Monitoring Coral Reef Ecosystems with Quadrats

Background & Key Concepts
Coral reefs grow at rates ranging from 1 cm to 100 cm per year. Over long periods of time, they can form huge structures, making them the oldest living systems on Earth. For example, Australia's 2,000-km long Great Barrier Reef was formed over the course of five million years (**http://.panda.org/about_wwf/what_we_do/marine/blue_planet/coasts/coral_reefs/coral_threats/**). While coral reefs have survived years of natural variation, they are sensitive animals that may not be able to survive the rapid changes Earth is experiencing (see Activities 2 and 5). Roughly one-quarter of coral reefs worldwide are already considered damaged beyond repair, with another two-thirds under serious threat.

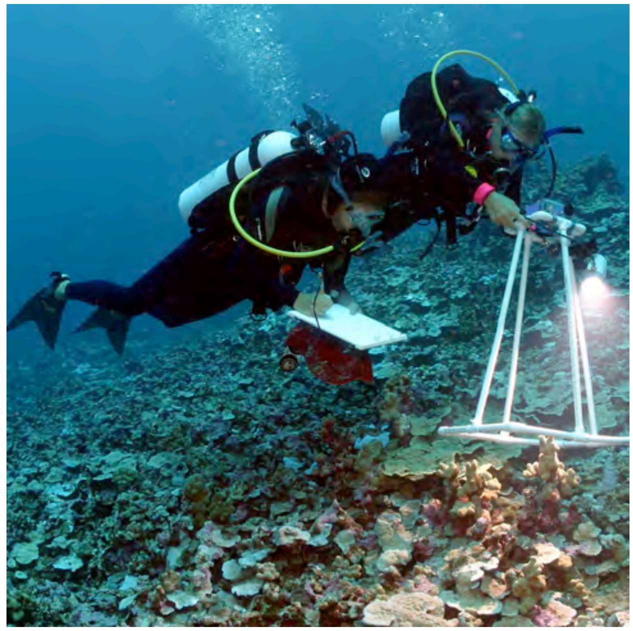
Coral polyps have small algae, or zooxanthellae, growing inside them. This is a symbiotic venture – the zooxanthellae get shelter and nutrients (from captured plankton) from the polyp, while in return the polyp gets food (from photosynthesis) from the zooxanthellae. Because they photosynthesize, zooxanthellae need sunlight to live; this is why most corals only grow where the sea is shallow. The zooxanthellae also give corals their colors. If the zooxanthellae become stressed, for example due to high water temperature, they may leave the polyp. This results in coral bleaching, where the white, calcium carbonate skeletons of the corals are exposed. Some corals do not recover from coral bleaching and death can result.

The fate of corals may be determined in the coming century by the relative timing of sea level rise, global warming, and other anthropogenic (human) impacts. Corals can only grow within a very narrow window of ecological conditions, determined by depth, temperature, and salinity. Some of the major stressors to coral reefs include higher ocean temperatures, high nutrient loads from soil erosion and fertilizers (land-based pollution), overfishing, impacts from tourism, and competition from invasive alien algae (**http://news.bio-medicine.org/biology-news-2/Climate-change-and-coral-reefs-9588-1/**).

http:/.botany.hawaii.edu/GradStud/smith/websites/ALIEN-HOME.htm

Healthy coral reef ecosystems are typically dominated by reef-building corals and coralline algae. On reefs subject to anthropogenic disturbances, corals tend to be outcompeted by invasive algae or to be smothered by sedimentation. The long term consequences of coral loss include decreased productivity and biodiversity, decreased economic value of the reef, changes in the community structure of reef fishes, and ultimately the erosion of the reef structure. Such shifts have been documented here in Hawai‘i. For example, nineteen species of algae, including *Gracilaria salicornia*, or "gorilla ogo," have been introduced to O‘ahu since 1950 (Doty 1961, Brostoff 1989, Russell 1987). Some of these nonnative species appear to have spread throughout all of the main Hawaiian Islands, while others are only found on O‘ahu.

How do Scientists Monitor Coral Reefs?



Sampling is the process by which organisms in small areas can be counted, or quantified, to estimate abundance over a larger area. The small areas, or samples, must be representative of the larger area for these estimates to be accurate. Sampling a reef allows us to estimate species richness, or the number of species in a given area. Species richness is one measure of the health of a reef, as healthy reefs generally have more species than degraded reefs. To calculate species richness, scientists count all the different species they find while sampling. Species richness does not tell us anything about the relative abundance of these species, but simply lets us know how many are present.

Transects and quadrats are two tools commonly used when sampling and monitoring coral reefs. A transect line is any line marked at regular intervals, such as a measuring tape, that is easy to use in the field. Quadrats are framed areas, such as squares made from PVC pipes, as shown in the photograph above. These tools provide a systematic method for determining species richness.

Hawai'i Content & Performance Standards (HCPS III)

The following standards and benchmarks can be addressed using this lesson:

Math Standard 1: Numbers and Operations: NUMBER SENSE: Understand numbers, ways of representing numbers, relationships among numbers, and number systems.

Grade 6 Benchmarks for Math:

Benchmark MA.6.1.1 Compare and order fractions, decimals, and percents.

Math Standard 11: Data Analysis, Statistics, and Probability: FLUENCY WITH DATA: Pose questions and collect, organize, and represent data to answer those questions.

Grades 3-4 Benchmarks for Math:

Benchmark MA.3/4.11.1 Pose questions, collect data using surveys, and organize the data into tables and graphs.

Math Standard 13: Data Analysis, Statistics, and Probability: DATA ANALYSIS: Develop and evaluate inferences, predictions, and arguments that are based on data.

Grade 4 Benchmarks for Math:

Benchmark MA.4.13.1 Propose and justify conclusions/predictions based on data.

Science Standard 1: The Scientific Process: SCIENTIFIC INVESTIGATION: Discover, invent, and investigate using the skills necessary to engage in the scientific process.

Grade 3 Benchmarks for Science:

Benchmark SC.3.1.1 Pose a question and develop a hypothesis based on observations.
Benchmark SC.3.1.2 Safely collect and analyze data to answer a question.

Grade 5 Benchmarks for Science:
Benchmark SC.5.1.2 Formulate and defend conclusions based on evidence.

Grade 6 Benchmarks for Science:
Benchmark SC.3.1.2 Use appropriate tools, equipment, and techniques safely to collect, display, and analyze data.

<u>Social Studies Standard 7</u>: Geography: WORLD IN SPATIAL TERMS-Use geographic representations to organize, analyze, and present information on people, places, and environments and understand the nature and interaction of geographic regions and societies around the world.

Grade 3 Benchmarks for Social Studies:
Benchmark SS.3.7.2 Compare the physical and human characteristics of different communities and regions.
Benchmark SS.3.7.3 Describe the physical and human characteristics that make different regions unique.
Benchmark SS.3.7.4 Examine the ways in which people modify the physical environment and the effects of these changes.

Materials

- Quadrat (1 per student)
- Transect (1 or 2, to share)
- Copies of **Worksheet 6.1: Coral Reef Quadrat Data** and **Worksheet 6.2: Coral Reef Quadrat Data Analysis**. Worksheets are provided below, although you may need to modify the organisms based on your field location. Each student will need several copies of **Worksheet 6.1** and one copy of **Worksheet 6.2**.

Procedure

1) Choose the site you wish to monitor. You can sample a shallow-water coral reef environment, or these techniques can also be used to sample other habitats such as the rocky intertidal zone or the forest.
2) Your students will characterize this area's species richness by placing quadrats at regular intervals along the transect line. Follow the **Instructions: Monitoring Coral Reef Ecosystems with Quadrats** to complete the activity.

Extension

If your class is unable to get out into the field, a fun alternative is to draw your own coral reef. Adding a few art classes to this activity will allow students to further familiarize themselves with their local ocean environment. Have students check out marine classification guides and books and assign each participant a species or substrate to draw. The class can work on one large mural or create two smaller ones, perhaps comparing the health of an impacted reef with a pristine reef. The murals can be made of canvas or butcher paper, and can be decorated with paints or markers. A large collage with picture cut-outs will also work. Students then complete the quadrat activity using their murals.

References Cited

Brostoff, W. 1989. *Avrainvillea amadelpha* from O'ahu Hawai'i. *Pacific Sciences* 43:166-9.

Doty, M.S. 1961. *Acanthophora*, a possible invader of the marine flora of Hawai'i. *Pacific Sciences* 15:547-52.

Russell, D.J. 1987. Introductions and establishment of alien marine algae. *Bulletin of Marine Science* 42: 641-642.

Additional References

Invasive Algae: **www.botany.hawaii.edu/GradStud/smith/websites/ALIEN-HOME.htm**

Invasive Algae (Gorilla Ogo): **http://hawaiiinvasivespecies.org/pests/gorillaogo.html**

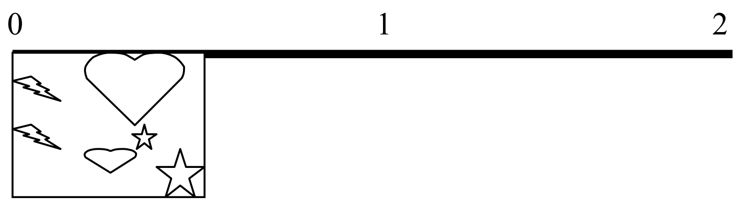
Coral Reef Ecology: **www.coralreefnetwork.com/reefs/ecology/default.htm**

Instructions: Monitoring Coral Reef Ecosystems with Quadrats

Worksheet 6.1: Coral Reef Quadrat Data Collection:

1. On **Worksheet 6.1: Coral Reef Quadrat Data Collection**,

2. Lay out your transect line. Place your quadrat so that one side is flush with the transect line, and one corner of the quadrat touches the 0 meter mark on the transect, as shown below:



3. Obtain a copy of **Worksheet 6.1: Coral Reef Quadrat Data.** On the top of the page, next to "Transect Location", record the location of your transect. For example, will you be studying a coral reef in the Northwest Hawaiian Islands or the Main Hawaiian Islands? Next to "Quadrat Location", write "0 m".

4. Record each species or substrate type contained within your quadrat by placing a hatch mark in the corresponding row on the data sheet. If you find a species or substrate type that is not listed on the data sheet, add it to the worksheet by creating a new row.

5. When you have finished recording all of the species and substrate types in your first quadrat, move your quadrat to the 5m mark on the transect. Obtain a new, blank copy of **Worksheet 6.1: Coral Reef Quadrat Data;** this time write "5 m" for transect location. Repeat the exercise and record your results. Continue to repeat this procedure at 5 meter intervals along the entire transect line (that is, collect data at the 5 m mark, 10 m mark, etc). For example, if you are using a 20 meter transect, you will have a total of 4 quadrats and will record your data on 4 separate data sheets.

Worksheet 6.2: Coral Reef Quadrat Data Analysis

1. Obtain a blank copy of **Worksheet 6.2: Coral Reef Quadrat Data Analysis.** All data analysis will be completed on this worksheet, but you will need to use data from the **Worksheet 6.1: Coral Reef Quadrat Data Collection** worksheets that you completed.

2. For each species, sum the hatch marks from all of your **Worksheet 6.1: Coral Reef Quadrat Data Collection** worksheets, and record the total on **Worksheet 6.2: Coral Reef Quadrat Data Analysis**.

   <u>Example 1</u>: Suppose the number of reef fish in each of your four quadrats was: 5, 3, 2, and 6, which adds up to 16. On the first row of your **Worksheet 6.2: Coral Reef Quadrat Data Analysis**, you would write "16" under "Sum of Quadrat Counts".

3. Species richness is the number of species that are present. To calculate "Species Richness" for the transect, look at the values you listed for "Sum of Quadrat Counts" for each of the species. Count how many are non-zero. Record your answer under "Species Richness."

   Example 2. Suppose the numbers listed in the "Sum of Quadrat Counts" column are 16 reef fish, 5 coral, 0 gorilla ogo, 4 sea urchins, and 0 sea cucumbers. Then, species richness is 3, because only 3 species (reef fish, coral, and sea cucumbers) appeared in at least one of your quadrats.

   Note: Unless you added additional rows, the greatest number you can get for species richness is 5 (because there are only 5 species on your worksheet),

4. Relative abundance is the abundance of each organism relative to all of the other organisms present. To calculate the relative abundance of each species:
   a. Add up the "Sum of Quadrat Count" values for the five species listed, and record the number in the "SPECIES TOTALS" row.
   b. For each of your five species, divide the "Sum of Quadrat Counts" of that species by the value listed in the "SPECIES TOTALS" row. Multiply by 100% to get a percentage.
   c. Record your result in the "Species Relative Abundance" column. Sum the values in the "Species Relative Abundance" column; the total should be 100%.

      Example: Using the numbers given in Example 2, the "SPECIES TOTALS" for the "Sum of Quadrat Counts" would be 16+5+0+4+0 = 25.

      Relative Abundance of reef fish: 16/25 * 100% = 64%
      Relative Abundance of coral: 5/25 * 100% = 20%
      Relative Abundance of sea urchins: 4/25 * 100% = 16%

5. Using the relative abundance data, at the bottom of the worksheet, record which species that are most and least common on your transect.

Worksheet 6.1: Coral Reef Quadrat Data Collection

Transect location: ____________
Quadrat location (distance along transect): _______________
(Use one worksheet per quadrat location)

Species	**Picture**	**Quadrat Count**
Reef Fish		
Coral	 	
Invasive Algae (“Gorilla Ogo”)		
Sea Urchins		
Sea Cucumbers		

Substrate	**Picture**	**Present or Absent?**
Substrate		

Images courtesy of Keoki Stender (www.marinelifephotography.com)

Worksheet 6.2: Coral Reef Quadrat Data Analysis

Species	Picture	Sum of Quadrat Counts	Species Relative Abundance (%)
Reef Fish			
Coral	 		
Invasive Algae (“Gorilla Ogo”)			
Sea Urchins			
Sea Cucumbers			
	SPECIES TOTALS		

Species Richness: __________________
Which Species is most abundant? ______________ Least abundant? ________________

Images courtesy of Keoki Stender (www.marinelifephotography.com)

Marine Science Career Information

Background and Key Concepts
The field of marine science is exciting and diverse, especially in Hawaiʻi. There are numerous job opportunities and career paths – for example, managing fisheries, working on ships, becoming a laboratory technician, and educating others about marine conservation. A career as a marine scientist offers many opportunities to travel and explore the world around you. In this field, you are constantly learning and experimenting, seeking to gain new knowledge and insights. One has to be a curious and independent thinker. A scientist does not accept a conclusion until s/he has enough evidence to reasonably exclude all other possibilities. A scientist also has to be clever and creative so that s/he can dream up experiments to answer her/his questions. Additionally, a scientist must be a 'go-getter'. If scientists conduct their own research, they cannot wait around passively for somebody to tell them what to do. They have to take initiative and show independence. Marine scientists work varying hours, depending on the job and what type of research they are currently doing. The hours are typically longer when one is just starting out. The salaries range greatly and the competition for positions can be high.

So, you're thinking about a career in marine science? Then, it is a good idea to take all the math and science courses you can in high school and college. Expect to spend at least four years in college to get your Bachelor of Science degree. Possible majors include Global Environmental Science, Oceanography, Marine Biology, and Marine Science. Regardless of your major, you will need to develop a basic understanding of science (e.g., biology, chemistry and physics) and mathematics (at least up to calculus), as well as computer, technical and writing skills. It is also important to be comfortable in the water and to be knowledgeable about the marine environment. We recommend that you acquire SCUBA certification and a valid driver's license, and learn to handle a boat.

While you're in high school and college, take advantage of the many opportunities to volunteer or work in the marine science field. For example, you could get a summer or weekend position in an aquarium, government agency, ocean engineering firm, coastal geology consulting company, marine laboratory, fish pond, wildlife rescue center, or marine education center. There are a lot of opportunities for college students to volunteer on research cruises, such as the four-day Hawaiʻi Ocean Time-series (HOT) cruises. Gaining this experience now will help you build a strong resume, which will help you secure a job following graduation.

Hawaiʻi Content & Performance Standards (HCPS III)
The following standards and benchmarks are relevant to marine science careers:

Career and Technical Education Standard 2: CAREER PLANNING: Explore and understand educational and career options in order to develop and implement personal, educational, and career goals.

Grade 3 Benchmarks for Career and Technical Education:
Benchmark CTE.3.2.1: Describe how different careers may require different skills, knowledge, and attitudes.

Grade 4 Benchmarks for Career and Technical Education:
Benchmark CTE.4.2.1 Analyze how doing well in school affects future career opportunities.

Grade 6 Benchmarks for Career and Technical Education:
Benchmark CTE.6.2.1 Establish personal and learning goals related to career and life interests.

Additional References
Most marine science research stations and organizations have their own websites, which you can visit to seek additional information. These websites provide some general information about marine science careers:

http://www.naml.org/videos/

http://oceanlink.island.net/career/career2.html

http://hopkins.stanford.edu/careers.htm

http://life.bio.sunysb.edu/marinebio/mycareer.html

http://aquarium.ucsd.edu/Education/Learning_Resources/So_You_Would_Like_To_Be_A_Marine_Biologist/