



## 2006 Laser Line Scan Expedition

# What's Down There?

### FOCUS

Mapping Coral Reef Habitats

### GRADE LEVEL

9-12 (Life Science/Earth Science)

### FOCUS QUESTION

What type of data do scientists collect to monitor coral reefs, and how are these data used?

### LEARNING OBJECTIVES

Students will be able to access data on selected coral reefs and manipulate these data to characterize these reefs.

Students will be able to explain the need for baseline data in coral reef monitoring programs.

Students will be able to identify and explain five ways that coral reefs benefit human beings.

Students will be able to identify and explain three major threats to coral reefs.

### MATERIALS

- Copies of "Coral Habitat Data Worksheet," one copy for each student group
- Copies of "Habitat Analysis Grid" photocopied onto transparencies; one for each student group

### AUDIO/VISUAL MATERIALS

- None

### TEACHING TIME

One 45-minute class period, plus time for student research

### SEATING ARRANGEMENT

Groups of 3-4 students

### MAXIMUM NUMBER OF STUDENTS

32

### KEY WORDS

Coral reefs  
Zooxanthellae  
Monitoring  
Benthic habitat  
Fish census  
Bleaching

### BACKGROUND INFORMATION

Coral reefs are one of the most biologically productive ecosystems on Earth, and benefit humans in a variety of ways that include protecting shorelines from erosion and storm damage, supplying foods that are important to many coastal communities, and providing recreational and economic opportunities. In addition, these highly diverse biological communities are proving to be very promising sources of powerful new antibiotic, anti-cancer and anti-inflammatory drugs. Most drugs in use today come from nature. While almost all of these drugs are derived from terrestrial plants and microbes, recent systematic searches for new drugs have shown that marine invertebrates produce more antibiotic, anti-cancer, and anti-inflammatory substances than any group of terrestrial organisms.

Particularly promising invertebrate groups include sponges, tunicates, ascidians, bryozoans, octocorals, and some molluscs, annelids, and echinoderms. For more information about drugs from the sea, see "More About Drugs from the Sea" below. You may also want to visit the Ocean Explorer Web site for the 2003 Deep Sea Medicines Expedition (<http://oceanexplorer.noaa.gov/explorations/03bio/welcome.html>).

Even though they provide numerous benefits to humans, many coral reefs are threatened by human activities. Sewage and chemical pollution can cause overgrowth of algae, oxygen depletion, and poisoning. Fishing with heavy trawls and explosives damage the physical structure of reefs as well as the coral animals that build them. Careless tourists and boat anchors also cause mechanical damage. Some of the most severe damage appears to be caused by thermal stress. Shallow-water reef-building corals live primarily in tropical latitudes (less than 30° north or south of the equator). These corals live near the upper limit of their thermal tolerance. Abnormally high temperatures result in thermal stress, and many corals respond by expelling the symbiotic algae (zooxanthellae) that live in the corals' tissues. Since the zooxanthellae are responsible for most of the corals' color, corals that have expelled their algal symbionts appear to be bleached. Because zooxanthellae provide a significant portion of the corals' food and are involved with growth processes, expelling these symbionts can have significant impacts on the corals' health. In some cases, corals are able to survive a "bleaching" event and eventually recover. When the level of environmental stress is high and sustained, however, the corals may die.

Prior to the 1980s, coral bleaching events were isolated and appeared to be the result of short-term events such as major storms, severe tidal exposures, sedimentation, pollution, or thermal shock. Over the past 20 years, though, these events have become more widespread, and many

laboratory studies have shown a direct relationship between bleaching and water temperature stress. In general, coral bleaching events often occur in areas where the sea surface temperature rises 1° C or more above the normal maximum temperature.

In 1998, the President of the United States established the Coral Reef Task Force (CRTF) to protect and conserve coral reefs. Activities of the CRTF include mapping and monitoring coral reefs in U.S. waters, funding research on coral reef degradation, and working with governments, scientific and environmental organizations, and business to reduce coral reef destruction and restore damaged coral reefs. NOAA monitors reefs using a system of specially designed buoys that measure air temperature, wind speed and direction, barometric pressure, sea temperature, salinity and tidal level, and transmit these data every hour to scientists. Satellites are also used to monitor changes in sea surface temperatures and algal blooms that can damage reefs. Research and restoration projects on selected coral reefs are conducted by NOAA's National Undersea Research Program (NURP). Using high-resolution satellite imagery and Global Positioning Satellite (GPS) technology, NOAA has made comprehensive maps of reefs in Puerto Rico, the U.S. Virgin Islands, the eight main Hawaiian Islands and the Northwestern Hawaiian Islands. Maps of all shallow U.S. coral reefs are expected to be completed by 2009.

While these maps show where various reef habitats are located, they are unable to provide detailed information needed for effective management of complex coral reef systems. Side-scan sonar techniques are able to cover large areas, but cannot distinguish individual organisms in communities of fish, algae, and invertebrates. Video and photographic data can be collected by divers in areas shallower than 20 to 30 meters, and by towed cameras, remotely operated vehicles, and manned submersibles in deeper waters. None of these methods, though, are able

to collect the large amounts of visual data needed to make detailed maps of coral reef habitats.

A new technology called laser line scan (LLS) may provide a bridge between broad-scale approaches such as side-scan sonar and fine-scale video and still photography. LLS systems can detect objects as small as about one centimeter. This is much better resolution than is possible with side-scan sonar, but not quite as good as video. While LLS systems are unable to cover as much area as side-scan sonar, these systems provide two to five times the coverage of video. One of the most publicized uses of LLS was in the search for wreckage from TWA Flight 800, which went down off Long Island in 1996. In 2001, the Ocean Explorer program and NURP co-sponsored a field test of a commercial LLS system for imaging seafloor habitats. Results from this test confirmed the potential of LLS technology for mapping benthic habitats. The laser images revealed details of low relief sediments such as sand waves and ripples, and showed a variety of fishes, salp chains, sea anemones, sea pens, kelp and other macro-algae. These images allowed scientists to identify fish and invertebrate species within a given habitat, and to observe the relationships of these animals to their habitats. The purpose of the 2006 Laser Line Scan Expedition is to test the ability of LLS technology to provide detailed information about a variety of coral reef habitats in the Hawaiian Archipelago.

In this lesson, students will learn about some sources of data on coral reefs, and will have hands-on experience with manipulating and interpreting some of these data.

### LEARNING PROCEDURE

#### 1. To prepare for this lesson:

- Read the introductory essays for the 2006 Laser Line Scan Expedition at <http://oceanexplorer.noaa.gov/explorations/06laserline/welcome.html>.
- Review instructions and Web site contents provided in the "Coral Habitat Data Worksheet."

Depending upon the quality of Internet connections and printing equipment available to students, you may want to download the PDF files for the maps that will be assigned to students (Step 3), and possibly print the images in advance. Each file is approximately 16 Mb, and the maps are approximately 8.5" x 16.5." Notice that each map file contains four layers:

- "Zone" which shows the boundaries of various coral reef zones;
- "Geomorphological Structure" which shows geological structures;
- "Biological Cover" which shows the distribution of coral, algae, and sea grasses; and
- "Background" which shows adjacent land area.

The first three layers can be made visible or invisible by clicking in the box to the left of the layer name in the "Layers" window on the left. The Background layer is locked and is always visible. The key window on the right shows the meaning of the colors and patterns used for each layer. Decide which layers you want students to analyze (Geomorphological Structure, Biological Cover, or both), and make copies of the necessary maps if students will not have access to adequate printing equipment.

If you are not already familiar with coral reefs, you may also want to review the coral reef tutorials at [http://oceanservice.noaa.gov/education/tutorial\\_corals/](http://oceanservice.noaa.gov/education/tutorial_corals/).

A somewhat more sophisticated alternative to using the transparent grid to quantify coral habitats is to have your students use an image analysis program such as NIH Image (available at no cost from <http://rsb.info.nih.gov/nih-image/>). Details for using this program are included in the National Ocean Service Discovery Classroom lesson, "Who Has the

Data?" (11 pages, 352kb; [http://oceanservice.noaa.gov/education/classroom/lessons/01\\_data.pdf](http://oceanservice.noaa.gov/education/classroom/lessons/01_data.pdf)).

2. Lead a brief discussion about the importance of coral reefs, and reasons that they are threatened. You may want to mention the purpose and activities of the U. S. Coral Reef Task Force (visit <http://coralreef.gov/> for more information). Discuss the importance of monitoring to identify threatened reef areas and to improve understanding of reef ecosystems. Highlight the limitations of conventional monitoring and mapping techniques (e.g., satellite and aerial photography, side-scan sonar, diver observations), and introduce laser line scan technology. You may want to have students read some or all of the introductory essays on the 2006 Laser Line Scan Expedition Web site.
3. Tell students that their assignment is to use online data tools to investigate nearshore coral reef habitats around Molokai Island, Hawaii. Assign each student group one of the map frames (89 – 105) on the "Molokai Maps" page ([http://ccma.nos.noaa.gov/products/biogeography/hawaii\\_cd\\_07/htm/maps/maps\\_molokai.aspx](http://ccma.nos.noaa.gov/products/biogeography/hawaii_cd_07/htm/maps/maps_molokai.aspx)).

Provide each student group with a "Coral Habitat Data Worksheet." If you have made the necessary printouts from the map files, instruct students to ignore Step 1. Have each student group complete the tasks described on the Worksheet.

4. Lead a discussion of students' results. Students should realize that a primary purpose of habitat surveys is to establish baselines that can be compared with subsequent surveys to detect changes in coral reef systems. Discuss the variability of habitats around Molokai Island. Students should recognize that there often is considerable variability among habitats, even though the habitats are in the same geographic area. An important part of developing a comprehensive understanding of coral reef ecosys-

tems is knowing how reefs change over time in response to various types of environmental change. Particularly striking is the difference between nearshore habitats on the southwestern end of the island compared to habitats on the northeastern end. Ask students to speculate on possible reasons for these differences. Images of adjacent land in the two areas show striking differences in topography; the northeastern coast is much more rugged and appears more heavily eroded than the southwestern coast.

Remind students that heavy sediment loads are often detrimental to reef-building corals. Students may also speculate that volcanic activity may be involved. Molokai was formed by two volcanoes: West Molokai (also called Mauna Loa) on the western half of the island East Molokai (also known as Wailau) on the eastern two-thirds of Molokai. Much of the East Molokai volcano grew below sea level. In addition, parts of this volcano have collapsed in giant landslides, which contribute to the heavily eroded appearance as well as the influx of sediment to adjacent coastal waters. Some pieces of landslide debris are so large that they have been given individual names as seamounts.

#### THE BRIDGE CONNECTION

[www.vims.edu/bridge/](http://www.vims.edu/bridge/) – Click on "Ocean Science Topics" in the navigation menu to the left, then "Habitats," then "Coastal", then "Coral Reef."

#### THE "ME" CONNECTION

Have students write a short essay on why coral reefs are personally important and specific actions that individuals might take to reduce threats to coral reef systems.

#### CONNECTIONS TO OTHER SUBJECTS

English/Language Arts, Mathematics

#### EVALUATION

Written reports and discussions in Steps 3 and 4 provide opportunities for assessment.

## EXTENSIONS

Online data and tools introduced in this activity can be used for a wide variety of additional activities related to coral reefs and coral reef management. Many of these data and tools can be accessed through "Discover NOAA's Data" at the CoRIS home page (<http://coris.noaa.gov/>) and the "Corals Roadmap to Resources" ([http://oceanservice.noaa.gov/education/kits/corals/supp\\_coral\\_roadmap.html](http://oceanservice.noaa.gov/education/kits/corals/supp_coral_roadmap.html)). The National Ocean Service Coral Reef Discovery Kit (<http://oceanservice.noaa.gov/education/kits/corals/welcome.html>) also contains a variety of other coral reef-related lessons, information, and activities.

## OTHER RELEVANT LESSON PLANS FROM NOAA's OCEAN EXPLORATION PROGRAM

### Mapping the Canyon

<http://oceanexplorer.noaa.gov/explorations/deepeast01/background/education/dehslessons2.pdf>

(pages 1-4 of 10 page document, 72k) (from the 2001 Deep East Expedition)

Focus: Hudson Canyon Bathymetry (Earth Science)

In this activity, students will be able to compare and contrast a topographic map to a bathymetric map; students will investigate the various ways in which bathymetric maps are made; students will learn how to interpret a bathymetric map.

### Keep It Complex!

[http://oceanexplorer.noaa.gov/explorations/03bump/background/education/media/03cb\\_complex.pdf](http://oceanexplorer.noaa.gov/explorations/03bump/background/education/media/03cb_complex.pdf)

(5 pages, 272k) (from the 2003 Charleston Bump Expedition)

Focus: Effects of habitat complexity on biological diversity (Life Science)

In this activity, students will be able to describe the significance of complexity in benthic habitats to organisms that live in these habitats and will describe at least three attributes of benthic habi-

tats that can increase the physical complexity of these habitats. Students will also be able to give examples of organisms that increase the structural complexity of their communities and infer and explain relationships between species diversity and habitat complexity in benthic communities.

### Currents: Bad for Divers, Good for Corals

[http://oceanexplorer.noaa.gov/explorations/02hawaii/background/education/media/nwhi\\_currents.pdf](http://oceanexplorer.noaa.gov/explorations/02hawaii/background/education/media/nwhi_currents.pdf)

(6 pages, 464kb) (from the 2002 Northwestern Hawaiian Islands Expedition)

Focus: The effect of bottom topography on deep-sea currents; the effect of currents on precious coral communities (Earth Science)

In this activity, students will be able to describe, compare, and contrast major forces that drive ocean currents and discuss the general effects of topography on current velocity. Students will also be able to discuss how velocity affects the ability of a current to transport sand and explain why deep-sea precious corals are more frequently found in areas having strong currents.

### Are You Related?

[http://oceanexplorer.noaa.gov/explorations/05deepcorals/background/edu/media/05deepcorals\\_related.pdf](http://oceanexplorer.noaa.gov/explorations/05deepcorals/background/edu/media/05deepcorals_related.pdf)

(11 pages, 465k) (from the Florida Coast Deep Corals 2005 Expedition)

Focus: Molecular genetics of deepwater corals (Life Science)

In this activity, students will define "microsatellite markers" and explain how they may be used to identify different populations and species, explain two definitions of "species," and describe processes that result in speciation. Students will also use microsatellite data to make inferences about populations of deep sea corals.

### **C.S.I. on the Deep Reef (Chemotrophic Species Investigations, That Is)**

[http://oceanexplorer.noaa.gov/explorations/03mex/background/edu/media/mexdh\\_csi.pdf](http://oceanexplorer.noaa.gov/explorations/03mex/background/edu/media/mexdh_csi.pdf)

(6 pages, 444k) (from the 2003 Gulf of Mexico Deep Sea Habitats Expedition)

Focus: Chemotrophic organisms (Life Science/Chemistry)

In this activity, students will describe at least three chemotrophic symbioses known from deep-sea habitats and will identify and explain at least three indicators of chemotropic nutrition.

### **Gellin**

[http://oceanexplorer.noaa.gov/explorations/03mex/background/edu/media/mexdh\\_gellin.pdf](http://oceanexplorer.noaa.gov/explorations/03mex/background/edu/media/mexdh_gellin.pdf)

(4 pages, 372k) (from the 2003 Gulf of Mexico Deep Sea Habitats Expedition)

Focus: DNA analysis

In this activity, students will explain and carry out a simple process for separating DNA from tissue samples, explain and carry out a simple process for separating complex mixtures, and explain the process of restriction enzyme analysis.

### **How Does Your (Coral) Garden Grow?**

[http://oceanexplorer.noaa.gov/explorations/03mex/background/edu/media/mexdh\\_growth.pdf](http://oceanexplorer.noaa.gov/explorations/03mex/background/edu/media/mexdh_growth.pdf)

(6 pages, 456k) (from the 2003 Gulf of Mexico Deep Sea Habitats Expedition)

Focus: Growth rate estimates based on isotope ratios (Life Science/Chemistry)

In this activity, students will identify and briefly explain two methods for estimating the age of hard corals, learn how oxygen isotope ratios are related to water temperature, and interpret data on oxygen isotope ratios to make inferences about the growth rate of deep-sea corals.

### **Cool Corals**

<http://oceanexplorer.noaa.gov/explorations/03edge/background/edu/media/cool.pdf>

(7 pages, 476k) (from the 2003 Life on the Edge Expedition)

Focus: Biology and ecology of *Lophelia* corals (Life Science)

In this activity, students will describe the basic morphology of *Lophelia* corals and explain the significance of these organisms, interpret preliminary observations on the behavior of *Lophelia* polyps, and infer possible explanations for these observations. Students will also discuss why biological communities associated with *Lophelia* corals are the focus of major worldwide conservation efforts.

### **OTHER RESOURCES**

<http://oceanservice.noaa.gov/education/kits/corals/welcome.html> – The National Ocean Service Coral Reef Discovery Kit, with a variety of coral reef-related lessons, information, and activities.

<http://www.coris.noaa.gov/> – NOAA's Coral Reef Information System

<http://oceanexplorer.noaa.gov/projects/laser01/laserlinescan.html> – Essay about laser line scan technology

[http://response.restoration.noaa.gov/topic\\_subtopic\\_entry.php?RECORD\\_KEY%28entry\\_subtopic\\_topic%29=entry\\_id,subtopic\\_id,topic\\_id&entry\\_id\(entry\\_subtopic\\_topic\)=5&subtopic\\_id\(entry\\_subtopic\\_topic\)=8&topic\\_id\(entry\\_subtopic\\_topic\)=1](http://response.restoration.noaa.gov/topic_subtopic_entry.php?RECORD_KEY%28entry_subtopic_topic%29=entry_id,subtopic_id,topic_id&entry_id(entry_subtopic_topic)=5&subtopic_id(entry_subtopic_topic)=8&topic_id(entry_subtopic_topic)=1) – A basic overview of coral ecology, types of things that can harm coral, and see how resource managers go about response and restoration efforts; from the National Ocean Service Office of Response and Restoration

<http://saltaquarium.about.com/cs/aqstylesetup/a/aa031399.htm> – Article about miniature reef aquaria

[http://saltaquarium.about.com/od/startinganaquarium/How\\_to\\_Start\\_a\\_Saltwater\\_Aquarium.htm](http://saltaquarium.about.com/od/startinganaquarium/How_to_Start_a_Saltwater_Aquarium.htm) — Web page with lots of articles and information on starting salt water aquaria

<http://www.garf.org/> — Web site for the Geothermal Aquaculture Research Foundation with lots of information about corals in aquaria

Roberts, S. and M. Hirshfield. Deep Sea Corals: Out of sight but no longer out of mind. <http://www.oceana.org/index.php?id=699> — Background on deep-water coral reefs

Ariadne, D. and D. Diamante-Fabunan. 2000. Coral Bleaching: the Whys, the Hows and What Next? OverSeas, The Online Magazine for Sustainable Seas. [http://www.oneocean.org/overseas/200009/coral\\_bleaching\\_the\\_hows\\_and\\_whys\\_and\\_whats\\_next.html](http://www.oneocean.org/overseas/200009/coral_bleaching_the_hows_and_whys_and_whats_next.html)

<http://www.coral.noaa.gov/> — Web site for NOAA's Coral Health and Monitoring Program

<http://www.mesa.edu.au/friends/seashores/> — "Life on Australian Seashores" by Keith Davey on the Marine Education Society of Australasia website, with an easy introduction to Cnidaria, including their method of reproduction.

<http://www.calacademy.org/research/izg/calwildfall2000.pdf> — Article from California Wild: "Stinging Seas - Tread Softly In Tropical Waters" by Gary C. Williams; an introduction to the venomous nature of tropical cnidarians, why and how they do it

<http://oceania.cofc.edu/activities.htm> — Project Oceanica Web site, with a variety of resources on ocean exploration topics

## NATIONAL SCIENCE EDUCATION STANDARDS

### Content Standard A: Science As Inquiry

- Abilities necessary to do scientific inquiry

- Understandings about scientific inquiry

### Content Standard C: Life Science

- Interdependence of organisms

### Content Standard D: Earth and Space Science

- Geochemical cycles

### Content Standard E: Science and Technology

- Understandings about science and technology

### Content Standard F: Science in Personal and Social Perspectives

- Natural resources
- Environmental quality
- Natural and human-induced hazards
- Science and technology in local, national, and global challenges

## OCEAN LITERACY ESSENTIAL PRINCIPLES AND FUNDAMENTAL CONCEPTS

### Essential Principle 1.

The Earth has one big ocean with many features.

- *Fundamental Concept h.* Although the ocean is large, it is finite and resources are limited.

### Essential Principle 5.

The ocean supports a great diversity of life and ecosystems.

- *Fundamental Concept e.* The ocean is three-dimensional, offering vast living space and diverse habitats from the surface through the water column to the seafloor. Most of the living space on Earth is in the ocean.
- *Fundamental Concept f.* Ocean habitats are defined by environmental factors. Due to interactions of abiotic factors such as salinity, temperature, oxygen, pH, light, nutrients, pressure, substrate and circulation, ocean life is not evenly distributed temporally or spatially, i.e., it is "patchy." Some regions of the ocean support more diverse and abundant life than anywhere on Earth, while much of the ocean is considered a desert.

### Essential Principle 6.

#### The ocean and humans are inextricably interconnected.

- *Fundamental Concept b.* From the ocean we get foods, medicines, and mineral and energy resources. In addition, it provides jobs, supports our nation's economy, serves as a highway for transportation of goods and people, and plays a role in national security.
- *Fundamental Concept c.* The ocean is a source of inspiration, recreation, rejuvenation and discovery. It is also an important element in the heritage of many cultures.
- *Fundamental Concept e.* Humans affect the ocean in a variety of ways. Laws, regulations and resource management affect what is taken out and put into the ocean. Human development and activity leads to pollution (such as point source, non-point source, and noise pollution) and physical modifications (such as changes to beaches, shores and rivers). In addition, humans have removed most of the large vertebrates from the ocean.
- *Fundamental Concept g.* Everyone is responsible for caring for the ocean. The ocean sustains life on Earth and humans must live in ways that sustain the ocean. Individual and collective actions are needed to effectively manage ocean resources for all.

### Essential Principle 7.

#### The ocean is largely unexplored.

- *Fundamental Concept a.* The ocean is the last and largest unexplored place on Earth—less than 5% of it has been explored. This is the great frontier for the next generation's explorers and researchers, where they will find great opportunities for inquiry and investigation.
- *Fundamental Concept b.* Understanding the ocean is more than a matter of curiosity. Exploration, inquiry and study are required to better understand ocean systems and processes.
- *Fundamental Concept c.* Over the last 40 years, use of ocean resources has increased

significantly, therefore the future sustainability of ocean resources depends on our understanding of those resources and their potential and limitations.

- *Fundamental Concept d.* New technologies, sensors and tools are expanding our ability to explore the ocean. Ocean scientists are relying more and more on satellites, drifters, buoys, subsea observatories and unmanned submersibles.
- *Fundamental Concept f.* Ocean exploration is truly interdisciplinary. It requires close collaboration among biologists, chemists, climatologists, computer programmers, engineers, geologists, meteorologists, and physicists, and new ways of thinking.

### SEND US YOUR FEEDBACK

We value your feedback on this lesson.

Please send your comments to:

[oceaneducation@noaa.gov](mailto:oceaneducation@noaa.gov)

### FOR MORE INFORMATION

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### ACKNOWLEDGEMENTS

Produced by Mel Goodwin, PhD, Marine Biologist and Science Writer, Charleston, SC for NOAA. Design/layout: Coastal Images Graphic Design, Charleston, SC. If reproducing this lesson, please cite NOAA as the source, and provide the following URL: [oceanexplorer.noaa.gov](http://oceanexplorer.noaa.gov)

Problem links updated May 2011.

## Student Handout

### Coral Habitat Data Worksheet

1. Obtain a map of benthic habitats for your assigned area:
  - a. Navigate to [http://ccma.nos.noaa.gov/products/biogeography/hawaii\\_cd\\_07/htm/maps/maps\\_molokai.aspx](http://ccma.nos.noaa.gov/products/biogeography/hawaii_cd_07/htm/maps/maps_molokai.aspx). This is an index page for benthic habitats around Molokai Island, and is part of the Shallow-Water Benthic Habitats of the Main Hawaiian Islands project from NOAA's Center for Coastal Monitoring and Assessment.
  - b. In the "Molokai Maps" box, click inside the frame that was assigned to your group, to download a PDF file that contains information about benthic habitats in the area enclosed by the frame. When you open this file, you should see a large map with two smaller windows on the right and left. Information on the map is organized into layers. Each layer is listed in the "Layers" window on the left, and contains a certain type of information:
    - The "Zone" layer shows the boundaries of various coral reef zones;
    - The "Geomorphological Structure" layer shows geological structures;
    - The "Biological Cover" layer shows the distribution of coral, algae, and sea grasses; and
    - The "Background" layer shows adjacent land area.The first three layers can be made visible or invisible by clicking in the box to the left of the layer name. The Background layer is locked and is always visible. The window on the right shows the meaning of the colors and patterns used for each layer. Print the layers assigned by your teacher on a color printer. If you are able to print onto 11" x 17" (tabloid) size paper, be sure to select "None" in the "Page Scaling" window in the Print dialogue box. If you need to use a smaller size paper, select "Tile All Pages" in the "Page Scaling" window in the Print dialogue box. The maps must be printed full size in order for the "Habitat Analysis Grid" to work properly.
2. Using the transparent "Habitat Analysis Grid," count the number of grid squares occupied by each Geomorphological Structure or Biological Cover type as instructed by your teacher. Each grid square corresponds to an area of approximately 0.01 square kilometers.
3. Make a table and pie charts summarizing these data.

**Student Handout**

**Habitat Analysis Grid**

(one square represents approximately 0.01 km<sup>2</sup>)

