although these impacts affect fishers negatively, individual fishers have no incentive to protect fish for future years because there's no guarantee that someone else will not catch those fish. Because fish are a shared resource, each fisher tries to catch as many fish as possible despite the un-sustainability of such practices. This scenario is known as the Tragedy of the Commons.

Even though individual fishers don't necessarily have incentive to conserve, the damage done by these unsustainable fishing practices can be mitigated. Many nations have taken a first step by passing laws that prohibit destructive fishing practices. Some places have implemented strategies such as regulating technology and establishing marine reserves. Although cyanide fishing and blast fishing are illegal in most places, governments are looking into better enforcement and detection strategies. In order to preserve fisheries and coral reefs we need to work together to implement sustainable fishing practices.

In this exercise, students will gain first hand experience with how destructive fishing practices such as blast fishing and cyanide fishing are unsustainable. They will also brainstorm ideas about how to make fishing more sustainable and prevent a Tragedy of the Commons scenario in the future.

Activity

Introduction

Remind students of their trip to the California Academy of Sciences' Philippine coral reef exhibit. Tell students that they are going to be fishers in the Philippines and will explore the sustainability of fishing practices. Ask them what sustainability means. To do something sustainably means meeting the needs of people who live now without limiting the ability of people in the future to meet their own needs. This relates to fishing because some of the ways that people currently fish are not sustainable, such as blast fishing and cyanide fishing. These practices destroy habitat, deplete fish populations, and might even lead to the extinction of a species. All of these impacts of fishing limit the ability of future fishers to catch fish.

Procedure

1. Explain the game rules:
    - ❖ Each student will be a "fisher" whose livelihood depends on catching fish.
    - ❖ Each piece of popcorn represents a reef fish.
    - ❖ Each fisher must catch at least two fish in each round to survive to the next fishing season.
    - ❖ When the fishing season begins, students must hold their hands behind their backs and use the "fishing rod" (straw) to suck "fish" (pieces of popcorn) from the "ocean" (plate) and deposit them into their "boat" (cup).
    - ❖ The fish remaining in the ocean after each fishing season represent the reproductive population, and thus one new fish will be added for every fish left in the ocean (plate).
    - ❖ After each round, fishers must record their catch in their Fishing Log.
2. Divide the class into groups of three or four students and have them come up with a name for the coral reef where they fish.
3. Give each group one plate and each student one cup, one straw, and one copy of the Fishing Log.
4. Put 30 popcorn pieces on each group's plate. These are the fish that inhabit their coral reef.
5. Remind students that all fishers fish at the same time and must keep their hands behind their backs and wait for a signal to start fishing.
6. Give students 20 seconds for the first "season" of fishing. Note: You can change the time allotted for each season to get the required effect. For

example, if students are not depleting their stocks fast enough, you may increase the "season" to 30 seconds or if they are depleting the stocks too fast, you can decrease the time.

7. After the first round, have each fisher count his or her catch (fish in their cup), the total bycatch for the table (dropped before reaching the cup), and the total fish left in the ocean (plate). Have them record the data in their Fishing Log. Note: Bycatch is any fish (or other creature) that is unintentionally wasted. In the game, a "fish" that leaves the ocean but is not placed into the "boat" is considered bycatch and cannot be put back into the ocean or counted as catch.
8. In order to survive to the next fishing season, fishers must catch at least two fish. Fishers who did not catch the minimum amount must sit out for the following round.
9. Add one new fish for every fish left on the plate, explaining that the fish reproduced in between the seasons.
10. Play a second round and have students record catches on the Fishing Log.
11. For the third round, tell students that some fishers have decided to use explosives and/or cyanide to increase their catch. Give a spoon to a few fishers from each group. Use of the spoon represents the blast fishing or the cyanide fishing because a fisher can just scoop up the fish that have been stunned.
12. Continue playing more rounds until one group runs out of fish. Note: If students are not depleting their stocks fast enough, you may give all fishers spoons.
13. When one group runs out of fish, ask them what they would do in the real world if they caught all of the fish who inhabited their reef and the surrounding waters. (One option is to switch to a different profession, but another option is to move to another area to fish.) Allow students to "invade" other groups when their coral reef is depleted, but don't tell them that they can do this beforehand. Fishers may either go as a group or they may disperse separately to other reefs.
14. Repeat fishing, recording, and replenishing fish stocks until all (or most) groups fish out their reefs. The Fishing Log allows for up to six seasons.
15. Conduct a discussion about the concept of sustainability. If any group did not completely deplete their fish discuss why this happened (less people fishing, etc.) Ask why sustainability might be an important goal for a community and why it might be difficult to achieve that goal. Have each group of students brainstorm ways that they might have made the fisheries more sustainable. Some possible ways are catch limits (a certain number of popcorn pieces), marine reserves (an area of the plate where fishing is not allowed), bans against blast fishing and cyanide fishing (no use of spoons).
16. Have each group decide on a plan to make their fishery more sustainable.
17. Conduct another six rounds (or less) of fishing, using the sustainability plans that the students developed. Because students know how to play, these rounds will go faster. Have students record their new season catches and compare them to the trend seen in the previous seasons.
18. Have students finish filling out their Fishing Log and answer the question, "Was your group successful in making fishing sustainable?"

Wrap-Up

Ask students what happened when they used cyanide and blast fishing (scooped up fish with their spoons). It was much easier to capture lots of fish and the fish populations declined much quicker. Remind students that these ways of fishing also damage coral reefs. Tell the students some of the ways that Filipinos have been working to preserve Philippine reefs (see teacher background section.) Then, discuss ways in which everyone can help make fishing more sustainable.

- If you have an aquarium, know where your fish come from and make sure they were captured or grown in a sustainable way.
- Most of the fish we eat in California don't come from coral reefs, but there are still more sustainable and less sustainable fish choices. Pay attention to the fish you buy at the store or select from a restaurant menu.
- Investigate where the fish comes from, and how it was caught.
- Use the Monterey Bay Seafood Watch guide to help you choose fish that are Best Choices.
- If you can't find the answers, ask! You can help create a market for sustainable fishing by increasing demand for these options.
- Educate others about the importance of sustainable fishing and coral reef conservation.

Resources

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Fishing Log

Reef Name:_________________________ Fisher:____________________________________

Record your catch, bycatch, and fish left after each season:

Season	Your Catch	Bycatch	Fish left in the Ocean
	Fish Caught This Season		
1			
2			
3			
4			
5			
6			

How could your group have made fishing more sustainable?

Record your catch, bycatch, and fish left after each season:

Season	Your Catch	Bycatch	Fish left in the Ocean
	Fish Caught This Season		
1			
2			
3			
4			
5			
6			

Was your group successful in making fishing sustainable?

Adapted from *Fishing for the Future* in Curriculum Guide 2002: www.facingthefuture.org

Correlated California Content Standards

Kindergarten – Fifth Grade

Historical and Social Sciences Analysis Skills: Chronological and Spatial Thinking

4. Students use map and globe skills to determine the absolute locations of places and interpret information available through a map's or globe's legend, scale, and symbolic representations.

Third Grade

Life Sciences

3. Adaptations in physical structure or behavior may improve an organism's chance for survival. As a basis for understanding this concept:

- **a.** Students know plants and animals have structures that serve different functions in growth, survival, and reproduction.
- **b.** Students know examples of diverse life forms in different environments, such as oceans, deserts, tundra, forests, grasslands, and wetlands.
- **c.** Students know living things cause changes in the environment in which they live: some of these changes are detrimental to the organism or other organisms, and some are beneficial.
- **d.** Students know when the environment changes, some plants and animals survive and reproduce; others die or move to new locations.

Investigation and Experimentation

5. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations. Students will:

- **c.** Use numerical data in describing and comparing objects, events, and measurements.

English Language Arts: Listening and Speaking

1.9 Read prose and poetry aloud with fluency, rhythm, and pace, using appropriate intonation and vocal patterns to emphasize important passages of the text being read.

Fourth Grade

Life Sciences

2. All organisms need energy and matter to live and grow. As a basis for understanding this concept:

- **a.** Students know plants are the primary source of matter and energy entering most food chains.

b. Students know producers and consumers (herbivores, carnivores, omnivores, and decomposers) are related in food chains and food webs and may compete with each other for resources in an ecosystem.

3. Living organisms depend on one another and on their environment for survival. As a basis for understanding this concept:

a. Students know ecosystems can be characterized by their living and nonliving components.

b. Students know that in any particular environment, some kinds of plants and animals survive well, some survive less well, and some cannot survive at all.

d. Students know that most microorganisms do not cause disease and that many are beneficial.

English Language Arts: Listening and Speaking

1.9 Use volume, pitch, phrasing, pace, modulation, and gestures appropriately to enhance meaning.

Fifth Grade

Life Sciences

2. Plants and animals have structures for respiration, digestion, waste disposal, and transport of materials. As a basis for understanding this concept:

a. Students know many multicellular organisms have specialized structures to support the transport of materials.

f. Students know plants use carbon dioxide (CO_2) and energy from sunlight to build molecules of sugar and release oxygen.

Sixth Grade

Ecology (Life Sciences)

5. Organisms in ecosystems exchange energy and nutrients among themselves and with the environment. As a basis for understanding this concept:

e. Students know the number and types of organisms an ecosystem can support depends on the resources available and in abiotic factors, such as quantities of light and water, a range of temperatures, and soil composition.

Resources

6. Sources of energy and materials differ in amounts, distribution, usefulness, and the time required for their formation. As a basis for understanding this concept:

e. Students know different natural energy and material resources, including air, soil, rocks, minerals, petroleum, fresh water, wildlife, and forests, and know how to classify them as renewable or nonrenewable.

Seventh Grade

Evolution

3. Biological evolution accounts for the diversity of species developed through gradual processes over many generations. As a basis for understanding this concept:

   e. Students know that extinction of a species occurs when the environment changes and the adaptive characteristics of a species are insufficient for its survival.

Vocabulary

acidification: the increase in acidity (measured by a lower pH) of ocean water due to increased levels of carbon dioxide absorbed from the atmosphere.

adaptation: a change in the way an organism looks or behaves that improves its chance of survival in a specific environment

algae: a general term for microscopic or larger aquatic plants. They differ from trees and bushes because they don't have true roots, stems, and leaves.

biodiversity: the degree of variety of species of plant and animal life within a region.

bycatch: unwanted marine creatures that are caught in the nets while fishing for another species

calcium carbonate: a chemical compound that is a common substance found in rocks throughout the world, and is the main component of shells of marine organisms, snails, pearls, and eggshells.

carbon dioxide: a colorless, odorless gas that is the waste product of both cell respiration and the combustion of fossil fuels.

cnidarians: a phylum of animals containing over 9,000 species found exclusively in aquatic environments, including hydras, jellyfishes, sea anemones and corals.

cnidocytes: specialized stinging structures found on corals' and other cnidairans' tentacles and used to help catch planktonic food.

cold currents: cold currents bring unusually cold water from the bottom of the ocean into warmer areas, preventing coral reef growth. All of these cold currents are found along the Western coasts of major continents.

colony: a group of animals of the same species living together and benefitting from each other's presence.

coral bleaching: the effect of zooxanthellae leaving their coral hosts, resulting in the corals' bleached appearance.

extinction: when the last individual of a particular species dies

global warming: the warming of the lower atmosphere due to the increased emission of greenhouse gases such as carbon dioxide.

hard coral: marine animal that produces a hard, calcium carbonate skeleton and grows into coral reefs

latitude: a measure of distance north or south from the equator at any given point on the earth's surface

photosynthesis: the conversion of solar energy to chemical energy, by the action of chlorophyll in plants, algae, and zooxanthellae.

plankton: plants and animals which drift in the ocean currents because they are not strong swimmers.

polyp: an individual coral organism, whether living solitarily or colonially.

predator: animals that eat other animals

salinity: a measure of a concentration (as in a solution) of salt

sedimentation: the process of soil, debris and other materials being deposited in bodies of once clear water such that sunlight is unable to penetrate the murkiness.

sustainable: meets the needs of the present without compromising the ability of future generations to meet their own needs

symbiosis: the relationship between organisms of two different species that live together and have direct contact with each other. This relationship may be one where both species benefit from the interaction (mutualism), only one of the species benefits (commensalism), or one of the species is harmed (parasitism). Corals and zooxanthellae have a mutualistic sybiosis.

tentacles: a flexible body part that is used for feeding, grasping, or moving

Tragedy of the Commons: a metaphor dealing with the overexploitation of resources in an area where there is not clear ownership, showing that unrestricted access to a common and finite resource ultimately dooms the resource through over-exploitation

zooxanthellae: single-celled organisms that, like plants, are able to produce their own food through photosynthesis. When not living in a host animal, most zooxanthellae are planktonic.

Resources

Books

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Web Resources:

http://coralreef.noaa.gov/

http://www.coral.org/

http://reefrelief.org/

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