THE CORAL REEF TEACHER'S GUIDE

LESSON PLANS FOR 9-12:

- **What and Where are the Coral Reefs?**
- **Life on the Coral Reef**
- **Benefits, Threats, and Solutions**

Moray eel. (Photo: Terry Brown)

Where in the World?

Objective: Students compare the political, social, and economic issues involved with the protection and use of coral reefs, and analyze the activities, roles and responsibilities of the various agencies or governments with dominion over the locales involved.

Vocabulary: coral reef, Great Barrier Reef, tropics, equator, tropic of Cancer, tropic of Capricorn

Interdisciplinary Index: Science, Social Studies, Geography, Civics, Economics

Materials:

- World map
- a copy of the coral reef map, Figure 1-6, on page 1-6 of the **Background Information**, one per student
- a copy of the **Coral Reef Map**, one per student
- colored pencils, pens, or markers

PRESENTATION:

1. Look at a world map. Discuss where in the world coral reefs form and the conditions necessary for their development.
2. Referring to Figure 1-6, have the students mark the location of coral reefs on their copy of the **Coral Reef Map**. Referring to the world map, have them mark the names of countries adjacent to the reefs. Review students' maps and note the distribution of reefs near the equator.
3. Discuss some of the native coastal people in these areas and their political, economic, and cultural aspects in preparation for the following projects.

   These projects are designed to be done by individuals or groups and presented to the class in a creative and interactive manner, using role-play, debate, discussion, illustrations, etc.

Projects

A. Choose a country with a coral reef and research the following questions: Who uses and lives near the reef? How does the reef impact their lives in terms of economics, geography, or politics? Do they view the reef as an asset, and if so, why? What is the country doing to protect the reef?

   Create a skit featuring several students representing the people involved with the reef.

B. Compare and contrast two different countries' programs to govern their coral reef ecosystems in terms of commerce, fishing, tourism, and ecological concerns.

C. Research the various international organizations involved with reef governance and/or protection and write to them for information on their programs. Discuss the differences/similarities and any conflicts/agreement among them.

D. Select a law which governs reefs and learn who enacted it, who is affected by the law, the effectiveness of the law, and how it might be improved.

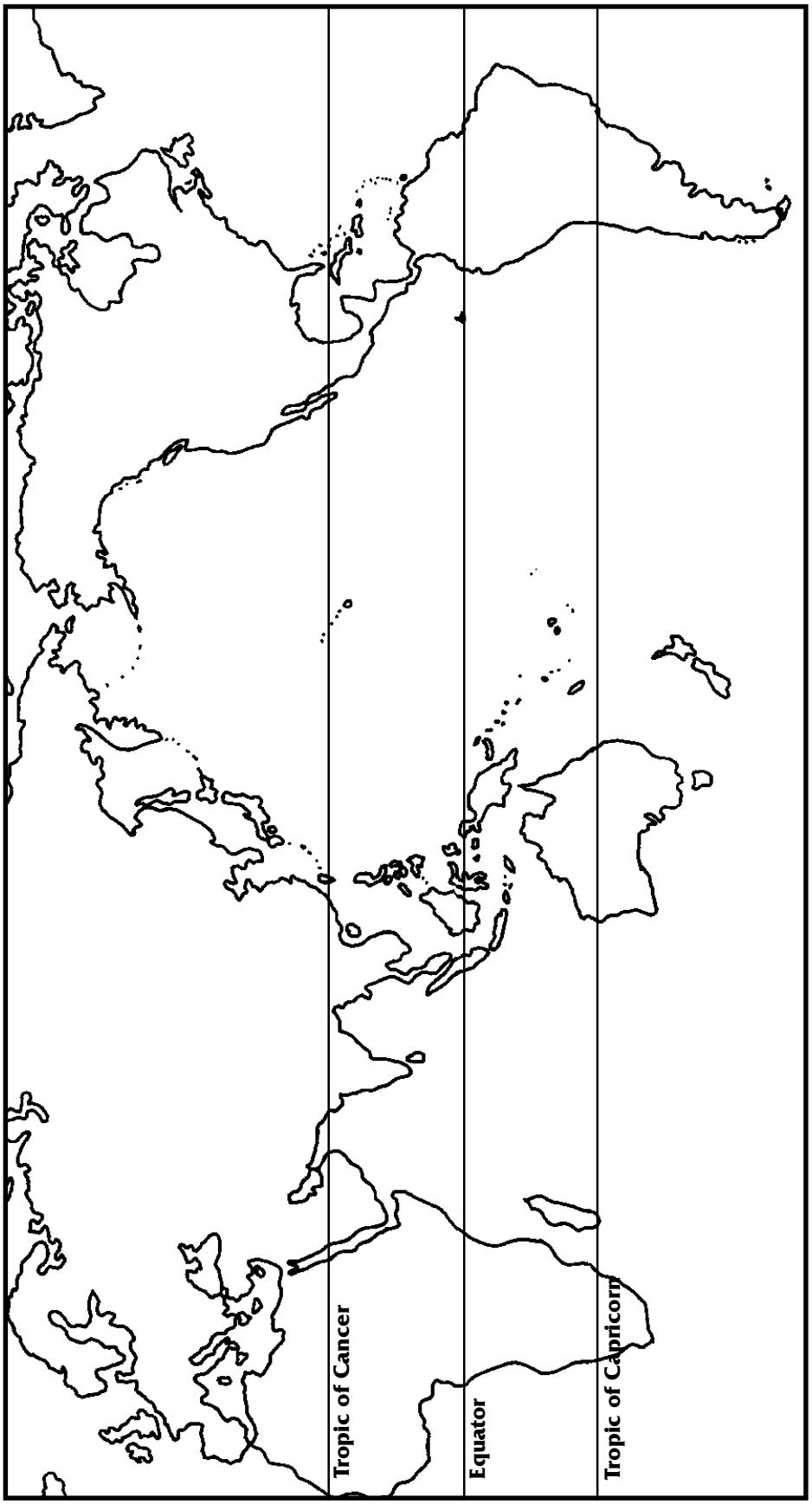
E. Find out who is responsible for governing the world's coral reef ecosystems (individual countries, international organizations, trade organizations, etc.) and where conflicts arise among the various groups. What are possible solutions?

FOLLOW-UP/EXTENSIONS:

If possible, use the Internet to connect with people and organizations involved with coral reef communities.

Write, as individuals or as a class, to express your opinions on various issues to national or international agencies with the power to affect reef ecosystems.

CORAL REEF MAP



Reef Formation Animation

Objective: Students describe the stages and conditions necessary for the formation of a reef, and how geographical locations impact reef formation.

Interdisciplinary Index: Science, Geography, Art, English

Vocabulary: fringing reef, barrier reef, atoll, lagoon, storyboard, animation, claymation

Materials:

Project A:

- **Storyboard**
- **Video Animation Project A**
- plain notebook paper or white drawing paper (8 1/2" x 11")
- markers, crayons, paints, etc. to color images
- video camera and videotape
- lights.

Project B:

- **Storyboard**
- **Video Animation Project B**
- Plastelina-type clay in colors
- painted background on cardboard or butcher paper
- video camera and videotape
- lights.

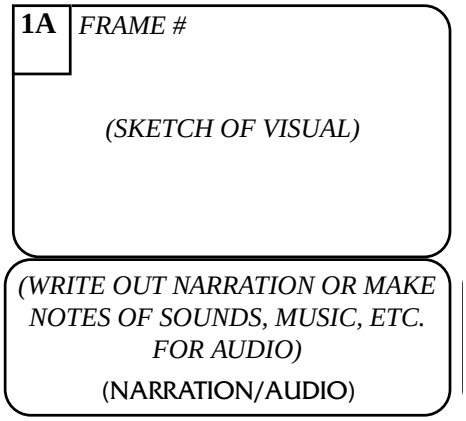
PRESENTATION:

Present to the class the conditions and stages of reef formation using the information found in the **What and Where are the Coral Reefs?** section in the **Background Information**, and use the enclosed form to create a storyboard to serve as a guide to animating the series of steps in this process. Introduce the class to the animation techniques below. Discuss how these techniques could be used to illustrate other scientific principles which are difficult to see in action because they occur over long periods of time or are hidden in some manner (i.e. microscopic or internal).

PROJECT A: 3-RING BINDER ANIMATION

1. Draw each step in the process of reef formation horizontally on a separate 8 1/2" x 11" plain paper, and arrange in proper order in a notebook.
2. Place notebook upright on an easel or other surface
3. Videotape each page in the sequence in order.
4. Add narration, sound effects, music, etc.

STORYBOARD FRAME



PROJECT B: CLAYMATION

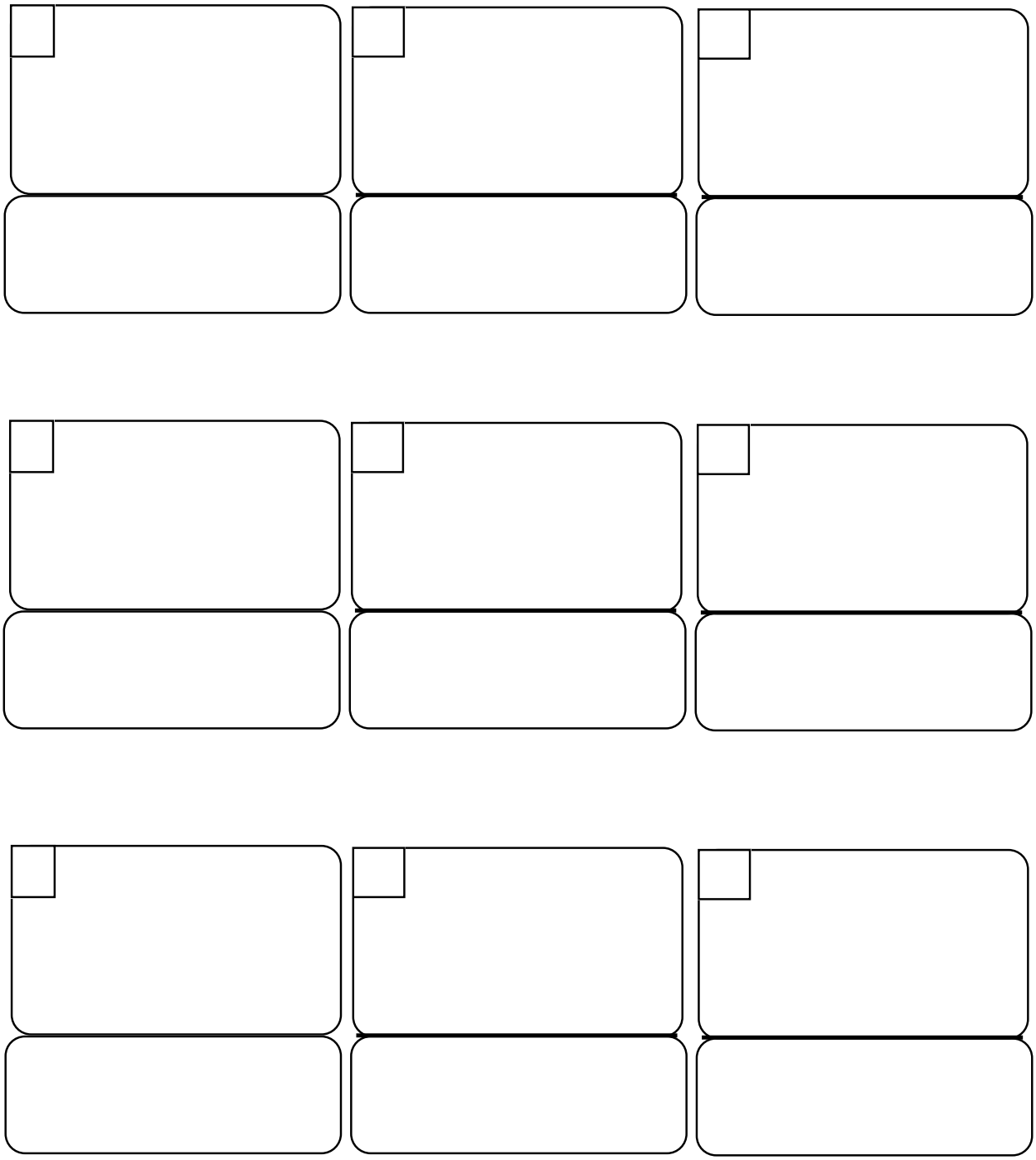
1. Create a clay model of the first stage of reef formation.
2. Videotape according to the above directions.
   (NARRATION/AUDIO)
3. Change the model, moving clay parts approximately 1/4" for each frame.
4. Videotape the next frame.
5. Change.
6. Video.
7. Proceed through the entire sequence of reef formation, following the storyboard.
8. Add narration, sound effects, music, etc.

FOLLOW-UP/EXTENSION:

Present the animations to other students.

Following the storyboard, use a software program such as KidPix SlideShow, or Multimedia Workshop to create a multimedia version for use on computers.

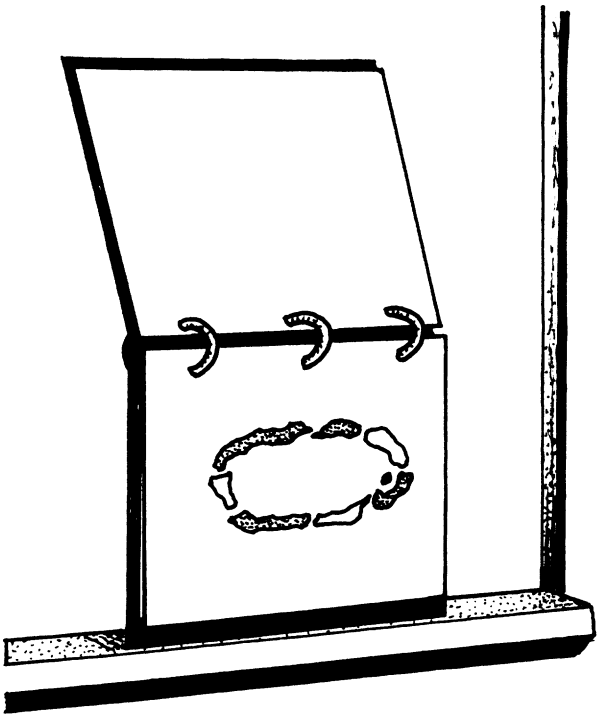
STORYBOARD

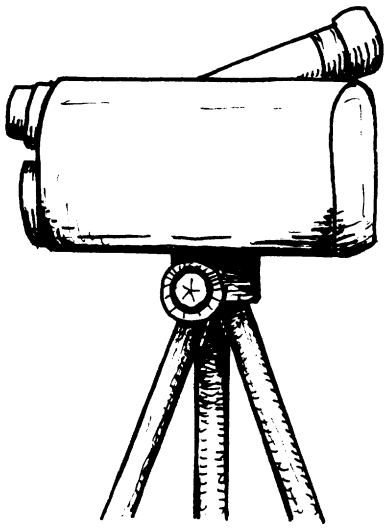


VIDEO ANIMATION PROJECT A

3-RING BINDER ANIMATION

1. Draw each step in the process of reef formation horizontally on a separate 8 1/2" x 11" plain paper and arrange in proper order in a notebook.
2. Place notebook upright on an easel or other surface.
3. Videotape each page in the sequence in order.
4. Add narration, sound effects, music, etc.



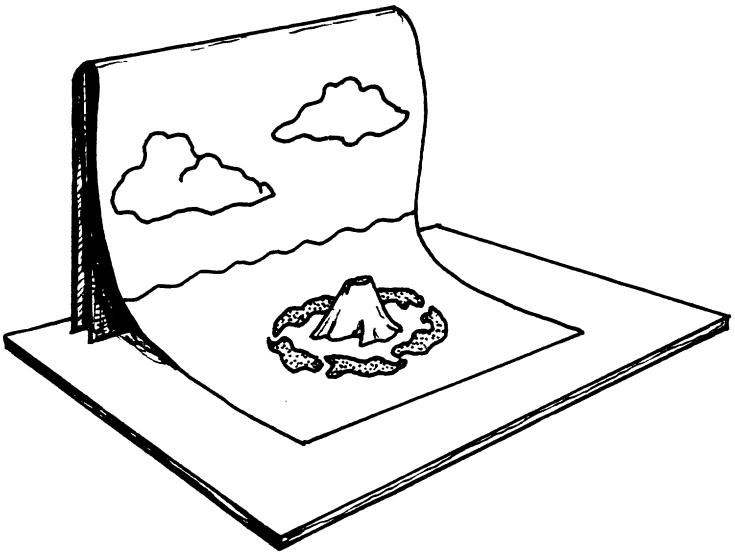


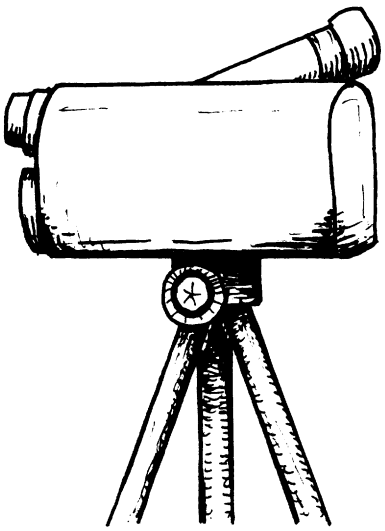
Use a 3-ring binder to hold animation sequences in order while videotaping.

VIDEO ANIMATION PROJECT B

CLAYMATION

1. Create a clay model of the first stage of reef formation.
2. Videotape.
3. Change the model, moving clay parts approximately 1/4" for each frame.
4. Videotape the next frame.
5. Change.
6. Videotape.
7. Proceed through the entire sequence of reef formation following the storyboard.
8. Add narration, sound effects, music, etc.





Butcher paper can make a painted backdrop for claymation scenes.

Who Am I?

Objective: Students present in-depth the characteristics of a species in the coral reef community, and analyze and classify information to name other species when they are described by characteristics.

Interdisciplinary Index: Science, English, Drama

Vocabulary: hard and soft corals, anemones, sharks, clownfish, nudibranchs, sea stars, squids and octopi, sponges, etc. See the **Life on the Coral Reef** section in the **Background Information** for more.

Materials:

- **Who Am I?** handout for each student
- paper, pencils, or computer/word processor

PRESENTATION:

1. Present information about the various species of life on the coral reef. Have the class list and classify the types of coral, sponges, fish, etc. and their characteristics. Brainstorm more statements to add to the list below which would give a clear picture of the plant or animal.
2. Assign groups to develop presentations on a particular type of marine plant or animal. For example, one group might represent the different types of coral. Each person in the group should be prepared to "be" the appropriate coral and complete the following types of statements.

I live _____(where).

I prefer _____(conditions).

I am made of _____(structure).

I have _____(physical adaptations).

I eat _____(diet).

I hunt/forage/feed _____(when/where).

I live _____(life span).

I reproduce _____(how, how often).

I am threatened by_____(predators, environmental hazards).

3. Each member of a group presents the statements above, in turn, with other students trying to guess "Who Am I?" The presenting group who can elicit the correct response quickest wins. This would necessitate ordering the statements with the most distinctive characteristics first.

FOLLOW-UP/EXTENSION:

Create a game using index cards with two or three of the statements on one side, the name of the animal on the other side. The object would be to draw a card, read the statements, and guess "Who Am I?"

WHO AM I?

To develop presentations on a particular type of coral reef animal, you will need to research its habits and environment. For example, one group might represent the different types of coral, another group the different types of fish. Each person in the group should be prepared to "be" the appropriate plant or animal and complete the following types of statements. As the class thinks of other statements, add them to the list.

Lionfish. (Photo: Terry Brown)

I live_____(where).

I prefer_____(conditions).

I am made of_____(structure).

I have_____(physical adaptations).

I eat_____(diet).

I hunt/forage/feed_____(when/where).

I live_____(life span).

I reproduce_____(how, how often).

I am threatened by_____(predators, environmental hazards).

3-D Mobile

Objective: Students identify individual members of the coral reef community and discuss their relationships with one another.

Interdisciplinary Index: Science, Art

Vocabulary: food chains, ecosystem, herbivores, omnivores, carnivores

Materials:

- butcher paper or drawing paper (white)
- crayons, paint or markers
- scissors
- glue and staples
- old newspaper for stuffing
- nylon fishing line or string

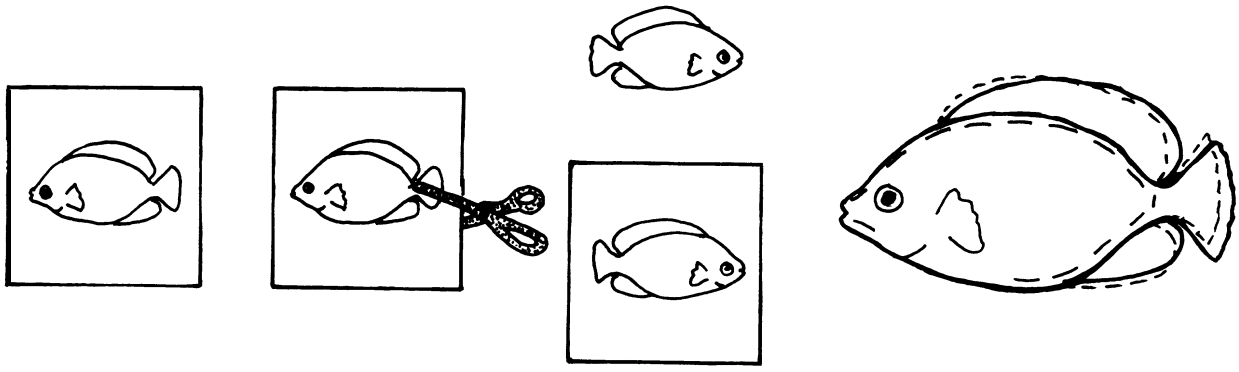
PRESENTATION:

1. Use the **Background Information** to introduce students to the variety of life on a coral reef. Discuss the interrelated nature of a reef ecosystem, food chains, etc. Create with the class a life-sized hanging mural/mobile of the coral reef community to depict the various life forms and the connections among them.
2. Draw the fish, coral etc. on paper.
3. Cut out and flip over to make a template to draw the other side, and cut it out.
4. Color both sides in accordance with the accurate depiction of the animal or plant.
5. Staple the two sides togther, leaving a space to stuff the newspaper inside.
6. Stuff bodies loosely and leave fins and tails free.
7. Staple fishing line to the top of the creature and hang all of them from a ceiling or in a display window.

FOLLOW-UP/EXTENSION:

Students in each group present their part of the project to the class.

Play a game in which students on one team give a description of an unnamed animal and the second team must choose the correct animal and then tell one fact about their animal or lose their turn. Go back and forth between group one and two. The group that has the most correct answers wins.



Coral Reef Comparisons

Objective: Students use compiled data to create a variety of graphs, and use these graphs to draw conclusions about coral reef populations.

Interdisciplinary Index: Math, Science

Vocabulary: data, species, population, herbivore, carnivore, omnivore

Materials:

- graph paper
- colored pencils or markers
- overhead projector and transparencies (optional)

PRESENTATION:

1. Tell students that they are going to compare the number of various coral reef species found on an Australian reef and a Caribbean reef.
2. Put the following data on an overhead or the chalkboard for everyone to see.

	% of Total Community	
Species	**Australia**	**Caribbean**
Damselfish (herbivore)	18%	20%
Parrotfish (herbivore)	8%	5%
Giant clam (herbivore)	7%	0%
Barracuda (carnivore)	3%	3%
Grouper (carnivore)	10%	15%
Shark (carnivore)	2%	3%
Angelfish (omnivore)	12%	9%
Hard coral (omnivore)	31%	35%
Sea star (omnivore)	9%	10%

(Note: The percentages given here are fictional, and are presented for the sake of comparison only.)

3. Discuss and describe the species listed.
4. Have students construct a bar graph comparing the percentage of herbivores, carnivores, and omnivores which dwell on the Australian reef.
5. Once the graphs are completed, discuss the following questions.
   - Which group accounts for the largest population in the Australian reef? Smallest?
   - What percentage of coral reef life eats plants? (include both herbivores and omnivores)
   - Predict what would happen to the number of carnivores if the number of herbivores decreased.
   - Predict what would happen to the number of herbivores if the number of carnivores decreased.
6. Repeat steps 4 and 5 using data from the Caribbean reef.
7. Have students construct a bar graph comparing the percentage of each species of herbivore in the Australian reef to the percentage of that species in the Caribbean reef.
8. Repeat this process for the carnivores and omnivores, and discuss any similarities or differences that may occur.

FOLLOW-UP/EXTENSION:

Have students average the two percentage figures for each species. Once students have calculated the average, have them graph it on a large piece of paper. Students can then draw pictures of each species represented and arrange pictures and graphs on a bulletin board.

Coral Reef Word Find

Objective: Students will review and become familiar with words related to the coral reefs in the **Life on the Coral Reef** section of the **Background Information**.

Interdisciplinary Index: Language Arts, Science

Vocabulary: phytoplankton, damselfish, trunkfish, barracuda, clam, clownfish, polyp, shark, juvenile, zooplankton, parrotfish, anemone, lobster, triton, nudibranch, zooxanthellae, octopus, mollusk, crab, crepuscular, lagoon, coral, seagrass, triggerfish, sponge, mangrove, omnivore, herbivore, carnivore

Materials:

- A blank **Coral Reef Word Find**, one for each student
- pencils

PRESENTATION:

1. Review the vocabulary.
2. Tell students they are going to make their own **Word Find**.
3. Have students place the review words (one letter in each square) randomly across, down, or diagonally on the grid.
4. When all of the words have been placed on the grid, students will fill in the empty squares with letters.
5. Have students exchange **Word Finds** and solve.

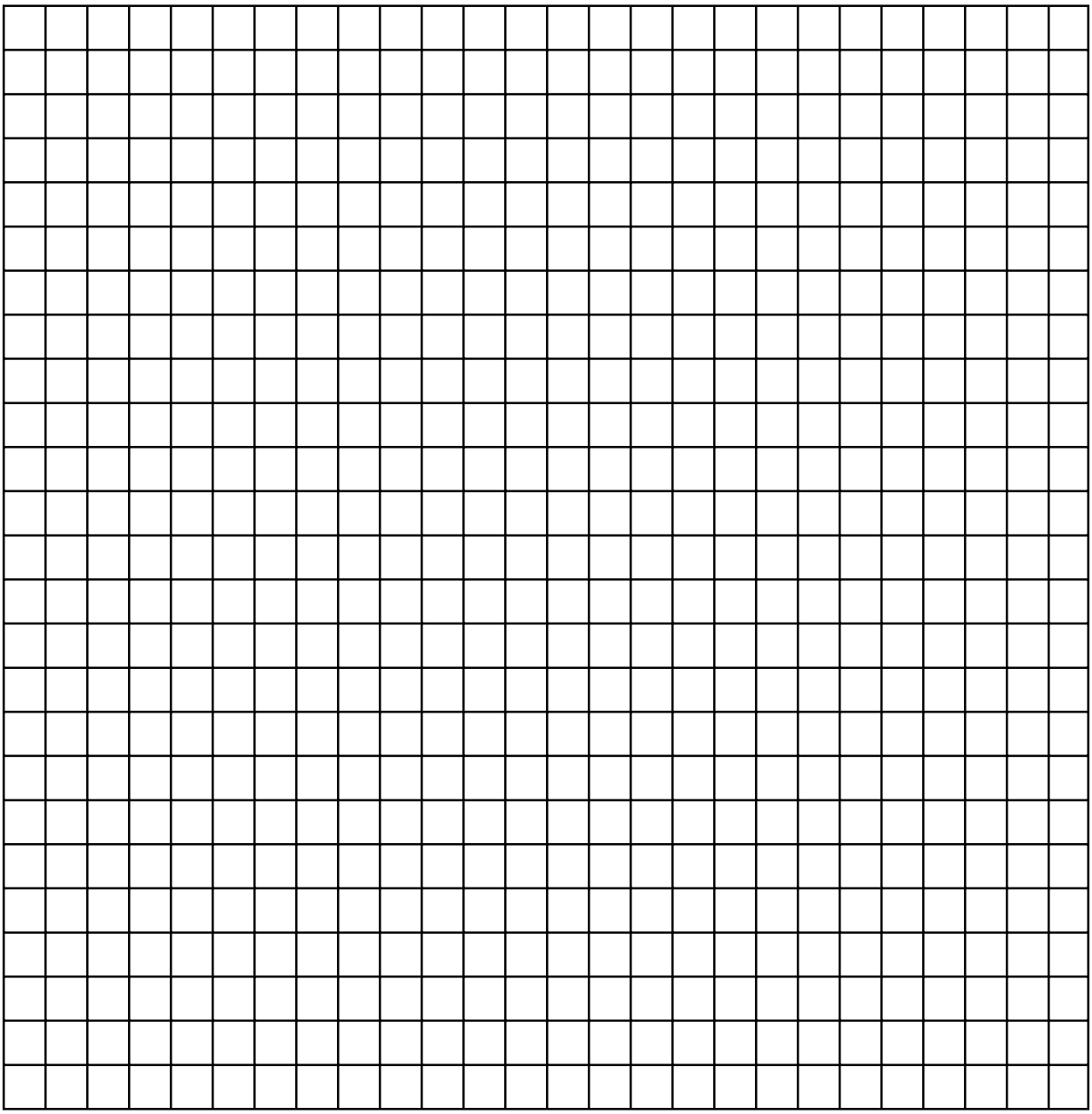
FOLLOW-UP/EXTENSION:

Give each student another **Word Find** sheet as homework. The student can make a word find for a friend or relative to solve. Encourage students to add their own coral reef words.

CORAL REEF WORD FIND

Use the words related to life on the coral reef to make a word search. See if someone else can solve your puzzle. Do they know what these words mean?

phytoplankton	polyp	lobster	crab	sponge
damselfish	shark	triton	crepuscular	mangrove
trunkfish	juvenile	nudibranch	lagoon	omnivore
barracuda	zooplankton	zooxanthellae	coral	herbivore
clam	parrotfish	octopus	seagrass	carnivore
clownfish	anemone	mollusk	triggerfish	



Living Together in a Coral Reef Community

Objective: Students will become familiar with the many diverse and intimate relationships in coral reef ecology. Topics to be discussed and developed for roll-playing presentations are from the **Life on the Coral Reef** section of the **Background Information**.

Interdisciplinary Index: Science, Art

Vocabulary: the marine food chain, predation, protection, symbiosis

Materials:

- transparency of page 2-7, "The Food Chain"
- copy of the **Coral Reef Color Page** on page M-21 for each student in the class

PRESENTATION:

The Marine Food Chain

1. Using a transparency of the marine food chain, discuss how the sun's energy is utilized and transferred between the different participants in the food chain. Introduce the terms primary producers, primary consumers (herbivores), secondary consumers (carnivores and omnivores), and decomposers. Handout copies of the **Coral Reef Color Page** and have students identify and label each of the organisms by common name and role in the marine food web. Refer to the "Marine Food Chain Answer Key" at the end of this lesson plan. Consider having the groups divide up the work and present their results to the class.
2. Have students diagram their own marine food chain using a representative organism from the color page. They can refer to "The Food Chain" transparency while doing this.

EXAMPLE:

Sun

- primary producers: plants, i.e. seagrass, phytoplankton, algae, zooxanthallae
- primary consumers: herbivores, i.e. sea urchin, parrotfish, damselfish, giant clam, conch
- secondary consumers: omnivores, i.e. feather stars, sponges, angelfish; and carnivores, i.e. sharks, moray eel, trumpet fish
- decomposers, i.e. bacteria and algae (recycle nutrients)

3. Discuss the possible effects of removing one of the players from the marine food chain and its effect on the entire ecosystem. For example, discuss the possible impact of the removal of sharks from the food chain. How about herbivorous fish?

EXPLANATION:

Sharks are a crucial secondary consumer at the top of the marine food chain that have lived in the ocean for over 300 million years. They are an integral factor in controlling the size of many coral reef fish populations and their removal can cause some fish populations to increase drastically resulting in the concurrent loss or crowding out of other species. These effects can be felt at all levels of the marine food chain, resulting in unforeseen damage to the marine environment. The coral reef food chain is a finely balanced system and human disturbances can have devastating effects.

If herbivorous fish, such as damselfish, are overfished or removed from coral reefs, algae can quickly overgrow the corals and block them from receiving the sunlight that they need for photosynthesis. This algal overgrowth can cause reefs to die out. In the late 1980's overfishing in Jamaica contributed to the overgrowth and loss of several major reefs.

Predation and Protection

4. Discuss the importance of predation and protection on survival in the coral reef ecosystem. Describe different protective strategies used by organisms on the reefs and their adaptive importance. Using the **Coral Reef Color Page**, have students form small groups and discuss the protective strategies utilized by as many of the organism as they can. Have each group pick their favorite relationship or adaptive strategy and have them present a short role playing skit to the class.

EXAMPLES OF PROTECTIVE STRATEGIES:

Blue Dash Butterflyfish: The blue dash butterflyfish is shaped like a thin pancake so that it can hide easily among the coral and be safe from predators. It is bright yellow with a blue streak on its body and a "fake eye" on its tail to confuse any predators that try to attack. The predator thinks that it is aiming for the head when in reality it is aiming for the tail, enabling the butterflyfish to dart forward and escape.

Clown Triggerfish: The clown triggerfish is marked with large white polka dots which help to break up its outline and camouflage it against the reef. It is also very poisonous so predators do not try to eat it. The clown triggerfish attacks small reef animals, such as fish that hide in the sand and sea urchins, by blowing streams of water out its mouth to uncover or overturn its prey.

Hard Coral: Hard corals build reefs by secreting a hard external limestone skeleton. During the daytime, the coral polyp retracts into its limestone base for protection from hungry fish but at night it comes out to feed on floating plankton.

Nudibranch: The nudibranch feeds on the tentacles of sea anemones but does not trigger their stinging cells (called nematocysts). Instead, the stinging cells migrate to the nudibranch's exposed gill where they serve as a defense against predators. Nudibranchs come in a wide variety of shapes and bright colors. Their bright colors warn predators of their deadly poison.

Pufferfish: Pufferfish protect themselves by drawing water into their abdomen to inflate themselves to more than twice their normal size thereby making it difficult for predators to swallow them. They also have large protruding eyes that can see in all directions enabling them to spot predators quickly. Pufferfish produce a powerful poison called *tetraodontoxin* which discourages predators from eating them.

Stonefish: The stonefish uses more than one method for protection: camouflage to blend in with its environment, and lethal poison in its dorsal spine to avoid being eaten. It is reported to be the most deadly venomous fish in the Indo-Pacific region.

Symbiosis

5. Discuss the importance of symbiotic relationships for life on the coral reef. Pick one of the following symbiotic relationships: coral - zooxanthellae, sea anemone - clownfish, or cleaner wrasse - fish being cleaned, and discuss the energetic, ecological, and survival benefits for each of the organisms involved. Have the class break up into small groups and prepare a short poem, role playing presentation, or artistic representation about the importance of symbiosis on the coral reef. As an extension have each student prepare a research essay describing a symbiotic relationship and its evolutionary and ecological importance to the organisms involved.

EXAMPLES OF SYMBIOSIS:

Corals and zooxanthallae: Within the tissue of the coral polyp live many microscopic algae called zooxanthallae. These algal cells provide the coral with food through the process of photosynthesis in which zooxanthallae cells use sunlight to convert the carbon dioxide and water in the polyp tissue into oxygen and carbohydrates. The oxygen is used by the polyp for respiration and the carbohydrates are used for energy to build its limestone skeleton. In return, the polyp provides the zooxanthallae with nutrients, protection, a place to live, and carbon dioxide, a by-product of respiration which is vital for photosynthesis.

Sea anemone and clownfish: The clownfish has a symbiotic relationship with its partner, the sea anemone. The clownfish hides among the anemone's poisonous tentacles, safely protected from predators. It is believed that the mucus coating on the clownfish protects it from the stinging cells in the sea anemone's tentacles. In return, the clownfish, being extremely territorial, drives off any fish that try to prey on the anemone. The clownfish also drops bits of food among the tentacles which the anemone can eat.

Cleaner wrasse and fish being cleaned: The cleaner wrasse cleans debris and parasites off of larger fish which keeps the larger fish healthy and gives the cleaner wrasse nourishment and protection. The fish being cleaned will allow it to move freely about its gills and mouth without trying to eat it. In some places fish actually line up for this service, forming cleaning stations along the reef. Cleaner fish are very important in keeping fish, and therefore the reef, healthy and strong.

MARINE FOOD CHAIN ANSWER KEY

1. **White tip reef shark**
   secondary consumer - carnivore (page 2-9)
2. **Lettuce coral**
   primary producer (zooxanthallae), and secondary consumer - omnivore (polyps) (page 1-2)
3. **Butterfly cod (lionfish)**
   secondary consumer - carnivore (page 2-10)
4. **Parrotfish**
   primary consumer - herbivore (page 2-8)
5. **Soft coral**
   secondary consumer - omnivore; soft corals lack zooxanthallae and feed entirely on passing plankton (page 1-5)
6. **Sea whips**
   secondary consumer - omnivore; a gorgonian soft coral (page 1-5)
7. **Brain coral**
   primary producer (zooxanthallae), and secondary consumer; omnivore (polyps) (page 1-2)
8. **Olive sea snake**
   secondary consumer- carnivore
9. **Soft Coral**
   secondary consumer - omnivore (page 1-5)
10. **Feather star**
    secondary consumer - omnivore
11. **Damselfish**
    primary consumer - herbivore; damselfish are a reef "farmer" that actively guard and grow small patches of algae as a food source (page 2-8)
12. **Plate coral**
    primary producer (zooxanthallae), and secondary consumer - omnivore (polyps) (page 1-2)
13. **Vasiform sponge**
    secondary consumer - omnivores (plankton)
14. **Cuttlefish**
    secondary consumer - carnivore (page 2-13)
15. **Needle coral**
    primary producer (zooxanthallae), and secondary consumer - omnivore (polyps) (page 1-2)
16. **Batfish (juvenile)**
    secondary consumer - carnivore
17. **Moorish Idol**
    secondary consumer - omnivore; a bottom feeder
18. **Gorgonian fan coral**
    secondary consumer - omnivore; a soft coral (page 1-5)
19. **Sea anemone**
    secondary consumer - carnivore
20. **Mushroom coral**
    primary producer (zooxanthallae), and secondary consumer - omnivore (polyps) (page 1-2)
21. **Giant clam**
    primary consumer - herbivore, and primary producer (zooxanthallae) (page 2-8)
22. **Six-banded trevally**
    secondary consumer - carnivore also known as jacks
23. **Trumpetfish**
    secondary consumer - carnivore
24. **Coral cod**
    secondary consumer - carnivore; a grouper
25. **Yellow margin moray eel**
    secondary consumer - carnivore
26. **Spotted seahorse**
    secondary consumer - carnivore
27. **Sponge**
    secondary consumer - omnivore (plankton)
28. **Blue sea star**
    secondary consumer - carnivore (page 2-11)
29. **Flowery flounder**
    secondary consumer - carnivore
30. **Branching coral**
    primary producer (zooxanthallae), and secondary consumer - omnivore (polyps) (page 1-2)
31. **Emperor angelfish (juvenile)**
    secondary consumer - omnivore
32. **Banded coral shrimp**
    secondary consumer - carnivore; cleans parasites from anemones, corals and other hosts

Fishy Problems

Objective: Students gain a greater understanding of the problems facing coral reefs and native coastal people by calculating the answers to the questions on the following page.

Interdisciplinary Index: Math

Materials:

TABLE OF EQUIVALENTS

1 kilogram = 2.205 pounds

1 metric ton = 2,204.623 pounds

1 kilometer = .621 miles

1 mile = 5,280 feet

- one **Fishy Problems** handout per student

PRESENTATION:

1. Discuss the various anthropogenic threats affecting coral reefs and the native coastal people dependent upon them for survival.
2. Distribute a copy of the **Fishy Problems** handout to each student and have them answer the questions.
3. Discuss the answers with the students and their feelings about the impact these situations are having on the environment, people, local and global economies, etc. What solutions might they recommend? Emphasize that all of the questions are based upon actual scientific information.

ANSWERS TO FISHY PROBLEMS:

1. a) 3 million
   b) 4
   c) 50
2. 22,500
3. 12,000
4. a) 48
   b) 37.5 kg.
   c) 3969 lbs.
   d) 496 lbs.
5. a) 3279 ft.
   b) $3,660/ft.
6. $62 million
7. a) between 20 to 35 metric tons
   b) 44,092.5 to 77,161.8 lbs.
8. a) 429,730 metric tons
   b) 3 million people eat 0 lbs. of fish
   6 million people eat 58.42 lbs./person

FISHY PROBLEMS

QUESTIONS:

1. The world's oceans are fished by over one million large fishing ships and two million smaller ones. Around the world, 12.5 million people make their living catching fish, and another 150 million people are employed in on-shore operations or the processing of fish.
   a) How many ships fish the world's oceans?
   b) For every single fishing boat, how many people are needed, on the average, to catch fish?
   c) For every single fishing boat, how many people are needed, on the average, to handle on-shore fishing operations and processing?
2. "Almost all tuna stocks worldwide are in peril from overfishing, with the Atlantic bluefin tuna declining 90 percent in the last two decades, from 225,000 in 1970 to only _____ in 1990."

   Calculate the number of bluefin tuna remaining in the ocean in 1990.
3. Shrimpers off the southern coast of the United States catch approximately 48,000 endangered sea turtles a year. It is estimated that one quarter of these are killed in the shrimp nets. How many turtles are killed each year?
4. In a coral reef area near Santiago Island in the Philippines, observers recorded 6 dynamite fishing explosions per hour, with an estimated catch of 1800 kg of fish per day.
   a) Assuming there are eight hours in the fishing day, how many dynamite explosions occured in one day?
   b) How many kg of fish on the average would have been caught after each explosion?
   c) How many pounds of fish would have been caught in a day?
   d) How many pounds caught in one hour?

   Surveys indicated that more than half of the corals in that area had been killed by the dynamite blasting.
5. In the Maldives, a coral reef was destroyed which caused increased erosion of the beach and loss of sand. This could have the disastrous effect of increasing the loss of life and property during storms, decreasing income from tourism, and harming habitat. As a result, the government spent $12 million for 1 km of seawall to replace the destroyed reef.
   a) How many feet long was the seawall?
   b) What was the cost per foot to build?
6. It is important to consider the economic value, both short term and long term, of environmental conservation. However, often this is not done. For example, in the Philippines a logging concession was expected to yield $13 million from cutting down the rainforest over a 10-year period. The resulting environmental problems, such as erosion and siltation, would have severely damaged the adjacent coral reefs where fishing was done. If this had happened, it was estimated that up to $75 million in fishing revenue would have been lost. If this logging concession had been granted, what would have been the net loss of revenue?
7. In the Philippines, it is estimated that 1 square kilometer of coral reef in poor condition produces only 5 metric tons of fish per year, just enough to feed 100 people. A healthy reef, however, can feed between 400 to 700 people per year.
   a) How many metric tons of fish would be produced by a healthy reef?
   b) How many pounds of fish would this equal?
8. At a conservative estimate, coral reef destruction in the Philippines has meant a loss of 37% in fish production each year, or 159,000 metric tons.
   a) If the coral reefs were healthy and fish production was at 100%, how many metric tons of fish would be produced?

   This 37% loss means that 3 million people now get no seafood protein, or 6 million people get only half the protein they need.
   b) How many pounds of fish does each of these people now eat in a year?

Don't Teach Your Trash to Swim!

Objective: Students describe marine debris and its effect on coral reef ecosystems. They then propose some possible solutions to the problem.

Interdisciplinary Index: Science, English, Journalism

Vocabulary: marine debris, reduce, reuse, recycle, journalistic style, inverted pyramid

Materials:

- **Stop Trashing the Reef!** and **Journalistic Writing Style** handouts to each student
- paper, pencil, or computer

PRESENTATION:

Trash found in the ocean is directly affecting the health of the world's coral reefs. The accompanying handout for students and the information in the **Benefits, Threats, and Solutions** section will provide more background on this threat and point to solutions.

1. Present the background information on the threat posed by trash, and offer recycling as a possible solution. Read the **Stop Trashing the Reef!** handout and discuss the recycling concepts of reduce, reuse, recycle.
2. Read the **Journalistic Writing Style** handout. Introduce the suggestions for journalistic writing style and the inverted pyramid.
3. Have students write a newspaper article using journalistic writing style and an inverted pyramid explaining why reef systems are important to people in your community and what makes trash such a threat to reefs. Link local recycling efforts to global effects on the reefs. Cite resources for information. Include photos, artwork, or clip art to illustrate the articles.
4. Allow students to edit each other's articles and display the finished products.

FOLLOW-UP/EXTENSION:

Submit the best articles to the local newspaper for possible publication.

Research other newspapers or magazines which might publish the articles.

DON'T TEACH YOUR TRASH TO SWIM

Trash in the water or along the shore is called marine debris. Ocean sources of garbage include recreational vessels, merchant, military, and commercial fishing boats, and oil platforms. People on the beaches who allow trash to blow or wash into the water, illegal dumping and waste disposal, and plastics are major land-based contributors to the problem.

We must all realize that the products we use in our homes, even if far away from the oceans and coral reefs, can ultimately reach the sea. The planet is indeed linked, and each system affects the others. Therefore, recycling efforts in our communities can have a direct effect on the health of a coral reef in another part of the world. If at home and at school we can reduce, reuse, and recycle, the positive impact will be tremendous.

Brainstorm ideas to add to the lists below.

California sea lion entangled in fishing net, Sea of Cortez, Mexico. (Photo: Hal Beral)

REDUCE: Use a plate or glass instead of paper plates or cups; use fewer paper towels; buy products in bulk or in less packaging, or buy products in recycled packaging.

REUSE: Use reusable containers for lunch; use a reusable lunch bag; use margarine tubs, shoeboxes, etc. for other things.

RECYCLE: Newspaper, glass, plastic, aluminum; oil and other auto fluids, paint, solvents and thinners can also be recycled.

JOURNALISTIC WRITING STYLE

Writing a newspaper or magazine article requires a different style than you would use to write an essay, a short story, or a biography. The reporter must keep in mind the purpose of the article and the readers' needs. The purpose of the article might be to convey information, to expose corruption, or to portray all sides of an issue. Entertainment would probably not be the primary purpose of the article, unless it were part of the entertainment section of the newspaper. The article can be humorous, as long as that serves the main purpose of the article.

The readers need to have answers to their questions. There are five questions which traditionally form the basis for the journalistic style of writing. They are: Who?, What?, Where?, When?, and Why? Answering these questions in your article will allow you to be thorough, precise, and concise. The writer must decide in which order to answer these questions, whether the topic is about who is involved, or what is happening, or one of the other "5 W's." Following are the "5 W's" and some examples of other questions you might ask to clarify your writing. Apply these questions, or others you may think of, to the topic of your article.

"5 W's"

Who? – Who is involved? Who did it? Who is affected?

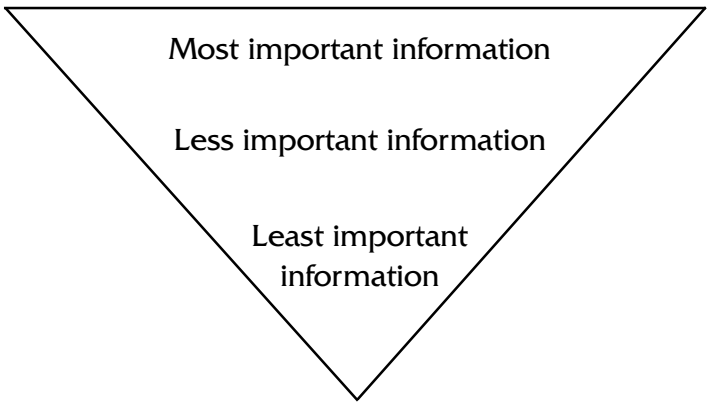
What? – What happened? What was the outcome? What is it?

Where? – Is the location important?

When? – Is this story about the past, present, future, or all three?

Why? – Why did the people act the way they did? Why did it happen here? Why is this happening here? Why is this a problem? Why should we care about this?

Another characteristic of journalistic writing involves writing in an inverted pyramid style. Think of it in terms of putting the most important information first, the second most important information next, and so on. This is a good idea for two reasons: 1) the reader gets hooked into the story right away and is more likely to keep reading, 2) the editor is often forced to cut articles because of space, and this allows cuts to be made from the bottom up without deleting the important information.



Destructo Diver

Objective: Students discuss the dangers of human activities to reefs, particularly diving, and encourage proper techniques which will lessen human damage to reefs.

Interdisciplinary Index: Science, English, Writing, Drama

Vocabulary: anthropogenic, sedimentation, weight and buoyancy control

Materials:

- **Destructo Diver Vs. Dependable Diver** and **Destructo/Dependable Diver Behaviors** handouts to each student
- painted backdrops
- props such as masks, fins, and other diving equipment

PRESENTATION:

1. Discuss the nature of threats to the coral reef and brainstorm possible solutions. Discuss the problem that people, such as divers, who enjoy and are interested in the reefs can still have a negative impact on the fragile coral community.
2. Have the students call local dive shops or dive clubs and interview some divers in preparation for writing a series of short skits in which they role-play the actions of **Destructo Diver vs. Dependable Diver**.
3. As a class, discuss the behaviors associated with **Destructo Diver** and with **Dependable Diver**. Cover such topics as boat diving, collecting, spearfishing, etc. using the **Destructo/Dependable Diver Behaviors** handout.
4. Assign specific behaviors for each group to portray.
5. In groups, students write a short skit illustrating the behavior.
6. Assign roles, practice.
7. Produce the skits for the class, including props and backgrounds if possible.
8. Critique the skits in class, discussing which was most effective and why.

FOLLOW-UP/EXTENSION:

Perform the skits for other audiences such as dive clubs.

Videotape the skits and distribute to others.

Create a series of posters based on the skits and send them to dive shops in your community.

Create a comic book or coloring book illustrating the lesson(s).

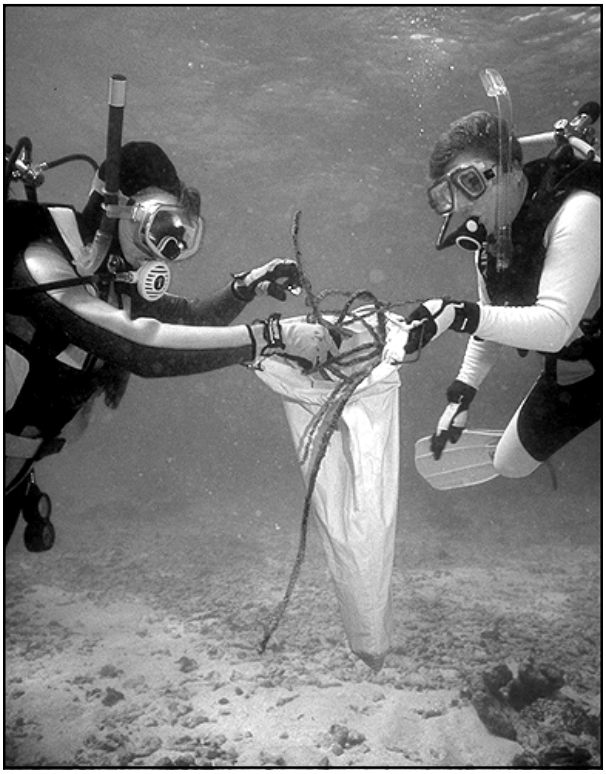
DESTRUCTO DIVER VS. DEPENDABLE DIVER

DESTRUCTO DIVER VS. DEPENDABLE DIVER

Living coral reefs attract people who want to experience their beauty first-hand. Unfortunately, many of these same people are damaging the very environment which they love. It is estimated that the average scuba diver has negative contact with a coral reef approximately seven times for every 30 minutes underwater. Multiply this by the millions of divers from the U.S. alone making multiple dives every year, and the impact is clear. Coral reefs are being carelessly and needlessly damaged.

Read the following information on the proper and improper behaviors of divers, then write a short skit portraying several of the behaviors. Present your skit to the class.

Make notes here about your skit:



Dependable Diver: coral reef sweepers do underwater reef clean-up. (Photo: Larry Benvenuti)

DESTRUCTO DIVER BEHAVIORS

Bad Boating: Careless diving off the dive boat can run the boat aground a coral reef, shearing off corals and stirring up sediments. Dropping anchor onto the reef damages the coral below.

Trashing the Reef: Dumping trash, emptying toilets, and spilling or leaking fuel and oil pollutes the water and can ultimately damage the reef ecosystem.

Careless Entries: Divers who jump into the water without looking can smash into corals and kill them.

Poor Buoyancy Control: Being overweighted and grabbing at live coral for balance or dragging fins over corals and kicking wildly to keep in balance can stir up the bottom silt and cloud the water with sediment which settles on the coral. Large amounts of silt smothers the coral, interfering with the coral's natural filtration system.

Standing on Corals: Sitting, kneeling, or standing on coral damages the living animal, creating wounds and dead areas which can become infected and spread to the entire coral colony. The stress of battling infection can be fatal to an organism already in delicate balance.

Trailing Equipment: Regulators, dive computers, net bags, bulky photography equipment, and other dangling articles can hit or become entangled in coral, ripping it off in chunks.

Interacting with Marine Life: Feeding the reef fish disrupts their natural patterns, making them more vulnerable to predators, both other marine animals and fishermen. Using bangsticks or spearguns to kill reef fish results in serious overfishing, diminishing an important part of the live coral reef. Collecting live specimens of coral, sponges, and fish as souvenirs or for resale is carelessly destroying life on the reefs. Chasing and grabbing onto fish or pulling animals out of their hiding places weakens and stresses them needlessly, often causing injury or death.

DEPENDABLE DIVER BEHAVIORS

Good Boating: Careful boat handling includes operating at a safe speed, and anchoring either at a buoy or far enough away from the reef that anchor and chain will not tear off coral as the boat drifts or sways.

Caring for the Reef: Carrying out trash and waste, and keeping boat engines in good repair to minimize fuel and oil leaks will help stop pollution.

Careful Entries: Gently dropping into open water and orienting yourself, once underwater, will allow you to approach the reef carefully.

Buoyancy Control: Practice buoyancy control in a pool or other quiet body of water where there is no surge from waves. Being able to hover over the reef without touching it with hands or feet protects the reef, reducing the chance of silt being churned up in the water. The feeling of flying is one of the real thrills of diving.

Floating Over Corals: Proper weighting allows the diver to float comfortably without having to stand on the coral.

Controlling Equipment: Keep all equipment tucked into belts or close to the body. Use a compact camera with an attached strobe.

Observing Marine Life: Enjoy the sights of dazzlingly beautiful sea creatures in their natural environment. Do not disturb or feed wild fish or collect specimens. "Take only pictures, leave only bubbles."

Benefits, Threats, and Solutions Crossword Puzzle

Objective: Students will learn about the benefits derived from coral reefs, the threats to them, and possible solutions by finding words to complete the crossword puzzle.

Interdisciplinary Index: Language Arts, Science

Materials:

- a copy of the **Benefits, Threats, and Solutions Crossword Puzzle** and **Puzzle Clues**, one per student
- pencils

PRESENTATION:

1. Review the **Benefits, Threats, and Solutions** section in the **Background Information**.
2. Hand out a copy of the crossword puzzle and clues to each student.
3. Ask them to read the description and find the word that both answers the description and fits into the boxes.
4. When everyone is finished, discuss the answers with the students.

FOLLOW-UP/ EXTENSION:

Have students create their own crossword puzzles for the class to answer.

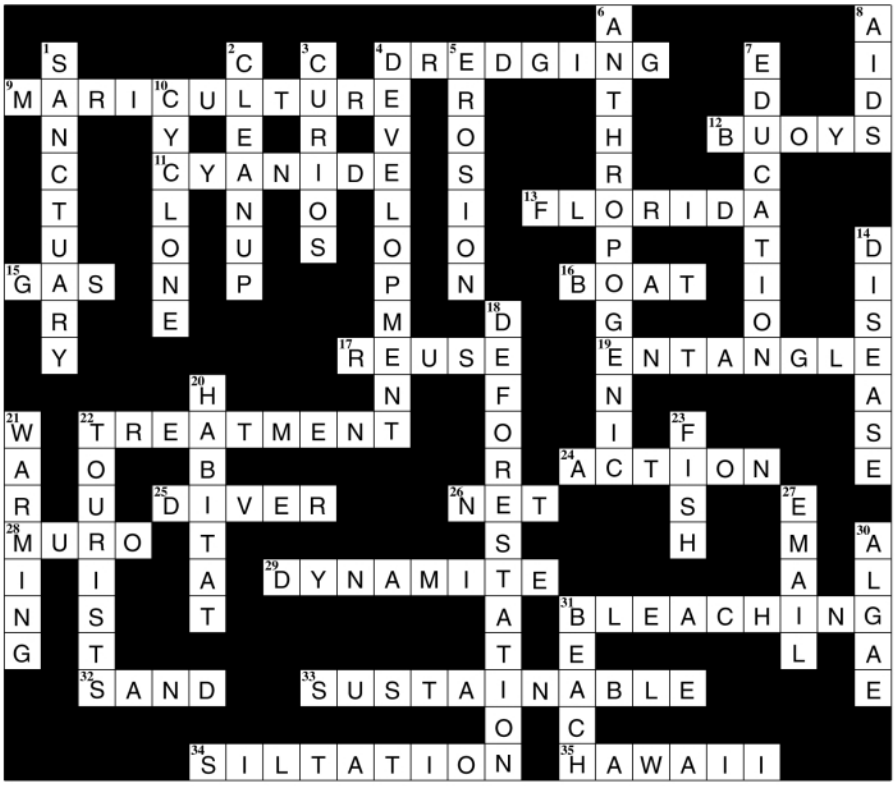
ANSWER KEY

ACROSS:

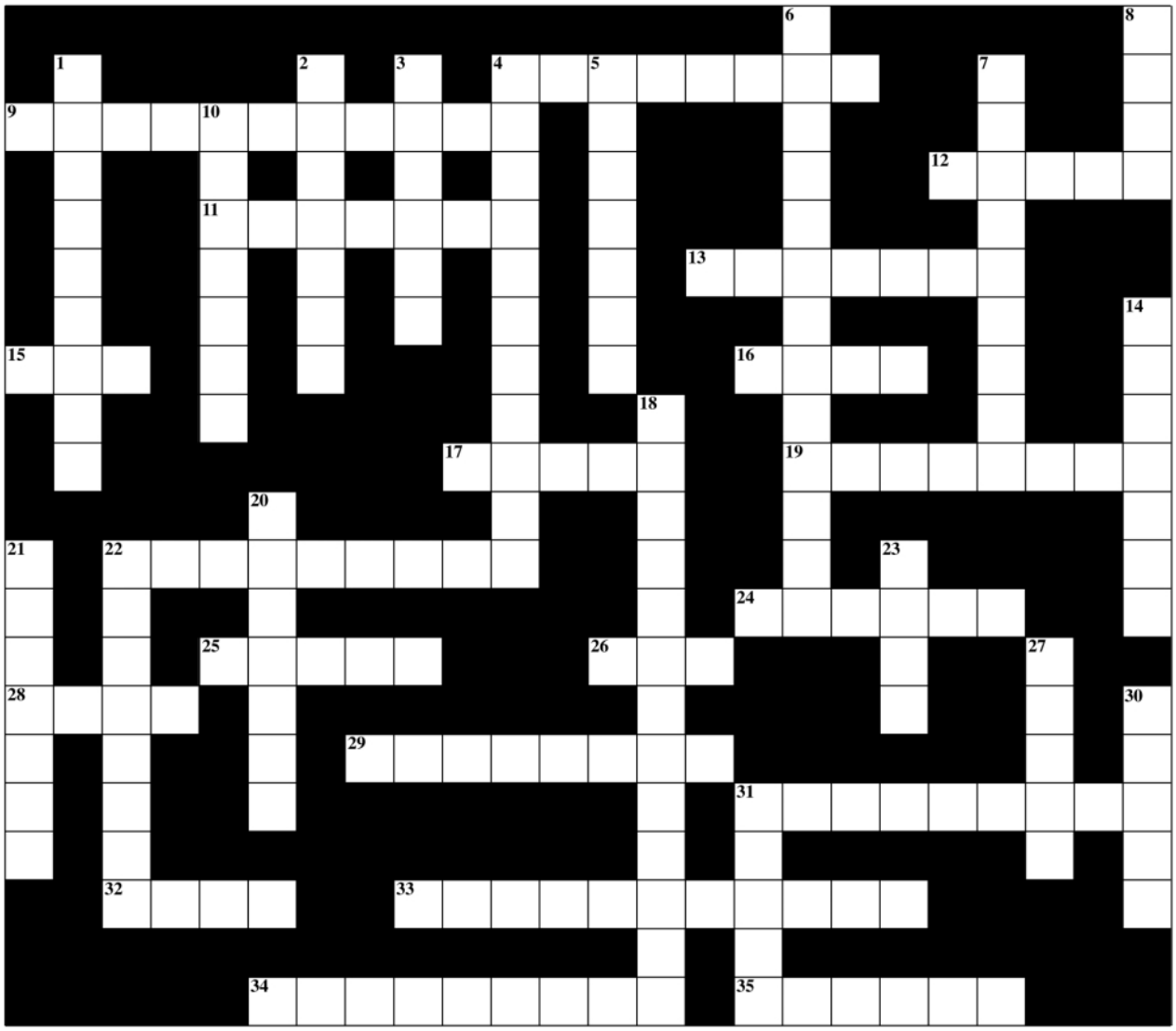
4. **dredging**
9. **mariculture**
11. **cyanide**
12. **buoys**
13. **Florida**
15. **gas**
16. **boat**
17. **reuse**
19. **entangle**
22. **treatment**
24. **action**
25. **diver**
26. **net**
28. **muro**
29. **dynamite**
31. **bleaching**
32. **sand**
33. **sustainable**
34. **siltation**
35. **Hawaii**

DOWN:

1. **sanctuary**
2. **cleanup**
3. **curios**
4. **development**
5. **erosion**
6. **anthropogenic**
7. **education**
8. **AIDS**
10. **cyclone**
14. **disease**
18. **deforestation**
20. **habitat**
21. **warming**
22. **tourists**
23. **fish**
27. **email**
30. **algae**
31. **beach**



BENEFITS, THREATS, AND SOLUTIONS CROSSWORD PUZZLE



BENEFITS, THREATS, AND SOLUTIONS CROSSWORD PUZZLE CLUES

ACROSS:

4. the clearing of channels
9. the farming of marine plants and animals
11. a type of poison used to catch fish
12. moorings used by boats
13. a southeastern state with coral reefs
15. riding a bike saves this type of fuel
16. a vehicle that causes damage by grounding and anchoring
17. to use over and over again
19. to get caught in nets, fishing lines, garbage
22. medical care
24. to do something to protect the environment; take _____
25. someone who wears SCUBA gear underwater
26. a nylon or fiber mesh used in fishing
28. _____-ami, a type of net used in fishing
29. an explosive used to kill fish
31. the expelling of zooxanthellae from coral polyps due to stress
32. fine grains of limestone, rock and shells
33. non-exploitative use of natural resources
34. the covering of coral with sediment
35. the western island state with coral reefs

DOWN:

1. a marine protected area
2. picking up trash
3. gifts made from coral and shells
4. building and construction
5. the washing away of soil
6. human-caused
7. learning
8. a deadly virus, a treatment for which might be found in coral reefs
10. a fierce storm in the southern hemisphere
14. illness
18. clear-cutting of trees
20. the place where a plant or animal naturally lives
21. global _____, increase in water temperature
22. a source of income that wears tacky shorts and carries cameras
23. a source of protein that lives in the sea
27. a way to communicate electronically with others using the computer
30. a green marine plant that thrives on excess nutrients
31. sandy shore

Student Assessment

Tell and Show What You Know

Objective: Students will review what they have learned about the coral reef by illustrating their knowledge and sharing it with others.

Interdisciplinary Index: Science, Language Arts, Art

Materials:

- writing paper or butcher paper for each student
- colored pencils, pens, crayons, and felt pens

PRESENTATION:

1. Have students fold paper into 4, 8, or 16 equal parts.
2. Tell students that they are to think of the 4, 8, or 16 most interesting things that they have learned about the coral reefs.
3. Have students draw or write down their thoughts in the 4, 8, or 16 parts of the paper.
4. Have students share their thoughts/pictures in small groups or with the class.
5. The finished product can be used as a mural.

FOLLOW-UP/EXTENSION:

Ask students to repeat the activity based on one of the following formats:

What would happen if...

What would you do if...

How I can help...

The 4, 8, 16 most interesting coral reef creatures are...