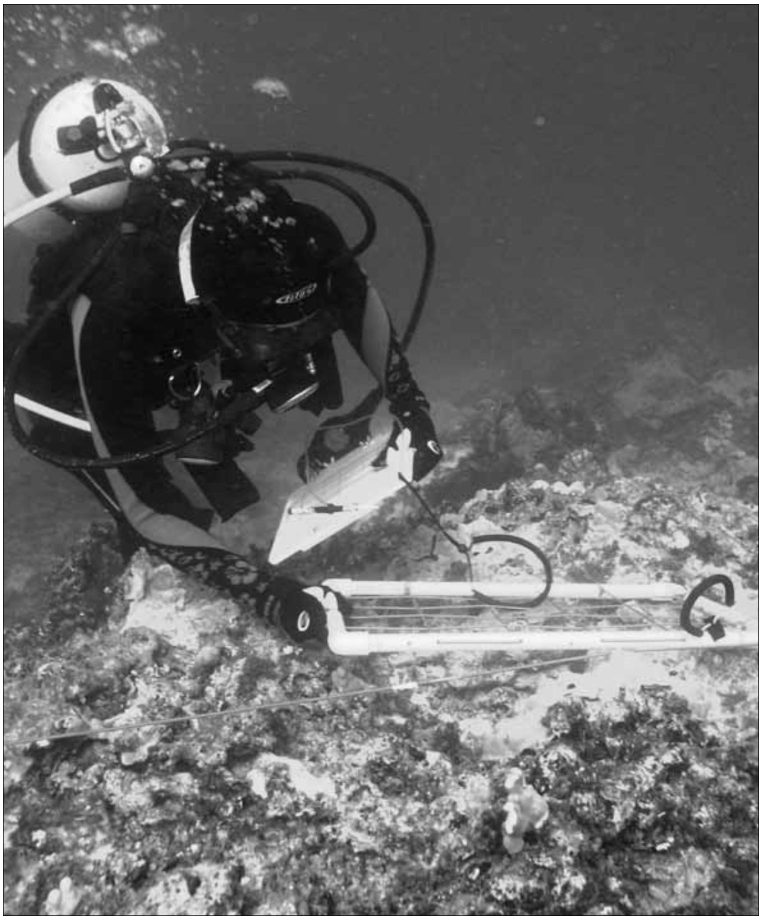

Dave Nichols

Figure 1

Monitoring Coral Reefs using Quadrats

This lesson for 9–11 year olds compares species abundance and distribution on pristine and degraded reefs

by **Carlie Wiener**, **Barbara C. Bruno**, **Jim Foley**

CORAL REEFS ARE THE “rainforests of the ocean”[1] and are home to an estimated one-quarter of the world’s marine species; however, their future is under serious threat. Roughly 70% of coral reefs worldwide have been threatened or destroyed, and an estimated 20% have been damaged beyond repair.[2] To understand why, we need to take a closer look at the anatomy of coral reefs.

Coral polyps have small algae, or *zooxanthellae*, growing inside them. In this symbiotic venture, the polyps provide shelter and nutrients for the zooxanthellae. In return, the algae produce food for the polyps through photosynthesis. Because they photosynthesize, the zooxanthellae need sunlight to live: this is why most corals grow in shallow water. If the zooxanthellae become stressed, for example due to high water temperatures, they may leave the polyps.[3] This exposes the white calcium carbonate skeletons of the corals, resulting in “coral bleaching”. Some corals do not recover from bleaching and die.[4] The fate of corals in the coming century may be determined by the relative timing of sea level rise, global warming, and other *anthropogenic* impacts.

In order to assess the health of these important ecosystems, scientists are monitoring coral reefs worldwide. Hawai‘i is the world’s most isolated island chain, and home to one of the world’s largest marine areas, the Papahānaumokuākea Marine National Monument. Through a partnership with the Office of National Marine Sanctuaries, scientists at the Hawai‘i Institute of Marine Biology examine and compare coral health in the main and Northwestern Hawaiian Islands using a range of monitoring techniques. One of the most common methods involves taking random samples of the coral reef ecosystem by counting all species in a square area contained within a *quadrat* (Figure 1).

In this hands-on science lesson, students use the quadrat technique to compare the relatively pristine reefs in the unpopulated Northwestern Hawaiian Islands with the more degraded reefs in the main Hawaiian Islands, which have been exposed to greater human impacts. The following lesson is a classroom-based activity with optional field and art extensions. It is targeted at grades 4 and 5, but can be modified for other audiences. A vocabulary list is provided in Appendix 1. This lesson can be integrated into a variety of curricular areas and is aligned with the National Science Education Standards[5] and Ocean Literacy Principles[6].

Activity

Students compare two coral reef ecosystems using the maps and worksheet provided. The maps are artistic renderings of: (a) the Northwestern Hawaiian Islands, which show high diversity of marine species; and (b) the main Hawaiian Islands, which show lower species diversity and increased *invasive* algae. These maps can be downloaded from <www.oceanfest.soest.hawaii.edu/links.htm>; miniature versions are shown in Figures 2 and 3. The maps are large (5×7

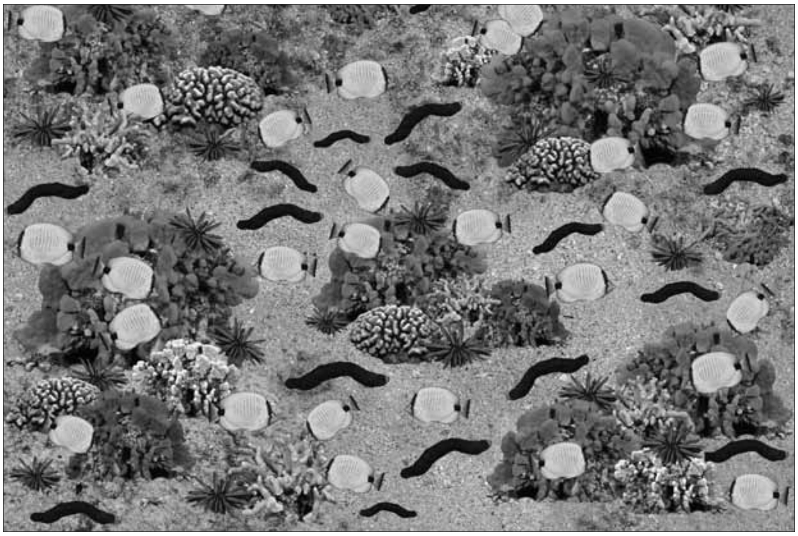

Figure 2: Artistic rendition of a pristine coral reef ecosystem in the Northwestern Hawaiian Islands.

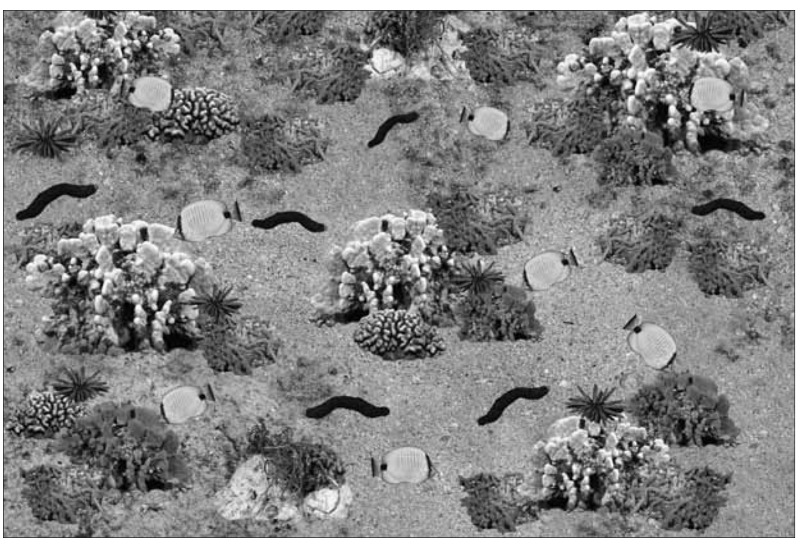

Figure 3: Artistic rendition of a coral reef ecosystem in the main Hawaiian Islands

feet); unless a large-format printer is available, each map can be printed out as a series of letter-size sheets and taped together. Each student will need a copy of the double-sided student worksheet (found at <www.greenteacher.com/contents92.html>) and materials and instructions to make a quadrat (Appendix 2). This activity was developed to compare coral reefs in Hawai'i, but can be easily modified to be relevant to any ecosystem.

Introducing the Activity

Begin with a discussion of the importance of coral reefs and the various ways in which human activities can adversely affect these ecosystems. Lay out the two coral reef maps on the classroom floor or outside. Explain that one of these maps represents coral reefs in the Northwestern Hawaiian Islands, which is far away from where people live. The other map is of coral reefs near the Main Hawaiian Islands, where over a million people live, but don't tell them which is which! Explain that scientists monitor coral reefs using a tool called a quadrat, and the students will be using this same technique today.

This activity starts with students making their own quadrat from PVC pipe and connecting elbows (Appendix 2). If PVC is not available, the students can tape four rods or rulers together to form a square.

Data Collection

Divide the class into groups of four. Give each group a number and assign half of the groups to Map A and the other half to Map B. Two or three groups can work on each map simultaneously. Students place their quadrats randomly on their assigned map, count the number of organisms of each species contained in their quadrat, and record these data on the worksheet entitled "Part 1: Data Collection". If any part of an organism falls within the quadrat, it should be counted as one whole organism, (no fractions are used). Each group of students then repeats the same procedure on the other map, again recording their data on Part 1 of the worksheet.

Using the same worksheet, have students complete "Part 2: Data Analysis" in their groups. Then, bring the class together to compare results. Students typically find that Map A has higher counts for all species except the invasive algae, suggesting Map A is the healthier ecosystem. Ask the class to guess which map is which (Map A is Northwestern Hawaiian Islands and Map B is main Hawaiian Islands), and why they look different (Map B shows more degradation due to anthropogenic (human) impacts). This can lead to a more in-depth discussion about these impacts on reef ecosystems and how students can get involved in marine conservation.

Extensions

Monitoring Local Ecosystems: After completing this classroom activity, students will have the skills to monitor ecosystems in their local area, such as forests, coastal environments, or school fields, using the same quadrat technique. To monitor seasonal variations, students can make monthly measurements throughout the year. To assess longer-term trends, students can input their data into a spreadsheet or database to be used as a benchmark for comparison by other classes in future years. Even if students simply perform the field-based monitoring activity on a single occasion, it provides them a useful means of exploring their local environment.

Creating your Own Ecosystem Map (art project): Have students create their own maps of coral reefs or other local ecosystems (Figure 4), and revise the worksheet accordingly. In preparation, students would need to first research the species found in the chosen ecosystem and create a planning sketch. Alternatively, students could photograph species in their local ecosystems and make a map using a computer drawing program.

This activity allows students to collect and analyze data

Carlie Weiner

Figure 4: Students place their quadrats on a hand-painted map of a coral reef ecosystem.

on coral reef ecosystems using the same monitoring technique as scientists. Evaluations indicate that after conducting this activity, students have a better understanding of coral reef ecosystems.

Carlie Wiener is the Northwestern Hawaiian Islands Research and Outreach Specialist for the Hawai'i Institute of Marine Biology (HIMB). **Barbara C. Bruno** is the Education Coordinator and **Jim Foley** is a marine science educator for the Center for Microbial Oceanography: Research and Education (C-MORE). Both HIMB and C-MORE are part of the University of Hawai'i at Mānoa's School of Ocean and Earth Science and Technology. For more information, or to obtain a list of US and Hawai'I science standards associated with the above activity, contact: fest@soest.hawaii.edu.

This lesson was field-tested with Hawaiian elementary students through the ocean-themed Families Exploring Science Together (Ocean FEST) program. Ocean FEST was developed jointly by HIMB and C-MORE. We are grateful to the numerous students, parents, scientists, and educators who provided feedback on this activity. The coral reef maps were produced by B. Bays, using images generously provided by K. Stender (www.marinelifephotography.com).

The worksheet required for this activity can be found at www.greenteacher.com/contents92.html.

Resources

Tice and Duncan[7] provide inquiry-based lessons that guide students in developing and testing hypotheses regarding coral bleaching. Additionally, Our Project in Hawai'i's Intertidal (OPIHI) describes a range of classroom and field-based activities on their website: <www.hawaii.edu/gk-app12/opihi/index.shtml>.

Appendix 1. Vocabulary List

Anthropogenic – caused by human activities.
Coral Bleaching – exposure of the white, calcium carbonate skeletons of the corals. This typically happens when colorful algae leave the coral polyp due to changed conditions such as increased temperature. When this happens, the coral loses its color.
Coral Polyp – the individual animal that makes up the coral. Each coral polyp contains *zooxanthellae*.
Invasive species – organisms that do not originate in the area where they are found and can harm native species (organisms that are naturally found in an area).
Main Hawaiian Islands – the main eight islands within the Hawaiian Archipelago where most of the state of Hawai'i's population resides. These islands are more developed than the Northwestern Hawaiian Islands.
Northwestern Hawaiian Islands – The northwestern island chain in the Hawaiian Archipelago consisting of ten islands and atolls. Also known as the Papahānaumokuākea Marine National Monument, it was declared one of the world's largest marine protected areas in 2006. This chain is more pristine and significantly less populated than the main Hawaiian Islands.
Quadrat – a square tool used to monitor coral reef environments. Scientists count the species found within the square, and make generalizations about the coral reef ecosystem based on these data.
Zooxanthellae – small algae found within the *coral polyp* that provide food for the coral. Corals need zooxanthellae to survive.

Notes

1. Reaka-Kudla, M., "The global biodiversity of coral reefs" in *Biodiversity II: Understanding and Protecting our Biological Resources*, Reaka-Kudla, M., Wilson, D. and Wilson, E. ed., Joseph Henry Press, 1997, pp. 83-108.

2. Serageldin, I., "Coral reef conservation: Science, economics, law" in *Coral Reefs: Challenges and Opportunities for Sustainable Management*, Fodor, M., Hatziolos, M., and Hooten, A. ed., The World Bank, 1998, pp. 3-7.

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Obura, D., "Coral reef resilience: Policies for coastal zone management to enhance resilience", *Blue Diamonds: Oceans and Coasts March Newsletter* (United Nations Environmental Programme), 2010, pp.4-5.,

3 Hoegh-Guldberg, O. and Smith, J., "The effect of sudden changes in temperature, light and salinity on the population density and export of zooxanthellae from the reef corals *Stylophora pistillata* Esper and *Seriatopora hystrix* Dana", J*ournal of Experimental Marine Biology and Ecology* 129 (3), 1989, pp. 279-303.

Kuhl, M., Cohen, Y., et al. "Microenvironment and photosynthesis of zooxanthellae in scleractinian corals studied with microsensors for 02, pH and light. *Marine Ecology Progress Series*, 117, 1995, pp. 159-172.

4 Serageldin, I., "Coral reef conservation: Science, economics, law" in Coral Reefs: Challenges and Opportunities for Sustainable Management, Fodor, M., Hatziolos, M., and Hooten, A. ed., The World Bank, 1998, pp. 3-7.

5. National Research Council, *National Science Education Standards*, National Academies Press, 1996.

6. National Geographic Society and National Oceanic and Atmospheric Administration, *Ocean literacy: The essential principles of ocean sciences K-12*, <www.coexploration.org/oceanliteracy/documents/OceanLitChart.pdf>, 2006.

7. Duncan, K. and Tice, K., "The case of the sick coral: A model for integrating research and education to translate authentic research into a classroom inquiry investigation of ocean literacy principles", *Current* 25 (2), 2009, pp. 2-9.

Appendix 2: Instructions for Making a Quadrat

Materials

(can be obtained at any hardware store):

- 4-foot length of 3/4" PVC pipe (one per student)
- Four (per student) 3/4" diameter 90° PVC elbows
- Rulers or tape measures
- Pencils
- PVC pipe cutters

Assembly Instructions:

- Using a ruler or tape measure, make a pencil mark every 12 inches on the 4-foot length of PVC pipe. There should be a total of 3 pencil marks (not counting the ends of the pipe).
- Use the PVC pipe cutter to cut the pipe at each pencil mark. Lay out the 4 sections to form a square.
- Insert a PVC elbow at each corner.
- Lay the quadrat on a flat surface. Can the quadrat lie completely flat on the surface? If not, adjust the elbow positioning as needed.
- We do not recommending gluing the quadrats – they are much easier to store when disassembled.