Marine Unit 4

Keeping an Eye on Coral Reefs

Overview

Coral reefs are found throughout the tropical oceans of the world. These ecosystems are among the most diverse in the world. In many parts of the world, coral reefs are severely degraded and threatened by a range of human-caused impacts including pollution, overfishing, and direct destruction through activities such as dredging and contact during recreational activities.

Around the world, there is growing concern over reef health. The Coral Reef Initiative is a new international effort to reverse the trends that have damaged about ten percent of the world's coral reefs beyond recovery. An initial assessment suggests that Hawaiian coral reefs are generally in better shape than reefs in many other parts of the world. Still, people are putting pressure on Hawaiian coral reefs, and the extent of our impact is not always known. In this unit, students learn why coral reef monitoring is done, practice some essential reef-monitoring skills, and research problems with coral reefs around the world.

Length of Entire Unit

Three class periods

Unit Focus Questions

1) How and why do scientists monitor coral reefs?

2) What are some of the essential skills of coral reef monitoring?

3) What are the main threats to coral reef health around Maui and around the world?

Unit at a Glance

Activity #1

Coral Reef Monitoring Simulations

Through simulated exercises, students learn some fundamental skills and techniques used in monitoring coral reefs.

Length
Two class periods

Prerequisite Activity
None

Objectives
- Describe, critique, and apply skills and techniques associated with coral reef monitoring, including:
  - Estimating percent cover,
  - Performing cover assessments on photographs, and
  - Identifying corals and other reef-related plant and animal species.

DOE Grades 9-12 Science Standards and Benchmarks
LIVING THE VALUES, ATTITUDES, AND COMMITMENTS OF THE INQUIRING MIND: Students apply the values, attitudes, and commitments characteristic of an inquiring mind.
- HONESTY: Report findings accurately without alterations and draw conclusions from unaltered findings.

Activity #2

Protecting Coral Reefs

Students perform Internet research on one of the main threats to coral reefs in Hawai‘i and around the world.

Length
One class period preceded by homework reading and a research assignment

Prerequisite Activity
None

Objectives
- Describe threats to local coral reefs or other reefs around the world.
- Describe actions people are taking to protect coral reefs from these threats.

DOE Grades 9-12 Science Standards and Benchmarks
LIVING THE VALUES, ATTITUDES, AND COMMITMENTS OF THE INQUIRING MIND: Students apply the values, attitudes, and commitments characteristic of an inquiring mind.
- QUESTIONING: Ask questions to clarify or validate purpose, perspective, assumptions, interpretations, and implications of a problem, situation, or solution.
- SELF-DIRECTED: Use research techniques and a variety of resources to complete a report on a project of one’s choice.

RELATING THE NATURE OF TECHNOLOGY TO SCIENCE: Students use the problem-solving process to address current issues involving human adaptation in the environment.
- Identify and explain current issues or problems based on evidence found in available information.

Enrichment Ideas

- Research a favorite coral reef to learn more about whether it has been studied, what the studies reported, the current health of the coral reef, current threats, and so forth.

- Apply sampling methods to estimate the number of students, numbers of males and females, or ethnic composition of students in the school. Check against enrollment figures.

- Participate in volunteer opportunities to monitor local coral reefs. (See the introduction to this module for organizations that offer these opportunities.)

- Watch the video *Coral Reefs: Their Health, Our Wealth* (included with this curriculum or see "Resources for Further Reading and Research" for ordering information). Use the information in the video, which focuses on Guam coral reefs, as the basis for a research project that compares the status of and threats to Guam coral reefs with those in Hawai'i.

Resources for Further Reading and Research

- Klemm, E. Barbara, Francis M. Pottenger III, Thomas W. Speitel, S. Arthur Reed, Ann E. Coopersmith, *The Living Ocean: Biological Science and Technology in the Marine Environment,* Curriculum Research and Development Group, University of Hawai'i, Honolulu, 1995.

  The chapter on corals and coral reefs covers how a coral grows; symbiosis; coral identification; reef formation, structure, and evolution; biological and physical agents of change on reefs; and the worldwide distribution of coral reefs.

- University of Guam Marine Laboratory, and Guam Department of Agriculture Division of Aquatic and Wildlife Resources, *Coral Reefs: Their Health, Our Wealth.* This 24-minute video is available from the Guam Department of Agriculture Division of Aquatic and Wildlife Resources,192 Dairy Road, Mangilao, Guam 96923, Facsimile (671) 734-6570.

- Basic information about coral reef ecology is available on the Coral Reef Ecology website at <www.uvi.edu/coral.reefer/index.html> and on the Coral Reef Alliance website at <www.coral.org/faq.html>.

- Resources related to coral reef monitoring and volunteer opportunities in Hawai'i is available on the Reef Environmental Education Foundation website at <www.reef.org>, the Coral Reef Assessment and Monitoring Project website at <cramp.wcc.hawaii.edu>, and the Reef Check website at <www.reefcheck.org>.

- Hawai'i Sea Grant has published an online bibliography of reference works related to coral reefs at <www.soest.hawaii.edu/SEAGRANT/iyorbib.html#monitor>.

Activity #1

Coral Reef Monitoring Simulations

● ● ● Class Period One *Observing Reef Fish Underwater*

Materials & Setup

- *Hawai'i's Reefs: Oceanic Oasis* video (included with this curriculum)

For each student

- Student Page "Reef Fish Checklist" (pp. 12-14)
- "Reef Fish Identification Chart" (master, p. 11 — Options: laminate these charts for durability, divide students into small groups to share a chart.)

Instructions

1) Show the video, *Hawai'i's Reefs: Oceanic Oasis* (8 minutes). Rewind the tape when you finish, so it's ready to be played again later in the class.

2) Hold a brief discussion about the video: Did students learn anything new? What struck them from the video?

3) Pass out a copy of the Student Page "Reef Fish Checklist" to each student and review the instructions. Also pass out the "Reef Fish Identification Chart" to each student or small group.

4) Play the video again, this time with the sound off. Students will be filling in the 1st Survey Column of the "Reef Fish Checklist" as they watch the video. Once again, rewind the tape when you finish, so it's ready to be played again.

5) Briefly discuss students' experience with this exercise by asking, "What are some of the challenges facing divers who do underwater fish surveys?"

   Some of the answers might include the numbers of fish to count, the fact that the fish are moving, uncertainty about whether a particular fish has been counted before, and having to recognize species quickly.

6) Ask students whether they think it would be easier to accurately count fish if they could see the video again.

7) Test their predictions by playing the video again (with the sound off) and having students fill in the 2nd Survey column of the "Reef Fish Checklist."

8) Ask students whether they see a difference in their counts. If so, do they think their counts were more accurate the first time or the second time? Why?

   For anyone conducting fish surveys, there is a learning curve during which they become more familiar with the species of fish they are likely to see. Their observations become more accurate as they learn.

9) Have students pair up with a partner and compare their findings by filling in the second page of the Student Page "Reef Fish Checklist." Students should simply compare observations with each other. Each student should fill in his or her partner's tallies from the *second* video survey where indicated on the student page. Students should not complete the calculations at this time.

10) Bring the class back together and ask whether they saw differences in their partner's observations and theirs. If so, why do students think these differences might occur? How do they think that differences between observers might influence the results of a coral reef monitoring study? How could researchers compensate for those effects?

    This effect is called "observer bias" in research studies. Even with extensive training, underwater observers generally do not record exactly the same data. One way to compensate for observer bias is to pair researchers to make observations and adjust the data to reflect the differences in data sets.

11) Assign the remainder of the student page as homework.

● ● ● Class Period Two *Coral Reef Monitoring Simulations*

Materials & Setup

For each student

- Student Page "Estimating Percent Cover" (pp. 15-17)
- Ruler (If you do not have enough rulers to go around, have students share in small groups.)
- Black pen

For each pair of students

- Student Page "Get the Point" Note: Color photocopies are best for this activity, but black and white will work, as well. (pp. 18-21)

Instructions

1) Hand out the Student Page "Estimating Percent Cover."

2) Tell students that researchers often use "percent cover" as a way of estimating the species composition of a coral reef. This means they are looking at how much of the ocean's floor is covered by corals, and which types of corals. Tracking changes over time helps them describe and evaluate the health of the coral as well as growth and change within the reef community. Changes in the relative proportions of coral reef species, as well as in total coral coverage, are both important. Percent cover is used to evaluate other types of marine and terrestrial habitats, as well.

3) Have students work through the activity, making all estimates and calculations.

4) Write the actual percent black cover for each of the figures on the board. Figure #1 is 36 percent black. Figure #2 is 34.5 percent black.

5) Review student results using the following discussion questions:
   a) Were students more accurate at estimating cover when the shapes have straight sides or when they are rounded? What implications might this have for the study of coral reefs?

      Coral reef researchers must estimate percent cover of irregularly shaped coral, adding difficulty to an already tricky task.

   b) Were students more accurate at estimating cover with or without the grid? What might explain this? What implications does it have for studying percent cover on coral reefs?

      Breaking up a larger area into smaller areas typically increases accuracy. For even more accurate analysis, many studies of coral cover use a system in which slides of the reef taken at designated locations along a transect are projected over an image containing many randomly selected coordinates. At each set of coordinates, the substrate/cover is recorded and an average made based on those data.

   c) Which was more accurate, using all of the cells in the grid, or just a sample?

      Although using all of the cells may be more accurate than just a sample, it is not feasible for researchers to examine every bit of the extensive coral reefs they study. The trick is to make the sample size large enough to estimate coverage with confidence but small enough to be manageable. Researchers have spent much effort testing the validity of their sampling schemes.

6) Divide students into pairs. Give each pair one copy of the Student Page "Get the Point."

7) Explain that researchers collect data about the presence and abundance of marine species in different ways.

   - One way is to set up a "transect" (a line across the reef) and swim along it, counting and recording fish and other species, or stopping at predetermined points to make and record observations. The exercise with the video observations was something like this, only there was not a continuous transect.

     In the "visual strip-transect search" method, for example, two divers swim side-by-side down either side of a transect, counting all fishes seen within a corridor three meters wide and extending to the surface. In another method, divers make one pass along the transect, recording fish they see swimming above the reef and a return pass to search for organisms sheltered in cracks and crevices.

   - Another approach, most often used when looking at coral cover or at invertebrate species that live on the reef, is to set up a transect and then to sample at points along that transect.

     One sampling method, called the "point-intercept" method, involves identifying the type of cover at various sampling points along the transect.

     Another sampling method is called the "photoquadrat" method. With this method, researchers use an underwater camera fitted with a square frame that enables researchers to take a

picture of a small square portion of the ocean bottom, and then to analyze what is in that photograph later. Researchers may set up fixed locations for these photoquadrats that they return to again and again to track changes over time. This is called the "fixed photoquadrat" method.

When researchers analyze the photographs, they generate a number of points that they overlay onto the photograph, recording the type of cover that lies directly underneath each point. Researchers then extrapolate percent cover of various corals based on this sample.

8) Have student partners work through the photo analysis exercise on the student page. (Note: The area in the photo not covered by the blue leather coral is the rock substratum and small growths of algae, sponges, or other organisms.)

9) If there is time left, briefly discuss the photo analysis by asking, "Why is this a good way to estimate percent cover?" and "What do researchers need to know or do to make this technique accurate?"

Photo analysis is a good way to estimate percent cover because the analysis itself takes place out of the water and can be more rigorous than analyses conducted underwater. It also allows researchers to track changes in particular areas over time. To make this technique accurate, researchers must take all photographs from the same distance away from the ocean bottom and must be able to identify organisms based on the photographs.

10) If students need more time to finish their photo analysis, have each partner take home the photo he or she was working on during class, and allow partners some time during the following class period to compare results. During this time, you may also wish to discuss student responses to the questions in the Student Page "Get the Point."

Journal Ideas

- In traditional Hawaiian society, fishing areas were declared *kapu* (off-limits) either seasonally or as they became depleted and needed time to recover so they could support fishing again. What would you look underwater for if you were determining when the *kapu* would begin and end?
- Do you think it is possible to eliminate observer bias in underwater research? If so, how? If not, why not?

Assessment Tools

- Student Page "Reef Fish Checklist" (teacher version, p. 9)
- Student Page "Estimating Percent Cover" (correct answers in unit instructions, p. 7)
- Student Page "Get the Point" (teacher version, p. 10)
- Participation and conduct during pairs exercises
- Journal entries

Teacher Version

Reef Fish Checklist

Questions

1) Which set of observations—your first or your second—do you think is more accurate? Why?

   The second is likely to be more accurate because students are likely to become more familiar with the species of fish they are likely to see. Their observations may become more accurate as they learn.

2) If you had to use both data sets for a study, how confident would you be in the precision of your results (i.e., in how well they reflect the real underwater situation). Explain your answer.

   Well reasoned answers are acceptable. If there are significant differences between the two sets of data, one possible answer is that the second set of data could reflect the underwater situation more accurately than the first set, leading to questionable precision.

3) Name two factors that could help explain differences between your counts and your partner's counts. Describe how each might influence the accuracy of an underwater fish survey that is conducted as part of a scientific research project.

   Well reasoned answers are acceptable. Possible responses include:

   - There could be difficulties in seeing and recording every fish, especially when there are many fish congregated in an area.
   - Different observers may tend to see certain kinds of fish, or fish in certain parts of the transect, and miss others.
   - There may be difficulties counting fish accurately when they move in and out of the area being observed.

   All of these factors could cause imprecision in scientific research. These sources of imprecision may be partially countered by comparing or compiling data from more than one observer.

Teacher Version

Get the Point

3) Do you think that one method was more accurate than the other? Why or why not?

Well reasoned responses are acceptable.

4) How would you test to see whether one method was more accurate than the other?

Well reasoned responses are acceptable. A possible response is to analyze cover in the photograph using a large number of points to achieve a response of greater precision against which to compare the results of both methods used.

5) How could you make both of these methods more accurate?

Well reasoned responses are acceptable. One way to increase accuracy is to increase the number of sampling points used.

6) How do you think this kind of analysis could help scientists studying coral reefs? Why?

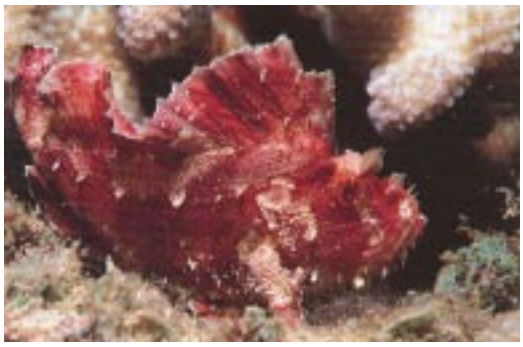
Well reasoned responses are acceptable. A possible response is that this kind of analysis can help scientists monitor changes in the composition of the coral community over time.

Reef Fish Identification Chart

Photos: Leaf scorpionfish, Marjorie L. Awai, all others John P. Hoover, Hawaii's Fishes, *Mutual Publishing*

Hawaiian cleaner wrasse
Labroides phthirophagus

Pākuʻikuʻi or Achilles tang
Acanthurus achilles



Leaf scorpionfish
Taenianotus triacanthus
(color varies from grayish white to yellow, red, brown, or black)

Manini or Convict tang
Acanthurus triostegus

ʻŪʻū or Big-scale soldierfish
Myripristis berndti

Lauʻīpala or Yellow tang
Zebrasoma flavescens

Reef Fish Checklist

Based on the video *Hawai'i's Reefs: Oceanic Oasis*, fill in the following reef fish checklist. For each "survey" or fish count that you do, tally the number of separate times you see each species, and how many fish you see each time. If you need to estimate how many fish you see, do so. Use hash marks to keep count, rather than numerals (e.g., Ⅲ instead of 3).

	1st Survey		2nd Survey	
	# of Sightings	# of Fish	# of Sightings	# of Fish
Hawaiian cleaner wrasse *Labroides phthirophagus*				
Leaf scorpionfish *Taenianotus triacanthus* (can be grayish white, yellow, red, brown, or black)				
ʻŪʻū or Big-scale soldierfish *Myripristis berndti*				
Pākuʻikuʻi or Achilles tang *Acanthurus achilles*				
Manini or Convict surgeonfish or tang *Acanthurus triostegus*				
Lauʻīpala or Yellow tang *Zebrasoma flavescens*				

Reef Fish Checklist Comparison Table

Compare the results of your second survey with a partner. Notice whether there are differences between your tallies. Fill in the first two appropriate columns in this table with your results (following the "Y") and your partner's results (following the "P"). If there is not time in class, you may complete the "Quantifying Comparisons" section and the questions that follow as your homework assignment.

	2nd Survey Results		Percent Difference	
	# of Sightings	# of Fish	%Difference # of Sightings	% Difference # of Fish
Hawaiian cleaner wrasse *Labroides phthirophagus*	Y P	Y P		
Leaf scorpionfish *Taenianotus triacanthus* (can be grayish white, yellow, red, brown, or black)	Y P	Y P		
ʻŪʻū or Big-scale soldierfish *Myripristis berndti*	Y P	Y P		
Pākuʻikuʻi or Achilles tang *Acanthurus achilles*	Y P	Y P		
Manini or Convict surgeonfish or tang *Acanthurus triostegus*	Y P	Y P		
Lauʻīpala or Yellow tang *Zebrasoma flavescens*	Y P	Y P		

Quantifying the Comparisons

Fill in the third and fourth columns of this table using the numbers from the first two columns. Use the formula below to calculate the percent difference between your results and your partner's results.
Note: Your calculations may result in negative or positive numbers.

Percent difference = (Your result – Partner result/Your result) x 100

Questions

1) Which set of observations—your first or your second—do you think is more accurate? Why?

2) If you had to use both data sets for a study, how confident would you be in the precision of your results (i.e., in how well they reflect the real underwater situation). Explain your answer.

3) Name two factors that could help explain differences between your counts and your partner's counts. Describe how each might influence the accuracy of an underwater fish survey that is conducted as part of a scientific research project.

   •

   •

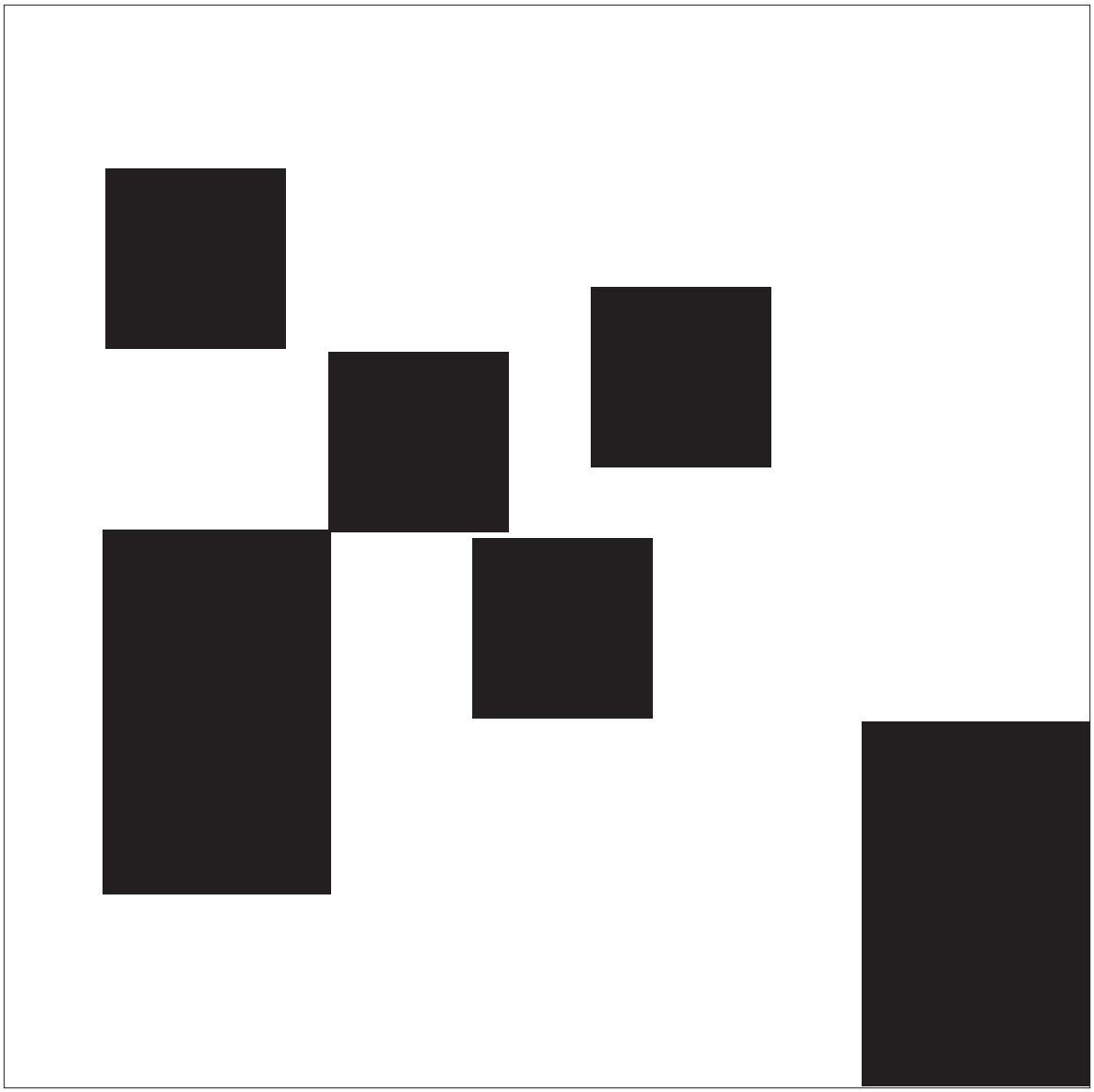
Estimating Percent Cover

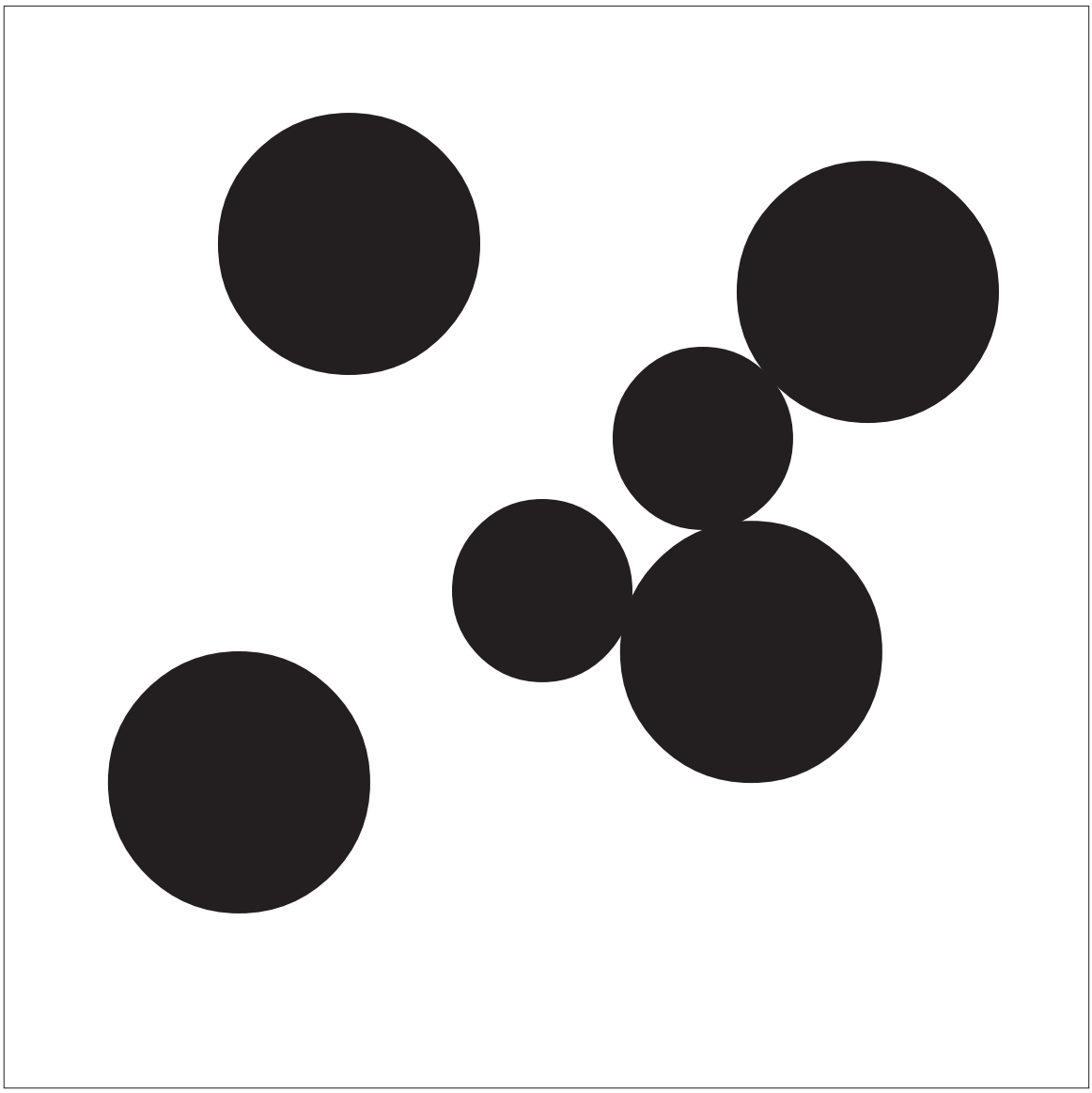
Researchers often estimate "percent cover" as a way of approximating the species composition of a coral reef. Percent cover simply refers to the proportion of a given area covered by a particular species of coral.

Tracking changes in percent cover over time helps scientists describe and evaluate the health of the coral as well as growth and change within the reef community. Changes in the relative proportions of coral reef species, as well as in total coral coverage, are both important because they help scientists understand the natural life cycle of coral reefs and may be signs of changes in factors such as water quality, temperature, numbers and types of predatory marine animals on the reef, or disease.

In this exercise, you'll practice estimating percent cover using different techniques.

1) Estimate the percentage of the area inside the box covered by black without doing measurements.





2) Estimate the percentage of the area inside the box covered by black (no measuring).

3) Go back to the figures used in #1 and #2 above. *For each figure*, make a new estimate of percent cover using the following method:
   a) Draw a four -by-four grid that divides the box into 16 sections of equal size. Estimate percent cover in each of these sections, writing your estimates in or next to each cell of the grid.
   b) Average these estimates to come up with a total percent cover estimate.

   Figure #1 percent black cover estimate:

   Figure #2 percent black cover estimate:

4) Pick three numbers between one and 16. Write them down here.

Now, go back to the figures used in #1 and #2 above. Your grids divide the box into 16 equal sections. Using the following numbering scheme, select the percent coverage for the sections that correspond to the numbers you selected above.

1	2	3	4
5	6	7	8
9	10	11	12
13	14	15	16

Write the corresponding percent cover estimates below and average them:

	Figure 1	Figure 2
Section number ____	_____ percent cover	_____ percent cover
Section number ____	_____ percent cover	_____ percent cover
Section number ____	_____ percent cover	_____ percent cover

Average percent cover (include your calculations)

Get the Point

When researchers analyze photographs of coral reefs, they may use a method in which they generate a number of points that they overlay onto the photograph. The easiest way to generate these points is to use special computer software designed for this purpose. They then record the type of cover that lies directly underneath each point. Researchers then "extrapolate" or predict percent cover of various corals for the entire reef based on this sample. Comparing changes in coverage over time can help researchers track the growth of corals, damage to corals, and how well different species of coral are doing relative to each other.

In this exercise, you'll work with a partner to determine the percent coral cover in a photograph using two different methods. Each of you will use a different method, and then you will compare findings.

1) You take one of the two photo assignment sheets, and your partner takes the other. Follow the directions on your sheet, and when you are finished, compare your findings with your partner's findings below.

2) Fill in the following table with your findings.

	Percent Coral Cover	Percent Other Cover
Grid method		
Random method		

3) Do you think that one method was more accurate than the other? Why or why not?

4) How would you test to see whether one method was more accurate than the other?

5) How could you make both of these methods more accurate?

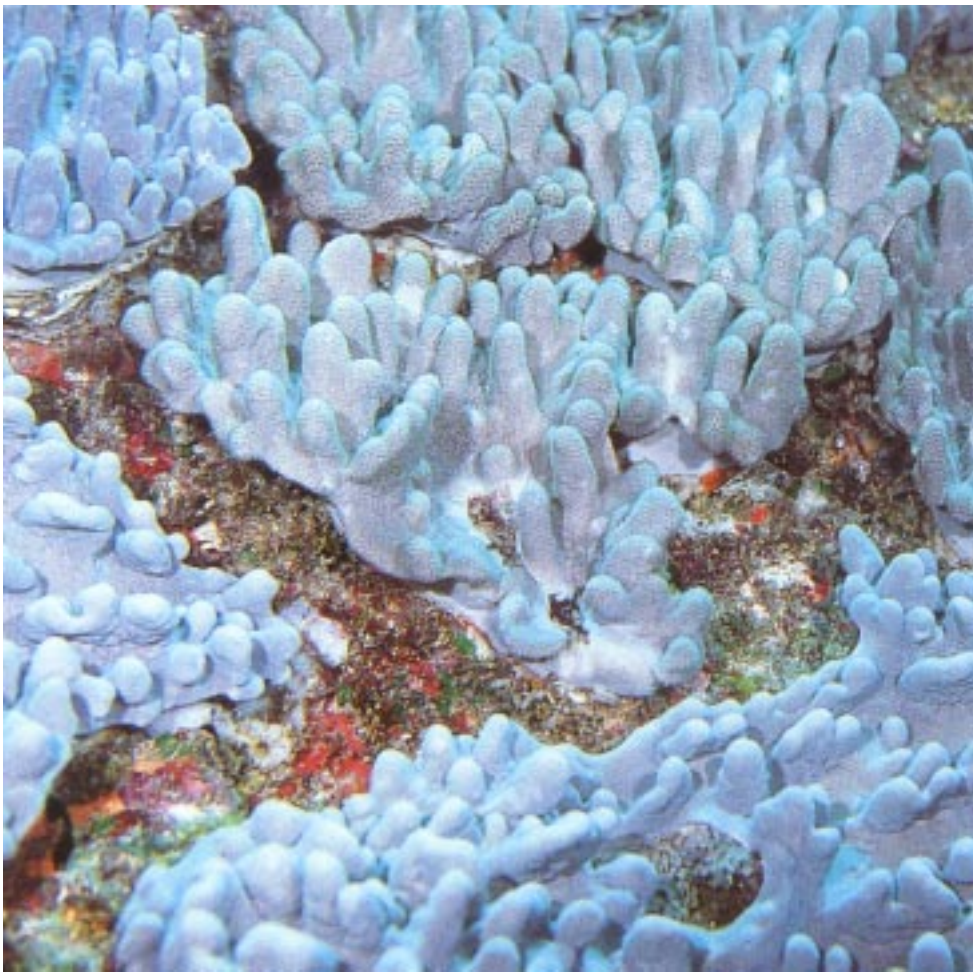
6) How do you think this kind of analysis could help scientists studying coral reefs? Why?

Photo Assignment Sheet #1: Grid Method

1) Draw a five-by-five grid over this photo that divides it into 25 equal sections. Number the intersection points on this grid from one to 16, and write the numbers near each intersection.

2) For each intersection point, record what lies under it on the photo: coral or something else.

1.	7.	13.
2.	8.	14.
3.	9.	15.
4.	10.	16.
5.	11.	
6.	12.	



Leather Coral (Photo: John P. Hoover, Hawai'i's Sea Creatures, *Mutual Publishing)*

Photo Assignment Sheet #2: Random Method

1) Close your eyes and use your pen to mark dots on the photograph, as randomly as you can. Continue making dots until you have 16 of them on the photograph itself. Number these points from one to 16, and write the numbers on the photograph.

2) For each intersection point, record what lies under it on the photo: coral or something else.

1.

2.

3.

4.

5.

6.

7.

8.

9.

10.

11.

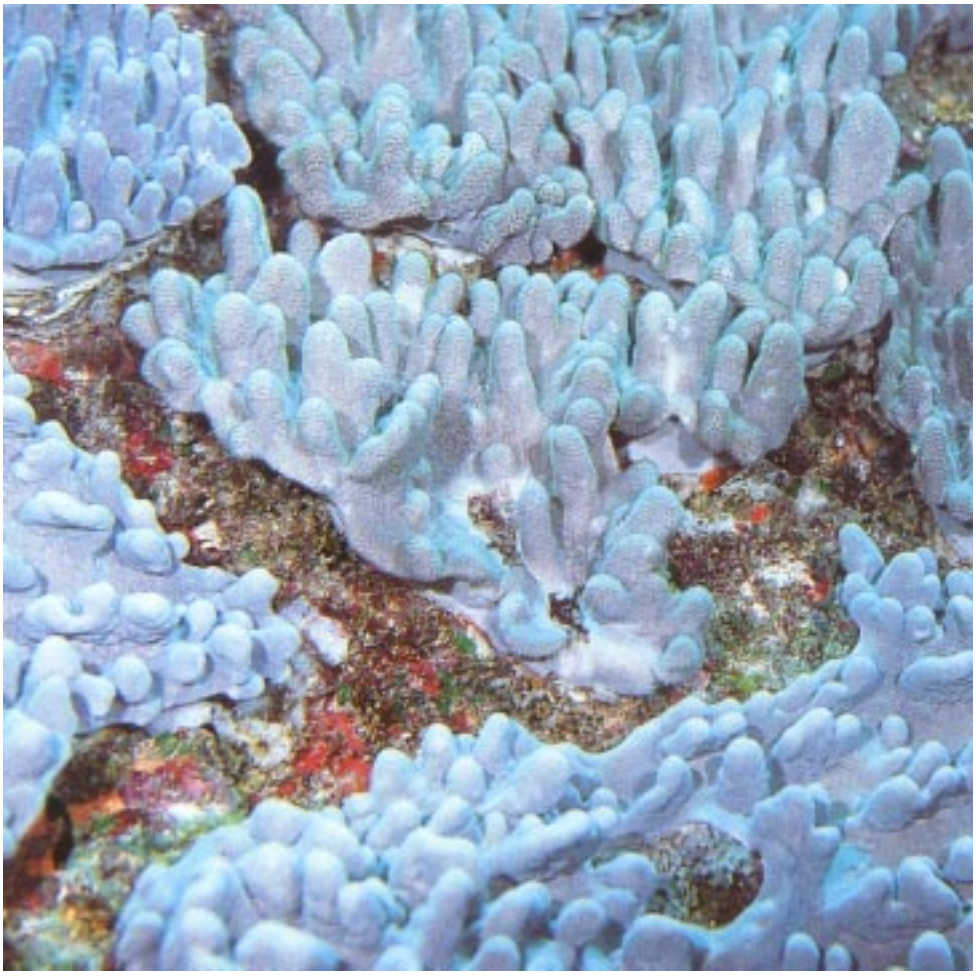
12.

13.

14.

15.

16.



Leather Coral (Photo: John P. Hoover, Hawai'i's Sea Creatures, *Mutual Publishing)*

Activity #2

Protecting Coral Reefs

● ● ● In Advance *Student Assignment*

- Assign the Student Page "Keeping an Eye on Coral Reefs" (pp. 22-25) as homework. This homework assignment includes Internet research on coral reef problems and protection.

● ● ● Class Period One *Protecting Coral Reefs*

Materials & Setup

For each student

- Student Page "Keeping an Eye on Coral Reefs" (pp. 24-27)

Instructions

1) Lead a class discussion that focuses on the ideas students generated through their Internet research. The discussion should cover:
   - How monitoring is being used to document the health of coral reefs,
   - What is being done in other parts of the world to protect coral reefs from specific threats,
   - What is being done on Maui and in other parts of Hawai'i to protect coral reefs,
   - What students think should be done to protect Maui coral reefs,
   - What students could do to help protect Maui coral reefs,
   - How people's actions on land and in the water affect coral reefs, and
   - What other information students might need to make informed decisions about Maui coral reef protection.

Journal Ideas

- Have you ever been snorkeling, swimming, or diving near coral reefs? If so, what was it like? If not, what do you think it would be like?
- Why are Maui coral reefs important to you?
- How do you think you and your family affect Maui coral reefs in your daily lives? (This question could be used before and after the unit to see if student views change based on what they learn.)
- What are the most important things one person can do to help protect Maui coral reefs?
- In *Kumulipo*, the Hawaiian creation chant, the coral polyp is considered to be the first living organism created and the origin of all life. How do you think ancient Hawaiians treated coral reefs based on this belief? What would be the same and what would be different today if people acted in this way?

Assessment Tools

- Two-page Internet research report
- Participation in class discussion
- Journal entries

Keeping an Eye on Coral Reefs

Coral reefs are found throughout the tropical oceans of the world. Coral reef ecosystems are among the most diverse in the world. According to the National Ocean Service, coral reefs are the second most productive biological system in the world after tropical rain forests. That means that, acre for acre, they produce the second greatest amount of "biomass," measured as the weight of all living organisms.

Threats to Coral Reefs

In many parts of the world, coral reefs are severely degraded and threatened by human activities. Scientific monitoring of coral reefs has helped to establish that globally, the most damage to reefs is caused by:

Marine Pollution

Much of the pollution in the ocean started out on land. Construction in coastal areas as well as development, logging, or mining along streams that run to the sea can cause soil to erode and get washed into the ocean. In this process of "sedimentation," dirt, silt, and sand can cloud the water or settle directly on reefs, reducing available light and smothering the polyps, making it difficult for coral to thrive. Fertilizers and sewage also make their way into the ocean from land. The nitrogen and phosphorus in this runoff are nutrients that encourage rapid algae growth. Algae overgrowth can choke coral polyps by cutting off their supply of light and oxygen.

And as coastal areas become more built-up and urbanized, there is more paved-over area and less open area to absorb rains. This water may run off into the ocean, carrying with it pollutants such as oil and grease, metals such as mercury and lead, chemicals, and pesticide residues from lawns and landscaping. Trash dumped into or near the water can also kill coral reef animals, getting lodged in animals' stomachs or strangling them.

Fuel leaks from boats, dumping of wastewater holding tanks and bilges, and occasional large oil spills can also damage local coral reefs and interfere with coral reproduction.

Unsound Fishing Practices

People catching fish can harm the reef environment in many ways. In some parts of the world, fishermen desperate to catch fish use explosives, which kill all of the marine life in the surrounding area (making it easier to collect) and reduce nearby coral to rubble. In other places, people use cyanide, chlorine bleach, and other poisons to stun and capture valuable reef fish for the aquarium fish market and for sale in live fish restaurants and markets. The poisons affect not only the fish but also coral "polyps" (the flower-shaped, mature stage of corals) and other marine life in the area.

Overfishing is another concern. In areas where fishing pressure is high, fishermen may change their methods to catch smaller, younger fish that would once have been allowed to get older and reproduce more often. Or they may target new species of fish when the traditional ones become rare.

When people take too many fish from a reef, it can upset the balance of the natural community. For example, overfishing of fish species that eat algae that naturally grows on corals can allow the algae to grow so much that they smother the corals.

Collecting Coral for Trade

Corals are popular as decorations, jewelry, and medicinal supplements. In some parts of the world, they are also collected for use as construction material. Alive, they are sold for use in salt-water aquariums. Taking live corals damages reef communities, especially when collection is concentrated in one area.

Direct Physical Damage

Divers, snorkelers, and recreational boaters can damage reefs by touching them, walking on them, or dropping anchor. Reefs are sometimes dredged or dynamited to make way for coastal construction or to improve access to a harbor. Large seagoing vessels sometimes run aground, damaging large sections of reef.

There are also natural causes of damage to coral reefs, including hurricanes and typhoons, which can break up reefs with powerful waves, and cause heavy rains which increase runoff and sedimentation. Another common threat to corals is the crown-of-thorns starfish (*Acanthaster planci*). It is a large starfish that feeds on corals, and in some parts of the Pacific, large booms in crown-of-thorns populations have caused serious effects on coral reefs. *Acanthaster planci* breakouts have been linked to regions of increased development and "eutrophication" or low oxygen conditions caused by algae overgrowth.

Hawaiian Coral Reefs

Around the world, there is growing concern over reef health. The International Coral Reef Initiative is a new international effort that aims to reverse the trends that have damaged about ten percent of the world's coral reefs beyond recovery. The initiative, which began in 1994, now includes more than 90 member countries.

In Hawai'i there is also concern about the health of our coral reefs. An initial assessment and the results of coral reef monitoring suggest that Hawaiian coral reefs are generally in better shape than reefs in many other parts of the world. Still, people are putting pressure on Hawaiian coral reefs, and the extent of our impact is not always known. One long-term study of coral reefs along the Maui coastline found that, between 1994 and 1998, coral cover declined at the northern sites, which are heavily used by people. In contrast, the more lightly used southern sites remained relatively stable.

In a series of meetings held during 1997 and 1998, scientists and resource managers identified four major problems facing Hawaiian coral reefs:

- Over-fishing,
- Sedimentation,
- Eutrophication, and
- Algal outbreaks.

Developing better research methods, tracking changes in coral reef systems, studying the effects of human-caused impacts such as those listed above, and basing management decisions on that information are all reasons that growing effort is being put toward assessing and monitoring the health of Hawaiian coral reefs.

The Hawai'i Coral Reef Assessment and Monitoring Program (CRAMP) was begun in 1998 to help make the most of the effort that is being put into studying and monitoring coral reefs. CRAMP is developing and applying standard scientific techniques that will allow the results of many different studies of Hawaiian coral reefs to be compared.

Some monitoring programs rely on volunteer effort. Reef Check, for example, is a worldwide program for gathering basic information about coral reefs. Reef Check volunteers receive training that prepares them to do underwater surveys looking at fish, invertebrates, and coral cover. Reef Check has created special Hawai'i data sheets because of the unique species that are found here.

Another volunteer monitoring program is conducted by the Reef Environmental Education Foundation (REEF). Through REEF, divers and snorkelers can participate in fish surveys as part of their regular diving activities. REEF has produced a waterproof color identification card for Hawaiian fishes and a special REEF survey form for Hawai'i. (Websites listed on the following pages provide more information about these volunteer opportunities.)

Protecting Coral Reefs — Internet Research

People around the world are concerned about the health of coral reefs and what people can do to protect these important natural systems. We can learn a lot from what is happening in other parts of the world as we work to protect our coral reefs around Maui and the other Hawaiian Islands.

Your Assignment

1) Select one of the threats to coral reefs listed on the preceding pages.

2) Formulate a question about this threat to guide your Internet research and write it in the space below. Your question may have to do with how this threat is affecting specific coral reefs around the world, actions that people and organizations are taking to protect coral reefs from this threat, government policies designed to minimize this threat, how monitoring is being used to document this threat or the effect of protective actions, or another topic of your choosing.

3) Use the Internet to research your question and write a two-page report based on your research. As a reference, provide the URLs where you got the information on which your report is based.

Website Ideas

Hawai'i Coral Reef Assessment and Monitoring Program at <cramp.wcc.hawaii.edu>.

Reef Environmental Education Foundation at <www.reef.org>.

Reef Check at <www.reefcheck.org>.

Coral Reef Alliance at <www.coralreefalliance.org>.

Coral Reef Ecology website at <www.uvi.edu/coral.reefer>.

U.S. Environmental Protection Agency, Office of Water, "Coral Reefs and Your Coastal Watershed" at <www.epa.gov/owow/oceans/factsheets/fact4.html>.

Key Word Ideas

- Coral reef
- Coral reef ecology
- Coral bleaching
- Coral diseases
- Coral reef threats
- Coral reef monitoring
- Marine protected areas
- Mooring balls